HIGH TECH SYSTEMS & MATERIALS SECTOR

AN IN-DEPTH OVERVIEW OF THE HIGH TECH SYSTEMS & MATERIALS SECTOR IN BRABANT

BRABANT IS BRIGHT.nl

Index

Index

Index

Colophon

Brabant, the Netherlands – an in-depth analysis of its High Tech Systems & Materials industry,
a publication of the Brabant Development Agency (BOM), Tilburg, the Netherlands

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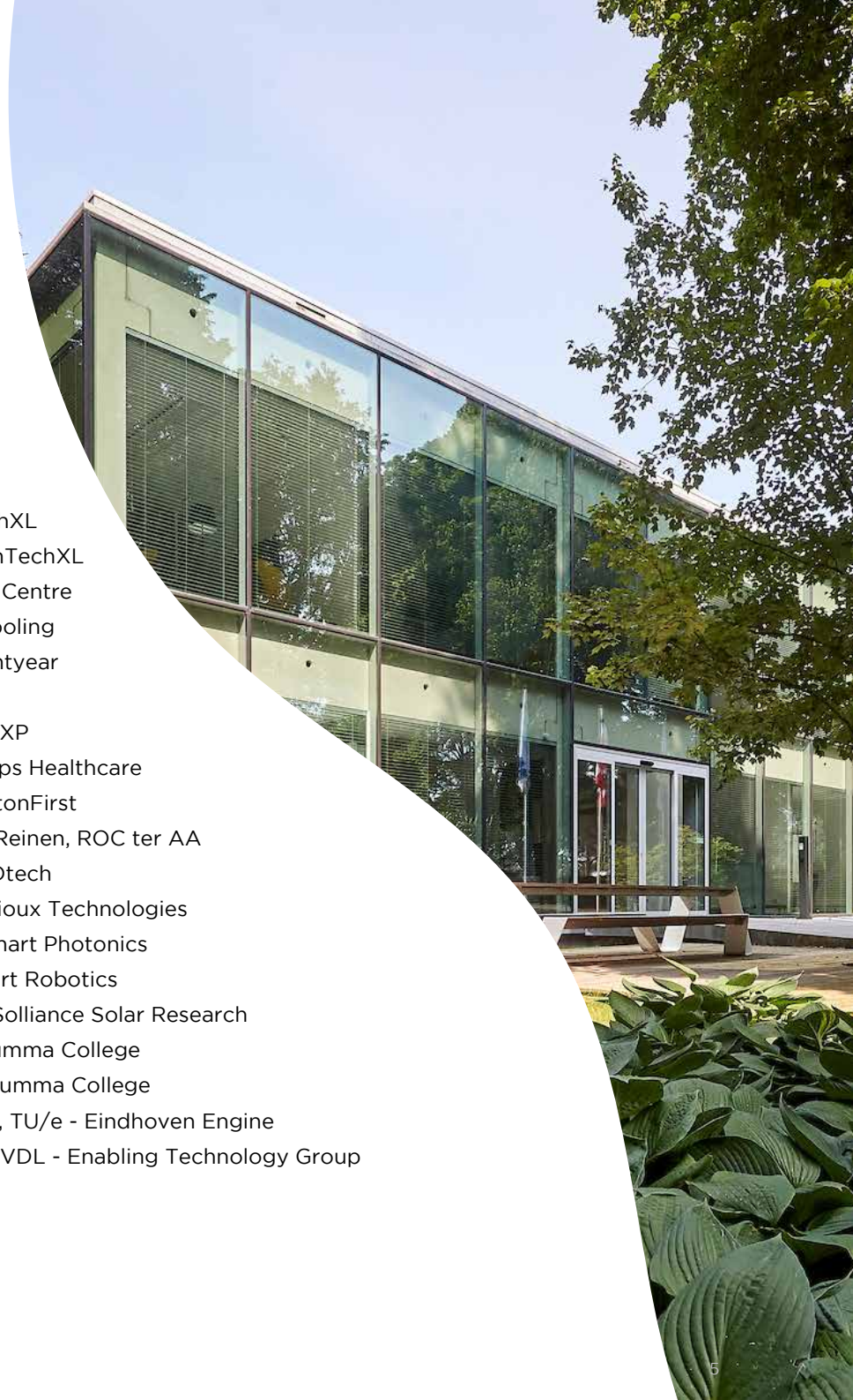
DESIGN

Maan identity. design. content. - Ulvenhout



1. INTRODUCTION TO THE STUDY

High Tech Systems & Materials sector in Brabant
An in-depth overview

Dear Reader,

We are the Brabant Development Agency (BOM) and we are proud to present to you our new in-depth overview of the High Tech Systems & Materials (HTSM) sector in Brabant.

The goal of this report is to provide you with a detailed overview of the High Tech Systems & Materials sector in Brabant, including the strengths and opportunities the region has to offer. Brabant is home to 15,560 HTSM companies, employing a total of 129,110 people. This means the province has 16.2% of all companies and 21.5% of all jobs in the HTSM industry in the Netherlands. In other words, the high tech manufacturing and systems industry has a strong presence in Brabant. Brabant has a long and world class track record in high complexity machine building and complex systems. The ecosystem is built around an industrial cluster with top players like Philips, ASML, NXP, DAF Trucks. Next to that, the various campuses and (applied) knowledge institutes, play an essential role.

The current COVID-19 pandemic, but also recent geo political developments, identified the vulnerability of the ecosystem however. Next to that, we face serious societal challenges: e.g. the energy transition and increasing healthcare costs. These findings are also backed by this report.

During the various interviews for this in-depth study, we learned that in many aspects, the Dutch and Brabant ecosystem could (largely) contribute to these challenges. If we, as a region, want to maintain and strengthen a sustainable competitive advantageous position - and tackle societal challenges - an integral approach in which the various stakeholders (triple helix approach) is needed. We should work closely together in order to identify and target the strategic international parties that are able to contribute to this ecosystem.

Whilst conducting this study, the responsiveness and collaborative nature of our interviewees really struck us. Collaboration and the willingness to join forces are in the capillaries of the Brabant technology ecosystem. This has been of great value.

So who are we? We are the Brabant Development Agency. Based in Tilburg, our BOM Foreign Investments & International Trade department assists new and existing foreign companies to make optimal use of the opportunities offered by Brabant as a business location. We also provide hands-on support to companies based in Brabant that are growing their business abroad.

We hope you will enjoy reading this in-depth review, and if you would like to know more about what Brabant has to offer, then please feel free to reach out to us!

With kind regards,
Frits Hoeve

Senior Project Manager, High Tech Systems & Materials
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Introduction

This review is a sequel to the first in-depth study of the High Tech Systems & Materials sector in Brabant, created for and by BOM Foreign Investment & International Trade in 2015. The 2015/2016 study was authored by Henry de Vaan (Fanion Onderzoek & Advies) and Onno Huiskamp (BOM). This 2020/2021 study aims to provide a comprehensive overview of the High Tech Systems & Materials (HTSM) industry in Brabant, including international trends and developments and its priority niches and development areas. The report is laced with profiles of inspiring regional and national players in the high tech world.

The target audience of this report is primarily professionals with an interest in the high tech systems and materials industry, persons that represent companies already established in Brabant or those with an interest in doing so, as well as investors from the Netherlands or abroad or innovation partners in the Brabant HTSM network. The report is also of value to specific national, regional, or local government bodies, industry organizations, economic development agencies, and media companies that wish to gain further insight.

The review is based on desk research, extensive data-analysis, stakeholder and sector-specialist interviews, and intensive cooperation between the authors and representatives of BOM and its key partner organizations in Brabant.

The report contains Brabant-specific facts and figures but is written with the clear recognition that the HTSM sector is a global industry where regional and even national borders are of little importance. This is why the report focuses in its entirety on the province of Brabant embedded in a wider national perspective of the Netherlands, operating in the global market.

This review aims to give the reader an accurate profile of what Brabant has to offer. While we have strived to make this study as complete and accurate as possible, we always appreciated hearing readers' comments and thoughts, as they are valuable for future editions of this document. We hope this study will provide valuable insights and prove to be an entertaining read.

Above all else, we hope it provides the stakeholders in the HTSM industry with tools such as the following:

- A looking glass to see the important sector details
- A helicopter to see the bigger picture across regional and national borders and across society as a whole
- A compass to help determine the future strategic direction of the industry in key enabling technologies and in areas of application
- Scales to help prioritize, choose, and focus
- A crystal ball providing inspiration to work together and to invest time, effort, and money in developing HTSM solutions for a more sustainable and happier future society

We would like to acknowledge and thank all our contributors for the input they provided. It would have been absolutely impossible to create this report without them.

Ben Engel, Engel – Een Heldere Blik
Henry de Vaan, Fanion Onderzoek & Advies

2. INTRODUCTION TO BRABANT, THE NETHERLANDS

A. What has Brabant got to offer?

The Dutch province of Noord-Brabant is located in the southern part of the Netherlands, strategically situated between Amsterdam Schiphol Airport, Europe's leading seaport in Rotterdam, the Port of Antwerp, Brussels and the major German economic heartland of the Rhine-Ruhr region. Brabant covers an area of 5,082 km2, making it the second largest province in the Netherlands, and is home to some 2.5 million people spread across 62 municipalities.

- From a geographic perspective, Brabant offers easy access to 170 million Europeans within a 500 km (310 m) radius. Physical and telecommunication infrastructure are best-in-class when it comes to establishing head office, marketing and sales, R&D, manufacturing and/or logistics operations.

- In terms of costs, the Netherlands has a company-friendly tax structure when compared to most other European countries.

- Research, product and process development and manufacturing are part of Brabant's DNA. Ranging from primary production in agriculture and the food industry to the manufacture of semi-finished products all the way through to OEM manufacturing for the most complex electronic, biopharmaceutical, nutraceutical and IT products and equipment, all of these activities can be found in the region in abundance.

- The well-developed industrial and knowledge networks or 'ecosystems' in the High Tech Systems, Logistics, Life Sciences & Health, AgriFood, Chemicals and Aerospace industries offer opportunities for joint ventures at a very high level. Cross-industry partnerships in the region are a given.

Source: BOM, Info & Graphics

B. Brabant's main benefits

The province of Brabant offers a business-friendly environment and a high willingness to collaborate. Next to that, it has a number of favourable geographical benefits:

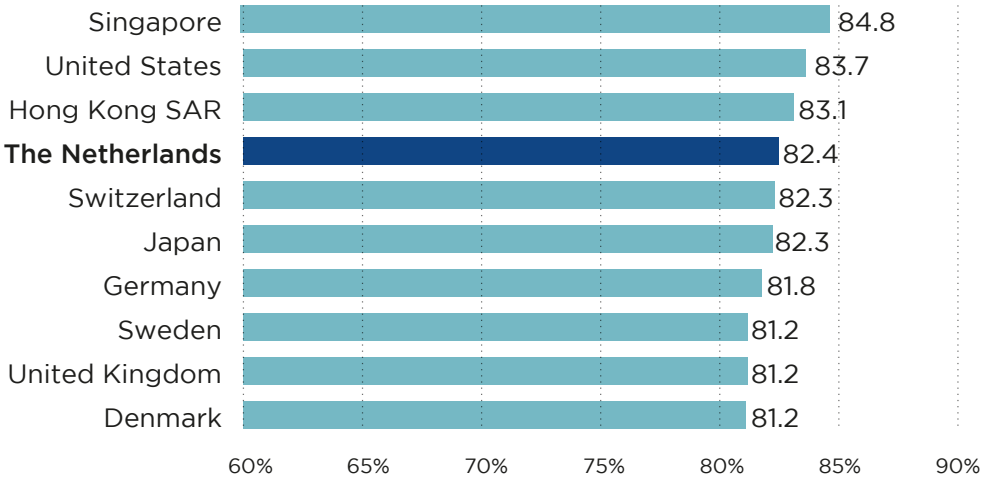
The Netherlands as a whole and Brabant offer:

- an attractive tax climate, including personal and corporate income tax and value-added tax (VAT)
- a stable economic, political and social climate
- competitive labor costs

Brabant is particularly strategically well-located in Europe because:

- it is centrally located in north-western Europe
- it is easily accessible
- it has excellent infrastructure

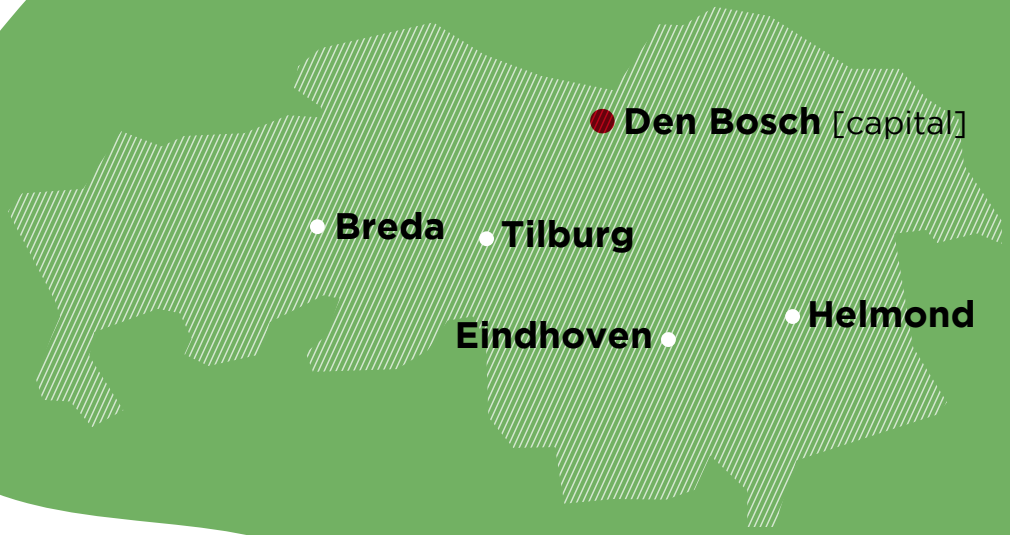
As a whole, time and time again, the Netherlands – with Brabant as its innovative heart – has proven to be a very competitive economy on a global scale!



THE NETHERLANDS, ONE OF THE WORLD'S MOST COMPETITIVE ECONOMIES (WORLD ECONOMIC FORUM (2019) – THE GLOBAL COMPETITIVENESS REPORT 2019

C. Brabant's main cities

Covering 5,000 square kilometres (2,000 square miles), almost 15% (2.5 million inhabitants) of the Dutch population lives in Brabant. The capital of Brabant is Den Bosch, while its largest city is Eindhoven followed by the cities of Tilburg, Breda, Den Bosch and Helmond.



D. Brabant: industry, science and innovation

Brabant is a productive, highly industrialised and knowledge-intensive province in the Netherlands and as such provides attractive opportunities to companies looking for (partnerships in) industrial innovation and/or state-of-the-art manufacturing.

In fact, Brabant is the most intensive region in the Netherlands when it comes to R&D and one of the most innovative regions in Europe, as aptly illustrated by the following three facts:

1. **30% of all industrial R&D in the Netherlands is undertaken in Brabant**
2. **50% of all European patent applications from the Netherlands are generated in Brabant**
3. **Brabant holds fifth place in Europe for regions with the highest number of patent applications**

Source: BOM, Info & Graphics

With over 34,000 people engaged in R&D activities, Brabant can provide the required brainpower thanks to its bright people and numerous research and educational institutes. Geographical clustering results in ready partnerships between businesses, universities and public research institutions. Cooperative R&D results in a mutual bolstering of strengths and inspiration and involves sharing technological know-how, expensive research facilities and being a part of national and European technology programmes. This distinctive collaborative research style is the secret to significantly advancing R&D and innovation activities.

Eindhoven metropolitan area: Brainport Eindhoven

Metropolitan Eindhoven is a conglomeration of 21 municipalities in the southeast of the province of Brabant. The adjoining municipalities comprise a total area of approximately 1,500 km² and are home to 750,000 people. The three largest centers in the region are Eindhoven (with 240,000 inhabitants), Helmond (95,000), and Veldhoven (45,000).

The Eindhoven Metropolitan Region coordinates economic, spatial planning, and mobility policy between the 21 regional municipalities, helping the Brainport Eindhoven knowledge region to fulfil its ambitions. Brainport Eindhoven is a partnership between municipalities, companies, and knowledge institutes in the Eindhoven Metropolitan Area, which is often referred to as the Triple Helix. The region is home to an exceptionally well-developed high tech and advanced manufacturing industry and is the heart of Holland High Tech.

In 2016, Brainport Eindhoven was officially granted Dutch Mainport national status, joining the Amsterdam and the Rotterdam regions. Six companies in Brainport Eindhoven are in the Dutch top 30 of Dutch when it comes to research and development spending: ASML (1), Philips (2), NXP (5), DAF (7)), VDL (9), DEMCON (18), and Neways (29).

LEVEL OF PRIVATE R&D INVESTMENT IN THE REGION

In 2019, company R&D expenditure in Brainport Eindhoven rose to the highest level ever, at 2.4 billion euros. As such. the region continues to lead the way in the Netherlands in the field of industrial innovation. The region's industrial players are responsible for more than one-fifth (20%) of all Dutch corporate R&D, and in 2019 it grew for the seventh consecutive year. The COVID pandemic resulted in setbacks in the first two quarters of 2020, but the decline in Brainport Eindhoven was less than the national average.

HIGH-LEVEL AND HIGHLY PROFITABLE EXPORTS

At 31.9 billion euros worth of exports in 2018, the southeast of Brabant is the third-largest export region in the Netherlands, after Rotterdam and Amsterdam. But while Rotterdam and Amsterdam also benefit from imports and re-exports (trans-shipment), as they are home to the largest port and the third-largest airport in Europe, Brainport Eindhoven's high tech products and systems are **'made in Brabant'**!

BRAINPORT EINDHOVEN

E. Facts and figures

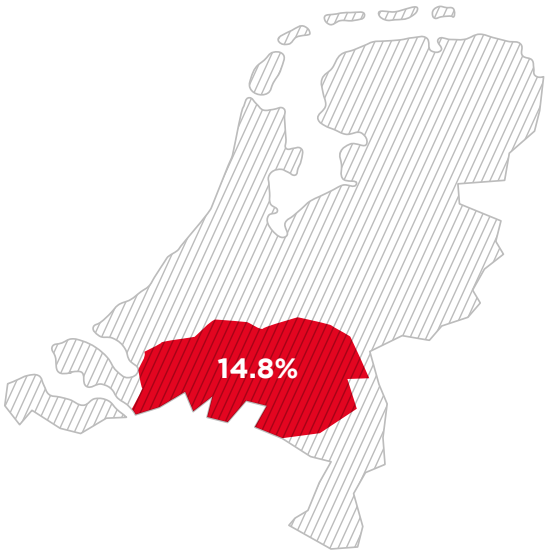
DEMOGRAPHICS

Population as of 01-01-2019
Brabant 2,544,806 14.8%
The Netherlands 17,282,163 100%

Population growth in 2018
Brabant 0.65%
The Netherlands 0.59%

Population density per km²
Brabant 416
The Netherlands 513

Non-Dutch nationals 2019
Brabant 151,254 5.9%
The Netherlands 1,110,859 6.4%



Age groups

	The Netherlands	Brabant
0 - 14	16.1%	15.5%
15 - 64	65.1%	64.9%
65+	18.9%	19.7%
Total	100%	100%

Source: The Dutch Central Bureau for Statistics (CBS), Eurostat, LISA, BOM, Province of Brabant

THE ECONOMY

GDP for 2018 (in euros x1000, market prices)
Brabant 116,090,000 15%
The Netherlands 774,039,000 100%

Economic growth 2018
Brabant 3.0%
The Netherlands 2.6%

Total own R&D spend as a % of GDP 2017
Brabant 3.06%
The Netherlands 1.98%

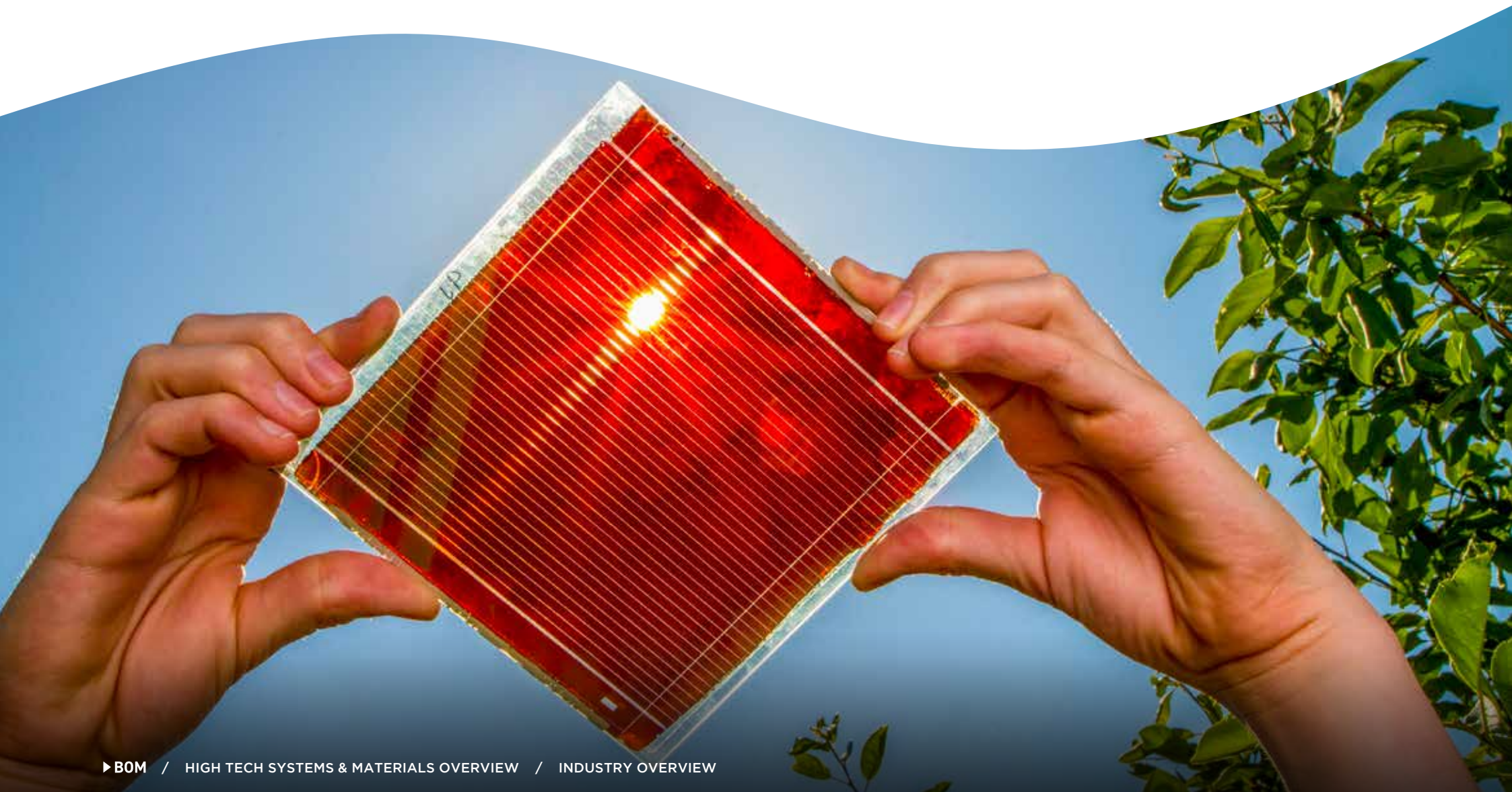
Companies
Brabant 231,990 14.2%
The Netherlands 1,630,070 100%

Jobs
Brabant 1,297,560 15%
The Netherlands 8,651,830 100%

Foreign companies 2019
Number of companies in Brabant 1,660
Brabant workforce 119,870

Industrial property
Total available in January 2019 (ha) 1,790
Immediately available in January 2019 (ha) 790

3. INDUSTRY OVERVIEW



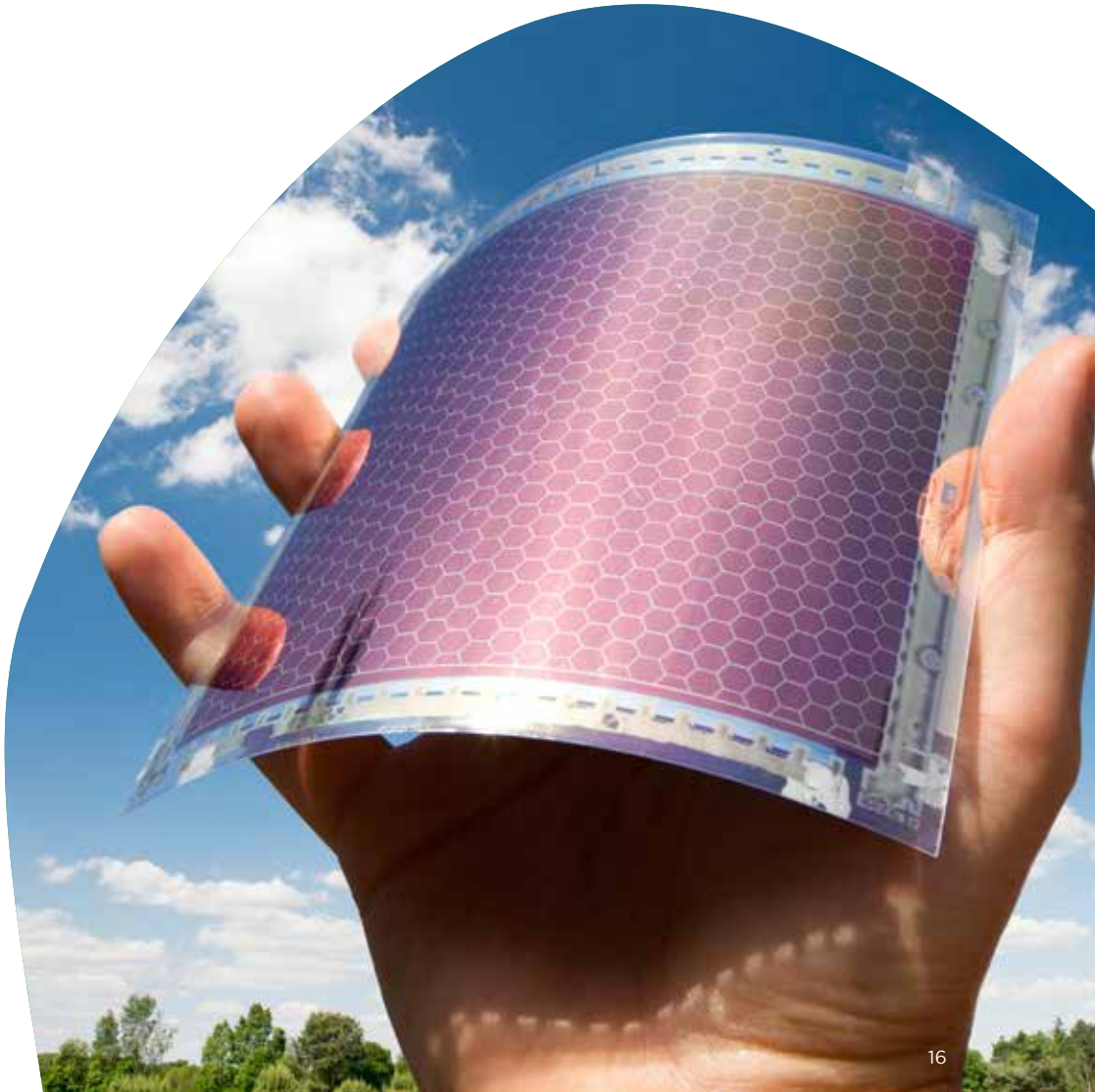
A. The complete HTSM value chain is present and well-developed

This in-depth overview and analysis of the High-Tech Systems & Materials industry in Brabant examines all possible aspects that define a successful ecosystem, from industrial prowess to academic excellence, educational strength, willingness to cooperate and share, ambition, the labor market, real estate, and all other facets.

Our analysis concludes that the complete HTSM value chain is both present and well-developed in Brabant, the Netherlands.

Moreover, one can confidently assert the following with regard to the High Tech Systems & Materials ecosystem in the region:

Because of the fact that, all expertise and every skillset in High Tech Systems & Materials conceivable is available in Brabant, the Netherlands, and because cooperative partnerships are deeply ingrained in the region's DNA, one can objectively declare that every conceivable machine, piece of equipment, integrated and/or cyber-physical system can be invented, designed, engineered, manufactured & assembled, commercialized, and (remotely) maintained in Brabant.



THE INTEGRATED VALUE CHAIN HTSM BRABANT - INCLUDING A SELECTION OF COMPANIES

RESEARCH & DEVELOPMENT

- Altran (TASS)
- AME Applied Micro Electronics
- ASML
- DEMCON
- Malvern Panalytical
- NXP
- Philips Healthcare
- RAITH
- Sioux Technologies
- Thermo Fisher Scientific

- Dimenco

DESIGN & ENGINEERING

- AAE Advanced Automated Engineering
- Bradford Engineering
- DEMCON
- Frencken Mechatronics
- The MathWorks
- NXP
- Prodrive Technologies
- Proven Concepts
- VDL ETG, Enabling Technologies Group

- IME Elektrospinning

PROTOTYPING & INDUSTRIALIZATION

- ASML
- Ceratec Technical Ceramics
- NXP
- NTS Group
- Philips Healthcare
- Philips Innovation Services

- Incooling
- Lightyear
- SALDtech
- Smart Photonics
- Smart Robotics

COMPONENT & SUB-ASSEMBLIES MANUFACTURING

- Anteryon
- Frencken Engineering
- GKN Fokker Technologies
- KMWE
- NTS Group
- Teledyne DALSA
- VDL Group

- Additive Industries
- Leyden-Jar Technologies
- LionVolt
- SALDtech
- Smart Photonics

SYSTEM INTEGRATION

- ASML
- DAF Trucks
- Dasault Systèmes
- GEA Food Solutions
- Kulicke & Soffa
- Marel Poultry
- PlantLab
- Thermo Fisher Scientific
- HTSC (EAISI)

- Additive Industries
- LIQAL
- Pixelfarming Robotics
- PrecEyes

COMMERCIALIZATION

- ASML
- Bosch Security Systems
- DAF Trucks
- NXP
- Philips Healthcare
- PlantLab
- Signify
- Thales Cryogenics
- Thermo Fisher Scientific
- Vanderlande Industries

- PAL-V International

SERVICE & MAINTENANCE

- ASML
- Chromalloy Holland
- DAF Trucls
- DVC Machine Vision
- ENGIE
- Flowserve
- Philips Healthcare
- SPIE
- SPM Instrument
- Stork Thermeq

- LIQAL

(OUTSOURCED) SUPPLY CHAIN & SUPPORT CHAIN

Rhenus – O&M Movianto – DB Schenker – Systemair – Tjoapack – Neways Technology – IT&Care – Arnold & Siedsma – PerkinElmer / One Source – Axxicon Moulds – Bestronics – BKB Precision Bronkhorst Flow Technology – Ceratec Technical Ceramics – DEMCON – Eurofins Materials Science – Fujitsu Glovia – Gain Automation Technology – Goudsmit Magnetics – HighTechXL – The Gate KMWE Toolmakers – Mevi Advanced Technology – NTS Group – Philips Innovation Services – Sioux Technologies – TMC Group – Unicorn Industrial Cleaning Solutions Van Veghel Industrial Packaging – VanBerlo Goup – Xycarb Ceramics – YASKAWA

UNIVERSITIES, RESEARCH INSTITUTES & EDUCATION

TU/e, Eindhoven University of Technology – JADS, Jheronimus Academy of Data Science (a.o. Den Bosch) – Avans University of Applied Sciences (a.o. Breda) Fontys University of Applied Sciences (a.o. Eindhoven, Den Bosch) – Breda University of Applied Sciences – Holst Centre (Eindhoven) – Summa College – ROC ter AA Solliance Solar Research Institute (Eindhoven) – DIFFER Basic Energy Research Institute (Eindhoven) – EAISI Eindhoven Artificial Intelligence Systems Institute – Eindhoven Engine

Source: Engel – Een Heldere Blik helder@benengel.nl – +31 (0)652612671

- Start-up, scale-up or newly spun-off company
- High Tech Systems & Materials

B. Definition of the High Tech Systems & Materials industry

Metal industry	
2410	Manufacture of iron and steel and of ferro alloys
2420	Manufacture of steel pipes, tubes, hollow profiles
2431	Cold drawing of bars
2432	Cold rolling of strip steel
2433	Cold forming and cold seaming
2434	Cold drawing of wire
2441	Manufacture of precious metals
2442	Manufacture of aluminum
2443	Manufacture of lead, zinc and tin
2444	Manufacture of copper
2445	Manufacture of other non-ferrous metals
2446	Melting and refining of uranium
2451	Iron casting
2452	Casting of steel
2453	Casting of light metals
2454	Casting of other non-ferrous metals
2521	Manufacture for boilers, radiators for central heating
2529	Manufacture of metal tanks and reservoirs
2530	Manufacture of steam boilers (not for central heating)
2540	Manufacture of weapons and ammunition
2550	Forging, pressing, stamping and profile rolling of metal
2561	Surface treatment and coating of metal
2562	General metalworking
2573	Manufacture of tools
2591	Manufacture of steel drums, etc.
2593	Manufacture of wire and chain articles
2594	Manufacture of bolts, screws, and nuts
2599	Manufacture of other metal products (rest)
3311	Repair of metal products

Manufacturing of Transportation equipment	
2211	Manufacture of rubber tires and retreading
2229	Manufacture of other plastic products
2910	Manufacture of cars
29201	Bodywork construction
2931	Manufacture of electrical and electronic parts
2932	Manufacture for non-electrical, electronic parts
3020	Manufacture of rolling track and tramway equipment
3030	Manufacture of aircraft and parts therefore
3040	Manufacture of military fighting vehicles
3091	Manufacture of motorcycles and mopeds
3092	Manufacture of bicycles and invalid carriages
3099	Manufacture of other transport equipment (rest)
3316	Aircraft repair and maintenance
3317	Repair and maintenance of other transport equipment

Research & Development and Software development	
6201	Develop, produce and publish software
7112	Engineers and other technical design and advice
71202	Inspection and control of machines, equipment, and materials
72192	Technical research and development work

This study is based on the definition for the High Tech & Maintenance top sector as outlined by the The Dutch Central Bureau for Statistics (CBS).

Continued on next page >

Machines and appliances

2611	Manufacture of electronic components
2612	Manufacture of electronic circuit boards
2620	Manufacture of computers and peripheral equipment
2630	Manufacture of communication equipment
2640	Manufacture of consumer electronics
2651	Manufacture of measuring, control, navigation, and control app.
2652	Manufacture of watch movements
2660	Manufacture of irradiation equipment, etc.
2670	Manufacture of optical instruments and equipment
2680	Manufacture of information media
2711	Manufacture of electric motors, electric generators
2712	Manufacture of switch gear and control gear assemblies
2720	Manufacture of batteries and accumulators
2731	Manufacture of optical fiber cables
2732	Manufacture of other electrical and electronic cables
2733	Manufacture of switches, plugs, sockets etc.
2740	Manufacture of electric lamps, lighting devices
2751	Manufacture of electrical household appliances
2752	Manufacture of non-electric household appliances
2790	Manufacture of other electrical equipment
2811	Manufacture of engines, turbines (not for aircraft)
2812	Manufacture of hydraulic equipment
2813	Manufacture of non-hydraulic pumps and compressors
2814	Manufacture of valves
2815	Manufacture of gears, bearings, etc.
2821	Manufacture of industrial furnaces and burners
2822	Manufacture of hoisting, lifting and transport equipment
2823	Manufacture of office machinery and equipment
2824	Manufacture of pneumatic and electrical hand tools
2825	Manufacture for machines, app. for industrial cooling
2829	Manufacture of other machinery and equipment
2830	Manufacture of machines, tools for land and forest b.
2841	Manufacture for metalworking machine tools
2849	Manufacture for machine tools not for metal working
2891	Manufacture of machines for metallurgy
2892	Manufacture for machines for the construction and extraction of minerals
2893	Manufacture of machines for the production of V & G
2894	Manufacture of machines for the prod. of textile, clothing
2895	Manufacture of paper making machinery
2896	Manufacture for machines for the plastic and rubber industry
2899	Manufacture of other machinery, equipment, and tools
32501	Dental companies
32502	Manufacture of medical instruments and devices
33121	Repair and maintenance of general-purpose machines
33122	Repair and maintenance of pneumatic/electric tools
33123	Repair and maintenance of machines (specific company
3313	Repair of electronic and optical equipment
3314	Repair of electrical equipment
3319	Repair of other equipment
3321	Installation of boilers and tanks
33221	Installation of general-purpose machines
33222	Installation of pneumatic and power tools
33223	Installation of machines for a specific industry
3323	Installation of electronic and optical equipment
3324	Installation of electrical equipment
3329	Installation of other accessories
2211	Manufacture of rubber tires and retreading
2229	Manufacture of other plastic products
2910	Manufacture of cars
29201	Bodywork construction
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2932	Manufacture for non-electrical, electronic parts
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3099	Manufacture of other transport equipment (rest)
3316	Aircraft repair and maintenance
3317	Repair and maintenance of other transport equipment

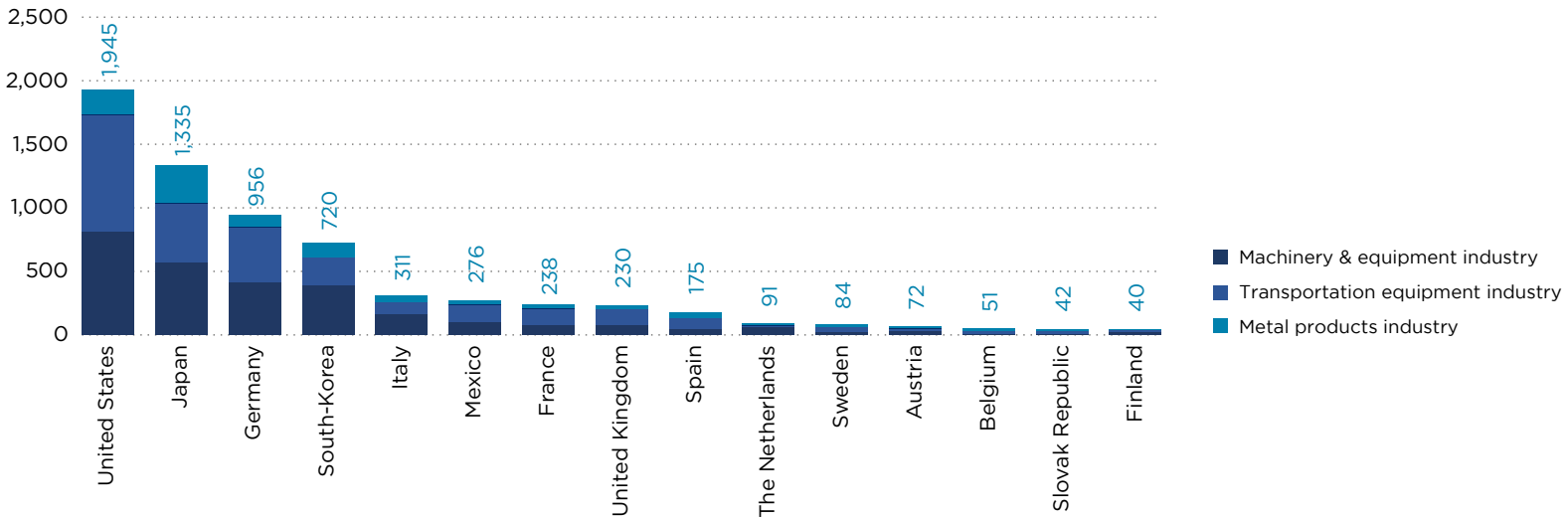
C. The Dutch HTSM industry in an international perspective

There are 94,800 companies, employing 601,690 people, active in the HTSM industry. Many of these are innovative small and medium-sized enterprises (SMEs), startups, and scaleups. Together, these companies are responsible for 159.475 billion euros in production value, and 59 billion euros in export. They invest 4 billion euros in R&D every year, over a quarter of which is in public-private partnerships.

1. The Netherlands in top 10 of OECD high tech systems manufacturers

The Netherlands ranks tenth among OECD countries in the manufacture of metal products, machinery & equipment, and transportation equipment. In Europe it is the sixth-largest, after Germany, France, Italy, the United Kingdom, and Spain.

TOP 15 OECD COUNTRIES BY PRODUCTION VALUE: METAL PRODUCTS, MACHINERY & EQUIPMENT AND TRANSPORTATION EQUIPMENT INDUSTRIES, IN BILLIONS OF €, 2015*)

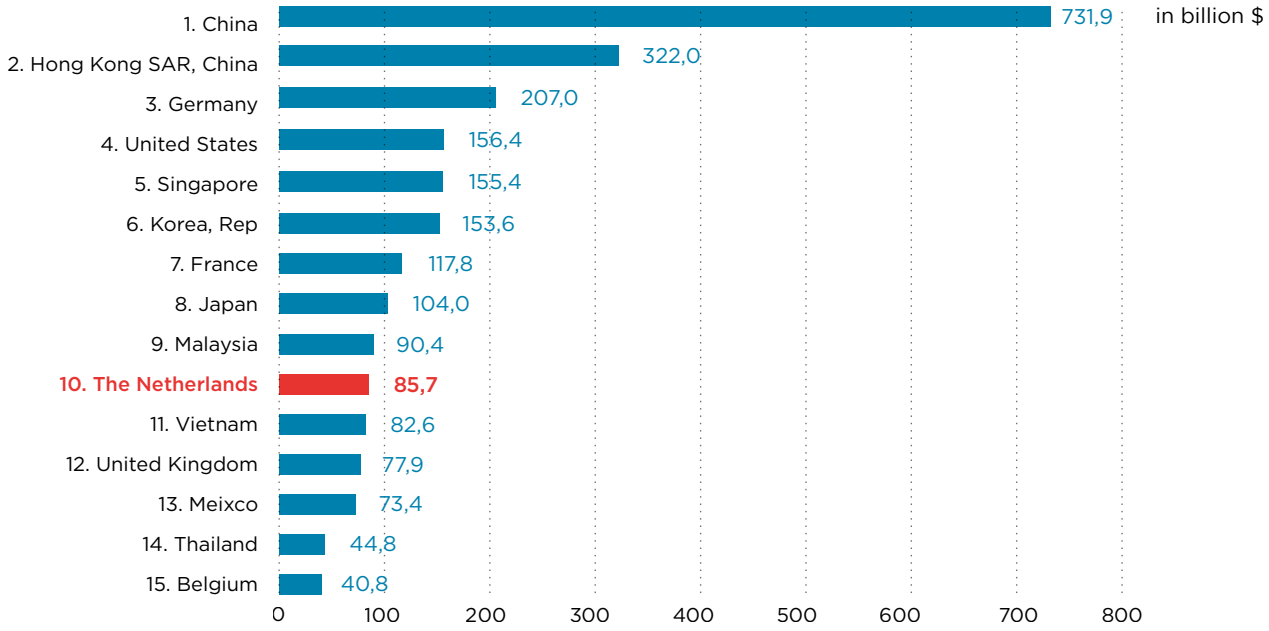


Source: OECD Stat, STAN Industrial Analysis, adapted by Fanion Onderzoek & Advies

2. Top 10 in high technology exports

According to data from the UN Comtrade Database, the Netherlands is the tenth-largest exporter of high tech, with an export value of $85.7 billion. This figure includes the re-export of high-tech goods, over and above the products manufactured in Holland, as the country's major ports and airport play a significant role in trans-shipment.

EXPORT VALUE OF HIGH TECH EXPORTS, IN BILLIONS OF $* IN 2018



World Trade Bank: United Nations Comtrade Database, through the WITS platform * *Definition: High-tech exports are products that involve intensive R&D, such as those manufactured for aerospace, computers, pharmaceuticals, scientific instruments, and electrical machinery.*

3. Dutch industry scores well on readiness for future production

In 2018 the World Economic Forum published its *Readiness for the Future of Production report*, in which it identified six drivers for future production: technology & innovation, human capital, global trade & investment, institutional framework, sustainable production, and demand environment. The Netherlands was ranked fifth, scoring very well on the global trade & investments and institutional framework drivers.

READINESS FOR THE FUTURE OF PRODUCTION REPORT 2018

	Drivers for production	Technology & Innovation	Human Capital	Global Trade & Investments	Institutional Framework	Sustainable Resources	Demand Environment
1. United States	8.16	8.52	7.91	7.73	8.55	6.69	8.54
2. Singapore	7.96	7.36	8	9.02	9.13	6.1	6.38
3. Switzerland	7.92	7.87	8.47	7.21	8.83	8.75	6.68
4. United Kingdom	7.84	8.05	7.48	8.29	8.24	7.42	7.08
5. Netherlands	**7.75**	**7.73**	**7.12**	**8.37**	**8.69**	**7.73**	**6.56**
6. Germany	7.56	7.16	7.49	7.32	8.22	7.78	7.55
7. Canada	7.54	7.08	7.9	7.49	8.47	7.71	6.42
8. Sweden	7.4	7.31	7.51	6.77	8.82	8.78	5.88
9. Denmark	7.2	6.9	7.3	6.79	8.84	8.38	5.41
10. Finland	7.16	7.45	7.34	6.06	8.89	8.46	5.29

D. Brabant's HTSM industry

Brabant was home to 15,560 HTSM companies in 2018, employing a total of 129,110 people. This means the province has 16.2% of all companies and 21.5% of all jobs in the HTSM industry in the Netherlands. To put this into perspective, 14.7% of all Dutch people live in Brabant and 15% of both the total of number of Dutch jobs and of companies are found in Brabant. In other words, the high tech manufacturing and systems industry has a strong presence in Brabant.

1. Brabant as part of the Netherlands

COMPANIES AND JOBS IN BRABANT AND THE NETHERLANDS IN THE HTSM TOP INDUSTRY, 2018

	Number of companies	Number of jobs
Brabant	15,560	129,110
The Netherlands	94,800	601,690
Share Brabant	16.2%	21.5%

HTSM is divided into four main subsectors in the official company registers:
1. Metal products
2. Manufacturing of transportation equipment
3. Machines & appliances
4. R&D & software development

Most jobs in Brabant's HTSM industry fall under machinery and appliances, at 37.8%, followed closely by R&D and software development (35.8%). The metal products category accounts for 13.7% of employment and manufacture of transportation equipment for 12.8%.

Source: Brabant Register of Establishments, adapted by Fanion Onderzoek & Advies

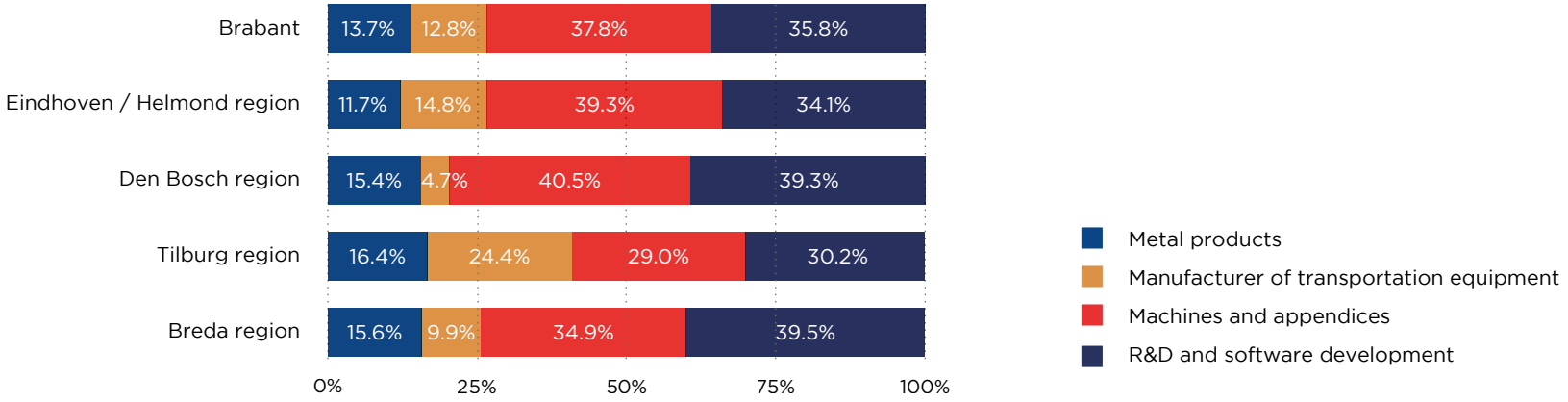
The Eindhoven/Helmond region (southeast Brabant, commonly known as Brainport Eindhoven) has by far the largest HTSM share in the province and the country with 5,503 companies and 66,140 jobs. Next is the Den Bosch region, with 3,487 companies or branches and 28,170 jobs, and Breda region with 3,745 companies and 21,720 jobs.

The composition of the HTSM industry also differs per region. The machines & appliances category is strongly represented in the Eindhoven/Helmond and Breda regions (west Brabant) and the manufacture of transportation equipment is relatively well-represented in the Tilburg region (central Brabant). The Den Bosch (northeast Brabant) and Breda regions (west Brabant) are home to a large share of R&D and software development.

2. Number of HTSM jobs by subregion, subsector and branch

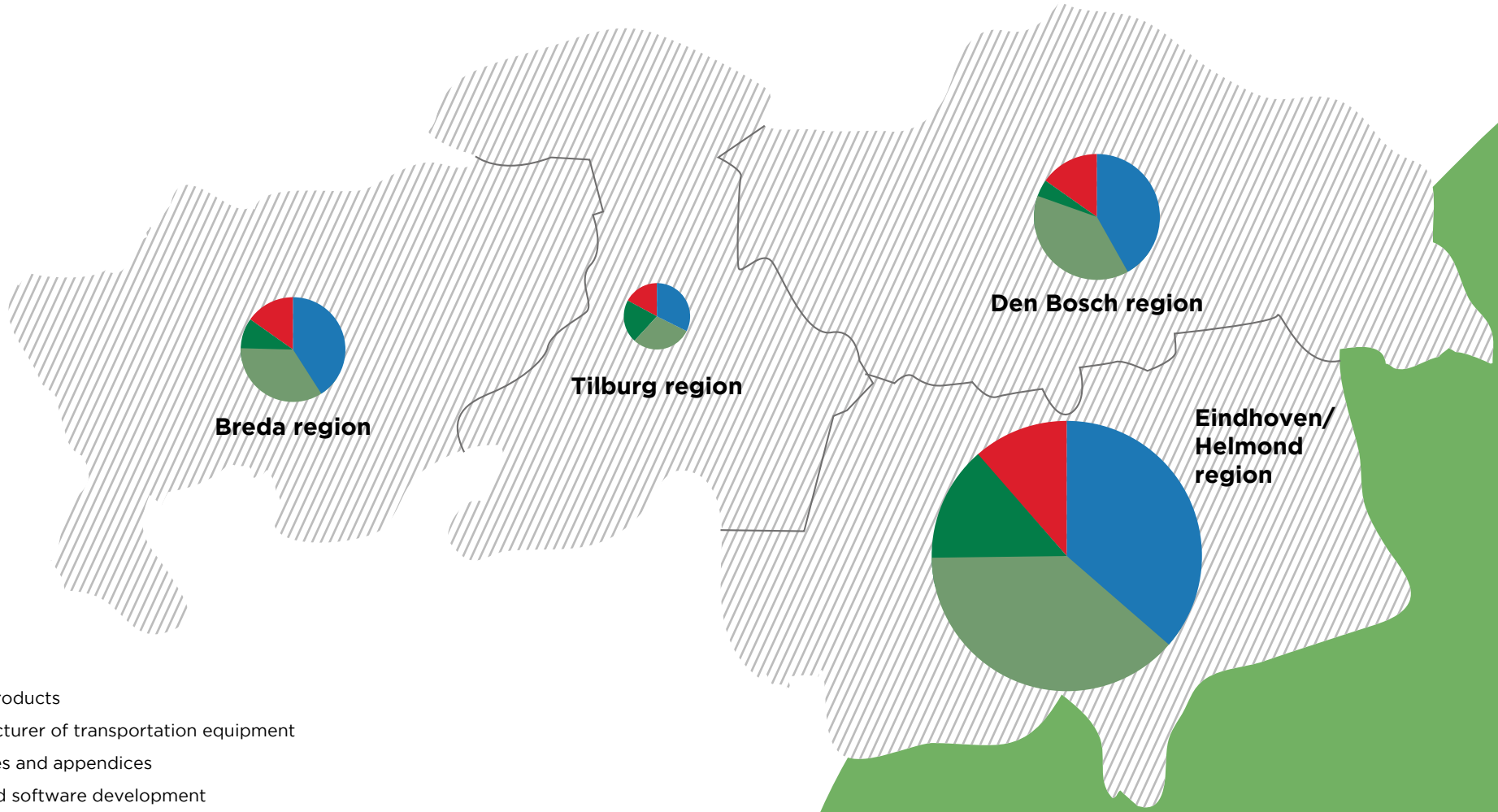
Region	Metal products	Manufacturing of transportation equipment	Machines and appliances	R&D and software	Total HTSM jobs
Breda region	3,380	2,160	7,580	8,590	21,720
Tilburg region	2,150	3,190	3,790	3,950	13,080
Den Bosch region	4,350	1,330	11,420	11,070	28,170
Eindhoven/Helmond region	7,760	9,820	26,010	22,560	66,140
Brabant region	17,630	16,500	48,810	46,170	129,110

HTSM SUBSECTOR EMPLOYMENT, IN BRABANT AS A WHOLE AND IN SUBREGIONS



Source: Brabant Register of Establishments, adapted by Fanion Onderzoek & Advies

HTSM SUBSECTOR EMPLOYMENT, IN BRABANT AS A WHOLE AND IN SUBREGIONS



Source: Brabant Register of Establishments, QGIS, adapted by Fanion Onderzoek & Advies

LARGEST HTSM INDUSTRY BRANCHES IN BRABANT, 2018 EMPLOYMENT FIGURES

In terms of jobs, the largest branches in the HTSM sector are:

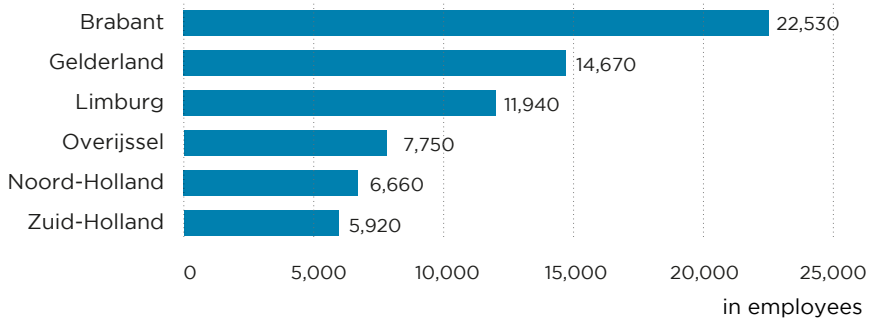
- Engineering and other technical design & consultancy (22,530 jobs)
- Developing, producing and publishing software (14,670 jobs)
- Manufacture of other machinery, equipment, and tools (11,940 job)
- Technical research and development (7,750 jobs)
- Manufacture of cars (6,660 jobs)
- General metalwork (5,920 jobs)

Overall, 15% of Dutch jobs are in Brabant, but the province's share of HTSM jobs is much higher, at 21.5%. For 34 of those HTSM branches, employing at least 500 people in Brabant, the slice held by the region is even greater.

Compared to the composition of the HTSM industry in the Netherlands as a whole, Brabant is particularly well-represented in the following branches:

- Manufacturing of irradiation equipment, etc.
  (Brabant's share in Netherlands: 73.5%)
- Manufacture of other machinery, equipment, and tools
  (Brabant's share: 67.8%)
- Manufacture of bolts, screws, and nuts
  (Brabant's share: 67.4%)
- Manufacture of machines for the production of textile and clothing
  (Brabant's share: 67.4%)
- Manufacture of electric lamps, lighting apparatus
  (Brabant's share: 45.1%)

LARGEST BRANCHES WITHIN THE HTSM SECTOR IN BRABANT, 2018 EMPLOYMENT FIGURES



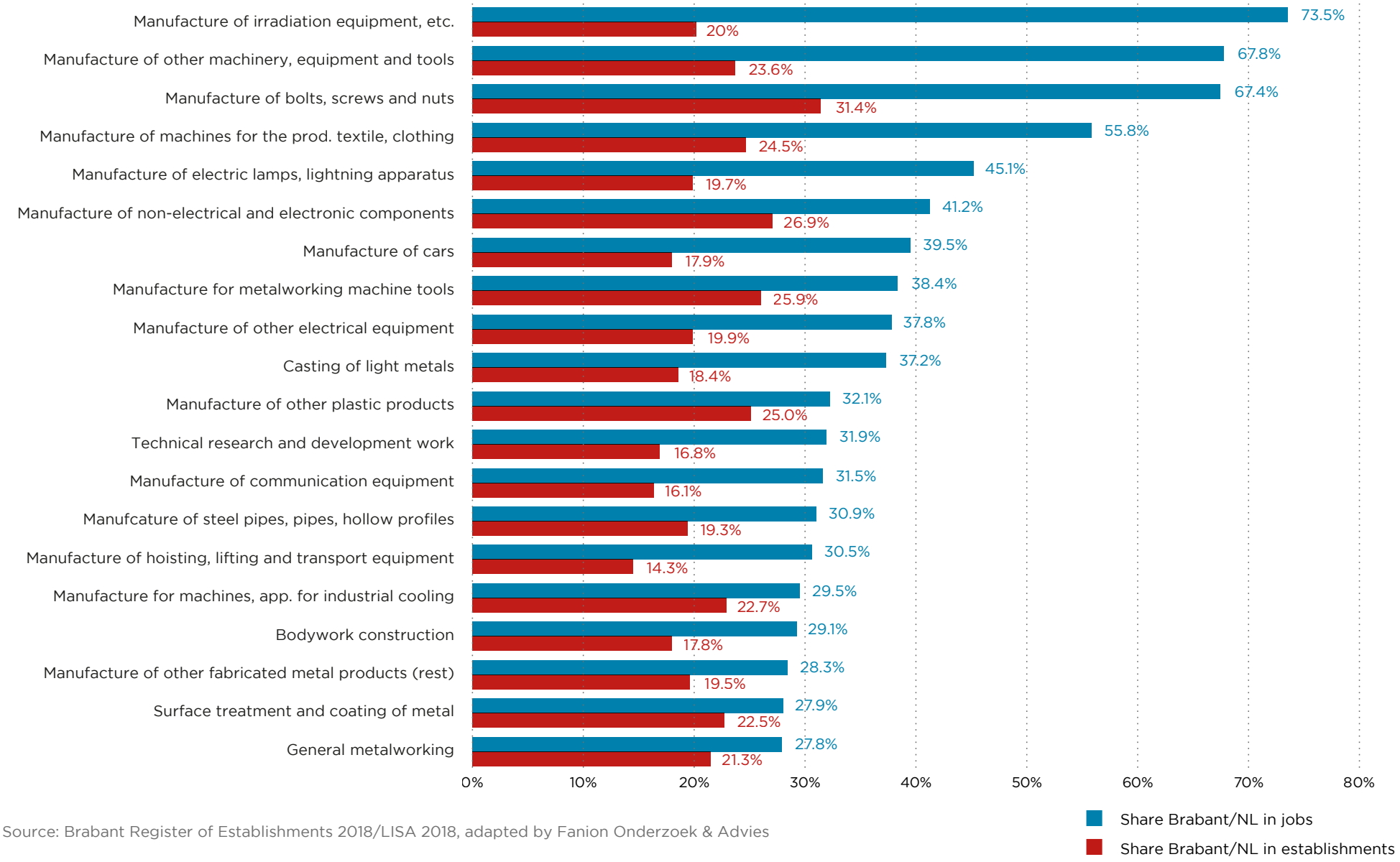
LARGEST BRANCHES WITHIN THE HTSM SECTOR IN BRABANT (CONTINUED), 2018 EMPLOYMENT FIGURES

Branches	Employees
Manufacture of hoisting, lifting, and transport equipment	3,590
Manufacture of other plastic products	3,530
Manufacture of other machines and equipment	3,160
Manufacture of irradiation equipment, etc.	3,050
Surface treatment and coating of metal	2,980
Manufacture of non-electrical and electronic components	2,730
Manufacture of machines to produce food & drinks	2,470
Manufacture of other electrical equipment	2,300
Repair and maintenance of general-purpose machines	1,950
Manufacture of other fabricated metal products (rest)	1,820
Manufacture for machines, app. for industrial cooling	1,800
Manufacture of machines, implements for land and forest b.	1,710
Manufacture of electric lamps, lighting apparatus	1,640
Bodywork construction	1,470
Forging, pressing, stamping and profile rolling of metal	1,430
Repair and maintenance of machines (specific industry)	1,350
Manufacture of communication equipment	1,260

Branches	Employees
Inspection and control of machines, equipment, and materials	1,220
Manufacture of measuring, control, navigation, and control app.	1,170
Manufacture of medical instruments and aids	1,140
Manufacture of electronic components	1,110
Manufacture of aircraft and parts therefor	990
Manufacture of hydraulic equipment	980
Manufacture of tools	960
Dental companies	820
Manufacture for metalworking machine tools	800
Manufacture of fittings	740
Casting of light metals	740
Manufacture of bolts, screws and nuts	670
Manufacture of machines for the prod. textile, clothing	610
Installation of electronic and optical equipment	580
Installation of general-purpose machines	560
Manufacture of steel pipes, pipes, hollow profiles	530
Manufacture of aluminum	510

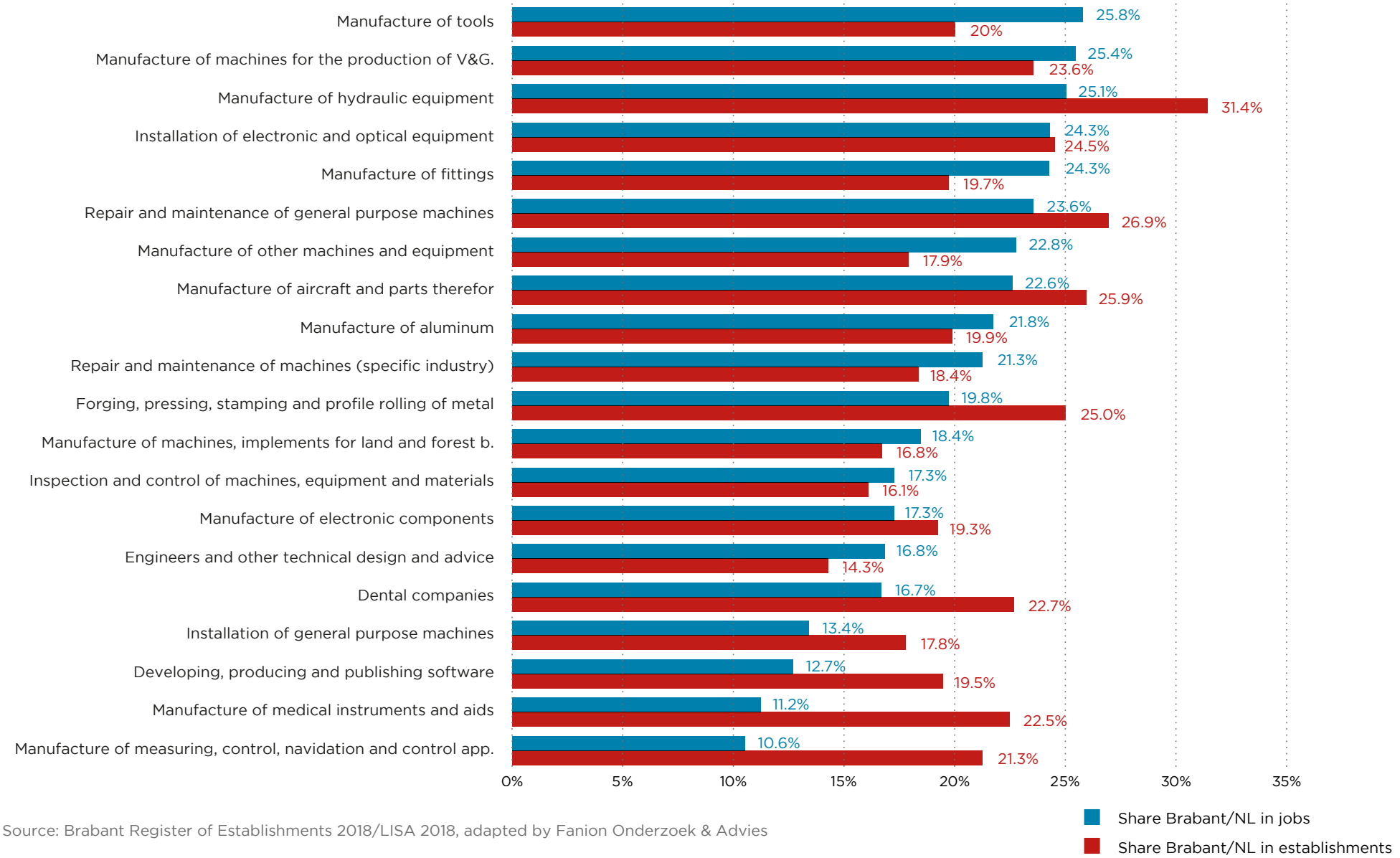
Source: Brabant Register of Establishments, adapted by Fanion Onderzoek & Advies

HTSM BRANCHES FOR WHICH BRABANT HAS THE LARGEST NUMBER OF JOBS IN THE NETHERLANDS (AT LEAST 500 OR MORE) (1)



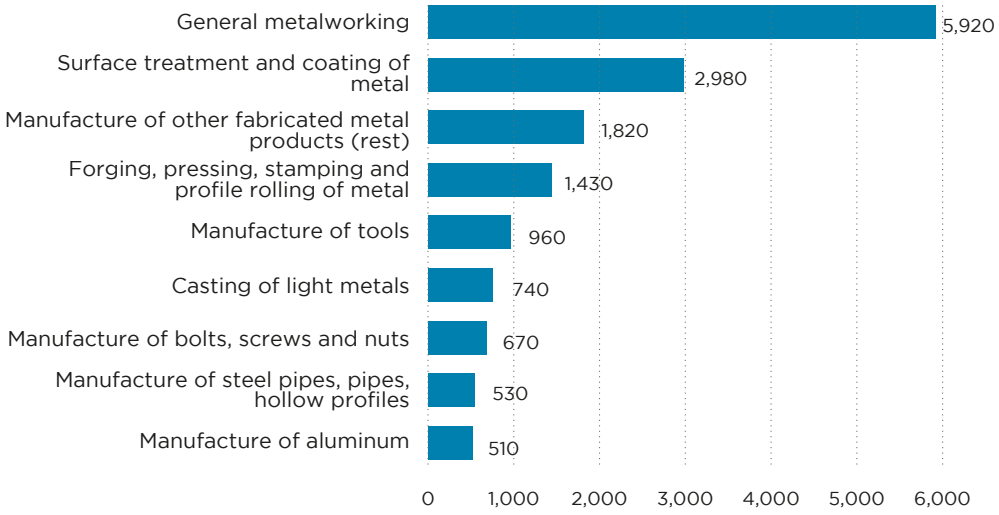
Source: Brabant Register of Establishments 2018/LISA 2018, adapted by Fanion Onderzoek & Advies

HTSM BRANCHES FOR WHICH BRABANT HAS THE LARGEST NUMBER OF JOBS IN THE NETHERLANDS (AT LEAST 500 OR MORE) (2)

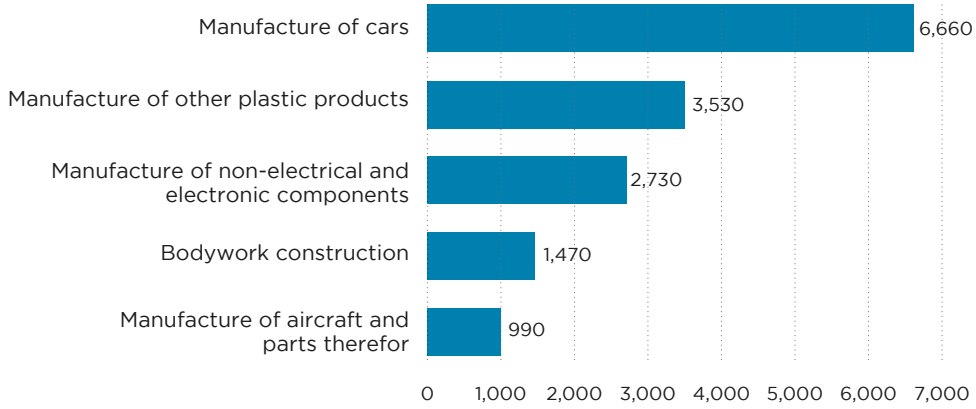


Source: Brabant Register of Establishments 2018/LISA 2018, adapted by Fanion Onderzoek & Advies

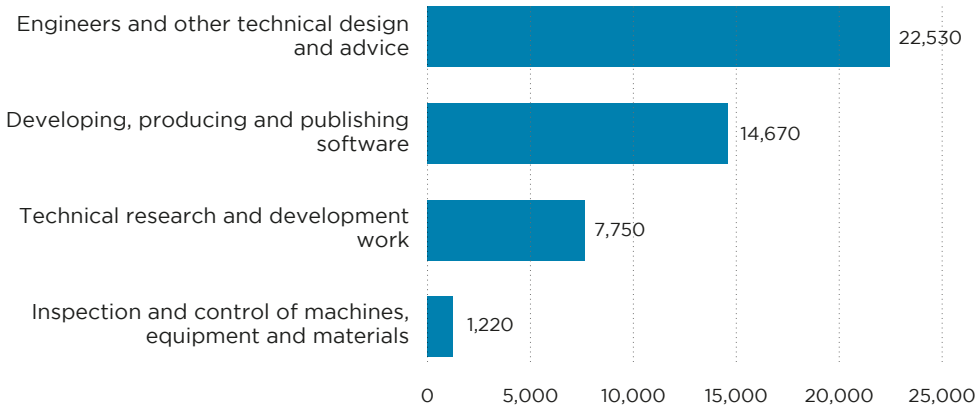
METAL PRODUCTS BRANCHES WITH AT LEAST 500 JOBS, 2018



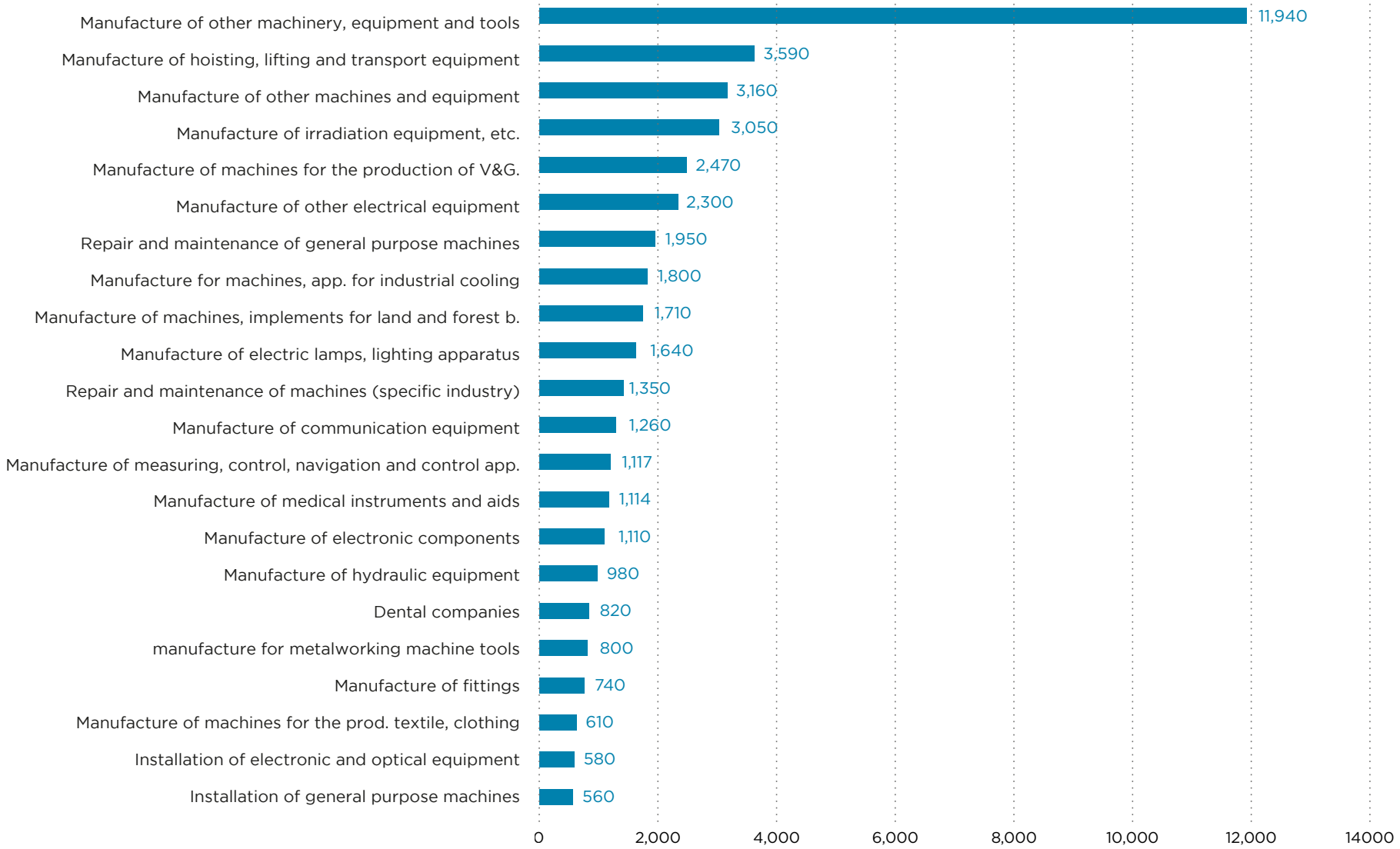
TRANSPORTATION EQUIPMENT, LARGEST BRANCHES, 2018 (AT LEAST 500 JOBS)



R&D AND SOFTWARE DEVELOPMENT BRANCHES WITH AT LEAST 500 JOBS, 2018



MACHINERY AND APPLIANCE BRANCHES WITH AT LEAST 500 JOBS, 2018



Source: Brabant Register of Establishments, adapted by Fanion Onderzoek & Advies

AVERAGE NUMBER OF EMPLOYEES PER COMPANY VARIES BY SUBSECTOR

There is a high percentage of small companies in the HTSM industry in Brabant: 83.8% of HTSM companies have fewer than five employees, with only 0.9% employing over a hundred people.

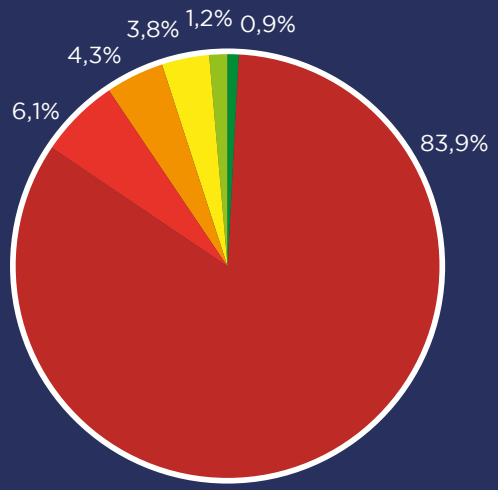
On the other hand: these larger companies (100+) are responsible for almost half of the HTSM jobs in Brabant.

There are important differences between the subsectors:

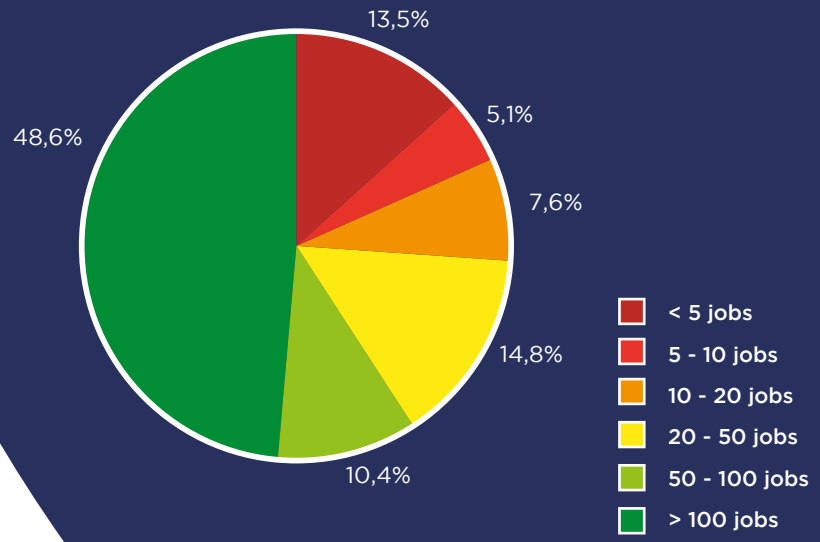
- In R&D and software development, almost 90% of companies have fewer than five employees and only 0.4% have over a hundred staff.
- In machines and appliances (2.2%) and in transportation equipment manufacturing (5.9%) there are significantly more companies with over a hundred employees, while there are fewer small companies.
- The metal industry consists of a relatively large proportion of midsize companies.
- In manufacturing of transportation equipment, over three-quarters of all jobs are found in the 100+ companies.
- In machines and appliances, the same is true for more than 60% of the companies.
- In R&D and software and metal products, smaller companies have a much larger share in the employment figures.

Source: Brabant Register of Establishments, adapted by Fanion Onderzoek & Advies

PERCENTAGE OF HTSM COMPANIES IN BRABANT BY COMPANY SIZE, 2018



EMPLOYMENT IN BRABANT HTSM COMPANIES, GROUPED BY COMPANY SIZE, 2018



TOTAL HTSM COMPANIES AND SUBCATEGORIES BY COMPANY SIZE, 2018

	Metal products	Manufacturing of transportation equipment	Machines and appliances	R&D and software development	HTSM
< 5 jobs	72.6%	52.5%	71.1%	89.9%	83.8%
5-10 jobs	9.4%	14.6%	10.6%	4.1%	6.1%
10 - 20 jobs	8.2%	10.1%	7%	2.7%	4.3%
20-50 jobs	7.1%	12.4%	6.6%	2.2%	3.8%
50-100 jobs	1.5%	4.5%	2.7%	0.6%	1.2%
> 100 jobs	1.1%	5.9%	2.2%	0.4%	0.9%
Total	100%	100%	100%	100%	100%

TOTAL HTSM AND SUBCATEGORY EMPLOYMENT BY COMPANY SIZE, 2018

	Metal products	Manufacturing of transportation equipment	Machines and appliances	R&D and software development	HTSM
< 5 jobs	11.5%	1.8%	5.9%	26.4%	13.5%
5-10 jobs	7.7%	2.3%	3.9%	6.5%	5.1%
10 - 20 jobs	13.8%	3.6%	5.4%	8.9%	7.6%
20-50 jobs	26.7%	9.7%	11.4%	15.8%	14.8%
50-100 jobs	13.5%	7.4%	11.1%	9.6%	10.4%
> 100 jobs	26.7%	75.3%	62.3%	32.9%	48.6%
Total	100%	100%	100%	100%	100%

Source: Brabant Register of Establishments, adapted by Fanion Onderzoek & Advies

3. The growth of HTSM companies and employment

COMPANIES

The number of companies active in HTSM in Brabant grew by 8.3% between 2014 and 2018, from 14,187 15,359. In the country as a whole, the figure was a little higher, at 9.7%.

