

A woman with long brown hair is looking intently at a 3D printer. The printer is a large, industrial-looking machine with a white nozzle and a clear protective enclosure. It is printing a small, orange, textured object on a white platform. The background shows a clean, modern laboratory or workshop environment with white walls and equipment.

GTS

Technology for Danish businesses:

performance statement by the Danish GTS institutes

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Frontpage:

3-D printed carrots? The Danish Technological Institute is working on new technology that will customise meals for patients with special dietary needs.

Preface

The Danish innovation system aims to promote the best possible conditions for innovation among Danish businesses. This performance statement by the GTS institutes addresses the special role played by the institutes in the Danish innovation system as a whole.

The overall objective of the performance statement is to present an overview of the impact of Danish society's investment in the GTS institutes and to show how the institutes' specific measures and initiatives bring technology to life by accelerating technology adoption by Danish businesses.

The performance statement is structured in terms of an effect chain showing how the GTS institutes work to accelerate technology adoption among Danish businesses. The effect chain, presented in detail on page 9, forms part of the frame of reference for the oversight of the GTS institutes by the Danish Agency for Institutions and Educational Grants.

Chapter 1 introduces the GTS institutes.

Chapter 2 presents an effect chain showing how the GTS institutes work through the entire process from input to output and the impact on Danish business life.

Chapter 3 focuses on the input into the GTS institutes in the form of R&D performance contracts, competitive R&D funds, and self-financing R&D.

Chapter 4 reviews selected key activities initiated by the GTS institutes in connection with various R&D projects or in establishing new technological facilities.

Chapter 5 surveys the output of the GTS institutes in the form of knowledge transfer and partnerships with the Danish business community.

Chapter 6 highlights the GTS institutes' effects on Danish businesses, including four case studies.

An overview of the various different types of partnership established between the GTS institutes and Danish businesses is provided on page 26 and 27.

Key facts and figures for the GTS institutes are presented at the end of the performance statement.

This document is an English translation of the performance statement of the GTS institutes 2018, taken from the institutes' annual report to the Danish Agency for Institutions and Educational Grants. This English version is a shortened version produced for an international audience.

We wish you an enjoyable reading experience.



FORCE Technology works closely with the Danish offshore industry in several areas including inspection of bridges, wind turbine blades and other hard-to-reach locations.

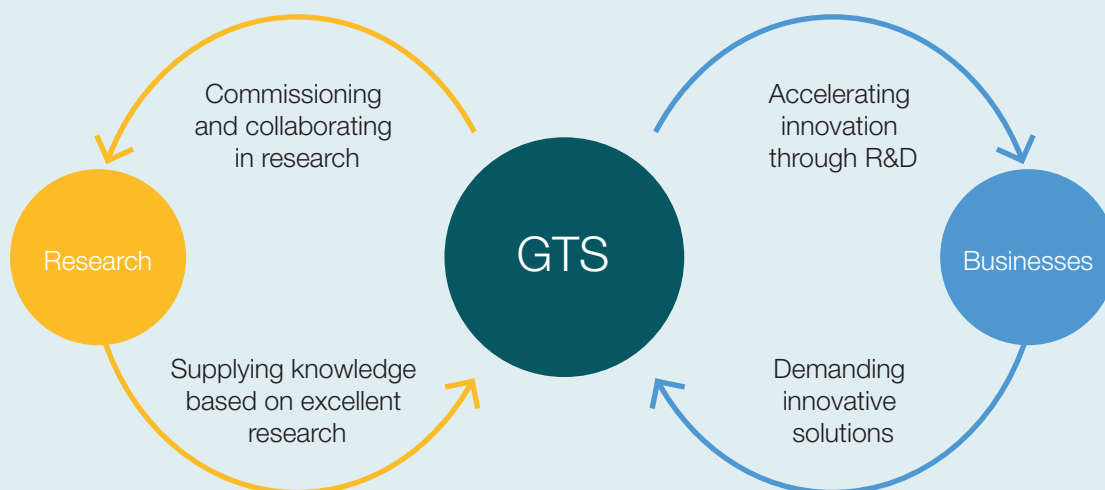
Technological knowledge transfer between research and business

The seven Danish government-approved Research and Technology Organisations – the GTS institutes – play a key role in the Danish innovation system as the link between technology and business. They seek to make new technological methods applicable to businesses and promote businesses' uptake of new technology.

For many businesses, keeping up with accelerating technological development and implementing new technologies in products and processes can be a major challenge. Investing in new technologies can be both expensive and uncertain – an uncertainty that is particularly difficult for small and medium-sized enterprises (SMEs) to handle.

The GTS institutes therefore have a key role to play particularly for SMEs in the Danish innovation system, because they can ensure better and more efficient use of new research and technology by Danish businesses. In so doing they increase and promote innovation, productivity, and growth in Danish society.

The GTS institutes in the innovation system



The illustration above is a simplified representation of how the GTS institutes operate in the critical area between national basic research and commercialisation, bridging the gap between research and businesses. This bridging role works in both directions, because the knowledge needs of businesses are translated into research questions. Drawing on their technological insight and their knowledge of the market, the GTS institutes accelerate work with innovation, pave the way for better products and processes, and strengthen the overall competitiveness of Danish businesses.

To support the maintenance and especially the renewal of the GTS infrastructure, the Ministry of Higher Education and Science invests more than € 40 million annually in the institutes' development of technological knowledge. This investment takes the form of performance contract activities which allow the institutes to develop new technological services ahead of market demand and in areas where the market itself cannot or does not meet the need.

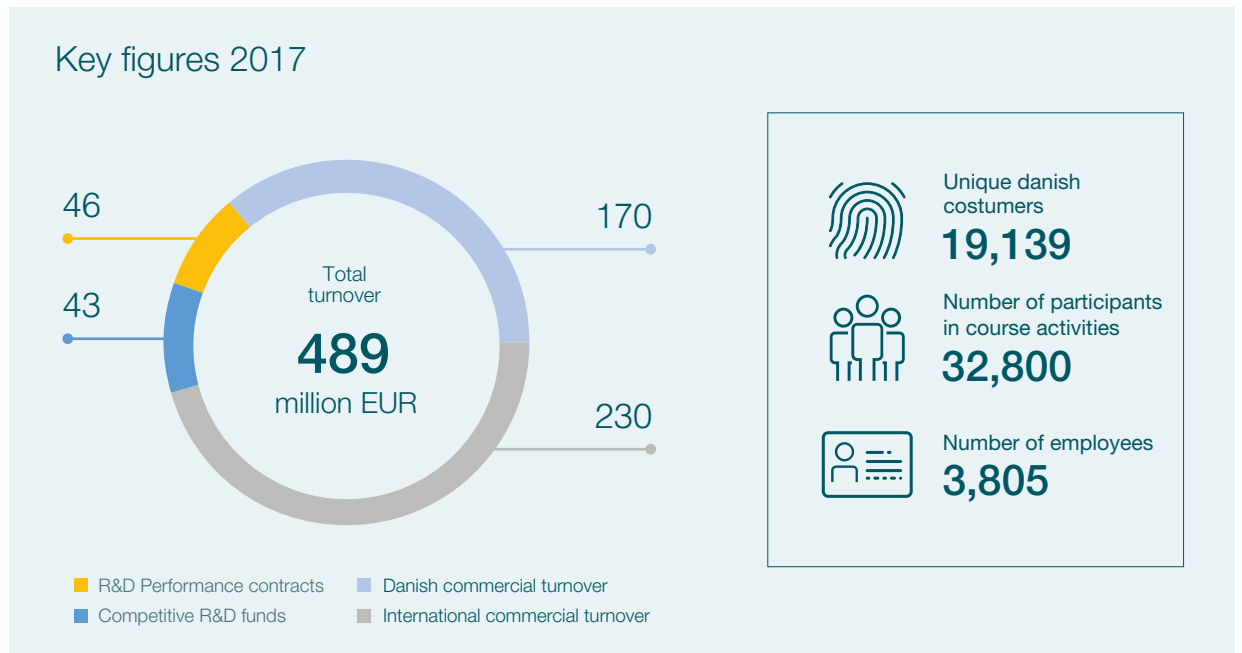
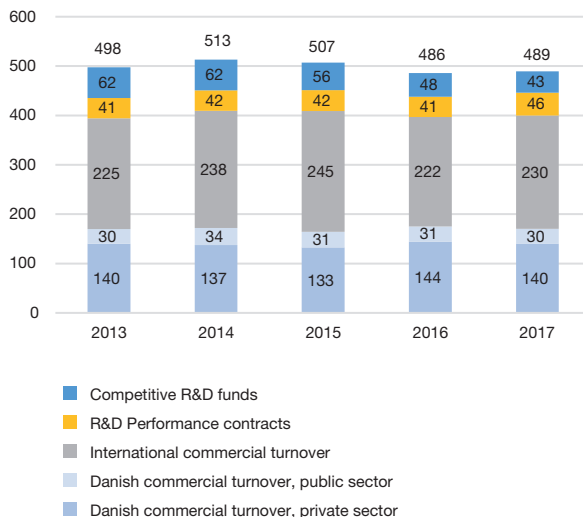


Figure 1: Development in total turnover, million EUR (current prices)



Seen in overview, the GTS institutes perform three vital functions within the Danish innovation system:

- Building and supporting R&D competence**
 The GTS institutes participate in both Danish and international R&D projects with the objective of developing new technological knowledge in close collaboration with businesses, universities, and research institutions.
- Developing and maintaining a technological infrastructure**
 The GTS institutes' technological infrastructure comprises laboratories and test facilities run and operated by specialists. This infrastructure enables businesses to develop, test and certify products easily and promptly. To sustain this infrastructure, the institutes keep track of emerging trends and tendencies to bring technologies relevant to Danish businesses home to the Danish market and to develop new technological services targeted particularly at SMEs.
- Knowledge transfer**
 The GTS institutes work proactively to transfer and apply the technological knowledge obtained. Their focus is on the application of technology as broadly and widely as possible to build and support levels of innovation in as many Danish businesses as possible.