The machines and appliances branch (18.6%) grew the fastest in Brabant, exceeding the national growth rate (15.8%). Country-wide growth of the number of companies in software development and R&D (11.2%) was a good deal higher than in Brabant (5.7%), while both metal products and transportation equipment saw similar growth rates in both Brabant (8.9%) and in the Netherlands (8.6%).

EMPLOYMENT

The number of HTSM jobs in Brabant increased between 2014 and 2018 by 13.5%, a higher growth rate than in the Netherlands (9.5%). The biggest HTSM employment growth was in the machines and appliances branch, with an increase of 17.9% (6.9% in the Netherlands overall), and employment in Brabant in metal products (10.3%) was also better than the country (7%).

In the transportation equipment branch, national job growth (21.3%) exceeded job growth in Brabant (16.3%), while software development and R&D saw similar levels in Brabant (9.5%) and the Netherlands overall (9.7%).

In Brabant, the HTSM branches employing at least 500 people and with the strongest job growth were manufacture of electric lamps, lighting apparatus (119.5%), manufacture of other electrical equipment (86.5%), inspection and control of machines, equipment and materials (61.7%), repair and maintenance of machines (49.9%) and manufacture of hoisting, lifting, and transport equipment (46.6%).

The HTSM branches employing at least 500 people and exhibiting a major decline in employment are: manufacture of aircraft and parts therefore (-10.1%), manufacture of other fabricated metal products (-13.0%), bodywork construction (-13.9%), manufacture of hydraulic equipment (-16.0%) and manufacture of fittings (-20.4%).

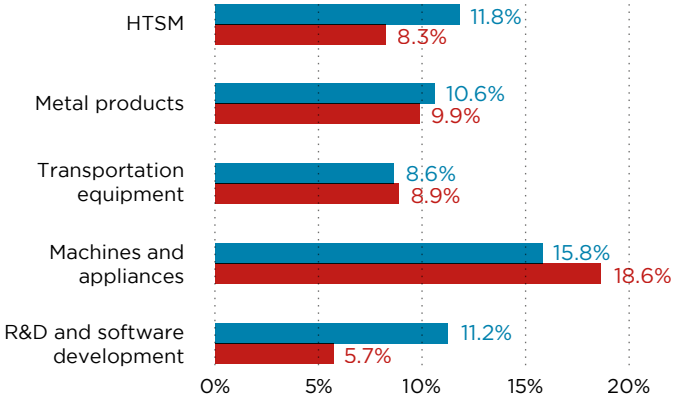
GROWTH OF HTSM COMPANIES AND EMPLOYMENT IN BRABANT AND NETHERLANDS, 2014-2018

	Business Brabant			Business Netherlands		
(Sub)sector	2014	2018	2014-2018	2014	2018	2014-2018
Metal products	1,721	1,891	9.9%	8,030	8,881	10.6%
Transportation equipment	327	356	8.9%	1,599	1,737	8.6%
Machines and appliances	2,173	2,577	18.6%	12,004	13,906	15.8%
Software development and R&D	9,966	10,535	5.7%	63,200	70,277	11.2%
HTSM	14,187	15,359	8.3%	84,833	94,801	11.8%

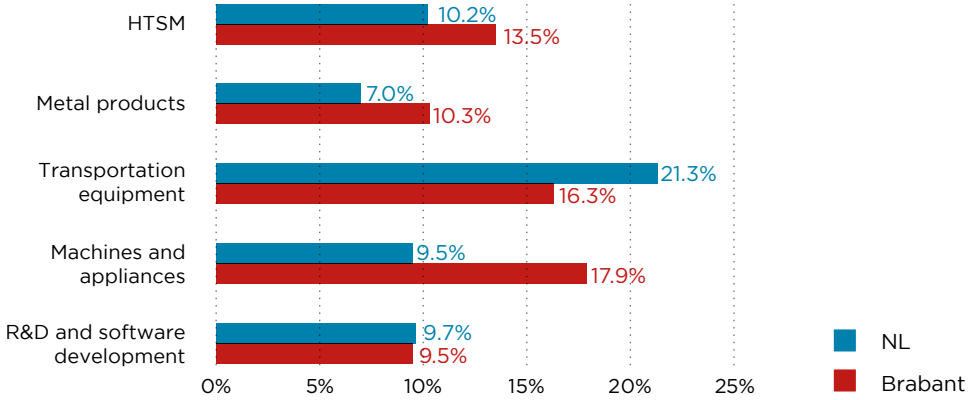
	Jobs Brabant			Jobs Netherlands		
(Sub)sector	2014	2018	2014-2018	2014	2018	2014-2018
Metal products	15,980	17,630	10.3%	73,380	78,550	7.0%
Transportation equipment	14,190	16,500	16.3%	44,760	54,310	21.3%
Machines and appliances	41,390	48,810	17.9%	171,990	188,300	9.5%
Software development & R&D	42,150	46,170	9.5%	255,840	280,530	9.7%

Source: LISA, Brabant Register of Establishments, 2014-2018, adapted by Fanion Onderzoek & Advies

GROWTH OF COMPANIES IN BRABANT AND THE NETHERLANDS, 2014-2018

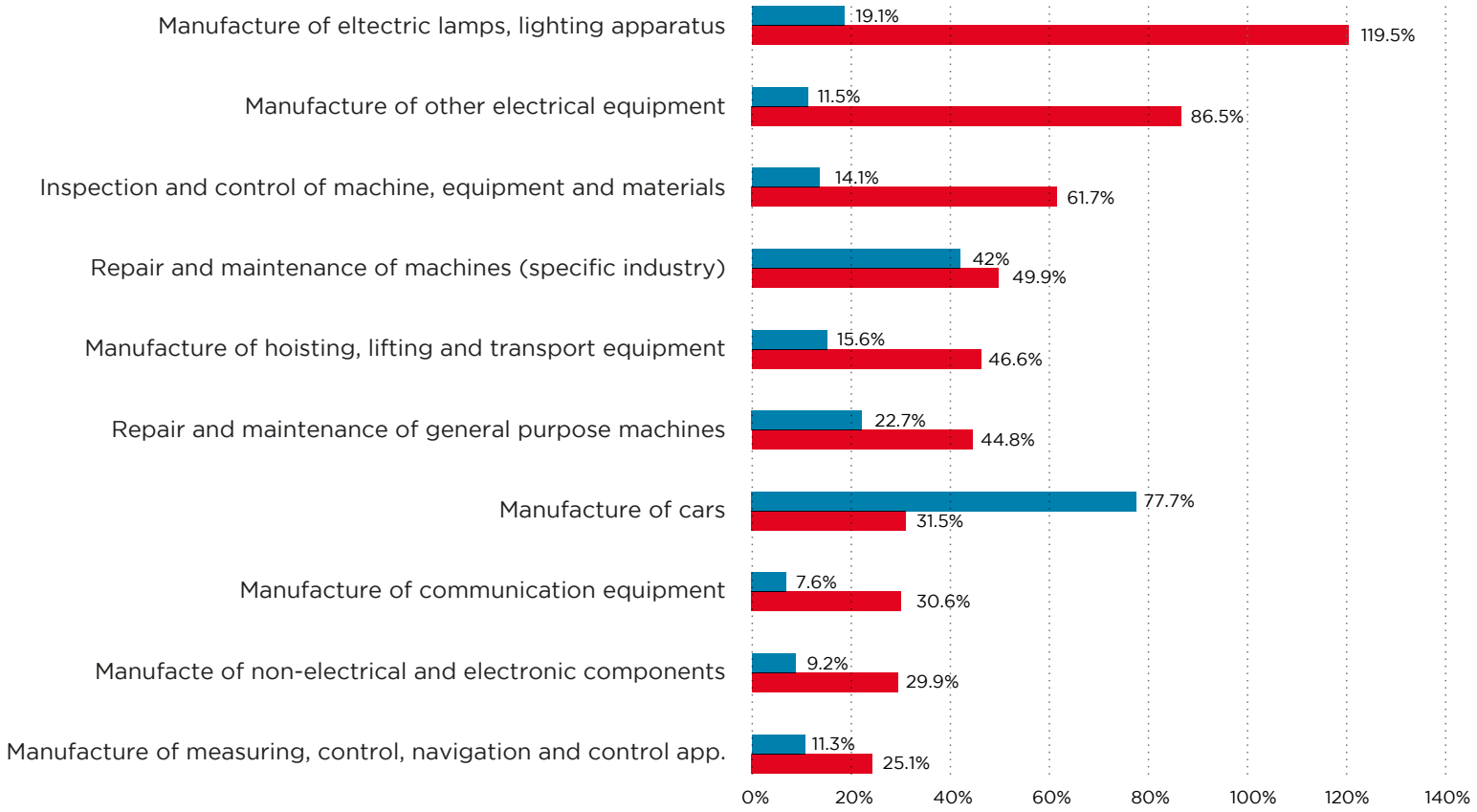


GROWTH IN EMPLOYMENT IN BRABANT AND THE NETHERLANDS, 2014-2018



Source: LISA, Brabant Register of Establishments, 2014-2018, adapted by Fanion Onderzoek & Advies

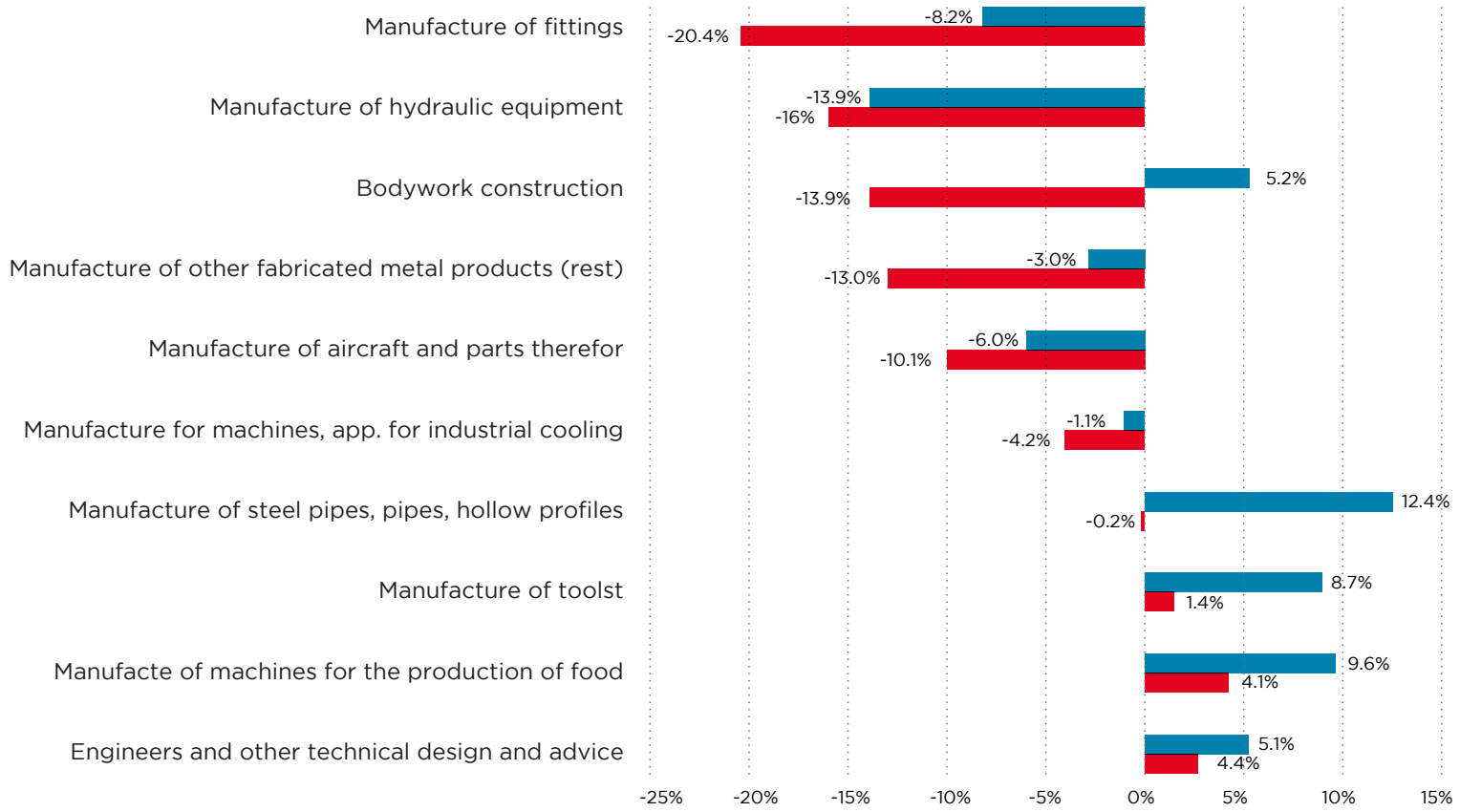
TOP 10 BRANCHES* FOR EMPLOYMENT GROWTH IN BRABANT, 2014-2018



*) branches employing 500 people or more in Brabant

Source; LISA, Brabant Register of Establishments, 2014-2018, adapted by Fanion Onderzoek & Advies

TOP 10 BRANCHES* FOR EMPLOYMENT DECLINE IN BRABANT, 2014-2018



*) branches employing 500 people or more in Brabant

Source; LISA, Brabant Register of Establishments, 2014-2018, adapted by Fanion Onderzoek & Advies

4. Regional distribution of HTSM activities in Brabant

In total, the HTSM sector in Brabant comprises more than 129,000 jobs, representing 10% of all employment in Brabant. Employment is mainly clustered in the Eindhoven/Helmond region, in municipalities such as Eindhoven, Veldhoven, Best and the larger cities of Breda, Den Bosch, and Tilburg, where larger HTSM companies are located.

Eindhoven is the undisputed HTSM capital in both Brabant and in the Netherlands, with the city hosting 29,580 people employed in that field. Major HTSM companies such as Philips, Signify, DAF Paccar, Atos Origin, and Thermo Fisher Scientific all have major centers in the city. Veldhoven (which in reality is contiguous with Eindhoven) is runner-up with ASML headquartered there. Den Bosch in turn is home to major software developers, including SAP, Dassault Systèmes, PinkRoccade, Siemens Industry Software, Omron, and Dialog Semiconductors.

The biggest HTSM companies in Breda are VDL Steelweld, SPIE, Emerson Automation Solutions, Bosch Power Tools, and Caligen, while Tilburg hosts Bosch Transmission Technology, Elho, Fabory, Chromalloy, Iris Ohyama, and Lan Handling Technologies.

The cities that are home to the greatest share of HTSM jobs are Veldhoven (including ASML), Best (Philips Healthcare and others), Son en Breugel (including Prodrive and Neways), Cranendonck (Nyrstar and others), and Eindhoven (Philips Research, Signify, DAF Paccar, and NXP). It is important to note that Eindhoven, Veldhoven, Son en Breugel, and Best are all contiguous cities and make up the Brainport Eindhoven Metropolitan area, together with Cranendonck, Helmond, and a number of other smaller municipalities. The distance between the heart of Eindhoven and the center of Cranendonck is no more than 20 kilometers (12 miles) by car.

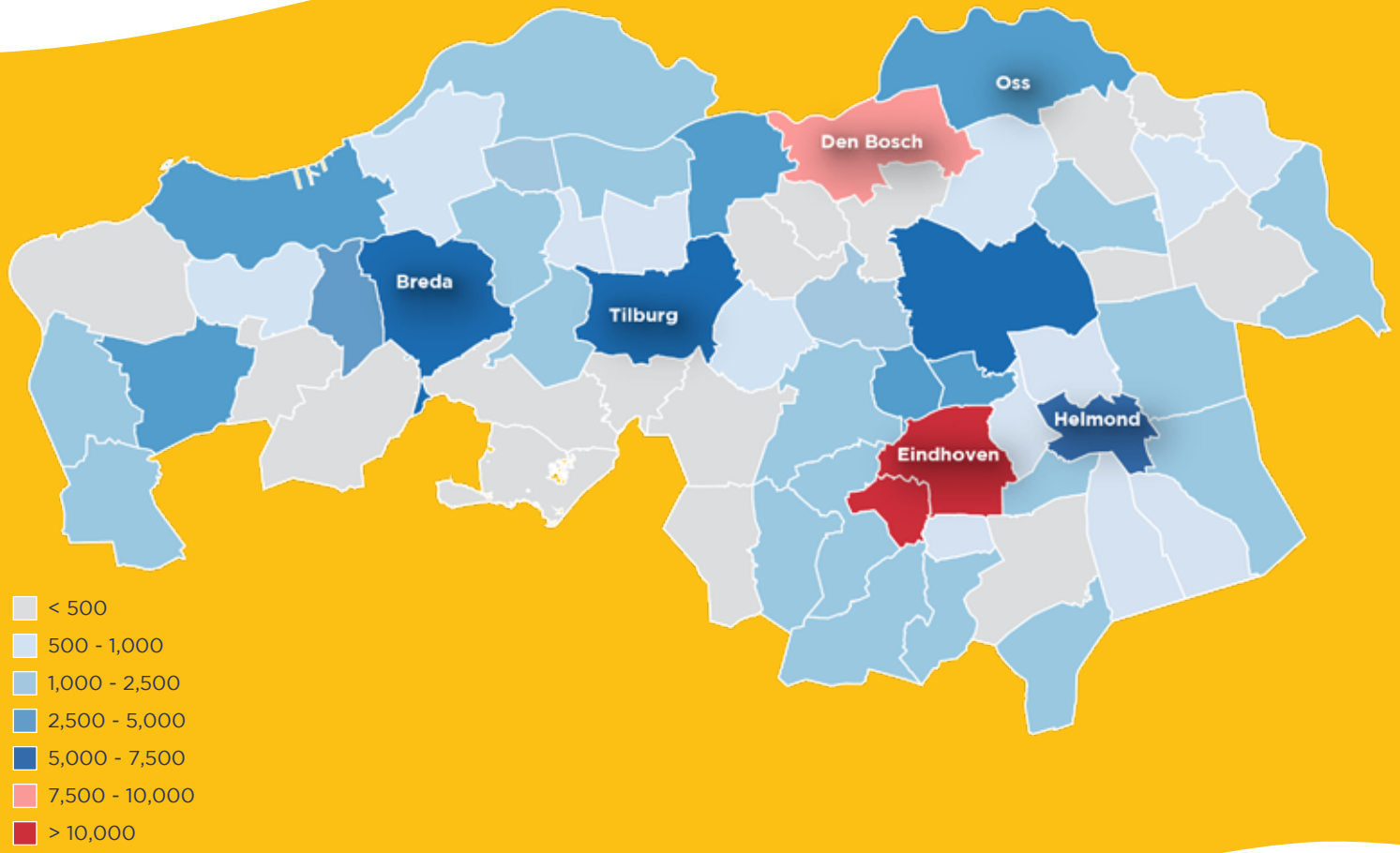
LEADING BRABANT MUNICIPALITIES A) IN TOTAL NUMBER OF HTSM JOBS AND B) HTSM JOBS AS A PERCENTAGE OF TOTAL NUMBER OF JOBS

The five leading municipalities in Brabant in total number of HTSM jobs		*The five leading municipalities in Brabant in HTSM jobs out of all employment*	
Municipality	**# of jobs**	**Municipality**	**% HTSM in total jobs**
Eindhoven	29,580	**Veldhoven**	35.1%
Veldhoven	11,160	**Best**	24.4%
Den Bosch	8,390	**Son en Breugel**	19.2%
Breda	6,660	**Cranendonck**	18.3%
Tilburg	6,590	**Eindhoven**	18%

Source: LISA, Brabant Register of Establishments 2014, 2018, adapted by Fanion Onderzoek & Advies

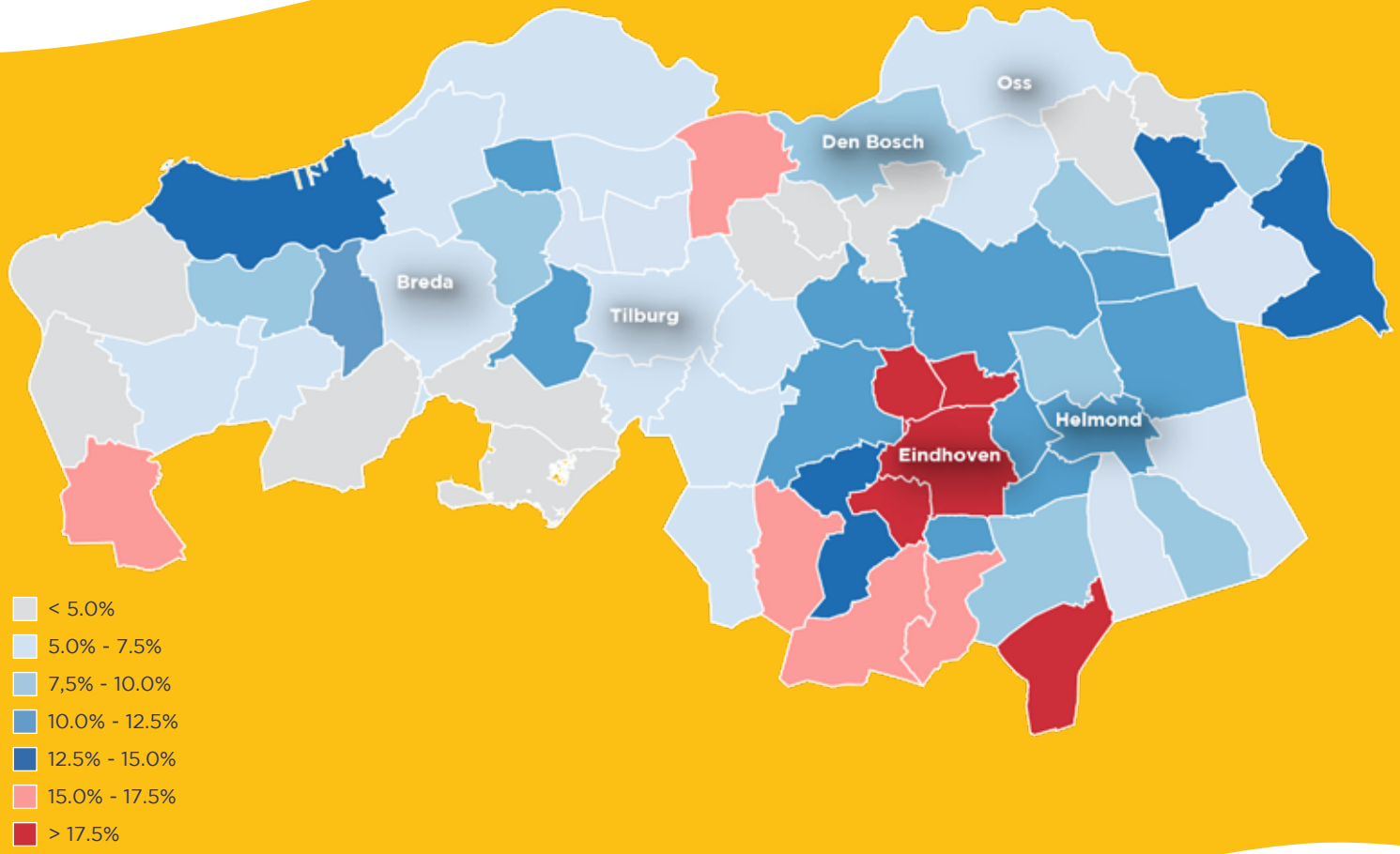
NUMBER OF HTSM JOBS BY MUNICIPALITY

The map shows the total number of HTSM jobs per municipality.



Source: Brabant Register of Establishments 2018, adapted by Fanion Onderzoek & Advies

SHARE OF HTSM JOBS BY MUNICIPALITY

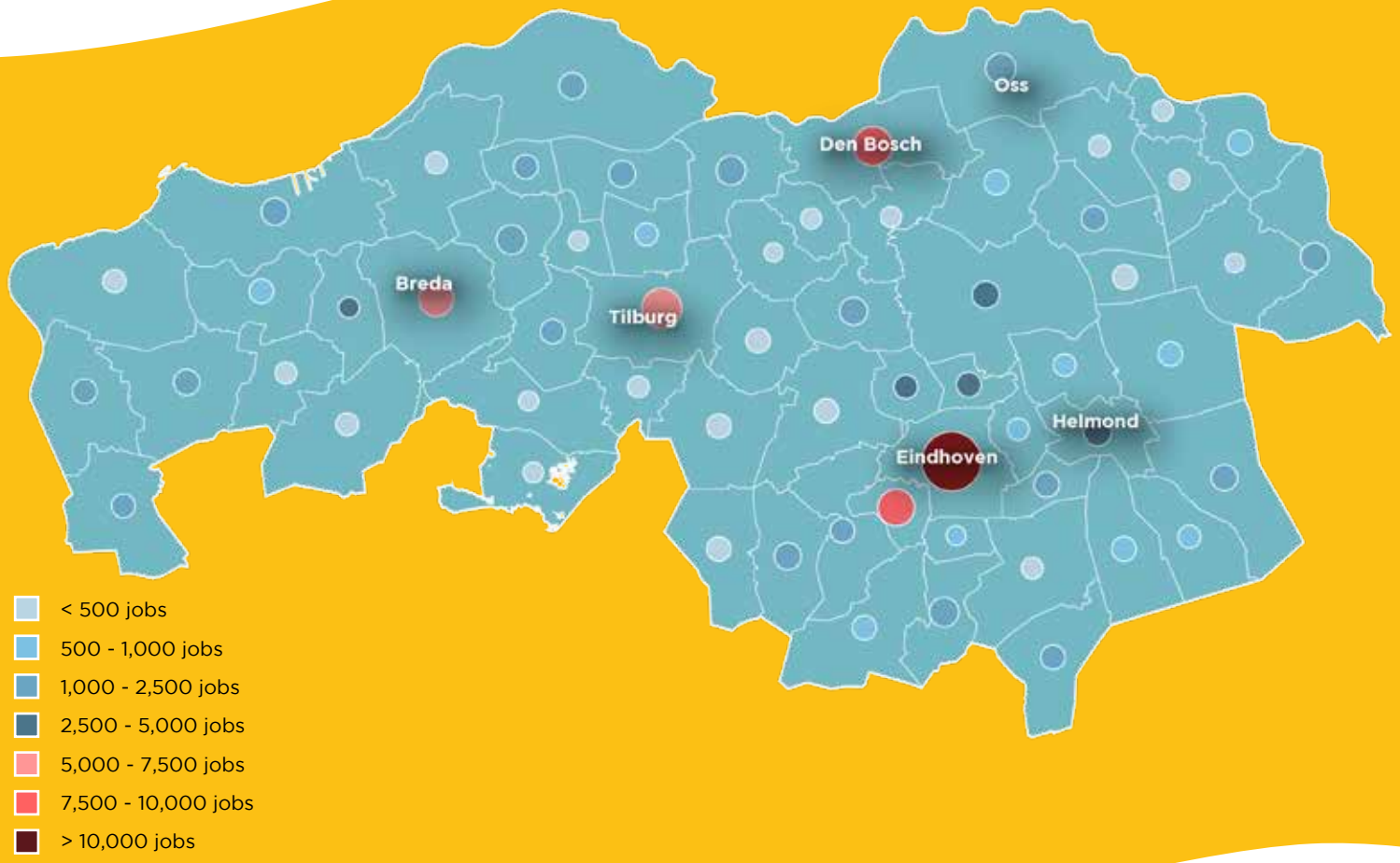


The map shows the number of jobs in HTSM as a portion of the total employment each municipality.

Source: Brabant Register of Establishments 2018, adapted by Fanion Onderzoek & Advies

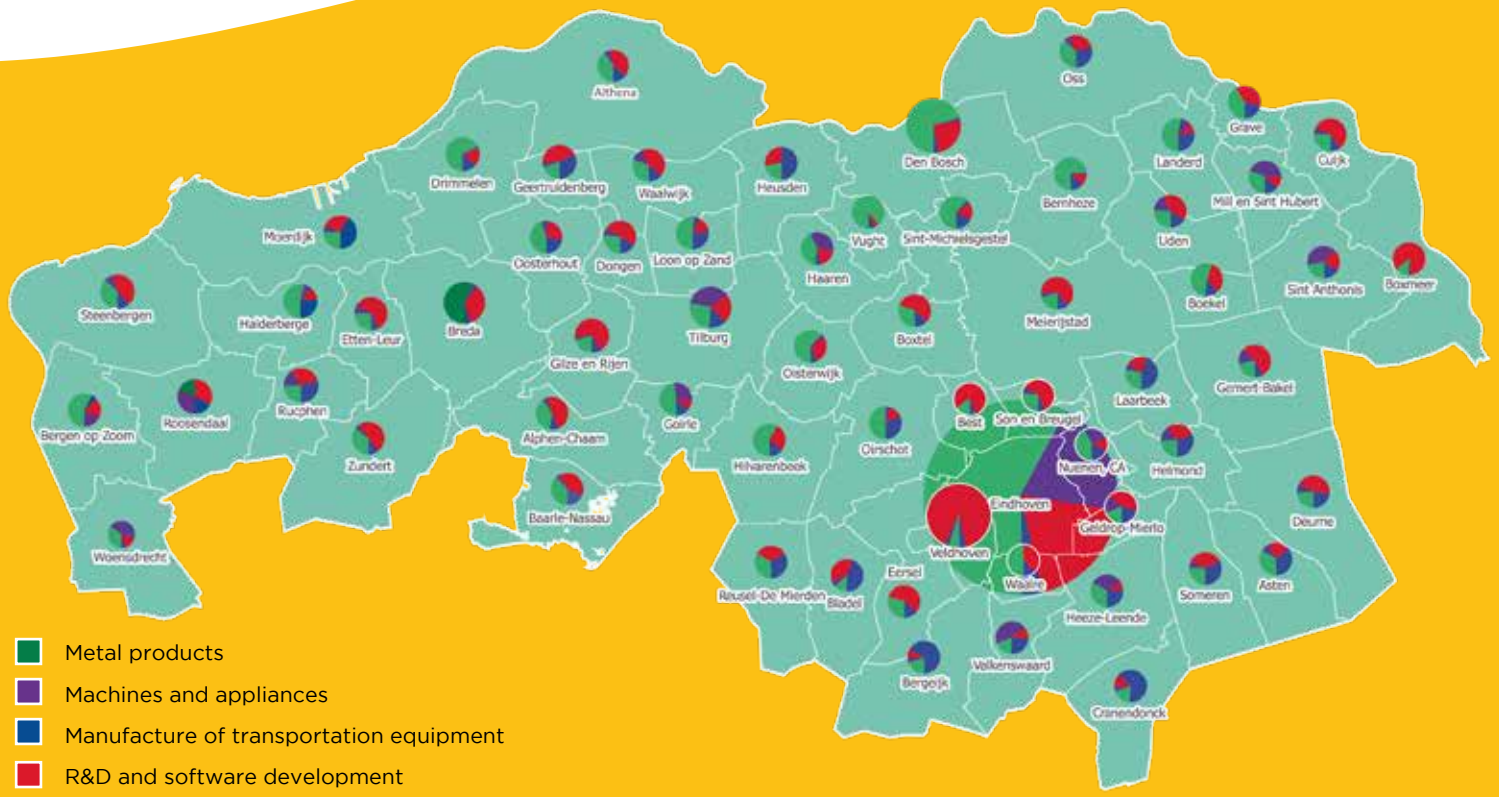
HTSM EMPLOYMENT HOTSPOTS BY MUNICIPALITY

The map below shows HTSM employment per municipality.



Source: Brabant Register of Establishments 2018, adapted by Fanion Onderzoek & Advies

HTSM EMPLOYMENT HOTSPOTS BY SUBSECTOR AND MUNICIPALITY

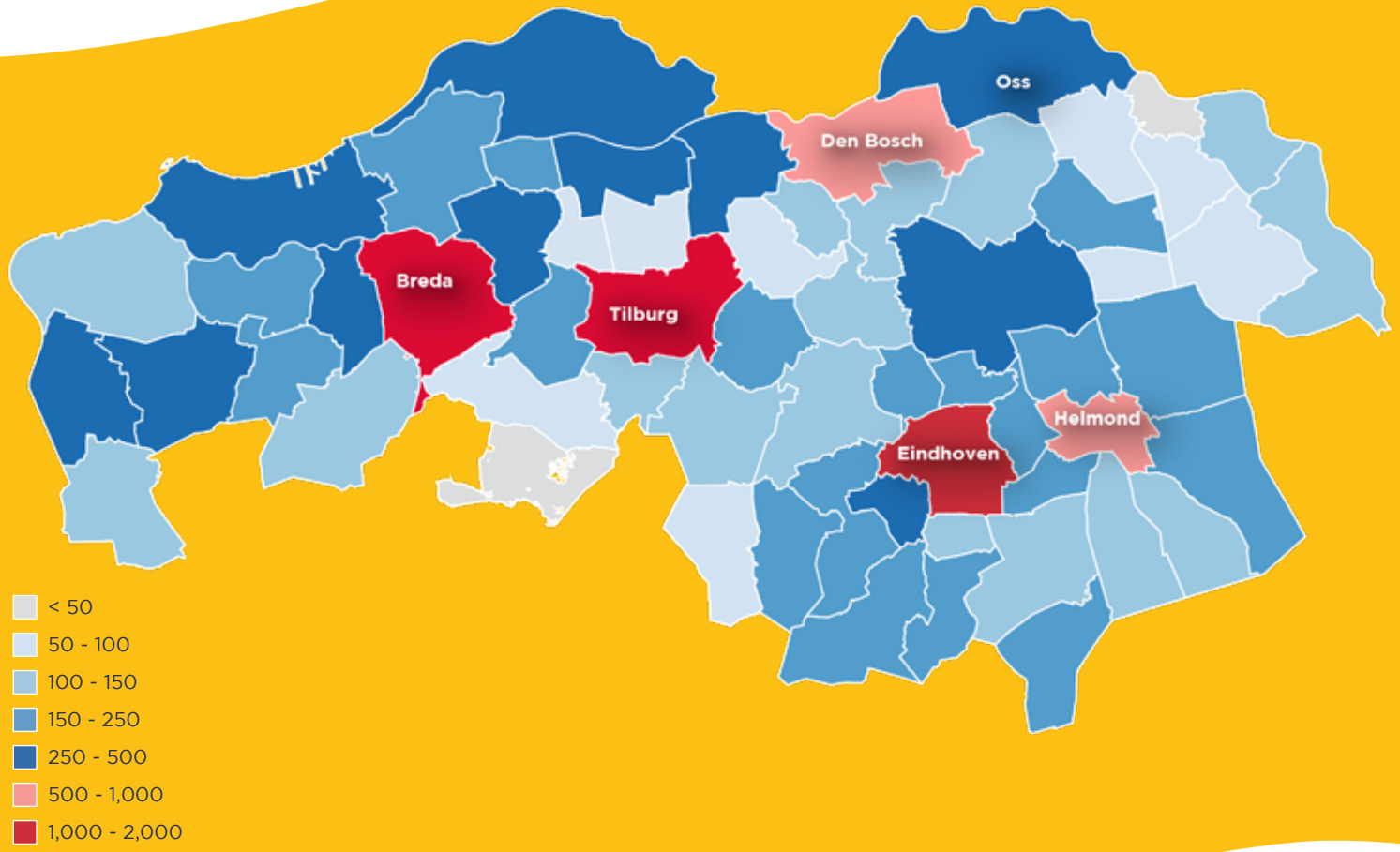


The map shows the HTSM employment rates by subsector and municipality. Regions have vastly different profiles when it comes to employment in the different HTSM subsectors. In Veldhoven and Best the focus is on machines and appliances, chiefly due to the presence of ASML and Philips. However, Son en Breugel, Boxmeer, Boxtel, Gemert-Bakel, and Cuijk also host a relatively large share of machines and appliances jobs. The area's biggest cities of Eindhoven, Breda, and Den Bosch have a relatively large share of R&D and software development jobs, while metal products manufacturing is strongly represented in Heusden, Cranendonck, and Bergeijk.

Source: Brabant Register of Establishments 2018, adapted by Fanion Onderzoek & Advies

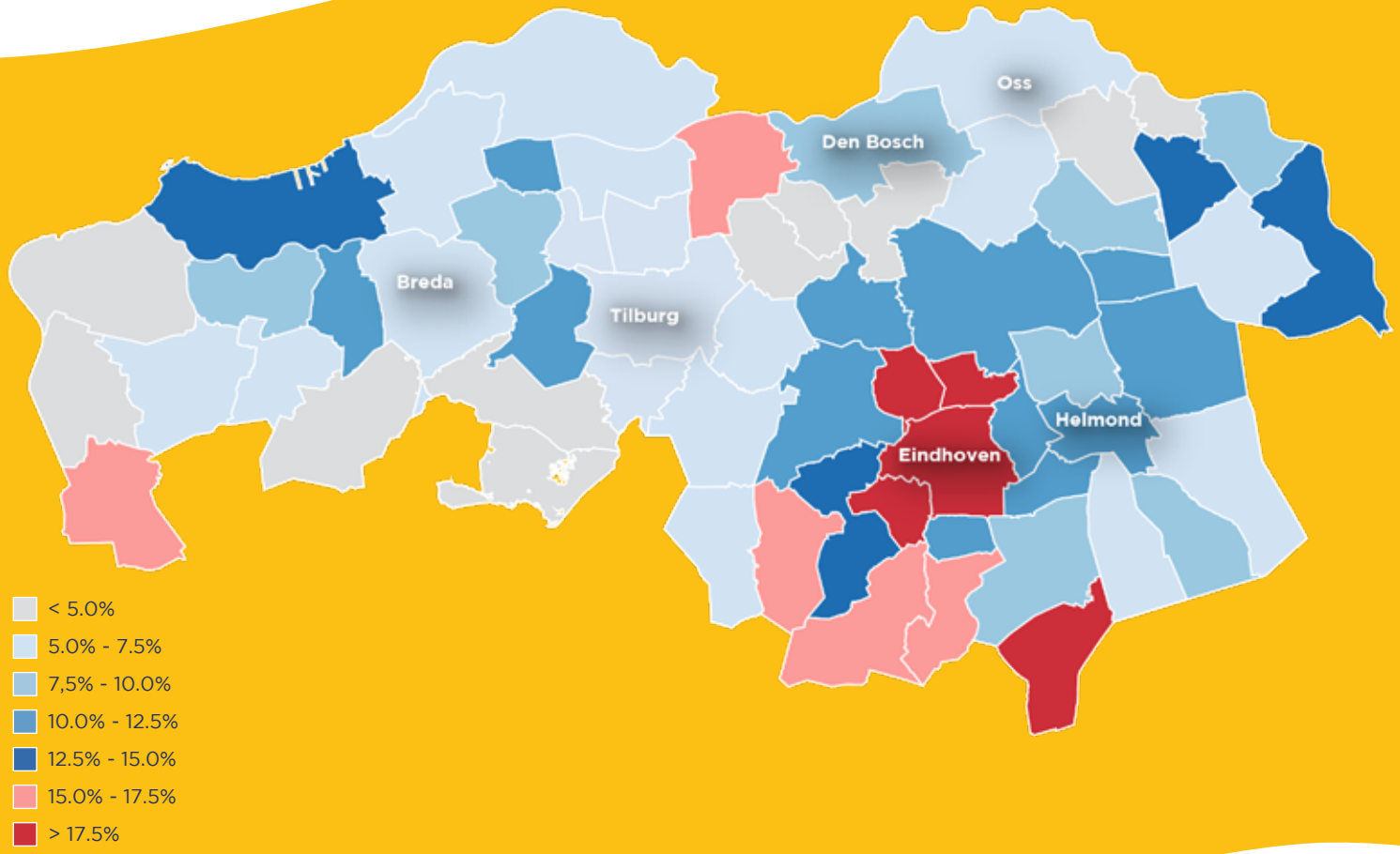
NUMBER OF HTSM COMPANIES BY MUNICIPALITY

The map shows the total number of HTSM companies per municipality.



Source: Brabant Register of Establishments 2018, adapted by Fanion Onderzoek & Advies

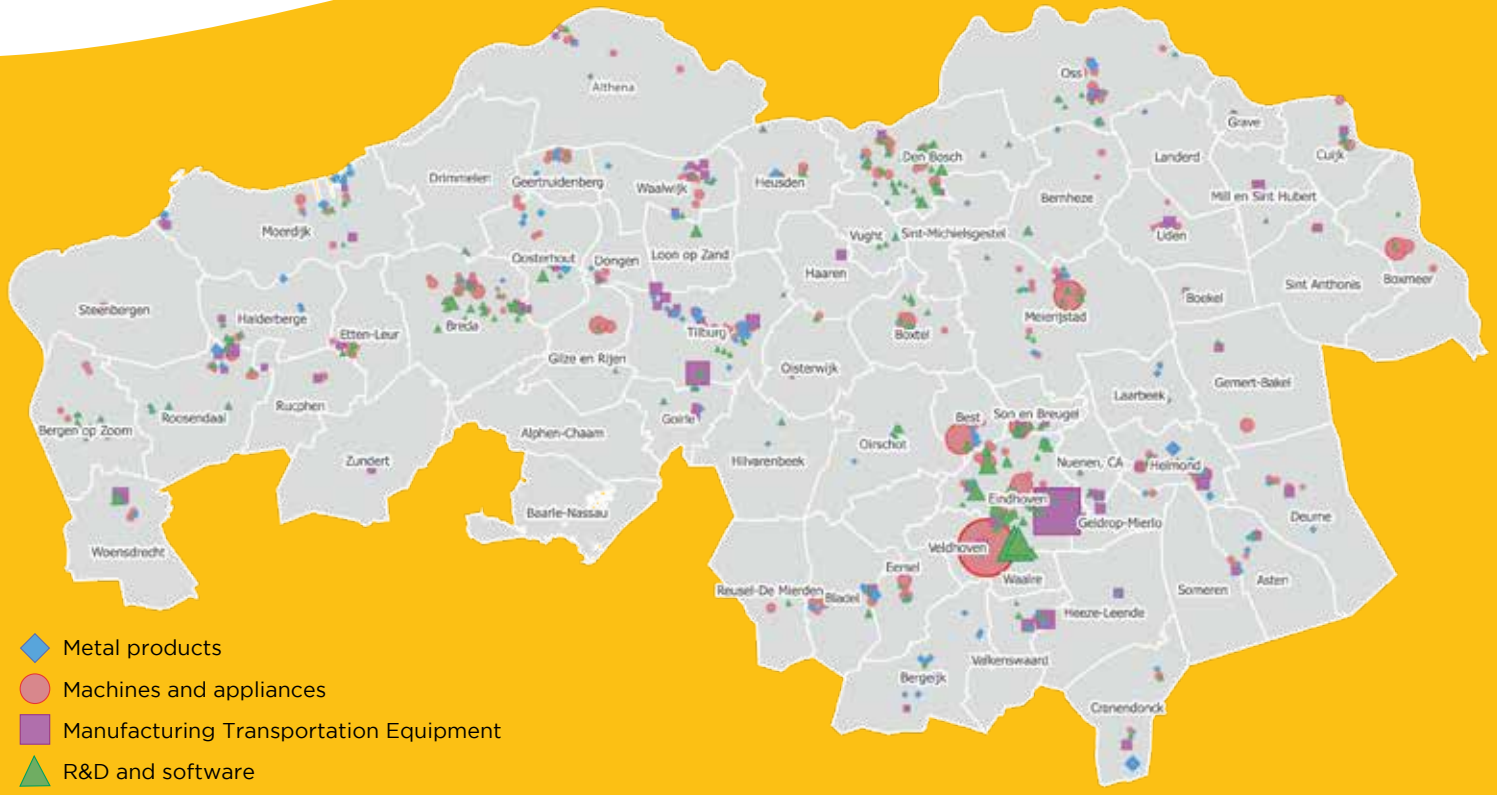
SHARE OF HTSM COMPANIES BY MUNICIPALITY



The map shows the number of HTSM companies as a portion of the total employment figures in each municipality.

Source: Brabant Register of Establishments 2018, adapted by Fanion Onderzoek & Advies

SPREAD OF COMPANIES EMPLOYING MORE THAN 20 PEOPLE, BY SUBSECTOR

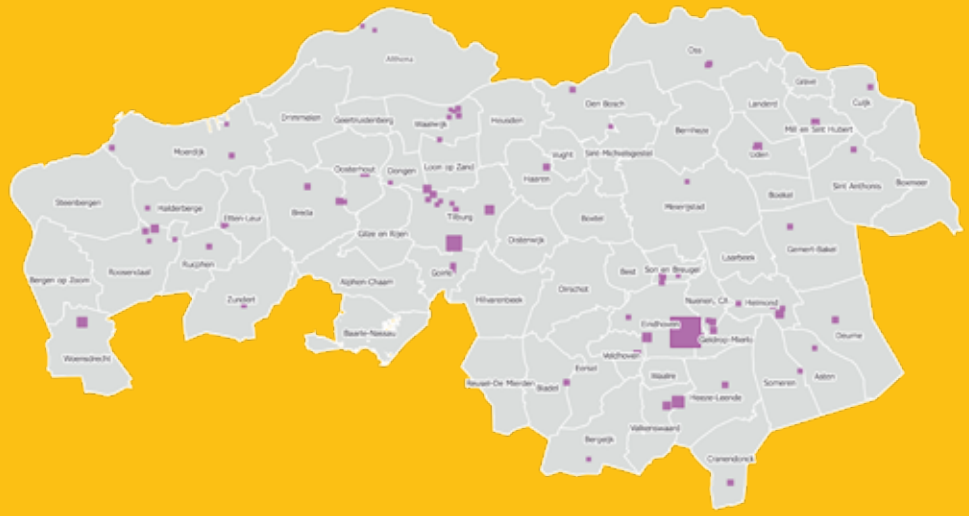


The largest companies active in the machines and appliances, manufacturing of transportation equipment, and R&D and software subsectors are concentrated in and around Eindhoven. Tilburg is home to many manufacturing of transportation equipment companies, while Den Bosch also has many R&D and software companies.

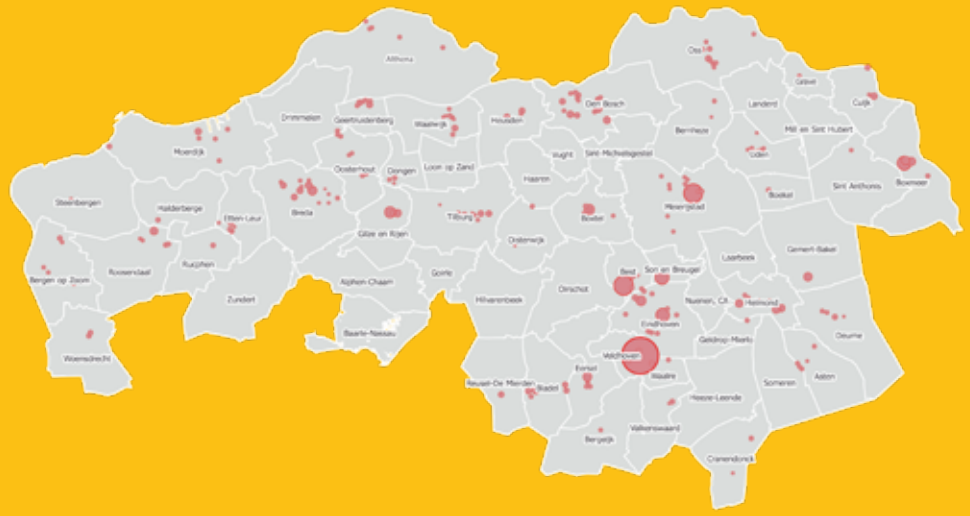
Source: Brabant Register of Establishments 2018, adapted by Fanion Onderzoek & Advies

SPREAD OF METAL SUBSECTOR COMPANIES EMPLOYING MORE THAN 20 PEOPLE

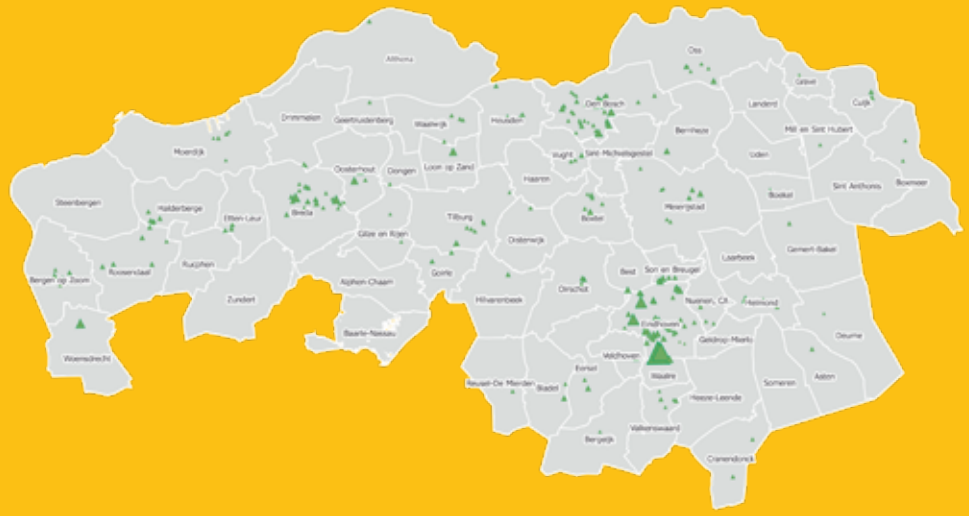
SPREAD OF TRANSPORTATION EQUIPMENT COMPANIES EMPLOYING MORE THAN 20 PEOPLE



SPREAD OF MACHINES AND APPLIANCES SUBSECTOR COMPANIES EMPLOYING MORE THAN 20 PEOPLE



SPREAD OF R&D AND SOFTWARE DEVELOPMENT COMPANIES EMPLOYING MORE THAN 20 PEOPLE



Source: Brabant Register of Establishments 2018, adapted by Fanion Onderzoek & Advies

5. The markets of Brabant's HTSM companies

MARKETS

The categorization of the HTSM industry into four subgroups does not do justice to the large variety of technologies and applications encompassed by High tech Systems and Materials. That is why we took a closer look at the 1,600 biggest HTSM companies in Brabant, examining the markets in which they operate and their types of technology. This section highlights some of the results of that study.

While nearly three out of ten HTSM companies focus exclusively on just one market, most of them are active in several end markets. More than 25% are active in two different markets, 16% in three markets, 11% in four markets, and 17% in five markets or more.

In terms of the number of business locations, construction and infrastructure is the largest market at 37%, followed by AgriFood (31%), machine building and engineering (26%), and the automotive (22%) industries.

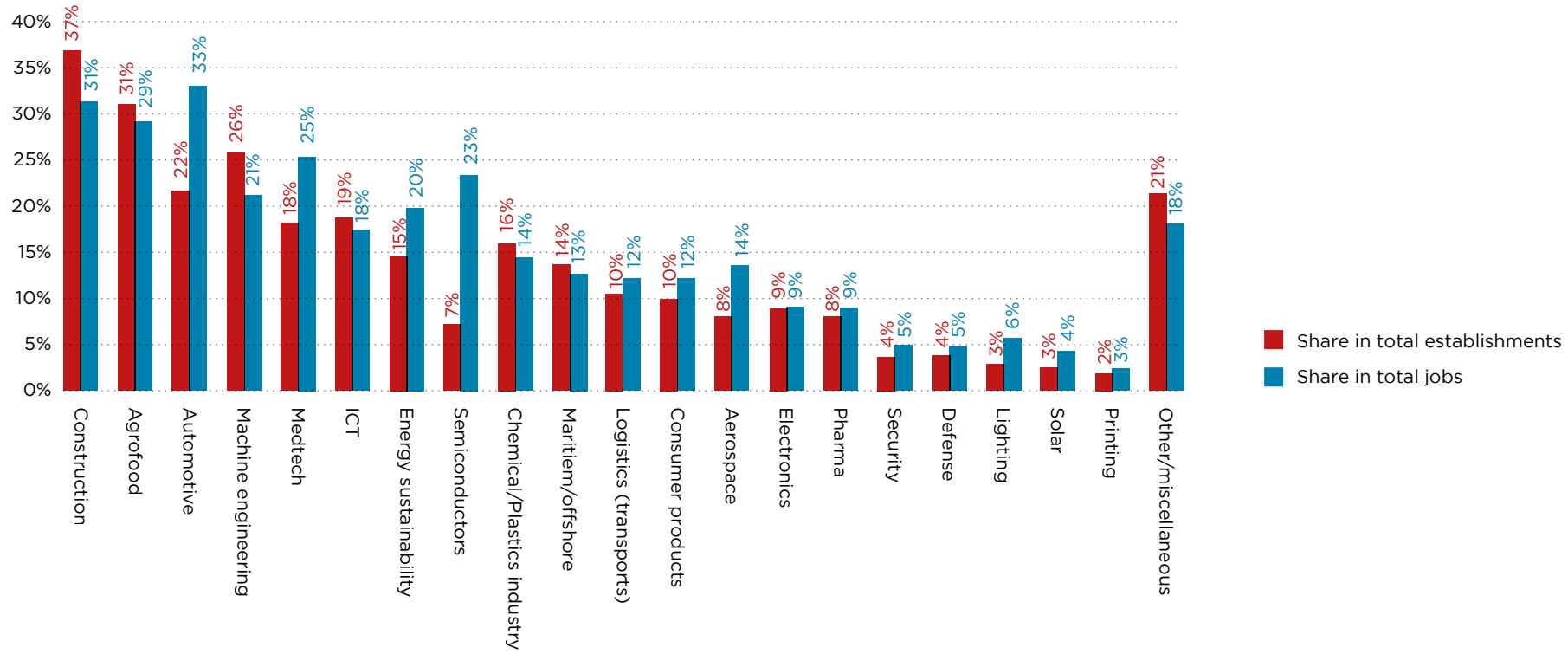
In terms of the number of jobs, automotive is the largest market, with 33% of jobs, followed by construction and infrastructure (31%), AgriFood (29%), MedTech (25%), and semiconductors (23%).

OEMS AND SUPPLIERS

Nine out of ten companies predominantly supply original equipment manufacturers (OEMs). These suppliers could have different roles in different markets, being classified as a tier 1 supplier in market 1 and as a tier 2 supplier in other markets, for example. Seventy percent of the Brabant companies are tier 1 suppliers in one or more markets, 18% are tier 2 and 5% are tier 3.

Eight percent of the HTSM companies in Brabant are an OEM. Please note that OEMs could be both a manufacturer and tier 1 supplier. A good example is ASML, which is an OEM when it comes to manufacturing wafer steppers but is also a supplier to chip manufacturers. Most OEMs in Brabant are active in AgriFood, construction, consumer products, the automotive industry and MedTech. The biggest and best-known of these are Royal Philips (healthcare), ASML, NXP, and DAF Trucks.

SHARE OF HTSM COMPANIES ACTIVE IN A SPECIFIC MARKET



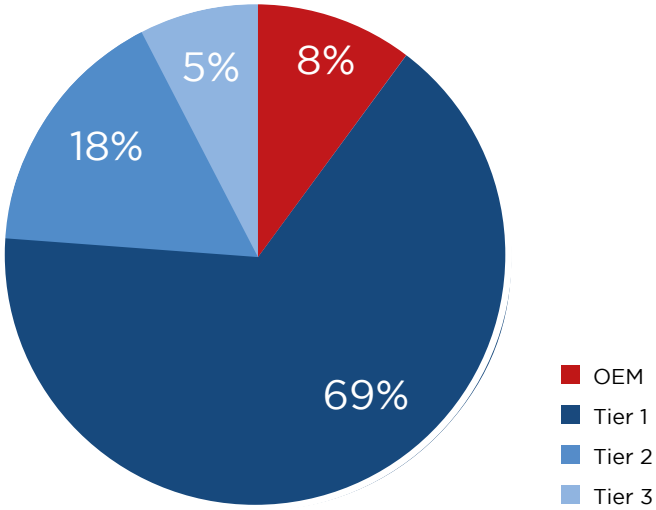
Source: Brabant Register of Establishments 2018, Fanion Onderzoek & Advies 2020

NUMBER OF OEMS AND SUPPLIERS BY MARKET

	Number of companies			
Sector	**OEM**	**Tier 1**	**Tier 2**	**Tier 3**
AgriFood	43	298	116	29
Construction and infrastructure	36	404	87	43
Consumer products	29	79	29	14
Automotive	21	195	87	34
MedTech	17	192	59	13
Logistics	14	118	22	8
Maritime/offshore	10	140	46	17
Energy/sustainability	9	162	44	10
Chemicals/plastics	7	170	53	18
Machine building & engineering	7	188	165	40
Pharma	7	102	15	2
Aerospace	6	74	35	8
Semiconductors	5	59	40	7
IC	3	279	10	0
Defense	2	48	9	3
Electronics	2	85	45	9
Security	2	55	3	0
Lighting	1	36	8	1
Printing	1	22	5	0
Solar	1	30	9	2
Miscellaneous/other	15	231	68	19

Source: Brabant Register of Establishments 2018, Fanion Onderzoek & Advies 2020

SHARE OF OEMS AND SUPPLIERS IN HTSM IN BRABANT



BRIEF PROFILES OF HTSM COMPANIES IN THE VARIOUS MARKETS

1. **Construction and infrastructure** (36.8% of companies and 31.4% of jobs): this subsector includes metal construction work, roofing, materials, lighting, building control, air treatment and climate control, architectural, and spatial consulting, as well as suppliers of parts, maintenance and inspection services and surface treatment for materials (coatings).

2. **AgriFood** (31.1% of companies and 29.1% of jobs): agrotechnology covers barn construction, air treatment and climate control, barn and greenhouse automation and technical agricultural vehicles, harvesting machines, and handling machines for sorting and packaging the harvest, as well as all parts suppliers. In the food industry this covers process technology and advice on process optimization, maintenance and inspection services, handling machines, packaging machines, air treatment and climate control, system cabinets, (quality) control equipment, and all suppliers of parts.

3. **Automotive** (21.7% of companies and 32.9% of jobs): the subsector includes OEMs such as DAF (Paccar) and VDL as well as many tier 1,2, and 3 suppliers of parts. Design services and inspection services are also included.

4. **Machine building industry** (25.9% of companies and 21.1% of jobs): this is a common denominator throughout Brabant and the region is proud of its capacity to invent, design, engineer, build, commercialize, and maintain any possible complex machine or cyber-physical system. Machines are built for and in every possible industry and for many of the other markets. There are a large number of machine manufacturers in Brabant that build custom-made machinery for a wide range of markets, requiring significant engineering and design skills and work. Moreover, there are an array of tier 1 suppliers constructing modules, supply electronics and mechatronics applications and numerous engineering services (embedded software, design services, etc.). There is also an entire network of tier 2 and 3 suppliers for machine building, focusing on milling, grinding, turning, cutting, edging, casting and injection molding, and finishing every imaginable type of machine part. Some suppliers are all-rounders and others specialize in, for example, coating and finishing parts.

5. **MedTech** (18.2% of companies and 25.3% of jobs): Philips is of course the largest company in Brabant's MedTech sector, but there are also many other companies developing MedTech devices and applications. The network of suppliers for machine construction also plays a role in the MedTech sector, as do specialized suppliers that create make high-quality consumables for MedTech (fittings, hoses, etc.)

6. **Energy/sustainability** (14.5% companies and 19.9% of jobs): this is a very diverse sector with, on one hand, the more traditional companies linked to the energy market, such as construction and maintenance companies for pipelines and fittings and their suppliers, and many other companies engaged in safety, inspection, and process optimization. Then there is also a large number of companies active in the market for clean and sustainable energy, such as solar and wind energy, a category that also includes many consultancy and engineering services.

7. **Semiconductors** (7.2% of companies and 23.4% of jobs): the companies in the semiconductor industry are the biggest employers, with ASML naturally dominating, together with its many suppliers nearby and in the region.

8. **Chemicals/plastics** (16% of companies and 14.4% of jobs): this sector primarily consists of plastics suppliers to HTSM companies that make plastic parts for the machine and automotive industries. Brabant is also home to many HTSM companies supplying the chemical and plastics industries, including products such as process vessels, boilers, pipes, fittings, process optimization, measurement and control technology, air treatment and climate technology, safety, inspection and maintenance services, and engineering services.

9. **Maritime/Offshore** (13.6% offices/12.7% jobs): Brabant is home to a surprising number of shipbuilders, focusing on oceangoing luxury superyachts and river barges. Even more companies supply the maritime market with hydraulics and hoisting installations, pumps, motors, pipes and fittings, coatings, maintenance, safety and inspection services, engineering services, etc.

10. **Logistics equipment** (10.4% of establishments and 12.3% of jobs): many companies are connected to the automotive industry, such as builders of trailers, specialized vehicles, and the maintenance and overhaul of trucks. Also included are GIS and IoT systems. The other principal category includes suppliers for storage and distribution facilities, such as lifting equipment, order picking, handling and packing machines, air treatment, and climate control.

11. **Consumer products** (9.9% of establishments and 12.3% of jobs): the province is home to some 30 OEMs that market consumer products, ranging from heaters to blinds, buckets, soda water systems, and medical devices. There are also many suppliers of metal and plastic parts and design and engineering services to companies active in the consumer market.

6. Technologies employed in the HTSM industry in Brabant

Research has shown that the following five categories of technologies employed by HTSM companies in Brabant are the most common.

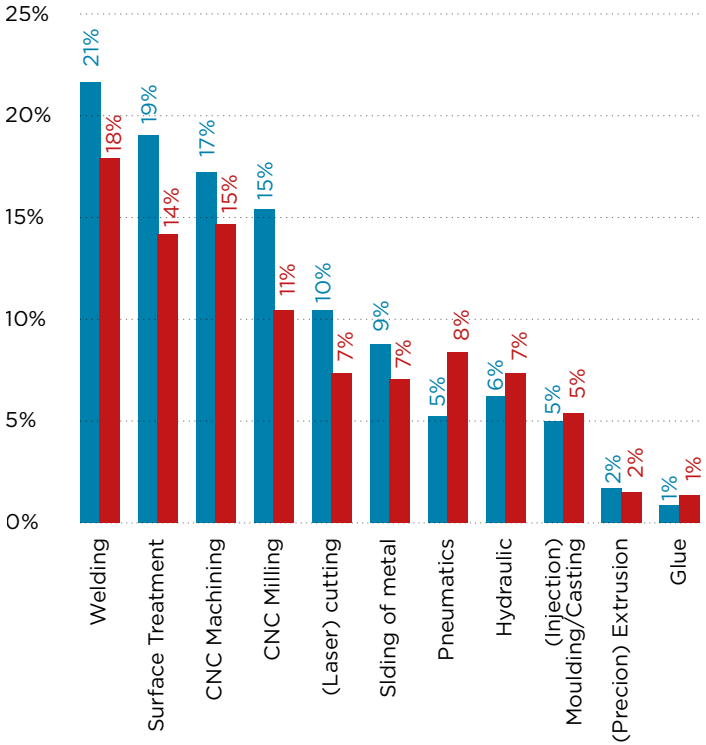
1. Basic technologies	*Welding (21%), surface treatment (19%), CNC machining (17%), and CNC milling (15%)*
2. General technologies	*Engineering (43%) and assembly (34%)*
3. High tech technologies	*Sensors (17%), mechatronics (14%), electronics (12%), and advanced instrumentation (12%)*
4. IT technologies	*Software (19%), embedded software (8%), IoT (6,2%), and artificial intelligence/computer modeling (5,8%)*
5. **Other**	*Various*

Engineering (43%) and assembly (34%) are the most commonly-cited general technologies used by HTSM companies, and they come in the top five in all markets. The most common high tech technologies are sensors (17%), mechatronics (14%), electronics (12%), and advanced instrumentation (12%). The larger companies in particular are intensive employers of these technologies.

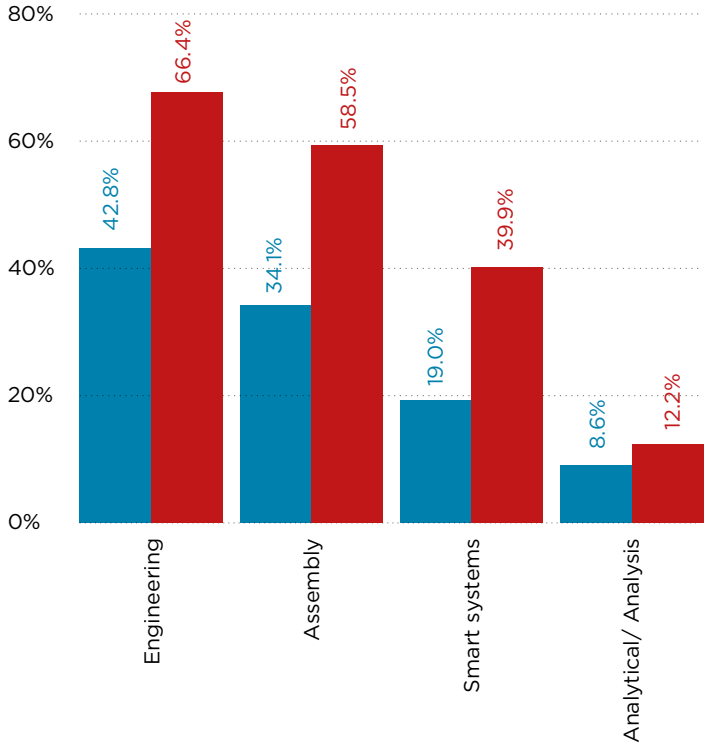
Studies demonstrate clearly that embedded software impacts upon 28% of all HTSM jobs, confirming its increasing significance in the sector's activities.

Important new technologies in the top five are sensors, advanced instrumentation, and smart systems.

SHARE OF HTSM COMPANIES AND ASSOCIATED JOBS IN BRABANT THAT EMPLOY BASIC TECHNOLOGIES



SHARE OF HTSM COMPANIES AND ASSOCIATED JOBS IN BRABANT THAT EMPLOY GENERAL TECHNOLOGIES

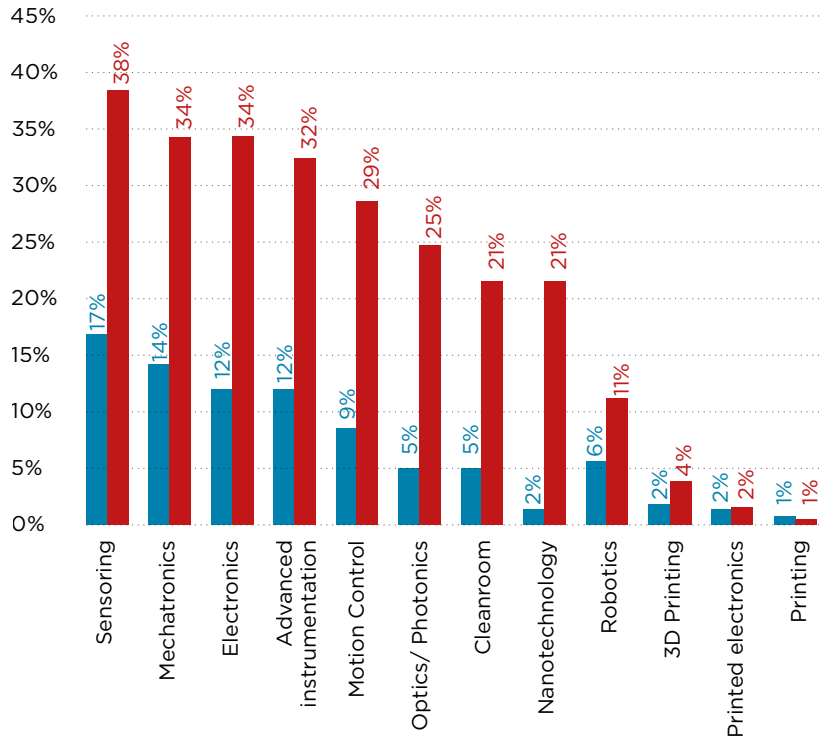


Share establishments

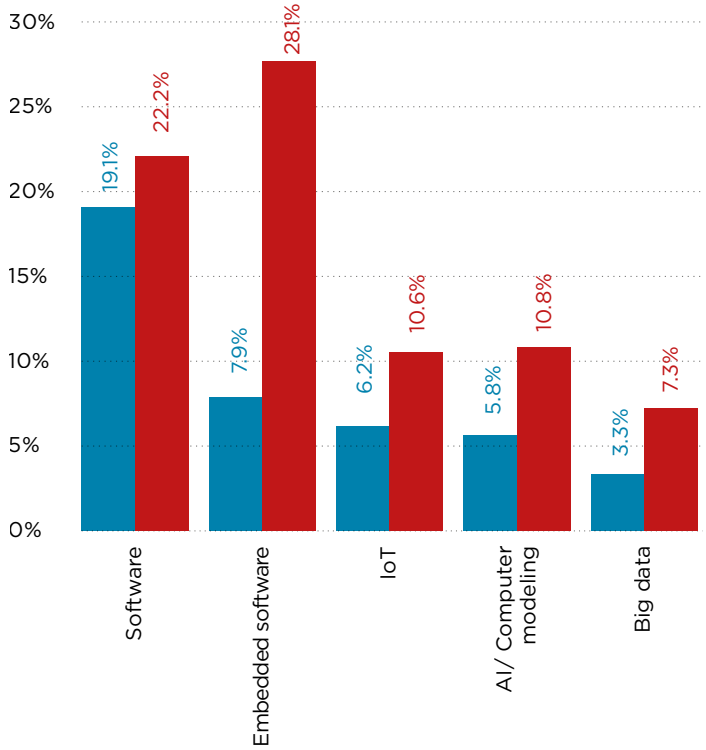
Share jobs

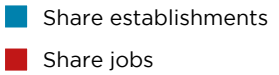
Source: Brabant Register of Establishments 2018, Fanion Onderzoek & Advies 2020

SHARE OF HTSM COMPANIES AND ASSOCIATED JOBS IN BRABANT THAT EMPLOY HIGH TECH TECHNOLOGIES



SHARE OF HTSM COMPANIES AND ASSOCIATED JOBS IN BRABANT THAT EMPLOY IT TECHNOLOGIES





Source: Brabant Register of Establishments 2018, Fanion Onderzoek & Advies 2020

TOP 5 TECHNOLOGIES BY MARKETS

TOP 5 TECHNOLOGIES BY MARKETS					
MARKETS	**1**	**2**	**3**	**4**	**5**
Automotive	Engineering	Assembly	CNC Machining	Welding	Surface Treatment
Aerospace	Engineering	Assembly	Smart systems	Advanced instrumentation	CNC Machining
Agrofood	Assembly	Engineering	Smart systems	Welding	Mechatronics
Chemical/plastics	Engineering	Assembly	Welding	Smart systems	Sensors
Construction	Engineering	Assembly	Welding	Surface Treatment	Smart systems
Consumer products	Assembly	Engineering	Welding	Surface Treatment	Smart systems
Defense	Engineering	Advanced instrumentation	Smart systems	Mechatronics	Software
Electronics	Engineering	Electronics	Smart systems	Assembly	Sensors
Energy/sustainability	Engineering	Assembly	Smart systems	Welding	Sensors
ICT	Software	Smart systems	IoT	Engineering	Sensors
Lighting	Electronics	Optics/ Photonics	Assembly	Smart systems	Sensors
Machine/engineering	CNC Machining	Assembly	CNC Milling	Engineering	Welding
Maritime/offshore	Engineering	Assembly	Welding	Mechatronics	Smart systems
MedTech	Engineering	Assembly	Smart systems	Sensors	Advanced instrumentation
Logistics	Assembly	Engineering	Welding	Smart systems	Mechatronics
Printing	Printing	Software	Engineering	Assembly	Mechatronics
Pharma	Engineering	Smart systems	Sensors	Mechatronics	Advanced instrumentation
Security	Engineering	Smart systems	Sensors	Software	Advanced instrumentation
Semiconductors	Engineering	CNC Machining	CNC Milling	Assembly	Smart systems
Solar	Engineering	Mechatronics	Assembly	Smart systems	Optics/ Photonics

Source: Brabant Register of Establishments 2018/Fanion Onderzoek en Advies 2020

A BRIEF DESCRIPTION OF THE TECHNOLOGIES MOST COMMONLY USED BY HTSM COMPANIES

1. **Engineering:** 42.8% of all companies (66.4% of the jobs) state they have in-house knowledge and technical R&D activities and services. These range from small, specialized suppliers to large multinationals. Many companies provide tailor-made solutions to their customers. There are naturally also a large number of specialized engineering services providers in the province.

2. **Assembly,** with 34.1% of companies and 58.5% of jobs: Brabant excels at assembling individual parts into larger parts and modules as well as complete machines, vehicles, and equipment. Companies that supply a limited range of parts also offer assembly and assembly services, which is a part of the province's strength in developing and manufacturing highly complex products, components, and systems at a low volume.

3. **Smart systems,** with 19% of companies and 39.9% of jobs: Brabant com panies are looking increasingly towards smart systems in which sensors, IoT, optics, and (embedded) software play a major role, whether for building management, air treatment and climate control, lighting, machine building, for the automotive sector, or anywhere else.

4. **Sensors,** with 16.8% of companies and 38.2% of jobs: sensors are playing an increasingly crucial role in many markets (including mechanical engineering, construction and infrastructure, automotive, and MedTech) and are an important precondition for the development of smart systems and advanced instrumentation.

5. **Mechatronics,** 14.3% of companies and 33.6% of jobs: Brabant is extremely strong in mechatronics, an industry that is often at the heart of mechanical engineering. The province is home to many suppliers of mechatronics parts and modules as well as embedded control software. Machine-builders all install mechatronics in their systems.

6. **Electronics,** 12.1% of companies and 34.3% of jobs: electronics are inextricably linked to smart systems and mechatronics, and a number of Brabant-based companies produce and supply electronic parts, while others employ a wide range of electronics in their mechatronic modules or machines.

7. **Advanced instrumentation,** 12% of companies and 32.3% of jobs: these companies are skilled in advanced measurement and control technology, analysis equipment, control systems, etc. Advanced instrumentation is closely related to smart systems and sensors.

8. **Software,** 19.1% of companies and 22.2% of jobs: a large number of HTSM companies active in IT specialize in developing (embedded) software for both the industrial market and for business information. Software is of course a precondition for developing smart systems and advanced instrumentation.

9. **Welding,** 21.4% of companies and 17.9% of jobs: welding is one of the most common basic techniques in the metal industry.

10. **Motion control,** 8.7% of companies and 28.7% of jobs: this field is natural closely related to the machine industry, whether in respect of the handling machines used in the AgriFood sector, logistics or in the semiconductor (wafer steppers) and electronics industries, as well as technologies for controlling movement in these high-precision processes. Once again, the strong overlap with sensors and mechatronics is obvious here.

7. Large HTSM companies and their official subsector

THE 25 LARGEST METAL PRODUCT COMPANIES

Company	City	Activity	Size (employees)
Nyrstar Budel	Budel-Dorplein	Manufacture of lead, zinc, and tin	200-500 jobs
Wärtsilä Netherlands	Drunen	Manufacture of ship equipment	200-500 jobs
Nedschroef	Helmond	Manufacture of bolts, screws, and nuts	200-500 jobs
Shiloh Industries Netherlands	Oss	Casting of light metals	200-500 jobs
KMWE Precision	Eindhoven	General metalworking, specialist in aerospace	200-500 jobs
VDL VDS Technische Industrie	Hapert	Forging, pressing, stamping, and profile rolling of metal	200-500 jobs
VDL HMI	Helmond	Manufacture of other fabricated metal products	50-100 jobs
VDL Technics B.V.	Boxtel	General metalworking	50-100 jobs
VDL Laktechniek	Eindhoven	Surface treatment and coating of metal	50-100 jobs
Tata Steel Nederland Tubes	Oosterhout	Manufacture of steel pipes, pipes, hollow profiles	200-500 jobs
Buvo casting	Helmond	Casting of light metals	200-500 jobs
Hydro Extrusion Drunen	Drunen	Manufacture of aluminum	200-500 jobs
Bilfinger Brabant Mobiel	Roosendaal	Surface treatment and coating of metal	100-200 jobs
Fabory Nederland	Tilburg	Manufacture of bolts, screws, and nuts	100-200 jobs
Wuppermann Staal Nederland	Moerdijk	Manufacture, surface treatment, and coating of metal	100-200 jobs
Barbas Bellfires	Bladel	Manufacture of fireplaces and stoves	100-200 jobs
Chromalloy Holland	Tilburg	Design, manufacture, and repair of gas turbine engine parts: aerospace and energy	100-200 jobs
KS Profiel	Moerdijk	Manufacture of metal profiles	100-200 jobs
Andritz Feed & Biofuel	Geldrop	Manufacture of dies and rolls for pellet mills animal feed and biomass pelleting industries.	100-200 jobs
Inno-Metaal	Eindhoven	Manufacture of metal covers for machines	100-200 jobs
LDM Brass	Drunen	Manufacture of copper alloy rod and billets for high-grade applications.	100-200 jobs
DE WIT B.V.	Helmond	Manufacture of wire and chain articles	100-200 jobs
NFB coatings	Best	Surface treatment and coating of metal	50-100 jobs
Heurkens & van Veluw B.V.	Oss	Forging, pressing, stamping, and profile rolling of metal	50-100 jobs
NedZink B.V.	Budel-Dorplein	Manufacturer of rolled titanium zinc	50-100 jobs

THE 25 LARGEST TRANSPORTATION EQUIPMENT COMPANIES

Company	City	Activity	Size class
DAF Trucks/Paccar	Eindhoven	Manufacture of trucks	> 1,000 jobs
Bosch Transmission Technology	Tilburg	Manufacture of gear boxes	> 1,000 jobs
VDL Bus & coach and VDL Bus Modules	Valkenswaard	Manufacture of busses	500 - 1,000 jobs
VDL Bus Chassis	Eindhoven	Bodywork construction	200 - 500 jobs
VDL Parts	Veldhoven	Bodywork construction	100 - 200 jobs
VDL Kunststoffen	Heeze	Manufacture of other plastic products	100 - 200 jobs
Fokker Elmo	Hoogerheide	Manufacture of aircraft cabling	500 - 1,000 jobs
Modine	Uden	Heat transfer products	200 - 500 jobs
Polytec Composites	Roosendaal	Manufacture of plastic components	200 - 500 jobs
Fokker landing gear	Helmond	Manufacture of landing gears for aircraft	200 - 500 jobs
NedTrain	Berkel-Enschot/Eindhoven	Manufacture of railway and tramway rolling stock	200 - 500 jobs
NRF	Mill	Manufacture of cooling products	200 - 500 jobs
Sunrise Medical HCM	Helmond	Manufacture of transport for invalids and mobility scooters	100 - 200 jobs
NedTrain	Eindhoven	Manufacture of railway and tramway rolling stock	100 - 200 jobs
Saris Aanhangers	Hapert	Manufacture of trailers	100 - 200 jobs
Knapen trailers	Deurne	Manufacture of truck trailers	100 - 200 jobs
DPI	Geldrop	Manufacture of car seats for children	100 - 200 jobs
Caligen Europe	Breda	Manufacture of polyurethane foams	50-100 jobs
MCPP Netherlands	Helmond	Manufacture of plastics	50-100 jobs
Heavac	Nuenen	Manufacture of car air treatment systems	50-100 jobs
Nanogate Eurogard Systems	Geldrop	Manufacture of specialized surfaces	50-100 jobs
Goodyear (Nederland) B.V.	Tilburg	Manufacture of rubber tires and retreading	50-100 jobs
Matador B.V.	Helvoirt	Injection molding of plastics	50-100 jobs
Lolaar spuitgiettechniek	Helmond	Casting of light metals	50-100 jobs
Berdex	Wanroij	Bodywork construction	50-100 jobs

THE 25 LARGEST MACHINE AND APPLIANCE COMPANIES

Company	City	Activity	Size (employees)
ASML Netherlands	Veldhoven	Manufacture of wafer steppers	> 1,000 jobs
Philips Health Care	Best	Manufacture of irradiation equipment, etc.	> 1,000 jobs
Vanderlande Industries	Veghel	Manufacture of hoisting, lifting, and transport equipment	> 1,000 jobs
NXP	Eindhoven	Manufacture of semiconductors	> 1,000 jobs
Prodrive Technologies	Son en Breugel	Manufacture of electrical systems and modules	> 1,000 jobs
Signify	Eindhoven	Manufacture of electric lamps, lighting apparatus	> 1,000 jobs
Marel Stork Poultry Processing	Boxmeer	Manufacture of machines for the processing of poultry	500 - 1,000 jobs
VDL Enabling Technologies Group.	Eindhoven	Manufacture of other machines and equipment	500 - 1,000 jobs
VDL Steelweld	Breda	Manufacture of metalworking machine tools	200-500 jobs
VDL Industrial Moulds	Helmond	Manufacture of other machinery, equipmen,t and tools	200-500 jobs
Bosch Rexroth	Boxtel	Manufacture of hydraulic equipment	500 - 1,000 jobs
Ericsson	Rijen	Manufacture of communication equipment	500 - 1,000 jobs
Kuhn-Geldrop	Geldrop	Manufacture of farm machinery	200-500 jobs
SPG Prints	Boxmeer	Manufacture of machines, printing and engraving	200-500 jobs
GEA Food Solutions	Bakel	Manufacture of machines for the food industry	200-500 jobs
Bosch Security Systems	Eindhoven	Manufacture of communications and security equipment	200-500 jobs
Vencomatic Group	Eersel	Manufacture of systems for poultry breeding	200-500 jobs
Flowserve Service & Repair	Etten-Leur	Repair and maintenance of pumps, seals, and valves	200-500 jobs
TE Connectivity	's-Hertogenbosch	Manufacture of connectors	200-500 jobs
Tennant	Uden	Cleaning machines	200-500 jobs
Emerson valves and controls	Breda	Manufacture of valves, actuators, and regulators	200-500 jobs
Caterpillar Work Tools	's-Hertogenbosch	Manufacture of hoisting, lifting and transport equipment	200-500 jobs
Flowserve	Roosendaal	Manufacture pumps, seals, and valves	200-500 jobs
Contiweb	Boxmeer	Manufacture of offset and printing machines	200-500 jobs
Advanced Automated equipment (AAE)	Helmond	Manufacture of custom-made printing and assembly automations	200-500 jobs

THE 25 LARGEST COMPANIES IN OTHER BRANCHES: R&D AND SOFTWARE DEVELOPMENT

Company	City	Activity	Size (employees)
Philips Research Eindhoven	Eindhoven	Technical research and development work	> 1,000 jobs
Philips Health	Eindhoven	Technical research and development work	>1,000 jobs
Atos	Eindhoven	Developing, producing, and publishing software	500 - 1,000 jobs
Thermo Fisher Scientific	Eindhoven	Electron microscopes	500 - 1,000 jobs
SAP	's-Hertogenbosch	Developing, producing, and publishing software	500 - 1,000 jobs
Fokker Techniek	Hoogerheide	Aircraft maintenance and completion	200 - 500 jobs
SPIE	Breda	Engineering, installation and other technical design and advice	200 - 500 jobs
Dassault Systèmes	's-Hertogenbosch	Developing, producing, and publishing software	200 - 500 jobs
VDL ETG Technology & Development	Eindhoven	Engineering and other technical design and advice	200 - 500 jobs
Heijmans Infra	Rosmalen	Engineering and other technical design and advice	200 - 500 jobs
PinkRoccade Local	's-Hertogenbosch	Developing, producing, and publishing software	200 - 500 jobs
Applied Micro Electronics 'AME'	Eindhoven	Development and manufacture of high quality electronic products	200 - 500 jobs
Antea Nederland	Oosterhout	Engineering and other technical design and advice	200 - 500 jobs
Super Micro Computer	's-Hertogenbosch	Computer components	200 - 500 jobs
Fluor Consultants	Bergen op Zoom	Engineering and other technical design and advice	200 - 500 jobs
HERE Global	Eindhoven	GPS and navigation appliances	200 - 500 jobs
Altran	Eindhoven	Engineering and R&D services	200 - 500 jobs
SGS Search	Heeswijk-Dinther	Inspection agency for the (sustainably) built environment	100 - 200 jobs
Heijmans Infra	Eindhoven	Engineering and other technical design and advice	100 - 200 jobs
PharmaPartners	Oosterhout	IT solutions for pharmaceuticals	100 - 200 jobs
Vecozo	Tilburg	IT solutions for healthcare	100 - 200 jobs
KTBA Kwaliteitszorg	Kaatsheuvel	Inspection and control of machines, equipment, and materials	100 - 200 jobs
TÜV Nederland QA	Best	Inspection and control of machines, equipment, and materials	100 - 200 jobs
Sioux Technologies	Eindhoven	Engineering and R&D services	100 - 200 jobs
Kulicke & Soffa	Eindhoven	Engineering and other technical design and advice	100 - 200 jobs

8. Brabant's HTSM production value

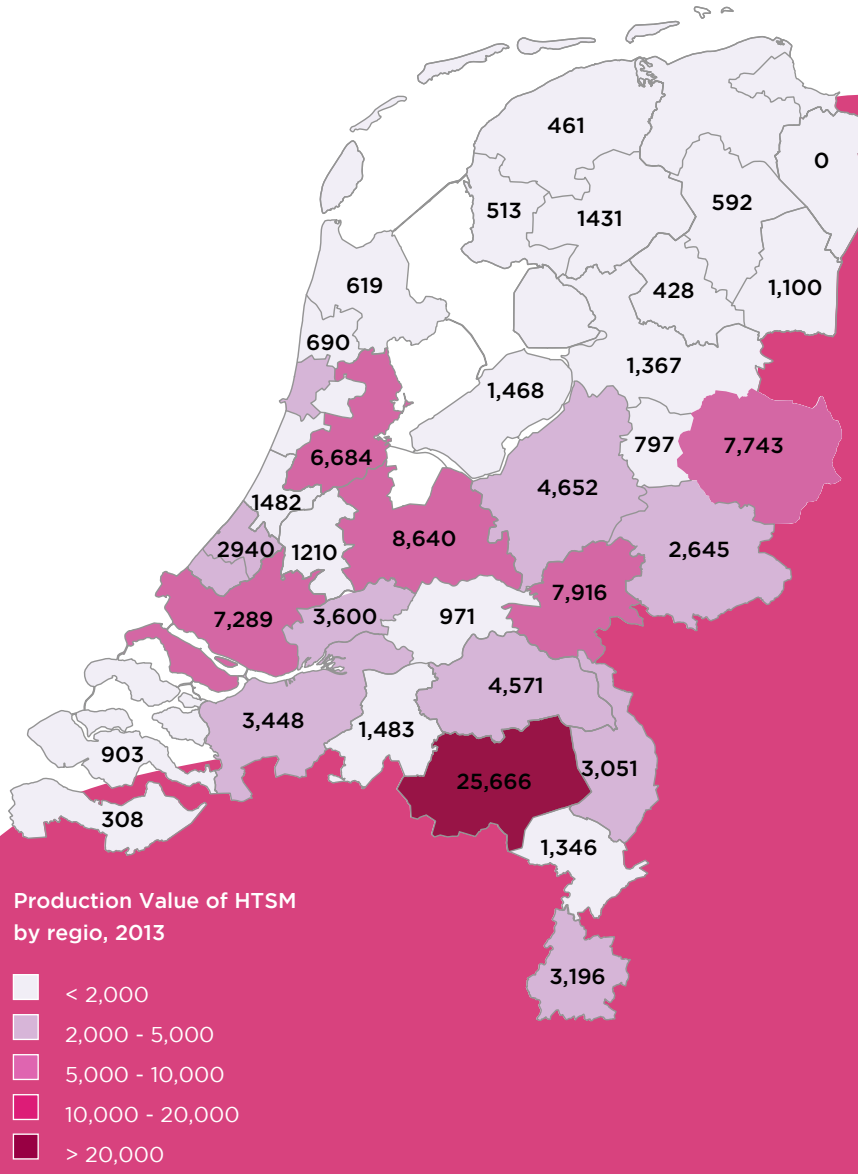
PRODUCTION VALUE

The Dutch Central Bureau for Statistics (CBS) has published data for the production value of HTSM in 2013 at the geographical level of the regions. The total production value of HTSM in Brabant in 2013 added up to 35 billion euro. Representing 29% of total Dutch production value, this was by far the largest regional contribution in the Netherlands.

The Southeast region in Brabant – Brainport Eindhoven and its surroundings – delivers the largest regional contribution to the BBP of Dutch HTSM by far. It was 25.5 billion euro in 2013, outpacing the second ranked Dutch region (Twente) with its production value of 7.7 billion euros by miles.

CBS has stopped registering the production value of the HTSM sector by province and region after 2013 – 14. It is however safe to say that the province of Brabant is still by far the most significant 'heavy-weight' region in the Netherlands in HTSM.

Production Value of HTSM by region in millions of euros, 2013.



Source: The Dutch Central Bureau for Statistics (CBS) 2016, QGIS, adapted by Fanion Onderzoek & Advies

9. HTSM logistics service providers

(not falling under the Priority Industry classification)

Adding to Brabant's overall HTSM strengths is the abundance of specialized logistics service providers with dedicated expertise, skills, and facilities for HTSM products and services. Below is a selection of logistics service providers in Brabant that specifically service the HTSM industry, most of which have multiple distribution and operations centers in the province.

Company	City	Country of origin	Size (employees)
Syncreon	Waalwijk, Tilburg	USA	> 1,000
DB Schenker Logistics Nederland	Tilburg, Eindhoven	Germany	500-800
ID Logistics	Tilburg	France	500-800
Rhenus	Tilburg, Eindhoven, Son, Etten-Leur, Best	Germany	500-800
CEVA logistics	Eindhoven	France	200-500
DSV	Moerdijk, Zevenbergen	Denmark	200-500
Van Rooijen Logistiek	Eindhoven	Netherlands	200-500
Vos Logistics	Oss, Helmond	Netherlands	200-500
Broek Logistics	Helmond	Netherlands	100-200
Jan de Rijk Logistics	Geldrop, Eindhoven, Roosendaal	Netherlands	100-200
KLG Europe	Eersel	Netherlands	100-200
Base Logistics	Klundert	Netherlands	50-100
BF Global Logistics	Tilburg	Netherlands	50-100
XPO logistics	Eindhoven	USA	50-100
Baetsen	Veldhoven	Netherlands	20-50
Jan van Dam Machine Transport	Oudewater	Netherlands	20-50
Yusen Logistics Benelux	Moerdijk	Japan	20-50
Crane Worldwide Logistics	Tilburg	USA	10-20
Pantos Logistics	Oosterhout	South Korea	10-20

10. Key enabling technologies in Brabant and their application areas

INTRODUCTION

As an HTSM region and with Brainport Eindhoven as its beating heart, Brabant is in a robust and healthy condition.

The region boasts extremely sturdy foundations in HTSM, with almost all key enabling technologies (KETs) well represented and highly developed:

- Electronics
- High-tech materials
- Nanotechnology
- Photonics
- Smart industry (advanced manufacturing)
- Systems engineering

The same is true for artificial intelligence, especially when it comes to its application in the real world of complex machine building, evolving towards cyber-physical systems.

The region also excels in many application areas (AAs):

- Semiconductors (equipment)
- Advanced instrumentation
- High-tech healthcare
- Automotive
- 3D printing

Brainport Eindhoven is also consistently a leader in the field of lighting, particularly in the world of innovation and design. But this field has become less prominent due to the advent of LED in all its variations, as LED technology is less complex, costs are lower, and production has largely moved to Asia. This has made the sector less of a priority for the wider region as a whole.

It is also notable that, even in the aerospace and space industries, smaller clusters of companies or individual key companies are to be found in Brabant that are global leaders in their fields – whether for the supply of supercritical parts (KMWE, GKN Fokker ELMO), aircraft or satellite electronics or subsystems (APP Propulsion Products, Fokker Landing Gear (GKN Aerospace), Bradford Engineering, and Thales Cryogenics), or the maintenance of complex systems (StandardAero, Fokker Techniek (GKN), and OneLogistics). Brabant is a small but powerful player in these domains.

The only field that is not particularly well developed in Brabant is security, and although there are is activity in electronic security systems and cameras, cybersecurity companies are rare in the province.

THE KEY ENABLING TECHNOLOGIES VERSUS APPLICATION AREAS IN BRABANT

Strenght in Brabant		Energietransitie en Duurzaamheid	Electronics	High Tech Materials	Nanotechnology	Photonics	Smart Industry (Advanced Manufacturing)	Artificial Intelligence
			+/+	+	+/+	+/+	+/+	+
	Application Areas (Aas)							
+/+	Advanced Instrumentation		X		X	X	X	X
0	*Aerospace*		X	X	X		X	
+	Automotive		X	X	X		X	X
+/+	High Tech Healthcare		X	X	X		X	X
+	Lighting		X	X	X	X	X	X
0	*Security*		X				X	X
+/+	Semiconductor Equipment		X	X	X	X	X	X
0	*Space*		X	X	X		X	
+/+	3D Printing		X	X	X		X	X
+	**Energy (Solar)**		X	X			X	
-/-	Very Weak							
-	Weak							
0	Neutral							
+	Strong							
+/+	Very strong							
Smaller print	Small but robust sector							
Energy (Solar)	Societal challenge / Theme							
	Systems Engineering							

SOME EXAMPLES OF BRABANT COMPANIES IN THE KETS AND AAS
15 ADVANCED INSTRUMENTATION COMPANIES

Company	City	Activity	Size (employees)
Philips Innovation Services	Eindhoven	R&D & engineering services, research & testing facilities	> 1,000
Prodrive Technologies	Son en Breugel	Systems supplier	> 1,000
VDL ETG (Enabling Technology Group)	Eindhoven	Mechatronic modules	> 1,000
Atos Nederland	Eindhoven	Digital services	800-1,000
Thermo Fisher Scientific (formerly FEI Electron Optics)	Eindhoven	Electron microscopes	500-800
Bosch Rexroth	Boxtel	Machine parts and modules	500-800
Ericsson	Rijen	IT service provider	500-800
Dassault Systèmes	Den Bosch	Smart systems provider and integrator	200-500
Omron Manufacturing	Den Bosch	Electronic components and devices	100-200
Neways Technologies	Son en Breugel	Electronic systems	100-200
TüV Nederland QA	Best	Inspection and certification services	100-200
Teledyne Dalsa	Eindhoven	Imaging and microelectromechanical systems	100-200
Vinçotte Nederland	Breda	Inspection and certification services	100-200
IMEC	Eindhoven	R&D hub for nano and digital technologies	100-200
Actemium	Veghel	Industrial automation and solutions	100-200

Photo: Assembly of Titan Krios transmission electron microscopes at Thermo Fisher (FEI) in Eindhoven.
Source: ED.

15 AUTOMOTIVE COMPANIES

Company	City	Activity	Size (employees)
DAF Trucks/Paccar Inc.	Eindhoven	Trucks	> 1,000
VDL Group	Valkenswaard	Buses, coaches, and cars and their supply chains	> 1,000
Bosch Transmission Technology	Tilburg	Transmission systems	> 1,000
Prodrive Technologies	Son en Breugel	System supplier	> 1,000
TNO	Eindhoven/Helmond	Testing and research facilities and services	200-500
Shiloh Industries	Oss	Casting & stamping of aluminum car parts	200-500
POLYTEC Composites	Roosendaal	Developer and manufacturer of top-quality plastics solutions	200-500
BUVO Castings	Helmond	High-pressure casting of aluminum parts	200-500
HERE	Eindhoven	Maps and navigation software	200-500
Saris Trailers	Hapert	Trailers	100-200
Knapen Trailers	Deurne	Truck trailers	100-200
Goodyear	Tilburg	Tires for cars and airplanes	50-100
Ebusco®	Helmond	Buses and coaches	20-50
PAL-V International	Raamsdonksveer	Flying cars	20-50
TASS International Safety Center	Helmond	Crash testing	20-50

Pal-V Liberty Flying Car – made in Brabant

20 HIGH TECH HEALTHCARE COMPANIES

Company	City	Activity	Size (employees)
Philips Healthcare	Best	Health technology: diagnostic imaging, image-guided therapy, patient monitoring, health informatics, consumer health, and homecare	> 1,000
Philips Innovation Services	Eindhoven	R&D and engineering services, research & testing facilities	> 1,000
VDL Group	Eindhoven	Mechatronic modules	> 1,000
Thermo Fisher Scientific (former FEI Electron Optics)	Eindhoven	Electron microscopes	500-800
TE Connectivity Nederland	Den Bosch	Connectors and sensors	200-500
KMWE Precision	Eindhoven	Metal parts/semifinished products	200-500
AAE Advanced Automated Equipment	Helmond	Mechatronic modules	200-500
Fluor Consultants	Bergen op Zoom	Engineering and technical services	200-500
Neways Industrial Systems	Son en Breugel	Electronic systems	100-200
Sioux Embedded Systems	Eindhoven	Smart system provider and integrator	100-200
Össur	Eindhoven	Prostheses and braces	100-200
Frencken Engineering	Eindhoven	Semifinished machine modules	100-200
Malvern Panalytical	Eindhoven	Machines for the chemical, physical, and structural analysis of materials	50-100
Luminex	Den Bosch	Medical testing equipment	50-100
Raith	Best	Nanolithography	20-50
Stirling Consulting Group	Son en Breugel	Standalone cryogenic cooling systems	20-50
Rovers Medical Devices	Oss	Screening and analysis instruments and devices	20-50
Steris	Etten-Leur	Medical devices and equipment	20-50
Nuclear Fields International	Boxmeer	Collimator technology	20-50
IME Medical Electrospinning	Geldrop	Electrospinning medical nanofibers	20-50

ROYAL PHILIPS/PHILIPS HEALTHCARE

Royal Philips is one of the three leading healthcare companies in the world and the largest high tech healthcare company in Brabant and the Netherlands. It is a technology company focused on improving people's health and wellbeing across the full spectrum of healthcare activities, from healthy living and prevention to diagnosis, treatment, and homecare. Philips leverages advanced technology and clinical and consumer insights to deliver integrated solutions.

Headquartered in the Netherlands, the company is a leader in diagnostic imaging, image-guided therapy, patient monitoring and health informatics, as well as in consumer health and homecare. Philips generated sales of 19.5 billion euros in 2019 and employs some 81,000 people, offering sales and services in over a hundred countries.

Philips is a global company with operations on all continents, and even though only two percent of its global turnover is generated in the Netherlands, the core focus of global R&D is still in Eindhoven. It is the stage for 40% of all research, with 8,000 employees on the High Tech Campus and in Best alone.

In the Brainport Eindhoven region, both the knowledge infrastructure, including the Eindhoven University of Technology, and a large part of the industrial fabric of the region have been co-developed by and for Philips over a period of more than 120 years. All possible tier 1, 2, and 3 suppliers required to develop and manufacture high tech medical systems are present in the region.

THE TOP 15 3D PRINTING COMPANIES

Company	City	Activity	Size (employees)
ASML	Veldhoven	Wafer (semiconductor) fabrication for lithography equipment & services	> 1,000
NXP	Eindhoven	Semiconductors	500-800
Xycarb Ceramics	Helmond	Graphite, quartz, and ceramic products	200-500
Dialog Semiconductor	Den Bosch	Semiconductors	100-200
Kulicke & Soffa (K&S)	Eindhoven	Semiconductor and electronics assembly solutions	100-200
IMEC	Eindhoven	R&D hub for nano and digital technologies	100-200
Anteryon	Eindhoven	Optical solutions, components, and sub-assemblies	100-200
Teledyne Dalsa	Eindhoven	Imaging and microelectromechanical systems	100-200
Catena Radio Design	Son en Breugel	System IP and IC design	50-100
Industrial Packing Support	Eindhoven	Industrial packaging, tooling, and testing	50-100
Meco Equipment Engineers (Besi)	Drunen	Semiconductor equipment	50-100
Mecal Semiconductor Product Development	Eindhoven	Engineering consultancy	50-100
Possehl Electronics Netherlands	Den Bosch	Electronic components	50-100
Raith	Best	Nanolithography	20-50
Mintres	Cuijk	Ceramic components	20-50

ETCHING AND LITHOGRAPHY COMPANIES

Company	City	Activity	Size (employees)
ASML	Veldhoven	Wafer (semiconductor) fabrication for lithography equipment & services	> 1,000
Dialog Semiconductor	Den Bosch	Semiconductors	100-200
Possehl Electronics Netherlands	Den Bosch	Electronic components	50-100
Meco Equipment Engineers (Besi)	Drunen	Semiconductor equipment	50-100
Raith	Best	Nanolithography	20-50
Mintres	Cuijk	Ceramic components	20-50
Anopanel	Eindhoven	Housings, panels, and fronts	10-20
Innplate Surface Technology	Son en Breugel	Electrochemical surface treatment	10-20

COMPANY SKETCH: ASML, BASED IN VELDHOVEN, PART OF BRAINPORT EINDHOVEN

ASML is an innovation leader in the semiconductor industry. The company provides computer chip manufacturers with everything they need – hardware, software, and services – to mass produce patterns on silicon using lithography. ASML was founded in Eindhoven in 1984 and has grown into a global company with almost 25,000 employees of 118 different nationalities... and counting.

ASML's headquarters are located in Europe's top tech hub, the Brainport Eindhoven region in the Netherlands, and global operations are spread across Europe, Asia, and the US. ASML, with 13,000 highly-skilled employees in the Eindhoven region, is by far the largest Dutch investor in research and development. ASML's turnover in 2019 was a record high of 11.8 billion euros, and it is aiming for revenue figures of 24 billion euros by 2024, partially thanks to the burgeoning chip industry in Asia

HOW LITHOGRAPHY WORKS

A lithography system is essentially a projection system. Light is projected through a blueprint of the pattern that will be printed (known as a 'mask' or 'reticle'). The blueprint is four times larger than the intended pattern on the chip. With the pattern encoded in the light, the system's optics shrink and focus the pattern onto a photosensitive silicon wafer. After the pattern is printed, the system moves the wafer slightly and makes another copy on the wafer.

This process is repeated until the wafer is covered in patterns, completing one layer of the wafer's chips. To make an entire microchip, this process will be repeated a hundred or more times, laying patterns on top of patterns. The size of the features to be printed varies depending on the layer, which means that different types of lithography systems are used for different layers – from the latest-generation EUV (extreme ultraviolet) systems for the smallest features to older DUV (deep ultraviolet) systems for the largest.

DUV LITHOGRAPHY

ASML's DUV (deep ultraviolet) platform is the industry 'workhorse', offering immersion and dry lithography solutions that help manufacture a broad range of semiconductor nodes and technologies. ASML's immersion and dry systems are leading in the industry in productivity, imaging and overlay performance for high-volume manufacturing of the most advanced logic and memory chips. The immersion systems can deliver both single-pass and multi-pass lithography and have been designed to be used in combination with EUV lithography to print the different layers of a chip.

EUV LITHOGRAPHY

ASML is the world's only manufacturer of lithography machines that use extreme ultraviolet light. EUV lithography uses light with a wavelength of just 13.5 nanometers (nearly x-ray level), a reduction of almost 14 times that of the other enabling lithography solution in advanced chipmaking, DUV (deep ultraviolet) lithography, which uses 193-nanometer light.

ASML's EUV platform extends its customers' logic and DRAM roadmaps by delivering resolution improvements, state-of-the-art overlay performance and year-on-year cost reductions. The expectation is that the EUV product roadmap will drive affordable scaling to 2030 and beyond.

To harness the power of extreme ultraviolet light and bring EUV lithography to the market, ASML had to tackle some of its biggest technical challenges over more than 20 years of sustained R&D. These challenges included fundamental paradigm shifts in lithography system architecture, such as imaging in high vacuum instead of air, working with ultra-flat multi-layer mirrors instead of lenses, and generating the required light by vaporizing droplets of tin with a high-power laser.

METROLOGY AND INSPECTION

The company's metrology solutions can quickly measure imaging performance on silicon wafers and feeds that data back into the lithography system in real-time, helping to keep lithography performance stable in high-volume chip manufacturing. These inspection solutions help to locate and analyze individual chip defects amid billions of printed patterns.
Software

ASML jokingly describes its software innovations as the 'Robin' to its 'Batman' hardware innovations. Even though ASML is best known as a hardware company, it is home to one of the world's largest and most pioneering software communities. It would be impossible for ASML's lithography systems to manufacture chips at such increasingly small dimensions without matching software development. Current lithography systems are a hybrid of high tech hardware and advanced software.

THE TOP 15 3D PRINTING COMPANIES

Company	City	Activity	Size (employees)
Philips Innovation Services	Eindhoven	R&D & engineering services, research & testing facilities	> 1,000
VDL Group	Eindhoven	System supplier	> 1,000
KMWE Precision	Eindhoven	Metal parts/semifinished products	200-500
AAE Advanced Automated Equipment	Helmond	Mechatronic modules	200-500
Siemens Industry Software	Den Bosch	Industrial software	100-200
Mitsubishi Chemical Corporation (Former Dutch Filaments)	Helmond	Manufacture of polymer 3D filaments	50-100
VanBerlo	Eindhoven	Product design and development	50-100
Possehl Electronics	Den Bosch	Electronic components	50-100
Wilting Components	Eindhoven	Industrialization and production of repeat series of complex parts	50-100
Additive Industries	Eindhoven	Metal additive manufacturing	20-50
Edumar Metaalbewerking	Someren	Fine mechanical products in various metals	20-50
BLW Kunststoffen	Nuenen	Plastic semifinished and finished products	20-50
Proven Concepts	Valkenswaard	Product design and prototyping	20-50
Poly Products	Werkendam	Products of fiber-reinforced composites	20-50
Leves Fijnmetaal (Blok Group)	Someren	General metalworking	20-50

ADDITIVE INDUSTRIES

Additive Industries is a 3D metal printer manufacturer for high-quality metal parts. It offers a system specifically aimed at high-end and demanding industrial markets. With class-leading build volume, robustness as well as productivity, Additive Industries redefines the business case for aerospace, automotive, energy and high-tech equipment. Headquartered in the Netherlands, Additive Industries has demo and service centers in the USA, UK and Singapore and is a global key player in large volume metal printing systems.

Established in 2012 in the “Brainport Ecostructure” around Eindhoven in The Netherlands, Additive Industries is the world’s first dedicated equipment manufacturer for industrial metal additive manufacturing systems. Built on the high tech systems, optics and electronics heritage of this region, founders Jonas Wintermans and Daan Kersten have created a company of talented professionals committed to industrialising 3D printing using ‘open innovation’ principles to capitalise on proven technology. By putting the customer first in everything we do, we enable them to improve their designs, product performance and business cases for the best competitive position in their market. Additive Industries has renowned customers such as Formula One Team Alfa Romeo Racing ORLEN, ArcelorMittal, K3D, the Volkswagen Group and many more.

20 ELECTRONICS COMPANIES

Company	City	Activity	Size (employees)
Signify	Eindhoven	Lighting solutions	> 1,000
TE Connectivity Nederland	Den Bosch	Connectors and sensors	200-500
AME Applied Micro Electronics	Eindhoven	High-quality electronic products	200-500
Altran (TASS)	Eindhoven	IT and R&D consultancy	200-500
Bosch Security Systems	Eindhoven	Security and surveillance systems	200-500
TNO	Eindhoven	Testing and research facilities and R&D services	200-500
Omron	Den Bosch	Electronic components and devices	100-200
Kulicke & Soffa (K&S) Netherlands	Eindhoven	Semiconductor and electronics assembly solutions	100-200
Teledyne Dalsa	Eindhoven	Imaging and microelectromechanical systems	100-200
Anteryon	Eindhoven	Optical solutions, components, and subassemblies	100-200
Grass Valley Nederland	Breda	Audiovisual equipment	100-200
ECS Electronics	Breda	Production of connection systems, cabling, and software for the automotive industry	100-200
Neways Electronics	Son en Breugel	Electronic systems	100-200
Nanogate Eurogard Systems	Geldrop	Largescale production of components and surface treatment	50-100
Adimec	Eindhoven	Industrial cameras	50-100
Possehl Electronics	Den Bosch	Electronic components	50-100
Liad Electronics	Breda	Electronic modules and circuit boards	20-50
GTV Elektro	Den Bosch	Electronic systems integrator	20-50
QnQ Engineering	Eindhoven	Electrotechnical solutions	20-50
Delta Electronics	Eindhoven	Electronic modules and industrial automation	20-50

It is a given that the electronics industry in Eindhoven and the Netherlands is largely due to the presence of Royal Philips. Even though it has deliberately evolved into a B-to-B high tech healthcare company, while it used to be an all-encompassing (consumer) electronics giant, Royal Philips' electronics' expertise and skills are still second-to-none. As already stated, the core focus of its global R&D is still in Eindhoven, where 40% of all research takes place and 8,000 employees on the High Tech Campus and in Best alone. Its total work-force in the Netherlands is close to 11,000.

15 HIGH TECH MATERIALS COMPANIES

Company	City	Activity	Size (employees)
Xycarb Ceramics	Helmond	Graphite, quartz, and ceramic products	200-500
Nyrstar Budel	Budel-Dorplein	Production of zinc and lead	200-500
Modine Uden	Uden	Heat transfer products	200-500
POLYTEC Composites	Roosendaal	Developer and manufacturer of top quality plastics solutions	200-500
Vacumetal	Oosterhout	UV metallizing and UV lacquering	100-200
Sibelco	Geertruidenberg	Industrial minerals	50-100
Caligen Europe	Breda	Foam products	50-100
Mitsubishi Chemical Corporation (former Dutch Filaments)	Helmond	Manufacture of polymer 3D filaments	50-100
Nanogate Eurogard Systems	Geldrop	Largescale production of components and surface treatments	50-100
Goudsmit Magnetics	Waalre	Magnetic solutions	50-100
Bakker Magnetics	Son en Breugel	Magnetic materials and tools	50-100
Dhatec	Bergeijk	Pipe treatment	20-50
Mintres	Cuijk	Ceramic components	20-50
Spiro Production	Helmond	Fluids for HVAC systems	20-50
Wellco Seating	Best	Medical seat solutions	20-50
Elekta	Best	Precision radiation medicine	20-50

XELTIS IN EINDHOVEN HEALS EIGHTEEN HEART PATIENTS WITH A SOLUBLE HEART VALVE

Source: March 12th 2020, Eindhovens Dagblad by Harrie Verrijt (extract)

EINDHOVEN - What could be better than curing sick children? With its regenerative heart valve, Xeltis in Eindhoven already gives eighteen children a normal life.

[...] It is a solution that did not seem possible, but is possible now thanks to an invention that came to life in Eindhoven. Martijn Cox obtained his doctorate in 2007 on a body-soluble synthetic material that he co-developed for this specific purpose at Eindhoven University of Technology (TU/e). Later on, he started the company QTIS/e that merged with Xeltis and now creates these bio-synthetic heart valves.

70 million euro has already been invested in the company

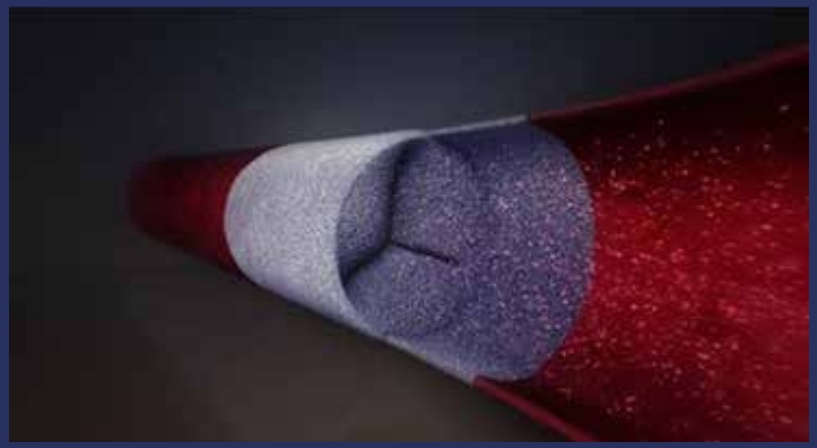
Now that these heart valves are working well with eighteen children, there is a happy atmosphere among the approximately thirty people of Xeltis in the Catalyst building on the TU / e grounds. “In the past ten years, about 70 million euros has been invested in our company,” says general manager Eliane Schutte. “That these children can now lead a normal life with our heart valve is a wonderful result. After 2023, tens of thousands will follow after approval in Europe and America. ” [...]

SMALL FACTORY OF HEART VALVES

The Xeltis laboratory is a small factory of heart valves. With the so-called electrospinning process, a perfect thread is spun with a voltage of 1,000 volts with the synthetic material developed at TU/e. That very thin thread is wound in a zigzag pattern on a bobbin in the exact shape of the desired heart valve. Under the microscope, it looks like spaghetti with 60 percent free space between the wires. In the body, this porous material absorbs blood and the patient’s own body tissue grows between the threads. The plastic slowly dissolves and in the period of time that happens, the patient has grown his own heart valve that grows into adulthood with the child.

It almost seems like a miracle and Schutte wants this miracle to be made available to the tens of thousands of children who are born with a faulty heart valve every year. “We are starting a new clinical study with 50 patients in Europe and the US. We want to get the approval from the authorities. ”

In addition, Schutte also sees opportunities for other products. She shows a flexible tube of the same material. “A bypass, an operation for heart patients that is done a million times a year, usually still has a vein taken out of the leg. With this tube there is no need to cut elsewhere in the body and the solution is more durable. ”



An artist’s impression of the plastic heart valve developed in the Xeltis laboratory.

THE NANO-SPAGHETTI CAN ALSO BE USED FOR OTHER ORGANS

The medical sponges from which the heart valves of Xeltis are made are a pure Eindhoven product that can also be used for many other purposes. The plastic was developed at TU / e and the company IME Medical Electrospinning in Waalre also originated from the university. IME supplies machines to Xeltis, but also to dozens of laboratories and medical companies around the world.

IME machines make a wire that is a factor of 5 to 500 thinner than a human hair, with which “nano-spaghetti” is formed. It is a porous material in which blood circulates and in which new body cells feel so at home that they multiply into new human tissue. It is the body’s own tissue, so no rejection symptoms occur.

Magnification of the material resembles spaghetti

According to experts, the material can replace tissue in many places in the body. In addition to the heart, it can also serve the eyes, skin, veins, windpipe and esophagus. For some tissues, the plastic can dissolve completely in the blood after some time, in others a certain amount of support is required.

15 HIGH TECH MATERIALS COMPANIES

Company	City	Activity	Size (employees)
ASML	Veldhoven	Wafer (semiconductor) fabrication of lithography equipment & services	> 1,000
Philips Healthcare	Best	Health technology: diagnostic imaging, image-guided therapy, patient monitoring, health informatics, consumer health, and homecare.	> 1,000
Philips Innovation Services	Eindhoven	R&D & engineering services, research & testing facilities	> 1,000
Prodrive Technologies	Son en Breugel	System supplier	> 1,000
VDL Group	Eindhoven	Mechatronic modules	> 1,000
Thermo Fisher Scientific (FEI Electron Optics)	Eindhoven	Electron microscopes	500-800
Xycarb Ceramics	Helmond	Graphite, quartz, and ceramic products	200-500
Altran (TASS)	Eindhoven	IT and R&D consultancy	200-500
Dialog Semiconductor	Den Bosch	Semiconductors	100-200
Teledyne Dalsa	Eindhoven	Imaging and microelectromechanical systems	100-200
TNO	Helmond	Testing and research facilities and services	100-200
IMEC	Eindhoven	R&D hub for nano and digital technologies	100-200
Malvern Panalytical	Eindhoven	Machines for the chemical, physical, and structural analysis of materials	50-100
Nanogate Eurogard Systems	Geldrop	Largescale production of components and surface treatment	50-100
Raith	Best	Nanolithography	20-50

15 HIGH TECH MATERIALS COMPANIES

Company	City	Activity	Size (employees)
ASML	Veldhoven	Wafer (semiconductor) fabrication of lithography equipment & services	> 1,000
Prodrive Technologies	Son en Breugel	System supplier	> 1,000
Signify	Eindhoven	Lighting solutions	> 1,000
Thermo Fisher Scientific (FEI Electron Optics)	Eindhoven	Electron microscopes	500-800
Frencken Mechatronics	Eindhoven	Semifinished machine modules	100-200
Teledyne Dalsa	Eindhoven	Imaging and microelectromechanical systems	100-200
IMEC	Eindhoven	R&D hub for nano and digital technologies	100-200
Anteryon	Eindhoven	Optical solutions, components, and sub-assemblies	100-200
TMC	Eindhoven	High tech consultancy	100-200
TNO	Eindhoven	Testing and research facilities and services	100-200
Adimec	Eindhoven	Industrial cameras	50-100
Heidenhain Numeric	Eindhoven	Measurement and control technology	20-50
The MathWorks	Eindhoven	Artificial intelligence systems and models	20-50
IBS Precision Engineering	Eindhoven	Ultra-precision measurement	20-50
VTEC Lasers & Sensors	Eindhoven	Lasers and sensors	10-20

DUTCH GOVERNMENT INVESTING IN SMART PHOTONICS "TO PRESERVE THIS COMPANY AND THE ECOSYSTEM FOR THE NETHERLANDS"

Source: June 30, 2020, Innovation Origins, Bart Brouwers

SMART Photonics, an independent foundry for photonic integrated circuits, today announced a 35 million Series C investment from a Dutch consortium led by Innovation Industries. More than half of the sum is from the Dutch government, in a rare move to help the company and the industry. "To ensure that this company and the ecosystem for integrated photonics is preserved for the Netherlands, I have decided – in addition to contributions from various other parties – to make an amount of 20 million euros available as a loan to meet the financing needs of SMART Photonics," State Secretary Mona Keijzer (Economic Affairs and Climate Policy) wrote in a letter to parliament.

According to Keijzer, there was interest from investors in other countries and they were prepared to make substantial investments, but "the access of local ecosystem partners to the production facilities of Smart Photonics is essential for the success of the ecosystem". The importance of SMART Photonics for the ecosystem is mainly due to its role as partner and supplier for local startups in photonics, Keijzer said. "Production process and product design using this key technology are so closely intertwined that physical proximity and face-to-face consultation between engineers is required." That is why the State Secretary is also convinced that SMART Photonics must continue to fulfill its role in the Dutch ecosystem if it is to avoid the risk of the production and research facilities relocating.

SMART Photonics, founded in 2012, will use the funds to expand its capacity for wafer manufacturing at the High Tech Campus in Eindhoven, to accelerate the development of its photonic integration technology, and to help establish the technology in the marketplace through its customers.

Lead investor Innovation Industries is one of Europe's most active independent photonics investors and has invested in many companies across the photonics value chain. The contribution from the Ministry is through the Brabant Development Agency (BOM), while other participants are KPN Ventures, PhotonDelta, and existing shareholders, reaffirming the position of SMART Photonics as a central player in the European photonics ecosystem.

©SMART Photonics

AMBITION

SMART Photonics aspires to be the leading independent foundry for photonic integrated circuits, which provide small-scale integration and high performance combined with low energy consumption. "Photonic integrated circuits will play a key role in our lives by enabling new and radically improved applications that make our world better, greener, and safer," said CEO Johan Feenstra. SMART Photonics' integration technology allows its customers to design chips for a variety of next-generation communication systems and highly accurate sensor applications in telecoms, healthcare, smart mobility, and sustainable industrial processes.

Since being founded in 2012, SMART Photonics has attracted a global customer base. "We are very excited to have the new consortium aboard and to be able to bring our foundry to the next level thanks to this investment. It will allow us to scale up our volumes as we support our customers in bringing their first commercial products using photonic integration technology to the market," said Feenstra.

EUROPE'S LEADING POSITION

"SMART Photonics is perfectly positioned as Europe's leading independent foundry for integrated photonics through its flexible production process of photonic integrated circuits, proprietary process design kit, and tremendous know-how," said Nard Sintenie, General Partner at Innovation Industries. "For Europe to maintain a leading position in the development of new technologies for the rapid-growing photonics industry, we believe it is essential to invest in infrastructure. We are confident that SMART will contribute to a strong and healthy photonics ecosystem that will drive cutting-edge technology development, guaranteeing the continued formation of exciting startups and scaleups in this appealing industry."

Miriam Dragstra, CCO of the Brabant Development Agency (BOM), which played an important role in the deal sourcing, emphasized the strategic importance of the deal. "Recognized as one of Europe's key enabling technologies, Photonics has the potential to drive economic growth and provide solutions to some of the most pressing societal and environmental challenges of our time. SMART Photonics allows Dutch technology companies to play a leading role in the development of this promising technology. It is on those grounds that BOM is committed to supporting the financial and strategic development of this game-changer."

THE 15 BIGGEST COMPANIES ACTIVE IN SMART INDUSTRY/SMART SYSTEMS

Company	City	Activity	Size (employees)
Philips Innovation Services	Eindhoven	R&D & engineering services, research & testing facilities	> 1,000
Prodrive Technologies	Son en Breugel	System supplier	> 1,000
Sioux Embedded Systems	Eindhoven	Smart system provider and integrator	100-200
Altran Engineering	Helmond	IT and R&D consultancy	200-500
Dassault Systèmes	Den Bosch	Smart system provider and integrator	200-500
TMC	Eindhoven	High tech consultancy	200-500
Siemens Industry Software	s-Hertogenbosch/Breda	Industrial software	100-200
VDL ETG Research	Eindhoven	Mechatronic modules	100-200
Teledyne Dalsa	Eindhoven	Imaging and microelectromechanical systems	100-200
Actemium	Veghel	Industrial automation and solutions	100-200
Ingram Micro CFS Technology	Waalwijk	E-fulfillment and warehouse management	20-50
ABB	Eindhoven	Industrial automation	20-50
Esprit Management & IT Services	Sint-Oedenrode	Industrial automation	20-50
Tegema	Son en Breugel	Smart system provider and integrator	20-50
Tummers Food Processing Solutions	Hoogerheide	Processing equipment for potatoes and tubers	20-50

INVESTING IN NEXT-GENERATION MEDICAL IMAGING - SIOUX TECHNOLOGIES BACKS SAMANTREE MEDICAL IN REVOLUTIONIZING TUMOR SURGERY

The introduction of digital technologies such as 3D printing, robotics, and nanotechnology heralds a new future for medical care. One of the companies shaping this revolution is the Swiss firm SamanTree Medical. It developed the Histolog® Scanner, which allows surgeons to identify cancer tissue in real time, and the company is now preparing its commercial rollout. "In all of this, we have found an indispensable partner in Sioux," said the company's CTO, Etienne Shaffer.

Tumor surgery normally stretches past a single procedure. Removing malignant tissue and simultaneously retaining as much healthy tissue as possible – such as when treating breast cancer – is not an easy task, while success levels are not known until afterwards in a pathology lab, where the periphery of the removed tissue is analyzed and assessed.

SUBCELLULAR LEVEL

"This regularly reveals that an additional operation is required," said Shaffer. "These operations are stressful to the patient and very expensive. Our Histolog Scanner offers a solution. We bring ultrafast digital confocal microscopy to the operating theatre. After dipping fresh tissue in a contrast medium, it can be placed in the Histolog Scanner; there is no need to cut it or fix it to glass. Within a minute it is ready for imaging and, within another minute, you get a detailed picture of the morphology at a subcellular resolution. This allows the surgeon to determine margins much more accurately during surgery, to work more precisely, and avoid follow-up surgery. But our technology can also be applied more broadly to, for example, biopsies or as part of the pathology workflow."
Data management

The Histolog Scanner marks a breakthrough in medical imaging. It can scan and process tissue samples with a diameter of up to 8 cm in near real time. While this large field of view – typical tissue sections measure 1.5 cm – offers considerable advantages, it also requires a great deal in terms of data management. According to Shaffer, the second major challenge is the development of user applications. "The accuracy with which specialists interpret images

depends on many factors, like their levels of training and experience. We want to help clients eliminate this subjectivity and speed up the analysis process. The first step here is to automate the initial rough analysis, and we recently released an application for our Histolog Scanner that independently identifies areas of interest for further inspection. We created this application together with Sioux's software and Mathware specialists."

SIOUX TECHNOLOGIES

DEEP LEARNING

"This tool is cutting-edge technology at the interface between data analysis and artificial intelligence," says Robbert van Herpen, head of the Mathware division at Sioux Technologies. "The system needs to quickly, accurately, and reliably recognize various patterns in a variety of tissue types. That forms the basis for the data model. During its development, we applied the latest insights in the field of deep learning. By feeding it the right data, optimizing the hyperparameters, and deploying it in the SamanTree system, we made the leap towards a high tech solution. Right now, the tool is very good at pinpointing areas of interest and is ready for use in operating theatres. The holy grail would be an autonomous system that is 100% correct and excludes human error. We are not there yet, but the current scanner and applications are already facilitating a revolution in tumor surgery."

EARLY ADOPTERS

SamanTree Medical operates eight Histolog Scanners for demonstrations in various European medical centers, ahead of the commercial roll-out. Sioux also plays a key role in this aspect. "When looking for a development and manufacturing company, we came across Sioux three years ago," said Shaffer. "Now, in 2020, we are connected in many different ways. The Sioux Tech Fund joined up as an investor. Apart from being an extension for our R&D, Sioux is also our exclusive partner in industrialization and manufacturing. Production has been fully transferred, which allows us to focus on our customers. The market launch will be a step-by-step process due to the revolutionary nature of our technology. But the masses will follow the early adopters, of that I am certain. Sioux's engineering and manufacturing skills will also help us at that stage in terms of further development, upscaling production and cost-down operations."

Source: www.sioux.eu

THE 20 BIGGEST COMPANIES ACTIVE IN SMART INDUSTRY/MACHINE ENGINEERING

Company	City	Activity	Size (employees)
ASML	Veldhoven	Semiconductor machines	> 1,000
Philips Healthcare	Best	Medical systems	> 1,000
Vanderlande Industries	Veghel	Value-added logistics process automation and handling systems	> 1,000
VDL Group	Eindhoven	Mechatronic modules	> 1,000
Marel Poultry	Boxmeer	Poultry, meat, and fish processing systems	800-1,000
Thermo Fisher Scientific (FEI Electron Optics)	Eindhoven	Electron microscopes	500-800
KUHN-Geldrop	Geldrop	Farm machinery, particularly crop packaging	200-500
Wärtsila Netherlands	Drunen	Maritime solutions, including propulsion technology & services and training academy	200-500
GEA Food Solutions	Bakel	Air treatment and ventilation systems	200-500
Vencomatic Group	Eersel	Poultry husbandry systems	200-500
AME Applied Micro Electronics	Eindhoven	High-quality electronic products	200-500
AAE Advanced Automated Equipment	Helmond	Mechatronic modules	200-500
Omron Manufacturing of the Netherlands	Den Bosch	Electronic components and devices	100-200
Benier Nederland	Nieuwkuijk	Bakery machinery	100-200
Fuji Seal Europe	Deurne	Sealing machines	100-200
Frencken Mechatronics	Eindhoven	High-mix, low-volume, high-complexity and high-flexibility production of assemblies and systems for the medical, analytical, and semiconductor markets	100-200
A.O. Smith Water Products Company	Veldhoven	Heating and warm water systems	100-200
Thales Cryogenics	Eindhoven	Cryocoolers, incl. rotary monoblock coolers, linear pulse tube coolers and linear flexure bearing split Stirling coolers for cooling small sensors and circuits	50-100
Bradford Engineering	Heerle	Aerospace systems	20-50
TOMRA Sorting	Eindhoven	Sensor-based sorting and peeling equipment	20-50

THE 15 BIGGEST SYSTEMS ENGINEERING COMPANIES

Company	City	Activity	Size (employees)
Philips Innovation services	Eindhoven	R&D and engineering services, research & testing facilities	> 1,000
Prodrive Technologies	Son en Breugel	System supplier	> 1,000
VDL ETG (Enabling Technologies Group)	Eindhoven	Mechatronic modules	> 1,000
Atos Nederland	Eindhoven	Digital services	800-1,000
Dassault Systèmes	Den Bosch	Smart system provider and integrator	200-500
Fluor Consultants	Bergen op Zoom	Engineering and technical services	200-500
Altran	Eindhoven	IT and R&D consultancy	200-500
TMC	Eindhoven	High tech consultancy	200-500
Sioux Embedded Systems	Eindhoven	Smart system provider and integrator	100-200
Brabant Engineering	Best	Engineering consulting	50-100
Mecal Semiconductor Product Development	Eindhoven	Engineering consultancy	50-100
The MathWorks	Eindhoven	Artificial intelligence systems and models	20-50
Sogeti	Den Bosch/ Eindhoven	Digital services	20-50
HSPro	Uden	Engineering, maintenance, and automation	20-50
Alten DDA	Eindhoven	Consultancy and engineering	20-50
Contecto	Beugen	Mechatronics engineering	20-50

15 ARTIFICIAL INTELLIGENCE COMPANIES

Company	City	Activity	Size (employees)
Philips Innovation services	Eindhoven	R&D and engineering services, research & testing facilities	> 1,000
Prodrive Technologies	Son en Breugel	System supplier	> 1,000
VDL ETG (Enabling Technologies Group)	Eindhoven	Mechatronic modules	> 1,000
Atos Nederland	Eindhoven	Digital services	800-1,000
Dassault Systèmes	Den Bosch	Smart system provider and integrator	200-500
Fluor Consultants	Bergen op Zoom	Engineering and technical services	200-500
Altran	Eindhoven	IT and R&D consultancy	200-500
TMC	Eindhoven	High tech consultancy	200-500
Sioux Embedded Systems	Eindhoven	Smart system provider and integrator	100-200
Brabant Engineering	Best	Engineering consulting	50-100
Mecal Semiconductor Product Development	Eindhoven	Engineering consultancy	50-100
The MathWorks	Eindhoven	Artificial intelligence systems and models	20-50
Sogeti	Den Bosch/ Eindhoven	Digital services	20-50
HSPro	Uden	Engineering, maintenance, and automation	20-50
Alten DDA	Eindhoven	Consultancy and engineering	20-50
Contecto	Beugen	Mechatronics engineering	20-50

ASML, NXP, and Signify are all very involved in the field of artificial intelligence, working with hundreds of specialists. These companies have not been listed above in order to highlight some of the slightly less well-known high tech players in the region.

ASML, Philips and NXP are all (founding) partners of both EAISI, the Eindhoven Artificial Intelligence Systems Institute of the TU/e, Eindhoven University of Technology, and of the AI Innovation Center on the High Tech Campus. Signify is the other founding partner of the latter. Further information on EAISI can be found in Chapter 4, section C.

15 COMPANIES ACTIVE IN ENERGY TECHNOLOGIES

Company	City	Activity	Size (employees)
Wärtsila Netherlands	Drunen	Maritime solutions, including propulsion & wind energy technology and services & training academy	200-500
Flowserve	Roosendaal	Pumps	200-500
IMEC	Eindhoven	R&D hub for nano and digital technologies	100-200
TNO	Helmond	Testing and research facilities and services	100-200
Chromalloy Holland	Tilburg	Turbine maintenance	100-200
GEA Food Solutions	Den Bosch	Air treatment and ventilation systems	100-200
Bilfinger Tebodin Netherlands	Eindhoven	Engineering consulting	50-100
Thermobile Industries	Breda	Mobile climate solutions	50-100
VDL (V-Storage)	Valkenswaard	Energy storage systems	20-50
Stork Thermeq	Moerdijk	Consultancy, engineering, and maintenance energy systems	20-50
R & R systems	Gemert	Sustainable energy systems	20-50
Fluidics instruments	Eindhoven	Atomizers, nozzles, burner lances, and related products for oil burners	20-50
Kinetron	Tilburg	Motion based energy harvesting systems	10-20
Actiflow	Breda	Consultancy for fluid dynamics/aerodynamics	10-20
Micro Turbine Technology	Eindhoven	Micro gas turbines	10-20

Lightyear One is a great example of a company that applies energy technology in the automotive industry. This start-up originated from the Eindhoven University of Technology (TU/e). CEO Lex Hoefsloot says that the Lightyear One is more than just a car with solar panels mounted on the roof: "The car is an independent entity, because the energy source is incorporated in the car itself. For this concept to be technically possible, the car must be extremely efficient, and so the chassis and drive system must be adapted and the car must be made even more aerodynamic. That is why we focused in recent years on developing a fully integrated electric platform powered by solar energy. This platform means we can guarantee that the Lightyear One is three times as efficient in terms of energy consumption as the electric vehicles currently on the market."

4. UNIVERSITIES AND KNOWLEDGE INSTITUTES

A. General

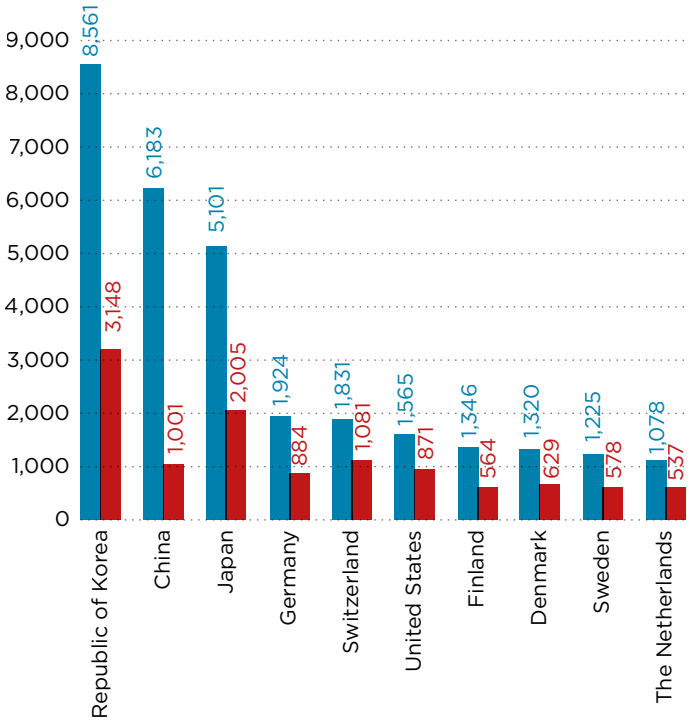
UNIVERSITIES AND PATENT APPLICATIONS

The Netherlands has a large number of high-quality universities and knowledge institutions, which is also why the country took fourth place in the Global Innovation Index 2019 of the World Intellectual Property Organization (WIPO) and is ranked tenth among countries with highest number of patent applications in proportion to GDP and population.

GLOBAL INNOVATION INDEX 2019

Ranking	Country	Global Competitiveness Index
1.	Switzerland	67.24
2.	Sweden	63.65
3.	United States	61.73
4.	**Netherlands**	**61.44**
5.	United Kingdom	61.30
6.	Finland	59.83
7.	Denmark	58.44
8.	Singapore	58.37
9.	Germany	58.19
10.	Israel	57.43

NETHERLANDS IN THE GLOBAL TOP 10 FOR PATENT APPLICATIONS



Resident patent applications per billion $ GDP & million population for the top 10 originators, 2018

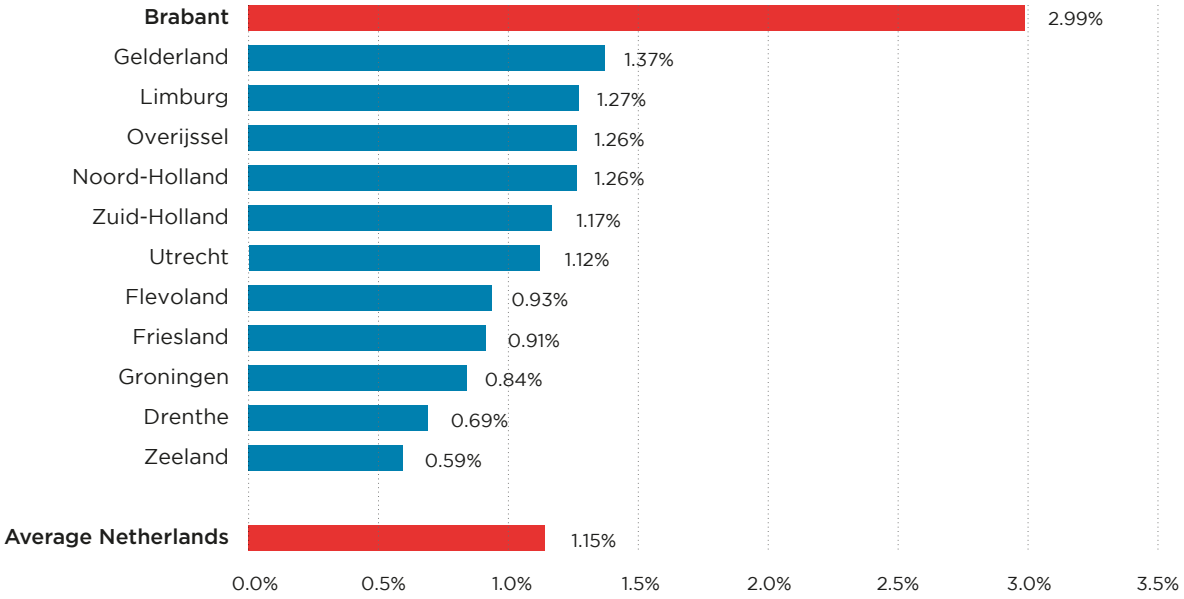
- Residents patents per USD 100 billion GDP
- Residents patents applications by million population

Source: World Intellectual Property Organization (2019), World Intellectual Property Indicators 2019

HIGH R&D LEVELS IN BRABANT

Brabant has the most R&D activity of all provinces in the Netherlands. Total private sector R&D expenditure in proportion to regional gross domestic product is 2.99%, more than double the national average (1.15%).

PRIVATE R&D EXPENDITURE (PERCENTAGE OF GDP) IN 2017



Source: The Dutch Central Bureau for Statistics (CBS) (2019), adapted by Fanion Onderzoek & Advies

HIGH-SCORING R&D REGION IN EUROPE

Brabant is well-known for its activities and strong showing in industrial R&D. On the European stage, Brabant ranks fifth in the list of regions with the highest number of patent applications.

LEADING EUROPEAN REGIONS IN PATENT APPLICATIONS AT THE EUROPEAN PATENT OFFICE 2018

	Region	Country	2018	Growth
1	Bayern	Germany	8.238	8.8 %
2	Île-de-France	France	6.713	-4.4%
3	Nordrhein-Westfalen	Germany	5.125	3.9%
4	Baden Württemberg	Germany	5.082	2.2%
5	**North Brabant**	**The Netherlands**	**3.582**	**-0.8%**
6	Stockholm	Sweden	2.280	7.7%
7	Hessen	Germany	2.205	-0.5%
8	Greater London	Great Britain	1.943	11.9%
9	Niedersachsen	Germany	1.712	16.6%
10	Rhienland-Pfalz	Germany	1.598	0.9%
11	Vlaanderen	Belgium	1.482	7.2%
12	Hovedstaden	Denmark	1.465	9.8%
13	Lombardia	Italy	1.406	-1.5%
14	Auvergne-Rhône-Alpes	France	1.319	3.0%
15	Vaud	Switzerland	1.192	1.2%
16	Helsinki-Uusimaa	Finland	1.188	-11.4%
17	South Holland	The Netherlands	1.066	3.2%
18	Austria West	Austria	1.023	4.4%
19	Zürich	Switzerland	1.014	7.3%
20	Basel-Stadt	Switzerland	980	3.7%

Source: European Patent Office in Link Magazine (March 2019)

B. HTSM Universities in Brabant

1. EINDHOVEN UNIVERSITY OF TECHNOLOGY (TU/E)

The facts and figures of the TU/e are:

- 13,690 students (2020/2021)
- 5,000 knowledge workers
- 90 nationalities
- 14 unique laboratories

SPIRIT OF COLLABORATION

Eindhoven University of Technology is a young university, founded in 1956 by industry, local government and academia. Today, that spirit of collaboration is still at the heart of the university community. The university fosters an open culture where everyone feels free to exchange ideas and take initiatives.

Eindhoven University of Technology provides academic education that is driven by both fundamental and applied research. Its educational philosophy is based on personal attention and room for individual ambitions and talents. TU/e's research meets the highest international standards of quality and the work produced pushes the boundaries of science. This puts TU/e at the forefront of various rapidly emerging areas of research.

Eindhoven University of Technology combines scientific curiosity with a hands-on approach. Fundamental knowledge enables the institution to design solutions for the highly complex problems of today and tomorrow. Its motto is: 'We understand things by making them and we make things by understanding them'.

The TU/e Campus is in the centre of one of the most powerful technology hubs in the world, Brainport Eindhoven. Globally, the university stands out when it comes to collaborating with advanced industries, as it has done with Royal Philips since its inception. Together with other institutions, TU/e forms a thriving ecosystem with one common aim – to improve quality of life through sustainable innovations.

TU/E HAS 10 RESEARCH DEPARTMENTS

I. Biomedical Engineering
II. Built Environment
III. Electrical Engineering
IV. Industrial Design
V. Industrial Engineering and Innovation Sciences
VI. Chemical Engineering and Chemistry
VII. Applied Physics
VIII. Mechanical Engineering
IX. Mathematics and Computer Science
X. Eindhoven School of Education

TU/E HAS 10 STRATEGIC RESEARCH AREAS

1. Artificial Intelligence
2. Smart Mobility
3. Energy
4. Engineering Health
5. Integrated Photonics
6. High Tech Systems
7. Complex Molecular Systems
8. Data Science
9. Humans and Technology
10. Smart Cities

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Established in the 1950s, the TU/e has always had strong values: optimism, collaboration, and a dedication to society. These values helped Brainport Region Eindhoven flourish and resulted in the university being ranked in first place by the Times Higher Education Ranking for collaboration with industry. Fifteen percent of the TU/e's scientific publications are created in partnership with industry, and the university has the highest number of part-time professors who work in industry in the country.

Societal challenges on health, energy and smart mobility are the driving force for the TU/e. Its research institutes, the Eindhoven Artificial Intelligence Systems Institute (EAISI), the Eindhoven Institute for Renewable Energy Systems (EIRES), the Institute for Complex Molecular Systems (ICMS), and the Institute for Photonic Integration (IPI), Eindhoven Engine, The Gate combine the strengths of the university with industry needs and government strategy. TU/e researchers play an important role in new products and companies in the Brainport Eindhoven area, in Brabant, and around the world.

The most important HTSM research groups in the TU/e are the following:

THE MOST IMPORTANT HTSM RESEARCH GROUPS IN THE TU/E ARE THE FOLLOWING: DEPARTMENT OF APPLIED PHYSICS

Research Group	Research topics
Advanced nanomaterials and devices	Research on new nanomaterial systems and investigating their properties (crystal structures, surfaces, size)
Coherence and quantum technology	The central theme is dilute matter at high phase space density. The goal is to exploit quantum coherence. The tools used include high power lasers and compact particle accelerators.
Elementary processes in gas discharges	Research on the elementary processes in gas discharges through a mix of theory, modeling, and the development of diagnostics.
Physics of nanostructures	Exploration of novel ways of controlling the electron spin and magnetic textures at the nanoscale for a wide range of applications.
Physics of semiconductor nanostructures	Research on the physics of individual nanostructures by investigating a wide range of available nano objects, ranging from the confinement in two dimensions to the extreme limit of zero-dimensional quantum dots.
Plasma & materials processing	The scientific objective of this group is to obtain an atomic-level understanding of the interaction of plasmas and reactive gases with materials in the field of atomic scale processing.
Theory of polymers and soft matter	Enabling a sustainable, functional, and resource-efficient next generation of materials by uncovering the physical mechanisms underlying the behavior of soft and biological matter.
Transport in permeable media	Research on understanding the physics of transport and phase changes in complex permeable media in order to develop
Turbulence and vortex dynamics	better materials for a sustainable society, i.e., materials for energy storage and technological porous materials. Research on the fundamental questions in fluid dynamics in an integrated approach.

DEPARTMENT OF MECHANICAL ENGINEERING

Research Group	Research topics
Control systems technology	The CST group develops new methods and tools in the area of systems theory, control engineering and mechatronics. The research focuses on understanding the fundamental system properties that determine the performance of mechanical engineering systems, and exploiting this knowledge for the design of the high tech systems of the future.
Dynamics and control	High-level research in the area of dynamics and control, with the emphasis on modeling, analysis, and control of mechanical and mechatronic systems.
Energy technology	This groups mission is to advance heat & flow technologies for energy and high tech applications. This mission encompasses the scientific development of new methods and tools (science); optimizing advanced systems (technology); transferring knowledge to application partners (commercialization); and educating and challenging future generations of engineers (education).
Polymer technology	The polymer technology group provides education on and conducts research in the broad area of polymer technology, i.e., the industrial arts of manufacturing of polymer-based products.
Power & flow	Power & Flow focuses on clean and efficient combustion and process technology, to cater for fast-growing energy demands.

DEPARTMENT OF ELECTRICAL ENGINEERING

Research Group	Research topics
Center for wireless technology Eindhoven (CWTE)	CWTE explores boundaries and explores new applications of wireless technology by creating a coherent, integrated approach to wireless systems, from the propagation of radio waves up to and including optical and wireless access networks. Our goal is to push boundaries and explore.
Control systems	Research on dynamic modelling and model-based control of complex dynamic systems.
Electromagnetics	Enabling 'electromagnetic engineering' by developing new modeling strategies for analysis and synthesis of a range of applications, e.g. antenna systems, medical electromagnetic stimulation, and metrology used in semiconductor manufacturing equipment. In order to do so, this group develops new facilities for experimental research in the area of antennas and wireless communications systems.
Electronic systems	This group creates constructive design trajectories for electronic systems that lead to high-quality, cost-effective systems with predictable properties (functionality, timing, reliability, power dissipation, cost).
Photonic integration	The goal is to provide major contributions to photonic integration and the associated applications, with a particular focus on indium phosphide technology.
Advanced network management and control	Research on the impact of emerging applications on the network and the effects that network impairments have on services. Our main focus is on cognitive Internet of Things communications.

DEPARTMENT OF MATHEMATICS AND COMPUTER SCIENCE

Research Group	Research topics
Applied analysis	The applied analysis group focuses on these mathematical disciplines and their application to the real world. This brings together many mathematical topics, such as differential equations, dynamical systems, variational calculus, functional analysis, geometry, and approximation theory.
Artificial intelligence	Artificial intelligence (AI) refers to apparently intelligent behavior in machines, distinct from human and animal intelligence. AI represents the general concept of intelligence, resting on technical pillars.
Scientific computing	Scientific computing is a fast-growing, highly interdisciplinary field that brings together methods from numerical analysis, high-performance computing, and various application fields. It is the area of research that provides better simulation tools aimed at many different applications.

OTHER DEPARTMENTS AND INTER-DEPARTMENTAL WORK

Research Group	Research topics
Department of biomedical engineering and department of applied physics	
Molecular biosensing for medical diagnostics	The MBx group develops technologies based on micro and nanoparticles for monitoring patients and treating diseases. With this goal in mind, the unique approach of MBx is to use advanced optical imaging techniques that quantify molecular processes with single molecule resolution within complex bio-macromolecular environments.
Department of Built Environment	
Building lighting	Major technology advances are enabling smart lighting solutions and LED technology is linking lighting technology to the digital world. This creates a wide range of new challenges.
Department of Industrial Design	
Future everyday	Future Everyday aims at bridging the gap between emerging technologies and everyday life: how to deal with
	uncertainties that come naturally with new and still evolving technologies, and how to translate them into meaningful
	products, systems, and services that seamlessly blend into everyday life.
Departments of Applied Physics and Chemical Engineering and Chemistry	
Molecular materials and nanosystems	The interdepartmental research group M2N investigates and develops functional molecular materials and nanosystems
	with tailored physical properties. Examples of applications are organic and polymer solar cells, light-emitting diodes,
	electrochemical and photovoltaic cells, and solar fuels.
Departments of Applied Physics and Mathematics and Computer Science	
Center for Quantum Materials and Technology Eindhoven	This group is part of a worldwide race to control the quantum states of elementary particles, and to integrate them in technology platforms. This so-called second quantum revolution will enable exponential advances in many fields of research and technology.

2. JHERONIMUS ACADEMY OF DATA SCIENCE (JADS)

The Jheronimus Academy of Data Science (JADS) is a unique concept in the Netherlands, which allows graduates to study, research and apply data science at three different Data Science Centres (TU Eindhoven, Tilburg University and Mariënburg Campus, Den Bosch) as part of the PDEng programme and to incorporate what they learn into existing ecosystems. The mission of JADS is to understand and further the value of data for solving complex societal and business challenges, with the academy serving as a linchpin between industry and the applied data science research conducted throughout JADS. The AgriFood industry is a Priority Industry to JADS, given that linking AgriFood to high tech by means of data communication, big data processing and artificial intelligence (AI) is one of society's challenges when it comes to sustainably feeding the world's growing population.

The Data Science and Entrepreneurship Graduate School turns out entrepreneurial and innovative data scientists who are just as good at performing cutting-edge scientific research as they are at applying it to the most pressing societal and business challenges. These graduates learn to operate in a collaborative ecosystem, fostering a stream of new scalable (or exponential) business models in Brabant and beyond.

The current JADS student body numbers 1,500-2,000 scattered across a range of programmes and three research centres.

JADS Jheronimus Academy of Data Science

APPLIED RESEARCH LABS

In the applied labs research focuses on how data science can be used in specific industries, creating specialist knowledge that can be applied directly, is in-depth and relevant.

- **DATA & AGRIFOOD**
  Fourth paradigm research and innovative crossovers between AgriFood, data and engineering in all its forms will be essential for feeding the world by 2050 while simultaneously reducing the environmental footprint of current food production systems. Solutions will only be created by working together.
- **DATA & HEALTH**
  Data & Health aims to bridge the gap between technical possibilities and practical ambitions. Exploring innovative methods for disease prevention, detection, treatment and follow-up. Advancing and accelerating learning capabilities within the full healthcare ecosystem.
- **DATA & CITIES**
  Data & Cities focuses on providing a novel perspective on the complexity of cities (and urban areas) by developing new data-based envisioning methods for *cities4people*.
- **DATA & SMART INDUSTRY**
  Data & Smart Industry uses data science to deal with the complex dynamics of production systems. Detailed real-time information allows the right product to be delivered to the right customer at the right time and at a minimal cost. Data science helps to improve the daily planning and monitoring of operations, is the basis for optimising production systems, and enables new concepts in the design of products and services.
- **DATA & SMART MOBILITY**
  Data & Smart Mobility aims to improve and perfect the way data is used from two perspectives – smarter connected vehicles and improved services surrounding mobility (such as *Maas*). The success and sustainability of these developments is greatly dependent on the quantity and quality of the underlying data.

FUNDAMENTAL LABS

The fundamental labs focus primarily on establishing and advancing the scientific side of data science:

- Computational Personalisation
- Dynamic Organisational Networks
- Jheronimus Academy Data Engineering (JADE) Lab
- Recommender Lab
- Digital Business Models & Ecosystems
- Ambitious Digital Entrepreneurship

JADS AND THE AGRIFOOD INDUSTRY: DATA-DRIVEN FOOD VALUE CHAIN MANAGEMENT

This JADS course connects the challenges faced in the AgriFood industry to the potentials offered by data science. Guest speakers from the TU/e and HAS University of Applied Sciences provide insight into the data-driven food chain: from precision agriculture to control engineering and marketing.

Students also receive lectures in the fields of AI (artificial intelligence), control systems, statistics and experimental design, sensing, data fusion and analytics and software engineering. They then use that knowledge to work on a current case, with the following options available: the business model of strip farming (multi-cropping), the smart pig value chain or the use of data in tomato farming.

The course provides students with a better understanding of the AgriFood industry and the available opportunities for creating value using technology and data science. They are required to review both existing and new business models and to seek out and exploit the opportunities on offer in an era of digitisation and sensing technology. From a teaching perspective it is a tough challenge to bring together these large and complex areas (Agriculture & Food and Data Science/AI), all of which are evolving globally at lightning pace. It is a major undertaking to get students to grasp the relationships and opportunities within such a short period of time. The course coordinators are Dr Rogier Brussee and Prof. Jakob de Vlieg.

THE JADS SME DATA LAB

The JADS SME Datalab helps companies create value through data by conducting short-term projects with professional and student data scientists. The students receive professional guidance from experienced professionals and scientists. Wherever a student hits a stumbling block, the JADS lab will always ensures that the project reaches completion.

The lab works together with its clients to define a data project with a concrete outcome. Preference is given to projects that deliver immediate savings or increased profits. Sometimes the client's aims extend beyond a single project, in which case we examine how a series of projects might produce the intended outcome.

A student spends about 60 to 80 hours on a project over six to ten weeks (depending on examination periods and other obligations). The JADS SME Data Lab charges a fixed price of 2,750 euros per project, part of which goes to the student involved in the form of remuneration.

3. FONTYS UNIVERSITY OF APPLIED SCIENCES

Fontys University of Applied Sciences has campuses in Eindhoven, Tilburg, Den Bosch, Helmond, and Veghel and focuses on five research topics:

- High-tech systems & materials
- Health
- Learning society
- Smart society
- Creative economy

Fontys is the largest university of applied sciences in the southern Netherlands. Its mission is to provide inspiring, challenging, and outstanding higher vocational education and to conduct practical research that is truly meaningful to society. Education and research at Fontys are directly in line with the current and future demands and needs of students, the professional arena, and (regional) society.

FONTYS FACTS AND FIGURES

- 477 bachelor's, master's, and other courses
- 44,320 students
- 34 programs in English
- 7,697 graduates per year
- 5,200 international students
- From 100 different countries
- 4,938 professional and educational staff

EMBEDDED IN KNOWLEDGE REGIONS

Fontys is embedded in the knowledge-intensive regions in the southern Netherlands, Brainport Region Eindhoven, Greenport Venlo/KennisAs Limburg, and Midpoint Brabant. The demand for highly qualified people in these regions is immense, and it is growing. A number of human capital agendas have been formulated to this end, which Fontys has helped to develop. Together with fellow institutions, companies, and industry, Fontys has developed living labs, professional workshops, centers of expertise, and other facilities. Students, lecturers, and researchers from a range of disciplines work together with industry professionals.

FONTYS HTSM RESEARCH GROUPS

Research Group	Research topics
Additive manufacturing	Research topics are design guidelines for additive manufacturing, including the finishing and removal of support material, monolithic structures in additive manufacturing, and hybrid manufacturing technology.
Agrimechatronics	Technological applications for biological agriculture, increasing pressure on and poverty in the soil, and socially responsible and safe food.
Business Service Innovation **Big Data**	This group's objective is to increase the innovative performance of (small) companies through services. Big data science aims to provide insight into and create value from both structured and unstructured data.
Industrial Engineering & Entrepreneurship	Focus areas of the research are entrepreneurship, in particular entrepreneurship in technology, open Innovation, including collaboration between companies and collaboration with knowledge institutes, and operational excellence, or the continuous improvement of business processes.
Distributed Sensor Systems	Important research objectives are: Sensing: signal conditioning, data fusion Processing: signal processing: audio, video, Computing architectures: FPGA, SoC, embedded systems, real-time Actuating: human machine interfaces, cyber-physical systems, Interconnectivity: WIRED and wireless: IoT/IIoT, communication protocols
Future Powertrain	The main research topics are electric vehicle technology and advanced thermal propulsion systems.
High tech Embedded Software	The professorship focusses on two application areas – mobile robots and sensor networks. These systems are examined from a system perspective and four system aspects are identified, being architecture, integration and testing, modeling and learning, and software quality.
Centre of Expertise High Tech Systems & Materials'	FCE links higher vocational eduction with the business community, via research and joint development projects, and sharing knowledge.
Interaction Design	The interaction design research group is engaged in research into various aspects of gaming.

Source: https://fontys.nl/Innovatie-en-onderzoek.htm

Continued on next page >

FONTYS HTSM RESEARCH GROUPS

Research Group	Research topics
Mechatronics & Robotics	Fields of research are: Flexible Manufacturing: the flexible production of multiple products by a machine or robot, with as little changeover time as possible. Manufacturing Logistics: the use of mobile robots on the work floor to transport products between different machines or robots. Human-Robot Interaction: how humans and robots can work together. Precision Engineering: controlling machines quickly and accurately for, for example, installing components in the electronics industry.
Humanities and Technology	The Humanities and Technology research group studies the influence of people and technology upon each other and conducts hands-on research at the interface of technology and psychology
Serious Game Design and Technology	The Serious Game Design research group is engaged in research into various aspects of gaming. The group researches and comes up with new possibilities for the use of games in healthcare, culture, entertainment, and education.
Applied Natural Sciences	The special interest groups (SIGs) of Applied Natural Sciences are Thin Films & Functional Materials, Diagnostics & Test Development, Solar fuels, Polymers, Sustainable process technology, and Detection & Measurement.
Virtual Reality	The Fontys Virtual Reality Lab has state-of-the-art techniques in computer graphics, visualization and virtual reality. Here, new products or processes can be visualized on behalf of companies.
Smart manufacturing	This group devotes itself to disruptive technologies and their application in the manufacturing industry. Examples include the internet of things, artificial intelligence, connectivity, robotics, 5G, 3D printing, and autonomous mobility.

Source: https://fontys.nl/Innovatie-en-onderzoek.htm

4 AVANS UNIVERSITY OF APPLIED SCIENCES

AVANS University of Applied Sciences provides education and hosts research in ten different fields and across 13 locations in Breda, Den Bosch, Tilburg, and Roosendaal. AVANS has six centers of expertise and more than 25 research groups. These groups of researchers conduct practical research.

The total number **35,083 students** were attending AVANS in December 2020.

The **professional staff** contingent numbers **3,300**.

The Expertise Center for Technical Innovation (ETI) focuses on the creating technical innovations for a sustainable world and its overarching theme is the Resilient City: a livable, resilient, and sustainable urban environment.

All AVANS technical courses are a part of the ETI, and lecturers, researchers, teachers, and students conduct practical research through various research chairs into creating the Resilient City. This research is commissioned by companies and institutions.

Various research chairs and departments play an active role in the expertise center, creating forward-looking concepts and practical solutions for a more sustainable world. The ETI also collaborates with universities of technology, other colleges, and partner companies. The knowledge gained is shared and immediately applied in practice and in educational programs, so that students immediately become familiar with the new technologies.

The Expertise Center for Technical Innovation at AVANS has five research groups that have strong links to the HTSM sector. Seen on the next page.

RESILIENT CITY

The research chairs and departments cover various aspects of the Resilient City. It is of great importance that cities are readied for a sustainable future, thanks to increasing urbanization, the energy transition, and material scarcity and waste. An integrated approach is required for this transition. Accessibility, quality of life, sustainability, air quality, sound health, and economic vitality are all inextricably linked.

In addition, increasing urbanization and the changing composition of households pose environmental, infrastructural, and safety challenges. The ETI is seeking in areas such as the circular economy, robotization, and the creation of smart cities, being cities with, for example, highly developed public transport systems and online platforms that make urban administration more efficient.

avans hogeschool

THE EXPERTISE CENTER FOR TECHNICAL INNOVATION AT AVANS

Research Group	Research topics
Data Science & IT	Research on new, challenging practical data science solutions that contribute to the Resilient City. This includes the efficient storage and transport of data, correct processing of the data and, finally, securing the data, whereby the usability of that data is not jeopardized.
Built Environment	The focus is on integral design and development, Design-driven innovation where design is seen as the core of engineering, innovation-driven professionalization, the interaction between knowledge and concepts, and design-research methodology
New Materials and their Applications	Material transition and sustainability are spearheads in the New Materials research group, as is their application.
Robotization and Sensors	The research primarily focuses on new applications using innovative technology and pushing the boundaries, concentrating on a broad integration of technology. Design methodologies such as system engineering and sensory and control engineering play a role in this field.
Smart Energy	The research primarily focuses on new applications using innovative technology and pushing the boundaries, concentrating on a broad integration of technology. Design methodologies such as system engineering and sensory and control engineering play a role in this field.

Source: https://www.avans.nl/onderzoek

5. BREDA UNIVERSITY OF APPLIED SCIENCES

Breda University of Applied Sciences is a medium-sized, government-funded higher education institution, with over 7,000 Dutch and international students from around a hundred countries. The BUAS offers bachelor's and master's degree courses at a professional and academic level in the fields of games, media, hospitality, facilities management, logistics, the urban environment, tourism, and leisure and events.

For the HTSM industry, the research on gaming conducted at the BUAS is of particular interest.

The BUAS Games research program focuses on digitally enhanced realities (DER), new forms of human interaction in environments designed using games blended with big data, geo-data, simulations, robotics, and artificial intelligence (AI). The next generation of games and digital media products and services are designed and created in the CRADLE lab.

- *Entertainment games focuses* on game cultures and designing and creating video games. Students study the content of video games, the processes and tools for creating them, and the surrounding culture. Within this broad field there is a focus on issues relating to diversity, storytelling, interface design/ feedback, and puzzle design (using 'escape rooms' as a thematic entry point). The research team works closely with the international AAA video game industry.

- *Serious games focuses* on how games can be used to improve the performance of organizations and systems. Many industries and societal sectors are interested in harvesting the potential benefits of game technologies and game concepts. In this department, game technology (including VR and AR) and game concepts are designed, developed, and used to profit from the deep impact that they can have on professionals, teams, organizations, or complex systems. Application areas for serious games are spatial planning, logistics, sustainability & ecological systems, tourism, entrepreneurship, management, leadership, and change.

Breda University OF APPLIED SCIENCES

C. Research Institutes in HTSM in Brabant (selection)

1. EINDHOVEN ENGINE

Eindhoven Engine accelerates innovation in the Brainport Region through challenge-based research in its public-private research facility at the TU/e Campus. Teams of the region's most talented researchers from industry, knowledge institutes and students work together in Eindhoven Engine research programs to deliver breakthrough technological solutions.

Eindhoven Engine unlocks the collective intelligence in the Brainport region. Thanks to a unique formula, innovators from companies can join forces with students and experienced researchers and staff of knowledge institutes in order to work together to accelerate innovation and create disruptive projects in which colocation is a prerequisite.

The Eindhoven Engine was founded by three knowledge institutes – the Fontys University of Applied Sciences, the TNO (Netherlands Organization for Applied Scientific Research), and TU/e, Eindhoven University of Technology, since 2020 the three shareholders of Eindhoven Engine BV. Other founding partners include the high tech companies Philips Healthcare, Signify, ASML, VDL, NTS, and NXP. These companies, extended with Brainport Industries and the shareholders form the Advisory board of Eindhoven Engine.

Eindhoven Engine is described in more detail in Chapter 8, section C under successful 'Public-Private Partnerships & Networks (P189)

2. EAISI - THE EINDHOVEN ARTIFICIAL INTELLIGENCE SYSTEMS INSTITUTE

The Eindhoven Artificial Intelligence Systems Institute (EAISI, pronounced 'easy') is a new institute of Eindhoven University of Technology devoted to the field of artificial intelligence (AI). Through EAISI, the university aims to contribute to the growing importance of AI in society, business, and science, and to meet the rapidly increasing demand for education, engineers, and expertise in the field of AI. The TU/e has been active in the field of artificial intelligence for decades, giving the new institute a very solid foundation.

The TU/e intends to invest 100 euros million in EAISI's education and research through to 2025, with the money primarily from the university. EAISI is aiming to attract a further 30 million euros each year from what are known as third-tier grants (the Dutch Research Council, EU, and other funders) and from the private sector. There are already about a hundred AI scientists working at TU/e, and the university wants to add a further 50 researchers, with a total of 150 people directly or indirectly involved in EAISI.

EAISI will focus on using data and algorithms in machines, such as robots, autonomous cars, and medical equipment. This field has always been an area of focus for the TU/e and Eindhoven Brainport region. The new institute will also study the interaction between humans and systems, including reliable and transparent methods for creating moral and ethical AI.

The TU/e has been active in the field of AI for years, conducting innovative research in the fields of intelligent machines, smart mobility, and healthcare. It has two leading institutes that are actively involved in studying AI and its applications – the Data Science Center Eindhoven and High Tech Systems Center.

PARTNERS

In keeping with the TU/e's traditional close ties to the private sector, EAISI has partnered with numerous companies and organizations at a regional, national, and European level. These include ASML, Philips, NXP, Brainport Eindhoven, the AI NL Coalition, 4TU.Federation, and EuroTech.

APPROACH AND OBJECTIVES

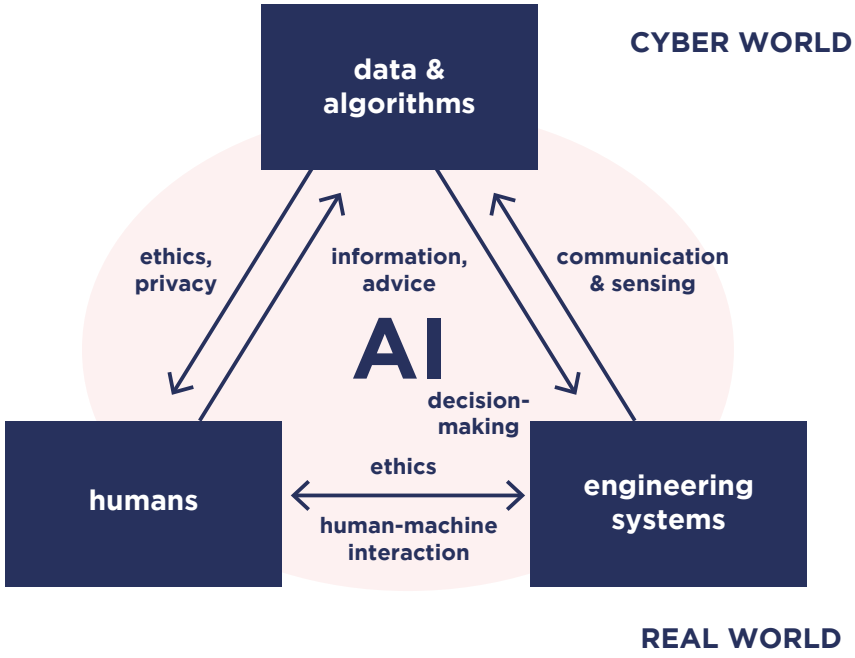
EAISI aims to develop AI technology for real-time autonomous decision-making in engineering systems that interact with humans. By focusing on engineering systems, the effect of AI technology will be in the real (physical) world, and generally in the presence and with the involvement of humans. Decision-making needs to be interpreted as any operational action for diagnosis, monitoring, and analysis, as well as control, task-performance and optimization of systems behavior.

TU/e
EAISI

These major challenges require expertise and contributions from different scientific disciplines. An integrated system view of AI will be developed in this multidisciplinary institute, with key contributions from three key domains:

a. Data and algorithms
b. Humans and ethics
c. Engineering systems

The research performed in the institute will generally be focused on the lower TRL levels 1 – 5/6, ranging from basic technology research to technology development.



Source: EAISI Mission & Vision

RESEARCH TOPICS

EAISI research will focus on the following three topics:

1. High tech Systems & Robotics:
   - Guaranteed machine performance
   - Autonomous machine operation and smart human-operator support
   - Multi-agent robotics
   - Predictive maintenance
2. Health Applications:
   - Improved diagnostics
   - Personalized and wearable health systems
   - Better understanding of personal health
   - Preventive health management
3. Mobility:
   - Vision and sensor capabilities for autonomous driving
   - Data analytics for effective transportation systems and distributed traffic management
   - Advanced driver assistance systems

AI AND STUDENT TEAMS

The TU/e is a breeding ground for young engineers that wish to address the challenges faced by society. These students participate in projects that combine education, innovation, and entrepreneurship that are funded by the TU/e and its sponsors. Several student teams use AI in their projects:

- Blue Jay: this team aims to create safe, interactive, and autonomous drones that can serve as autonomous assistants, both indoors and outdoors.
- Solar Team Eindhoven: the team focuses on sustainable mobility, working on a comfortable self-driving family car that maximizes the use of solar energy by efficiently consuming and sharing energy. The team has won the Bridgestone World Solar Challenge in Australia four times in a row.
- Tech United: Tech United competes in the autonomous soccer robots and autonomous service robots world championships, and it is the defending world champion in both categories.
- University Racing Eindhoven: URE builds high tech autonomous electric racecars for the Formula Student competition, constructing a new car each season.

3. HOLST CENTRE

The Holst Centre was launched in 2005 by imec (Flanders, Belgium) and the TNO (the Netherlands) and is supported by local, regional, and national governments. It is named after Gilles Holst, a Dutch pioneer in research and development and the first head of Philips Research. Located on the High Tech Campus Eindhoven, the Holst Centre benefits from, and contributes to, the state-of-the-art on-site facilities. The Holst Centre has over 200 employees from 28 nations and, has 56 industrial partners and has funding for 45 ongoing projects.

The Holst Centre is an independent research and innovation center that focuses on innovations for improving health and wellbeing and on guaranteeing sustainable environments. The institute bolsters its industry partners by developing world-class breakthrough technology solutions that can be marketed. To help solve global challenges, the Holst Centre links the Dutch Brainport region with a global ecosystem of industry partners and academia, allowing each sector to benefit from the other's expertise.

WIRELESS SENSOR TECHNOLOGIES AND FLEXIBLE ELECTRONICS

Combining expertise in wireless sensor technologies and flexible electronics means that the Holst Centre is in a unique position. The institution's partner companies value its ability to create demo models and prototypes and, using such a proof-of-concept, industrial partners transform the innovative technologies into new products and new manufacturing processes. The Holst Centre frequently takes technologies to a point where they are almost ready for market. Thanks to knowledge transfer, the Holst Centre contributes to the expertise and market position of its partners.

OPEN INNOVATION MODELS

The goal of open innovation is faster, cheaper, and more effective innovation, reducing risks and creating a rapid time-to-market for new products. At the Holst Centre, partners complement their in-house R&D with shared R&D, leveraging each other's talents and knowhow in a well-structured and professional environment. Outcomes generated at the Holst Centre tend to be shared on a non-exclusive basis between program partners, under agreements that are tailored to the needs and scenarios of each partner.

Where necessary, the Holst Centre also performs dedicated research in the form of a one-on-one agreement with a single partner. This is often done to speed up technology transfer and the industrial uptake of results garnered through such shared research, and which have reached a higher level of technological readiness. This working model also plays a role in partnerships with SMEs, which typically have more immediate R&D needs. Dedicated partnership and IP agreements are negotiated with these companies.

Holst Centre
Open Innovation by imec and TNO

HOLST CENTRE TECHNOLOGY SPINOFFS

- **Keiron (2020):** after many years of research, the Holst Centre has taken microelectronics printing to the next level. Laser-based printing technology is a contactless, digital, and laser-controlled technique for depositing both solid and liquid materials on any surface, including biomaterials, conductive adhesives, electronics, and metals. Laser printing allows complex functionalities to be added to chips, while microelectronics production processes are much faster and more precise. The technology equates to extraordinary opportunities for the mass-production of flexible electronics.

  Together with HighTechXL, the Holst Centre's TNO created a solid business case and a promising venture from the technology in the form of Keiron. This deep-tech startup provides a new direct-writing manufacturing machine for high-volume micro-manufacturing for microfluids and microelectromechanical systems (MEMS). The global market for laser-printed electronics has been estimated to be worth some ten billion euros by 2025.

- **LionVolt (2020):** thanks to an investment of 4.5 million euros from the Province of Brabant and the Ministry of Economic Affairs and Climate Policy, the Holst Centre's TNO has taken a significant step forward in developing its revolutionary 3D solid-state lithium-ion batteries. These batteries are made using the patented spatial atomic layer deposition (sALD) technique, and are intrinsically safe and light, recharge quickly, and have a long life.

  Major car manufacturers are keeping a close eye on progress, given that these batteries are a perfect solution for electric vehicles. The funding will be used to build a range of demo models for demonstrating that this promising technology is suitable for large-scale battery production. The Dutch government recognizes the importance of retaining this technology so that the Netherlands can maintain its strong competitive position in Europe. To further accelerate the development of this technology in the fast-growing battery market, the Holst Centre's TNO has created a spinoff company, LionVolt, dedicated to the 3D solid-state batteries

- **SALDtech (2018):** the Holst Centre has devoted over a decade to a new technology called spatial atomic layer deposition, which creates large-area ultra-thin layers. SALDtech, a Centre spinoff, was founded in 2018 to further develop, build and sell spatial atomic layer deposition (SALD) systems to the flat panel display industry. The SALDtech tool will help enable the production scaleup of next-generation display technologies. Related end-product display markets include smartphones, tablets, TVs as well as new form-factor displays in (autonomous) cars and on almost any surface. SALDtech has undergone numerous funding rounds and will use the money to develop and build production equipment.

HOLST CENTRE PARTNERS, 2019-2020

- Alpine
- Amore Pacific Group
- Analog Devices
- ARM
- Asahi KASEI
- Atlas Copco
- BAMBI Medical
- BASF
- BioTelemetry
- bloom
- China Lucky Group Corporation
- DAIJANG
- Datwyler
- DENSO
- DSM
- DuPont
- Faurecia
- FujiFilm
- GlobalFoundries
- Heliatek
- Henkel
- HITACHI Maxell
- Hugo Boss
- ILLUMIX
- Intrinsic ID
- Johnson&Johnson
- KANEKA
- LeydenJar Technologies
- LifeSense Group
- MegaChips
- Methods2Business
- Microsemi
- muRata
- Mitsubishi Chemical
- Nanogate
- NeuroPro
- New Cosmos Electric Co.
- NiKo
- Niraxx
- Novacentrix
- Onera
- Orange
- Orbotech
- OSRAM
- Packetcraft
- Panasonic
- Philips
- Pragmatic
- Renesas
- Rexroth Bosch Group
- ROHM Semiconductor
- Royole
- SABIC
- SALDtech
- Samsung
- Sekisui
- ShinEtsu
- SHINKO
- SILEX Inside
- Smart Floor
- SONY
- spgprints
- SUNPLUS
- technospark
- TEN Flecs
- touch biometrix
- VDL
- Water Future
- Water Link

4. SOLLIANCE SOLAR RESEARCH INSTITUTE

Solliance aims to use thin-film solar technology as an employment-driver. The research institute, a partnership between the TNO, imec, ECN, Holst Centre, TU/e, TUDelft, UHasselt, and FZJ, focuses on developing thin-film PV technologies and making them available to the private sector. Solliance links the worlds of science and commerce with the goal of creating sustainable energy.

The institute, which turned ten in January 2021, has made enormous strides, with the thin-film solar technology research a great success and with almost 180 scientists and a research budget of over 20 million euros to its name.

Solliance's industrial partners include CCM, DSM, Hanergy, Heijmans, Kameleon Solar, Monier, Panasonic, PolyPlastic, Rexroth, Rockwool, Shell, Solaris, SolayTec, and the VDL Group.

SOLAR RESEARCH
SOLLIANCE

RESEARCH PROGRAMS

Solliance Solar Research focuses on shared research. It works with industrial partners, universities, and research institutes, and shares facilities and knowledge as well as the risks inherent to the research. Learning from each other's perspective means that the research becomes more effective and that technology is brought to the market faster.

Every step in the value chain requires research in other disciplines, and it differs each time, from fundamental material and process research through to developing practical solutions in new applications. Three research programs have been created, each with their own roadmap but with a common vision:

1. Perovskite-based Solar Cells: the research focuses on creating perovskite solar cells and in particular on the lifespan, efficiency, and scalability of the production technology. The research is often of a fundamental nature.
2. Innovative Module Technology: for low cost/high performance and new applications, such as reducing absorber materials, fully adaptable monolithic interconnections on flexible substrates, and creating a cost-effective barrier and protective layer.
3. Application Integration Technology: aimed at the aesthetic use of thin-film modules in building materials, infrastructures, and vehicles, by developing technology for semifinished products and creating dedicated solar foils that can be seamlessly integrated in existing production methods.

THE POTENTIAL OF THIN-FILM SOLAR

Thin-film solar means that the layer of active material is many times thinner than in conventional solar panels, allowing solar cells to be flexible and making them less vulnerable to breakage and point load.

There is greater freedom in terms of form. The active material in traditional solar panels is silicon, which is into thin slices known as 'ingots'. These slices are about 200 microns thick and very fragile. The technology has been in existence since the 1950s and has evolved into an efficient and cost-effective way to generate renewable energy.

But the use of the material in thin-film solar is fundamentally different. The material, perovskite, copper indium gallium selenide (CIGS) or cadmium telluride, is simultaneously placed on a large surface using a printing or vapor deposition process. At a later stage individual cells are created, often in straight strips but also in other forms.

These two steps mean that thin-film solar cells can take on any form and be fully adapted to the requirements of the application. Solliance seeks solutions for integrating these thin-film solar cells into existing products or applications, such as vehicles or building materials. Because the shape can be adapted to the application, a much larger surface area can be clad with solar energy-generating foils.

5. DIFFER - THE DUTCH INSTITUTE FOR FUNDAMENTAL ENERGY RESEARCH

DIFFER research focuses on developing a clean, inexhaustible energy supply that available to anybody, anywhere in the world.

While the global climate changes due to fossil fuel emissions, the world's population – and the global demand for demand – continues to grow. The demand for sustainable and relevant energy solutions is high, whether for domestic, transport and industrial use.

DIFFER is helping to meet that demand through its fundamental scientific research into new and improved energy sources for the future. Research focuses on two major energy themes:

I. DIFFER researchers are investigating how the enormous potential of generating clean power from fusion energy can be achieved.

   The worldwide energy transition from fossil fuels to sustainable energy requires technology that allows large quantities of clean, sustainable, and reliable energy to be generated in compact power stations. Fusion energy could satisfy this demand without greenhouse gases being emitted. Nuclear fusion is the energy source of our sun, and in its core energy is released when hydrogen atoms react at high temperatures to produce helium. DIFFER strives to make this fusion process a safe and clean one on our planet.

   The first fusion reactor for demonstrating the technical feasibility of nuclear fusion as an energy source on Earth is now being constructed in the south of France. ITER (the International Thermonuclear Experimental Reactor) is a joint project between Europe, the United States, Russia, Japan, India, South Korea, and China, and is both larger and more complex than the International Space Station. DIFFER is the leading Dutch research center for nuclear fusion and the point of contact between Dutch researchers and companies that are part of the worldwide research into nuclear fusion. The research institute is the Dutch partner in the Horizon 2020 program EUROfusion and works with the Fusion for Energy EU body that is responsible for the EU's contribution to ITER.

II. Research is conducted into ways of converting sustainable energy cleanly and efficiently into fuel for storage and transport: solar fuels.

   Research conducted by DIFFER into solar fuels addresses the global challenge of efficiently converting sustainable energy into chemicals and storing it. This approach provides the greatest amount of energy and is ideal for the long-term storage and long-distance transport of sustainable energy. DIFFER focuses in particular on splitting water molecules (using sustainable energy generated by, for example, solar or wind power) into hydrogen and oxygen and the reduction of carbon dioxide (CO) to carbon monoxide as an important starting point for the synthesis of CO -neutral chemical fuels. The research involves the synthesis and design of novel materials and processes to obtain scalable, efficient, and cost-effective systems.

COOPERATIVE VENTURES

In order to achieve its goal, DIFFER works with industry and knowledge partners in a range of fields, including physicists, chemists, engineers, and other specialists. The organization aims to play a role in developing the technology required to generate and store sustainable energy as efficiently and cheaply as possible, using the right materials – enabling the acceleration of the transition to a sustainable society.

HISTORY

DIFFER was launched in 2012 as the focal energy research activity of the Dutch Research Council (NWO) as part of its Dutch Foundation for Fundamental Research on Matter (FOM). In 2017 FOM became part of a new body, merging with other NWO divisions. DIFFER grew out of the former FOM Institute for Plasma Physics Rijnhuizen into a multi-disciplinary national home for fundamental energy research. In order to optimize interaction with the broader academic world and to expand its facilities, DIFFER constructed an environmentally-friendly building on the Eindhoven University of Technology (TU/e) campus in the southern Netherlands. The institute moved to its new BREEAM-NL Excellent (sustainability-certified) building in May 2015.
International (research) staff

A broad spectrum of knowledge and expertise is represented at DIFFER, with physicists, chemists, engineers, and other specialists working together in multi-disciplinary teams that seek to accelerate the transition to a sustainable society. Some 90 scientists and 60 guest staff and interns work together at DIFFER, supported by 40 technicians and 30 support staff members. The global nature of the energy challenge is evident in the fact that our employees come from over 30 different countries.

RESEARCH FACILITIES

DIFFER's role as a national institute allows it to run research facilities that are beyond the scope of individual universities. These facilities help DIFFER to scale up the insights gained from fundamental research into ones that could have industrial applications. DIFFER's highly experienced engineers design, manufacture, and operate DIFFER's facilities.

Our mid-sized laboratory setups, Magnum-PSI and Ion Beam Facility, offer unique opportunities for researchers and partners, while well-equipped labs for optics or materials research are dedicated to research into solar fuels.

MAGNUM-PSI – MATERIALS UNDER FUSION-REACTOR CONDITIONS

Fusion reactors such as ITER and its successors will expose materials to intense heat and particle impacts when the hot plasma exits the magnetic cage and hits the exhaust wall. So a reactor wall must be designed that can withstand an environment as extreme as the surface of the sun. Magnum-PSI is the world's only laboratory able to test materials under conditions akin to ITER and future nuclear fusion reactors. An extensive set of diagnostics mean that changing materials properties can be studied in detail.

ION BEAM FACILITY – THE IN-DEPTH STUDY OF ENERGY MATERIALS

What happens to materials that are exposed to the extreme conditions in a nuclear fusion reactor? How can we improve the catalytic properties of materials and surfaces in chemical reactions? DIFFER's Ion Beam Facility is the only ion beam facility in the Netherlands. The 3.5 MV ion accelerator offers a suite of ion beam analysis techniques that allow researchers to characterize (sub-)surface material properties and investigate processes in materials for fusion energy, solar fuels, and others.

1. Magnum-PSI tests ITER wall materials, setting a world plasma fluence record.
2. overview of Magnum-PSI with the connection to DIFFER's Ion Beam Facility.

5. TALENT AND EDUCATION, INCLUDING THE LABOUR MARKET

A. General characteristics of Brabant's labor market

Brabant's workforce has proven to adapt easily to the cultures of foreign companies and multilingualism is the norm. Over 94% of the labour force has conversational knowledge of a second language, with English (90%), German (71%) and French (29%) being the most common. At least three-quarters of the population speaks two languages aside from Dutch and a third are competent in four languages. Two world-class universities (one offering technical studies, the other economics and law) and numerous universities of applied sciences guarantee a steady influx of new talent into the province.

LABOUR FORCE BY GENDER AND AGE

Gender	Breda region	Tilburg region	Den Bosch region	Eindhoven region	Brabant	Participation rate
Male	180,000	139,000	191,000	226,000	736,000	76.0%
Female	157,000	119,000	164,000	187,000	628,000	66.3%
Total	**337,000**	**258,000**	**355,000**	**413,000**	**1,364,000**	**71.2%**

Age	Breda region	Tilburg region	Den Bosch region	Eindhoven region	Brabant	Participation rate
15-24 yr	54,000	45,000	57,000	65,000	221,000	72.1%
25 - 44 yr	130,000	102,000	135,000	167,000	534,000	89.0%
45 -74 yr	153,000	111,000	163,000	181,000	609,000	60.4%

LABOUR FORCE, 2018

Brabant 1,364,000 people (14.9% of total)

The Netherlands 9,125,000 people (100%)

Source: The Dutch Central Bureau for Statistics (CBS), 2019

NUMBER OF STUDENTS ATTENDING SECONDARY AND HIGHER EDUCATIONAL INSTITUTIONS IN BRABANT (2018/2019)

	Secondary education (Prevocational or general secondary education)	Medium vocational education (Vocational secondary education)	Higher Professional education (University of technology)*	University BSc, MSc
Breda region	36,980	15,690	See Brabant total	70
Tilburg region	24,820	17,640	See Brabant total	15,730
Den Bosch region	36,950	22,880	See Brabant total	x
Eindhoven/Helmond region	43,420	22,280	See Brabant total	11,970
Brabant	**142,170**	**78,490**	**86,910**	**27,770**

** Data for universities of technology unavailable at sub-regional level due to mergers between these institutions. Data only available at provincial level. Universities of technology have institutions in all four sub-regions.*

QUALITY OF EDUCATION AND TRAINING SYSTEM

Unlike many other countries, the Netherlands offers multiple forms of secondary education, giving children the opportunity to choose their path based on their talents and interests. The Netherlands has an excellent system of lower, secondary, higher and professional education. The World Economic Forum's Global Competitiveness Report ranks the Netherlands third in the world, as evaluated by business leaders, based on the quality of education and training systems.

GRADUATE SKILLS LEVELS

RANKING		SKILLS OF GRADUATES
1.	Switzerland	81.4
2.	Finland	77.0
3.	**The Netherlands**	**74.4**
8.	Singapore	73.4
3.	United States of America	71.2
6.	Luxembourg	71.1
7.	Denmark	71.0
8.	Quatar	70.9
9.	Austria	70.8
10.	Iceland	70.1

Source: DUO, 2019, World Economic Forum, The Global Competitiveness Report 2019

B. The battle for top talent in technology and business

MONITORING THE ECONOMY AND LABOR MARKET: BRAINPORT MONITOR 2020

Every year the state of the economy in the Brainport Eindhoven region is evaluated. As it is the core region of Brabant's HTSM industry, it generally provides useful insights into market and labor market developments for the Brabant region as a whole. The Brainport Monitor 2020 was a unique report, given that it was compiled in the middle of the Covid-19 pandemic, which was obviously rather disruptive to the economy. The following is adapted from the Brainport Monitor 2020 published on ArbeidsMarktInZicht.nl.

THE ECONOMY AND COVID-19: GENERAL EXPECTATIONS ARE POSITIVE

The 13th edition of the Brainport Monitor is a special one, thanks to the coronavirus. Many of its facts and figures refer to the situation in southeast region of Brabant as it was in early 2020, pre-coronavirus, figures that demonstrate that the region, where the Brainport Eindhoven ecosystem has its center of gravity, has a robust foundation for looking confidently to the future. The regional economy grew for the seventh year in a row, unemployment was at its lowest since monitoring started, and private sector R&D expenditure in the region was higher than ever.

But it is certain that the Covid pandemic will impact on the recent growth figures. Measures to contain the spread of the virus have hit some industries extremely hard and the 'new normal' at home and abroad has disrupted growth plans. However, in some cases these developments could also accelerate those plans! A large part of tech industry, in particular chip technology and high tech healthcare, has been able to continue manufacturing in compliance with the new rules.

Yet insecurity and doubt mean some caution is required. Doubts about future market growth or declines may cause companies to temporarily postpone or even adjust investments – investments that play a significant role in their future earning capacity. Nevertheless, the foundations of the Brainport Eindhoven ecosystem are robust, thanks to its large manufacturing industry and the fact that innovation is so intertwined with the aim to achieve the Netherlands' societal goals. The region accounts for 23% of private sector R&D expenditure in the country and more than 41% of Dutch patents, while 19% of all R&D researchers work in Brabant, most in Brainport Eindhoven. In view of its focus on knowledge and innovation, the region can count on its resilience to emerge stronger from the crisis and work on its future earning capacity.

CHALLENGES

There are also challenges. One of these is the scarcity of tech and IT professionals in the regional and national labor markets. The HTSM priority industry, always on the look-out for more tech and IT personnel, is the region's largest employer, and almost 17% of regional jobs are in HTSM while over one out of every ten HTSM jobs in the country is in the Brainport region. The clustering of tech and IT personnel in specific (sub-)sectors in the region has led to the exchange of knowledge and expertise and has greatly benefited innovation. At the same time, a shortage of suitable staff has inhibited economic growth. The high demand for tech and IT professionals is evident from the fact that almost a third of all vacancies in southeast Brabant are in tech and IT.

And even though the Covid-19 pandemic resulted in slightly higher unemployment figures, the shortage of professionals for technology-related jobs has not significantly shrunk.

To be able to continue to fill these vacancies, both now and in the future, training, development, lifelong education, and attracting sufficient talent at all levels is crucial. The number of students pursuing technology and IT courses has been on the rise in southeast Brabant since 2006, exceeding 32,000 students in 2019, with university and vocational graduates increasing in particular.

It remains a challenge to make technology careers appealing to secondary vocational students as well. This challenge presents a lose-lose situation to industry and potential students alike, as nearly a quarter of vacancies for secondary vocational graduates in the region are in tech. The tech companies are meanwhile willing to pay excellent salaries and job benefits for suitable candidates.

The rise in secondary education students pursuing technology courses is minimum at best, but there are clear differences at different education levels. The proportion of preuniversity students (high school graduates) who opt for a technology major is highest, with 63% choosing to major in NT (Nature & Technology) or NG (Nature & Health). Meanwhile, 43% of senior general secondary students focus on tech, while only 27% of prevocational secondary students pursue this option.

As a result, the number of graduates focusing on tech is not keeping pace with the growing demand for tech and IT professionals in the labor market, a demand that will only increase as a result of the energy transition and digitization of SMEs. Although there has not yet been a large rise in unemployment and welfare claims in the region, the coronavirus means this cannot be ruled out in the future. That means retraining (enabling unemployed professionals to find jobs in other industries) will become increasingly important, over and above regular training, education, and recruitment – activities that already are the highest priority.

A third challenge is international trade. The United States and China are important sales markets for the Brabant's HTSM industry, and together these countries account for almost 23% of all Brabant's HTSM exports. A trade war between the two countries consequently impacts upon the province, the southeast region in particular, which accounts for 81% of Brabant's HTSM exports.

In addition, Brabant has a good import and export relationship with Germany. Issues in the German automotive and other industries affect related industries and suppliers in Brainport Eindhoven. The effects of existing and possible new coronavirus measures abroad will continue to impact supply chains in 2021 and thereafter.

All this means it may be wise for Brabant's HTSM companies to widen their focus and diversify, find new geographical markets, and reduce their single-market dependence.

BRABANT PROJECTS FOR ATTRACTING AND KEEPING TOP HTSM TALENT

1. Public-private partnerships between industry and educational institutions for engaging students and encouraging them to work in Brabant's high tech industry:
- Student teams
- The Eindhoven Engine at the TU/e
- High Tech Systems Center at the TU/e
- Joint innovation and education programs at Brainport Industries Campus: industry, universities, universities of applied sciences, and secondary vocational schools

2. Holland Expat Center South, Eindhoven. Holland Expat Center South is a non-profit governmental agency that is a joint initiative of the participating municipalities, the Netherlands' Immigration and Naturalization Services (IND), Brainport Development, and the province of Brabant. The Center compiles the procedures and provides information that helps expats and their families to settle into their new living (and working) environment. Expats can obtain information about the region from the Expat Center and learn more about events organized specifically for the expat community. Its main purpose is to help expats feel welcome and at home.

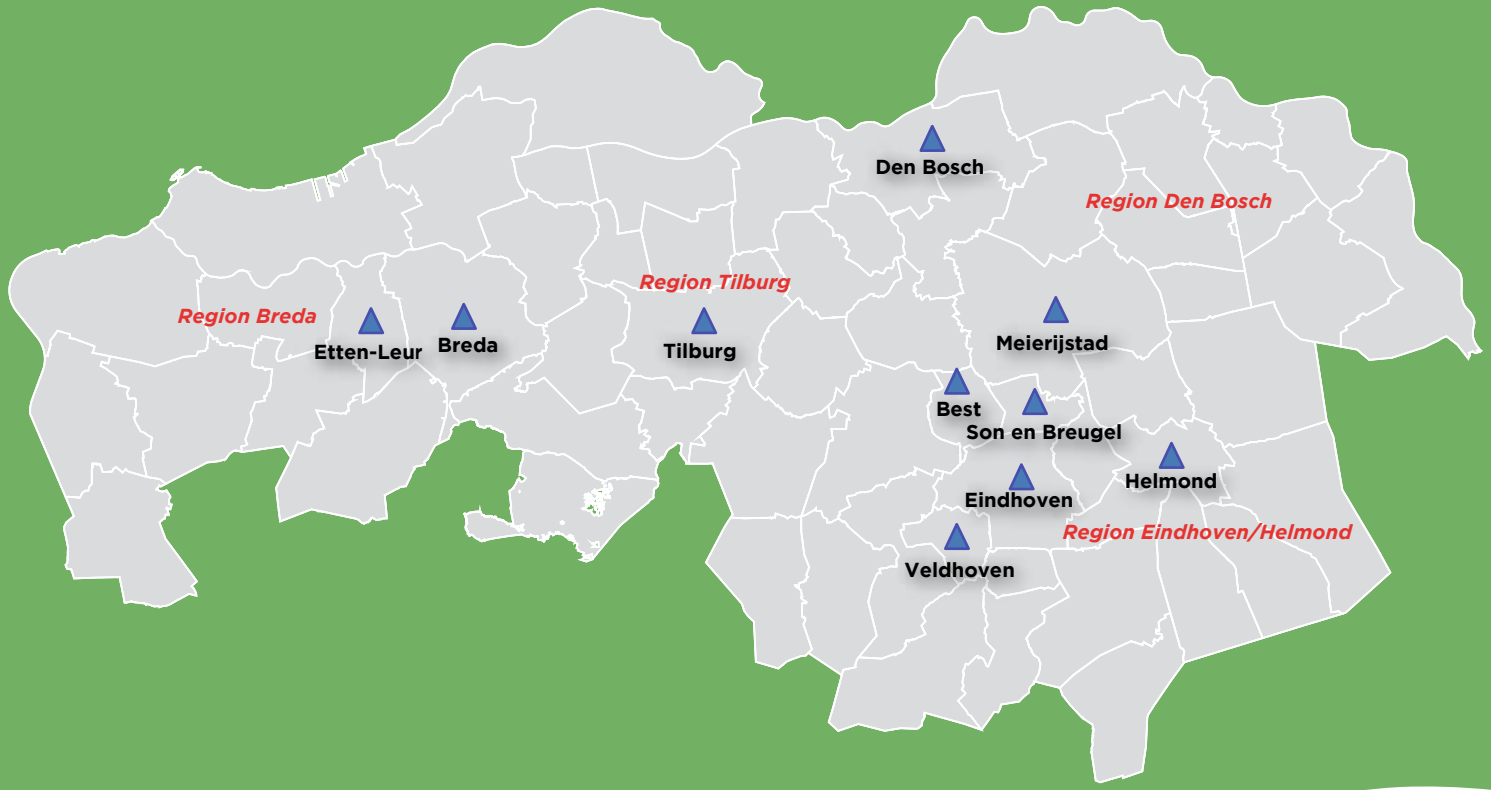
3. HighTechXL: a partnership between industry and science to create deep-tech startups and scaleups involving highly-motivated students and alumni.

4. Support programs for startups and scaleups in several of the regional economic development agencies, such as the Brabant Development Agency (BOM), REWIN, StartersLift, Brainport Development, Midpoint Brabant, and others.
- Brainport Development SME Talent Attraction Program
- Brainport Eindhoven tech and IT job portal
- Brainport Traineeship Program for foreign trainees
- Brainport Industries College – hybrid work/study training programs
- Brainport Industries Human Capital Online Platform

C. The Brabant HTSM labor market

1. Current employment figures
2. Education: students and graduates
3. Unemployment: registered jobseekers

REGIONS IN BRABANT AND CITIES WITH MORE THAN 2,500 HTSM JOBS



1. Current employment

As stated in Chapter 1,129,150 people in Brabant are currently employed in the HTSM sector. The Eindhoven/Helmond region (southeast Brabant, including the cities of Veldhoven, Best, and Son en Breugel) has the largest workforce in HTSM, with 66,190, followed by the Den Bosch region (northeast Brabant). The fact that HTSM is a knowledge-intensive industry can be seen in the large proportion of highly-educated staff, with over 40% of the workforce being highly educated. In the Eindhoven/Helmond region that figure reaches 50%. The average level of education for employees in the Tilburg (mid-Brabant) and Den Bosch (northeast Brabant) regions is slightly lower, possibly reflecting the fact that HTSM in these regions leans more towards manufacturing metal products and plastics.

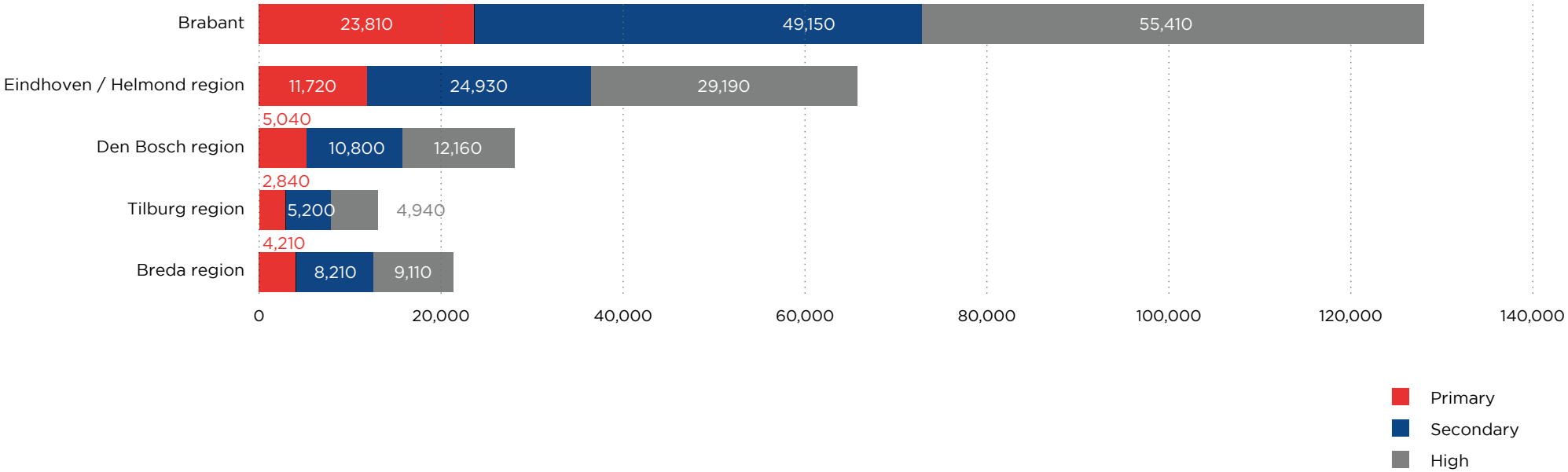
HTSM JOBS ACCORDING TO EDUCATION LEVEL

Education level	Total	low	medium	high	unknown
Breda region	21,720	4,210	8,210	9,110	180
Tilburg region	13,080	2,840	5,200	4,940	90
Den Bosch region	28,170	5,040	10,800	12,160	170
Eindhoven/Helmond region	66,190	11,720	24,930	29,190	340
Brabant	**129,150**	**23,810**	**49,150**	**55,410**	**790**

Proportion of education level	Total	low	medium	high	unknown
Breda region	100%	19.6%	38.1%	42.3%	0.8%
Tilburg region	100%	21.9%	40.1%	38.1%	0.7%
Den Bosch region	100%	18%	38.6%	43.4%	0.6%
Eindhoven/Helmond region	100%	11.7%	34.7%	53.7%	0.6%
Brabant	**100%**	**18.5%**	**38.1%**	**42.9%**	**0.6%**

Source: Brabant Register of Establishments 2018, The Dutch Central Bureau for Statistics (CBS) 2018, adapted by Fanion Onderzoek & Advies

HTSM JOBS IN BRABANT ACCORDING TO EDUCATION LEVEL



2. Education in HTSM: students and graduates

A. THE TU/E, EINDHOVEN UNIVERSITY OF TECHNOLOGY

The Eindhoven University of Technology is a young university, founded in 1956 by industry, local government, and academia. It prides itself on being solutions-driven, educating students and advancing science and technology for the benefit of humanity. It aims to integrate education and research so that its students and scientists become thought-leaders and design and achieve what is still unimaginable today. Working closely with public and private partners, the university strives to translate its basic research into meaningful solutions for society as a whole.

The TU/e still maintains its longstanding leading position in the world when it comes to cooperative research with industry. According to the 2019 CWTS Leiden Ranking, almost 16% of TU/e publications are in partnership with one or more industrial partners, putting it in second place in the world for general universities of applied sciences that partner with industry in their research. This figure has been stable for years, standing at 15.4% in 218. In Europe, the TU/e takes the number-one spot with at least 5,000 publications, and globally only North Carolina State University (USA) betters its score.

TECHNICAL STUDENTS AND GRADUATES AT THE TU/E, EINDHOVEN UNIVERSITY OF TECHNOLOGY

The total number of students at the TU/e, Eindhoven University of Technology in the 2020–2021 academic year is 13,690, with 28% being female and 72% male.

- 7,582 of these students are enrolled in a bachelor's degree course
- 505 are registered in a pre-Master program
- 5,503 are pursuing a master's degree

There are 2,103 foreign students, up from the previous academic year despite the fact that the Covid pandemic has significantly hampered studying abroad for much of the world.

The TU/e is highly focused on the interests, knowledge, and expertise required in the Brainport Eindhoven region, a high tech systems and materials hotspot. Therefore, its students probably all have an academic profile matching the HTSM sector. However, 716 students are engaged in the program of Chemical Engineering and 115 in the School of Education: programs that that may not be HTSM by formal definition. The same may apply to the departments of Mathematics & Computer Science (2,426 students) and Built Environment (1,471 students), but some of the most important developments in High Tech are the integration with Artificial Intelligence and Big Data and the development of smart buildings and factories.

What this means is that virtually all TU/e graduates closely match the high tech industry's requirements.

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Using the formal definition of the HTSM Priority Industry, as referred to previously in this study, only the students in the following university programs would technically be counted:

- Bach. Electrical Engineering
- Bach. Industrial Design
- Bach. Technical Innovation Sciences
- Bach. Applied Physics
- Bach. Mechanical engineering
- Bach. Technical Informatics
- Bach. Applied Mathematics
- Mast. Applied Physics
- Mast. Automotive Technology
- Mast. Electrical Engineering
- Mast. Industrial Design
- Mast. Innovation Management
- Mast. Innovation Sciences
- Mast. Mechanical Engineering
- Mast. Science and Technology of Nuclear Fusion
- Mast. Sustainable Energy Technology
- Mast. Systems and Control
- Mast. Computer Science and Engineering
- Mast. Embedded Systems
- Mast. Industrial and Applied Mathematics

Following that definition, in 2018 slightly fewer students were in an HTSM program, with 9,120 enrolled.

B. BRABANT'S UNIVERSITIES OF APPLIED SCIENCES

GRADUATES IN TECHNICAL STUDIES FROM UNIVERSITIES OF APPLIED SCIENCES, 2018

	2013	2014	2015	2016	2017
AVANS UoAS	1,050	1,150	1,240	1,260	1,260
Fontys UoAS	900	1,000	1,170	1,230	1,310
Breda UoAS	190	240	260	430	300

GRADUATES OF HTSM PROGRAMS AT UNIVERSITIES OF APPLIED SCIENCES

	2013	2014	2015	2016	2017
AVANS UoAS	310	380	430	440	440
Fontys UoAS	850	930	1,100	1,150	1,230
Breda UoAS	160	190	210	290	250

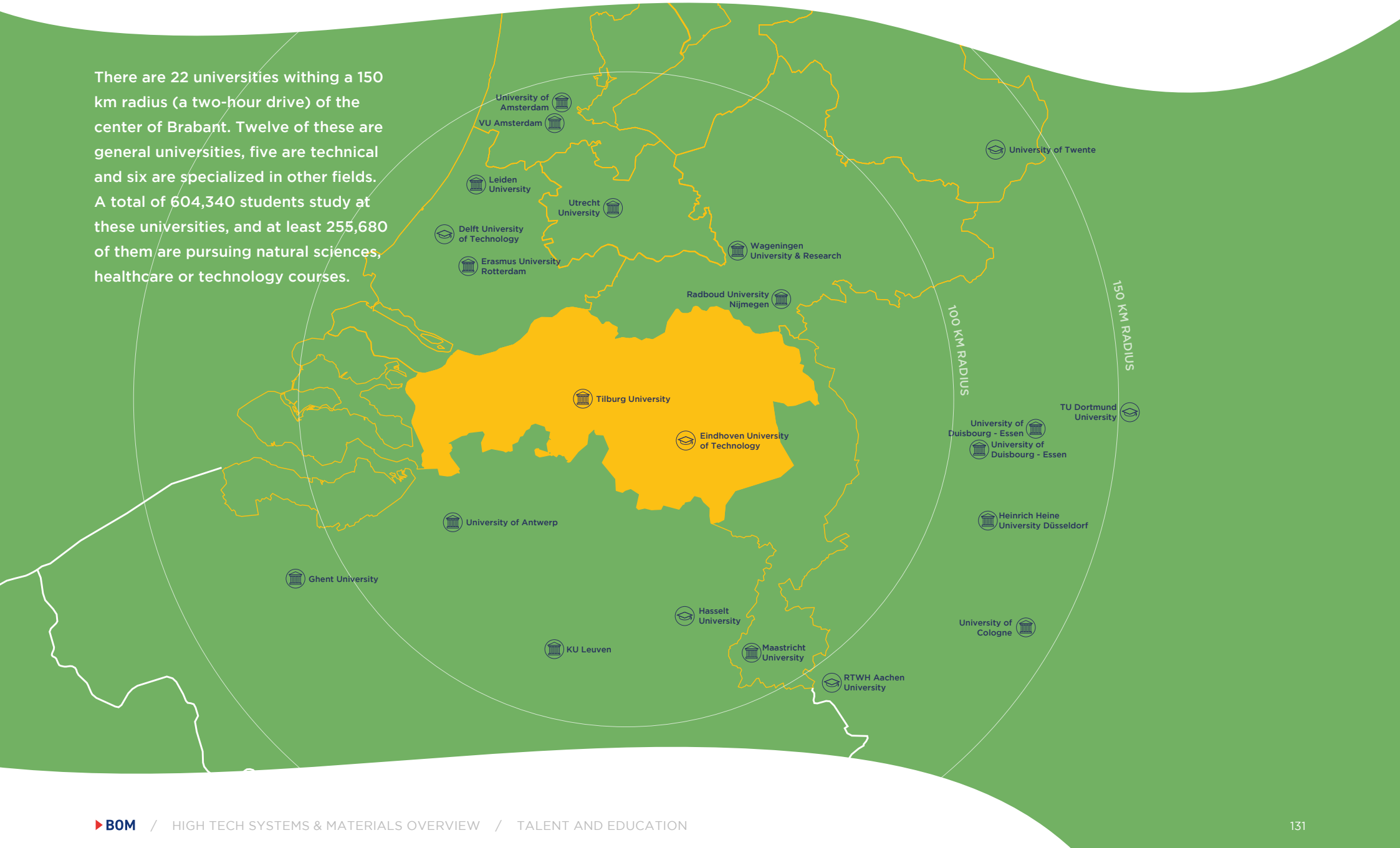
C. HTSM GRADUATES AT A MEDIUM AND SECONDARY EDUCATION LEVEL (2018)

HTSM	MBO	HAVO	VWO	Total
Breda region	480	390	650	1,520
Tilburg region	340	240	330	910
Den Bosch region	670	520	670	1,860
Eindhoven/Helmond region	850	580	750	2,180
Brabant	**2,340**	**1,730**	**2,400**	**6,470**

Source: DUO 2019, adapted by Fanion Onderzoek & Advies

ALL UNIVERSITIES WITHIN A 150 KILOMETERS (A TWO-HOUR DRIVE) RADIUS

There are 22 universities withing a 150 km radius (a two-hour drive) of the center of Brabant. Twelve of these are general universities, five are technical and six are specialized in other fields. A total of 604,340 students study at these universities, and at least 255,680 of them are pursuing natural sciences, healthcare or technology courses.



UNIVERSITIES WITHIN A 2-HOUR DRIVE

Netherlands			**Total Netherlands**	**260,140**	**111,250**
City	**University**	**Driving distance**	**Type of university**	**Number of students**	**Students in Nature, Health and Technology**
Tilburg	Tilburg University	0	Specialized University	15,730	460
Eindhoven	Eindhoven University of Technology	0	Technical University	11,970	11,900
Nijmegen	Radboud University Nijmegen	80 km	Broad University	21,680	7,090
Utrecht	Utrecht University	90 km	Broad University	31,800	13,580
Rotterdam	Erasmus University Rotterdam	90 km	Specialized University	26,960	3,830
Delft	Delft University of Technology	110 km	Technical University	24,510	23,900
Wageningen	Wageningen University & Research	110 km	Specialized University	11,940	11,840
Maastricht	Maastricht University	110 km	Specialized University	17,190	5,590
Leiden	Leiden University	130 km	Broad University	29,050	6,390
Amsterdam	VU Amsterdam	130 km	Broad University	24,570	10,060
Amsterdam	University of Amsterdam	130 km	Broad University	34,070	8,960
Enschede	University of Twente	180 km	Technical University	10,670	7,650
Belgium			**Total Belgium**	**133,860**	**65,110**
City	**University**	**Driving distance**	**Type of university**	**Number of students**	**Students in Nature, Health and Technology**
Hasselt	Hasselt University	70 km	Specialized University	5,700	3,330
Antwerp	University of Antwerp	90 km	Broad University	20,220	9,310
Leuven	KU Leuven	110 km	Broad University	56,490	29,110
Ghent	Ghent University	150 km	Broad University	51,450	23,360
Germany			**Total Germany**	**210,350**	**79,320**
City	**University**	**Driving distance**	**Type of university**	**Number of students**	**Students in Nature, Health and Technology**
Duisburg	University of Duisburg - Essen	130 km	Broad University	15,870	.
Dortmund	TU Dortmund University	130 km	Technical University	33,810	33,810
Aachen	RTWH Aachen University	130 km	Technical University	45,510	45,510
Essen	University Duisburg - Essen	140 km	Broad University	26,600	.
Düsseldorf	Heinrich Heine University Düsseldorf	140 km	Broad University	35,560	.
Cologne	University of Cologne	170 km	Broad University	53,000	.
			Total number of students	**604,340**	**255,680**

Source: DUO, Dataloep Vlaanderen, DEStatis/Statistisches Bundesambt (2019), edited Fanion onderzoek & advies

3. Jobseekers

The final category of available workers is longer-term jobseekers. The overall unemployment rate in the Netherlands is very low, and while Covid-19 has led to higher unemployment rates, they are not expected to last very long.

In 2018, 1,350 professionals with an agricultural background and 25,510 people with a technical background were unemployed. Most of these have a low to medium education level, while two to four percent have a higher education.

JOBSEEKERS WITH A TECHNICAL PROFESSION

	low	medium	high
Breda region	4,600	1,350	330
Tilburg region	4,630	1,000	220
Den Bosch region	4,090	1,100	290
Eindhoven/Helmond region	6,050	1,420	430

Source: UWV, 2018 Breda region

6. LOCATION, CAMPUSES AND FACILITIES

A. Location

1. BRABANT, THE NETHERLANDS: YOUR GATEWAY TO EUROPE

In geographic terms the Netherlands – and Brabant in particular – has historically been the key port of entry to mainland Europe.

This is also true in a literal sense, as Brabant is part of the delta stretching between Rotterdam (Europe's largest port) and Antwerp (the continent's second largest port) and three of Western Europe's busiest airports: Amsterdam Schiphol, Brussels Airport and Dusseldorf International Airport. Excellent infrastructure (by road, rail, water and air) and IT and data communication networks that are second-to-none anywhere in the world are added bonuses.

This combination of strengths helps industry in the area to fluidly reach 170 million consumers in a radius of 500 kilometres (300 miles). These consumers with significant financial means (north-western Europe is one of the wealthiest markets in the world) are all within 24 hours of Brabant.

#1 LOGISTICS
Hub in Europe

3 MAINPORTS
For air, data and sea

Efficient logistics services empowered by **INNOVATION & COLLABORATION**

COMPETITIVE COST
for labour, real estate and transport

EXCELLENT CONNECTIVITY
To Europe and all continents

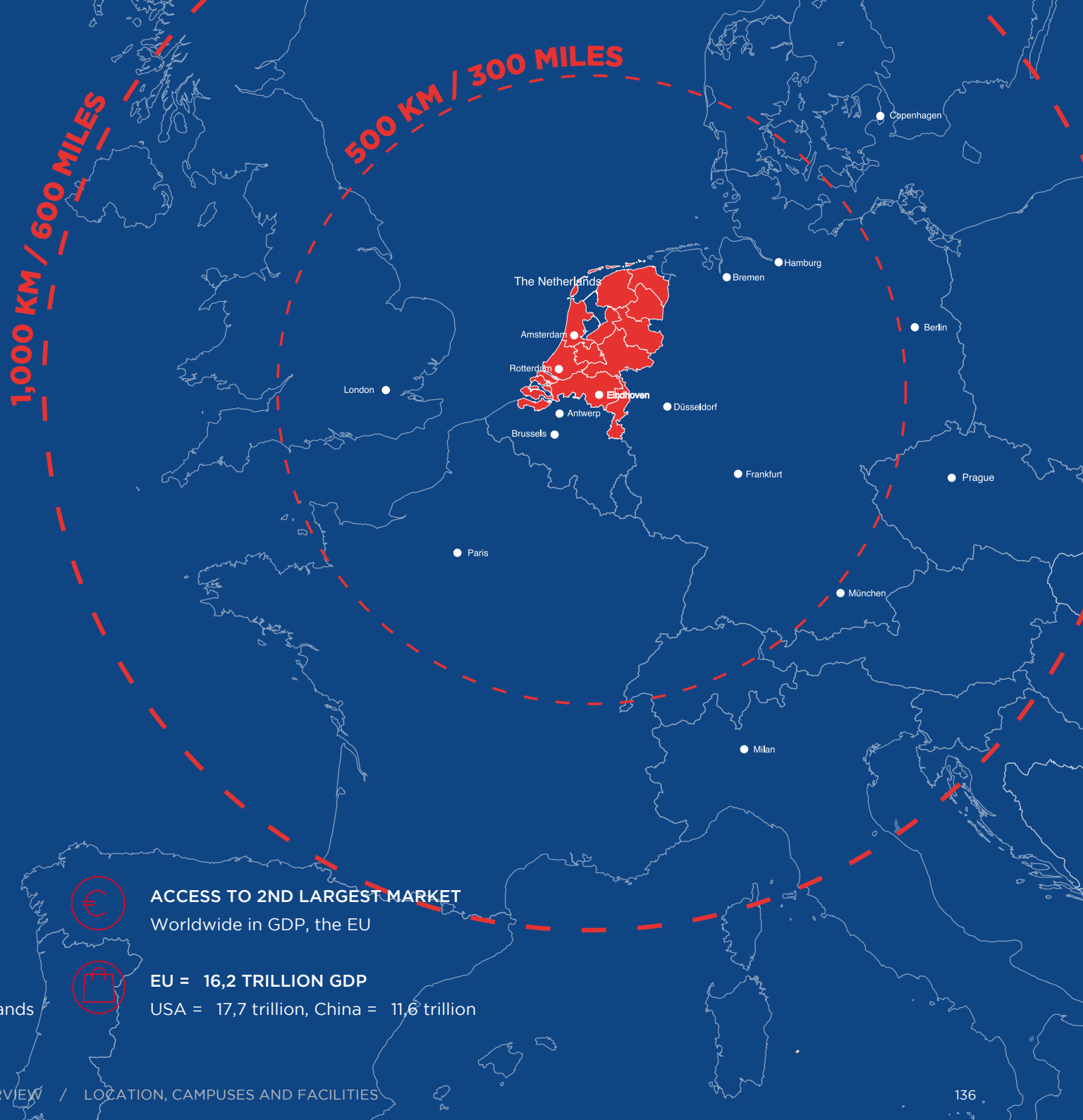
#1 ENTRY POINT
In Europe for overseas products

500 km proximiy to European markets
170 MILLION CONSUMERS

World class & competitive business environment
NO VAT PAYMENT AT IMPORT

2. BRABANT, THE NETHERLANDS: ACCESS TO THE SECOND LARGEST MARKET IN THE WORLD

Within a radius of 500 kilometres, businesses can reach 170 million consumers in Western Europe, and if that circle is extended to a radius of 1,000 kilometres (600 miles) – still within easy and rapid reach – this figure grows to 250 million people. The largest European economies – Germany, France, the United Kingdom and the Benelux region – are all within a day's reach. The rest of the European Union (the second largest market in the world in GDP terms) is just as accessible from Brabant, with an additional 24 to 36 hours in transit time.



170 MILLION CONSUMERS
Within a 500 km / 300 mile radius

250 MILLION CONSUMERS
Within a 1,000 km / 600 mile radius

PERFECT SPRINGBOARD
into European market

MAJOR EUROPEAN ECONOMIES
are within a day's reach of the Netherlands

Source: Invest in Holland, 2018

ACCESS TO 2ND LARGEST MARKET
Worldwide in GDP, the EU

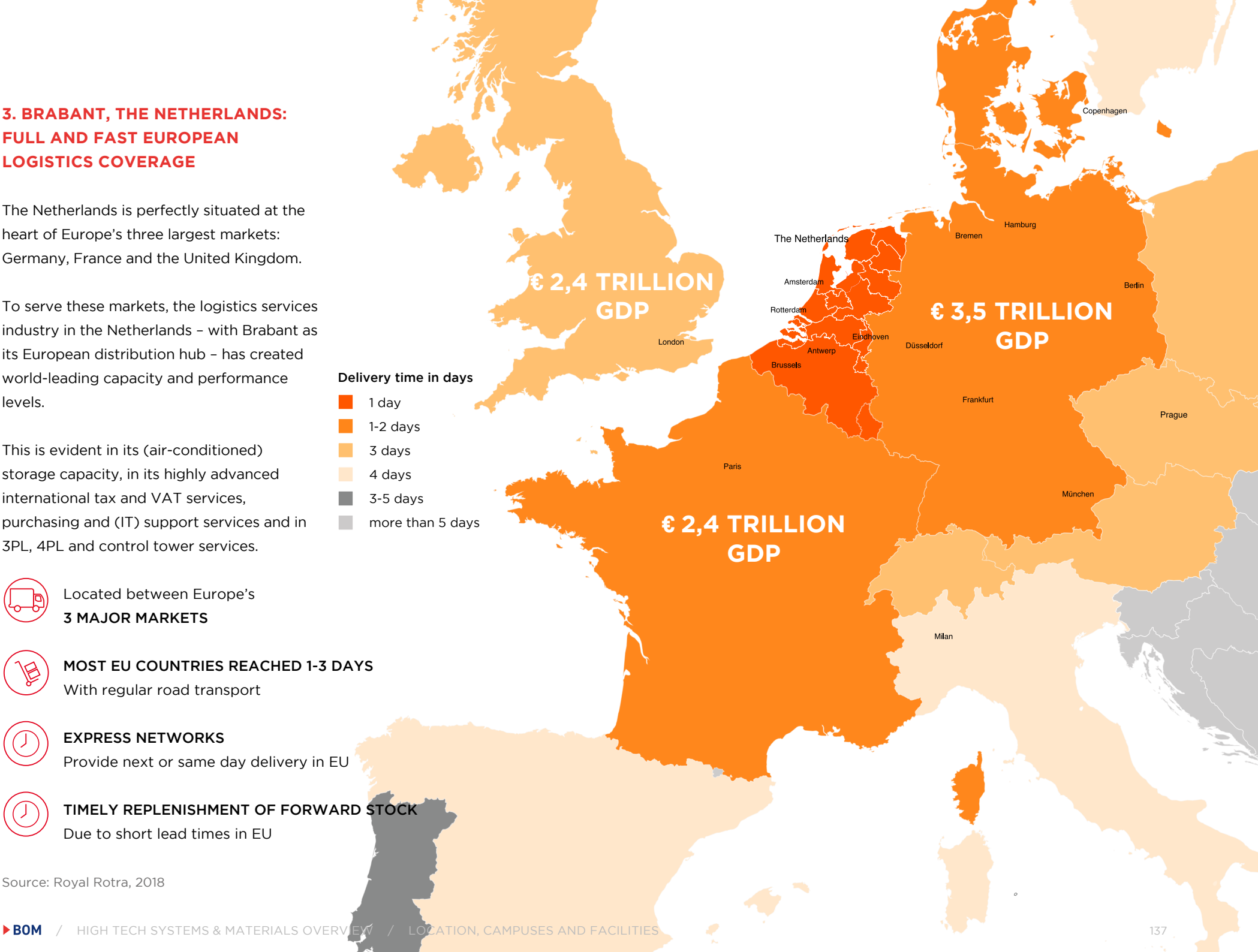
EU = 16,2 TRILLION GDP
USA = 17,7 trillion, China = 11,6 trillion

3. BRABANT, THE NETHERLANDS: FULL AND FAST EUROPEAN LOGISTICS COVERAGE

The Netherlands is perfectly situated at the heart of Europe's three largest markets: Germany, France and the United Kingdom.

To serve these markets, the logistics services industry in the Netherlands – with Brabant as its European distribution hub – has created world-leading capacity and performance levels.

This is evident in its (air-conditioned) storage capacity, in its highly advanced international tax and VAT services, purchasing and (IT) support services and in 3PL, 4PL and control tower services.



Located between Europe's
3 MAJOR MARKETS

MOST EU COUNTRIES REACHED 1-3 DAYS
With regular road transport

EXPRESS NETWORKS
Provide next or same day delivery in EU

TIMELY REPLENISHMENT OF FORWARD STOCK
Due to short lead times in EU

Source: Royal Rotra, 2018

B. Campuses and facilities

1. High Tech Campus Eindhoven

High Tech Campus Eindhoven is the smartest square kilometer in Europe, with over 200 companies and institutions, and 12,000 researchers, developers and entrepreneurs working on developing future technologies and products. The professionals on campus come from all over the world, with more than 85 nationalities featuring. The Campus helps companies to accelerate their innovations by offering easy access to high tech facilities and international networks. Campus companies (such as Philips, NXP, TomTom, Shimano, Signify, IBM, and Intel) decide, on a strategic basis, what knowledge, skills and R&D facilities to share in order to achieve faster, better and more customer-oriented innovations in the fields of health, energy and smart environments. Located in the heart of the city, also known as Brainport Eindhoven, Campus companies account for nearly 40% of all Dutch patent applications.

HIGH TECH CAMPUS EINDHOVEN

HISTORY

The driving force behind the High Tech Campus Eindhoven was Philips. At the end of the 1990s, the company's R&D activities were spread across the city, and so in 1998 Philips decided to establish the Philips High Tech Campus which would serve as a single location for all its Dutch R&D activities. The approach proved extraordinarily successful and the atmosphere of openness and the concentration of high-end knowledge produced considerable interaction between company researchers working in different fields.

Knowledge-sharing and mutual inspiration considerably boosted its innovative capacity and, to further bolster that process, in 2003 Philips decided to open up its Campus to other technology companies. The result was massive growth with many innovative companies – large and small alike – vying to become part of this R&D hotspot.

The Campus entered a new phase in March 2012 when High Tech Campus Eindhoven (HTCE) became an independent entity in the wake of its sale to Ramphastos Investments. In recent years the Campus has witnessed further growth with the arrival of new companies and the expansion of existing ones. Philips is still one of the principal HTCE tenants: Philips Research alone employs over 1,200 professionals from 50 different countries. Their professional healthcare services focus on diagnostic imaging and minimally invasive image-guided procedures, patient care and clinical decision-making support. Its personal health researchers are studying technologies and solutions that encourage a healthy lifestyle, optimized personal care and exploring ways to enhance a fulfilling home and interactive lifestyle.

One unique Philips facility is the ExperienceLab, where a natural setting is provided in which proposed new technologies and applications can be tested and actually experienced. The ExperienceLab involves multi-disciplinary teams, including psychologists, sociologists and designers, observing people and monitoring their behavior and interaction with innovative concepts.

Signify (formerly Philips Lighting) also remains highly active on the High Tech Campus Eindhoven. Signify is the world leader in lighting for professionals, consumers and lighting for the Internet of Things, with sales reaching €6.4 billion in 2018 and some 29,000 employees worldwide. Signify continues to innovate in the field of LED lighting and is leading the industry's expansion when it comes to lighting systems. Signify's global headquarters are located on the Campus, together with 550 employees in innovation and 1,400 employees in enabling services as well as a large IT and sales contingent.

OPEN INNOVATION

The High Tech Campus is famous for its system of open innovation, which sees companies working together and having shared access to high tech facilities and international networks.

A SAMPLE OF OPEN INNOVATION PROGRAMS AND RESEARCH INSTITUTES ON THE HTCE

Research Group	Research topics
Solliance Solar Research DSM	Thin-film solar research with academic partners such as TU/e, TUDelft, TUTwente, imec, TNO, and Jülich and industrial partners including CCM, DSM, Hanergy, Heijmans, Kameleon Solar, Monier. Panasonic, PolyPlastic, Rexroth, Rockwool, Shell, Solaris, SolayTec, VDL, and many more.
Holst Centre including AM	Combining expertise in wireless sensor technologies and flexible electronics to improve the vitality and wellbeing of people and ensuring sustainable environments. Founding partners TNO and imec work on 45 funded projects with 56 industrial partners from all over the world, including AM Systems, BASF, DuPont, Hitachi, Leyden Jar, NeuroPro, Mitsui Chemicals, Novacentrix, Philips, Samsung, SALDtech, ShinEtsu, SONY, and Touch Biometrix.
AI Innovation Center	The High Tech Campus Eindhoven and co-founders Philips, ASML, NXP, and Signify launched the AI Innovation Center in 2020 to create an open innovation facility. Its aim is to accelerate the application of data science and artificial intelligence technologies by companies in the Brainport Eindhoven area.
5G Hub	Ericsson, VodafoneZiggo, High Tech Campus Eindhoven, and Brainport Development have created a powerful consortium called 5G Brainport Eindhoven, with the 5G Hub physically located at the HTCE. Here, industry, science, and education can experience inspiration sessions, test new technologies in fields such as 5G, AI, VR/AR, blockchain and photonics, and learn from one another.

SUSTAINABILITY

The HTCE has set an ambitious goal: to become the most sustainable campus in Europe by 2025. Issues such as global warming and the growing population are extremely hot topics and these phenomena come with huge societal and environmental challenges. Technology and innovation can play an important role in solving the problems the world faces. As a central hotspot for technological innovations in Europe, the HTCE strongly feels it should also take the lead in sustainability and underscore the urgency of the matter – not in 2030, but in 2025.

The first thing that comes to mind when discussing sustainability is often energy – reducing consumption and clean generation – which is why energy is part of the HTCE sustainability roadmap. Just two of the many KPIs the HTCE has set for itself:

- To be CO2-neutral by 2025
- Reducing the use of fossil fuels by 50% by 2025

As the saying goes, 'the proof of the pudding is in the eating', and in January 2020 the HTCE started installing 30,000 solar panels on the roofs of all Campus buildings.

FACILITIES AND SERVICES

High Tech Campus Eindhoven provides numerous technical and research facilities and is also home to companies offering CRO and CMO services. Most of the technical research facilities are made available by Philips Innovation Services, Eurofins and other companies. Advanced innovation services, expertise and high tech facilities are available for the entire innovation process – concept creation, product development, prototyping and small series production right through to sustainability and industrial process-consulting.

In practice, this means access to 25,000 m^2 of multi-purpose labs (physical, optical and chemical) and cleanrooms, reliability testing and materials analysis, electromagnetic compatibility (EMC) testing and RF/DC measurement labs. Furthermore, equipment such as high tech water scanners. printers for printing foils on substrates, and a high-end fiber data network for data exchange and rapid analysis are all available.

PHILIPS INNOVATION SERVICES (PINS)

Philips Innovation Services is a service provider in innovation. With 1,000 specialists in Eindhoven, the company acts as an advisor and partner in bridging gaps all the way from innovation concept through to market. The company's approach involves bringing together all the required experience, expertise, methods and tools, and it can boast of a tradition of innovation and entrepreneurship stretching back more than 125 years. And because it works both for Philips as well as for external medical and high tech companies, Philips Innovation Services' is always cutting-edge.

PINS has the following areas of expertise in the world of medical technology:

1. High-precision Engineering
2. Medical Devices Design & Engineering
3. Electronic Systems & IoT
4. MEMS & Micro Devices
5. Manufacturing Systems & Industry 4.0
6. Design for Reliability Solutions
7. Industry Consulting
8. Environment, Health & Safety

A SELECTION OF MAJOR COMPANIES ON THE HTCE

- ABB
- Accenture
- Analog Devices
- ASML
- Capgemini
- Cognizant
- Dassault Systèmes
- Huawei
- IBM
- Intel
- KeyTec
- NXP
- Philips
- Shimano
- Siemens
- Signify
- STMicroelectronics
- Techwave
- Teledyne DALSA
- TMC
- TOMTOM
- Wipro
- **Aircision**
- **Bambi Medical**
- **Carbyon**
- **bloomlife**
- **Dynaxion**
- **Incooling**
- **Intrinsic ID**
- **Silicon Integrated**
- **Smart Photonics**
- **SALDtech**

Startups/scaleups

INSTITUTES ON THE HTCE

The presence of research institutes is crucial to the open innovation system on the High Tech Campus, as they attract both companies and fundamental research projects. The following institutes are located on the HTCE. The AI Innovation Center is being launched in 2021.

Institutes	Activity
5G Hub	An eco-system of municipalities, politics, companies, start-ups, and education and knowledge institutes to increase the quality of life and the economic appeal of Brainport Eindhoven through new technologies (such as 5G, AI, VR/AR, blockchain, and photonics) and innovative applications
ARTEMIS Industry Association	Embedded Intelligent Systems
Biotech Systems Platform	The Biotech Systems Platform aims to publicize and stimulate innovation and collaboration between biotechnology, life sciences, and the field of high tech systems and equipment
ECN	R&D on sustainable energy systems
TU/e	Eindhoven University of Technology
EIT Digital	Innovation and education on digital transformation
Holst Centre	Generic technologies for wireless autonomous sensors and for flexible electronics
IMEC	Imec is a world-leading R&D and innovation hub in nanoelectronics and digital technologies
ITRI	R&D on information and communications, electronics and optoelectronics, advanced manufacturing, biomedical and devices, material and chemicals, and energy and environment
ITEA3	Software intensive Systems & Services
PhotonDelta	Ecosystem to accelerate integrated photonics solutions
Solliance Solar Research	Development of thin-film photovoltaic solar energy
SEAC	Solar energy applications
TNO	Scientific research

Source: High Tech Campus

INSTITUTES ON THE HTCE (CONTINUED)

Institutes	Activity
Signify EMC Electromagnetic Compatibility & Wireless Connectivity lab	Profound and accurate testing, consulting on and certification in the fields of: • Electromagnetic compatibility (EMC) • Wireless approbation • Wireless robustness (multipath performance, total radiated power, antenna diagrams) • Electrical safety **Focus on:** lighting, medical, semiconductors and IoT/RF products and systems
Philips Innovation Services	• Laser Job prototyping services • Product prototyping • Instrumentation services • Technical support and technology consultants
Eurofins: Material Analysis lab	*The Material Analysis lab is the former Materials Analysis lab of Royal Philips and Philips Lighting and was purchased by Eurofins in 2018* **Services:** The Eurofins facility in Eindhoven specializes in materials analysis and reliability investigation of high tech materials and products. It also has specific expertise in the areas of: • Chemical analysis and& physical inspection of materials and objects • Analytical methodology • Contamination control • Chemical compatibility • Material reliability • Glass characterization **Analytical techniques** • **Compositional analysis:** GF-AAS, CV-AAS, ICP-OES, (LA-)ICP-MS, Elemental Analysis, FT-IR, Raman, GC-MS, HPLC, IC-MS, MALDI, NTM, XRF, Gravimetry, Titrimetry, Thermal Desorption • **Surface and thin-film characterization:** Ellipsometry, SAM, ToF-SIMS, XPS • **Advanced imaging:** FIB, Image processing and analysis, SEM-EDX, TEM, IR imaging, Optical interferometry, Profilometry, SPM/AFM, Thermal imaging/Thermography, X-Ray inspection • **Physical characterization:** Materialography, mechanical testing, particle size analysis, permeability, physical properties of glass, rheology, sample preparation laboratory, specific area of powders, strain analysis, thermal analysis, thermo-mechanical analysis, XRD, electrochemical testing

Source: High Tech Campus

INSTITUTES ON THE HTCE (CONTINUED)

Institutes	Activity
Eurofins: Reliability lab	*The EAG facility in Eindhoven is the former Reliability Lab of Royal Philips And Philips Innovations Services, purchased by Eurofins in 2018.* **Environmental Simulation:** • High/low temperature • Temperature and humidity • Power temperature cycling (PTC) • Thermal cycling • Thermal shock • HAST/Corrosion testing • Solar/UV simulation **In-Situ Test Service:** • LED lifetime (Optical Output) • Event detection (Low Resistance) • Monitor (I/V/L/R vs. Time) **Highly Accelerated Lifetime Test (HALT):** • HALT test • MEOST test **Mechanical Test Service:** • Bump and shock • Drop test and free fall (mechanical and simulation) • Surface affection • Waterproof pressure test • Drawbench and tensile test **Water Vapor Transmission Test (WVTR):** • Calcium test on thin-film barriers

Source: High Tech Campus

HIGH-LEVEL HOUSING FOR HIGH TECH START-UPS - TWICE

TWICE offers a special stimulating environment for young, innovative technology companies with growth potential. Our shareholders – Brabant Development Agency, municipality of Eindhoven, Eindhoven University of Technology, Brainport Development and Rabobank Eindhoven-Veldhoven - have joined forces in order to ensure that business can be successful at TWICE in Brainport Eindhoven region.

Twice has four thematically unified housing formulas. Strategically positioned in the heart of the absolute high tech hotspots in the Brainport region: Eindhoven University of Technology and High Tech Campus Eindhoven.

- Office spaces and laboratories from 25 to 500 m^2
- High-quality laboratories including equipment
- Server rooms with server boxes
- High-quality redundant IT infrastructure

Mμ - Growing in LifeTec and New Energy

Mμ is for companies in Research & Development, with a focus on LifeTec and New Energy. These next generation, high tech companies can accommodate themselves in flexible office spaces and laboratories.

Bèta - Growing in high tech R&D

βèta is the ideal location for young, innovative high-tech companies in Research & Development. βèta is fully equipped with modern office spaces and high-quality, electrical engineering laboratories.

Mμ and βèta are part of the High Tech Campus Eindhoven (HTCE): with more than 12,000 technicians the source of innovation. The building is located at the foot of “The Strip”: the lively heart of HTCE with, among other things, restaurants, a conference center and a shopping center. The HTCE is seen as the smartest square kilometer in Europe.

Twinning - Growing in IT, (embedded) software and electronics

Twinning offers office spaces to companies active in IT, (embedded) software and electronics. Twinning is aimed at young tech companies with a flexible, proven formula for the launch of technological products, processes and services.

Catalyst - Growing in electrical engineering, mechanical engineering and (bio) chemistry

Catalyst consists of small-scale office and laboratory spaces on the TU / e Campus with a stimulating environment for young, innovative technology companies within the themes: mechanical engineering, electricity, physics and (bio) chemistry.

The location of Catalyst and Twinning is perfect at the TU / e Campus of the Eindhoven University of Technology: “a preferred place” for innovative activities. The companies in Catalyst and Twinning form an energetic network in the middle of the world of the university. With access to knowledge, specialist research facilities, potential business partners and clients.

2. TU/e Campus - University of Technology Eindhoven

The TU/e Campus is an open and accessible community for technology education, scientific research and knowledge valorization. It is a lively hotspot in the Brainport Region Eindhoven which connects students, researchers, entrepreneurs and high-tech companies. The green TU/e campus is becoming an attractive hotspot for students, researchers, entrepreneurs, investors and high-tech companies with state-of-the-art offline and online facilities. The campus is a terrain in development, but it is already a lively, green place in the city center of Eindhoven.

- Company accommodation - Apart from the university, around 100 companies and organizations are located on the campus, from large research institutes to smaller start-ups. The TU/e campus wants to be a place where these parties connect and therefore offers various accommodation possibilities.
- Living on campus - The campus has 700 apartments for (international) students and people working on the campus.
- Congress and conferencing facilities - The campus has good possibilities for organizing congresses, and for smaller meetings and conferencing there are various rooms for hire.

FACTS & FIGURES

- 13,000 + students (2020-2021 academic year)
- 5,000 knowledge workers
- 90 nationalities
- 14 unique labs

TU/E INNOVATION LAB

One of the TU/e's greatest assets is the TU/e Innovation Lab, a proven concept that the TU/e itself describes as follows:

"The TU/e Innovation Lab - How can you bring knowledge to the market?

Where innovation starts - that is our slogan and it complements the growth of our knowledge and education. We turn our academic and technological discoveries into solutions that help tackle societal challenges. The successful commercialization of knowledge places us at the very heart of the Dutch knowledge economy. But how can you bring knowledge to the market? We do that within our business expertise center by turning knowledge into business, using an enthusiastic and experienced team of coaches, advisors, and supervisors available to help TU/e staff and students as well as external parties.

A proven track record – we have a proven track record in commercializing knowledge. In recent years our team has overseen:

- 115 spinoff companies
- 123 student companies
- 60 TU/e patents
- 60 patent licenses
- 500 third-party patents

Exploring opportunities together – we explore all opportunities together, compile the business case, track down suitable forms of funding, establish business models and seek out potential partnerships. This allows us to co-create solutions for societal and global problems in the fields of health and healthcare, energy and mobility.

Research Support Network – a new initiative is available for researchers who need help with external funding to conduct research and develop project proposals on a national and European level: the Research Support Network. This network also offers support in establishing contacts with relevant companies (setting up consortiums) and networks, and helps researchers with patenting inventions and creating contracts.

TU/e Campus - the TU/e campus is growing in leaps and bounds, as can be seen in the activities and the growth of the campus. It is a meeting place for students, researchers, entrepreneurs, investors and high tech companies. The campus is place of national significance and international allure with state-of-the-art research facilities. And there is plenty of scope for R&D-driven (startup) companies, no longer on the basis of closed but instead based on open multidisciplinary innovation processes, with all the associated benefits for startups, companies and investors alike."

RESEARCH LABS

Eindhoven University of Technology has 14 major research laboratories on campus and a further 40 smaller laboratories are also available.

OVERVIEW OF MAJOR LABORATORIES AT THE TU/E

TU/e research laboratory	Activity
Atlas Living Lab	Atlas Living Lab is the largest indoor living lab in Europe. Research into intelligent lighting and climate systems. Eight operational office floors are equipped with the LED Smart Energy-saving Lighting (SEL) system and CO2 sensors.
Center for Multiscale Electron Microscopy (CMEM)	The CMEM offers unique facilities for the study of soft materials and uses the knowledge gained to develop synthetic materials.
Center for Wireless Technology (CWTe Lab)	The CWTe facilitates research on wireless systems and antennas, raising the Internet of Things to a higher level.
Darcy Lab	The Darcy Lab offers unique MRI facilities specially equipped for researching the properties of technological porous materials.
Digital Twin Lab	Modelling real-world situations and creating data interfaces between the real context and model. The Digital Twin lab will provide tools such as Virtual Reality (VR) and Augmented Reality (AR) to allow deeper interaction with the virtual models
Equipment & Prototype Center	The Equipment & Prototype Center (EPC) makes custom experimental setups and prototypes for various fields of research.
Future Fuels Lab	In the Future Fuels Lab scientists are researching green fuels and cleaner combustion methods for engines.
High Capacity Optical Transmission Lab	The High Capacity Optical Transmission Lab facilitates research on innovative optical fibers and signal processing techniques to enable transmission of ultra-high capacity.
Institute for Complex Molecular Systems	ICMS brings together mathematics, physics, biology, chemistry, and engineering to help education and research in the field of complex molecular systems
Laboratory for Cell & Tissue Engineering	The Laboratory for Cell & Tissue Engineering facilitates culturing of autologous tissues across the full spectrum of the research field.
Microfab/Lab	The Microfab/Lab facilitates the development of new micromanufacturing technologies for use in life sciences applications.
Multiscale Lab	The Multiscale Lab facilitates research on the deformation and failure behavior of composite materials. The insights gained lead to innovative materials.
NanoAccess	NanoAccess makes it possible to produce, process and analyze innovative materials with nanometer accuracy, without releasing the necessary vacuum.
NanoLab@TU/e	The NanoLab@TU/e offers a unique combination of equipment for developing optical chips and other applications based on compound semiconductor technology.
SolarLab	With the facilities of the SolarLab, atomic layers can be applied to solar cells, in a quick, controlled manner, making solar cells even more efficient.
Wind Tunnel	The wind tunnels on campus facilitate aerodynamic and boundary layer research on static and moving objects, at both small and large scale.

Source: TU/e

OTHER TU/E LABORATORIES

Department	Laboratory	
Biomedical Engineering	• Cardiovascular Biomechanics	• Molecular Biosensing for Medical Diagnostics
	• Laboratory for Chemical Biology	• PULS/e Laboratory
Electrical Engineering	• Electromechanics & Power Electronics	• ECO Autonomic Networks
	• Electrical Energy Systems	• ECO Packaging Lab
	• Electronic Systems	• ECO Optical Packet Switching
	• Signal Processing Systems	• ECO Transmission Lab
	• Control Systems	• PHI OLA 1&2
	• Radio over Fiber	• Educational labs
	• ECO Autonomic Networks	• ID Labs
Industrial Design	• Human Technology Interaction (HTI Labs)	• Operations, Planning, Accounting and Control (OPAC facilities)
	• Human Performance Management (HPM Lab)	• Innovation, Technology Entrepreneurship and Marketing (ITEM databases)
Chemical Engineering and Chemistry	• Inorganic Materials Chemistry (facilities)	• Micro Flow Chemistry and Process Technology
	• Membrane Materials and Processes (facilities)	• Molecular Science and Technology (MST)
	• Stimuli-responsive Functional Materials and Devices (SFD)	
Department of Applied Physics	• Photonics and Semiconductor Nanophysics (PSN labs)	• Coherence and Quantum Technology (CQT labs)
	• Turbulence and Vortex Dynamics (WDY labs)	• Plasma and Materials Processing (PMP labs)
	• Magneto-optics & femtosecond laser laboratory	• Mesoscopic Transport Phenomena (MTP labs)
	• Magnetic, electrical & structural nano-characterization	• Science and Technology of Nuclear Fusion (FUSION)
	• Molecular Biosensing for Medical Diagnostics (MBx labs)	• Elementary Processes in Gas Discharges
	• Molecular Materials and Nanosystems (M2N labs)	
Mechanical Engineering	• TFE Laboratory	• Automotive Engineering Science Laboratory
	• System Engineering Laboratory	• Simulation Lab
	• Robotics Laboratory	• Rheology Lab
	• Motion Laboratory	• Mechanical testing
	• Constructions and Mechanisms Laboratory	• Polymer processing lab
Mathematics and Computer Science	• Geometry Laboratory	
	• Databases	

Source: TU/e (2017)

COMPANIES AND INSTITUTES ON THE TU/E CAMPUS

More than a hundred 100 companies and research institutes are located on the TU/e Campus, besides the TU/e body itself. Most of them are active in engineering, technical design, and consultancy. The largest organizations of these are the TNO research institute and GE Healthcare Life Sciences Core Imaging (formerly Medical Diagnostics).

THE TEN LARGEST ORGANIZATIONS ON THE TU/E CAMPUS

Organization	Activity	Jobs
TNO	Research and development on technology	100-200
GE Healthcare	Production of radiopharmaceutical products	100-200
Syntouch International	Business intelligence/ICT	20-50
Micro Turbine Technology	Manufacture turbines	10-20
Polymer Technology Group Eindhoven	Development of polymers	10-20
42 Solutions	Software development	10-20
MagnaView	Software development	10-20
Cytomate Technologies	Medical equipment	10-20
SyMO-Chem	Research and development on chemicals	10-20
AccTec	ion beams for the production of radionuclides	10-20

Source: Brabant Register of Establishments, TU/e

THE 10 LARGEST ORGANIZATIONS ON THE TU/E CAMPUS

Activity	Number of companies	Percentage
Engineers and other technical design and consultancy	15	14.2%
Writing, producing, and publishing software	13	12.3%
Research and development on technology	9	8.5%
Organizational planning	8	7.5%
Manufacture of other electrical equipment	5	4.7%
Manufacture of medical instruments and supplies (no dental laboratories)	3	2.8%
Patent agencies	3	2.8%
Wholesale of medical and dental instruments, nursing and orthopedic articles and laboratory equipment	2	1.9%
Computer consultancy activities	2	1.9%
Tax consultancy	2	1.9%
Other research and development on natural sciences (non-biotechnical)	2	1.9%
Job pools (no employment projects)	2	1.9%
Post-secondary non-tertiary education	2	1.9%
Daycare nurseries	2	1.9%
Other world view organizations	2	1.9%
Other manufacturing	8	7.5%
Other wholesale	6	5.7%
Other services	11	10.4%
Education	2	1.9%
Other	7	6.6%
Total	**106**	**100.0%**

Source: Brabant Register of Establishments and TU/e

3. BIC - Brainport Industries Campus

THE FACE OF THE HIGH-TECH MANUFACTURING INDUSTRY - THE FACTORY OF THE FUTURE

The most innovative and successful companies and institutions in the Brainport region come together as one on the Brainport Industries Campus. The campus is where the innovative and competitive strengths of the high tech manufacturing industry take shape.

Leading knowledge institutes and renowned companies work together at the Brainport Industries Campus in order to accomplish ideas and develop business cases. This is where the next generation of professionals in the high tech manufacturing industry is trained in a state-of-the-art working and learning environment. Brainport Industries Campus is the place to be for far-reaching partnerships between suppliers, specialist companies and innovative education and knowledge institutes.

Brainport Industries Campus is the very first location where high tech suppliers innovate and manufacture together, where the most successful companies share high-quality facilities, such as cleanrooms, flexible production areas, warehouses, and other advanced facilities, and where they present themselves as a unified force that they can showcase to their national and international customers.

Brainport Industries Campus

Source: Brainport Industries Campus

BRAINPORT INDUSTRIES CAMPUS TODAY

- Over 35 companies
- 2,000 high-level staff
- 1,500 students
- 105,000 m2
- 6,000 m of shared facilities
- 6,000 m of shared logistics

A few of the current tenants: ABAB Groep, Additive Center, AM Flow, AMS, Anteryon, Avans University, BG Legal, BOM, Brainport Development, Brainport Industries, Ceratec, Cordis Suite, Exploitatiemaatschappij BIC, Festa Solutions, Festo, Fluke Europe, Fontys University, Fujitsu Glovia, Full Fact, High Tech Software Cluster, IJsel, ITAM Solutions, K3D, Kieu Engineering, KMWE, KPN, Macroscoop, MakerPoint, Marketiger, Procureon, Province North-Brabant, RUBIX, Siemens, Sodexo, Solar Team Eindhoven, Summa School of Professional Education, TBP, Techpro, Yaskawa.

4. Automotive Campus Helmond

HELMOND AND THE AUTOMOTIVE INDUSTRY

The story starts in 1975, when Volvo Car took over DAF's passenger car division. The company chose to locate their operations on Steenovenweg in Helmond and, even now, this location forms the central point of the Helmond auto industry. Until the late 1970s, Volvo Cars produced DAF models branded with a Volvo nametag. In the next phase, the Volvo 300 and 400 series were actually developed in Helmond and manufactured at the factory in Born, Limburg. In those days, approximately 3,000 people worked at the Steenovenweg plant.

In 1991 NedCar was founded as successor to Volvo Car. NedCar was a joint venture between Mitsubishi Motors Corporation, Volvo Car Corporation, and the Dutch government. The models that were produced during this time were the Volvo S/V40, Mitsubishi Carisma, and the Spacestar. The NedCar design department in Helmond was responsible for the development and manufacturing was performed in Born, Limburg.

In 2001, the NedCar development department became an independent company called PDE Automotive. Later that year, PDE Automotive was sold to the German company Benteler, which in turn was acquired by Altran.

Parallel to these developments, the TNO research institute moved its VEHIL lab for active security systems to the area in 2003. Three years later, the TNO decided to relocate all its automotive activities from Delft to Helmond. These activities become the foundation of the Automotive Campus. In 2008, a plan for a new incentive for the automotive industry in the region was completed, marking the official launch of the High Tech Automotive Campus in Helmond.

Source: https://innovationorigins.com/

In June 2008, the Automotive House at the campus opened its doors, becoming the prime meeting place for automotive businesses, educational institutions, and public agencies. In 2010 the globally unique climatic-altitude chamber was opened on the Campus by the TNO. And in late 2013 the hydrogen fueling station was installed, one of only four hydrogen fueling stations in the Netherlands.

In January 2014 the Automotive Facilities Brainport Center (AFB Center), a shared facilities center for SMEs, was opened by Minister of Economic Affairs Henk Kamp. At the same time, the name AutomotiveCampusNL was changed to Automotive Campus.

In 2017, the scaleup Lightyear set up shop on the Automotive Campus. Lightyear is a World Solar Challenge race-winning student team from the TU/e that has developed an electric car that runs completely on solar power. In recent years, the complete Automotive Continuous Learning Program has also become a part of the Automotive Campus, a full-learning cycle cooperative venture between Summa College, Fontys Automotive, and the Eindhoven University of Technology.

AUTOMOTIVE CAMPUS

The Automotive Campus now houses over 1,250 people – including 600 students – working on the mobility solutions of the future. They are part of leading automotive companies, knowledge institutes, innovative startups, and educational institutes. In barely fifteen years, the campus has grown into a national and international hotspot when it comes to green mobility and smart mobility.

INNOVATION AND COLLABORATION

The Automotive Campus has become a hotspot where businesses, knowledge institutes, and student teams find one another and form partnerships. The campus is located in the heart of the high tech Brainport region. Working together and sharing knowledge are standard practices here.

The organizations on campus partner with the leading high tech businesses in the Netherlands, as well as leaders in other industries, including IT, energy, and infrastructure. This cross-pollination encourages innovation and creates partnerships that mean ideas can be turned into the technology of the future, faster than ever before.

KEY FIGURES

- 45 companies and organizations
- 25 labs and test facilities
- 620 engineers and research specialists
- 600 automotive students at all education levels
- 110,000 m^2 offices, workshops, and labs
- 140,000 m^2 still to be constructed
- 100 events per year
- 10,000 visitors per year

KNOWLEDGE INSTITUTES AND EDUCATION ON THE AUTOMOTIVE CAMPUS

Knowledge institutes	Activity
Automotive Center of Expertise	Connecting research institutes with companies
DITCM Innovations	Connecting research institutes with companies
European Centre for Mobility Documentation (ECMD)	Projects related to mobility documentation and automotive
FEV Group	Knowledge on automotive development
UAS Fontys	University of Applied Science
De Innovatiecentrale	Innovation lab smart traffic systems
De Car Academy	Vocational education center
NCAD Nederlands Centrum voor Autohistorische Documentatie	Historic documentation on cars
Summa Automotive	Vocational education organization
TNO	Scientific Research
RDW	Dutch National vehicle authority
Innovam	Education in automotive

Source: Automotive Campus

COMPANIES

More than 15 companies are established at Automotive Campus, the largest being Altran Engineering, TASS International, and VDL ETS

Companies	Activity	Country
Altran Engineering	Design and engineering services for the automotive industry: E-mobility, ADAS, Prototyping, testing	France
TASS International	Testing, crash testing, traffic technology	Germany
Lightyear	Solar-powered electric cars	The Netherlands
VDL ETS	Development and testing transport systems	The Netherlands
KPN	5G field lab in combination with smart mobility	The Netherlands
2 get there	Autonomous vehicle projects	The Netherlands
Durapower	Battery systems for electrical vehicles and energy storage	Singapore
V-tron	Fleet management systems	The Netherlands
Fier Automotive	Business development agency specialized automotive	The Netherlands
InMotion	Developing the race car of the future.	The Netherlands
Jumbo Groenewegen	Trailers	The Netherlands
Automan	Human Resources in Automotive	The Netherlands
Vehant Technologies	AI based security products	India
Spike	High-class and flexible battery solutions	The Netherlands
Electric Motorbikes	Innovative electric motorbikes	The Netherlands
XYZ Dynamics	Engineer services on electrical vehicles	The Netherlands
Goodmoovs	App for sharing electrical vehicles	The Netherlands
Dens	Sustainable engines on formic acid	The Netherlands
Saluqi Motors	Electric drive systems with integrated power electronics.	The Netherlands

Source: Automotive Campus

VOITURES EXTRAVERT

One of the tenants on the Automotive Campus is Voitures Extravert, which recreates and electrifies classic iconic cars like the Porsche 911. The all-new body is reproduced in Germany, where the original was born, and the control system hardware and software are designed in California, the home of the computer. Finally, drivetrain development and integration are performed in Eindhoven, the Netherlands, one of the most advanced EV regions in the world.

Source: Voitures Extravert

TEST AND INDUSTRIAL FACILITIES

The Automotive Campus is home to various high-quality technical facilities serving many purposes. A number of research laboratories and test facilities form part of the Automotive Campus Shared Facilities, while others are owned by test and research companies such as the TNO, TASS International, and Altran Engineering Services.

Technical center	Activity	
TNO Powertrain Center	• Powertrain testing	• Climate altitude chamber
TASS: Safety Center	• Full-scale crash testing • Inverse crash sled • Laboratory for pedestrian & interior protection and components	• Road furniture • Vehicle dynamics • Homologation
TASS: ADAS Testing	• Autonomous Emergency Braking – Car to Car • Autonomous Emergency Braking – Vulnerable road users	• Lane support systems • Advanced Emergency Braking
TASS: Automated Driving Validation	• Virtual Testing • Mixed Reality Testing	• Real World Testing
TASS: International Mobility Center	• DITCM test site • DITCM control room • DITCM CarLabs	• Simulation tool suite • Laboratory testing
Altran: Testing services & Facilities	• Low frequency testing • High frequency testing • Climate	• Corrosion • Final inspection lab • Custom-built test rigs
VDL: Rolling Road Testbench	• Engine performance tests • Specific speed profile tests • Suspension fatigue tests	• Fuel consumption tests • Road load simulation • Ambient temperature test
Hydrogen Fueling Station	• Hydrogen generator	
Traffic Innovation Center	• Innovation lab and Innovation desks	

5. Strijp-S: Smart Society

Strijp-S was once a Philips industrial complex that has been transformed over four phases into a working and residential neighborhood. The project started in 2005 and will continue until 2030, and the plan features the following:

- 92,000 m^2 of industrial and office space
- 2,500-3,000 homes (290,000 m^2)
- 60,000 m^2 of facilities (restaurants, designer clusters, shopping, culture, and creative industries)
- 135,000 m^2 gross floor space for (national) monuments
- 5,000 m^2 (built) parking spaces

The 27 hectare area is characterized by its high urban diversity, with many residents, hundreds of new businesses, and more than a million visitors a year. Almost 600 companies are located in the area, over 130 of them in the Ateliers, and most engaged in creative activities. Strijp-S is quickly developing into the creative hotspot of Eindhoven.

The city of Eindhoven aspires to become a 'smart city', one that leverages the power of technology, IT (such as open data and high-speed connections), and design (think) for the benefit of its inhabitants, a city that actively opens up as a pilot to companies and institutions with enhanced wellbeing, jobs, and sustainability as a goal. The development plan for Strijp-S is one of the pilot areas for that smart society plan, and Strijp-S explores smart city concepts in the form of a living lab.

The Strijp-S smart city concept consists of three layers.

1. The 'cloud layer' houses all data and online traffic. Analysis, communication, and content development all take place in this layer.
2. The 'livable layer': the tangible part of the city, the streets people walk on and the door handles they touch.
3. The 'infrastructure layer': roads, railways, pipes, and optical fiber cables.

The interaction between these layers makes the city smart. The layers communicate with each other and work together, thus creating crossovers and integrations. The result must become a more efficient and sustainable city with opportunities for innovative business models.

In addition, three strategic development directions have been identified, linking the layer-concept to:

1. Safety and comfort
2. Mobility and energy
3. Entertainment

STRIJP-S

OFFICE BUILDINGS

The main office buildings are the Apparatenfabriek (the 'Equipment Factory') en het Klokgebouw (the 'Clock Building'), office blocks that focus on the creative industry, including designers, architects, interior decorators, communications specialists, photographers, consulting engineers, publishing companies, music centers, concept developers, graphic companies, and other creatives. In addition, concert, dance party, festival and exhibition organizers use the very large event halls in the Klokgebouw.

COMPANIES ACCORDING TO INDUSTRY SECTOR IN THE ATELIERS

- Most of the 132 companies focus on IT services (16%) like web design, programming, game development, cloud services, internet safety, etc.
- Another big sector is communication (12%), including communication consultancy, corporate identity development, campaigns, and advertising.
- Other large sectors are general design (11%), graphic design (8%), industrial design (6%), fashion design (5%), and interior design (2%).
- 9% of the companies focus on events (5%) and audio and visual productions (4%).

6. Strijp-T

The Strijp-T industrial estate is part of the former Philips production sites in the Strijp neighborhood of Eindhoven, along with Strijp-S and Strijp-R. Strijp-T is currently dominated by post-war buildings, some waiting to be renovated or redeveloped while others are still used by companies such as Smurfit Kappa (manufacture of corrugated cardboard) and DutchAero (production aircraft components, acquired in 2014 by KMWE).

The power plant that previously provided the energy required by Philips has recently been acquired by the municipality of Eindhoven, which intends to turn it into an incubator for design and innovation but also wants a biomass plant. The idea is that the buildings in this part of Strijp-T will eventually accommodate small creative businesses, creating a transition area to the creative activities in Strijp-S. One section of Strijp-T is set aside for housing industrial and technology manufacturing companies.

Together with the owner of several of the buildings, customized housing could be created by renovating or adapting them.

FACTS AND FIGURES

- Total area (net): 30 hectares
- Type of site: mixed business
- Audience: manufacturing and wholesale companies
- Amenities and services
- Fiberglass available
- Strijp-S railway station within walking distance

Strijp-T focuses on innovative, creative, high-tech manufacturing companies. As such, it is the link that was missing – as a location – in the full high tech innovation value chain in Eindhoven.

source: GEVA Vastgoed

STRIJP-T

COMPANIES

Currently, 22 companies are located at Strijp-T. Aside from large companies such as Smurfit Kappa, Draka Comteq Fibre, and KMWE/Dutch Aero, there are many SMEs present, most of them active in the creative industry.

Activity	Number of companies	Jobs
Product design	6	20
Writing and other artistic creation	3	< 5
Advertising agencies	2	< 5
Machining	1	80
Manufacture of luggage, handbags and the like, saddlery, and harnesses	1	< 6
Manufacture of corrugated paper and paperboard	1	50
Manufacture of glass fiber	1	180
Manufacture of electronic components	1	20
Wholesale of beverages (non-dairy products)	1	< 50
Wholesale of other machines, equipment and supplies for manufacturing and trade	1	< 5
Wholesale of other waste and scrap	1	20
Writing, producing, and publishing software	1	< 5
Engineers and other technical design and consultancy	1	< 5
Communication and graphic design	1	< 5
Photography	1	< 5

THE LARGEST COMPANIES AT STRIJP-T ARE

Name	Activity	Size (employees)
Draka Comteq Fibre	Manufacture of glass fiber	100-200
KMWE – Dutch Aero	Design for manufacturing, prototyping, and manufacturing aero-engine and airframe parts for military and civil applications	50-100
Smurfit Kappa RapidCorr	Packaging	20-50
Smurfit Kappa Recycling	Wholesale of other waste and scrap	20-50
CelSian Glass & Solar	Consultancy for glass manufacturing	10-20

7. Aeroparc/Gate 2

Aeroparc, formerly known as the Ericsson site, is located in a prime location right next door to Gilze-Rijen Airbase. Aerospace and maintenance activities form the foundation of the park, hence the name Aeroparc. Aeroparc is located on the N282, the provincial road connecting Tilburg and Breda, and is within easy reach of the A27 and A58 motorways, as well as Gilze-Rijen railway station. The business park is 130,000 m² in size.

Gate2 is located at Aeroparc and offers accommodation to companies in the smart industry cluster. The focus was originally on the aviation and maintenance sector, but today Gate2 offers a full range of smart and flexible technologies: pilot training, world class maintenance, composites, big data, Internet of Things, 3D printing, sensor technology, adaptive robots, augmented and virtual reality, and interactive avatars.

All activities, capabilities, and companies at Gate2 can be categorized into two principal fields:

1. Simulation
2. Production technology

Source: www.aeroparc.eu

GROUNDMAP OF THE AVIOLANDA BUSINESS PARK

SIMULATION

The simulation activities are the following:

Air Mobility Training Center (AMTC)	At Gate2, the Air Mobility Training Center (AMTC) has been developed for training air force pilots for the KDC10 and C130. Simulator training has become essential, and the simulators here are D-type, the highest class. The crew can replace flight hours with simulator hours, which means an hour on the simulator is equivalent to an hour of training in an airplane. Two simulator sessions are available each day for crews.
Adrenaline Control	Adrenaline Control combines cutting-edge sports science services, state-of-the art simulator technology, and a unique training approach through a driver maturity model and a professional infrastructure into a blended one-shop training organization for open wheel and GT motorsport racers and teams. Trainees at Adrenalin Control have one common goal: to improve and excel at peak performance on demand and under pressure.
BlueTea	Training aircraft maintenance engineers using virtual training simulations and serious games. Real-life situations are brought to life to increase the skills required for performing specific work, create awareness of existing risks and dangers, strive for maximum safety, and prevent mistakes/losses in practice.
Helios (Helicopter Instruction & Operational Support Flight Training Center)	Provides specialized helicopter training for both civil and military aviation. Helios uses simulators and an innovative training system in which pilots are trained by means of advanced simulation flights in a sustainable, noise-friendly, and cost-efficient manner.
Merlin Aviation	Merlin Aviation builds and sells professional static aircraft simulators. The Boeing 737 and the Airbus series are especially popular among pilots, who say the simulators are indistinguishable from the actual aircraft. The 180 degree view nearly perfectly matches the real-world situation. The panels, electronics and software were all designed by Merlin Aviation.
VROOM Training	VROOM Training is specialized in immersive virtual reality, where you are immersed in the virtual world. It is used to train mechanics and engineers in real-life situations.
DAF Technology Lab	The DAF Technology Lab provides high tech facilities for students, researchers, and the business community. The combination of technology and behavioral sciences expertise offers unique possibilities for innovative teaching and research. The DAF Technology Lab consists of two spaces, the Experience Room and the Research Room.

Source: www.gate2.nl

PRODUCTION TECHNOLOGY

The activities focusing on production technology are:

3D Printing Lab	The 3D Print Lab provides SMEs with a 3D printing facility so that they can get the 3D print & additive manufacturing technique in-house at a low investment threshold. 3D Print Lab provides access to knowhow, its experimental lab and production space.
Campione	The CAMPIONE project is a field lab project with participants from the chemical and process industries from across the Netherlands. Several companies and institutions from central Brabant are also a part of it and play an important role in the project. The goal of the project is to make maintenance 100% predictable through advanced techniques that are at the cutting edge of condition-based maintenance and big data.
Composite Expertise Center	Training maintenance, repair and overall (MRO) specialists in composites.
Daedalus Aviation Group	Daedalus is a global company in the maintenance repair and overhaul (MRO) sector. The company focuses on deploying onsite support teams for performing first and second-line maintenance, component maintenance, depot maintenance, modifications, and upgrade programs in the military aviation sector. The vast majority of their technicians have at least 20 years of experience in the field of MRO, especially for the F-16 weapons system, Apache AH-64, Chinook CH-47, and Cougar AS-532.
The Carbon Specialist	The Carbon Specialist focuses on repairing carbon applications. It is the first and currently the only company in the Benelux that repairs carbon applications for the private sector and that holds a Boeing repair certificate. Its specialty is repairing high-end racing and ATB frames.
Glue Academy	Glue Academy works on partnerships with research centers, education, branch organizations, and companies active in the distribution and processing of glue and glue-related products. It performs a wide range of activities to promote the industry, including presentations at symposia, participating in trade fairs and developing and supporting educational packages for primary and secondary school students.
MATinspired	MATinspired gives customers more technical insight into the materials of their product. The company does this by means of advice, damage research, workshops, material research, analyzes and development of test kits.
Rotary Wing Training Center (RWTC)	The Rotary Wing Training Center (RWTC) trains helicopter fitters from all over the world to work on various types of helicopters, including Boeing and Airbus helicopters.
TiaT Europe	Threshold Inspection & Application Training Europe (TiaT Europe) has its roots in the aviation sector in the Netherlands. TiaT Europe specializes in non-destructive research (NDT).
Van Kempen Engineering & Consultancy (KEC)	Van Kempen Engineering & Consultancy offers leading consultancy, project and interim management to players in innovative and high tech markets. Aerospace is one of the markets in which KEC operates.

Source: www.gate2.nl

8. Werkendam Maritime Industries

Werkendam Maritime Industries is a cluster of 41 companies, employing over 2,000 people in the maritime industry. It consists of seven shipyards, 19 maritime suppliers, 13 maritime service providers, and five construction companies. Thanks to their common sense of purpose and cooperation, these companies either have everything required aboard, or can get it aboard.

The seven shipyards are Concordia Damen, Euro Offshore, Holland Shipyards Group, De Scheepsbouwers Maritiem, Veka Group, Scheepswerf De Werken, and ASTO Shipyard.

The Werkendam maritime cluster is conveniently located on the busy Merwede River and has an excellent reputation for the construction, repair, and maintenance of river barges.

www.werkendammaritimeindustries.nl

9. Business Park Aviolanda

Aviolanda Aerospace (Business Park Aviolanda) is part of the Woensdrecht Maintenance Cluster, the military and civilian Aerospace Innovation Hub, where the Woensdrecht Logistics Centre, the main support base of the Netherlands Royal Air force, works closely together with Business Park Aviolanda.

Over 20 companies employing about 2,600 people are part of this maintenance cluster. Aviolanda Aerospace is the Dutch one-stop-shop for innovative aerospace maintenance and knowledge exchange, located in a sustainable business park adjacent to the Woensdrecht Airbase. Much attention is given to education, innovation, and research, and the park is easily accessible and has excellent facilities, such as the long runway, park management, modern hangars, field labs, and internationally certified quality standards.

Business Park Aviolanda is also a real estate park, maintaining a portfolio of buildings with floor space of 60,000 m on a site approximately 30 hectares in size. Part of its strategy is to gradually redevelop parts of the existing property together with current and new tenants. Some buildings will be preserved, others will be renovated, and new state-of-the-art facilities for innovative maintenance purposes will be constructed.

Aerial view of the Woensdrecht Maintenance Cluster, Aviolanda Aerospace and Logistics Centre Woensdrecht

Source: www.aviolanda.nl

FACILITIES AT THE WOENSDRECHT MAINTENANCE CLUSTER

Capability	Explanation
Civil and military aircraft and helicopter maintenance	The Royal Netherlands Air Force concentrates its maintenance at Woensdrecht Airbase, its primary support base. Aviolanda is home to maintenance of both civil and military aircraft
UAV demo site	Testing location for unmanned air vehicles and drones
Aircraft redelivery	Conversion of the (VIP) interiors and exteriors of aircraft on behalf of lease companies
Aircraft spray painting	Repainting or restoring paint and lettering on aircraft
Composite maintenance	Restoring and repairing composite aircraft structures and components
Component maintenance	Repairing or replacing new or refurbished components, combined with back-end logistics. At Fokker Techniek, many of these services are performed in so-called back shops – small, specialized departments, each dealing with their own component (avionics, moving mechanics, interior, engine, etc.).
Aircraft Maintenance & Training School (AMTS)	Training maintenance engineers

COMPANIES LOCATED IN THE WOENSDRECHT MAINTENANCE CLUSTER

AERONAMIC SERVICES

Aeronamic will be responsible for the manufacturing, production, final assembly, testing and R&O of the Forward Module as part of the F-35 Power & Thermal Management System (PTMS), which will take place in the company's main facility in Almelo, the Netherlands.

The JPO (Joint Program Office) for the F-35 program selected the Netherlands – Aeronamic as the PTMS Sustainment Center for the F-35 Europe and Asia-Pacific-based fleet. The sustainment activities will be performed by Aeronamic Services and located at Aviolanda in Woensdrecht. Aeronamic carries out maintenance on the PTMS-system, a system that monitors the energy management, such as starting up the engine, emergency energy supplies, cabin pressure and on-board cooling in the F-35 fighter jet.

Source: www.aviolanda.nl

FOKKER SERVICES & FOKKER TECHNIEK (PART OF PANTA HOLDINGS)

Fokker Techniek is an integrated knowledge-based maintenance company that partners with manufacturers (OEMs), owners and operators of aircraft for keeping their fleets competitive, by improving technical dispatch reliability (TDR) and the comfort of passengers while reducing the direct operating costs (DOC) of clients.

FOKKER ELMO (PART OF GKN AEROSPACE)

Fokker Elmo's mission is to become the leading business in the design, manufacture, and support of electrical systems and solutions for the aviation and defense industry. Its core activities are design, integration, production, and support of electrical wiring linking systems (EWIS), including flight testing and instrumental cabling systems. Fokker Elmo offers affordable and competitive manufacturing in strategically important regions and supports its customers through industry participation.

4REPAIR

4Repair is a specialized company known for its structural repairs and modifications during base maintenance, line maintenance and AOG repairs. 4Repair offers customers experienced and structured specialization, including tools, materials, and fasteners. 4Repair is able to professionally analyze damaged areas (keeping in continuous contact with the engineering department) and consequently inspect and carry out repairs.

TIAT EUROPE

TiaT Europe provides a complete professional package for training in non-destructive research. The training courses are tailored to the needs of the customer and can be provided on-location, where required. Level one or level two inspector/researcher training concludes with an exam that complies with the ASNT SNT-TC-1A, EN-4179, NAS-410 and/or ISO 9712 requirements.

AIRLINE TECHNICAL SUPPORT (ATS)

Airline Technical Support (ATS) specializes in providing technical expert line/base maintenance and re-delivery. ATS's services include performing various tests, physical inspections of the aircraft, and maintenance tasks for companies with EASA 145 approval. Airline Technical Support also maintains an open dialog with graduates from the Aircraft Maintenance Academy & Training School, essentially creating more opportunities for their clients and developing the students into future assets.

ACRATS TRAINING SERVICES

ACRATS specializes in developing and providing courses and training in manufacturing, repair of composite parts and other lightweight structures such as aluminum sheet metal, sealing compounds, and corrosion control. An optimal learning environment is created by linking practical assignments to realistic work practices. In addition, the necessary skills and competences are instilled, which makes the expert even more valuable in their daily work.

AIRBORNE SERVICES

Airborne Services provides maintenance and repair services for composite structures, specializing in helicopter rotor blades. The company mainly focuses on shortening the turnaround time and works closely with the Woensdrecht Logistics Center of the Dutch Air Force. The business unit is part of the Airborne International Group, which has been a specialist in the design and production of advanced composites for the aerospace industry for over 20 years.

STANDARDAERO

StandardAero is based at the Woensdrecht Airbase and, together with the Woensdrecht Logistics Center, makes up a public-private partnership for aircraft engine maintenance. StandardAero primarily provides maintenance, repair and overhaul activities for military aircraft engines.

AAR

AAR is a leading provider of airline services to the global commercial space and defense industry. AAR combines a close-to-the-customer business model with an array of opportunities to assist its clientele.

AIRCRAFT MAINTENANCE & TRAINING SCHOOL (AMTS)

Under its EASA Part 147 certification for Basic and Type Training, AM&TS tackles sector specific issues. Its main focus is to educate qualified staff, develop the curriculum, and expand innovative educational concepts. This has made AM&TS an important and indispensable link between aircraft maintenance education and the demands of businesses. AM&TS works with companies, education, and (local) government agencies to achieve its goal, creating levels of interconnection that contribute to innovation and (educational) renewals.

INNOVATION IN MAINTENANCE AND DEVELOPMENTS

Development Center of Maintenance or Composites	• Research and development of new techniques on testing and repair composites • Consortium of Fokker Technologies, Airborne, NLR, and TU-Delft
Smart (additive) manufacturing	• 3D (metal) printing for aerospace MRO • Field lab in collaboration with Additive Industries
PTMS (gas turbine) knowledge center	• Field lab for the development of a digital twin • Civil-military cooperation • Integral part of the establishment of Aeronamic at Aviolanda
LR Systems	• Manufacturing laser coating removal robots • Certification in progress (SWI) • Assembly robots by the NTS group

10. Overview of shared facilities and high tech outsourcing contractors

PROTOTYPING

Name	Activity	Markets
Additive industries	MetalFab 1: 3D metal printing	High tech systems
Philips Innovation Services	PCBA prototyping	High tech systems
DPI Value Center	Polymers	High Tech Materials
FabLab Brainport	3D printing/prototyping	High tech systems
MAD Emergent Art Center	Art vs Technology	Product design
TNO: Rapid Manufacturing Demonstration Center	3D printing, additive industry	High tech systems
Waag Society	Art, science, technology	High tech systems/design
Quirky	Product design	Design
Textiel Lab	Textile design	Design
Vectren	Prototyping: Automotive	Automotive
De Factorij	Laser cutter/vinyl cutter	Product design
TU/e: Equipment & Prototype Center	High Tech Systems	High tech systems
TU/e Wind Tunnel	Wind tunnel	High tech systems
Wonderlab-S	Product design	Design
Proven Concepts	Engineering and prototyping	High tech Systems

SIMULATION

Name	Activity	Markets
TU/e Simulation Lab	Polymers	Plastics
Philips Innovation Services: Drop test simulations	Drop test	High tech materials
Philips Innovation Services: Reliability Lab	Environmental simulation	High tech materials
Philips Innovation labs: EMC & Wireless Connectivity lab	Electromagnetic Compatibility & Wireless Connectivity	High tech systems
Improvia	Flow & thermal simulations	High tech materials
MedSim	Medical Simulation	Health
Eindhoven Diabetes Education Simulator (E-DES)	Education on diabetics	Health
TASS International Driving simulator	Traffic simulator	Automotive
Solliance: Hybrid Solar Cell tester	Solar cells	Solar energy
Informed	VR patient information	Health
VisitU	VR patient information	Health
Automotive Campus: Lucas Nülle Unit	Simulator for a complete vehicle through software and hardware-in-the-loop	Automotive
Automotive Campus: Rolling Road Test Bench	One of the biggest rolling roads of Europe on site	Automotive

LIVING LABS

Name	Activity	Markets
Strijp-S	City renewal/creating creative technology hotspot	Design/creative
Slimmer Leven 2020 Brainport Healthy Living Lab	eHealth for patients and nurses	Health
Stratumseind 2.0 Living Lab	Public safety	Security
Eckart Vaartbroek Living Lab	Energy & health	Health/energy
Living Light Labs	Interactive Smart Lighting Solutions	Lighting
TU/e: Solar-Powered Vehicles	Participant in the World Solar Challenge	Solar/automotive
TU/e: Living Lab Light	Light experiments at TU/e Campus	Lighting
TU/e: Smart Mobility	Experiment smart mobility students and personnel TU/e	Automotive

INNOVATION ACCELERATOR

Name	Activity	Markets
TU/e Eindhoven Engine	Innovation acceleration	HTSM/Health/Mobility
TU/e Innovation Lab	Translating scientific and technological discoveries into solutions that contribute to societal challenges	HTSM
TU/e SURE Innovation	Connect master students to companies	HTSM
HighTechXL	Innovation acceleration	HTSM
Blue Accelerator	Innovation network	HTSM/AgTech
EIT Digital	Digital innovation	ICT
LifeTec Group	Life science Innovations	Health
Lumo Labs	Product design	Design
NextMove	Innovation network/advice	HTSM/health
Health Innovation Campus	Health innovation	Health
Metropool Regio Eindhoven	Innovation vouchers	HTSM
Fontys Center for Entrepreneurship	Education entrepreneurial skills	
Chamber of commerce (KvK)	Advice on innovation	
RVO Octrooi Centrum	Governmental patent center	

CONTRACT MANUFACTURING

Name	Activity	Markets
AAE Advanced Automated Equipment	High-precision machine parts	HTSM
Anteryon	Fiber, optical solutions	HTSM
Anubiss	Electronics/PCBs	HTSM
Assembleon Netherlands	Global developer and manufacturer of assembly equipment used in the electronics industry	HTSM
Axxicon Moulds Eindhoven	Ultra-precision dies and molds	HTSM
CCM Centre for Concepts in Mechatronics	Mechatronics: industrial printing, engineering	HTSM
De Rooy Slijpcentrum	Specialized grinding	HTSM
Edumar Metaalbewerking	Machine parts, turning and milling	HTSM
Famar	Cosmetics	Chemicals

CONTRACT MANUFACTURING (CONTINUED)

Name	Activity	Markets
Fokker Landing Gear	Landing gear	Aerospace
Frencken Mechatronics	Mechatronics, mechanical engineering	HTSM
GL Precision	Machining, laser, cleanroom	HTSM
KMWE Precision Technology	Mechatronic systems	HTSM
Kusters & Bosch Fijnmechanische Industrie	Laser cutting, typesetting, welding, turning, and milling	HTSM
Lastechniek Best	Machinery and Equipment manufacturing	HTSM
Lemmens Metaalbewerking	Machine parts, machining, milling	HTSM
Leves Metaal	Machine parts, turning and milling	HTSM
Machinefabriek Kusters Goumans	Machine parts	HTSM
Manufacturing Technical Assemblies (MTA)	Mechatronic systems	HTSM
Mecal Applied Mechanics	Engineering	HTSM
Metaalindustrie Feijen	Laser cutting, typesetting, welding, turning, and milling	HTSM
Mogema	Tech expert in welding, machining, and vacuum technology	HTSM
Neways Industrial Systems	Printed circuit boards (micro) electronics and cable solutions to complete box-built products and systems	HTSM
NTS Group	Mechatronic systems	HTSM
Rols Machineonderdelen	Machining, milling, welding, machine	HTSM
Smits Fijnmechanische Draaierij	Machine parts, turning and milling	HTSM
Smits Fijnmechanische Frezerij	Machine parts, turning and milling	HTSM
Smits Machinefabriek	Machine parts, turning and milling	HTSM
VDL Group	Mechatronics systems, cars	HTSM/automotive
VERMO	High-quality mechanical components from different materials (steel, stainless steel, aluminum, bronze, brass, copper, titanium, and plastics).	HTSM

SHARED CLEANROOMS

Name	Activity	Markets
TU/e: Equipment & Prototype Center	Cleanroom class 1,000 – 10,000/mini-environments class 10 – 100/High Tech Systems	HTSM
TU/e: Nanolab@TU/e	Cleanroom (ISO Class 6): Photonic and Nanotechnology	Semiconductor
TU/e: Micro FabLab	Cleanroom for health innovation	Health
High Tech Campus: Philips Innovation Services	Cleanrooms (ISO 5, 6 and 7 class cleanroom (equivalent to 100 – 10,000 FED standard class)	Health/HTSM
High Tech Campus: Holst Center	Cleanroom flexible electronics	HTSM/health

SHARED 3D PRINTERS

Name	Activity	Markets
Additive industries	MetalFab 1: 3D Metal	High tech systems
Fontys 3D Printing/Objexlab	3D printing/Additive industries	HTSM
TUE/e 3D Concrete Printing	3D Concrete printing	Construction
TU/e and TNO: AMSYSTEMS Center	3D printing multi-materials	HTSM
FabLab Brainport	3D printing/prototyping	HTSM
Shapeways	3D printing/product development	HTSM
TNO: Rapid Manufacturing Demonstration Center	3D printing/additive industries	HTSM

SHARED MACHINE PARKS

Name	Activity	Markets
AM – Lab: Additive industries and Brainport Industries	3D printing machine parts	HTSM
Brainport Industries Campus	Multiple applications & expanding	HTSM

SHARED LABS

Name	Activity	Markets
TU/e: Nanolab@TU/e	Photonics and nanotechnology	Semiconductor
TU/e: Micro FabLab	Cleanroom for health innovation	Health
TU/e: Center for Multiscale Electron Microscopy (CMEM)	Study of soft materials and use of the knowledge gained to develop synthetic materials	Health
TU/e: Center for Wireless Technology (CWTe Lab)	Research on wireless systems and antennas	HTSM
TU/e: Darcy Lab	Unique MRI facilities specially equipped for researching the properties of technological porous materials	HTSM
TU/e: Future Fuels Lab	Green fuels and cleaner combustion methods for engines	Automotive
TU/e: High Capacity Optical Transmission Lab	Innovative optical fibers and signal processing techniques to enable transmission of ultra-high capacity	HTSM
TU/e: Institute for Complex Molecular Systems	Complex molecular systems	Chemicals/Plastics
TU/e: Multiscale lab	Research on the deformation and failure behavior of composite materials	High tech materials
NanoAccess	Produce, process, and analyze innovative materials with nanometer accuracy, without releasing the necessary vacuum	High tech materials
SolarLab	Apply atomic layers to solar cells	Solar
Philips Innovation Services: Electromagnetic Compatibility & Wireless Connectivity lab	• Electromagnetic compatibility (EMC) • Wireless approbation • Wireless robustness (multipath performance, total radiated power, antenna diagrams) • Electrical safety	HTSM
Philips Innovation Services: Material Analysis lab	• Compositional analysis	
	• Surface and thin-film characterization	
	• Advanced imaging • Physical characterization	High Tech Materials

Sources: TU/e, High Tech Campus, Automotive Campus, Holst Center

Continued on next page >

SHARED LABS

Name	Activity	Markets
Philips Innovation Services: Reliability lab	• Environmental simulations • In-situ test service • Highly accelerated lifetime test (HALT) • Mechanical tests • Water vapor transmission test (WVTR) • Calcium test on thin-film barriers	HTSM
Twice: business complex Catalyst (TU Campus)	Electrical engineering, physics, and (bio)chemistry	HTSM/life sciences & health/chemicals
Twice: business complex Bèta (High Tech Campus)	Research & Development	HTSM
Twice: business complex Mu (High Tech Campus)	R&D focused on New Energy & LifeTech	Energy/life sciences & health
Permanent Future Lab Strijp-S	Robotics, virtual reality and Internet of Things	
Holst Center labs	Flexible electronics	HTSM/health/energy

Sources: TU/e, High Tech Campus, Automotive Campus, Holst Center

7. COOPERATION IN BRABANT AND NETWORKS (BUSINESS, SCIENCE, GOVERNMENT)

A. Cooperation in Brabant - History, Culture, Past & Present

INTRODUCTION

Brabant has a distinctly strong culture, history and tradition of informal constructive partnerships that are based on trust and 'open innovation'. This is particularly evident in the following respects, along with numerous others:

- The fact that some of Brabant's largest companies (VION, Cosun/SuikerUnie, FrieslandCampina) have a history of working together
- The century-old roots of some of the region's industrial giants and the fact that these companies are completely intertwined with the development of the region, the cities, the universities, the schools, housing, leisure, the football clubs, and so on (Philips in Eindhoven, MSD via Organon in Oss, MSD Animal Health through Akzo/Intervet and Hendrix in Boxmeer)
- The fact that Philips decided, 17 years ago, to open up its originally hermetically-sealed NatLab research site in Eindhoven and began to invest in 'open innovation' by inviting other companies to join in. The company invested hundreds of millions of euros in further developing the campus and facilities to optimise joint research, the result being the Philips High Tech Campus. The site, located in the middle of Eindhoven and home to 12,000 researchers from over 200 companies and institutes from around the world, is now owned by a property investor and named the Eindhoven High Tech Campus (HTCE). Key tenants remain Philips Healthcare, Philips Research and Signify (formerly Philips Lighting) as well as NXP, ASML, Holst Centre and Xeltis.
- The concept (joint research, shared facilities, intensive cooperation and significant outsourcing when it comes to drug discovery and development) and success of the Pivot Park biopharmaceutical campus in Oss.

The advantages of this culture are that cooperative ventures, both informal and highly intensive, are ingrained in the area. Many CEOs in the region, the mayors and councillors of the cities and knowledge institution academics are regularly cited as saying 'the door is always open, so don't hesitate to drop by', 'we make the best decisions sitting at the kitchen table' and 'we know each other's mobile phone numbers and we pick up the phone whenever we see a friend is calling'.

In short: building partnerships in the region is a quick and fluid process – and faster than anywhere else in the Netherlands. Outsiders who wish to join the club and make an actual contribution will quickly and easily reap the rewards.

CONNECTING GLOBAL GIANTS: BRABANT'S INDUSTRIAL ICONS

In Brabant a number of key ingredients have been fruitfully mixed together for over a century, creating one of the strongest high tech systems regions in the world:

- Entrepreneurship
- Corporate social responsibility
- Cooperation and open innovation
- Technology-focused in nature, but roots in Healthcare & AgriFood too
- Strong regional pride and loyalty, yet
- Focus on a global market

The growth of three remarkable Brabant business families in the past century exemplifies and characterizes how this region developed to attain its current strong position and open approach to working and partnerships. Three extraordinary individuals started businesses here that developed into three connected clusters of companies.

Clusters, ecosystems if you will, consisting of dedicated tier 1, 2, and 3 suppliers (often highly specialized SMEs) and renowned research institutes all the way through to engineering companies, system integrators, software developers, certification bodies, and a number of global multi-billion dollar OEM companies.

These three individuals were Frederik Philips, Saal van Zwanenberg and Wim Hendrix.

- In 1891, Frederik Philips built a modest light bulb factory in Eindhoven
- Saal van Zwanenberg founded a slaughterhouse for export in 1887 in Oss
- Wim Hendrix started off selling chickens in Boxmeer in 1916

They all started out small, some of them on their own. But their businesses grew, flourished, diversified and have been entering new markets ever since. And, in the process, the parent companies have bred hugely successful subsidiaries and spinoffs:

- Frederik founded Philips, today's Royal Philips (Healthcare), a global 18 billion euro-company with 74,000 employees that also gave birth to other icons, such as ASML, FEI Company, Thales and NXP, all of them still headquartered in the region or with their global research centres based in the province
- Saal started Zwanenberg, which became Organon and then Chefaro, and is part of today's MSD (Merck) that focuses on human health and specialises in pharmaceutical and biological research and manufacturing, including one of the world's latest cancer treatments, Keytruda (pembrolizumab)
- Wim started selling chickens to farmers, after which his entrepreneurial spirit saw companies born that grew to become Hendrix Genetics, MSD (Merck) Animal Health (formerly Intervet), Nutreco and Marel Poultry

All of these companies still have their headquarters and/or significant research and innovation operations in Brabant, employing thousands of highly-trained professionals.

And around them, the full value and supply chains in their core businesses developed, flourished, and grew, resulting in a region that is now home to three priority industries:

- High Tech Systems & Materials
  over 15,500 companies and nearly 130,000 employees
- Life Sciences & Health
  over 900 companies and more than 18,000 employees
- AgriFood
  close to 14,000 companies and more than 80,000 employees

Today, industry and science in Brabant in these sectors still leads the way, but cross-overs are also increasingly occurring between the three, with new solutions developed in areas such as:

- Imaging, monitoring, and guided surgery
- Big data and smart algorithms in animal husbandry
- Vision and sensor technology for welfare monitoring
- Needle-free, intradermal vaccination devices
- Flying cars
- Electric cars fueled only by solar panels
- Indoor farming systems
- New cooling technologies for ICs and data centers
- Communication technologies using lasers
- Direct air capturing of CO
- Hydrogen fueling systems and processing technology
- Precision farming using drones and satellites
- Autonomous weeding robots
- And many, many more

100 YEARS OF ROYAL PHILIPS GROWTH AND ITS VERY HEALTHY DESCENDANTS

Some of the spinoff companies involved have grown to similar sizes and have a higher stock market valuation than their Philips parent: ASML (with a turnover of 14 billion euros in 2020), FEI (now Thermo Fisher Scientific), and NXP (with a turnover of 8.6 billion USD in 2020), to name a few.

The tree gave rise to a new branch in 2019 – Signify (formerly Philips Lighting) has gone public and is a separate entity with a workforce of almost 38,000 people and a turnover in 2020 of 6.5 billion euros.

BRAINPORT INDUSTRIES

WHAT IS BRAINPORT INDUSTRIES?

More than a 100 tier 1, 2, and 3 suppliers in the open high tech supply chain in the Netherlands have joined forces to create Brainport Industries, an umbrella under which they design, develop, and manufacture leading, advanced, precise, and intelligent high tech components and equipment.

OEMs competing on the international market for high-mix, low-volume, high-complexity machines have been outsourcing the manufacturing of subassemblies and larger noncore submodules to strategic suppliers for quite some time, and are now also increasingly outsourcing the design and development of the equipment they manufacture. The upshot is that suppliers are given full responsibility for these modules, from design through to manufacturing.

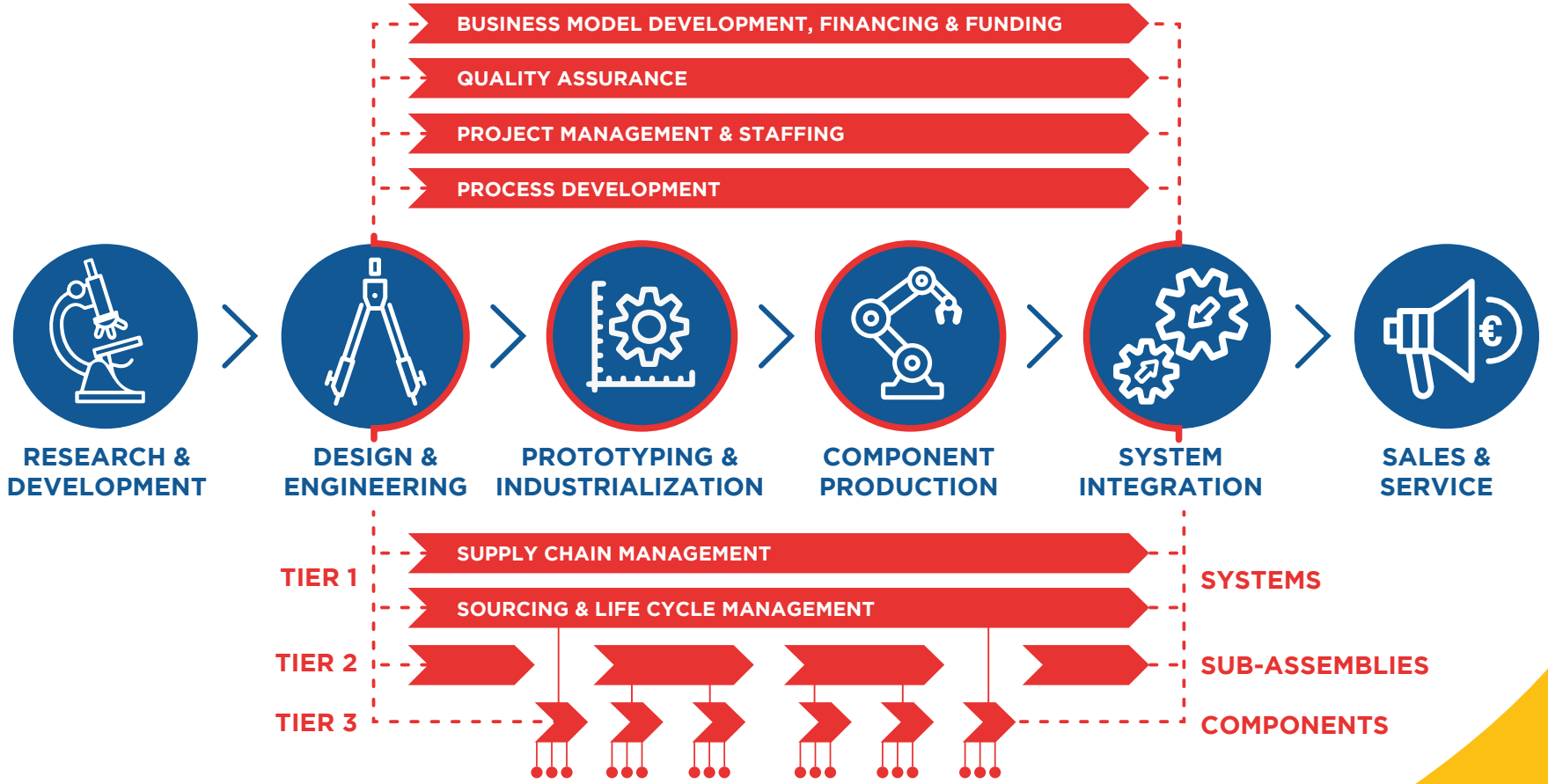
This shift is driving suppliers to push their own boundaries in terms of feasibility and responsibility, and to extend their reach across international borders in order to tap into new foreign markets. Brainport Industries provides a breeding ground and a solid framework for collaborative projects in technology, market, and people development. It is an environment that provides for a continuing flow and exchange of knowledge workers and experts and enables suppliers to strengthen their knowledge base, increase their output, and steadily grow into market leaders.

BRAINPORT INDUSTRIES: THE GLOBAL OPEN SUPPLY NETWORK FOR HIGH TECH COMPANIES

Together, the members of Brainport Industries create a unique ecosystem that can manage the entire supply chain for high-mix, low-volume and high-complex systems, sub-assemblies and components.

BRAINPORT INDUSTRIES

Any member company can grant clients easy and quick access to a wide variety of technology and high tech facilities. It is also easy to ramp up operations, as the members of Brainport Industries know each other well and work together on a regular basis.



Source: Brainport Industries

SERIES PRODUCTION OF CUTTING-EDGE TECHNOLOGY

The members of Brainport Industries design and manufacture very complex systems, subassemblies and components in series. They have a proven track record and long-standing B-2-B relationships with companies such as Philips, ASML, and FEI (Thermo Fisher Scientific), and are active in markets such as high tech, semiconductors, automotive, analytical, medical, printing, and photovoltaics.

A SELECTION OF BRAINPORT INDUSTRIES MEMBER COMPANIES:

Axxicon Moulds, Bestronics, BKB Precision, Bronkhorst Flow Technology, Ceratec Technical Ceramics, DEMCON, Eurofins Materials Science, Fujitsu Glovia, Gain Automation Technology, Goudsmit Magnetics, KMWE Toolmanagers, Mevi Advanced Technology, NTS Group, Philips Innovation Services, Sioux Technologies, TMC Group, Unicorn Industrial Cleaning Solutions, Van Veghel Industrial Packaging, VanBerlo Group, and YASKAWA.

B. International cooperation

The fact that cooperation is in Brabant's DNA can also be seen in cross-border cooperative ventures, whether they are regional or national borders.

HISTORICALLY OUTWARD-FOCUSED

International cooperation in innovation, trade and investment is a longstanding Dutch and Brabant tradition. The Netherlands is a global trading nation of many centuries' standing.

In high tech systems these international links might not be centuries old but they are still decades old, given that Royal Philips started distributing its consumer and business electronics globally in the 1950s and 1960s. This eventually led to building factories in Asia and the US and connecting with local supply chains, partnerships that have continued to develop in every aspect since.

GLOBAL SUPPLY CHAINS

Global supply chains are in place for the semiconductor and/or high tech healthcare industries, for example. Semiconductor fabrication equipment built in Eindhoven by ASML and its suppliers is exported predominantly to Asia and the US. Meanwhile, topnotch medical equipment is not only exported to the US in large quantities, Philips and its suppliers have also invested heavily in US manufacturing plants.

This means that Brabant OEMs (Philips, ASML, NXP, and DAF) and their suppliers (NTS, Sioux, VanBerlo, VDL, Frencken, and many others) have been operating at levels of success on an international level for a long time.

OPEN INNOVATION

Welcoming international partners is also a prerequisite for open innovation. The fact that the High Tech Campus in Eindhoven is home to so many foreign companies performing key research activities proves that they feel welcome and secure in the region.

The High Tech Campus Eindhoven is said to be the smartest square kilometer in Europe, with more than 220 companies and institutes and 12.000 researchers, developers, and entrepreneurs working on developing future technologies and products. It is a close-knit community of knowledge workers from 85 different countries.

Non-Dutch companies such as Shimano, Intel, NXP, IBM, ABB, Teledyne DALSA, Accenture, Capgemini, Cognizant, Dassault Systems, Eurofins, Huawei, ITRI, Siemens, Texas Instruments, and Wipro all have significant R&D operations at the High Tech Campus.

JOINT INTERNATIONAL RESEARCH

Even though it takes more effort to find foreign partners in innovation, international cooperation in R&D in Brabant is still on a significant scale. A perfect example is the international partnership in place in Eindhoven's Holst Centre since 2005, involving wireless sensor technologies and flexible electronics. The Centre (a joint venture of the TNO and imec, located on the High Tech Campus Eindhoven), with 180 employees from 28 countries, is based on open innovation and has 56 industrial partners and 45 ongoing funded projects in its 2020 portfolio. These partners are from around the globe.

INDUSTRIAL PARTNERS OF THE HOLST CENTRE

- Analog Devices (USA)
- ARM (UK)
- AsahiKASEI (JPN)
- ASM Assembly Systems (CHN)
- Bambi Medical (NET)
- BASF (GER)
- BioTelemetry (USA)
- Bloom (NET)
- Cloudtag (VCT)
- CPT (USA)
- Dätwyler (SWI)
- DSM (NET)
- DuPont (USA)
- eGIS (TW)
- Enmech (UK)
- Faurecia (FRA)
- FujiFilm (JPN)
- Global Foundries (USA)
- Heliatek (GER)
- Henkel (GER)
- HITACHI Maxell (JPN)
- Illumix (USA)
- Intrinsic ID (NET)
- Kanaeka (JPN)
- Lifesense Group (NET)
- MegaChips (JPN)
- Methods2Business (NET)
- Microsemi (USA)
- Mitsubishi Chemical (JPN)
- Murata (JPN)
- NeuroPro (SWI)
- NiKo (BEL)
- Niraxx (USA)
- NovaCentrix (USA)
- Orange (FRA)
- OrboTech (ISR)
- OSRAM (GER)
- Panasonic (JPN)
- Philips (NET)
- Renesas (JPN)
- Rexroth (GER)
- ROHM Semiconductor (JPN)
- Royole (CHN)
- SABIC (SAU)
- SALDtech (NET)
- Samsung (KOR)
- Sekisui (JPN)
- Shin-Etsu (JPN)
- Shinko Electric Industries (JPN)
- Silex Insight (BEL)
- SONY (JPN)
- SPG Prints (NET)
- Technospark (RUS)
- Tenflecs (RUS)
- VDL (NET)

The challenge for the future is enabling the smaller tier 2 and 3 suppliers in the Brabant HTSM industry to also expand their markets outside of the Netherlands. This growth requires funding, knowledge, experience, contacts, and market insights. The Brabant ecosystem is investing in all these building blocks, and has been doing this for a number of years.

Examples include:

- Brainport Industries – the open supply-chain branch organization for suppliers in HTSM – investing in training programs and knowledge exchange between large companies and smaller suppliers.
- Regional development agencies such as BOM, Brainport Development, REWIN, and Midpoint Brabant, providing training modules and coaching focused on expanding business in foreign markets.
- Joint trade and investment missions by Brabant's HTSM industry and the support agencies to the US, Asia, Israel, Germany, and other potential markets for finding buyers, innovation partners and even foreign HTSM companies interested in establishing a subsidiary in Brabant.

C. Successful public-private partnerships (PPPs) and networks

1. EINDHOVEN ENGINE

The Eindhoven Engine accelerates innovation in the Brainport Region through challenge-based research in its public-private research facility on the TU/e campus. Teams of the region's most talented researchers from industry, knowledge institutes and student bodies work together in Eindhoven Engine research programs to deliver breakthrough technological solutions.

The Eindhoven Engine unlocks the collective intelligence in the Brainport region. Thanks to a unique formula, innovators from companies can join forces with students and experienced researchers and employees from knowledge institutes to work together to accelerate innovation and create disruptive co-creation projects in which colocation is a prerequisite.

The founders of the Eindhoven Engine are the knowledge institutes Fontys, the TNO, and the Eindhoven University of Technology together with Philips Healthcare, Signify, ASML, VDL, NTS, and NXP. Eindhoven Engine's funds (75 million euros between 2019 and 2025) have been made available through the Brainport Regional Deal (national funding) and by industry partners.

INSPIRATION FOR THE EINDHOVEN ENGINE

The program is inspired by three regional and highly successful concepts:

1. The renowned former Philips NatLab (Philips Physics Laboratory) in Eindhoven, where boundaries between the various disciplines barely existed. In its heyday in 1975, NatLab employed some 2,000 people, including 600 graduate researchers. NatLab research ranged from product-specific work to fundamental research into electronics, physics, and chemistry, as well as computing science and information technology.
2. The successful Kenniswerkersregeling (Knowledge Worker Program) from the last economic crisis, when companies could temporarily outplace their R&D employees to a knowledge institute with a substantial subsidy.
3. The Eindhoven student teams, which have a knack for innovating quickly and disruptively. These teams have a proven track record in developing technologies and concepts that are leading on a global scale, such as solar powered cars, electric motorcycles, and autonomous soccer and care robots

Sources: with input from Bits & Chips, Alexander Pil, December 15, 2020

HOW HAS THE PROGRAM BEEN DOING?

In its first 18 months, the program issued three calls for proposals. "We had a very successful call this spring, with more than twenty interested parties, and ultimately eleven proposals," said Professor Maarten Steinbuch, initiator and scientific director of the Eindhoven Engine. "After a strict selection process by an independent committee, we accepted and launched six of them. Together with the five projects from the first call in 2020 and the four in 2019, the total now stands at 15 programs, with about 200 (part-time) researchers and students and private-sector engineers.

The Eindhoven Engine is also financially healthy. "It's a program of 75 million euros, of which 15 million has come from government," said Katja Pahnke, managing director of the Eindhoven Engine. The future calls will provide more clarity on the co-financing, but Pahnke expects that amount to be easily achieved and that projects can be financed for the next five years. "We are of course contemplating how to increase funding, including after 2025. I'm sure by then we will have shown that the concept works." The goal is to employ 500 engineers, researchers, and employees of social organizations over the next five years.

COLOCATION

Colocation is a requirement for the Eindhoven Engine. If companies and scientists wish to participate, they must spend part of their time at the offices and labs of the Eindhoven Engine. While this proved to be somewhat of a challenge during the COVID-19 pandemic, it gave Pahnke and her colleagues more time to renovate the Engine's homebase, the Multi Media Pavilion on the TU/e campus, or Hub 0, as they call it.

She immediately acknowledges it is a great loss that engineers cannot see each other regularly. "Cross-fertilization between disciplines and between research projects is one of the Eindhoven Engine's success factors. Because almost everyone works from home now, we were forced to think about how we could facilitate those unexpected encounters at the coffee machine in a different way. We have partly solved it with internal webinars and community events, but sometimes you need chaos and inefficiency to create crazy, inspiring conversations and ideas. Fortunately, I hear from project staff and students that they experience little delay, precisely because they can work calmly and with focus. But everyone is looking forward to a physical meeting place, with its dynamics, social cohesion, and room for creativity."

How does the Eindhoven Engine compare to EAISI? Both revolve around colocation with applied research performed where industry and science meet. "The Eindhoven Engine isn't part of the university like EAISI," said Steinbuch. "We're completely separate. Moreover, the Eindhoven Engine focuses on the broad spectrum of themes that are relevant to the Brainport Eindhoven region. We have projects from the high tech manufacturing industry, but also from architecture, life sciences, chemistry, and smart mobility. We include all the institutes of the TU/e, plus everything that happens at the TNO and Fontys, as long as it is relevant to the Brainport region. And the engineers from industry actually come to work on location. That is also different from research institutes such as the HTSC and EAISI, where only scientists from different faculties come together."

"EAISI could be a customer of the Eindhoven Engine," Pahnke explained. "Another clear distinction is that university institutes are often involved in more fundamental research. The Eindhoven Engine is much closer to the application. We aim for technology readiness levels TRL 4-6. Generally, this will be lower at EAISI."

RESEARCH EXAMPLES IN THE EINDHOVEN ENGINE

ASML – next-generation wafer stages

To illustrate the type of research performed in the Eindhoven Engine: ASML uses the disruptive nature of this environment to tinker with the next generation of wafer stages. The company is trying to get out of its comfort zone, free from its established design principles, to seek innovative alternatives. After all, a different perspective could lead to groundbreaking solutions. The researchers are trying to do this within the Eindhoven Engine project 'Advanced piezo-electric wafer stage'.

NXP: "We want real-time image recognition for use in cars"

The Eindhoven Engine project with NXP revolves around autonomous systems in cars for preventing accidents that occur due to unexpected situations or driver inattention, said Clara Otero Perez, head of Systems Innovations at NXP Automotive. "To begin with, you need to be able to measure with great accuracy where other vehicles and any other obstacles are located. Together with the TU/e, we are working on radar with Marion Matters' group, and on visual systems in collaboration with Gijs Dubbelman and colleagues. " Two PhD students will be appointed in the Eindhoven Engine in each of the two areas. There is also room for a postdoc, a PDEng trainee and ten graduates, said Otero Perez.

Because more and more cars are equipped with radar, there is a risk of misunderstandings, such as signals from other cars that are interpreted as those of your own car. To identify such ghost signals, cars could communicate with each other and match the frequency of their radar, or add their own 'label' to each radar signal so that its origin is immediately clear, she explained. "We also want to make the radar more accurate, so that you can recognize objects at a greater distance, and we also want to improve this for visual systems. Is an object a vehicle, a dog or a plastic bag? You don't want to make mistakes like that, so all false positives have to be removed." There is also the fact that image recognition already works well, but not yet in real-time, which is necessary to prevent accidents. "So we will be working with new algorithms for advanced neural networks, which are optimized for such tasks."

THE ULTIMATE GOAL OF THE EINDHOVEN ENGINE

"I think we'll have succeeded when, in a few years, employees of companies in the region will say to their boss: 'Can I take a sabbatical and work in the Eindhoven Engine for three months?'" Steinbuch said about the ultimate goal of the Eindhoven Engine. "I would be proud when the Eindhoven Engine becomes the place to be for researchers, engineers and others. Or in mechatronics terms, when we become the new Philips CFT (Center for Industrial Technology). I would also love it when similar initiatives arise in places like Munich, Lausanne, Aalborg, or Enschede. And finally, we would be over the moon when companies start a branch in the Eindhoven Engine as a disruptor for themselves."

EINDHOVEN ENGINE ENLARGED – PROPOSAL FOR SIGNIFICANT SCALEUP IN APRIL 2021

Management of the Eindhoven Engine has seen much increased interest in the current and potential contribution and role of the Eindhoven Engine, despite the COVID-19 pandemic. Four main developments have been noted:

1. An increasing need for a joint place of inspiration where it is possible to bring the knowledge and skills of knowledge institutes, industry, and civic organizations together. The objective is to create solutions at a rapid pace to societal challenges. Examples are subjects such as weed robots, a Dutch electrolyzer, organized crime undermining society, quality of life, and durable personal protective health equipment.
2. The interest from scaleups and SMEs in using this ecosystem demonstrates its success. It is precisely this category of industry that has outgrown the fledgling startup incubator, and struggles to find its way in the Netherlands.
3. Access to an innovation-driven community, the way of working, and especially the way of forming consortiums for innovation acceleration (methodical renewal, agile innovation) in the Eindhoven Engine have much added value for knowledge institutes and companies.
4. The 'war on talent' and the increasing pressure to stand out in order to attract and retain human capital, such as access to talented students (MSc, BSc from TU / e and Fontys) are a must for companies and knowledge institutions. This enables them to innovate and to attract and bind engineers of the future.
5. The interest in the Eindhoven Engine formula appears to be considerably higher than the current budget of 75 million euros allows.

The Engine consequently intends to launch the Eindhoven Engine Enlarged, a new phase with a broader range of tasks that will kick off as soon as possible.

For the Eindhoven Engine Enlarged – a scaleup of the Eindhoven Engine – an extra budget of 60 million euros over the next 5 years is required. Private sector matching of this amount is expected from industry, especially those under points 2 and 3 above, so that the total project size will exceed 120 million euros.

The proposed action points in the Eindhoven Engine Enlarged are:

1. Consortium formation and identification of opportunities for innovation aimed at solving the relevant societal issues (18.5 million euros).
2. Strengthening the current call structure for existing consortiums (30 million euros).
3. To function as an active landing site for larger startups and early scaleups, and as a follow-up to the One-Stop Shop star-up center, in close . collaboration with the other Brainport Campuses and accelerators, HighTechXL, Lumo Labs, and others (10 million euros).
4. Developing intensive links to the other campuses (both in the region and elsewhere in the Netherlands) and exploring other cooperation opportunities.
5. Challenge-based research into business innovation models, in combination with the Engine's own living lab for innovation acceleration. Disseminating the lessons learned and insights at international conferences. Sharing findings with other locations, within and outside of the Netherlands. Setting up several new PDEng (designer) courses focused on design, systems thinking, and business innovation (1.5 million euros).
6. Selecting modules of practical knowledge from the Eindhoven Engine projects so that these can be distributed and shared. Developing and providing course packages for life-long learning.

2. HIGHTECHXL

VENTURE-BUILDING AND STARTUP ACCELERATION

HighTechXL is a venture-building accelerator that builds teams of entrepreneurs and tech talent around the most advanced technology in the world: technology from CERN, the European Space Agency, the TNO, Philips, and other global innovators. As teams mature in the development program, HighTechXL helps them connect with the investors and mentors they will need to emerge as viable businesses.

HighTechXL is based on the High Tech Campus Eindhoven, right in the heart of Brainport Eindhoven's industrial innovation hub.

HighTechXL also works with multinationals in Europe and China, helping them become faster, leaner and more competitive. HighTechXL starts with next-gen technologies, including lasers and particle accelerators, carefully and strategically builds teams around that tech, then nine months later puts the new enterprises on the stage. HighTechXL started off in 2015 as a high tech startup accelerator and, six years later, over 60% of HighTechXL alumni companies are still alive.

Since its inception, HighTechXL has advanced 63 startups and created more than 20 deep-tech ventures, raising 122 million euros in venture capital and creating nearly 2,500 jobs. Some of the startups helped by HighTechXL are Accerion, Sustonable, Bambi Medical, Manus VR, Amber, and Sealeau. Deep-tech successes since 2018 include AlphaBeats, Carbyon, Dynaxion, Aircision, and Incooling.

OUR INSPIRED VALUES

WE ACCELERATE IMPACT PROJECTS BY MOBILIZING OUR GLOBAL NETWORK WORKING AT HYPER SPEED WITH GREAT PASSION FOR TEAMWORK AND INNOVATION TAKING FULL RESPONSIBILITY FEELING EMPOWERED BEING VERY PROUD MEMBERS OF A TRUE DIVERSE COMMUNITY.

TRANSITION TO DEEP-TECH VENTURE BUILDING

In 2018, HighTechXL announced its transition from high tech startup accelerator to a deep-tech venture-building company, which is more relevant to Eindhoven's ecosystem. Technologies that were explored were brought in by research institutes like CERN in Switzerland, the TNO in the Netherlands, and high tech companies like Philips and ASML.

Three startups were launched based on technologies developed at CERN, the particle research center in Switzerland. All three of those startups – Aircision, Dynaxion, and Incooling – have been, by startup standards, homeruns, raking in investments, making deals with international corporations, and getting global media attention:

AIRCISION

Aircision builds high capacity free space optics systems that can be deployed rapidly and that operate on a structured beam to deliver high reliability. The unique form of this technology will place Aircision's solution in the heart of high-precision systems of the future.

INCOOLING

Incooling adapted the unique properties of two-phase cooling originally designed to cool the largest scientific experiment on the planet, the Large Hadron Collider at CERN, and created a new generation of cooling systems dedicated to achieving the full potential of the data center industry. The cooling system is a direct-to-chip system installation, addressing the heat issue right at the source. A proprietary pressure control system allows for accurate temperature control in real-time, enabling best-in-class reliability and ensuring performance.

DYNAXION

Dynaxion developed a new-generation scanning solution for material identification for security purposes: scanning parcels, suitcases, and freight for dangerous and illicit content such as explosives and drugs. The scanner technology is based on particle accelerator technology and neutron-generation and is both non-invasive and fully automated. As opposed to x-ray scanners, Dynaxion's technology creates energy spectrums of the materials inside so that the scan is more specific and accurate and hidden goods can be detected. Dynaxion can distinguish between milk powder and cocaine and between maple syrup and nitroglycerine.

Two other phenomenally successful deep-tech start-ups are AlphaBeats and Carbyon:

ALPHABEATS

AlphaBeats is an Eindhoven-based deep-tech venture that uses Philips neurofeedback technology and implicit learning to lower stress by up to a factor of three by listening to whatever music one wants for as little as 10 minutes per day. AlphaBeats directly improves quality of life, making users feel fitter and healthier and giving them a higher level of resilience.

CARBYON

Carbyon has developed a technology to capture CO2 from ambient air. This allows the energy industry to produce 100% circular and renewable fuels using renewable electricity. Carbyon's unique solution enables the renewable energy sector to create fuels from water and air in a closed loop, powered by renewable electricity. Using this process, the consumption of the fossil fuels, oil and natural gas that cause worldwide climate change can be ended.

HIGHTECHXL TEAM AND DIVERSITY

The HighTechXL team's mission is to build high-performance teams so they become fast-growing deep-tech ventures. HighTechXL believes a diverse team is crucial for the success of any startup, and openness to diversity is evident on every level at HighTechXL, be it in terms of culture, age, or gender. The HighTechXL team has a male-female ratio of 60/40 and more than a dozen nationalities, with 55% are non-Dutch while 45% are Dutch. "We have cultivated a dream team of diverse individuals that, together, make everything happen. We are passionate, caring, resilient and – above all - fun people who choose to work on complex things that matter," says HighTechXL.

HIGHTECHXL'S PARTNERS AND CLIENTS

HighTechXL's partners and clients are diverse, ranging from large Netherlands-based high tech companies to research institutes and from Dutch regional development agencies to international financial consultancy firms and banks.

3. E/MTIC - EINDHOVEN MEDTECH INNOVATION CENTER (E/MTIC)

Improving value-based healthcare by creating and expanding an ecosystem to enable fast-tracking high tech health innovations. Taking technical innovations all the way from initial research through to implementation and commercialization can often take a long time and, especially in healthcare innovation, this lost time often equates to lost lives. The goal of the Eindhoven MedTech Innovation Center (e/MTIC) is to create and develop an ecosystem that dramatically accelerates the speed of high tech health innovation, maximizing value for patients.

PARTNERS

e/MTIC is a large-scale research partnership between the Catharina Hospital (CH), the Maxima Medical Centre (MMC), the Kempenhaeghe epilepsy and sleep center (KH), and the Eindhoven University of Technology (TU/e) in the fields of cardiovascular medicine, perinatal medicine and sleep medications. This partnership has evolved over several decades, has a strong scientific and commercialization track record and currently involves around a hundred PhD students, supervised by a similar number of experts from the various partners.

E/MTIC DEVELOPMENTS AND SPINOFFS

- **MEDSIM:** the Máxima Medical Centre is working with Medsim and Nemo Healthcare to provide simulation training using the world's most lifelike childbirth simulator, called Victoria. She is anatomically accurate and contains state-of-the-art pregnancy monitoring technology. Over 60% of Dutch obstetricians have been trained using her, and the consortium hopes it can also be used to contribute towards reducing maternal and perinatal mortality in Africa, the Americas and Asia.

- **SMART BABY BOTTLE:** the Smart Baby Bottle is a sensor-equipped sleeve that tracks bottle-feeding routines and provides parents with personalized advice regarding their baby. This data-intensive sleeve was developed in collaboration with end-users, first exploring what data will be of value and then validating the design using prototypes. Philips AVENT is currently developing the bottle for product launch.

- **SMART MONITORING:** hypertension, obstructive sleep apnea and atrial fibrillation are highly prevalent (affecting over 30%, 9% and 2% of people respectively) and underdiagnosed conditions. If left untreated, patients are at elevated risk of developing further incapacitating medical conditions such as strokes and heart failure. The e/MTIC partners are developing self-monitoring solutions for patients using unobtrusive wearable sensing technology integrated in watches or patches for timely detection.

- **3D NEEDLE:** ultrasound (US) imaging is widely used to visualize and guide needle and catheter procedures, but is very challenging and the failure rates are considerable (between 25% and 50%) while complications frequently arise (in between 5% and 15% of cases). The key problem is that the field of view is limited by the US beam width, requiring the probe to be extensively and manually repositioned. This is complex and error-prone, because of imaging artifacts and low signal-to-noise ratio. A new solution using a 3D US probe overcomes these problems to a radical extent by automatically detecting and visualizing the entire instrument. This enables the physician to be fully focused on a procedure, while easily and accurately guiding the instrument.

e/MTIC
Eindhoven MedTech Innovation Center

4. THE AI INNOVATION CENTER

The AI Innovation Center is an open innovation facility at the High Tech Campus Eindhoven. Its mission is to accelerate the application of data science and artificial intelligence technologies by companies in the larger Brainport Eindhoven area.

The Center is an initiative of the High Tech Campus Eindhoven and was co-founded by Brainport Eindhoven giants Philips, ASML, NXP, and Signify. It aims to drive the adoption of AI by companies of all sizes, improving the regional economy and society.

To achieve this mission, the AI Innovation Center brings together technology companies, platform and service providers, research and educational institutes, and other relevant ecosystem partners in a shared facility.

The AI Center focuses on:

- Providing an AI ecosystem and infrastructure
- Accelerating AI projects and applications
- Hosting AI events and education

INNOVATION CENTER
BRAINPORT

AI ECOSYSTEM AND INFRASTRUCTURE

The AI Innovation Center is an open ecosystem for large companies, startups, SMEs, research and educational institutes, and service providers. All activities are focused on stimulating organizations to apply data science and AI technologies.

AI PROJECTS & APPLICATIONS

The AI Innovation Center, together with its partners, helps companies to get off the ground in applying AI. Whether it is a startup or SME that wants to get more out of its data, or a mature data science and AI technology company looking for the right talent to execute a project, the AI Innovation Center is the place to find the solutions.

The AI Innovation Center is also the place to be for AI application demos to a broad audience. Conveniently located in the heart of the High Tech Campus Eindhoven, on The Strip, the Center has all the amenities to showcase a company's skills.

For the most promising startups, the AI Innovation Center offers an incubation period of six months – a soft landing spot. In this period, the startups get (flexible) office space in the Center and access to all relevant knowledge and partners in the ecosystem.

EVENTS AND PROFESSIONAL EDUCATION

Knowledge-sharing has been a vital aspect for the open innovation culture at the High Tech Campus Eindhoven. The AI Innovation Center builds on this tradition driving and facilitating knowledge-sharing on AI-related topics. The Center hosts open sessions to get people and organizations onto the learning curve or to keep experienced professionals updated on the latest developments in AI. A professional education portfolio is being prepared with partners.

5. 5G HUB BRAINPORT EINDHOVEN

The world is changing at an ever-increasing pace. A range of forecasts say that 80% of the worldwide population will live in megacities by 2050, a fact that requires a different approach to topics like sustainability, health, and inclusion.

CONSORTIUM

Ericsson, VodafoneZiggo, High Tech Campus, and Brainport Development have formed a powerful consortium, 5G Brainport Eindhoven, with the 5G Hub located at the High Tech Campus as its heart. The consortium researches and tests the potential of new technologies and it stimulates innovative applications thereof. This not only concerns 5G, but also artificial intelligence (AI), virtual reality (VR), augmented reality (AR), blockchain, photonics, and many other spheres.

AMBITION

The consortium aims to improve the quality of life and economic appeal of Brainport Eindhoven through new technologies, by working together with the complete ecosystem of startups, established companies, knowledge institutes, public agencies, and political bodies. The consortium is partnered with the Ministry of Economic Affairs in the Brainport National Agenda for Action, which means the solutions devised by the 5G Hub in Brainport Eindhoven can be scaled-up relatively quickly to the rest of the Netherlands.

The local network ranges from politicians and administrators to researchers and entrepreneurs. For example, consortium member Brainport Development is the economic development company that stimulates innovation and growth in the region on behalf of the 21 municipalities in southeast Brabant. They are behind the efforts of the 5G Hub. The same applies to the over 200 companies that are a part of the High Tech Campus, from Philips, DAF Trucks and ASML to promising startups.

5G HUB RECEIVES TWO ACCOLADES AT 2020 COMPUTABLE AWARDS - NOVEMBER 2020

5G Hub is the proud winner of two categories of the 2020 Computable Awards: Hardware & Infrastructure and Digital Innovation. Backed by Computable.nl and assessed by an independent jury, the awards showcase innovative achievements in the IT industry.

Seen as "an indispensable link in the introduction of the fifth generation of mobile internet in the Netherlands", 5G Hub's project was highlighted in the Hardware & Infrastructure category. The Connected Ambulance project received the Digital Innovation award, and 5G Hub's partnership with Philips, the GGD Brabant-Zuidoost (the regional healthcare services organization), and the Catharina Hospital exhibits "the possibilities of 5G for healthcare. 5G makes it possible to send more data and to give priority to data traffic by means of network slicing. For example, a reliable connection can be created between a doctor in the hospital and an ambulance team."

The 5G Hub team welcomed the news with enthusiasm. Rene Visser, 5G Hub board member for VodafoneZiggo, said that the award "is true recognition of the strong message of 5G Hub." For him, the ecosystem is key: "We need to work together to achieve results. That is the power of co-creation with so many remarkable organizations."

8. GOVERNMENT SUPPORT

A. Government support structure

On a national level, the Dutch national and regional authorities work together through the Invest in Holland consortium to help foreign companies to establish themselves in the Netherlands. The national investment agencies NFIA (the Netherlands Foreign Investment Agency), HIDC (the Holland International Distribution Council) and all Dutch provinces, regions and metropolitan areas work together under the Invest in Holland brand.

In the province of Brabant, a broad support structure has been developed by regional and local governments for AgriFood companies. The provincial government and the municipal authorities of all the larger Brabant cities generally have a positive, practical and supportive attitude towards the industry and want to see it prosper in the region. Teams of professionals exist in many organisations for providing operational and strategic support to AgriFood, including BOM, Brainport Development, REWIN, AgriFood Capital, the High Tech Campus Eindhoven team, the TU/e team, and many others.

Four operational government agencies in Brabant have been specifically established to support industry:

- **BOM - Brabant Development Agency**
- **Brainport Development Eindhoven**
- **Holland Expat Center South**
- **Midpoint Brabant**
- **REWIN West Brabant**

1. Invest in Holland/NFIA

Under the name of Invest in Holland (IiH), the Netherlands Foreign Investment Agency (NFIA) – an operational branch of the Ministry of Economic Affairs – has joined forces with the Ministry of Foreign Affairs and several regional partners in the Netherlands. This network represents and promotes the Netherlands abroad as an attractive location for investments or establishing businesses. It also provides support to foreign companies that are setting up or expanding their international activities in the Netherlands.

SERVICES

- The NFIA provides information, practical assistance and advice to foreign companies
- It was founded 40 years ago as an operational unit of the Dutch Ministry of Economic Affairs
- It is responsible for identifying and attracting direct investments (green field or expansion) from companies that could be made in various countries, including the Netherlands
- It provides access to a broad network of business partners and government agencies
- It is headquartered in The Hague and has a staff of 35
- NFIA initial support is provided abroad through its 27 offices and representatives around the world, staffed by around 75 people
- The NFIA works closely with embassies, consulates and other organisations that represent the Dutch government around the world, as well as with a broad network of partners in the Netherlands

www.investinholland.com

2. High Tech Systems & Materials Priority Industry, a.k.a. Holland High Tech

The High tech Systems and Materials (HTSM) Priority Industry brings together the technology industry and research organizations in the Netherlands into a world-class value chain of bottom-up collaboration and close interaction with the national government. HTSM develops key enabling technologies (KETs) for solutions to the major societal challenges of our time by creating products and services that make those solutions economically feasible. HTSM technologies are omnipresent in consumer and business applications, ranging from telecommunications, the internet, and energy supply through to medical instrumentation, automobiles, airplanes, and satellites.

The core process in the HTSM Priority Industry is the broad stimulation of public-private partnerships through bottom-up teams, with open and transparent participation by large and small enterprises, institutes and universities, government ministries, and regional public agencies.

The Dutch HTSM industry is one of nine Priority Industries in the Netherlands, as designated by the Dutch Ministry of Economic Affairs and Climate Policy. The HTSM Priority Industry is governed by a Top Team of leaders from industry, academia, and government, and is supported by a secretariat from industry, research organizations, and the Ministry of Economic Affairs and Climate Policy.

SERVICES

Holland High Tech (HHT) is the top consortium for knowledge and innovation in the HTSM Priority Industry. It coordinates the programming of public-private activities with academia and industry. The HHT provides the secretariat for the HTSM Priority Industry, in close collaboration with the Holland High Tech Partners.
The HHT Foundation is governed by a board of executives from the public and private sectors, and the HTSM Top Team members are a part of this board. Day-to-day management of the foundation is delegated to the Holland High Tech director, who is supported by an HHT office.

R&D programming for the Priority Industry is mandated to the HTSM Roadmap Council, with the Council's members chairing the Roadmap Teams. Each roadmap is kept up to date by a team of experts from public and private organizations and chaired by an industry representative.

Holland High Tech is mandated by the Ministry of Economic Affairs and Climate Policy to execute the public-private partnership grant instrument for R&D and the MIT scheme for networking activities and innovation brokerage in the HTSM Priority Industry. The Dutch National Research Council (NWO) supports the HTSM-KIA through an annual call for collaborative research projects within the scope of the combined HTSM roadmaps.

www.hollandhightech.nl

3. BOM - BRABANT DEVELOPMENT AGENCY

SERVICES

When companies are in the process of relocating, setting-up a new subsidiary or expanding their operations, they need the essentials to be taken care of quickly and comprehensively. BOM Foreign Investments was established to be the industry's partner for every one of those steps, providing a wide range of services and support that save on both time and money and clear any obstacles. BOM has a local team of experts available that provide free support for a wide range of matters – whether it be issues with building permits, finding new premises or sites for development, questions on employment law, understanding tax incentives or help with business development, networking and the creation of consortiums for joint research and innovation.

Based in Tilburg, BOM Foreign Investments is part of the Brabant Development Agency (BOM), which is staffed by 85 highly specialised professionals. In order to facilitate foreign investment in Brabant, the team combines its services with the unique expertise and support of their colleagues working in complementary fields within BOM, expertise that includes managing R&D programmes, initiating innovative industrial cooperative projects and venture capital funding.

1. SUPPORT FOR FOREIGN COMPANIES – THE STRENGTH OF BRABANT; A WORLD-CLASS ECONOMY

Located centrally in one of the world's largest markets and with a supply industry and a world-class knowledge economy, Brabant is an attractive location for many foreign companies. BOM Foreign Investments highlights the strengths that Brabant offers and assists newcomers and established foreign companies alike to fully utilise the province's opportunities as a business location.

BOM always works closely with the Netherlands Foreign Investment Agency (NFIA) and the Holland International Distribution Council (NDL), the country's logistics agency, in order to provide potential investors with the following essentials:

- Information: national and regional regulations are demystified by BOM's team of experts, and provides information on taxes and the business climate in the investor's industry.
- Network: a business and supply-chain network and talent acquisition are key to a company's success and often prove to make all the difference. BOM and partners introduce newcomers to Brabant (or companies looking to expand) to their extensive network of contacts in industry, academia and government, ensuring that investors immediately have the best possible contacts.
- Location and site selection: where and when – both crucial decisions in the investment process. BOM can function as a potential investor's guide and advisor from start to finish and help look for suitable sites until a perfect fit has been found

2. DOING BUSINESS ABROAD

BOM International Trade offers those businesses that have outgrown their Dutch roots hands-on support for growing successfully in foreign markets. BOM establishes relevant business and government contacts abroad and provides targeted information on markets and available funding. The International Trade team focuses on three of Brabant's Priority Industries: High Tech Systems & Materials, Life Sciences & Health and AgriFood.

BOM is a public agency that brings companies, knowledge institutions and public bodies together. As BOM has no commercial interests, its independent standing opens doors that often remain closed to commercial ventures. In this respect BOM's goal is to help to create a strong Brabant economy and guarantee that Brabant businesses play a leading role on the world stage. Current target markets for BOM International Trade include China (Jiangsu region), southern Germany (Baden-Württemberg and Bavaria regions) and the United States (Midwest and Texas). BOM International Trade works closely with partners such as the Netherlands Enterprise Agency, the Chamber of Commerce and embassies and consulates around the globe.

3. DOING BUSINESS IN BRABANT - EXPERTISE AND VENTURE CAPITAL FOR STARTUPS AND SCALEUPS

As a growth accelerator with over 35 years of experience, BOM Brabant Ventures helps ambitious Brabant companies to grow in a future-proof manner. Through its knowledge and risk capital, the agency focuses on startups and scaleups in Brabant's Priority Industries: High Tech Systems & Materials, Agrofood, the Biobased Economy, Life Sciences & MedTech and Maintenance & Supply Chain.

4. CREATING ENERGY PROJECTS - CONTRIBUTING TO ENERGY TRANSITION IN BRABANT

BOM Renewable Energy facilitates energy conservation and sustainable energy generation. The team works with businesses, property owners and citizens' initiatives to create sustainable energy projects. BOM Renewable Energy encourages energy conservation in the property market and industry and provides advice and assistance for cost-effective solutions that will help make Brabant energy-neutral.

BOM Renewable Energy advises on project organization and structuring and can also invest in the projects and use its network to kick-start projects. The team's focus is on major projects, such as wind farms and solar parks, and on connecting and bringing smaller projects together. Smaller projects are supported through BOM's EsCo (energy service company) partners, who are active in specific markets, such as solar panel manufacturing or social housing and energy conservation for SMEs.

www.brabantisbright.nl

4. BRAINPORT DEVELOPMENT EINDHOVEN

Brainport Development is a regional development agency that aims to improve the international competitive position of the Brainport Eindhoven region (southeast Brabant), increasing the prosperity and well-being of the region and making a robust contribution to a more sustainable, caring, clean, and safe Netherlands.

SERVICES

Brainport is especially active in linking public and private activities. It is:

- Branding the region nationally and internationally as a globally leading high tech region
- Developing projects and programs with companies and knowledge institutes
- Offering flexible, small-scale business premises with facilities in business centers
- Supporting SMEs with advice and capital
- Helping new businesses establish subsidiaries in the region

Furthermore, Brainport initiates and implements a diverse range of activities aimed at strengthening the economic structure of the region. Brainport is setting regional development agendas (with senior management from private and public organizations), monitoring the regional economy, organizing network activities, and lobbying at national and EU level.

One example is the development of the Brainport 2020 agenda, where stakeholders from public and private organizations are developing a common vision on the future of the region and the activities required to realize these ambitions.

In Eindhoven, Brainport Development helps with innovation and economic development. Brainport Development is helping the region to grow economically by attracting international high tech and manufacturing companies and by providing them with local support. From startups and scaleups to large multinationals, Brainport is sharing knowledge, providing advice on issues such as funding, and putting them in touch with other companies and (international) talent. It is also responsible for creating the economic strategy defined by the Brainport Foundation. In order to deliver that strategy, Brainport Development is working together with companies, knowledge institutes, and public agencies as an independent party.

www.brainporteindhoven.com/en/

5. HOLLAND EXPAT CENTER SOUTH

Holland Expat Center South is a non-profit governmental agency that is a joint initiative of the participating municipalities (almost every municipality in Brabant), the Netherlands' Immigration and Naturalization Services (IND), Brainport Development, and the province of Brabant.

SERVICES

The Holland Expat Center South compiles the procedures and provides information that helps expats and their families to settle into their new living (and working) environment. Expats can obtain information about the region from the Expat Center and learn more about events organised specifically for the expat community. Its main purpose is to help expats feel welcome and at home.

The Expat Center helps companies employing expats and expats themselves to fulfil the formalities required for residing in the Netherlands, such as acquiring the compulsory BSN (Citizen Service Number), help with visa/residence permits, work permits (if required), converting a driver's license, TB testing, etc.

www.hollandexpatcenter.com

6. Midpoint Brabant

As the economic cooperation program of mid-Brabant, Midpoint Brabant acts as a link between industry and business, government, education and science, and social organizations. The program helps to develop new ideas and bring these ideas to the market, with the objective being to stimulate innovation that makes the economy 'smart and strong' and makes society future-proof. Priority sectors of the regional economic development program are Smart Industry, Smart Logistics, and Smart Leisure. The region is already a strong international player in this area and is aiming to bolster that position.

SERVICES

The region is known for its smart pooling of knowledge and skills. For example, there is a strong knowledge and education infrastructure, with three intermediate vocational schools, two universities of applied sciences, one of the leading Dutch universities, and many associated knowledge institutes. Midpoint Brabant strives to connect the knowledge infrastructure to industry and business, supporting the entire trajectory from generating innovative ideas to their successful implementations. Combining vocational education with parttime work in industry, business, retail, or leisure also ensures the development of innovations that can actually work in real life.

Projects are conceived and developed in field labs (experimental cooperative centers), in which ideas are tested and put into practice. These living lab projects work best in well-functioning industrial ecosystems, in which the meeting places and campuses that Midpoint Brabant helps to set-up play an important role. In these centers and campuses, potential cooperation partners with the right social and technological knowledge and skills are brought together. Midpoint Brabant then supports these companies in finding talent and funding and contributes to SME start-up and growth support.

Finally, the successes are showcased, both in the Netherlands and abroad in order to demonstrate the areas in which mid-Brabant excels and also to offer others the opportunity to utilize the innovations from the region or join the many cooperative projects.

www.midpointbrabant.nl

7. REWIN WEST-BRABANT

REWIN West-Brabant, the regional development agency for the western region of Brabant province, works to boost the regional economy by encouraging business investment. REWIN provides support for establishing and/or relocating both branch offices and entire companies, and it has a special interest in the following key industries: logistics, maintenance, agrifood/ biobased economy and creative services.

SERVICES

REWIN provides help and guidance on a wide range of issues, including:

- Advice on availability and the pricing of business locations in the western part of Brabant, including advice on locations and viewing properties together with you
- Support for legal and tax issues, such as incorporating a business or appealing a tax assessment
- Information on the regional business climate, labour market and residence and work permits
- Guidance on the availability of financial assistance, grants, venture capital and private investment opportunities
- Assistance with grant and permit applications
- Information on staff recruitment and training, current labour and salary conditions

REWIN will assist newcomers to western Brabant through introductions to its network of local authorities, educational institutions, knowledge networks and technological expertise and business networks throughout the region. Companies can also participate in a range of business development programmes in the key economic industries of logistics, maintenance and the biobased economy.

www.rewin.nl/en

B. Incentives and Grants/Support Programs

1. Highly-skilled migrant permit

Highly-skilled migrants do not require an employment permit to work in the Netherlands. The national scheme for highly-skilled migrants is available for employee transfers that do not fall under the scope of the EU's intra-corporate transfers (ICT) directive. This may be the case for employees who, for the duration of their assignment, are placed on the Dutch payroll of the recipient company. Japanese nationals and Turkish nationals do not require an ICT residence permit either; they can apply for a highly-skilled migrant residence permit.

WHAT IS A HIGHLY-SKILLED MIGRANT?

A highly-skilled migrant or knowledge migrant (in Dutch, a kenniswerker) is any foreign employee who:

- comes to the Netherlands to work as an employee
- earns at least €4,752 (excluding holiday allowances and 13th cheque) gross per month
- or earns at least €3,484 (excluding holiday allowances and 13th cheque) gross per month, if under the age of 30

These salary amounts are applicable for 2021. The sums are index-linked annually.

Fixed allowances for housing and a company car may be added to the employee's base salary in order to comply with the above salary criteria, but only if these allowances are agreed to in writing and paid in monthly instalments.

Reduced salary criterion (€,497 gross per month)

The exception to this rule applies to a highly-skilled migrant who falls under the reduced salary criterion. This threshold criterion also remains in effect when the highly-skilled migrant subsequently changes employers, and it is not age-dependent.

The reduced salary criterion applies if one meets the conditions for the orientation year for highly-educated persons and the residence permit for employment as a highly-skilled worker is applied for within three years of graduating, the date on which a doctorate was awarded, or the date on which the residence permit for scientific research expired. This means the reduced salary criterion also applies if you did not have a residence permit for the orientation year for highly-educated persons, but you do meet the conditions for this purpose of residency.

The general conditions for an orientation year are that you have graduated, obtained a PhD, or performed scientific research in the Netherlands and wish to find a job or start your own company, whether you live abroad or are still in the Netherlands.

An application for a permit can be declined if the salary is not a competitive one in the industry in question. This income requirement does not apply to scientific researchers and physicians training to become specialists, or to people working for educational or research institutions.

Employers that wish to employ highly-skilled migrants are no longer required to also apply for work permits for these employees, and they now only have to submit an application for admission and residence for the employee and his family to the Immigration and Naturalization Department (IND). The application procedure takes two to three weeks. A residence permit for highly-skilled migrants will be granted for the duration of the intended employment, up to a maximum of five years.

Professional soccer players and ministers or teachers of religion are not eligible for residency as highly-skilled migrants. Directors and major shareholders cannot apply for the knowledge migrant scheme either if they hold a stake larger than 24% in the company, as they are then liable for any company risks and can influence their own incomes.

The income requirement for highly-skilled migrants will be reviewed on 1 January of every year on the basis of the most recent index figure for negotiated salaries, as published by The Dutch Central Bureau for Statistics (CBS). The average yearly increase of the salary criteria has been 2.6% for the past three years. Whenever a highly-skilled migrant submits an application for the extension of his or her residence permit or switches employers, the IND will apply the most recently indexed salary criteria. Thus, if a highly- skilled migrant applies to extend his or her residence permit three years after being admitted for the first time, he or she must take into account that the applicable salary criteria has increased by almost 8%.

If a highly-skilled migrant under the age of 30 continues working for the same employer after turning 30, the lower salary requirement that was in force when he or she first applied for a residence permit remains applicable. If the highly-skilled migrant applies for an extension and continues to work for the same employer, the most recently indexed salary criteria for the under-30 age category is applicable. However, if this employee switches employers after turning 30, the most recently indexed salary for those over the age of 30 is applicable.

2. The 30% Ruling (Tax-free Allowance)

The Netherlands has a special tax regime for expatriates, known as the 30% ruling, which exempts them from a substantial portion of their income tax (up to 30%). This is viewed as a reimbursement of the extra costs involved in living abroad, the extraterritorial expenses. Rather than having to specify and prove the extraterritorial expenses incurred by an employee or an employer for its employees each year, the costs are set at a maximum of 30% of the taxable remuneration. In addition, the employer may reimburse certain costs tax-free. This includes international school fees, certain relocation expenses and a moving allowance up to a given limit.

THE PART OF THE INCOME TO WHICH THE ALLOWANCE APPLIES

Under the tax rules, the employer may grant the employee a tax-free allowance of up to a maximum of 30% of his or her taxable remuneration package. Incidental and flexible forms of income such as bonus payments and stock options that are paid out during the duration of the 30% ruling are also included. Severance and pension payments, however, are excluded.

METHOD OF CALCULATION

Under the regulation, the taxable and the non-taxable part of the income has to be split in the employment contract itself. In other words, the 30% tax-free allowance must be granted as a separate part of the employee's salary. Standard wording is used to state this in either the employment contract or in a separate addendum to the contract. For employees with net salary contracts and irregular payments, it can be difficult to precisely determine the non-taxable part of 30% on a monthly basis, and so in these cases they may determine and pay the exact tax-free reimbursement on an annual basis.

RULING AND PENSION

An employee cannot accrue a pension under a qualifying plan in the Netherlands (or social security benefits) on the tax-free allowance. This affects employees who have a pensionable base equal to their full gross salary. Employees who may apply the 30% ruling may only accrue pension on the taxable part of their salary. There is way to avoid this, although the employer must fulfil a number of legal formalities and draft special documents for this purpose.

EXTRATERRITORIAL COSTS

The 30% ruling is a practical solution for employers wishing to reimburse, tax-free, the additional costs incurred by the employee working in the Netherlands as opposed to their home country, the extraterritorial costs (instead of keeping all receipts of the actual costs claimed by the employee). The Dutch State Secretary passed a special decree that further detailed which costs, allowances and benefits in kind that are typically paid to expatriates qualify as extraterritorial costs. In the case an employee who was hired or assigned from abroad to work in the Netherlands and was not deemed eligible for the 30% ruling, it is still possible to reimburse the de facto extraterritorial costs to this employee tax-free. In this event, the employer must retain proof of the extraterritorial expenses incurred.

INTERNATIONAL SCHOOL FEES

Under the 30% ruling, the employee may receive an additional tax-free reimbursement of the fees paid for children to attend an international school. A school is regarded as an international school when a) the education is based on a foreign school system, and b) in principle the school only accepts the children of foreign employees.

RELOCATION EXPENSES/MOVING ALLOWANCE

The costs of moving as well as the costs for transporting household goods as part of the employment or secondment package are not considered extraterritorial costs, which means that these costs can - to a certain extent - be reimbursed tax-free. Actual relocation costs of up to €7,750 (2019) can be reimbursed.

PERIOD OF VALIDITY OF THE 30% TAX-FREE ALLOWANCE

The 30% ruling is available for a period of five years (60 months). The rules stipulate that the tax authorities can demand that the employer demonstrates at all times that the employee still meets the conditions. Where the employee no longer meets the conditions of the 30% ruling, it can no longer be applied. This will result in a retroactive adjustment (when required). If the employee's contract in the Netherlands has ended, the 30% ruling will also simultaneously cease to apply. As such, the 30% ruling cannot be applied to any payments made after that time.

The duration of any previous stay or period of employment in the Netherlands is subtracted from the maximum five-year period. However, this reduction will not occur if the expatriate has not stayed or worked in the Netherlands during the 25 years preceding his or her most recent arrival date in the Netherlands (or has only stayed in the country for very limited periods).

CONDITIONS FOR QUALIFYING

In order to qualify for the 30% ruling, the following conditions must be met:

- The employee (board members and supervisory board members also qualify for the 30% ruling) must be recruited (or assigned) from abroad;
- The employer must be a Dutch wage tax-withholding agent. If the employee has a Dutch resident employer (a Dutch corporation or branch of a foreign corporation) this condition is usually met. If the employee has a foreign based employer which has no taxable presence in the Netherlands, the employer must have one or more employees working in the Netherlands, perform payroll administration in the Netherlands, and be registered as a withholding tax agent with the tax authorities.
- The employee must have lived outside of a 150 km radius from the Dutch borders for at least two-thirds of the 24 months prior to the start of their employment in the Netherlands;
- The employee must have the specific expertise required to perform the function and which is not available or scarce on the Dutch labour market. This is based upon a salary standard that must be met; and
- The 30% ruling must be contractually agreed upon between the employer and employee. This also implies that the employee is aware that the 30% ruling reduces his or her gross salary.

3. Incentives for Research and Development Costs in the Netherlands (WBSO)

Companies established in the Netherlands performing research and development work (Speur- en Ontwikkelingswerk: S&O or R&D) may be eligible for tax relieve on wage costs and additional costs. The WBSO R&D scheme is intended to provide entrepreneurs with an incentive to invest in research by means of reducing the R&D wage costs. The WBSO scheme for R&D includes salary and other costs and expenses directly related to R&D activities.

The benefit amounts to 32% of the first EUR 350,000 of R&D costs (both salary and other costs and expenses) and 16% for R&D expenses above €350,000. For startups, the percentage for the first bracket is higher, at 40% instead of 32%. The WBSO does not have an upper limit, although the maximum benefit may not exceed the wage sum.

CONTRIBUTION

The R&D allowance takes the form of a reduction in wage taxes and social security contributions. The WBSO can be applied to costs and expenditure directly allocable to the company's R&D activities, whereby:
1) costs must be incurred exclusively (for 100%) for R&D;
2) expenditure must serve R&D (can also be partly allocable).

When applying for the WBSO one can choose between a lump-sum application (based on the number of R&D hours; no R&D expenditure will be subsidised) or an estimate of the actual amount of costs and expenditure incurred.

ACTUAL COSTS AND EXPENDITURES

Only costs and expenditure directly allocable to R&D and which serve R&D purposes can be taken into account. In this respect, note that not all activities related to R&D projects can be recognised as R&D work. For example, administrative and organisational costs are excluded.

As far as the costs are concerned, it is only those costs that are borne by the taxpaying company itself). When it comes to expenditure, the allowance only applies to newly manufactured business assets insofar as:

- these assets have not been previously used;
- they have not been included in previous R&D declarations (subsidy applications);
- these assets fall under own R&D activities;
- expenses are borne by the taxpaying company payer (or a group company of an affiliation, in tax terms, that the taxpaying company is a part of)

CONDITIONS

The R&D project must meet the following conditions before one can apply for the R&D allowance:

- the proposed R&D activities take place within your own company
- the technological development is new to your company
- the development brings with it technical issues
- the R&D work has yet to be undertaken (which means you must always submit a WBSO application in advance).

R&D work is defined as a systematically organised activity, related directly and exclusively to:

- technical scientific research
- the development of:
  - (Parts of) physical products
  - (Parts of) physical production processes
  - Software (technically new (parts of) software)
  - Software components (technically new)

WBSO support is explicitly NOT intended to support feasibility studies, software upgrading, software modifications for different hardware or software platforms, developing services, routine activities, market research, organisational or administrative work, policy and strategy studies, the adaptation or deployment of purchased goods, quality control and assurance, the adaptation or implementation of existing technology, pilot plants and related products on a production scale with commercial value.

4. Innovation Box

Companies can benefit from an effective tax rate of just 9% for income from intangible assets created by their Dutch taxpaying entity. Patented intangible assets as well as intangible assets that have been created by the Dutch taxpaying entity and for which an R&D declaration (an approved WBSO application) was obtained, may qualify for the Innovation Box. In practice, this means that technological innovations developed in-house qualify.

The reduced tax rate of 9% instead of 25% increases the return of companies on R&D investments. The reduced R&D costs mean that companies can invest more, accelerating the R&D process and increasing the value of the company.

The Innovation Box does apply:

- in situations where the period between an application for a patent and the granting of the patent is unusually long. Subject to certain conditions, profits that are attributable to the relevant patented asset may, during the period from the year in which the patent was applied for up to the year preceding the year in which the patent was granted, also be brought within the scope of the Innovation Box.

The Innovation Box does not apply:

- to marketing intangibles such as trademarks and logos
- to intangible assets for which a patent was obtained if the asset was already in existence before 1 January 2007
- to intangible assets for which an WBSO R&D declaration was obtained if the asset was already in existence before 1 January 2008

As a result of EU talks on favorable EU IP regimes and the introduction of minimum rules for preferential IP regimes (OECD BEPS project), as of 2017 the Netherlands has altered the Innovation Box regime in order to be compliant with the new requirements. The changes relate to the entry tickets to the Innovation Box (you now require a WBSO R&D declaration) and allocation of income that qualifies for the special tax rate. Originally, there was no cap on the amount of profits that could be allocated to the Innovation Box, although a taxpayer had to be able to prove that the profit was related to the qualifying intangible assets. As of 2017, restrictions have been introduced (the modified nexus approach). It is recommended that an agreement be reached in advance with the Dutch tax authorities on which method to apply – they will do this on request. At present, the Innovation Box regime has the following relevant features:

R&D ACTIVITIES (ENTRY TICKET)

Originally, the Patent Box or Innovation Box incentive could only be applied to income generated from registered patents, but this has now been extended to include income from R&D projects for which a WBSO R&D declaration has been obtained. Henceforth, a distinction is drawn between small and other taxpaying companies.

Small taxpayers are companies with worldwide net group sales of under € 50 million per year and a gross benefit from IP not exceeding a total of € 37.5 million in five consecutive years (an average of €7.5 million per year). For small taxpaying companies the WBSO R&D declaration suffices as an entry ticket to the Innovation Box.

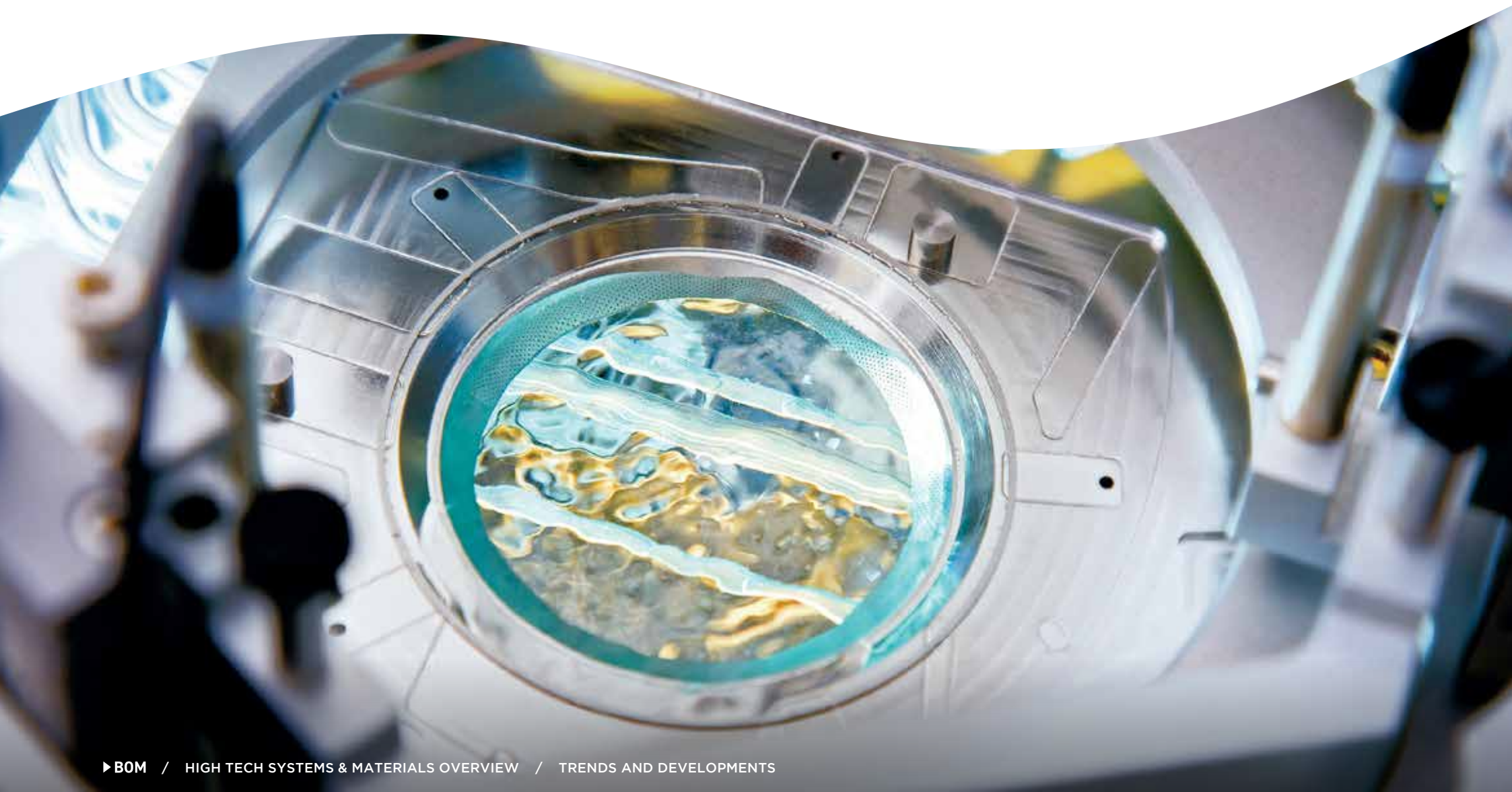
Small taxpayers are companies with worldwide net group sales of less than € 50 million per year and a gross benefit from IP not exceeding a total of € 37,5 million in 5 consecutive years (being on average € 7,5 million per year). For small taxpayers the WBSO R&D statement is sufficient to enter the innovation box.

Larger taxpaying companies not only need to obtain a WBSO R&D declaration but must also have a recognized legal access ticket. For larger taxpaying companies, only income from patents, utility models, software, plant breeders' rights and pharmaceutical certifications qualify for the Innovation Box. This category of taxpayers will thus be subject to a twofold test. A small taxpaying company can also include unprotected IP in the Innovation Box regime.

MAXIMUM REVENUES (ALLOCATION OF INCOME)

A restriction is in place with respect to the level of income that can be allocated to the Innovation Box (the modified nexus approach). It is now more important whether or not R&D will be performed in-house and how R&D costs are divided between the parties involved. This implies that the more R&D activities are outsourced to related parties, the lower the profits that can be allocated to the intangibles resulting from such R&D activities.

9. TRENDS AND DEVELOPMENTS THE BIGGER PICTURE



A. On an international level: the European Union

In the European Union, much like in most other parts of the world, a tremendous amount of effort, time, and money in 2021 and onwards will be invested in recovering from the damage the Covid-19 pandemic has caused, both in terms of human health and economically.

From a strategy perspective, the research and innovation (R&I) direction of the European Union is set out in the outline of the Horizon Europe program, the next joint EU Research & Innovation Investment Program spanning the years 2021 to 2027 (and worth around 100 billion euros).

1. HORIZON EUROPE

The vision of the innovation program is to create a sustainable, fair, and prosperous future for people and planet based on European values.

- Tackling climate change (35% of the budgetary target)
- Helping to achieve sustainable development goals (SDGs)
- Boosting the Union's competitiveness and growth
- While benefiting from world–class research and strong industries (the EU's knowledge and skills are its main resources) ...
- ... Europe can improve at transforming this vision into leadership in innovation and entrepreneurship.

LESSONS LEARNED IN THE PREVIOUS EU RESEARCH & INNOVATION PROGRAMS AND LOOKING FORWARD TO THE FUTURE

In 2018, the EU's High-Level Strategy Group on Industrial Technologies was asked to advise on future joint innovation programs. How should these programs be structured and organized to best boost the European Union's citizens' and industries' interest levels?

This High Level Group consisted of 14 very senior experts from industry, academia, and politics from across Europe:

- **Mr. Jürgen Rüttgers,** former Federal Minister for Science and Research in Germany
- **Ms. Cecilia Bonefeld-Dahl,** Director General of Digital Europe
- **Ms. Sabine Herlitschka,** CEO and CTO of Infineon Technologies Austria AG
- **Mr. Wim van Saarloos,** President of the Royal Netherlands Academy of Arts and Sciences
- **Ms. Anna Hultin Stigenberg,** Senior Manager Technology, Sandvik Coromant
- **Mr. Alistair Nolan,** Senior Policy Analyst, Directorate for Science, Technology and Innovation, OECD
- **Ms. Susan Rosser,** Director of the UK Mammalian Synthetic Biology Research Centre
- **Mr. Iñaki San Sebastian,** CEO of Tecnalia
- **Ms. Bernadette Ségol,** former Secretary-General, European Trade Union Con federation
- **Ms. Eva Stejskalová,** partner at MicroStep
- **Prof. Hugo Thienpont,** Chair of Applied Physics and Photonics Department, Vrije Universiteit Brussels
- **Prof. Tullio Tolio,** Politecnico di Milano (TU Milan), Faculty of System Engineering
- **Mr. Antti Vasara,** CEO VTT, vice-president of EARTO
- **Ms. Adiari Vazquez,** Investment Manager, Caixa Capital

After careful consideration, the High-Level Strategy Group proposed the following ideal outlines and priority areas of interest to the European Commission.

The primary drivers for future innovation & competitiveness should be:

I. Globalization
II. Digitization
III. Knowledge society

And the rationale behind the program should concern:

1. Global excellence
2. Systemic relevance
3. European sovereignty
4. Sustainability
5. Multi-purpose application

GRAPHICALLY, THE HLS GROUP'S SUGGESTION FOR THE WORKING PRINCIPLES OF THE NEW HORIZON EUROPE RESEARCH & INNOVATION PROGRAM WERE AS FOLLOWS

Key Enabling Technologies (KETs)		Examples	Societal challengers	Missions
Product Technologies	Advanced manufacturing technologies	Smart, high-performance, high-precision and additive manufacturing and processes; Robotics; Process industry; Green propulsion technologies' Integrated biorefineries	Environment	
			Energy	
	Advanced material and nanotechnologies	High performance, smart sustainable materials, Nanomaterials, Nanotechnology, Biomaterials, 2D Materials, Light-weight Technologies, New chemistry		**MISSIONS**
			Mobility	
		Industrial biotechnology, High-throughput biology; Synthetic biology; Genomics (genome engineering / synthetic genomes); Cell & tissue engineering; Biologizati-on of manufacturing; Biosensors; Bioactivators; Bioactuators; Lab-on-a-chip; New chemistry; Neurotechnologies	Health & Well-being	
Digital Technologies	Life science technologies			**MISSIONS**
		IoT; Smart / intelligent sensors; Quantum technology; Supercomputing (high power, high performance, neurocomputing, beyong CMOS). Displays (LCD, plasma) & Ligh-ting (LED, OLED); Photonics integrated circuits, Biophotonics	Food & Nutrition	
			Security	
	Micro- & Nano-electronics and photonics	Data generation ad handling; Big data analytics; Machine-learning and deep learning' Smart robotics; Virtual agents; Software technologies; decision-making technologies		**MISSIONS**
			Privacy	
Cyber Technologies	Artificial Intelligence	Secure & authenticated communication; Avoiding identification theft; Data protec-tion & privacy; IoT Data / connectivity safety & security; Human-machine interfaces; Human-computer / robot interaction; 5; Basehand / processor platforms	Inclusion & Equality	
		E-Governance; e-Administration; e-Voting; Cyberphysicial systems; eSafety & eSe-curity, Technology assessment; Blockchain		
	Security & connectivity			

Source: Re-Finding Industry, report from the High-Level Strategy Group on Industrial Technologies

FINAL PROGRAM STRUCTURE

In the years following the High-Level Group's advice (2018 – 2020), the European Commission designed the Horizon Europe program around a three-pillar structure.

Source: European Commission – Horizon Europe: the next EU Research & Innovation Investment Program (2021 – 2027)

KEY NOVELTIES IN THE PROGRAM

New features in the program are:

1. Stronger support for breakthrough innovations through the implementation of the European Innovation Council.

Support for innovations with a breakthrough and disruptive nature and scale-up potential that are too risky for private investors (70% of the budget earmarked for SMEs). The European Innovation Council functioning as a one-stop shop, helping innovators create markets of the future, leverage private finance and scale-up their companies. Innovation-centric, risk-taking and agile, pro-active management and follow-up.

Two complementary instruments bridging the gap from idea to investable project:

- Pathfinder: grants, from early technology to pre-commercial
- Accelerator: grants only & blended finance from pre-commercial to market and scale-up

2. Creation of greater impact by innovation through mission-orientation and citizens' involvement. Better relating EU's research and innovation (R&I) to society and citizens' needs through R&I missions with strong visibility and impact.

A mission is a portfolio of actions across disciplines intended to achieve a bold and inspirational and measurable goal within a set timeframe, with impact for society and policy-making as well as relevance for a significant part of the European population and wide range of European citizens.

Source: European Commission – Horizon Europe: the next EU Research & Innovation Investment Program (2021 – 2027)

3. A new generation of objective-driven and more ambitious partnerships in support of agreed EU policy objectives, with the following key features:

- A strategic orientation
- A simple architecture and toolbox
- A coherent life-cycle approach

Source: European Commission – Horizon Europe: the next EU R&I Investment Programme (2021 – 2027)

CONTENTS OF THE THREE PILLARS OF THE HORIZON EUROPE PROGRAM

PILLAR 1. EXCELLENT SCIENCE: REINFORCING AND EXTENDING THE EXCELLENCE OF THE EU'S SCIENCE BASE

Pillar 1 is all about strengthening the science base of the European Union's member countries and joint research facilities. Main components of this pillar are:

a. organizing excellent scientific cooperation structures, research teams and stimulating academic excellence
b. training Europe's researchers so they possess the most up-to-date knowledge and skills
c. provide Europe's research teams, institutes, and cooperation structures with the best possible research infrastructures and facilities

EUROPEAN RESEARCH COUNCIL

Frontier research by the best researchers and their teams

COMISSION PROPOSAL
€ 16.6 BILLION

MARIE SKŁODOWSKA-CURIE ACTIONS

Equipping researches with new knowledge and skills through mobility and training

COMISSION PROPOSAL
€ 6.8 BILLION

RESEARCH INFRASTRUCTURES

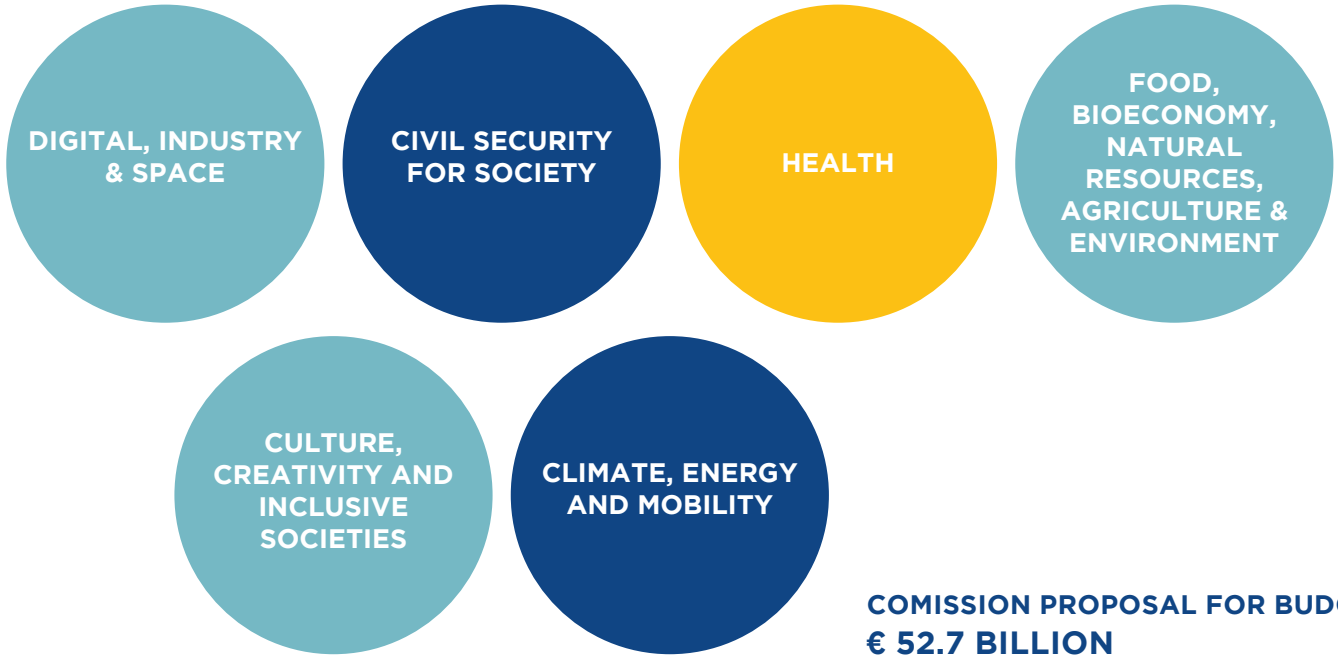
Integrated and inter-connected world-class research infrastructures

COMISSION PROPOSAL
€ 2.4 BILLION

Source: European Commission – Horizon Europe: the next EU R&I Investment Program (2021 – 2027

PILLAR 2. GLOBAL CHALLENGES AND EUROPEAN INDUSTRIAL COMPETITIVENESS, KEY CLUSTERS BOOSTING KEY TECHNOLOGIES AND SOLUTIONS UNDERPINNING EU POLICIES AND SDGS

Pillar 2 contains the bulk of Horizon Europe's support for research and innovation. The programs and initiatives deal with strengthening Europe's technological prowess and global competitiveness. Six key clusters will be targeted to receive priority attention and the largest budgets, as they are expected to provide the solutions for Europe's societal challenges. They underline the policies and vision of the European Union and help realize the sustainable development goals.



COMISSION PROPOSAL FOR BUDGET
€ 52.7 BILLION

Source: European Commission – Horizon Europe: the next EU R&I Investment Program (2021 – 2027

PILLAR 3. INNOVATIVE EUROPE: STIMULATING BREAKTHROUGHS CREATING NEW MARKETS AND ECOSYSTEMS THAT ARE CONDUCIVE TO INNOVATION

The main objective of Pillar 3 is to jumpstart the EU's innovative powers and Europe's ability to not only discover breakthrough technologies, models, and solutions but to also develop them into scaled-up, scientifically and commercially independent and successful versions too. To, this end investments are available to:

1. Accelerate and strengthen the EU's breakthrough innovation climate
2. Bring parties from all over Europe and beyond together in research, innovation, and building new businesses to optimally use all the available knowledge, skills, and experience
3. Develop, fund and scale-up new ecosystems and markets

EUROPEAN INNOVATION COUNCIL

Support to innovations with breakthrough and markets creating potential

COMISSION PROPOSAL
€ 10.5 BILLION,
INCL. UP TO € 500 MILLION FOR ECOSTYSTEMS

EUROPEAN INNOVATION ECOSYSTEMS

Connecting with regional and national innovation actors

COMISSION PROPOSAL
€ 10.5 BILLION,
INCL. UP TO € 500 MILLION FOR ECOSTYSTEMS

EUROPEAN INSTITUTE OF INNOVATION AND TECHNOLOGY (EIT)

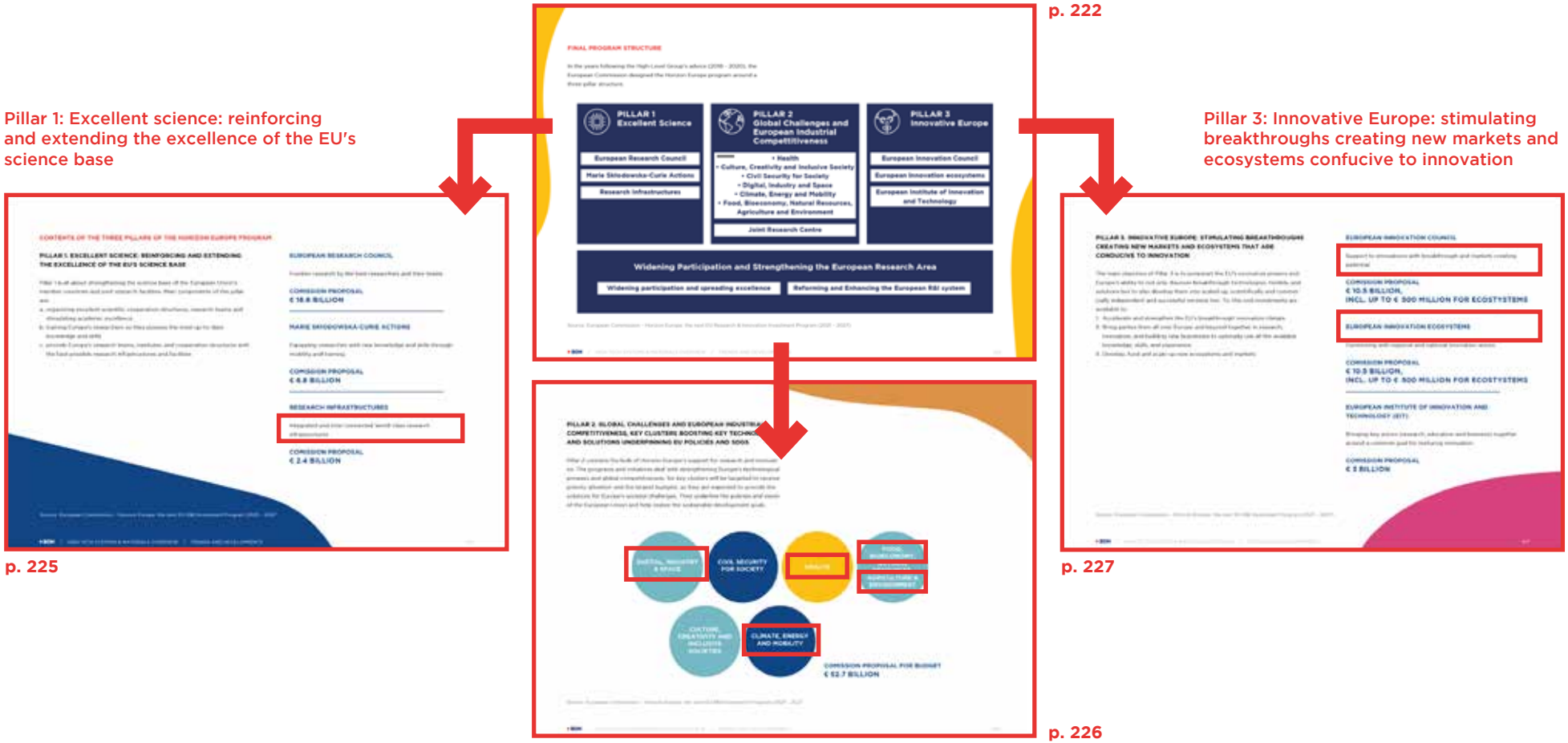
Bringing key actors (research, education and business) together around a common goal for nurturing innovation

COMISSION PROPOSAL
€ 3 BILLION

Source: European Commission – Horizon Europe: the next EU R&I Investment Program (2021 – 2027)

2. BRABANT'S STRENGTHS AS PART OF THE EUROPEAN LONG-TERM PERSPECTIVE

It is exceedingly clear that there are many overlaps and connections between the EU's Horizon Program objectives and Brabant's priority niches and development areas. In the combined illustration below, these overlaps are circled in red.



Pillar 2: Clusters: global challenges & european industrial competitiveness. Boosting key technologies and solutions underpinning EU policies and Sustainable Development Goals

Source: European Commission – Horizon Europe: the next EU R&I Investment Program (2021 – 2027); adapted by Engel – Een Heldere Blik

Further clarification of the research domains that Horizon Europe 2021 – 2027 aims at provides more details on the research domains in which EU objectives and Brabant's HTSM priority areas coincide. In the EU's intended Research & Innovation domains listed below, Brabant's regional strengths and development priorities are in red. The table clearly shows that Brabant's strengths in High Tech Systems & Materials can contribute significantly to the research and innovation challenges the European Union has formulated.

CLUSTERS UNDER PILLAR 2. GLOBAL CHALLENGES AND EUROPEAN INDUSTRIAL COMPETITIVENESS

Clusters in Horizon Europe	Research & Innovation domains/topics	
Health	• Health throughout the full lifecycle • Non-communicable and rare diseases • Tools, technologies and digital solutions for health and care, including personalized medicine	• Environmental and social health determinants • Infectious diseases, including poverty-related and neglected disease • Healthcare systems
Culture, Creativity & Inclusive Society	• Democracy and governance • Social and economic transformations	• Culture, cultural heritage, and creativity
Civil Security for Society	• Disaster-resilient societies • Protection and security	• Cybersecurity
Digital, Industry & Space	• Manufacturing technologies • Advanced materials • Next-generation internet • Circular industries • Space, including Earth observation • Emerging enabling technologies	• Key digital technologies, including quantum technologies • Artificial Intelligence and robotics • Advanced computing and Big Data • Low-carbon and clean industry
Climate, Energy & Mobility	• Climate science and solutions • Energy systems and grids • Communities and cities • Industrial competitiveness in transport • Smart mobility	• Energy supply • Buildings and facilities in energy transition • Clean, safe, and accessible transport and mobility • Energy storage
Food, Bioeconomy, Natural Resources, Agriculture & Environment	• Environmental observation • Agriculture, forestry, and rural areas • Circular systems • Food systems	• Biodiversity and natural resources • Seas, oceans, and inland waters • Biobased innovation systems in the EU • Bioeconomy

Source: European Commission – Horizon Europe: the next EU Research & Innovation Investment

B. On a national level: the Netherlands

On a national level, the following five agendas, roadmaps, and studies are important for the development of the High Tech Systems & Materials industry in the Netherlands:

1. **VISION ON THE FUTURE OF THE INDUSTRY IN THE NETHERLANDS 2020 – MINISTRY OF ECONOMIC AFFAIRS & CLIMATE, ON BEHALF OF DUTCH CABINET**

2. **GROWTH SECTORS IN THE NETHERLANDS FROM AN INTERNATIONAL PERSPECTIVE 2020 (TNO)**

3. **SWOT ANALYSIS OF STRATEGIC VALUE CHAINS IN THE DUTCH MANUFACTURING INDUSTRY (KPMG & TNO)**

4. **KNOWLEDGE & INNOVATION AGENDA FOR THE HIGH TECH SYSTEMS & MATERIALS PRIORITY INDUSTRY/ HIGH TECH HOLLAND (KIA - HTSM) 2018-2021**

5. **KNOWLEDGE & INNOVATION AGENDA FOR KEY TECHNOLOGIES (KIA - ST) 2020-2023**

1. VISION ON THE FUTURE OF THE INDUSTRY IN THE NETHERLANDS 2020
THE MINISTRY OF ECONOMIC AFFAIRS & CLIMATE, ON BEHALF OF THE DUTCH CABINET

THE FUTURE OF DUTCH INDUSTRY

The highest level of the Netherlands' national government is the Cabinet. Under the Dutch constitution, the Cabinet is composed of all government minister and its task is to make decisions on overall government policy and promote the coherence of policy. Below, the reader will find excerpts from an important cabinet policy letter to parliament dated October 30, 2020. It provides insight into the cabinet's vision on how to help Dutch industry develop its strengths in the future.

GROWTH

"The Dutch cabinet is committed to strong industry in the Netherlands and wants to grow it further in the Netherlands in a sustainable manner. This is necessary to help the economy achieve a higher growth path, to make Europe stronger and more resilient in the world, and to be able to continue to contribute to the societal challenges the country faces. It is valuable and desirable if this leads to a higher share of industry in the GDP, but this is not a goal in itself as this depends in part on the growth of the rest of the economy (the denominator effect).

IS DUTCH INDUSTRY READY FOR THIS GROWTH CHALLENGE?

The answer to this question is twofold. Yes, because we have an innovative industry and a well-educated workforce. We see growth in terms of labor productivity and added value, resulting in an increasing share in national income and more jobs. This however is no reason to relax. Competition in the world market is steadily increasing, and in the geopolitical climate the rules of the game are subject to change. The full answer is therefore: our industry is not yet totally ready.

WE SEE THE FOLLOWING CHALLENGES

MORE INNOVATION

Dutch industry will have to become even more innovative than it already is. An increasing number of countries are at the same technological level as us, and if the costs are lower there, we run a risk. This means that companies must continue to invest in new products with a high level of added value, because it is becoming increasingly difficult to maintain a position in commodity markets. Taking advantage of the opportunities offered by new digital technologies, Dutch industry will increasingly have to rely on more complex products and a stronger position in global growth markets. The social challenges also offer attractive opportunities. Dutch industry is fortunate in that exports of more complex products are growing. And the industry will have to respond to the trend of "servitization" and the move towards a platform economy, because those are ways to add more value to products.

SMART MANUFACTURING

However, having designed a good product is no guarantee that the industry can also develop and produce it cost-effectively in the Netherlands. This requires a smart and efficient design of the production process, whereby the use of new production technology and digital technologies is necessary. Due to the decrease in costs in these technologies, this also offers the opportunity to reduce manufacturing costs in sectors that manufacture to measure or in small series. It is clear that the use of robots in Dutch industry has increased in recent years, but wider application is certainly still possible.

All in all, the opportunities seem to lie mainly at the intersection of physical products and production and the digital world, and at the intersection of industry and services. This demands much agility from companies and their employees and the need for cooperation between different disciplines. Social innovation is therefore just as important as technological innovation.

MORE MANUFACTURING – BUT CHOSEN WISELY

The various described trends give the Netherlands the opportunity to attract more production. This offers opportunities for job creation for professionals or for people excluded from the labor market. Moreover, in the light of the necessary availability of essential goods, such as medicines and personal protective equipment, we also need to look more emphatically at what production capacity the Netherlands should have and what other possible solutions there are. The European perspective is important in this respect; if each member country is going to build up its own capacity, it will not be efficient.

The coronavirus pandemic has exposed a number of vulnerabilities for certain goods, while a subsequent crisis could lead to other vulnerabilities. It is therefore difficult to determine exactly for which goods greater independence or own production capacity is required. It is consequently also necessary that we are able to respond quickly and flexibly to shortages of certain goods. Experience was gained in this perspective during the pandemic. The Smart Industry program also focuses on flexible production systems, and it has formulated a vision of how vulnerabilities can be reduced by more flexible and robust chains. The Ministry of Economic Affairs and Climate Policy will explore the extent to which more knowledge and expertise in this field can be generated through the Smart Industry program and subsequently used.

Perhaps greater production will be brought back by Dutch industry. Although developments over the past ten years show that expectations in this respect should not be excessive, and forced reshoring has disadvantages, the government does not want to neglect possible opportunities for industry, employment, and safeguarding public interests in the Netherlands. That is why, in line with the Heerma et al. motion, the Social and Economic Council (SER) has been asked to advise in this matter (reshoring). The SER aims to provide recommendations by the end of 2020. The cabinet will then assess whether additional action is needed and will also enter into discussions with the regional authorities in this respect.

GOVERNMENT POLICY

The question is whether the government has its own affairs in order to achieve the ambitions described. Through the generic innovation policy, the mission-driven Priority Industries and Innovation Policy, the Dutch Digitization Strategy, the Technology Pact, the government-wide Circular Economy program, and the Climate Agreement, the cabinet has a solid foundation for supporting industry. The trade tools for international business are also committed to maintaining and strengthening the international earning capacity of the industry in order to contribute to sustainable recovery after Covid-19.

But, in the light of the ambition to increase the structural growth capacity of the economy and in the context of the rapidly changing geopolitical reality, we will have to continuously work on renewing the policy agenda. This requires an offensive approach, in which the following three elements are essential for the cabinet.

1. GREATER EUROPEAN COOPERATION

Firstly, we will have to work together on the European stage as never before. The scale that we can achieve in the Netherlands is often insufficient to compete in the world. A joint approach takes us much further. In many cases, this cooperation will have to be more intensive than is currently the case. We will have to work together to find out what the best form is for each sector and technology. However, this enhanced European cooperation does not mean that we should stop collaborating outside Europe. For the defense industry, for example, transatlantic partners such as the United States remain important.

2. HELP CREATE THE MARKETS AND KEY ENABLING TECHNOLOGIES FOR THE FUTURE

Secondly, the government sees the need to invest further in the growth markets of the future. This is necessary to allow the industry to grow over the long term and is important for creating a position in technologies that are meaningful from the point of view of public interest or from a national security perspective. The application of key enabling technologies can lead to an increase in labor productivity and to the creation of new growth markets. This consequently requires further investments in key technologies and in bringing them to the market by startups and scaleups, and other companies. The establishment of the National Growth Fund, at 20 billion euros, offers opportunities in this regard.

3. MORE ASSERTIVE FOREIGN TRADE POLICY TOWARDS THE WORLD OUTSIDE OF EUROPE BY DUTCH GOVERNMENT

Finally, in addition to an offensive industrial strategy, the Netherlands and Europe must not shy away from protecting economic and social interests against unwanted influence or unfair competition from outside Europe. This sometimes requires a more active and assertive role for the Dutch government than we have been accustomed to in recent decades.

For these three issues it is important to create a clearer picture of which technologies and sectors are of strategic importance to the Netherlands so as to subsequently determine which approach is appropriate.

In the mission-driven Priority Industries and Innovation Policy (including the KIA – HTSM), and in particular in the key technologies approach (KIA – ST), and in the Defense Industry Strategy, input has already been provided from various perspectives. As part of the Netherlands' approach to national security, an additional technology exploration is currently being carried out. These questions are currently also highly relevant in the domain of digital sovereignty. All these different perspectives will shortly be brought together, enabling the development of a coherent approach to investment, regulation, and protection. This analysis will include determining in which cases issues can best be handled at a European level and when the Netherlands must pursue its own national policies."

MAIN TAKEAWAY

After a number of decades in which subsequent Dutch national governments tended to focus on the growth of the services sector in the Netherlands, this Cabinet letter proves that the importance of the Netherlands' (manufacturing) industry has been once again recognized. And it is and will be supported from a government perspective to a greater degree than it has in almost two decades. This is particularly good news for the province of Brabant and Brainport Eindhoven, as that is where the heart, brains, and muscle of the Dutch high tech manufacturing industry can be found. A greater focus on the specific innovation concepts, competences, and requirements of the Brabant high tech industry is already manifest in the conduct and actions of Cabinet ministers and state secretaries.

2. GROWTH SECTORS IN THE NETHERLANDS FROM AN INTERNATIONAL PERSPECTIVE (TNO)

In 2015, the TNO authored the report Growth Sectors in the Netherlands in an International Perspective for the Ministry of Economic Affairs and Climate (EZK). In 2020, the TNO was asked to update its report. The report contains an analysis of the size and economic developments of each sector in the Netherlands, compared to the size and developments in OECD member states. The analysis focuses on the following variables: added value, employment, and labor productivity. Two periods are distinguished in the figures and tables: 1996-2011 (the analysis period for the 2015 TNO report) and 2012-2019 (or the most recent year for which a good international comparison is possible). The most relevant findings and conclusions for the HTSM industry in Brabant and the Netherlands are set out below.

A. ECONOMIC STRUCTURE: SIZE AND GROWTH OF SECTORS IN THE NETHERLANDS AND OECD

The Dutch economy is dominated by the service sectors. Both in terms of value added and employment, the main sectors of trade, transport and storage, business services, government, education and care have a large share in the economy. Over the years, growth in service sectors has been stronger than in manufacturing, leading to a decline in industry's share. In 1995, industry had a share of 16.9% of the added value of the Netherlands, while in 2019 this share stood at 12.3%.

A similar development is evident in OECD member states, where the share of industry in the total added value decreased from 19.2% in 1997 to 14.7% in 2017. On balance, the relative size of industry in the total OECD economy is larger than in the Netherlands. But once again the trend in the OECD is that service sectors grew faster on average than industry.

There is a great diversity of subsectors under the overarching industry title. Within Dutch industry, employment is concentrated in the following sectors: the furniture and other industry, food and beverage industry, metal products industry, and the machine industry. The graphics industry and the furniture and other industry had to deal with a continuous decline in employment, while other industrial sectors (especially in the period after 2012) experienced employment growth.

Recent growth in added value (that is, after 2011) is concentrated in the Dutch industrial sectors of the pharmaceutical industry, petroleum industry, basic metal industry, machine industry, and paper industry. In this context the decline of the electrotechnical sector and the contraction of the electrical appliance industry in the Netherlands are striking, when comparing growth from 2012 to the growth figures in the 1996-2011 period. [Author's note: a decline that can be largely explained by the fact that the development of consumer electronics and manufacturing activities were almost completely divested and outsourced to Asia and, to a lesser extent, to Eastern Europe in that period. This used to be a major part of Philips' and its full supply chain's core activities. It was Philips Electronics in those days, whereas today the company goes by the name Royal Philips or Philips Healthcare.]

Compared to the OECD average, the Netherlands is experiencing greater growth in the following industrial sectors in particular: the pharmaceutical industry, machine & equipment industry, food, beverages and tobacco industry, and the petroleum industry.

MAIN TAKE-AWAY

Apart from the petroleum industry, these industries are all strongly present in the Netherlands in Brabant. Taking this even further, the Dutch machine and equipment industry is almost completely centered on Brabant and Brainport Eindhoven, and the food industry has its center of gravity in the region too. The largest concentration and bulk of pharmaceutical manufacturing is likewise based in Brabant.

B. COMPETITIVENESS: LABOR PRODUCTIVITY

Labor productivity levels in the Netherlands are high when compared to the OECD. In most sectors, the Netherlands produces higher added value per hour worked than the OECD average. Labor productivity growth will level off in the period from 2012 compared to productivity growth in the period up to and including 2011, a trend that applies to many OECD countries. Labor productivity growth is mainly in OECD member states with lower productivity levels (catch-up growth).

The growth of labor productivity in the Netherlands in the period up to 2011 was in the principal sectors of information and communication, financial services and trade, transport and storage, and catering. In the principal sectors of industry and agriculture forestry and fishing, construction and mineral extraction lagged behind the average growth in the OECD and in the Netherlands.

From 2012, labor productivity increased most rapidly in the principal sectors of construction, industry, information and communication, financial services and agriculture, forestry, and fishing. Labor productivity growth in OECD member states was slightly stronger in many principal sectors in that period. Only productivity growth in construction was greater in the period after 2012 in the Netherlands. Compared to the OECD, the mineral extraction, energy, water and waste management sectors are also shrinking in the Netherlands.

Within the Dutch industry, labor productivity levels are highest in the petroleum industry, pharmaceutical industry, chemical industry, and the electrotechnical industry. In addition, mineral extraction also has a high level of labor productivity. In these sectors, the average productivity levels in the OECD are only higher in the Petroleum industry.

Throughout the period of analysis, labor productivity growth in industry was greater than the average productivity growth in the Netherlands. Up to 2011, labor productivity growth was highest in the electrical engineering industry, machine industry, chemical industry, and the auto and trailer industry. From 2012, labor productivity growth was primarily in the pharmaceutical industry, petroleum industry, graphic industry, and the basic metal industry.

In many industrial subsectors, labor productivity growth in the Netherlands was higher than the OECD average. This applies to the pharmaceutical industry, petroleum industry, electrotechnical industry, electrical appliances industry, wood, paper and printing industry, food, beverages and tobacco industry, and the machine industry.

MAIN TAKEAWAY

Labor productivity in the Netherlands is high, including when compared internationally, and also in the many industrial sectors that are well developed in Brabant, such as the pharmaceutical industry, electrotechnical industry, electrical appliances industry, food, beverages and tobacco industry, and the machine industry.

C. SPECIALIZATIONS IN THE DUTCH ECONOMY

There are a number of sectors in the Netherlands that hold a larger part of the economy than the OECD average for the same sectors. This can be interpreted as a form of economic specialization, which is the result of cost benefits and productivity benefits associated with specific favorable factors in the Netherlands: comparative advantages, such as unique knowledge, expertise, production technology, human capital, (international) accessibility, trust, etc.

Many of these sectors of the Dutch economy also have labor productivity levels that are higher than the OECD average, which makes them competitive in an international context.

A number of these sectors have been able to grow on this basis, even more than the average growth figures in the Netherlands. They have thus been important drivers of the Dutch economy. These sectors are all in the food, beverages and tobacco industry, chemical industry and the machine industry. On the basis of the average annual added value growth, the food, beverage and tobacco industry and the machine industry can be characterized as growth sectors. The average annual growth in the Netherlands in the period after 2012 was greater than in the OECD.

MAIN TAKEAWAY

Brabant's key industries (the food, beverage and tobacco and the machine and equipment industries) are identified as the growth industries in the Netherlands and as important drivers of the Dutch economy. The Netherlands' growth in these sectors has exceeded OECD growth since 2012.

3. SWOT ANALYSIS STRATEGIC VALUE CHAINS IN THE DUTCH MANUFACTURING INDUSTRY (KPMG & TNO)

KPMG was commissioned by the Dutch Ministry of Economic Affairs and Climate to perform, together with the TNO, a SWOT analysis on strategic value chains in the Dutch manufacturing industry. The research focuses on a number of value chains of a technological character that are of strategic importance for the Netherlands and specifically for the Dutch manufacturing industry.

With regard to these value chains, it is important to determine what the size and potential and how dominant the position of the Dutch (manufacturing) industry is. A dominant position (control point) in the global chain increases the competitiveness of the sector as a whole.

This research focuses on a variety of specific international value chains in which there is a risk that strategic technology will disappear abroad and/or the Dutch industry will lose its international competitive position. International developments such as globalization, emerging markets, and protectionism are examples of the forces that can have an impact on the competitiveness of the Netherlands. Covid-19 is a new factor that impacts upon supply chains.

The value chains examined are:

1. Life sciences (pharma, MedTech, biotech)
2. Cyber security
3. Artificial intelligence (AI)
4. Semiconductor industry
5. Quantum technology
6. Defense industry
7. Aerospace industry
8. Hydrogen industry

The main research questions:

1. What specific developments are emerging in relation to industrial sectors, in terms of sustainability, digitization, security, social, technological, and economic and geopolitical developments?
2. What are the opportunities for and threats to the relevant sectors?
3. What are the strengths and weaknesses of Dutch industry in relation to value chains?

MAIN FINDINGS OF THE STUDY

The manufacturing industry is the driving force behind the value chains that were analyzed. The high-value industry, with strong knowledge and technology components, in particular results in positive scientific and economic effects for the Netherlands.

OPPORTUNITIES

The Netherlands is known as a country with a large service sector, while its manufacturing industry is relatively small in relation to other countries. This study did however show that the Netherlands has a number of unique in-house capacities in the form of knowledge, technology, and companies and organizations. Further, there are opportunities as it is expected that the (international) market demand for these businesses will increase in certain areas.

It must be noted that a high level of investments in a specific technology and/or sector is important for achieving competitiveness at a European or global level. And so it makes sense to focus on those capabilities and technologies in which the Netherlands already excels. However, experience has shown that Dutch government is not always good at predicting which developments will be the high-scorers of the future.

These opportunities are described in the following paragraphs. One example is optical satellite communications. The Netherlands has a strong position in this field because science and industry operate at the forefront of technological knowledge. Worldwide demand for applications and components is expected to increase significantly.

Finally, the Netherlands has existing ecosystems and capacities available for series production. In short, there is a chance that the Dutch position in this technology can be further improved, enabling the Netherlands to build up a strong position in the sector in the coming years.

It is important to understand that foreign players are not standing still. If the Netherlands does not proceed quickly enough, leads in certain technological domains and sectors may be lost. There is much interest abroad in numerous technologies developed in the Netherlands, there is a lot of interest from abroad. Of course, one can always sell a technology abroad or have it manufactured outside of the Netherlands, but the question is if such scenario is ultimately the best solution for the Netherlands, especially because of the fact that it generally concerns strategic technology.

THREATS

In addition to clear opportunities for the Dutch manufacturing industry, a number of weaknesses and threats were also identified.

1. Perhaps one of the main bottlenecks lies in the fact that Dutch industry is not taking sufficient advantage of the available opportunities. Examples include the manifest potential in space and quantum technology. The larger Dutch high tech companies with experience in the field of complex machine building and component manufacturing are particularly well-placed to further develop these technological domains. It appears that a (hyper) focus on their core activities is stopping those companies from moving into the new fields. A clear and present danger is that unique technology is bought and adopted by foreign players, causing the Netherlands to lose its current position.

2. The Netherlands generally seems to follow European procurement rules more strictly, while other countries more often invoke Article 346 of the Treaty on the Functioning of the European Union, allowing them to select national companies for larger investment and development projects on the basis of national security arguments.

3. Availability of data is an important condition for the further development of many value chains, such as AI and Life Sciences. The EU has stricter regulations regarding the protection of personal data than the United States and China, and although these regulations protect the interests of EU citizens, the degree to which data is available in the EU and the Netherlands will play a role in the success or failure of these crucial sectors in the Netherlands.

4. Successful Dutch companies are regularly taken over by foreign players, which means that there is a risk that knowledge, technology, head offices, employment, and added value disappear abroad. In addition, Dutch and Dutch-educated scientists and experts are highly sought after in other countries, which means there is an even greater risk that unique knowledge, expertise, and technology leave the Netherlands.

5. There is a limited supply of qualified, highly-educated staff.

6. Scalability in the Netherlands is limited because of the country's relatively small size and market, and to make impact, cooperation with other countries (in Europe) is often necessary.

7. Lagging behind in the field of certain technologies can lead to security future risks, for example in the fields of defense, cybersecurity, privacy or financial systems.

KEY VALUE CHAINS IN BRABANT

Not all sectors are equally important to or strongly represented in the province of Brabant. For example, cybersecurity is not a core activity in the region.

The same goes for activities in the Defense industry, which is not a main driver of the Brabant economy. However, there are a number of niche companies and specific locations that do have a clear link with military technology. KMWE in Eindhoven is a large top-level supplier of components to the aerospace and space industry, GKN Fokker supplies key components, such as the landing gear of the Lockheed Martin F35 combat aircraft and engine maintenance for all European-based F35s is performed in Woensdrecht. While excellent work is being performed, they remain niche activities.

All other value chains are already well-developed in Brabant and/or have strong growth potential in terms of size, diversity and/or disruptive directions. Some of these opportunities for Brabant are highlighted in the following outline of the principal opportunities in each value chain.

PRINCIPAL OPPORTUNITIES IN VALUE CHAINS WITH A SIGNIFICANT CONNECTION TO BRABANT INDUSTRY AND SCIENCE

LIFE SCIENCES

The life sciences sector in the Netherlands is relatively small: there are a few production facilities belonging to Janssen and MSD, and Philips is a global player in MedTech. There are also several areas of clinical and pre-clinical research where the Netherlands performs well, such as oncology, cardiology, immunology, and neurology. Opportunities lie in the field of building a single Dutch Life Sciences 'brand', increasing the availability/applicability of data (taking into account the regulations) and picking up of new business through the arrival of EMA, Brexit and possible relocation of production after Covid-19.

OPPORTUNITIES AVAILABLE TO BRABANT

- Brainport Eindhoven is where 80% of all Dutch high tech healthcare solutions are developed and manufactured by companies such as Philips Healthcare, Thermo Fisher Scientific, and the complete MedTech value chain that surrounds these companies.
- 70% of all Dutch biopharmaceutical manufacturing performed in Brabant (MSD, MSD Animal Health, Janssen-Cilag, AMGEN, and Aspen Health).
- Several of the Netherlands' leading research projects in immunology, cardiology and oncology are conducted in Brabant, such as at Pivot Park and the Eindhoven University of Technology.

ARTIFICIAL INTELLIGENCE (AI)

AI is developing at an incredible rate worldwide, with winner-takes-it-all aspects that are also evident in other parts of the tech market. The growth potential is very high, and AI is expected to become an integral part of many products and services. The quality of Dutch computer science research is of a high level.

Well-qualified people are sometimes not sufficiently available. Successful companies are regularly taken over by foreign players. Availability of data as a result of privacy laws also plays a role, with China and the US having an advantage due to less stringent regulations. Additional investments are required for a strong knowledge and innovation base for the entire value chain (high-end research, commercialization, innovative applications, human capital, startups and scaleups, and social acceptance/responsible AI) in order for the Netherlands to compete with the front runners in Europe.

OPPORTUNITIES AVAILABLE TO BRABANT

- In Europe, the Netherlands is one of the front-running nations in digitalization and IT ecosystems. The world sees it as a testing ground for the introduction of AI applications such as the self-driving car. The autonomous vehicle and many other real-world AI applications in industry are developed in Brabant by companies and institutes, like the TU/e, Eindhoven University of Technology, Philips, NXP, TomTom, the TNO, and ASML and their first, second and third tier suppliers in and around Eindhoven
- The Netherlands is an excellent breeding ground for AI applications in various sectors (health and care, agriculture and food, technical industry, and logistics and mobility), all of which are technologically centered in Brabant. They served as an excellent starting point for creating AI value in the Netherlands.

SEMICONDUCTOR INDUSTRY

The Netherlands, and the ecosystem that evolved around ASML in particular, is a strong player in mechanical engineering. A number of other companies and technologies have also contributed to its standing in this respect. Opportunities can be found in the fields of metrology, autonomous cars and, further in the future, photonics and quantum technology. Continued innovation and development into mature applications is necessary to capitalize on the opportunities.

OPPORTUNITIES AVAILABLE TO BRABANT

- The Netherlands, together with the USA and Japan, is one of the three countries that has a complete semiconductor value chain within its borders. The bulk of the industry is located in Eindhoven around ASML, the world's leading manufacturer of lithography machinery, and NXP, which has its Dutch research center in Eindhoven. Together, ASML and NXP have a turnover of € 19.8 billion (2019). ASML has a workforce of 13,732 employees in Europe, the majority of them based in Brainport Eindhoven. The ecosystem around ASML is a global monopoly on lithography/chip machines, and the company is the only one in the world that can build EUV lithography machines that produce high-quality chips. This makes the Netherlands, and Brabant in particular, exceptionally strong in inventing, developing, engineering, building, commercializing, and maintaining complex machinery and capital assets.
- The Netherlands is also strong in photonics, part of which involves the production of photonic chips – chips that work on the basis of light (photons) instead of electron, which are much faster and more energy-efficient. Smart Photonics is one of the market leaders in this field and it received a public-private investment of €35 million in 2020 to prevent the company from falling into foreign hands. The center of gravity of the photonics industry in the Netherlands (and home to Smart Photonics) is Brabant.
- Metrology is the accurate measurement/testing of the results of the chip machines. This is a growth area in which the US and Japan are market leaders, while the Netherlands has the knowledge and technology for further growth. ASML and Thermo Fisher Scientific in Eindhoven already play a role here.
- Autonomous driving could be a major stimulus, as it requires specialist chips. These chips are expected to come from Europe and, while Germany and France will be important players, NXP in the Netherlands (Eindhoven and Nijmegen) specializes in chip development for the automotive sector and is already working with TomTom, the TNO, DAF Trucks, and others in autonomous driving research.
- Quantum technology is an opportunity for the Dutch semiconductor industry. The ecosystem around ASML in Eindhoven, for example, has the exact skills and knowledge needed and would be a logical environment for building quantum computers.

QUANTUM TECHNOLOGY

The Netherlands is in the top ten countries with the most knowledge in the field of quantum technology and has a number of leading institutions in this field (QuTech and QuSoft). Microsoft and Intel are investors in QuTech. The country is in a good position for building an industry for the production and supply of quantum technology hardware, including quantum computers. This is because we have in-house knowledge of quantum technology and of the production of complex machines (such as in the ecosystem around ASML). Lagging behind in quantum technology could lead to future security risks.

OPPORTUNITIES AVAILABLE TO BRABANT (AND A POSSIBLE THREAT)

- An important strength of the Netherlands and the Brainport Eindhoven region in particular is thinking in terms of systems: the HTSM ecosystem in the Netherlands excels at systems engineering. Combining and integrating extremely complex technologies into working systems with unique capabilities is best exemplified by the success of the Dutch semiconductor industry in the Brainport region.
- The knowledge and experience acquired here can be very useful in finding a way forward and achieving breakthroughs in the development of the quantum internet and the quantum computer.
- The research centers QuTech (Delft), QuSoft (Amsterdam) and QT/e (Eindhoven) are high quality and contribute to the position held by the Netherlands. Hubs have arisen around these centers which cooperate with the hubs in Twente and Leiden and have developed leading roles in the field. This has also led to foreign players such as Microsoft and Intel coming to the Netherlands to participate and invest.
- However, this also means there is a serious risk that Dutch experts will start working for foreign companies.
- All in all, the Dutch high tech manufacturing industry is still insufficiently involved in quantum technology, and other countries and/or foreign companies will capitalize on these opportunities. Companies such as ASML, NXP, and Philips (all based in Brabant), could play a role in this regard, but the question remains: how can they be tempted to come aboard?

AEROSPACE INDUSTRY

The Netherlands has specific niche technologies that sets it apart, such as optical satellite communications. The total satellite market was estimated to be worth $130 billion in 2017. The Netherlands has a manufacturing industry with expertise in making high-quality optical components, creating an opportunity for added value for the Dutch economy. There is also an increasing demand for earth observation instruments and space-as-a-service, providing opportunities. Space is also of increasing importance for national defense.

Expertise available in the Netherlands includes the development of (nano) satellites, earth observation instruments and high-quality optical components that are built in complete optical systems, launch systems, the development of solar panels, and miniaturized instruments. Foreign investors display much interest in these specific Dutch technological developments, especially in high-quality optical components.

There are opportunities for the manufacturing industry in the field of optical satellite communications. It is expected that demand for the technologies and systems containing such technology will grow significantly, and if the Dutch manufacturing sector can set-up serial production for these components, it could mean a major boost for the manufacturing industry in the Netherlands. The country has a good starting position because it is a technological leader in optical systems and has a manufacturing sector available that can produce high-complexity, high-quality components/systems. This ecosystem, with players such as VDL, DEMCON, Nedinsco, Hyperion Technologies, and the TNO, has already created FSO Instruments, an industry consortium active in developing and implementing technologies that enable high-speed communication laser links between space, air, and ground terminals.

OPPORTUNITIES AVAILABLE TO BRABANT

Brabant is home to a select but highly-developed group of companies active in the (aero)space sector. These companies could either become involved or are already taking the lead in research and innovation in highly specific space technologies. A selection of these companies includes:

- DEMCON Focal: optomechatronic systems for application in space and semiconductor manufacturing (lithography)
- KMWE Aero Structures & KMWE Aero Engine: tier one component supplier to the (aero)space sector
- APP Aerospace Propulsion Products: ignition systems for space launchers
- GKN Fokker Technologies: aerostructures, electrical wiring systems, and landing gear systems
- StandardAero Defense Services Europe: MRO jet fighter engine
- VDL Enabling Technologies Group: tier one design and contract manufacturing in semiconductor and deposition equipment, analytical instruments, medical systems, aerospace and science
- VDL GL Precision: flight-critical safety parts
- Bradford Space: sun sensors and reaction wheels, propulsion subsystems (pressure transducers, flow control units, cool gas systems and other subsystems), avionics and thermal subsystems, and fully operational space workstations
- Thales Cryogenics: cryogenic cooling systems

HYDROGEN INDUSTRY

Hydrogen is playing an increasingly important role in the energy transition. Relatively little sustainable energy generation takes place in the Netherlands, but the country is the second-largest producer of grey hydrogen for the chemical industry, after Germany. There is no Dutch original equipment manufacturer (OEM) in the field of (largescale) electrolysis systems, although it does have a high-quality (natural) gas infrastructure that can be used for the transport of hydrogen.

OPPORTUNITIES AVAILABLE TO BRABANT

- The Dutch manufacturing industry does not currently feature in any significant sense in the international market for electrolyzers, even though the industry has all the required skills and capabilities. This industry is located largely in Brabant. Building a completely new value chain around hydrogen (including the industrialization of the manufacture of electrolyzers) offers opportunities for companies in the fields of components and materials, hydrogen pipelines, storage, and others.
- However, the Netherlands does not (yet) have a large OEM for electrolyzers, and achieving that will not be easy due to the presence of larger players elsewhere. On the other hand, demand for electrolyzers will increase in the near future and, to meet expected demand, current electrolyzers with a capacity of 10 megawatts will have to be scaled up to gigawatt level or several thousand times greater. And so opportunities are available for manufacturers of electrolyzers and for suppliers of subsystems, components, and materials. It is important that the industry is built up and receives significant initial investments, so that the Dutch hydrogen sector can successfully gain a competitive position on the international stage.
- Companies such as Shell, GasUnie, Vattenfall, BP, and Engie have large-scale electrolysis plans. For example, Shell, GasUnie, and Groningen Seaports have announced the creation of the NorthH2 project, a mega-wind farm generating electricity using the sea for the production of hydrogen. The companies hope to generate 3 to 4 gigawatts of wind energy by 2030, and 10 gigawatts by 2040. Whereas these companies have extensive knowledge in energy generation, systems engineering and machine building skills from Brabant would make the required skill-set complete.

4. KNOWLEDGE AND INNOVATION AGENDA FOR THE HTSM PRIORITY INDUSTRY (KIA - HTSM), 2018 - 2021

SOCIETAL FRAMEWORK

To facilitate interaction on HTSM key enabling technologies between principal stakeholders, HTSM has established a thematic top-down framework containing five overarching societal challenges:

1. Health
2. Security
3. Climate (including energy and water)
4. Mobility
5. Sustainability (including the circular economy and food)

These societal themes are enabled from the bottom-up by the HTSM technology roadmaps (see below). Each roadmap is managed by a dedicated team of experts from the private sector, institutes, and universities.

KEY ENABLING TECHNOLOGIES

The HTSM technology roadmaps largely overlap with the key enabling technologies (KETs) defined by the European Commission. All technologies in the Priority Industry are intimately connected with IT. KETs are knowledge intensive and associated with high R&D intensity, rapid innovation cycles, high capital expenditure, and highly-skilled employment. They are multidisciplinary, cutting across many areas, and assist leaders in other fields to capitalize on their research effort.

SUSTAINED ECONOMIC DEVELOPMENT

The HTSM industry consists of 94,800 companies employing 601,690 people, many of them in innovative small and medium sized enterprises (SMEs), startups, and scaleups. Together, these companies create 159,475 billion euros in production value, and 59 billion euros in exports, while they invest 4 billion euros in R&D annually, of which over 500 million euros is in the form of public-private partnerships.

HUMAN CAPITAL AND INTERNATIONALIZATION

The success of the Priority Industry is critically dependent on the availability of qualified personnel. Knowledge workers in technology remain in short supply, and education and training in applied and application-oriented science are essential, as is access to the international labor market. The industry and research organizations operate in a global value chain. The HTSM industry actively collaborates with the international innovation attachés of the Dutch Ministry of Foreign Affairs to further expand the global Dutch network.

BUILDING BRIDGES WITH NEW STAKEHOLDERS

HTSM aims to partner actively with government ministries and regional public organizations to achieve a long-term alignment between scientific research, technological innovation, and societal challenges. Through the societal framework in the KIA - HTSM, value is added by building top-down bridges using the bottom-up HTSM roadmaps. Cross-over collaboration with other priority industries has become an increasingly significant factor for enhanced partnerships, with the explicit involvement of IT.

LEVERAGE FROM INTERNATIONAL R&D

As HTSM competes in a global market, participation in joint European R&D is a priority for both science and industry. Results from European projects leverage the Priority Industry's national contribution. The HTSM roadmaps closely follow the developmental direction of the European Horizon 2020 program and its successor, Horizon Europe (2021-2027), which is still being finalized.

TRANSPARENT PROGRAMMING WITH SCIENCE AND INDUSTRY

The Holland High Tech Foundation coordinates governance of and knowledge and innovation programming for the Priority Industry, co-funds research at institutes and universities through public-private partnership (PPP) grants, and supports SMEs in the Holland High Tech Partner organizations through the SME Innovation Stimulation and Priority Industries (MKB-innovatiestimulering Regio en Topsectoren) (MIT) scheme. Holland High Tech regularly coordinates with the key TNO, NLR, and NWO research institutes on the programming of research in applied and application-oriented science. Long-term partnerships are in place with the Delft, Eindhoven, and Twente technical universities as well as with the specialized HTSM research centers.

TECHNOLOGY TRANSFER AND GO-TO-MARKET

Process innovation and digitization are essential in the deployment of new manufacturing technologies. The Smart Industry Field Labs have created a foundation for joint experimentation and learning. Government policy and instruments must be put in place that support SMEs through the assessment of smart manufacturing and one-on-one stimulation. Marketing products and services that directly serve innovation in respect of societal challenges is not an automatic process. Public procurement, such as in Small Business Innovation Research (SBIR), can bridge the gap between R&D results and the creation of economic value, especially for SMEs. Meanwhile, successful implementation requires systemic improvement as well as processes for structural alignment with the relevant government ministries.

HTSM TECHNOLOGY ROADMAPS

The HTSM roadmaps are bottom-up initiatives from science and industry within the Priority Industry. They each set out the societal challenges and economic relevance, applications and technologies, priorities and implementation, partners and processes, and the anticipated investments in public-private research. The collective investments for the individual roadmaps add up to the Priority Industry HTSM multi-annual public-private R&D budget.

Priority Industry HTSM multi-annual public-private R&D budget (in millions of euros per year)

Year	2018*	2019*	2020**	2021**
Private	545	570	590	610
Public, specific	104	105	105	105
Public, non-specific	111	125	135	145
Total	**760**	**800**	**830**	**860**
Sub-total, European projects only	**470**	**500**	**530**	**560**

* topsectoren.nl/publicaties/publicaties/rapporten-2017/december/11-12-17/kic-2018-2019

** HTSM proposal, not confirmed

Source: Top Sector HTSM

CURRENT HTSM TECHNOLOGY ROADMAPS

Advanced instrumentation	Systems and technology for measuring radiation, light, and particles, determining and monitoring location, movement and vibration, management, processing, and interpretation of big (sensor) data for big science, instruments for R&D and production processes.
Aeronautics	Technology and innovation for more sustainable and safer air transport: aerostructures, engine subsystems and components, maintenance, repair and overhaul, aircraft systems, and novel materials.
Automotive	Solving problems like emission, congestion, and noise disturbance and promoting safety. Research topics: sustainable powertrain, smart mobility.
Electronics	Developing new generations of (chip) technology, electronic components, ICs, and electronic systems for use in alternative energy, electric cars, mobility and transport, logistics, communication, safety and security, privacy, healthcare, climate and water, intelligent cities, aviation, and space.
Embedded systems	Integrated hardware/software systems that add intelligence, decision-making and other possibilities to high tech products that foster economic activities and quality of life.
Healthcare	People-centered nanoelectronics, embedded systems, and mechatronics for prevention, diagnosis, intervention, and therapy, informal and formal primary care and homecare, and enabling technologies for healthcare.
High tech materials	Understanding materials and their properties during production, processing, use, and re-use as well as cost-reduction and safe handling for novel (nano) materials.
Lighting	Lighting technology from components and solid-state lighting (SSL) systems, to people-centered, energy-efficient, and intelligent lighting solutions.
Nanotechnology	Cross-sectoral technologies in materials, electronics/optics and sensors, for applications like lighting, energy, health, and water.
Photonics	Translating applications into requirements for components and performance, technologies for photonic-electronic integration, and processes for fast and smart design and production.
Printing (3D)	Printheads and functional materials, reliability and advanced measurement and control engineering, and architecture of digital print platforms.
Security	Protecting the security of people and society in the event of violence as well as situations that arise from crises and disasters. This is achieved with technology in the domains of systems-of-systems solutions, cybersecurity, and sensors.

Continued on next page >

CURRENT HTSM TECHNOLOGY ROADMAPS

Semiconductors equipment	Innovation with respect to the equipment for producing advanced integrated circuits: miniaturization of components, enlargement of chips and substrates, and fabrication techniques.
Smart industry	Mechatronics, production technology linked to IT, fast and accurate sensing, integration of micro and nano-technology and smart materials, and smart industry field labs.
Space	Development of products for satellites and launching vehicles, and new products and services based on satellite data in agriculture, food, water, energy, and logistics.

5. KNOWLEDGE AND INNOVATION AGENDA FOR KEY TECHNOLOGIES (KIA – ST), 2020 – 2023

The vision and mission of the Dutch government as contained in this knowledge and innovation agenda is that Dutch support for innovation must be aimed at helping industry and science to develop the key technologies the country needs to solve its most important societal needs.

INNOVATION POLICY

Through its mission-driven innovation policy, the Dutch national government has formulated a new approach for the Dutch priority industry (called top sectors in the Netherlands) and innovation policy. Economic opportunities and social challenges constitute two sides of the same coin in this approach. The government has selected the following four themes as the leading elements in research and innovation for the 2020-2023 period: Energy transition and Sustainability, Agriculture, Water and Food, Health and Care, and Safety.

In addition, government has committed to the development of key technologies for future economic opportunity and targeted technological contributions from priority industries for solving societal challenges. The Knowledge and Innovation Agenda for Key Technologies (KIA - ST) is the implementation plan for this aim by the Dutch priority industries, together with the relevant ministries and knowledge institutes.

PUBLIC INVESTMENTS

The importance of public investment in key enabling technologies is widely recognized. Most countries with a comparable economic structure and competitive position to the Netherlands (focus countries) invest several tenths of a percent of their GDP (gross domestic product) in key technologies. These investments will, as a whole, increase in the near future. Such investments are devoted to fundamental research as well as to more applied research and innovation and are spent on individual R&D programs and projects and also on public-private clusters, networks, and institutes in the field of key enabling technologies. Various focus countries are also investing in their R&D infrastructure in order to enable high-quality R&D in the field of key technologies.

SOCIETAL AND ECONOMIC RELEVANCE

The concept of key technologies in the KIA - ST includes both the Key Enabling Technologies (KETs) and the Future and Emerging Technologies from the European Horizon 2020 and its successor program, Horizon Europe. Key technologies are characterized by their wide field of application or scope in innovations and/or sectors, and will radically change the way we live, learn, innovate, work, and produce and provide opportunities for solving problems in society. Key technologies are essential in solving societal challenges and/or can make a major contribution to the economy by creating new business and new markets, increasing competitiveness, and enhancing job creation. They enable groundbreaking process, product and/or service innovations and are relevant to science, society, and the market.

CLUSTERS OF TECHNOLOGIES

From the perspective of the potential contribution of technology to societal challenges in the Netherlands, the Ministry of Economic Affairs has determined that the following clusters are the future key technologies for the Netherlands:

- Chemical technologies
- Digital technologies
- Engineering and fabrication technologies
- Photonics and light technologies
- Advanced materials
- Quantum technologies
- Life science technologies
- Nanotechnologies

These clusters together make up the technical framework for the Knowledge and Innovation Agenda.

APPROACH

The Ministry of Economic Affairs has tasked the HTSM Top Sector with the coordination of the preparation of this KIA - ST, working closely with the other priority industries and the relevant ministries. Given the breadth of the field, the HTSM Top Sector has put together a core team of representatives from a selection of priority industries, knowledge organizations, departments, and regions.

MULTIYEAR PROGRAMS (MYPS)

The choice was made to focus on a broadly supported portfolio of multiyear programs (MYPs), supplemented with knowledge and innovation challenges from science, a framework for key methodologies, options for commercialization and the creation of new markets, and directions for implementation and the future revision of the KIA - ST.

These MYPs are public-private partnerships (PPPs) of companies, governments, and knowledge institutes and are aimed at making an important contribution to societal missions, the future earning capacity of the Netherlands, and maintaining the prosperity and knowledge levels of the country. They cover the entire knowledge chain, from fundamental and applied research to commercialization and market creation.

In 2018, a general request for MYPs was sent to knowledge institutes, companies, and public agencies, including all the Dutch priority industries. Submitters of MYPs have been brought into contact with each other to create as much focus and dynamism as possible. In many cases, this led to the combining and strengthening of initiatives. The next step after this process phase saw the core team carry out a nominal test, and proposals that did not comply with the guidelines were rejected.

MULTIYEAR PROGRAM PROPOSALS

RESULT

Below are the remaining 51 MYP proposals. Leaders of thematic KIAs, departments and regions have stated that all these MYPs are relevant to their respective agendas. This MYP portfolio is an overview of possible programs in public-private partnerships and exhibits the technological ambitions of companies, knowledge institutes, social organizations, and governments in the priority industries. The aim is to provide inspiration and substantiation when it comes to decision-making by the parties in charge of the budget in the Knowledge and Innovation Covenant (KIC).

There is much diversity of intersections in the portfolio, with a great deal of overlap between MYPs as well as with the thematic KIAs, such as the KIA – HTSM described above. A number of MYPs are part of larger European research programs. Many of the MYPs have already been part-approved and funded, as can be seen in the last column that details the annual project budget (in thousands of euros) already allocated.

MJP nummer en naam		Energietransitie en Duurzaamheid	Landbouw, Water en Voedsel	Gezondheid en Zorg	Veiligheid	Toekomstbestendige Mobiliteit	Circulaire Economie	Chemical Technologies	Digital Technologies	Engineering and Fabrication Tech	Photonics and Light Technologies	Advanced Materials	Quantum Technologies	Life Science Technologies	Nanotechnologies	Begroting per jaar	Waarvan reeds gecommitteerd
01.	Fenotype - Genotype - Prototype	X	X				X		X		X			X		15	9
02.	Building Blocks of Life - Begrip en benutting van cellulaire systemen	X	X	X										X		13	7
03.	Veredeling 2.0: Exploreren, exploiteren en combineren van genomen	X	X						X					X		24	16
04.	High Tech to Feed the World	X	X	X				X	X	X	X	X	X	X	X	30	13
05.	Dutch contribution to Solar energy for the circular economy (Sunrise)	X	X					X	X	X		X		X	X	10	0
06.	Verbetering van d fotosynthese-efficiëntie	X	X						X					X		10	1
07.	Nationale Agenda Quantumtechnologie	X	X	X	X								X			102	69
09.	Nano-contamination control	X	X	X	X					X		X			X	16	1
10.	Nano4Society	X	X	X	X			X	X	X	X	X	X	X	X	175	56
13.	Smart personalized food and medicine	X	X	X					X	X				X		22	5
14.	Maatschappelijk gewenste en veilige biotech toepassingen door Safe-by-Design	X	X											X		3	2
16.	MedTech			X				X	X	X	X	X	X	X	X	502	322
17.	Biomedical engineering for Health			X				X		X				X	X	13	5
18.	Flexible electronics (IoT devices, sensors, sensor arrays, ...)			X		X			X	X	X				X	109	42
20.	Beyond 5G: Future Networks and Services)	X	X	X	X				X	X						236	112
21.	Photonics for Society (Nationale Agenda Fotonica)	X	X	X	X				X	X	X		X	X	X	550	500
22.	Integrated Photonics	X	X	X	X						X					68	14
23.	Light & Intelligent Lighting	X	X	X	X				X		X	X		X		17	3
24.	CITC (Chip Integration Technology Centre)	X	X	X	X					X	X	X				11	7
25.	Halfgeleider Fabricage Apparatuur	X	X	X	X			X	X	X	X	X			X	82	33
26.	Systeemarchitectuur en systeemintegratie	X	X	X	X	X			X	X						144	88
27.	Composiet	X					X	X	X	X		X				40	18
30.	Industry 4.0 for the Built Environment	X		X	X			X	X	X		X				80	40
32.	Materials Innovations (Brightlands MC)	X							X	X	X	X			X	11	5
33.	Circular plastics (CP)	X					X	X	X	X		X				28	9

MULTIYEAR PROGRAM PROPOSALS (CONTINUED)

MJP nummer en naam	Energietransitie en Duurzaamheid	Landbouw, Water en Voedsel	Gezondheid en Zorg	Veiligheid	Toekomstbestendige Mobiliteit	Circulaire Economie	Chemical Technologies	Digital Technologies	Engineering and Fabrication Tech	Photonics and Light Technologies	Advanced Materials	Quantum Technologies	Life Science Technologies	Nanotechnologies	Begroting per jaar	Waarvan reeds gecommitteerd
34. Smart Industry	X	X	X	X		X		X	X						175	61
38. Batteries of the future	X				X		X	X	X		X			X	45	7
41. Duurzame Luchtvaart, Ontwikkeling Hybride Elektrisch Vliegen	X				X		X	X			X				50	0
42. Maritieme Sleuteltechnologieën	X	X		X	X	X		X	X		X				12	5
44. Nationaal Artificiële Intelligentie (AI) Onderzoekscentrum	X	X	X	X	X			X							87	27
45. Nederland Werkt in Slimme Ketens aan Artificiële Intelligentie (AI)	X	X	X	X	X			X							52	12
48. AI enabled Electronic Components & Systems addressing societal solutions	X		X	X		X		X							500	380
49. Ruimtevaart (gebruik vd ruimte)	X	X		X	X		X	X	X	X	X	X	X	X	141	49
54. Dutch Blockchain Coalition (DBC)	X	X	X	X	X			X							10	4
55. Cybersecurity - Digitale Veiligheid en Privacy	X	X	X	X	X			X							22	5
56. Elektrochemische Conversie & Materialen (ECCM) en Industriele Electrificatie	X				X	X	X		X		X				85	53
58. Biorizon	X					X	X				X				11	4
59. Climate proof chemistry (Brightsite)	X					X	X								16	0
70. Katalyse en procestechnologie: enablers naar duurzame chemische industrie	X	X				X	X		X						21	7
71. Meet- en Detectietecnologie	X	X	X			X	X	X	X	X			X	X	16	2
72. Evidence Basaed Sensing	X	X	X	X		X	X	X	X	X			X	X	14	0
73. Soft Advanced Materials (SAM)	X					X	X		X	X	X		X	X	15	7
82. Materiaaltechnologie - made in Holland	X		X	X			X	X	X	X	X	X	X	X	83	28
84. Dutch contribution to International Big Science Facilities	X	X	X	X				X	X	X	X	X		X	185	100
86. Bridge - Life Science Technologies			X					X	X	X	X	X	X		87	13
87. Vitality, Lifestyle and Ageing-in-place for people with (early) dementia	X		X	X				X	X	X	X		X		29	5
88. D-ART; D-RACE Advanced Radar Technology				X					X		X			X	4	2
89. Technology for green smart and safe mobility	X				X		X	X	X	X	X			X	52	27
90. ARCNL	X	X	X	X						X	X			X	8	8
92. Medische Isotopen			X					X	X		X		X	X	108	44
93. Photovoltaic Technology (Solliance)	X								X	X	X			X	13	12

C. Regional trends and developments in HTSM

1. BRAINPORT'S MULTIYEAR DEVELOPMENT PLAN – THE BRAINPORT REGIONAL AGENDA, 2020 - 2025

INTRODUCTION

What follows is a summary of the Brainport Regional Agenda - the multiyear agenda of the Brainport Eindhoven region, containing the ten most important tasks for the region for the next five years and the associated actions. The results should be evident to everyone in the region, such as improved job opportunities or accommodation, reliable transport and good accessibility, new facilities, and cutting-edge care and education.

The strength of Brainport Eindhoven lies in the partnership between the authorities, education and knowledge institutes, and the business community – a cooperative approach dubbed as the triple helix. The agenda is in line with the strengths of this triple helix, and it must further bolster those strengths so that Brainport Eindhoven means even more for the people in the region and for the Netherlands. The level of ambition is high indeed.

The Brainport Agenda was drawn up with the contribution of hundreds of organizations and people, involving sessions with representatives from companies, institutions, and the authorities and in-depth interviews with experts. These contributions led to visions of the future concerning care, sustainability and mobility, while studies of the major developments in education, the labor market, and the manufacturing industry are presently ongoing.

The outcome has been this three-track Brainport Agenda: innovation, talent, and the living and business climate. The agenda comes in the middle of the coronavirus pandemic – a period of concern for vulnerable people in society and uncertainty about the socio-economic future. The crisis has raised new social questions and underscored the importance of economic resilience. However, the crisis has also shown that Brainport Eindhoven has a solid foundation, in stilling confidence, especially in these uncertain times. The Brainport Regional Agenda is intended to contribute to a stronger economy and respond to social issues.

THE 10 OBJECTIVES OF BRAINPORT EINDHOVEN

1. Developing key technologies: the technologies of the future
2. New technology market combinations for social issues
3. Support for SMEs, startups, and scaleups
4. Financing for startups and scaleups
5. All students and students in Brainport to receive innovative education
6. Everyone in Brainport engaged in life-long learning
7. Labor market in balance: the right person in the right job
8. Investments in joint facilities and accessibility
9. The triple helix as a support engine for society-wide welfare
10. Tools to support public-private ecosystems

Some of these objectives relate directly to Brainport's High Tech Systems & Materials sector.

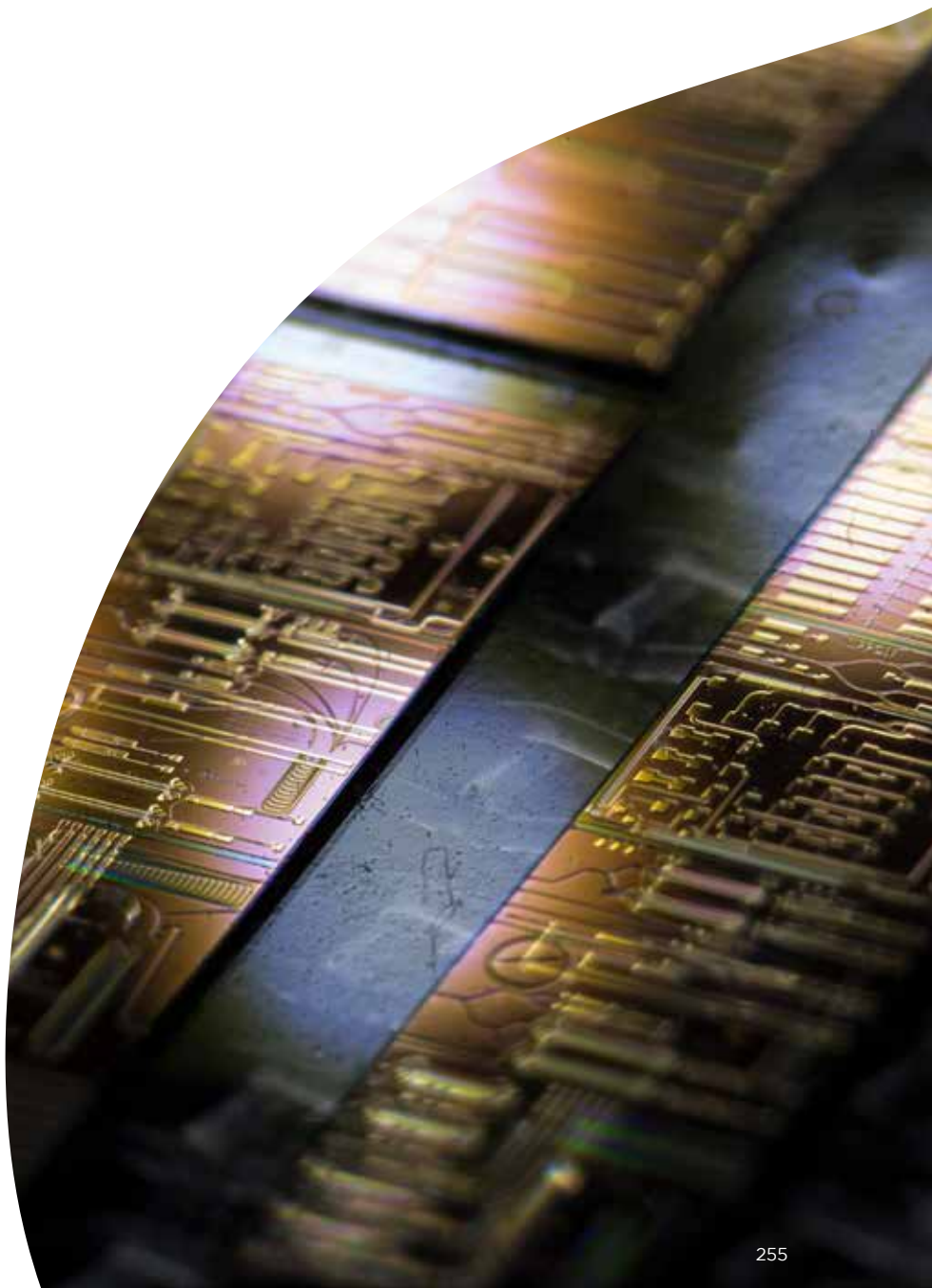
The first objective in particular, developing key technologies:

- Investing in the further development of and support for learning to implement and use systems engineering
- Investing in the further development of the key technologies that Brainport Eindhoven intends to be leading in:
  - advanced manufacturing (smart industry) and specifically additive manufacturing (3D printing)
  - integrated photonics
  - artificial intelligence
  - micro and nanoelectronics

CONNECTION BETWEEN THE NATIONAL AND REGIONAL LONG-TERM AGENDAS

The Brainport National Action Agenda (BNA) is the long-term cooperation agreement between the Netherlands' central government and the Brainport Eindhoven region, and it identifies the priority topics for cooperation between these two parties. The BNA is constantly evolving in order to respond to developments in both the region and the world.

The priorities in the Brainport Regional Agenda are the major components for future cooperation with the authorities in the context of the BNA. The Brainport Regional Agenda is also connected to the 'Regional Deal', a joint financial incentive provided by the national government (130 million) and regional government (240 million) to the Brainport Eindhoven region for projects relating to facilities, talent, and social innovations. These are projects that also contribute to the priorities of the Brainport Regional Agenda.



2. FACTORY OF THE FUTURE INNOVATION PROGRAM, BRAINPORT INDUSTRIES

Adapted from Innovation Origins contributor Milan Lenters' article 'The Factory of the Future requires more than just the development of new technology' (October 22, 2020).

In the Factory of the Future innovation program, companies, schools, knowledge institutes, and government work together in eight field labs on themes for digitizing and automating the manufacturing industry. The ultimate goal is to develop a 'digital factory' where manufacturers can monitor all the production processes in real-time and adjust them wherever necessary – from incoming quotations and design drawings through to a final product or system dispatched from the factory to a customer in the supply chain, all data-driven and interconnected. The underlying concept is that this is the only way the Netherlands can remain ahead of the competition.

Central to Brainport Industries' vision of the Factory of the Future is its analysis of how the 'Smart Industry of the Future' is developing; see illustration 1.

SOFTWARE AND HARDWARE GO HAND-IN-HAND

Software is crucial to this process. Software controls smart factories, it ensures that manufacturers can see exactly when maintenance is required and where the process can be optimized. The strength of the Brainport region is that it is home to both software and hardware companies, brought together in the High Tech Software Cluster, which is also one of the field labs. But companies that are not yet familiar with the potential of data and digitization are also welcome to join in.

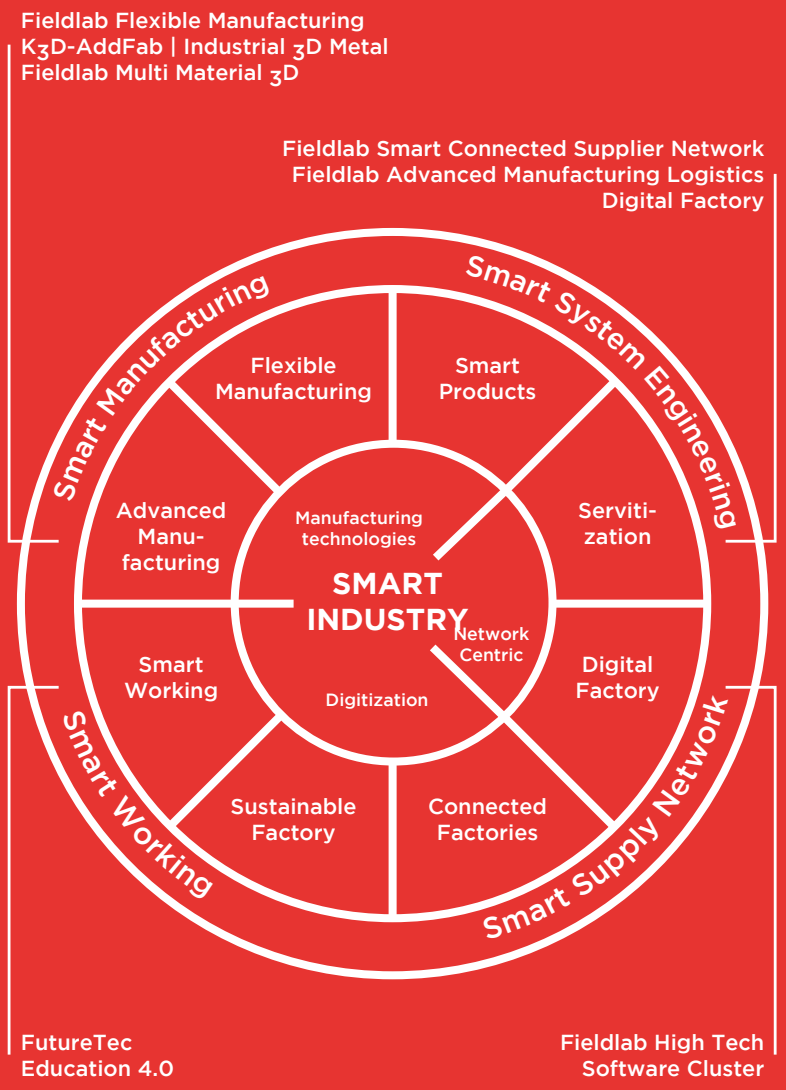


Illustration 1. What is the future makeup of Smart Industry?
Source: Brainport Industries/Brainport Industries Campus

The innovation program has been running for almost two years and different technologies and new working methods are being put into practice. One example is the Smart Connected Supplier Network field lab, a network that improves data exchange in the supply chain. The field lab deals with product specifications and order data that often change because of end-customer requirements, changes that are frequently introduced manually, a time-consuming process that increases the risk of errors. The process is now being automated and is much more intelligent.

The development of technology is not the only function of the field labs, with knowledge sharing, talent development, and demonstrating the potential of technology and digitization all playing a role. "Staff of the companies from all levels of education work together, which not only means smarter talent but also that employees benefit from knowledge gained in projects," said Michel Weeda, program manager of the Factory of the Future innovation program. "This occurs in the form of workshops, for example. The interaction means that you continue to learn and can stay ahead of developments."

There are now 115 companies and educational or knowledge institutes in the innovation program and some 50 business cases have been developed. "Various 3D printing innovations in both metal and multi-material printing are part of it. About 800 people have been educated and trained, and we also regularly take international delegations on tour to show what is happening here, and we organize events around current projects to further spread our message," Weeda said.

Yet the program manager has seen it can be difficult to connect new companies, and he is not exactly sure why that should be the case. "Everywhere I speak, I emphasize that the innovation program and facilities are not just for companies at the Brainport Industries Campus. The Smart Industry Hub South is an important network in this respect, as it involves our regional economic development agencies, industry associations, and their members/network partners. They help their members and clients to get going and offer support in the world of innovations and field labs. "

Although the program will run for two more years, a follow-up is already being developed. "Actually, we have only just started. Developments are continuous, so we are already working on creating new things. We only look in Brabant or in the Netherlands, and we also speak with German and Belgian partners in the Smart Factory EU project and are working on a European Digital Innovation Hub with our partners. We want to keep the facilities at BIC available and easily accessible in the coming years for experiments and research."

OTHER SMART INDUSTRY/HTSM FIELD LABS IN BRABANT

Next to the field labs in the Factory for the Future program, there are a number of other HTSM/Smart Industry field labs in Brabant.

- For example, the **Smart Industry – Data Value Center (DVC-SI)**, which serves to help companies create added value and become more competitive through the use of data. DVC-SI is a joint initiative of the Brabant Development Agency (BOM), Brainport Development, Brainport Industries, the metal industries sector organization, the FME, JADS, Koninklijke Metaalunie, Midpoint Brabant, REWIN, SURF, and the TNO, and is funded by the Province of Brabant and the Netherlands Ministry of Economic Affairs and Climate.

Numerous field labs focus on world-class maintenance. These tend to be located in the middle and western parts of Brabant, where the majority of Brabant's process industry is located, including a number of very large industrial companies such as IFF, Shell, SABIC, and Cargill:

- The **CAMPIONE** field lab (Condition-Based Maintenance for the Process Industry - Open Network Environment) was established to make maintenance 100% predictable for chemical companies, significantly improving the productivity, availability, and safety of production resources at a lower cost. It was initiated by the Brabant Development Agency (BOM), Midpoint Brabant, REWIN West-Brabant, Avans Foundation, and World Class Maintenance.

Participants: ABB • Actemium • Avans University of Applied Sciences • Axians • BlueTea • Delta • DOW Benelux B.V. • Ericsson Telecommunication • Frauenhofer Institute • Fujifilm • Zeeland University of Applied Sciences • Hoppenbrouwers Techniek • IJssel • IMS International BV • Inteliments • Interman • International Flavors & Fragrances (IFF) • KEC • Kennis- en Innovatiecentrum KicMPi • Mainnovation • Metatronics • Midpoint Brabant • Mobile Shutdown Systems • NLR • Pfaudler • Prezent • University of Groningen • ROC Tilburg • SABIC • Samure • Schneider Electric • Sitech • Tata Steel • Tilburg University • TNO • TU/e, Eindhoven University of Technology • World Class Maintenance.

- The **CAMPIONE 2** field lab is a further outgrowth of the CAMPIONE Smart Industry field lab. This new project will help regional SMEs to perform smart maintenance based on the knowledge, experience, and infrastructure of CAMPIONE. The CAMPIONE 2 field lab will accelerate the adoption and implementation of smart industry among SMEs in the region. SMEs can experiment with the possibilities of smart industry (data science, IoT, VR/AR, robotics) in the field lab at Gate2 in Gilze-Rijen, specifically targeting their own cases. This makes it easier to put smart industry into practice within their own companies. Initiated by the Brabant Development Agency (BOM), Midpoint Brabant, REWIN West-Brabant, Avans Foundation, and World Class Maintenance.

- In January 2021, the latest field lab was approved, the **SAMEN** WCM field lab (SmArt Maintenance Enabled busiNess). The SAMEN field lab revolves around strengthening the smart maintenance innovation system based on the theory that 100% predictable maintenance in the manufacturing and process industry will only be achieved through new revenue and organizational models. SAMEN establishes the link between technical and social innovation. Where technical innovation is more about new knowledge creation, social innovation concerns recognizing, acquiring, integrating, and applying this new knowledge. It is indispensable for the success of innovations.

SAMEN is a consortium of World Class Maintenance, Sitech Services BV, Alfa Laval, ASML, Ericsson, Tata Steel, Stork, SPIE, ABB, Canon, WEMO Nederland BV, Fokker Services, Fontys, Cargill, Logistics Community Brabant, Marel, ORTEC, Shell, Sofon, Jheronimus Academy of Data Science (JADS), Tilburg University, Eindhoven University of Technology, De Dommel Water Board, KPN, PDM, and Perfact. Support is provided by support from Aeronamic Services, IBM Nederland, Thales Nederland, and Vanderlande.

3. FACTORY OF THE FUTURE ROADMAP FOR THE 2020-2024 PERIOD

INTRODUCTION, ACTIVITIES, AND MAIN AREAS OF INTEREST OF THE FACTORY OF THE FUTURE PROGRAM

The Factory of the Future innovation program was drafted in consultation with 75 companies, knowledge institutes, educators, and sector associations and kicked off in 2018. The aim of the program is to jointly develop faster and smarter production processes and to share (innovation) facilities, leading to lower costs, higher quality and, above all, a faster time to market for innovative (high tech) products and systems.

The focus of the program is the industrialization and manufacturing stage of complex products and systems (high mix, low volume).

The initiators' vision is to stay competitive by being well-connected and to cooperate on precompetitive issues, from both the point of view of technology as well as human relations, while targeting a global market.

In the Digital Factory of the Future, data and raw materials will be converted into high tech, integrated components and systems. These factories will be f ully automated and operate the production equipment in the factory, with continuous optimization of supply chain planning and workflow. The factories will operate optimally because of real-time upgrading and improving of manufacturing performance, product and process quality, energy use, and the impact on sustainability. All the processes will be supported by machine-learning and artificial intelligence, in combination with human innovation and creativity.

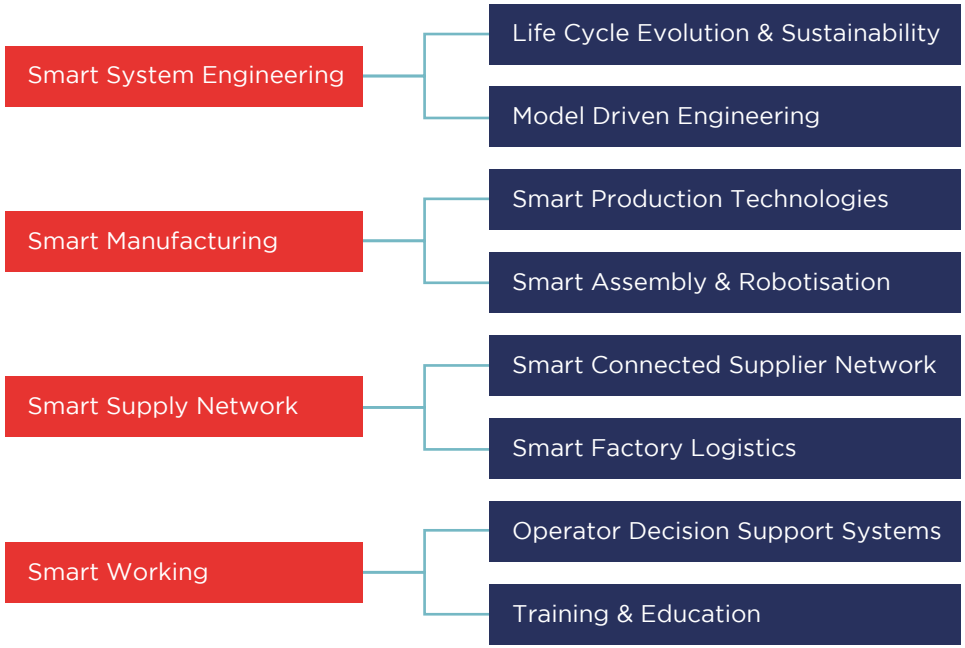
The home-base of the Factory for the Future innovation program is the Brainport Industries Campus in Eindhoven.

Source: Brainport Industries & Brainport Industries Campus

At present, eight field labs are operational, facilities have been provided and linked up, and a number of state-of-the-art technology projects have been launched. In addition, companies are given access through the program and Brainport Industries to experts that can assist in accelerating innovation efforts. In keywords: demonstration and showcases; test-before-invest; company-use cases; education and training for employees and students; pilot production (temporary workspace and facilities).

The main areas of interest for the Factory of the Future program can be found in the adjoining table.

FACTORY OF THE FUTURE: MAIN AREAS OF INTEREST



10. SUMMARY OF BRABANT'S STRENGTHS IN HTSM

A. Introduction

As a High Tech Systems & Materials region, with Brainport Eindhoven as its beating heart, Brabant is currently in a strong and healthy condition.

KEY ENABLING TECHNOLOGIES (KETS)

Firstly, the region boasts a very robust foundation in HTSM, with virtually all Key Enabling Technologies (KETs) well-represented and highly developed:

- Electronics
- High-tech materials
- Nanotechnology
- Photonics
- Smart industry (advanced manufacturing)
- Systems engineering

This also applies to artificial intelligence, especially when it comes to its application in the real world of complex machine building, and their transformation into cyber-physical systems.

SYSTEMS ENGINEERING

A second strength is systems engineering. Systems engineering is hard to categorize as either an enabling 'technology' or as an 'application', as it is neither (or both). But it is an extremely important skill/perspective or working approach for developing and manufacturing complex (cyber-physical) systems. In Brabant, and in the high tech center of Brainport Eindhoven in particular, this rare skill is abundantly available, given that it has been a prerequisite creating the medical technology, lithography, optical, automotive and consumer electronics systems that Philips, ASML, FEI, NXP, and DAF have been producing in recent decades.

Realizing its value to the region and future innovative capacity, the region is now capturing and nurturing this expertise and quality so as to benefit from its added value for years to come. The TU/e, Eindhoven University of Technology, has launched several (master/PDEng) courses in fields such as manufacturing systems engineering, with the goal of eventually incorporating training in systems engineering and systems thinking in all programs, including under-graduate, graduate, PDEng, and PhD programs.

For their part, the universities of applied sciences (such as Fontys) and secondary vocational schools (Summa College) are also finalizing specific training program. In some cases the focus is on 'systems thinking', a term also often used to describe the philosophy behind systems engineering. Industry is very involved. Ton Peijnenburg, for example, the deputy director of renowned high tech company VDL-ETG, is one of the leading fellows of the TU/e's High Tech Systems Center.

APPLICATION AREAS (AAS)

Thirdly, the region excels in many application areas (AAs):

- Semiconductor (equipment)
- Advanced instrumentation
- High-tech healthcare
- Automotive
- 3D Printing

Brainport Eindhoven has remained a leader in the field of lighting, especially in innovation and design. However, the domain itself has become less prominent due to the advent of LED in all its variations: the technology is less complex, costs are lower, and production has largely moved to Asia. That is why the sector has become less of a priority for the wider region.

Even in the aerospace and space industries, smaller clusters of companies or individual key companies can be found in Brabant which are international leaders in their field, whether for the supply of supercritical parts (KMWE), electronics or subsystems of aircraft or satellites (APP Propulsion Products, Bradford Engineering, Thales Cryogenics), or maintenance of complex systems (StandardAero, Aeronamic, OneLogistics). Brabant is a compact but powerful player in these fields.

The only domain that is not generally well-developed in Brabant is (cyber) security. There are activities involving electronic security systems and cameras, but dedicated cybersecurity companies are rare in the province. Cooperation with these companies in other parts of the Netherlands and abroad is taking place, however, and the Brabant manufacturers of expensive capital equipment invest significant effort, time, and funds in improving their own cybersecurity.

BRABANT AND BRAINPORT EINDHOVEN PLAY A MAJOR ROLE IN FINDING SOLUTIONS FOR THE MAJOR SOCIETAL CHALLENGES

The HTSM Priority Industry has incorporated into its plans the major societal challenges and themes as identified internationally and in the Netherlands: climate, sustainability, health, security, and mobility. Health and security have already been touched upon in the section above, under Key Enabling Technologies and Application Areas.

Climate and sustainability have become overarching societal challenges in the Netherlands. These challenges require that energy consumption be reduced in all fields technology. Brabant is a top region when it comes to solar energy – an example is the leading research institute Solliance at the High Tech Campus in Eindhoven - and has the components required for making it a major player in the hydrogen economy, not as a generator of hydrogen but as the technology-developer and supplier of the materials, components, and systems required for those processes.

The same applies to Brabant's place in the final major theme, mobility. The region is already at the forefront of what is called ‘smart mobility’, the combination of vehicle development and autonomous navigation. NXP, TomTom, NXP, TNO, HERE, DAF Trucks, and many other large and small specialists lead the way in this respect. Moreover, Brabant plays an important role in 'green mobility’, with various companies and institutes developing low-emission and zero-emission propulsion systems and fuels, as well as the required infrastructure. These include DIFFER, Holst Centre, DAF Trucks, NXP, TNO, Ricardo, Lightyear, Rolande LNG, LIQAL, Leyden-Jar Technologies, and LionVolt.

B. A summary of Brabant's High Tech Systems & Materials strengths

In this chapter an attempt has been made to summarize the core strengths of Brabant in the field of High Tech Systems & Materials. The authors are aware that there are many more subsectors, individual companies and/or clusters and initiatives in Brabant that are of excellent quality, and this summary is by no means intended to detract from their special qualities.

1. THE FULL HTSM VALUE CHAIN IS PRESENT AND VERY WELL-DEVELOPED

Every activity in the overarching HTSM value chain, and in various value chains of individual application areas or key technology fields, can be found in Brabant. These are all well-developed and strong and, generally speaking, always open to innovation or business partnerships.

THE INTEGRATED VALUE CHAIN HTSM BRABANT - INCLUDING A SELECTION OF COMPANIES

- Altran (TASS)
- AME Applied Micro Electronics
- ASML
- DEMCON
- Malvern Panalytical
- NXP
- Philips Healthcare
- RAITH
- Sioux Technologies
- Thermo Fisher Scientific

- Dimenco

- AAE Advanced Automated Engineering
- Bradford Engineering
- DEMCON
- Frencken Mechatronics
- The MathWorks
- NXP
- Prodrive Technologies
- Proven Concepts
- VDL ETG, Enabling Technologies Group

- IME Elektrospinning

- ASML
- Ceratec Technical Ceramics
- NXP
- NTS Group
- Philips Healthcare
- Philips Innovation Services

- Incooling
- Lightyear
- SALDtech
- Smart Photonics
- Smart Robotics

- Anteryon
- Frencken Engineering
- GKN Fokker Technologies
- KMWE
- NTS Group
- Teledyne DALSA
- VDL Group

- Additive Industries
- Leyden-Jar Technologies
- LionVolt
- SALDtech
- Smart Photonics

- ASML
- DAF Trucks
- Dasault Systèmes
- GEA Food Solutions
- Kulicke & Soffa
- Marel Poultry
- PlantLab
- Thermo Fisher Scientific

- Additive Industries
- LIQAL
- Pixelfarming Robotics
- PrecEyes

- ASML
- Bosch Security Systems
- DAF Trucks
- NXP
- Philips Healthcare
- PlantLab
- Signify
- Thales Cryogenics
- Thermo Fisher Scientific
- Vanderlande Industries

- PAL-V International

- ASML
- Chromalloy Holland
- DAF Trucls
- DVC Machine Vision
- ENGIE
- Flowserve
- Philips Healthcare
- SPIE
- SPM Instrument
- Stork Thermeq

- LIQAL

(OUTSOURCED) SUPPLY CHAIN & SUPPORT CHAIN

Rhenus – O&M Movianto – DB Schenker – Systemair – Tjoapack – Neways Technology – IT&Care – Arnold & Siedsma – PerkinElmer / One Source – Axxicon Moulds – Bestronics – BKB Precision Bronkhorst Flow Technology – Ceratec Technical Ceramics – DEMCON – Eurofins Materials Science – Fujitsu Glovia – Gain Automation Technology – Goudsmit Magnetics – HighTechXL – KMWE Toolmakers Mevi Advanced Technology – NTS Group – Philips Innovation Services – Sioux Technologies – TMC Group – Unicorn Industrial Cleaning Solutions – Van Veghel Industrial Packaging – VanBerlo Goup Xycarb Ceramics – YASKAWA

UNIVERSITIES, RESEARCH INSTITUTES & EDUCATION

TU/e, Eindhoven University of Technology – JADS, Jheronimus Academy of Data Science (a.o. Den Bosch) – Avans University of Applied Sciences (a.o. Breda)
Fontys University of Applied Sciences (a.o. Eindhoven, Den Bosch) – Breda University of Applied Sciences – Holst Centre (Eindhoven) – Summa College – ROC ter AA
Solliance Solar Research Institute (Eindhoven) – DIFFER Basic Energy Research Institute (Eindhoven) – EAISI Eindhoven Artificial Intelligence Systems Institute – Eindhoven Engine

Source: Engel – Een Heldere Blik helder@benengel.nl – +31 (0)652612671

- Start-up, scale-up or newly spun-off company
- High Tech Systems & Materials

2. BRAINPORT EINDHOVEN IS ONE OF THE SMARTEST ADVANCED MANUFACTURING HUBS IN THE WORLD

Eindhoven is the home of Royal Philips, ASML, NXP, DAF Trucks, Thermo Fisher Scientific (former FEI) and, over the past 125 years, a perfectly-woven network of knowledge institutes (TU/e, Holst Centre), suppliers, and partners has evolved in the region.

In High Tech Systems & Materials, including the semiconductor, automotive and high tech healthcare sector, every strand of expertise can be found here – strands that are continuously perfected, often through cooperative innovation projects.

It was Philips itself that launched the concept of open innovation in grand style when it opened up its highly confidential global research park in Eindhoven (the Philips NatLab) twenty years ago and started developing it into the open High Tech Campus Eindhoven of today.

Philips still has a very strong presence at the Campus, but close to 220 other research companies and institutes have joined it, all looking for cross-fertilization in research and development.

3. THE DISTINCTIVE AND CONSTRUCTIVE BRABANT COOPERATION MODEL ADDS VALUE TO ALL PARTIES IN THE ECOSYSTEM

Brabant has a distinctly strong culture, history, and tradition in informal constructive cooperation based on trust and open innovation. The advantage of this culture is that cooperation, whether informal and/or professional and intensive, comes naturally in the region. Opinion leaders in the region in business, science, and government publicly invite interested parties to contact them and explore mutual interests.

In keywords: building partnerships in the region is a quick and fluid process, and faster than anywhere else in the Netherlands. Outsiders seeking to join in and actually contribute will quickly and easily fit in and reap the benefits.

It can be exceptionally quick to get things done in Brainport Eindhoven. One of the reasons is the fact that the region is relatively small, as is the network consisting of the real movers and shakers in HTSM. As a result, distances – personally and even geographically – are easy to bridge and deals can be made quickly. It also means that the compact network is relatively fragile and must be properly cared for. When comparing Brainport Eindhoven/Brabant to the regions that compete globally in HTSM, it is one of the smaller ones.

This is not considered a disadvantage per se in the region itself. One of the most interesting quotes from an inspiring and young CEO of a high tech startup was that "Brainport Eindhoven is an excellent ecosystem for startups, because the region sometimes resembles a startup itself! Inventing wild ideas, looking for partners to help develop them and lots of energy and enthusiasm everywhere."

INSPIRING EXAMPLES OF EXISTING PUBLIC-PRIVATE NETWORKS AND PARTNERSHIPS INCLUDE

- e/MTIC: a large-scale research collaboration between the Catharina Hospital (CH), the Maxima Medical Center (MMC), Kempenhaeghe Epilepsy and Sleep Center (KH), Eindhoven University of Technology (TU/e), and Royal Philips Eindhoven (RPE) in the fields of cardiovascular medicine, perinatal medicine, and sleep medicine.

- AI Innovation Center: an open innovation facility at the High Tech Campus Eindhoven, aiming to accelerate the application of data science and artificial intelligence in industry in the Brainport Eindhoven area. Co-founders are Royal Philips, ASML, NXP, and Signify.

- 5G Hub Brainport Eindhoven: Brainport Development, High Tech Campus, Ericsson and VodafoneZiggo formed the 5G Brainport Eindhoven consortium, with its 5G Hub located at the High Tech Campus. The location offers industry and science the opportunity to organize inspiration sessions, test new technologies, and learn from each other. The objective is to improve the quality of life and economic strength of the region through new technologies like 5G as well as AI, VR/AR, blockchain and photonics.

- The Eindhoven Engine will accelerate innovation in the Brainport Region through challenge-based research in its public-private research facility at the TU/e Campus. Teams of the region's most talented researchers from industry, academia and student bodies will cooperate in Eindhoven Engine research programs to deliver breakthrough technological solutions. These multidisciplinary and cross-organizational teams cooperate by the colocation of team members at the Eindhoven Engine workspace. The colocation is an essential and substantial part of the project, necessary for the acceleration of innovations and to shorten time to market. Projects are executed by consortiums with key industrial partners, SMEs, and knowledge institutes such as Fontys, TU/e and the TNO.

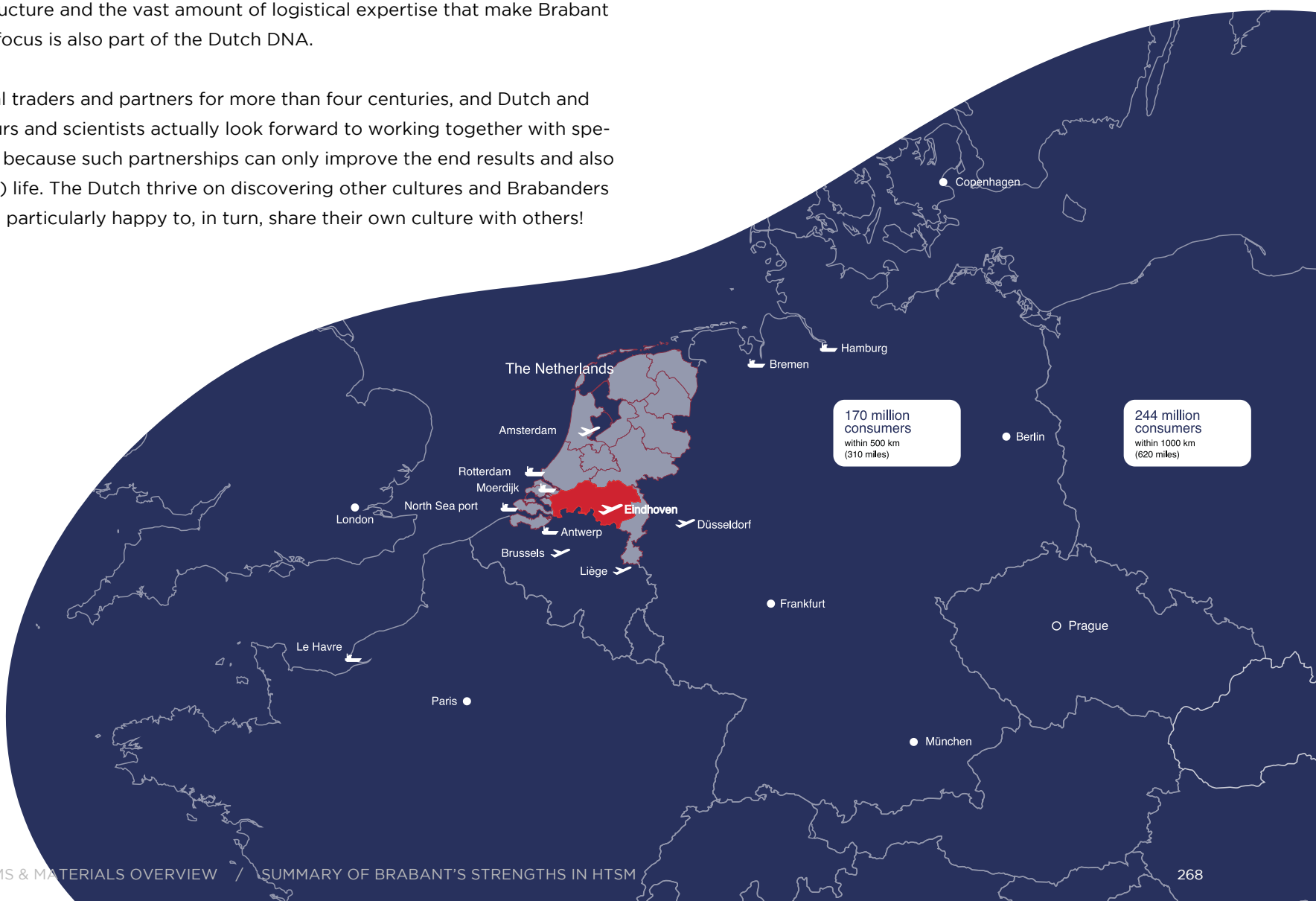
- HighTechXL: a venture-building accelerator that builds teams of entrepreneurs and tech talents around the most advanced technology in the world, technology from CERN, the European Space Agency, the TNO, ASML, Philips and other global innovators.

- Project GROW! – High tech Sensor Technology in Greenhouses: building and optimizing high tech greenhouses by the Holst Center research institute in Eindhoven, the Hoogstraten Experimental Center, HAS University of Applied Science, University of Antwerp, KU Leuven, LTO Glaskracht, and the Flemish Center for Storing Horticultural Products.

4. THE IDEAL GEOGRAPHIC LOCATION AND PERFECT STEPPINGSTONE INTO EUROPE

The Netherlands was dubbed the Gateway to Europe decades ago, and nothing has changed since. That is a label that is even more appropriate to Brabant, located midway between the largest ports, airports and markets in north-western Europe. And it is not just its geographic position, the excellent infrastructure and the vast amount of logistical expertise that make Brabant stand out; an international focus is also part of the Dutch DNA.

The Dutch have been global traders and partners for more than four centuries, and Dutch and Brabant-based entrepreneurs and scientists actually look forward to working together with specialists from abroad. This is because such partnerships can only improve the end results and also add enjoyment to (working) life. The Dutch thrive on discovering other cultures and Brabanders (the people of Brabant) are particularly happy to, in turn, share their own culture with others!



5. EXCELLENT UNIVERSITIES, KNOWLEDGE INSTITUTES, AND EDUCATION IN HTSM

- TU/e, Eindhoven University of Technology (Eindhoven)
- Holst Centre (Eindhoven)
- Solliance Solar Research (Eindhoven)
- Fontys, Avans & Breda Universities of Applied Sciences (Breda, Den Bosch, Eindhoven, Tilburg)
- JADS - Jheronimus Bosch Academy of Data Science (Den Bosch, Tilburg & Eindhoven)
- EAISI – Eindhoven Artificial Intelligence Systems Institute
- HTSC – High Tech Systems Center (Eindhoven)
- 5G Hub Brainport (Eindhoven)
- AI Innovation Center (Eindhoven)

There are ten or more knowledge institutes within a 50 kilometer radius, all interested in joint research and helping to create future High Tech Systems & Materials. And all of them are easy to find and easy to connect with, if necessary with free support from regional public agencies such as BOM and Brainport Development.

Brabant's HTSM education is equally strong, at all possible levels, from secondary school to vocational education and work training in the high tech manufacturing industry or further studies at universities and universities of applied sciences – the schools and institutes are all of a high quality, well-developed and located in the region.

6. HIGHLY-DEVELOPED HTSM CLUSTERS, CAMPUSES, AND JOINT FACILITIES WITH DISTINCT EXPERTISE AND RESOURCES

- High Tech Campus, Eindhoven
- TU/e Campus, Eindhoven
- BIC - Brainport Industries Campus, Eindhoven
- Automotive Campus, Helmond
- Aeroparc/Gate2, Rijen
- Aviolanda Aerospace, Hoogerheide
- Strijp-S, Eindhoven
- Strijp-T, Eindhoven
- Maritime Industries Werkendam, Werkendam

7. BRABANT IS HOME TO THE MOST POWERFUL LITHOGRAPHY-BASED WAFER FABRICATION EQUIPMENT CLUSTER IN THE WORLD

The most complete and advanced wafer fabrication equipment (WFE) cluster in the world is in Brabant. Brainport Eindhoven is the home of ASML, NXP, FEI, VDL, and the full value chain of the most advanced tier 1, 2, and 3 suppliers on the planet. There are also many partnerships with knowledge institutes such as the Eindhoven University of Technology. Eindhoven in Brabant is the birthplace and home of EUV manufacturing technology, the most advanced lithography in the world.

As a consequence, Brabant has the all the building blocks and ingredients for growing future sister-OEM companies of ASML and Philips, with all the signs already in place:

- In integrated photonics, with scaleup foundry Smart Photonics leading the way
- In spatial atomic layer deposition, with scaleups SALD, SALDtech, and S olayTec leading the charge
- In 3D visualization, guided by Dimenco
- In sustainable energy, with frontrunners such as Lightyear (solar-powered cars) and LIQAL (BioLNG and hydrogen storage, handling and tank systems)

8. BRABANT'S HIGH TECH HEALTHCARE CLUSTER IS SECOND TO NONE

Eindhoven is the home of Philips Healthcare, and over the course of 125 years a perfectly-woven network of knowledge institutes (TU/e, Holst Centre), suppliers, and partners has evolved in the region. Every strand of expertise in medical technology and advanced healthcare can be found, with OEMs such as Philips, ASML, NXP, FEI (Thermo Fisher), GE Healthcare Life Sciences Core Imaging and most of their tier 1, 2, and 3 suppliers in or within a radius of 50 kms of Eindhoven.

The Eindhoven MedTech Innovation Center (e/MTIC) is a large-scale research collaboration between Philips Healthcare, Eindhoven University of Technology (TU/e), the Catharina Hospital, the Maxima Medical Center, and Kempenhaeghe Epilepsy and Sleep Center in the fields of cardiovascular medicine, perinatal medicine and sleep medicine. This partnership has evolved over several decades, has a strong scientific and commercialization track record, and currently encompasses around 100 PhD students, supervised by a similar number of experts from the various partners.

Additional core strengths in the region:

- One of the core specialties of Philips and the region is in imaging, diagnostics and monitoring
- The largest and most advanced manufacturing facilities for (bio)pharmaceuticals and medical technology in the Netherlands are all l ocated in Brabant. The largest plants for human biopharmaceuticals are in Oss (MSD and Aspen), for animal vaccines in Boxmeer (MSD), and Amgen has a significant biopharma facility in Breda
- High Tech Campus Eindhoven jokingly calls itself the smartest square kilometer in Europe, as it is home to more than 220 research-based companies, startups and institutes. One of its priority areas is human health, and some 12,000 researchers, developers, and entrepreneurs from companies all over the world are working there on developing future technologies and products that will affect the lives of billions of people

9. BRABANT'S QUALITY OF LIFE IS EXCELLENT, ESPECIALLY FOR KNOWLEDGE WORKERS AND EXPATRIATE COUPLES OR FAMILIES

If there is one thing the Covid-19 pandemic has taught us, it is the importance of the quality of one's living environment. If travel is significantly hampered, living in an environment that is green, warm, safe, affordable. and welcoming all of a sudden becomes a top priority. Brabant offers those qualities, in buckets.

THE NETHERLANDS AND BRABANT ARE SMALL

Looking at the world map, one can see that the Netherlands is a very small country. The longest distance one can drive from the north to the south is 370 kilometers by car and will take about four hours. To the east, the Netherlands borders Germany, to the south, Belgium, and to the north and west, the Wadden Sea and the North Sea. The Netherlands has 12 provinces, with Brabant one of the larger ones. This immediately gives some perspective with respect to distances in the Netherlands: everything is very close by.

To travel from anywhere in Brabant to the metropolitan areas of Amsterdam, The Hague or Rotterdam will never take more than an hour or two at most, whether by train or by car. The same goes for the international airports of Schiphol Amsterdam, Düsseldorf (Germany), and Brussels International Airport. What this adds up to is that Brabant offers a quality of life that is increasingly appealing to knowledge workers and expatriates. The region has a green and friendly environment, with vibrant cities and quiet little villages. Accommodation is also cheaper than in the western part of the Netherlands, while it is fairly easy to find larger homes and ones with gardens, which is not the case in metropolitan areas such as Amsterdam and Rotterdam.

THE LANDSCAPE

One feature of the Dutch and Brabant landscape is unmistakable: the country is extremely flat. There are a few hills in the southeast corner of the country in Limburg, but even these barely infringe on the broad, unbroken expanse of sky that is so characteristic of Dutch landscape painting. Most people coming to the southern Netherlands will probably choose to live in the area near their workplace. However, Dutch infrastructure and transport networks are good and it is easy to commute from other areas to Brabant and its larger cities, such as Breda, Eindhoven, Den Bosch, and Tilburg.

Brabant itself is a wonderful area to live and work in. The landscape is characterized by vast forests, meadows, green pastures, farmland, moors, and waterways. The cities all have historic centers, often dating back more than 700-800 years, but offer modern architecture and residential areas too. The city of Den Bosch, for example, once the capital of the Duchy of Brabant stretching deep into current Belgium, was awarded its city charter and accompanying trading privileges by the Duke of Brabant, Hendrik I, in the year 1196.

And so, the living environment in Brabant is varied enough to suit everyone, from an apartment or urban dwelling in one of the vibrant cities to a quiet cottage in a remote village surrounded by greenery. And a night out in Amsterdam without having to book a hotel room is easy.

The housing market is just as varied as the landscape. Not only are there old-fashioned farms and craftsman's houses, but also new construction projects and villas. You can live in the green countryside or near the busy life of the town center.

The quality of life in Brabant and in the Eindhoven metropolitan area are often described as 'highly livable', which is a huge compliment. To put it into an international perspective, expatriates often compare the region to other cities in the world that are deemed to be very livable, such as Munich, Vancouver, Stockholm, and Zurich.

11. OPPORTUNITIES IN HTSM

BRABANT'S PRIORITY NICHES AND DEVELOPMENT AREAS

On the occasion of this in-depth review of Brabant's High Tech Systems & Materials sector, the authors have performed a SWOT analysis of the industry. The interviews with the many operational and academic representatives of the industry were of invaluable help in this work.

The analysis has led to the conclusion that 12 strategic areas can be identified as high potential targets for the activities of the Brabant Development Agency and its partners in the economic development community. This group of 12 areas has been divided in two categories: the priority niches and the development areas. In the first category, the priority niches, Brabant HTSM companies and clusters are already international market leaders. In the second category, the development areas, the Brabant HTSM sector has already developed such an outstanding business and science platform to build upon, that further development in these areas will also raise it to global leader levels.

This chapter ends with a development area which is described as a 'moonshot', because of its ambitious nature, far-reaching implications and required efforts and investments.

THE PRIORITY NICHES ARE

1. Brabant is the global center of excellence in advanced manufacturing and advanced manufacturing systems
2. Brabant is a center of excellence in advanced instrumentation
3. Brabant continues to be a global hotspot in the electronics, micro/nanotech, (integrated) photonics domain
4. Brabant is a global center of excellence in advanced medical technology, especially in imaging, diagnostics and monitoring
5. Brabant is home to the strongest lithography-based wafer fabrication equipment cluster in the world
6. Brabant is the center of excellence in AgriFood technology, component manufacturing and machine building
7. Brabant is the best place in the world to set up partnerships (PPPs) in research, engineering, assembly, and manufacturing

THE DEVELOPMENT AREAS ARE

1. AI for engineering: Brabant to become the go-to region for applying artificial intelligence in (the manufacturing of) cyber-physical systems
2. Brabant develops into/continues to be a source and growth support center for startups and scaleups
3. Brabant develops into a center of excellence in smart, connected mobility
4. Brabant develops into a center of excellence in sustainable mobility and drive systems
5. Brabant dives deeper into energy (enabling) technologies, such as Solar, Hydrogen and Batteries

THE MOONSHOT IS:

√ Attracting a leading global IC manufacturer to Brabant

A. Brabant's priority niches

1. Brabant is *the* global center of excellence in Advanced Manufacturing and Advanced Manufacturing Systems

USPs for Brabant	The breadth and depth of skills and expertise in Brabant is so extensive that it is no exaggeration to state that the Brabant HTSM cluster can invent, design, engineer, assemble, manufacture, commercialize, install, and maintain any machine, integrated and/or cyber-physical system.
Universities/Research institutes involved	TU/e, Eindhoven University of Technology; JADS - Jheronimus Academy of Data Science (Den Bosch/Tilburg/Eindhoven); Holst Centre (Eindhoven); Solliance Solar Research (Eindhoven); TNO (Eindhoven); IMEC (Eindhoven/Louvain); Avans, Fontys & Breda Universities of Professional Education (Breda/Den Bosch/Eindhoven/Tilburg); EAISI, Eindhoven Artificial Intelligence Systems Institute
Leading companies/disruptors/best practices	ASML; DAF Trucks; NXP; Thermo Fisher Scientific (FEI); Royal Philips; VDL Group; NTS Group; Frencken Europe; AAE, Advanced Automated Equipment; all 100 members of Brainport Industries; Eindhoven Engine
Leading programmes	Eindhoven Engine; Brainport Industries' Factory for the Future; Eindhoven Artificial Intelligence Systems Institute (EAISI); High Tech Systems Center (Eindhoven)
Facilities/Locations/Campuses	High Tech Campus Eindhoven; TU/e Campus Eindhoven; Eindhoven Artificial Intelligence Systems Institute (EAISI); JADS Campus (Den Bosch); Brainport Industries Campus (BIC, Eindhoven); Aviolanda Aerospace (Hoogerheide); AI Innovation Lab (Eindhoven)

INTRODUCTION

In the Digital Factory of the Future data and raw materials will be converted into high tech, integrated components and systems. These systems will be fully automated and operate the production equipment in the factory, with continuous optimization of supply chain planning and workflow. In addition, there will be the requirement of real-time upgrading and improving manufacturing performance, product and process quality, energy use, and impact upon sustainability. All of these factors can only be achieved if human innovation and creativity is supported by machine learning and artificial intelligence.

FINDING SOLUTIONS – WHY BRABANT?

Brabant is proud and fortunate to be home to the entire High Tech Systems & Materials value chain, which not only means the presence of the OEMs, the research institutes, universities, and vocational schools, but also that the whole spectrum of HTSM suppliers is located in the region.

What sets Brabant apart, even on the international stages, is the fact that the region hosts hundreds of tier 1, 2, and 3 suppliers that are highly specialized in specific high tech activities, even if some of those suppliers are relatively small. They are experienced in working with other suppliers and OEMs and are very familiar with performing outsourced development, testing, or manufacturing. This unique feature means a scaleup company can set up shop in Brabant and implement all the necessary development and manufacturing steps, without even having to employ these specialists. Nor will it have to invest in all the required equipment. That means such a company can save its energy to focus on its own core activities.

This distinguishing characteristic of the region can best be summarized as the presence of a full outsourced value chain. The Brainport Industries association is in fact based on this philosophy, and its members are the ‘open/outsourced supply chain’. Even the largest OEMs like ASML strive to outsource the majority of their manufacturing and development.

Brabant’s objective, today and tomorrow, is to out-innovate everyone, anywhere in the world, in cyber-physical systems engineering.

2. Brabant is *the* centre of excellence in Advanced Instrumentation

USPs for Brabant	A considerable portion of the Brabant HTSM cluster plays a leading role in several of the four advanced instrumentation clusters: big science, material characterization and manipulation, instrumentation for competitive production processes and societal instrumentation. In big science and material characterization, Thermo Fisher Scientific, with its SEM and TEM microscopes, and Philips' decades of experience in imaging and diagnostics serve as clear examples. As stated earlier: advanced manufacturing - competitive production processes - is one of Brabant's most obvious key strengths.
Universities/Research institutes involved	TU/e, Eindhoven University of Technology; JADS - Jheronimus Academy of Data Science (Den Bosch/Tilburg/Eindhoven); Holst Centre (Eindhoven); Solliance Solar Research (Eindhoven); TNO (Eindhoven); IMEC (Eindhoven/Louvain); Avans, Fontys & Breda Universities of Professional Education (Breda/Den Bosch/Eindhoven/Tilburg); EAISI, Eindhoven Artificial Intelligence Systems Institute
Leading companies/disruptors/best practices	Ceratec Technical Ceramics; Thermo Fisher Scientific (FEI); Teledyne DALSA; Royal Philips; CCM; Goudsmit Magnetic Systems; ASML; VDL Group; Neways Electronics; NXP; Malvern Panalytical; Prodrive; NTS Group; Frencken Europe; AAE, Advanced Automate Equipment
Leading programmes	Brainport Industries' Factory for the Future; Eindhoven Artificial Intelligence Systems Institute (EAISI)
Facilities/Locations/Campuses	High Tech Campus Eindhoven; TU/e Campus Eindhoven; Eindhoven Artificial Intelligence Systems Institute (EAISI); JADS Campus (Den Bosch); Brainport Industries Campus (BIC, Eindhoven)

INTRODUCTION

Advanced instruments can be found everywhere, but are often located behind the scenes. They open up a world of radical new science, support research and development, secure safety, provide effective production and offer the foundation for solutions to major societal challenges. Advanced instrumentation concerns the design and development of complex measurement and control systems using a mix of technologies. The instruments are typically built in low volumes and are used in (large) scientific programs, R&D centers, industrial production, and in societal applications such as high tech medical technology.

The community working on advanced instruments in the Netherlands consists of several hundred companies, both large and small, that develop and market advanced instruments mainly for industrial purposes and sometimes for scientific use. This innovative ecosystem with a recognized track record and profitable markets employs several tens of thousands of people. Moreover, one or two dozen institutes (universities, scientific institutes, and GTI's (Groot Technologisch Instituut)) are developing advanced instruments, typically for scientific purposes and with limited spin-off to industry. Increasing interaction between these two worlds will result in a higher level of innovative products.

Advanced instrumentation technology is enabling technology for many areas of science, as well as applications. It is a key player in the Knowledge & Innovation Agenda Key Technologies, with a primary focus on the following five key technology clusters:

- Photonics and light technologies
- Engineering and fabrication technologies
- Nano technologies
- Chemical technologies
- Digital technologies

FINDING SOLUTIONS – WHY BRABANT?

One of the most important application areas for advanced instrumentation involves creating competitive production processes. Creating intelligent production processes is core to Brabant's HTSM sector.

As described in the Priority Industry roadmap for advanced instrumentation, there is an increasing demand for production processes with advanced instrumentation based on sets of sensors create greater reliability and precision in decision-making and control processes.

Future advanced instrumentation will likely be aggregated systems of (connected) sensors, including layers of automated data processing. This could allow for meaningful interpretation of sensor data, which can be used as critical information in production selection decisions and process control.

Sensor data fusion will be boosted by advanced IoT technologies. Data science technologies, such as artificial intelligence/machine learning, are expected to contribute significantly to the conversion of data from complex sensor systems into valuable information.

The development and implementation of instrumentation for industrial processes is driven by the need for accurately controlled, efficient manufacturing processes, which in turn is driven by the need to remain competitive in a global economy and the need to be flexible in staying on top of the current volatile markets, limited natural resources, limited funding, and the limited availability of highly-educated technical experts.

Optimal quality, early detection of failure, and cost control are the main drivers for the need for continued investment in advanced instruments. Advanced instruments provide real-time control of the full product flow, measuring quantities such as shape, size, roughness, hardness, color, and composition (i.e. know-your-product). Other instruments allow for flexible

manufacturing by recognizing a range of shapes and positioning them very rapidly. This process must be non-destructive and reliable, rapid and precise.

SMART/ADVANCED MANUFACTURING

The Netherlands and Brabant are investing large sums in smart manufacturing, aiming to increase production in Dutch industry through solutions that add value. Improved national and international cooperation may advance the position of the advanced instrumentation industry considerably, which is already a world-beater in fields such as (opto)mechatronics, robotics, precision machining, vacuum, and cryotechnology.

OBJECTIVES OF THE ADVANCED INSTRUMENTATION ROADMAP

In the Advanced Instrumentation roadmap the short-term area of focus is on non-contact sensor technologies, multiple sensor data fusion, and real-time data processing. For the longer term, the focus will be extended to process control through (a combination of) artificial intelligence, machine learning, and model-based control algorithms, with the target being zero-defect production, adaptable systems, and autonomous production processes.

3. Brabant continues to be *the* global hotspot in the field of electronics, micro/nanotech, and (integrated) photonics

USPs for Brabant	Over a hundred years of history in electronics, starting with Philips, and growing into the development of micro and nanotechnology (ASML, NXP, FEI and many others), culminating in the new photonics paradigm (including smart photonics), makes Brabant and Brainport Eindhoven in particular a hotspot.
Universities/Research institutes involved	TU/e, Eindhoven University of Technology; JADS - Jheronimus Academy of Data Science (Den Bosch/Tilburg/Eindhoven); Holst Centre (Eindhoven); Solliance Solar Research (Eindhoven); TNO (Eindhoven); IMEC (Eindhoven/Louvain); Avans, Fontys & Breda Universities of Professional Education (Breda/Den Bosch/Eindhoven/Tilburg); EAISI, Eindhoven Artificial Intelligence Systems Institute
Leading companies/disruptors/best practices	Royal Philips; ASML; NXP; Thermo Fisher Scientific (FEI); Neways Electronics ; VDL Group; NTS Group; Sioux Technologies; Signify; AME - Applied Micro Electronics; Altran (TASS); Bosch Security Systems; Teledyne DALSA; Anteryon; ECS Electronics; Nanogate Eurogard Systems; Adimec; Possehl Electronics; QnQ Engineering; Delta Electronics; many of the 100 members of Brainport Industries; Neways Electronics
Leading programmes	ITEA; Brainport Industries' Factory for the Future; Eindhoven Artificial Intelligence Systems Institute (EAISI)
Facilities/Locations/Campuses	High Tech Campus Eindhoven; TU/e Campus Eindhoven; Eindhoven Artificial Intelligence Systems Institute (EAISI); JADS Campus (Den Bosch); Brainport Industries Campus (BIC, Eindhoven)

INTRODUCTION

The existence of a very strong electronics industry in Brabant is inextricably linked to the growth of Royal Philips (Philips Healthcare), which started out in Eindhoven in 1891 as a small lightbulb factory. Many decades later, the company, then known as Philips Electronics, had become one of the largest consumer electronics companies in the world, managed out of Eindhoven and with its core research in Eindhoven. In 1974 the company reached its zenith in terms of its workforce, with 412,000 employees worldwide, of which 91,000 were in the Netherlands.

Next to lighting, Philips has primarily focused on electronics and it has played a role in products of any type, shape or size, including medical equipment, household appliances, razors, toothbrushes, coffee machines, vacuum cleaners, food processors, coat irons, toasters, TVs, video players, records, audio cassette tapes, computers, monitors, and many others.

Over time, the company divested from many activities. Some of these disappeared abroad (most of the consumer electronics activities) and some of them became independent entities in Eindhoven, such as ASML, NXP and FEI (now Thermo Fisher). The full electronics supply chain that co-developed with Philips adapted its core activities and is still in Eindhoven, supplying companies both in the Netherlands and abroad. Philips is still a large client, particularly in the high tech healthcare domain.

FINDING SOLUTIONS – WHY BRABANT?

The definitions of the technology (and the sequence in which they are mentioned) already perfectly clarify why the Brabant region still leads in electronics and related fields and the technology domains that evolved from electronics. They mirror Brabant's historical growth and present strengths in High tech Systems & Materials from an electronics perspective:

1. Electronics: developing new generations of (chip) technology, electronic components, ICs, and electronic systems for use in alternative energy, electric cars, mobility and transport, logistics, communication, safety and security, privacy, healthcare, climate and water, intelligent cities, aviation and space.
2. Embedded systems: integrated hardware/software systems that add intelligence, decision-making and other possibilities to high tech products for fostering economic activities and improving quality of life.
3. Nanotechnology: cross-sectoral technologies in materials, electronics/optics and sensors, for applications like lighting, energy, health, and water.
4. (Integrated) photonics: translating applications into requirements for components and performance, technologies for photonic-electronic integration, and processes for fast and smart design and production.

The Brabant HTSM ecosystem is well-represented in all of these fields, as illustrated by the examples introducing this section.

4. Brabant is *the* global center of excellence in advanced medical technology, particularly in imaging, diagnostics, and monitoring

USPs for Brabant	The foundation and further growth of Royal Philips (also known as Philips Healthcare) is at the heart of the vast industrial and knowledge cluster in imaging, diagnostics, and monitoring that has been gathered together in Brabant, in particular in Brainport Eindhoven. OEMs such as Philips, ASML, NXP, FEI (Thermo Fisher), GE Healthcare Life Sciences Core Imaging and most of their tier 1, 2, and 3 suppliers can be found in or within a radius of 50 kms of Eindhoven.
Universities/Research institutes involved	TU/e, Eindhoven University of Technology; Holst Centre; Radboud UMC; Catharina Hospital; Jeroen Bosch Hospital; Maxima Medical Center; Kempenhaeghe Epilepsy and Sleep Center; other UMCs
Leading companies/disruptors/best practices	Philips Healthcare; GE Healthcare Life Sciences Core Imaging; Teledyne Dalsa; Thermo Fisher Scientific; Bambi Belt; LifeSense; Phenom; NTS Group; Sioux Technologies; Adimec
Leading programmes	e/MTIC, Eindhoven MedTech Innovation Center
Facilities/Locations/Campuses	High Tech Campus Eindhoven; TU/e University Campus; Healthcare Campus Philips (Best); Catharina Hospital and Maxima Medical Center (Eindhoven), Kempenhaeghe Epilepsy and Sleep Center (Heeze), TU/e, Eindhoven University of Technology and Royal Philips (Eindhoven/Best)

INTRODUCTION

Royal Philips is a global health technology company, leading in market segments such as diagnostic imaging, image-guided therapy, patient monitoring, and health informatics, as well as in consumer health and homecare. Philips' business groups are clustered around three themes:

1. **Personal Health** - Enabling people to take care of their health by delivering connected products and services
2. **Diagnosis & Treatment** - Enabling efficient, first-time-right diagnosis and precision therapies through digital imaging and clinical informatics solutions:
   - Diagnostic Imaging
   - Image-Guided Therapy
   - Ultrasound
3. **Connected Care & Health Informatics** - Empowering consumers and care professionals with predictive patient analytics and clinical informatics solutions with a high degree of informatics and software-related competencies:
   - Patient Care & Monitoring Solutions
   - Healthcare Informatics, Solutions & Services
   - Population Health Management

FINDING SOLUTIONS – WHY IN BRABANT?

Over the past 25 years, Philips laid the foundations for the Brainport Eindhoven region, as it is known today, a top technology region that is renowned for its open innovation, co-creation, and unique collaboration between companies, knowledge institutes, and government.

Today, healthcare is Philips' core business. In Brabant, the company runs a large Imaging Campus in Best and multiple labs and research departments on the High Tech Campus in Eindhoven (HTCE), the center for technology-enabled innovation in the Netherlands. In Best, Philips employs some 3,500 people, and in Eindhoven close to 2,000 Philips specialists work on healthcare technologies and treatments.

High Tech Campus Eindhoven jokingly calls itself the smartest square kilometer in Europe, as it is home to more than 220 research-based companies, startups, and institutes. Some 12,000 researchers, developers, and entrepreneurs from companies all over the world are working there on developing future technologies and products that will affect the lives of billions of people. As such, the High Tech Campus Eindhoven has become an incubator for innovation in its health, energy, and smart environments priority areas.

COOPERATION BETWEEN SCIENCE, HEALTHCARE, AND INDUSTRY – E/MTIC

The Eindhoven MedTech Innovation Center (e/MTIC) is a large-scale research partnership between Royal Philips Eindhoven, the Eindhoven University of Technology (TU/e), the Catharina Hospital, the Maxima Medical Center, and Kempenhaeghe Epilepsy and Sleep Center in the fields of cardiovascular medicine, perinatal medicine and sleep medications. This partnership has evolved over several decades, has a strong scientific and commercialization track record and currently involves around a hundred PhD students, supervised by a similar number of experts from the various partners.

The goal of e/MTIC is to create and expand an ecosystem that dramatically increases the speed of high tech health innovation, maximizing value for patients: bringing technical innovations all the way from early research to implementation and commercialization as rapidly as safely possible. Examples of the developments and spin-offs e/MTIC is currently involved are:

- **MEDSIM -** the world's most lifelike childbirth simulator called Victoria. She has accurate anatomic proportions and state-of-the-art pregnancy monitoring technology;
- **THE SMART BABY BOTTLE -** a sensor-equipped sleeve that tracks bottle feeding routines and provides parents with personalized advice for their baby;
- **SMART MONITORING -** patient self-monitoring solutions for hypertension, obstructive sleep apnea and atrial fibrillation using unobtrusive wearable sensing technology integrated in watches or patches for timely detection;
- **3D NEEDLE -** using a 3D ultrasound probe to visualize and guide needle and catheter procedures by automatically detecting and visualizing the entire instrument.

e/MTIC
Eindhoven MedTech Innovation Center

5. Brabant is *the* home to the most powerful cluster of wafer fabrication (lithography) equipment in the world

USPs for Brabant	Within a 25 kilometer radius of the Brainport Eindhoven region, the majority of all parts, components, and subsystems of ASML's deep UV and EUV lithography machines are designed, engineered, and manufactured. One crucial part comes from Germany, the Zeiss optical lenses. ASML spun out of Philips in Eindhoven in 1984 and has claimed a leading global position in the production of wafer steppers using lithography.
Universities/Research institutes involved	TU/e, Eindhoven University of Technology; JADS - Jheronimus Academy of Data Science (Den Bosch/Tilburg/Eindhoven); Holst Centre (Eindhoven); TNO (Eindhoven); IMEC (Eindhoven/Louvain); Avans, Fontys & Breda Universities of Professional Education (Breda/Den Bosch/Eindhoven/Tilburg); EAISI, Eindhoven Artificial Intelligence Systems Institute
Leading companies/disruptors/best practices	ASML; NXP; VDL Group; NTS Group; Zeiss; Dialog Semiconductor; Possehl Electronics; Besi (Meco Equipment Engineers); Raith; Mintres; Anopanel; Innplate; Xycarb Ceramics; Kulicke & Soffa; Anteryon; Teledyne Dalsa; Catena Radio Design; Industrial Packing Support; many of the 100members of Brainport Industries
Leading programmes	Brainport Industries' Factory for the Future; Eindhoven Artificial Intelligence Systems Institute (EAISI); AI Innovation Center
Facilities/Locations/Campuses	High Tech Campus Eindhoven; TU/e Campus Eindhoven; Eindhoven Artificial Intelligence Systems Institute (EAISI); JADS Campus (Den Bosch); Brainport Industries Campus (BIC, Eindhoven)

INTRODUCTION

ASML headquarters are located in Europe's top tech hub, the Brainport Eindhoven region in the Netherlands. Global operations are spread across Europe, Asia, and the US. ASML, with 13,000 highly-skilled employees in the Eindhoven region, is by far the largest Dutch investor in research and development, spending two billion euros on R&D in the Netherlands in 2019. ASML's turnover in 2019 was a record high of 11.8 billion euros.

FINDING SOLUTIONS – WHY BRABANT?

ASML is an innovation leader in the semiconductor industry. The company provides computer chip manufacturers with everything they need – hardware, software, and services – to mass produce patterns on silicon using lithography. ASML was founded in Eindhoven in 1984 and has grown into a global company with almost 25,000 employees of 118 different nationalities... and counting. An ASML lithography system contains tens of thousands of parts, and nearly all of them are manufactured by outsourced suppliers. Up to 85% of the total system costs are generated externally, allowing ASML to focus on what it does best: designing the system and integrating the different modules into a fine-ly-tuned machine.

ASML's knowledge network includes more than a hundred key suppliers, universities, and research institutes around the globe. A high concentration of these key suppliers can be found right next door in Brainport Eindhoven. The manner in which suppliers contribute to successful innovation illustrates how companies in Brainport Eindhoven operate. Nowhere else in the world do suppliers play such an important role in the research and development of such complex machines as they do in Brainport Eindhoven.

6. Brabant is *the* center of excellence in AgriFood technology, component manufacturing & machine building

USPs for Brabant	Both the full High Tech Systems & Materials and AgriFood value chains are present and well-developed, including 450 AgTech and FoodTech companies (employing 27,000 people)
Universities/Research institutes involved	TU/e, Eindhoven University of Technology; WUR, Wageningen University & Research; JADS - Jheronimus Academy of Data Science (Den Bosch/Tilburg/Eindhoven); HAS University of Applied Sciences (Den Bosch) DataLab AgriFood (Den Bosch) Holst Centre (Eindhoven); TNO (Eindhoven); IMEC (Eindhoven/Louvain)
Leading companies/disruptors/best practices	PlantLab; Signify GrowWise; Pascal Processing; Bodec; GEA Food Systems; Marel Poultry; VDL ETG; VMEngineering/Nirás; Fri-Jado; KSE Process Technology; SAVAL; Skalar Analytical; Premier Tech; Knapen Trailers; KIN Machinebouw; ENGIE Services; AAE, Advanced Automated Equipment; NXP; Dacom; Aris Vision; Brainport Industries
Leading programmes	Breed4Food (WUR, Hendrix Genetics, Cobb-Vantress, Topigs-Norsvin, CRV); Eindhoven Artificial Intelligence Systems Institute (EAISI)
Facilities/Locations/Campuses	High Tech Campus Eindhoven; TU/e Campus Eindhoven; Eindhoven Artificial Intelligence Systems Institute (EAISI); DataLab AgriFood (Den Bosch); JADS Campus (Den Bosch); Precision Agriculture Center South (Reusel); Application Center for Sustainable Food Processing/Food Tech Brainport (Helmond); PlantLab (Den Bosch); GrowWise Research Center by Signify (Eindhoven); Cosun Innovation Center/GPEC, Green Protein Center of Excellence (Dinteloord)

INTRODUCTION

In view of the many challenges the planet is facing (feeding nine billion people by 2050 while significantly reducing the impact on the climate and earth), it has become very clear that the further integration of advanced technology in all phases and types of agriculture and livestock farming could be a large part of the solution.

FINDING SOLUTIONS – WHY BRABANT?

The AgriFood sector in Brabant was the subject of a study in 2020 much like this HTSM sector review. This analysis demonstrated that the region is also home to the full AgriFood value chain, employing more than 80,000 people in close to 14,000 companies.

The in-depth analysis of the High Tech Systems & Materials sector in Brabant has confirmed that AgriFood and High tech are cooperating intensively in the Brabant region and are already developing solutions for global sustainable food production. Screening of the over 1,600 high tech companies in Brabant with more than 10 employees revealed that more than 30% of them are active in the AgriFood sector. These 487 companies currently employ over 27,000 people.

- AgTech: in AgTech (agriculture technology) the activities range from stable and animal housing constructions, air treatment and climate control via stable, and greenhouse automation to agricultural machines, harvesters, and handling systems for sorting and packing of the harvest, including the entire range of parts suppliers.

- FoodTech: in FoodTech (processing technology for the food industry) the companies are involved in process technology and optimization, maintenance and inspection services, handling machines, packaging machines, air treatment and climate control, system cabinets, (quality) control equipment and – again – the full supply chain for parts and components.

Dozens of companies in Brabant and the Eindhoven region cover both the development and construction of applications such as:

- Livestock and livestock farming: animal breeding, animal genetics and breeding technology, stables and animal enclosures, HVAC systems and air scrubbing systems, feeding and drinking water systems, animal welfare monitoring facilities, milking installations, on-farm mini milk factories, etc.
- Arable farming: robots, cobots, sowing, harvesting and mowing machines
- Slaughterhouses and meat processing
- Food processing and food industry: extraction, separation, heating, catalysis, blending, cooling, monitoring, sensors, QA/QC, etc.
- Manure processing, such as biogas plants

This all leads to the conclusion that, if AgriFood is going to meet High tech anywhere in the world, it is going to be in Brabant, the Netherlands.

Westerbeek, Brabant - December 15, 2020 www.bom.nl

AVL MOTION ACCELERATES SERIES PRODUCTION OF ASPARAGUS HARVESTING ROBOT

AvL Motion is accelerating the series production of its AvL Compact S1560, an autonomous robot for harvesting white asparagus. The super-fast robot that can harvest about 9,000 asparagus per hour with one operator and can be ordered from next spring. The accelerated development of the harvesting robot is thanks to an Innovation Loan from the Netherlands Enterprise Agency (RVO) and a financial boost from existing shareholders Brightlands Agrifood Fund, Future Food Fund, and the Brabant Development Agency.

AvL Motion has had a busy season. "Despite the shortened test period due to corona, we have shown this season that we are able to build a super-fast robot that can harvest 9,000 asparagus per hour," said founder Arno van Lankveld. "We also received many compliments about the maneuverability, the simple operations and the ease of maintenance. The AvL Compact S1560 is to the asparagus harvest what Mercedes is to Formula 1: fast, reliable and delivers top performance under all conditions."

"The AvL Compact is to the asparagus harvest what Mercedes is to Formula 1" - Arno van Lankveld

"Thanks to the new investment round, we can make the harvesting robot ready for production a year earlier," said Van Lankveld. "The series product we are currently working on will soon be fully electric, without hydraulics. We strive for the highest possible quality. And we are very happy with our financial partners who supported us in this phase with the new investment."

The new robots will be presented at the start of the upcoming asparagus season. By then, potential customers can see two AvL robots at work in Dutch and German asparagus fields.

7. Brabant is *the* best place in the world to set up partnerships (PPPs) in research, engineering, assembly, and manufacturing

USPs for Brabant	Brabant has a distinctly strong culture, history and tradition of informal, constructive cooperation based on trust and open innovation: cooperation & partnerships are in Brabant's DNA
Universities/Research institutes involved	TU/e, Eindhoven University of Technology; JADS - Jheronimus Academy of Data Science (Den Bosch/Tilburg/Eindhoven); Holst Centre (Eindhoven); Solliance Solar Research (Eindhoven); TNO (Eindhoven); IMEC (Eindhoven/Louvain); Avans, Fontys & Breda Universities of Professional Education (Breda/Den Bosch/Eindhoven/Tilburg); EAISI, Eindhoven Artificial Intelligence Systems Institute
Leading companies/disruptors/best practices	Royal Philips; ASML; DAF Trucks; NXP; KMWE; VDL Group; NTS Group; Frencken Europe; Sioux Technologies; HighTechXL; High Tech Systems Center; Eindhoven Engine; (members of) Brainport Industries; AI Innovation Center (Eindhoven); 5G Hub Eindhoven
Leading programmes	Eindhoven Engine; Brainport Industries' Factory for the Future; Eindhoven Artificial Intelligence Systems Institute (EAISI); AI Innovation Center (Eindhoven); 5G Hub Eindhoven; ITEA
Facilities/Locations/Campuses	High Tech Campus Eindhoven; TU/e Campus Eindhoven; Eindhoven Artificial Intelligence Systems Institute (EAISI); JADS Campus (Den Bosch); Brainport Industries Campus (BIC, Eindhoven); Aviolanda Aerospace (Hoogerheide)

INTRODUCTION

Historically speaking, Brabant has always found strength in partnerships, as can be seen in some of its largest enterprises, the cooperatives VION, Cosun and FrieslandCampina, as well as in the birth and growth, over a century, of Royal Philips in Eindhoven, Organon in Oss, and Intervet and Hendrix in Boxmeer. These companies remain fully intertwined with the development of the region, its cities, universities, schools, housing, leisure, football clubs, and many other facets.

FINDING SOLUTIONS – WHY BRABANT?

Today, the intuitive tendency to cooperate and build partnerships is evident in the fact that Brabant's HTSM companies virtually all participate in the priority industry's technology roadmap projects and that they regularly feature in EU and Eureka research projects like ITEA (Philips), Horizon 2020, and future Horizon Europe projects.

The fact that Philips decided to open up its hermetically sealed NatLab research site in Eindhoven 17 years ago and started to invest in open innovation by inviting other companies to join it had significant impact. The company invested hundreds of millions of euros in the further development of the campus and facilities for optimal joint research, finally resulting in the Philips High Tech Campus. Located in the middle of Eindhoven and home to 12,000 researchers from more than 220 companies and institutes from all over the world, the site is now the property of a real estate investor and named the High Tech Campus Eindhoven (HTCE). Key tenants are still also Philips Healthcare, Philips Research, Signify (formerly Philips Lighting), and also NXP, ASML, Holst Centre, and Xeltis.

The concept and success of the Brainport Industries Campus (BIC) is today a new high point in the region. This fully-integrated industrial campus is also home to educational institutes and an innovation program and has unique characteristics. It constitutes the next level in partnering in innovation, manufacturing, and logistics, as the 35 companies in BIC actually share real estate, facilities and services, technical facilities such as cleanrooms, and logistics services and are engaged in joint innovation. The revolutionary nature of this concept has not slowed down the speed of campus growth: it is home to 2,000 high-level employees and 1,500 students on grounds of 105,000 m2.

Some of the key tenants and initiators of the Brainport Industries Campus are Anteryon, BOM, Brainport Development, Brainport Industries, Ceratec, Festo, Fluke Europe, Fontys University, Fujitsu Glovia, KMWE, RUBIX, Siemens, Sodexo, Solar Team Eindhoven, Summa School of Professional Education and Yaskawa.

The advantage of this culture is that cooperation, both informal and highly intensive, comes naturally in the region. The process of building partnerships in the region is quick and fluid – faster than anywhere else in the Netherlands and many other places across the globe. Outsiders who want to join and are willing to contribute to the community and the HTSM ecosystem can quickly and easily reap the benefits.

B. Brabant's Development Areas

1. AI for engineering: Brabant becomes the go-to region in applying artificial intelligence in (the manufacture of) cyber-physical systems

USPs for Brabant	Over a hundred years of electronics history, starting with Philips, evolving into micro and nanotechnology development (ASML, NXP, FEI and many others) and culminating in the new photonics paradigm (including smart photonics), is what makes Brabant and, Brainport Eindhoven in particular, an electronics and systems and control hotspot. And in that same period, Brabant built up an equally impressive legacy in metalworking and construction of machines and appliances, supplying them to the building and construction, semiconductor, automotive, AgriFood, (aero)space and many other high tech industries.
Universities/Research institutes involved	TU/e, Eindhoven University of Technology; JADS - Jheronimus Academy of Data Science (Den Bosch/Tilburg/Eindhoven); Holst Centre (Eindhoven); Solliance Solar Research (Eindhoven); TNO (Eindhoven); IMEC (Eindhoven/Louvain); Avans, Fontys & Breda Universities of Professional Education (Breda/Den Bosch/Eindhoven/Tilburg); EAISI, Eindhoven Artificial Intelligence Systems Institute
Leading companies/disruptors/best practices	Royal Philips; ASML; NXP; Thermo Fisher Scientific (FEI); Neways Electronics ; VDL Group; NTS Group; Sioux Technologies; Signify; AME - Applied Micro Electronics; Altran (TASS); Teledyne DALSA; Anteryon; QnQ Engineering; Delta Electronics; High Tech Systems Center; many of the 100 member companies of Brainport Industries;
Leading programmes	ITEA; Brainport Industries' Factory for the Future; Eindhoven Artificial Intelligence Systems Institute (EAISI); AI Innovation Center; the Eindhoven Engine
Facilities/Locations/Campuses	High Tech Campus Eindhoven; TU/e Campus Eindhoven; Eindhoven Artificial Intelligence Systems Institute (EAISI); JADS Campus (Den Bosch); Brainport Industries Campus (BIC, Eindhoven); AI Innovation Center

INTRODUCTION

Artificial intelligence (AI) is fundamentally changing the world and is considered one of the greatest commercial opportunities in today's economy. AI is a key technology that is transforming our world. AI is increasingly used in almost all sectors: image recognition applications support doctors in diagnosing of certain types of cancer and it plays a major role in disruptive developments in the medium to long term, such as self-driving vehicles. In daily life, the convenience of AI can be seen in intelligent search engines that provide fast, correct information, translation algorithms, navigation systems, chatbots from web shops that automatically answer questions and complaints, and algorithms that provide recommendations or develop tailor-made products based on our needs. Finally, AI can be combined with robotics or manned systems, for example in the manufacturing industry. At the close of 2020, KPMG named AI one of the Netherlands' absolute key technologies.

FINDING SOLUTIONS – WHY BRABANT?

Brabant is home to virtually all the industries described above, working with and benefiting from AI and machine-learning. In addition, the region has decided to embrace AI, but in a realistic manner - AI for real-world applications is the motto of EAISI, Eindhoven's AI Systems Institute.

According to KPMG's 2020 SWOT analysis of AI in the Netherlands, a number of factors justify the finding that the Netherlands occupies a good starting point for AI:

- The quality of Dutch computer science research is high
- The Netherlands has an economy based on the service sector, strongly focused on digitization, even in government
- The Netherlands has an innovative breeding ground for AI applications in various sectors (health and care, agriculture and food, technical industry, logistics and mobility)
- In Europe, the Netherlands is one of the leaders when it comes to digitization and IT ecosystems. The Netherlands is certainly in an excellent position for creating AI value
- A number of prominent Dutch companies are involved in the development and application of AI, such as Philips, Shell, ING, TomTom, NXP, and ASML
- From an international perspective, the Netherlands is a testing ground for the introduction of AI applications (such as the self-driving car)
- The stimulation of Dutch AI activities is undertaken by an umbrella public/private organization called the NL AI Coalition
- The Netherlands is home to organizations that promote the AI (startup) culture in the Netherlands

In reality, the above could almost be seen as an assessment of Brabant itself. Every bullet point relevant to industry and education describes Brabant. Four out of the seven prominent Dutch companies active in AI are based in Brabant: Philips, ASML, NXP, and TomTom. Meanwhile, the autonomous vehicle testing ground is in Helmond, part of Brainport Eindhoven.

For that reason, and the fact that the Brabant HTSM ecosystem always tackles challenges with the full force of its entire value chain, it is expected that the required speed for becoming competitive on an international scale will be achieved first in Brabant.

2. Brabant develops into/continues to be a source and growth support center for startups and scaleups

USPs for Brabant	Brabant has a vibrant HTSM startup and scaleup community, especially in Brainport Eindhoven. The Triple Helix cooperation in the region (industry, science and education, and government work closely together) is a fundamental asset in that respect. Both industry (large and small) and science breed startups, and the universities and vocational schools support them. Local and regional governments provide funding, permits, facilities, and prevent legislation from hampering progress. The number of startup and scaleup initiatives are impressive, both in Brainport Eindhoven and elsewhere in Brabant (Breda, Tilburg, and Den Bosch).
Universities/Research institutes involved	TU/e, Eindhoven University of Technology; JADS - Jheronimus Academy of Data Science (Den Bosch/Tilburg/Eindhoven); Holst Centre (Eindhoven); Solliance Solar Research (Eindhoven); TNO (Eindhoven); IMEC (Eindhoven/Louvain); Avans, Fontys & Breda Universities of Professional Education (Breda/Den Bosch/Eindhoven/Tilburg); EAISI, Eindhoven Artificial Intelligence Systems Institute
Leading companies/disruptors/best practices	HighTechXL; ASML; Smart Photonics; DAF Trucks; SALDtech; NXP; Dimenco; Sioux Technologies; Liqal; Thermo Fisher Scientific (FEI); Incooling; Royal Philips; Lightyear; VDL Group; Leyden Jar; NTS Group; Aircision; Frencken Europe; Dynaxion; SolayTec; LionVolt; PrecEyes; Smart Robotics; BOM – Brabant Ventures; Brainport Development; Innovation Industries; Midpoint Brabant; REWIN
Leading programmes	HighTechXL; Eindhoven Engine; High Tech Systems Center; Brainport Industries' Factory for the Future; Eindhoven Artificial Intelligence Systems Institute (EAISI); AI Innovation Center; 5G Hub Brainport; StartersLift
Facilities/Locations/Campuses	The Gate - one-stop shop start-up center Brainport; High Tech Campus Eindhoven; TU/e Campus Eindhoven; Eindhoven Artificial Intelligence Systems Institute (EAISI); JADS Campus (Den Bosch); Brainport Industries Campus (BIC, Eindhoven); Aviolanda Aerospace (Hoogerheide); Station88/Braventure (Tilburg); MindLabs/Start-up Kitchen (Tilburg); Green Chemistry Campus (Bergen op Zoom)

INTRODUCTION

Historically, Brabant is a region where the manufacturing industry, the universities of applied sciences and the vocational schools work closely together in developing technology and products that makes life easier and more comfortable - lightbulbs, X-ray machines, insulin, CD and video players and recorders, airplane parts, husbandry equipment, trucks, monitors, contraceptives, thousands of food products and many, many more products.

This legacy goes back many decades. And in this long history of individuals launching companies, many have grown into healthy SMEs or even into large-scale OEMs. All the while, the cross-pollination between them and the educational and research institutions bred a continuous flow of new startup and scaleup companies, a process that continues to this day.

A successful and creative ecosystem needs to cherish this culture and supportive climate in order to retain and boost this 'nursery of breakthroughs, disruptions, and improvements' to remain healthy and competitive. This is increasingly important, as global competition in high tech becomes fiercer by the minute and the battle for talent, funding, and disruptive ideas rages.

In the past, the industrial icons of Brabant – Royal Philips Electronics and DAF Trucks – fulfilled the role of a high tech systems ecosystem almost alone. Philips was particularly active in virtually all conceivable fields of electronics (lighting, medical, optical, electronics, audio, video, computing, etc.), and performed all the research, development, manufacturing, marketing, distribution, and servicing of these products itself, operating on a global scale. It also co-founded the Eindhoven University of Technology together with DAF Trucks and the authorities.

Its research institutes, such as the famous NatLab (Philips Physics Laboratory) in Eindhoven, had near-unlimited funding and freedom to venture into any possible technological dimension. As such, they gave birth to many revolutionary new technologies, often multidisciplinary ones that we would dub 'disruptive' in the modern era. In its heyday in 1975, the NatLab employed some 2,000 people, including 600 graduate researchers.

Once these breakthrough ideas needed support in other areas, expertise and funding was sought and found in the many Philips departments in and around Eindhoven. One example is Philips CFT, the Center for Applied Technology, later renamed Philips Centre for Industrial Technology. New initiatives had the opportunity to develop in the sheltered Eindhoven community, with all possible academic, industrial, financial, and managerial support. And, in time, these new ventures became large-scale divisions of the corporation and in some cases they spun-out of Philips, such as ASML, FEI, and NXP.

FINDING SOLUTIONS – WHY BRABANT?

These industrial icons still exist today and are still in the region, but they do no longer have that all-encompassing role. It is impossible to even try to gather together all technological domains in high tech systems in one company, and generally speaking the most successful high tech companies are very focused on a single core activity. They have to be, to be able to match the speeds of market and technology development in their fields.

Industry, science, and the regional authorities are aware of the fact that this change has taken place and have been and still are actively investing in new joint initiatives, instruments, cooperative ventures, physical locations for high tech collaboration, and more in order to remain a flourishing start-up region. As it is still a widely-held ambition in the region to out-innovate everyone, anywhere in the world, in cyber-physical systems engineering:

- **The High Tech Campus in Eindhoven** was once the hermetically sealed location of Philips Research but opened its gates some 20 years ago and is now home to 220 high tech companies and 12,000 research professionals from all over the world. The Campus helps accelerate innovation by offering easy access to high tech facilities and international networks. Open innovation-minded companies (like Philips, NXP, TomTom, Shimano, Signify, IBM, and Intel) strategically decide what knowledge, skills and R&D facilities they share in order to achieve faster, better, and more customer-oriented innovation in the fields of health, energy, and smart environments. They do so in close cooperation with the world-class research institutes on Campus like the Holst Centre, Solliance and EIT Digital.

Add to that the fast-growing startup population (over 50 companies), the HighTechXL dedicated accelerator program, the high level of facilities and lots of (free) events, and it is clear why this is the ultimate startup ecosystem for high tech companies (further details can be found in Chapter 6, section B).

- **HighTechXL** is a very successful, deep-tech accelerator, building on technology provided by CERN, TNO, ASML, and many other advanced research institutes and companies from around the globe (further details can be found in Chapter 7, section B).

- **The Eindhoven Engine** accelerates innovation in the Brainport Region through challenge-based research in its public-private research facility at the TU/e Campus. It aspires to act as an active landing site for larger startups and early scaleups, as a follow-up to the one-stop shop start-up center The Gate, in close collaboration with the other Brainport Campuses and accelerators, HighTechXL, Lumo Labs, etc. (further details can be found in Chapter 7, section B).

- **The Gate** – the one-stop shop tech start-up support center of the Brainport Eindhoven region was launched in 2021 by the TU/e, Eindhoven University of Technology, Brainport Development, the Brabant Development Agency (BOM), Fontys University of Applied Science, and Summa College (a technology-focused vocational school).

- **The regional development agencies** such as BOM, Brainport Development, REWIN, and Midpoint Brabant are investing heavily in both startups and scaleups (further details can be found in Chapter 8).

SUPPORT IN BRABANT'S HIGH TECH OUTSOURCED VALUE CHAIN

Brabant is home to the entire High Tech Systems & Materials value chain – OEMs, research institutes, universities and vocational schools, and also the entire spectrum of HTSM suppliers call the region home.

What sets Brabant apart, even on the international stages, is the fact that the region hosts hundreds of tier 1, 2, and 3 suppliers that are highly specialized in specific high tech activities, even if some of those suppliers are relatively small. They are experienced in working with other suppliers and OEMs and are very familiar with performing outsourced development, testing, or manufacturing.

This unique feature means a scaleup company can set up shop in Brabant and implement all the necessary development and manufacturing steps, without even having to employ these specialists. Nor will it have to invest in all the required equipment. That means such a company can save its energy to focus on its own core activities.

This distinguishing characteristic of the region can best be summarized as the presence of a full outsourced value chain. The Brainport Industries association is in fact based on this philosophy, and its members are the 'open/outsourced supply chain'. Even the largest OEMs like ASML strive to outsource the majority of their manufacturing and development.

3. Brabant is developing into a center of excellence in smart, connected mobility

USPs for Brabant	In the Netherlands, the vast majority of automotive companies are located in Brabant and Limburg, the two adjoining southern provinces. The breadth and depth of skills and expertise in Brabant is so extensive that it is no exaggeration to state that the Brabant automotive HTSM cluster can invent, design, engineer, assemble, manufacture, commercialize, install, and maintain probably any component and/or system related to smart and connected mobility and sustainable or green mobility
Universities/Research institutes involved	TU/e, Eindhoven University of Technology; JADS - Jheronimus Academy of Data Science (Den Bosch/Tilburg/Eindhoven); EAISI, Eindhoven Artificial Intelligence Systems Institute; Eindhoven Engine; Holst Centre (Eindhoven); TNO (Eindhoven); IMEC (Eindhoven/Louvain); CWI – the Netherlands' research institute for mathematics and computer science (Amsterdam); AVANS, Fontys & Breda Universities of Professional Education (Breda/Den Bosch/Eindhoven/Tilburg)
Leading companies/disruptors/best practices	DAF Trucks; NXP; TNO; VDL Group; NTS Group; Ricardo; TomTom; Skialabs; Altran; TASS International
Leading programmes	European project ENSEMBLE (following up on the Brabant project EcoTwin): piloting multi-brand truck platooning on public roads; European ECSEL project PRYSTINE: programmable systems for intelligence in automobiles, with fail-safe operational sensor fusion and safety-compliant integration of artificial intelligence approaches for object recognition, scene understanding, and decision-making
Facilities/Locations/Campuses	Automotive Campus (Helmond); High Tech Campus Eindhoven; TU/e Campus Eindhoven; Eindhoven Artificial Intelligence Systems Institute (EAISI); JADS Campus (Den Bosch); Brainport Industries Campus (BIC, Eindhoven); Aviolanda Aerospace (Hoogerheide)

INTRODUCTION

The automotive sector is facing major challenges. National and international agreements on sustainability, such as the EU's climate agreement, social trends and international competition require smart and sustainable mobility. This has made investment in innovation a top priority for the Dutch automotive industry for maintaining a strong international position. Drivers for innovation in the Dutch automotive sector are the shared ambition to achieve zero fatalities and zero emissions in road transport. The themes of Sustainable Mobility and Smart Mobility are the building blocks for achieving this.

The vast majority of automotive companies in the Netherlands are located in Brabant and Limburg, the two adjoining southern provinces. As a result, the recently launched national HTSM Automotive roadmap strongly reflects the developmental direction of the Brabant automotive companies and research institutes. The roadmap describes the priorities in R&D up to 2030.

Green mobility focuses on development strategies related powering wheels with an energy source (tank-to-wheel). The aim is to achieve zero-emission road transport. ***Smart mobility*** is divided into four subthemes; cooperative driving, automation, connectivity, and smart mobility services. In the near future the first three themes are likely to come together and combine functionalities that will enable automated driving. The driver for innovation is to achieve zero fatalities in road transport. In the roadmap both green and smart mobility focus on vehicles.

Around the globe, the industry is on the brink of a major transition to a sustainable, smart, and safe mobility system. The growing population puts pressure on accessibility. In terms of road safety, the ambition of zero road casualties is still far-off. Meanwhile CO emissions from the transport sector have grown instead of decreasing since 1990, which puts additional pressure on achieving the climate targets. The Netherlands is well-prepared for taking a leading position in finding solutions to these challenges.

In addition to market leaders such as DAF Trucks, NXP, VDL, TomTom, and Bosch Transmission Technology, the Netherlands has a strong position and players in the field of navigation/localization (TomTom, HERE, NavInfo (MapScape)) and software/smart infrastructure (Vanderlande, Prime Vision, Dynniq, Vialis, and Siemens). These players – all but three of which are located in Brabant - are surrounded by a wide supply chain of SMEs and innovative startups and scaleups.

NXP IN THE NETHERLANDS & AUTOMOTIVE TECHNOLOGIES

The Netherlands is home to NXP global headquarters and three additional sites, with over 2,000 employees focused on R&D, manufacturing, product development, business operations, legal, and sales.

In 2020, NXP was listed sixth in the top 30 of private R&D investments in the Netherlands, published by the magazine Technisch Weekblad. Worldwide, NXP spent a total of 1,466 million euros on R&D, 14% of which (over 200 million euros) was spent in the Netherlands.

NXP's international headquarters are located on the High Tech Campus Eindhoven and is home to more than 700 staff, over 300 of whom focus on business operations. Security specialists within the Competence Centre for Crypto Security focus on security innovation, hardware and software IP development, and certification. The CTO Design Center, a center of excellence for state-of-the-art SoC integration methodologies and analog mixed signal design, is also located in Eindhoven. The Automotive System Innovations group of the CTO office anticipates future technology trends and drives system-level automotive innovation.

NXP Nijmegen includes manufacturing, R&D, testing, technology enablement, and support functions. With 1,700 employees and over 50 nationalities represented, it is a highly international operation. NXP Nijmegen is one of the largest chip manufacturing plants plant in Europe with over 565,000 wafers produced to date.

The product diagnostic center and global new product introduction (NPI) test center, based in Nijmegen, help NXP's NPI to meet manufacturing standards and successfully launch products. Product development teams for the NXP smart power, drivers and energy systems, in-vehicle networking, and smart antenna businesses focus on developing best-in-class solutions, spanning automotive, computing, gaming, multimedia, mobile, and wireless infrastructure applications.

The sites in Delft and Son en Breugel are home to hardware and software design teams for wireless automotive electronics such as radio, GPS, car access systems, and sensor electronics. These teams also have a wealth of knowledge and experience in designing wireless connectivity standards like Bluetooth® Low Energy, Wi-Fi, and proprietary standards.

FINDING SOLUTIONS – WHY BRABANT?

Smart Mobility in the national automotive roadmap co-developed in Brabant

Safety challenges in new (multi-modal and/or shared) mobility concepts need to be tackled for all road-users, including vulnerable road-users and users of new types of vehicles. The aim to achieve zero casualties is the main driver for the activities in the field of smart mobility.

The principal challenge is to develop and implement systems that address, to an optimal degree, the social drivers (safety, environment, and throughput) while making efficient use of the potential offered by digitalization, automation, and other developments. The four subthemes (cooperative driving, automated driving, connectivity, and smart mobility services) are linked and their development goes hand-in-hand. For the next stages of such development, cross sectoral cooperation with urban planners, telecom industry, and others is required. The connectivity enables data transfer, data storage and data sharing as part of the ongoing digitalization of mobility. Cybersecurity and AI are emerging topics, as well as connecting individual mobility needs to the overall mobility system. A balanced optimization for both must be established.

Within the Smart Mobility roadmap, a set of technologies and related research and innovation activities has been identified that require further development. For reasons of readability and simplicity, these technologies are grouped under one of the main themes (cooperative driving, automation, connectivity, and smart mobility services).

CONNECTED COOPERATIVE DRIVING

Focus: upscaling, multi-brand cooperation and interoperability. Safety and s ecurity are included, communication is an important enabler:

1. ADAS technologies (such as cooperative autonomous emergency braking)
2. Functional safety with respect to the impact of failure of vehicle-to-vehicle (V2V) communication
3. HMI user interface to support driver during cooperative driving
4. Cyber security and security for communication between vehicles and cooperative intelligent transport systems (C-ITS) (intruders, hackers)
5. Multi-brand heterogeneous cooperative automated driving
6. Architecture and platform design including networked control (improve safety, efficiency, etc.)
7. Digital infrastructure, communication and sensing network
8. System architecture and framework for data sharing
9. Environmental awareness using V2X (vehicle-to-everything) communication (shared world modelling), sensor fusion
10. AI-based perception, decision making and actuation
11. Improved interaction with other (vulnerable) road-users especially in urban areas
12. Developing and defining system architectures allowing scalability of ODD (operational design domain) with increasing complexity

AUTOMATED DRIVING

Focus: vehicle-centric developments, including safety and security and with communication as an important enabler. Aspects to be incorporated:

1. Combined real-life safety assessment and virtual homologation using a selection of real world scenarios
2. Functional safety, including robust and reliable system architecture for level 3 and level 4 automation, including the latest algorithms for longitudinal and lateral control
3. HMI user interface to lower driver workload and change driver behavior
4. High-precision localization of the host vehicle and other road-users and connected vehicle world models
5. Cybersecurity and security in vehicles and their interaction with the surroundings and trust provisioning
6. Environment perception by on-board sensors (sensor fusion combined with vehicle world model)
7. Human factors and user interface (information load, transition of control)
8. Artificial Intelligence for CCAM solutions, including the related testing and validation of AI-based modules

CONNECTIVITY

Focus: increasing available and required data, its handling and consequences of this increase and use of data.

1. New system design to address all connectivity topics in an integral approach
2. Data analytics, data storage and data sharing architecture to handle big data, supported by data value chains and multi-stakeholder business models
3. Predictive maintenance of vehicles and infrastructure
4. Security (authentication) methods
5. User-centric traffic management and traffic information
6. Sharing services, both for freight and passenger transport
7. Software lifecycle with over-the-air updates and alignment between software and hardware lifecycles

SMART MOBILITY SERVICES

Focus: the increase of ride-sharing ,and sharing mobility means, as well as the planning and tailored offering required. Key challenges:

1. Advanced connected-car and automated driving technologies and concepts for personal mobility and transport
2. Development of self-learning systems for e-vehicles (e.g. electric drives, energy storage systems) for improved availability and for remote maintenance services
3. Development of robot taxis for personal urban mobility, including the end-user service
4. Tools for providing sharing services, both for freight and passenger transport
5. Personal rapid transport (RPT) systems featuring small automated vehicles operating on a network of classed infrastructure, like (enhanced) bus lanes
6. Enabling use of vehicles in shared mobility services like MaaS (mobility as a service) and TaaS (transport as a service)
7. Investigating the potential of combining automated urban delivery and people transportation

OBJECTIVES OF BRAINPORT EINDHOVEN AND SMART MOBILITY

The Brainport Eindhoven region wants to be known as the place-to-be in Europe for smart mobility by 2022. Three objectives have been identified:

1. Residents can move from A to B in the smartest and easiest way. The region has a leading, comfortable, and sustainable 'Daily Urban System' that contributes to a green, livable environment.
2. In 2030, Brainport Eindhoven Region will be the European hotspot for applied knowledge concerning the technology for connected and autonomous driving (CAD) and mobility as a service (MaaS).
3. This also creates new economic activities in a growing smart mobility ecosystem, with the Automotive Campus as a focal point.

Multiple on-going projects give substance to these ambitions. The projects are also inter-connected, both strategically and in the implementation phase.

APPLIED TECHNOLOGY: FROM KNOWLEDGE TO PRACTICE

The high tech region of Brainport Eindhoven is a frontrunner in the field of developing advanced knowledge and technology. It was deliberately decided to also apply new technologies in the region, as these real-life experiments are the most effective way to learn about the technology's pros and cons so that they can be further developed and perfected. The region has two main focal points in the field of smart mobility:

I. Connected autonomous driving (CAD): vehicles that communicate with each other and with the infrastructure and can drive independently – the self-driving car.

II. Mobility as a service (MaaS): a single platform that connects all transport options (including public transport, shared cars, and shared bicycles). This includes travel time and planning, reservations, and user-friendly administration, as well as an overview of the means of transport that are available at that time, where they are, and so on.

A GROWING SMART MOBILITY ECOSYSTEM

Because there is an explicit aim to be a forerunner in the field of smart mobility in the Brainport Eindhoven region, the authorities are also investing in the field. Investments are made in knowledge, and in the development and application of products and services in the region. This means that the smart mobility ecosystem, economic value and exports, employment, and investments in research and development in this domain are all growing.

USE OF SMART MOBILITY DETERMINES SUCCESS

Ultimately, smart mobility will only be a success if it means that people in the region travel easier, safer, more comfortably and more sustainably. Smart mobility is therefore not only about technology or innovation, it is also about its use - a behavioral change for the traveler. Brainport Smart Mobility contributes to this by making products and services that meet the requirements of travelers, and by providing all the means of transport in a user-friendly approach.

THE BRAINPORT LINE – AN INNOVATIVE PUBLIC TRANSPORT CONNECTION BETWEEN ALL BRAINPORT CAMPUSES AND BEYOND

The Brabant authorities, industry, and knowledge institutes are aiming to develop the Brainport Line, a new and innovative transport system that will connect all Brainport campuses around Eindhoven with each other and with regional locations. Through Eindhoven Central Station it will provide connections to other economic centers in the Netherlands and abroad.

The province of Brabant, the municipality of Eindhoven, and Brainport Development are the initiators of the project, with the support of the business community and knowledge institutes at Brainport Eindhoven. The project has been submitted to the Ministry of Infrastructure and Water Management for consideration for funding of over a billion euros from the National Growth Fund.

The Brainport Line is a new, smart, and emission-free public transport system in which 'pods' of different sizes drive on free lanes, along transfer points at arterial roads and around existing public transport nodes. It uses sensor technology, autonomous driving, and proven technology such as platooning.

The Brainport Line can be introduced in phases between the present and 2030. The system brings together innovation and testing possibilities at the heart of the knowledge-intensive manufacturing industry in the Netherlands. The system is an economic showcase and is a flexible system because it is not bound to a route on rails, making it easy to scale up. It can be used in smaller cities and in larger metropolitan areas around the world.

This is a great economic opportunity for the business community in Brainport Eindhoven, which is developing the Brainport Line, and it also contributes significantly to the international stature of the Netherlands as a forerunner of innovative smart and green mobility applications.

THE NATIONAL GROWTH FUND

In September 2020, the Dutch national government announced that the National Growth Fund would have a budget of 20 billion euros. The fund can be used to finance projects that contribute to strengthening the long-term s ustainable earning capacity of the Netherlands.

Christophe van der Maat, deputy member for Mobility of the executive council of the province of Brabant believes the Fund is a great idea: "It is very important that we keep looking ahead in the Netherlands," he said. "There is a lot of creativity, entrepreneurship and innovation in our country, which will be activated by the Growth Fund. We have already done our homework and made this bid, which we believe fits seamlessly with the goals of the Fund. Through the Brainport Line, we not only improve accessibility to and between top locations in the economic engine of the south, the system also acts as a driver for the mobility transition in Brabant - and also generates money. According to the social cost-benefit analysis, it will yield about 150 million euros after the deduction of costs. "

STRONG GROWTH

The development of and investment in the Brainport Line is a real necessity for the Eindhoven region, given its economic success and growth: by 2040, 70,000 jobs will be added and more than 60,000 homes will be built in the urban area, including 6,000 in the area around Eindhoven Central Station. For example, Brainport Line will connect the economic hotspots within the region, and also bolster connections with economic centers such as Amsterdam and Rotterdam and important European regions such as Dusseldorf, Aachen, and Brussels.

According to Alderman Stijn Steenbakkers (Economic Affairs) in Eindhoven, the Brainport Line is much more than just a mobility system. "We are going to create jobs by developing, constructing, marketing, and exporting this innovative mobility system! Each step of the design, development, testing, and implementation phases generates lessons, developments, services, and products that can be marketed at home and abroad. This means employment at all educational levels, from vehicle technology to infrastructure development, underlying technologies and new mobility services. For example, we will actively work on the necessary innovations and developments that take the country further in the mobility and energy transition. Everything comes together here: transport, jobs and sustainability."

BUILD TOP POSITION

According to Hans de Jong, president of Royal Philips in the Netherlands and board member of the Brainport Foundation, the Brainport Line offers a unique opportunity to deploy the highest level of innovation at the interface of high tech manufacturing and automotive industry.

"Brainport Eindhoven is one of the engines of the Dutch economy. The technology that is being developed and produced in this region makes solutions possible for global social themes, such as digital care, smart mobility, and alternative energy generation.

Those solutions are world-class, and the region's accessibility must be too. This investment is in line with the ambition to further expand our international leading position. We can do this together, in a public – private partnership, that is the strength of Brainport."

The proposition has broad support from the business community and knowledge institutes in Brainport Eindhoven, which have already stated the transport system will be used for their employees, strengthening the business case for the Brainport Line.

CURRENT PARTNERS IN THE BRAINPORT LINE PROGRAM

4. Brabant is becoming a *global* center of excellence in sustainable mobility and drive systems

USPs for Brabant	The vast majority of automotive companies in the Netherlands are located in Brabant and Limburg, the two adjoining southern provinces. The breadth and depth of skills and expertise in Brabant is so extensive that it is no exaggeration to state that the Brabant automotive HTSM cluster can invent, design, engineer, assemble, manufacture, commercialize, install, and maintain almost any components and/or system related to smart and connected mobility and sustainable or green mobility
Universities/Research institutes involved	TU/e, Eindhoven University of Technology; JADS - Jheronimus Academy of Data Science (Den Bosch/Tilburg/Eindhoven); Holst Centre (Eindhoven); Solliance Solar Research (Eindhoven); TNO (Eindhoven); IMEC (Eindhoven/Louvain); Avans, Fontys & Breda Universities of Professional Education (Breda/Den Bosch/Eindhoven/Tilburg); EAISI, Eindhoven Artificial Intelligence Systems Institute
Leading companies/disruptors/best practices	DAF Trucks; LIQAL; Rolande LNG; VDL Group; NTS Group; members of Brainport Industries
Leading programmes	European ECSEL project 3CCAR will demonstrate next-generation, high-reliability and high-efficiency power systems for electric vehicles (with NXP, TU/e and TNO)
Facilities/Locations/Campuses	Automotive Campus (Helmond); High Tech Campus Eindhoven; TU/e Campus Eindhoven; Eindhoven Artificial Intelligence Systems Institute (EAISI); JADS Campus (Den Bosch); Brainport Industries Campus (BIC, Eindhoven); Aviolanda Aerospace (Hoogerheide)

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DAF TRUCKS – EINDHOVEN, THE NETHERLANDS

DAF Trucks in Eindhoven was founded in 1928 by Hub van Doorne. He set up a small construction workshop that he called DAF – van Doorne's Aanhangwagen Fabriek (Van Doorne Trailer Factory) that later became van Doorne's Automobiel Fabriek (van Doorne Car Factory). From these modest beginnings, DAF first developed cars and dive train systems and eventually became a leading global truck manufacturer.

The company is now an advanced technology company and leading commercial vehicle manufacturer. DAF is a wholly-owned subsidiary of PACCAR Inc, the American designer and manufacturer of premium light, medium, and heavy-duty commercial vehicles, including Kenworth and Peterbilt.

DAF and PACCAR are exploring several routes that will lead from clean to sustainable mobility: electric, hybrid and - in the long term - hydrogen. At the same time, the already very clean combustion engine is destined to become even cleaner in the future and more sustainable too, thanks to the arrival of new generations of fuels.

DAF Trucks has close to 10,000 employees, invests 150 million euros in R&D annually and manufactures 1/6 of all European heavy trucks sold each year. With a market share of 16.2% in the heavy (16+ tons) segment in 2019, the company is one of the three largest truck brands in Europe. The 16.2% market share in the heavy truck segment is the second-best result in DAF's history. In the light vehicles segment, DAF's market share grew from 9% to 9.7%. Total production in 2019 was over 64,000 trucks.

In 2020, in spite of the Covid-19 pandemic, DAF registered 37,580 trucks in a total European market of 230,400 heavy-duty vehicles, actually resulting in an increase of DAF's market share to 16.3%, replacing the 16.2% achieved in 2019 as the second-best result in the company's history.

FINDING SOLUTIONS – WHY BRABANT?

Green/sustainable mobility in the national automotive roadmap co-developed in Brabant

In the next few decades, the automotive industry will face enormous challenges in contributing to climate-neutral mobility by 2050. Over the short term, tailpipe CO_2 emissions from passenger cars as well as heavy duty vehicles must be cut by 30% by 2030 (compared to 2019). Simultaneously, very challenging real-world pollutant targets must be met and various European cities have announced the introduction of zero emission zones by 2030.

To achieve the massive reductions, an integrated systems approach is required. Besides changes to human behavior, a combination of logistical, traffic and vehicle measures is required. From a cross-sectoral, well-to-wheel perspective, it is essential that future vehicle technologies also support the energy transition by enabling the use of sustainable energy carriers. Currently, there is general consensus that there is no single energy transition pathway towards sustainable mobility. To meet future decarbonization targets at the lowest possible cost, all energy carriers that can make a contribution will be needed. Three pathways are considered most promising for mobility:

- Renewable electricity
- Renewable hydrogen
- E-fuels (or power-to-X)

For passenger cars, a clear shift towards battery electric vehicles (BEV) is on the rise, while fuel cell vehicles (FCEV) are also anticipated. A similar shift will take place for city distribution and bus applications. Internal combustion engines (ICE) will remain the primary power source for future heavy-duty powertrains in the upcoming decades. To meet requirements for zero emission zones, hybridization of ICE-based powertrains will play an important role.

Based on these trends, five research priorities have been identified in this section of the HTSM Automotive roadmap. These priorities can cater to for possible shifts in the energy mix and to the changing focus on energy carriers:

1. Battery technology is crucial for all pathways in the energy transition; new-generation battery systems are required to enhance energy density, cost efficiency, and durability.
2. For ICE-based concepts, highly efficient combustion concepts that enable a wide range of E-fuels are key. Besides the application of carbon-based E-fuels, hydrogen (H_2-ICE) is also attracting increasing attention as a zero (tailpipe) CO_2 emission solution.
3. There is a need for modular, highly efficient powertrain components and systems for all powertrain concepts.
4. Important enabling technologies: smart vehicle energy management and geofencing to maximize real-world performance within emission limits.
5. Advanced development tools to minimize development time and costs.

ADDITIONAL, TECHNOLOGY-FOCUSED PRIORITIES

- Driving in mixed traffic conditions, with road users equipped and unequipped with connected and/or automated vehicle functions;
- Developing advanced safety functions and human centered advanced driver assistance systems (ADAS);
- Defining and developing the essential digital and physical infrastructure to enable the large scale deployment of smart mobility solutions;
- Extending the operational design domain of ADAS and autopilot, creating clear steps beyond their use in confined areas;
- Developing understandable, explainable, and trustworthy AI solutions to further boost the smart mobility developments;
- Developing and using assessment tooling and facilities, including digital twins of physical infrastructure, supporting the development, validation, assessment and monitoring of automated driving functions;
- Further developments in radar technology and other perception system-related technologies.

The Automotive Campus in Helmond, Brabant is home to the Netherlands's largest community of research-based automotive companies. A selection of these companies and institutes:

Altran Engineering	Design and engineering services for the automotive industry: e-mobility, ADAS, prototyping, testing
TASS International	Testing, crash testing, traffic technology
Lightyear	Solar-powered electric cars
VDL ETS	Developing and testing transport systems
KPN	5G Field Lab in combination with smart mobility
2 get there	Autonomous vehicle projects
Durapower	Battery systems for electrical vehicles and energy storage
V-tron	Fleet management systems
Fier Automotive	Business development agency specialized in automotive
InMotion	Developing the race car of the future
Jumbo Groenewegen	Trailers
Automan	Human Resources in automotive
Vehant Technologies	AI based security products
Spike	High-class and flexible battery solutions
Electric Motorbikes	Innovative electric motorbikes
XYZ Dynamics	Engineering services on electrical vehicles
Goodmoovs	Car-sharing app for electrical vehicles
Dens	Sustainable engines on formic acid
Saluqi Motors	Electric drive systems with integrated power electronics

The Automotive Campus houses various high-quality technical facilities that serve a range of purposes. Many research laboratories and test facilities form part of the Automotive Campus Shared Facilities, while others are owned by testing and research companies such as the TNO, TASS International, and Altran, as well as a number of test centers at companies associated with the Campus.

EXAMPLES INCLUDE:

- **TNO's Powertrain Test Center:** to meet future powertrain requirements related to pollutants and CO emissions, exploiting the synergy between engine, drivetrain, and after-treatment subsystems has become increasingly important. TNO's focus is on automotive powertrain control systems that optimize overall system performance. This is achieved by using (virtual) sensors and model-predictive control strategies based on combined emission and energy management concepts. The developments concentrate on truck and bus applications for city distribution as well as long haul transportation.

- **TASS' Safety Center:** accurate data, fast results, and controlled development costs. These are the most important aims in crash-testing vehicles, components, and safety systems. The Safety Center offers fully equipped facilities to perform tests on a whole range of automotive applications, both indoor and outdoor. From vehicle components or even aircraft parts using passenger cars to buses and trucks up to a gross weight of 22 tons.

- **TASS' ADAS Testing Center:** the demand for advanced driver assistance systems (ADAS) in the automotive industry is greater than ever and will continue to grow rapidly. Vehicle integrated safety systems are becoming increasingly sophisticated to be able to cope with scenarios of increased complexity. TASS International is fully accredited to assess the performance of these systems using globally recognized testing procedures - Euro NCAP for passenger vehicles and UNECE regulations for trucks and buses.

- **TASS' Automated Driving Validation:** TASS believes the most effective way to develop and validate cooperative and automated driving systems is by using a combination of simulation, laboratory experiments, and real-world testing. Simulation results are used to define the physical experiments, whereas experimental results are used to validate the simulations. The methodology and tool-suite enable customers to validate cooperative and automated driving systems at a much earlier stage and for much smaller sums.

- **Altran:** the Altran facility at the Automotive Campus offers its clients special automotive engineering expertise in the fields of e-mobility, ADAS, vehicle armoring, and durability testing (low and high frequency, climate, corrosion, final inspection of components, and custom-built test-rigs).

- **VDL's Rolling Road Testbench:** the 800 ton, 7 x 22 meter long rolling road on the Automotive Campus is one of the largest rolling roads in Europe. Buses, trailers, and trucks up to 30 tons can be tested on it for engine performance, specific speed profiles, suspension fatigue tests, fuel consumption, road load simulation, and ambient temperature testing.

LIGHTYEAR

Lightyear's mission is to make clean mobility available to everyone, anywhere in the world. Lightyear develops electric cars with an energy-efficient design and integrated solar panels, allowing drivers to drive on sunlight for up to 20,000 kilometers a year, depending on the local climate.

Lightyear One has been designed from a radically new perspective. "Our entire team is specialized in optimizing the performance of a car," said CEO Lex Hoefsloot. "This ensured that we had a strong focus on optimizing the efficiency and safety. The design of Lightyear One started with a blank sheet of paper. So we have not been guided by conventions in car design, but by the laws of physics alone."

LIGHTYEAR ONE

"The Lightyear One is ultra-efficient, allowing the user to drive an unprecedented distance of 725 kilometers with a relatively small battery. In addition, the battery charges itself using solar energy, which can charge for up to 20,000 kilometers a year. That makes it a lot easier to charge, because you can cover longer distances with the same energy. You can also use regular sockets: using a standard 230 V socket you can charge for up to 400 kilometers a night. That's especially good news if you want to take a road trip, because you don't have to use the electric charging infrastructure."

The car is made of lightweight high tech materials that meet strict safety standards. Lightyear One is powered by four independent wheel motors, so no energy is lost between motor and wheels. The roof and hood are clad with five square meters of solar cells with safety glass, which is so strong that an adult person can safely walk over it.

Lightyear One can be charged using solar energy or at (fast) charging stations or via an ordinary socket.

Lightyear ∞

5. Brabant dives deeper into energy (enabling) technologies, such as solar, hydrogen, and batteries

USPs for Brabant	The breadth and depth of skills and expertise in engineering, system integration, and manufacturing in Brabant in energy technologies is very extensive. The HTSM sector covers parts, components, subassemblies, and integrated systems for virtually all utilities and has invested heavily in deepening its expertise in sustainable energy technologies such as wind, solar, and (bio) LNG during the past decade. The same goes for enabling technologies for the sector, the most eye-catching technology being battery technology. The latest development is that the sector is being asked to focus its considerable skills on the domain of hydrogen as an energy source and to provide components and subsystems for processing and transportation. Projects are in the pipeline and have been launched as part of the Netherlands' national Hydrogen for the Energy Transition 2020-2030 roadmap.
Universities/Research institutes involved	DIFFER, the Netherlands research institute for fundamental (sustainable) energy research (Eindhoven); Solliance Solar Research (Eindhoven); TU/e, Eindhoven University of Technology; JADS - Jheronimus Academy of Data Science (Den Bosch/Tilburg/ Eindhoven); Holst Centre (Eindhoven); TNO (Eindhoven); IMEC (Eindhoven/Louvain); Avans, Fontys & Breda Universities of Professional Education (Breda/Den Bosch/ Eindhoven/Tilburg); Eindhoven Engine; EIRES, The Eindhoven Institute for Renewable Energy Systems
Leading companies/disruptors/best practices	Leyden Jar; LionVolt; LIQAL; DAF Trucks; VDL Group; SolayTec; Rolande LNG; FujiFilm Europe; PTG/e, Polymer Technology Group Eindhoven; E-Trucks Europe; Robox Heat Technology; Fluidwell; DENS; WaterstofNet; Wärtsila Netherlands; Flowserve; Chromalloy Holland; GEA Nederland; Thermobile Industries; Stork Thermeq; R & R Systems; Fluidics Instruments; Kinetron; Actiflow; Micro Turbine Technology
Leading programmes	Solliance Solar Research – thin-film PV; Brainport Industries' Factory for the Future
Facilities/Locations/Campuses	High Tech Campus Eindhoven; TU/e Campus Eindhoven; JADS Campus (Den Bosch); Brainport Industries Campus (BIC, Eindhoven); Aviolanda Aerospace (Hoogerheide)

INTRODUCTION

The HTSM sector in Brabant develops and supplies parts, components, subassemblies, and integrated systems for virtually all utilities and has invested heavily in deepening its expertise in sustainable energy technologies such as wind, solar, and (bio) LNG during the past decade. The same goes for enabling technologies for the sector, the most eye-catching technology being battery technology. The latest development is that the sector is being asked to focus its considerable skills on the domain of hydrogen as an energy source and to provide components and subsystems for processing and transportation. Projects are in the pipeline and have been launched as part of the Netherlands' national Hydrogen for the Energy Transition 2020-2030 roadmap.

FINDING SOLUTIONS – WHY BRABANT?

Four telling examples of why Brabant could supply the energy technology solutions for the future are the ventures of the Solliance Research Center (solar/thin-film PV), Leyden-Jar Technologies (vapor deposition battery technology), and Carbyon DAC (CO_2 direct air capturing technology) in Eindhoven, and LIQAL (LNG and hydrogen technology) in Breda.

SOLLIANCE SOLAR RESEARCH

The mission of Solliance is to create jobs in thin-film solar technology. The research institute, which is a partnership between the TNO, imec, ECN, Holst Centre, TU/e, TUDelft, University of Hasselt (BEL), and Forschungszentrum Jülich (GER), does this by continuously developing the latest thin-film PV technologies and making them available to companies. Solliance aims to connect the worlds of science and business in order to create a sustainable energy system. The institute, which turned ten in January 2021, has made enormous strides, with the thin-film solar technology research a great success and with almost 180 scientists and a research budget of over 20 million euros to its name. Solliance's industrial partners include CCM, DSM, Hanergy, Heijmans, Kameleon Solar, Monier, Panasonic, PolyPlastic, Rexroth, Rockwool, Shell, Solaris, SolayTec, and the VDL Group.

LEYDEN-JAR'S BATTERY TECHNOLOGY

TNO spinoff company Leyden-Jar Technologies, with operations in Leiden and Eindhoven, is a high tech venture that develops pure silicon anodes and related production technology to boost the energy density of Li-ion battery cells for consumer electronics, electric vehicles, and residential energy storage. It will build machines for the production of battery anodes in Eindhoven. Batteries using this technology will last 50% longer than current state-of-the-art batteries. The anode is the negative pole through which the current flows in and out of a battery. Until now, these anodes have been largely made of graphite. Leyden-Jar uses a copper foil on which silicon, obtained from pure sand, is deposited in a very porous layer by means of a vapor deposition process. The new anode enormously increases the capacity of batteries.

Increasing the capacity of rechargeable batteries would give electric cars greater range, improve mobile phones, and bring electric planes a step closer. According to Leyden-Jar, the manufacturing advance can be integrated into existing production lines with limited intervention and delays.

Leyden-Jar emerged from research at Solliance Solar Research, the research institute in the field of solar cells on the High Tech Campus in Eindhoven. According to Christian Rood, director of Leyden-Jar, the team discovered that the vapor deposition process – used to produce the first flexible solar cells – could also be applied to battery production. That was a decade ago.

In July 2020, Leyden-Jar announced that it had achieved its goal of creating batteries able to recharge to a level 70% higher than current best-in-class ones. Batteries used in a trial series stored 1,350 Watt-hours per liter of battery. The test series of batteries were extensively tested by the Scandinavian inspection body DNV GL, successfully charging them a hundred times with 1,350 Watt-hours per liter of battery. Leyden-Jar is in talks with battery manufacturers for providing them with machines able to manufacture these renewed anodes.

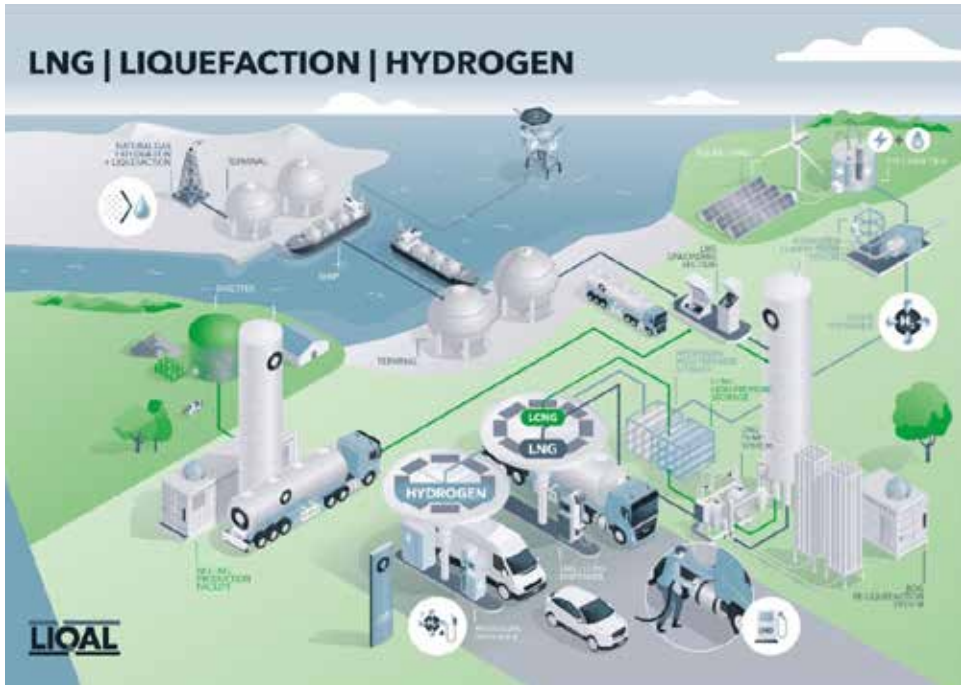
Rood explains that the company is now in the middle of the development process of the machines for battery production. Ultimately, he expects the company will become a machine-building company. "We want to be like ASML, with technology partners that develop and build the modules with us. In the Eindhoven factory we will assemble these modules into complete machines and systems and deliver them to customers. These customers should be all the world's major battery producers."

Leyden-Jar currently has around 18 employees in Eindhoven and Leiden and expects that figure to increase rapidly to 25. The company is funded to the tune of 4 million euros by the DOEN foundation, the Brabant Development Agency, and the EU, and is planning a future financing round for 15 million euros for further expansion.

LIQAL LNG AND HYDROGEN TECHNOLOGIES

Brabant-bred and Brabant-based LIQAL is a fast-growing company specialized in small-scale LNG technologies. LIQAL focuses on the design, engineering, production and turnkey construction of complete tank systems and fuel dispensers for LNG and hydrogen. In addition, the company has patented micro-liquefaction technology for controlling the conditions in LNG storage tanks and converting natural gas and biomethane into (BIO)LNG.

The company also provides maintenance services for the installations: service engineers take care of preventive maintenance and inspections of the installations, and the corrective service interventions. The standard equipment for LIQAL LNG fuel stations is advanced and very user-friendly process control software and an IPS package with local data storage and a remote access router with secured VPN tunnel. Using that, a monitoring and reporting service is offered where LIQAL engineers monitor the plant and supervise and audit the gas systems in order to minimize the risk of onsite malfunctions.



CARBYON DAC

Humanity is facing an unprecedented challenge in the form of global warming, driven by carbon dioxide (CO2) emissions from fossil sources such as oil and gas. However, these emissions, if captured, can be a renewable carbon source, with applications such as crop growth and sustainable fuel synthesis. Carbyon aims to develop direct air capture (DAC) technology to remove CO2 from the atmosphere and turn it into a green substitute to fossil fuels.

As the global demand for renewable carbon will increase once the price reaches € 50 per ton of CO2, Carbyon is challenging multidisciplinary teams within the Eindhoven Engine to collaboratively improve the main cost drivers of DAC technology.

Partners in this effort are energy research institute DIFFER and the TU/e, Eindhoven University of Technology, both based in Eindhoven.

carbyon
Closing the CO_2 cycle.

C. Moonshot – Attracting a leading global IC manufacturer to Brabant

- How can a joint Brabant/Dutch/EU effort result in attracting one of the leading IC manufacturers in the world to set up a semiconductor manufacturing plant in Europe?
- How can the Dutch community ensure that the plant comes to the Netherlands, preferably to Brabant?

The question then is, how the fledging photonic integrated circuits (PIC) eco-system in Brabant could develop and flourish in the future.

Developing a number of PIC building blocks in the Netherlands, which design companies and equipment manufacturers can use to realize specific sensors and other applications, should be the first step. The Dutch Photon Delta Technology Centers are tasked with collecting these individual company PIC needs and bringing them together. This will generate enough PIC volume to justify establishing PIC manufacturing in the Netherlands.

This would have to be a single large PIC factory in the Netherlands with distribution to the rest of the world. The only way to make that happen is to bring one the world's largest semiconductor manufacturers to the Netherlands to do contract manufacturing here.

Interestingly enough, other interviews and publications that dealt with developing specific technology niches in Brabant and Brainport Eindhoven provided supporting arguments for attracting a semiconductor manufacturer:

- Acclaimed Eindhoven scaleup SALDtech (spatial atomic layer deposition) is a frontrunner in its technology development, because the whole lithography value chain is present in Eindhoven. For the future success of the region, this value chain must be maintained and preferably expanded. Adding another IC manufacturer next to NXP could be the final step.

- Sooner or later, lauded scaleup Smart Photonics (a specialized PIC foundry) will have to strategically cooperate or integrate with one of the larger IC manufacturers. Having one of them in the Brainport region would be an exceptional added competitive edge.

- Brainport is still globally ahead in the development of sub-micro and sub-nano-level electronics and precision technology. The region was built on electronics, in all sizes and shapes (Philips), and the expertise is still present. IC manufacturing would fit right in.

- Brainport is home to the most powerful lithography wafer stepper equipment cluster in the world, with ASML at its center. And ASMI is an hour's drive away... what an ecosystem for an IC manufacturer to land in!

A FIRST ACTIVE STEP, LED BY THE BRABANT HIGH TECH COMMUNITY

The Brabant High Tech sector active in the semiconductors, led by global wafer fabrication equipment leader ASML, has an incredibly close and tight relationship with all large global IC manufacturers. ASML's leadership team and its technology and business development executives know all of the decision-makers within these IC giants personally.

- Why not initiate a Brabant semicon manufacturing task force right this very moment with the objective to research the feasibility of attracting semicon manufacturing to Brabant, the Netherlands? Most important step in that process: ask executives of ASML and the other semicon leaders in Brabant to join the task force and to function as advisors to the group and as ambassadors / linking pins to enable reconnaissance meetings / talks with responsible dignitaries at e.g. TSMC, Intel and Samsung. Maybe a current or former ASML executive with a warm heart for the Dutch semicon cluster would be willing to act as a special envoy for the group.
- BOM and Brainport Development could form and fund this task force and support team and coordinate with NFIA, The Netherlands Foreign Investment Agency, the Invest in Holland alliance and the Ministry of Economic Affairs and Climate.

Ester Meerman, NRC, February 24, 2021

MEGA-ORDER OF 3.6 BILLION EUROS FOR ASML

South Korean company SK Hynix has signed a five-year tender contract for the supply of EUV scanners used in the production of ICs.

A South Korean manufacturer of memory chips has placed an order worth 4.3 billion US dollars (3.6 billion euros) with the Dutch chip machine maker ASML, Reuters news agency reported on Wednesday.

SK Hynix has entered into a five-year tender contract for the supply of extreme ultraviolet (EUV) scanners used in chip manufacturing. The devices are the size of a bus and cost more than 100 million euros each. The relatively new EUV technology means that thinner connections can be made on the chips, shrinking their size even further.

ASML's turnover in 2020 was 14 billion euros, and at the close of last year, the manufacturer had 11.3 billion euros in orders outstanding.

EXCERPTS FROM AN ARTICLE IN THE NRC NEWSPAPER, FEBRUARY 19, 2021. BY MARC HIJINK.

THE AUTOMOTIVE INDUSTRY IS CRAVING ICS. HOW CAN PRODUCTION BE INCREASED?

IC shortage: the corona crisis is putting pressure on the semiconductor market. The fact that ICs are unavailable is a widely-heard complaint from the automotive industry. Can anything be done?

Employees at the Volkswagen factory in Bratislava, Slovakia. Due to the chip shortage, some car manufacturers are encountering production delays.

"We're sold out." That phrase is appropriate for a supermarket where hoarders run off with the toilet paper, but Dutch IC manufacturer NXP is now also saying it. Demand from NXP's customers, especially car manufacturers, is so great that production capacity will be sold out in the next few months.
It's not just NXP, and the entire semiconductor industry seems unable to meet the demand for processors and memory chips. Evidence of this is the waiting lists for game consoles, making it impossible for Sony to increase production of the PlayStation 5, but for the car industry in particular.

The car industry is sounding the alarm: a chronic IC shortage threatens to jeopardize production goals. Insiders say that IC manufacturers are giving priority to electronics companies. But is that really the case? [...] In reality, some automakers have stepped on the brakes too quickly and are now facing the consequences. [...]

HOW DID THIS SHORTAGE OF CHIPS COME ABOUT?

Car sales were already declining in 2019. When the Coronavirus pandemics added to the misery, many car manufacturers froze contracts for IC deliveries. The car industry is a tightly-managed logistics chain, where the aim is to not hold any stock and everything is delivered just in time - including ICs. [...]

In the summer of 2020, it appeared that car sales were picking up quickly. IHS is expecting a nine percent growth in 2021 (85 million cars). More ICs are needed to make more cars, but production capacity in the IC factories has already been given to other customers, such as PC makers. The Coronavirus pandemic has seen a dramatic upsurge in demand for laptops and desktop computers, with many home-bound people investing in a new computer. There is also a larger demand (and time available) for gaming – processors for the Sony PlayStation 5 and Microsoft Xbox Series X cannot be manufactured fast enough. The demand for 5G chips for telephones and antennas is also growing, while data centers are overloaded because so many people are working, playing, and studying from home. Server manufacturers have consequently ordered a large number of additional processors.

The IC manufacturers now complete their orders in the sequence they received them, and the car manufacturers, who only raised their orders in the summer of 2020, are last in line. [...]

Story continues on the next page >

WHERE ARE THE ICS MANUFACTURED?

The largest IC manufacturers in the world are in Asia and the US (Intel), while the most advanced chips are made by TSMC (Taiwan) and Samsung (South Korea). Intel is a few 'chip generations' behind. Samsung develops its own chips, but also produces third party IC designs - a foundry, in technical terms. Dutch NXP, one of the main suppliers to the automotive industry, manufactures about half of its chips in-house but outsources the other half of the production to specialist companies such as GlobalFoundries, Samsung, and TSMC. As IC production becomes more complex, the investments required to construct an IC manufacturing facility grow. A modern factory that can build the finest-meshed ICs costs more than $10 billion, and TSMC alone is investing $28 billion in expanding capacity this year. [...]

THEN YOU BUILD A NEW IC FACTORY, RIGHT?

Building a new IC manufacturing plant is not an option. Even if it is one that makes less complex ICs, it can still take a year for production to get up to speed. In really complex factories, which can produce the most advanced ICs, that lead time is much longer.

In the EU, plans are now being made to have Samsung and TSMC build a European IC factory on the longer term. [...] Asian expertise is indispensable: it makes no sense to have European IC manufacturers make the leap to the most complex production methods in one go.

Where would such a Samsung or TSMC site be in the EU? The Netherlands is interested in it - after all, with ASML and ASM International, the country has two advanced wafer stepper manufacturers.

The plan is still in its infancy, but there could be an outcome in five or ten years – a less vulnerable production chain and less dependence on Taiwan. The demand for ICs continues to grow, thanks to the advances of 5G and artificial intelligence. Right now (part of) the automotive industry is in trouble due to IC shortages, but in the future it could be any sector.

The production of ICs relies on a worldwide network of specialized suppliers. How complex that network is, is aptly illustrated by the following example. TSMC was choking on demand for ICs last year, resulting in a chain reaction. When Huawei ceased buying, due to American export restrictions, TSMC cut orders for new lithography machines from the Dutch wafer stepper manufacturer ASML. As a result, ASML ordered fewer lens systems from its supplier, German high tech company Zeiss.

However, the gap that Huawei left was immediately filled by other jobs, which is why TSMC again ordered more lithography machines. The problem is that ASML can only supply these machines when Zeiss has the lenses ready. This completes the circle: the German chancellor is now urging Taiwan to step up manufacturing of ICs for the German automotive industry. And Taiwan? It must wait for the machines from a Dutch manufacturer, containing a critical component, from Germany...

BRABANT DEVELOPMENT AGENCY (BOM): READY TO CONNECT YOU!

Based in Tilburg, BOM Foreign Investments & International Trade is part of the Brabant Development Agency (BOM). Our BOM Foreign Investments team assists new and existing foreign companies to make optimal use of the opportunities offered by Brabant as a business location. We can offer you our support when it comes to finding sites or real estate, building and environmental permits, labor market analysis, talent acquisition, matchmaking for logistics, employment regulations, fact-finding missions, incentives, and relevant networks in the regional private and public sector.

Our BOM International Trade specialists provide hands-on support to companies in Brabant in growing their business abroad. We offer valuable contacts in foreign countries and provide targeted information on markets and available funding. Our international trade specialists also promote the successful economy of Brabant and its thriving ecosystems to foreign companies around the world.

We offer a range of free services and support designed to provide you with the information and network you need to explore new (business) opportunities.

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