In comparison with the other players in the Danish innovation system – the universities and the Innovation Networks Denmark programme – the GTS institutes have succeeded in differentiating themselves in three respects: (1) through the extensive and advanced technological infrastructure that they make available for use

by businesses whenever they need it, (2) through their close interaction with Danish businesses, with more than 19,000 Danish customers signed up every year, and (3) through the specialist technological insights contributed by institute employees to address the specific challenge of each business.

About the GTS institutes

Most European countries have similar systems in place to the GTS institutes. Counterparts include Fraunhofer in Germany, TNO in the Netherlands and RISE in Sweden. Thus the GTS institutes form part of a European tradition whereby technology institutes act as a bridge between research and business. In the European context, these systems are designated research and technology organisations (RTOs). A large proportion of European RTOs are, like the Danish GTS institutes, members of EARTO (the European Association of Research and Technology Organisations).

The Danish GTS institutes are not-for-profit organisations. They are self-owned, impartial, and independent of business or political interests, placing knowledge and facilities at the disposal of all businesses on equal terms. All profits are reinvested in infrastructure, facilities and the creation of new technological knowledge.

Approval by the Danish Ministry of Higher Education and Science is necessary to be designated as a GTS institute.

The GTS institutes cover an exceptionally wide range of sectors, including:

- Digitalisation
- Production and robot technology
- Food and agriculture
- Materials technology
- Electronics and micro-electronics
- Ship-building and construction
- Water and environment

- Biomedicine
- Security
- Welfare technology.

The seven GTS institutes range in size from fewer than thirty to over one thousand employees. In 2017, the total number of employees was 3,805. The institutes also vary in the scope of their international focus, with some institutes focusing primarily on disseminating new knowledge and technology within Denmark, while others are very international in their service offerings and market orientation.

This performance statement focuses on the overall activity of the seven GTS institutes. Thus the development of particular institutes may vary from the overall picture presented.

In 2017, the seven GTS institutes were:

- The Alexandra Institute
- Bioneer
- DBI (Danish Institute of Fire and Security Technology)
- DFM (Danish Fundamental Metrology)
- DHI
- FORCE Technology
- DTI (Danish Technological Institute)

For further information on the GTS institutes in more detail than this performance statement, please go to <https://en.gts-net.dk>.



Effect chain

The performance statement takes the form of an effect chain which illustrates the work of the GTS institutes through the entire process from input to output and the effect on Danish business life. The effect chain is explained below.

As part of the oversight of the GTS institutes exercised by the Danish Agency for Institutions and Educational Grants, an effect chain has been developed with the objective of clarifying the most important contexts of the work of the institutes. For each link in the chain, a number of indicators illustrate the results of the work of the institutes.

The diagram "Effect chain of the GTS-institutes" on page 9 illustrates the work of the GTS institutes across the entire value chain towards their objective, which is to promote the application of technology and create value in Danish society.

Input

A prerequisite for the GTS institutes in their support for Danish businesses is their body of knowledge, competencies, and infrastructure. Building and maintaining this body of expertise requires funding in the form of performance contracts (public funding), competitive funds, and self-financed R&D. The combination of first class infrastructure and specialist employee knowledge that the institutes have built up is an exceptionally important resource.



One of DBI's current performance contract includes its development of new technological services to document fire safety and fire-safe design for components and systems for use in buildings and ships.

Activities

The input to the GTS institutes enables them to develop and maintain their technological infrastructure while launching new R&D activities and a diverse range of knowledge-sharing activities. The institutes take part in many standardisation activities to address Danish business interests and contribute Danish expertise.

A number of these activities take place in close cooperation with other research institutions and universities, both within Denmark and abroad in collaborations which open the doors to strong academic environments and contribute new knowledge to the institutes.

Output

Through these activities, the GTS institutes develop and supply a wide range of technological services targeted particularly at SMEs and intended to reduce the barriers that SMEs encounter as they apply new technologies. Educational courses and training are also offered. These services allow businesses to use the GTS institutes as an external R&D department and thus gain access to knowledge and expert knowhow from outside the company.

Key indicators of the success of the GTS institutes' knowledge transfer to Danish businesses include institute customer numbers and the level of commercial turnover, especially from Danish businesses. An additional indicator of the interaction between the institutes and Danish business is the volume of institute services purchased by businesses.

Effects at company level

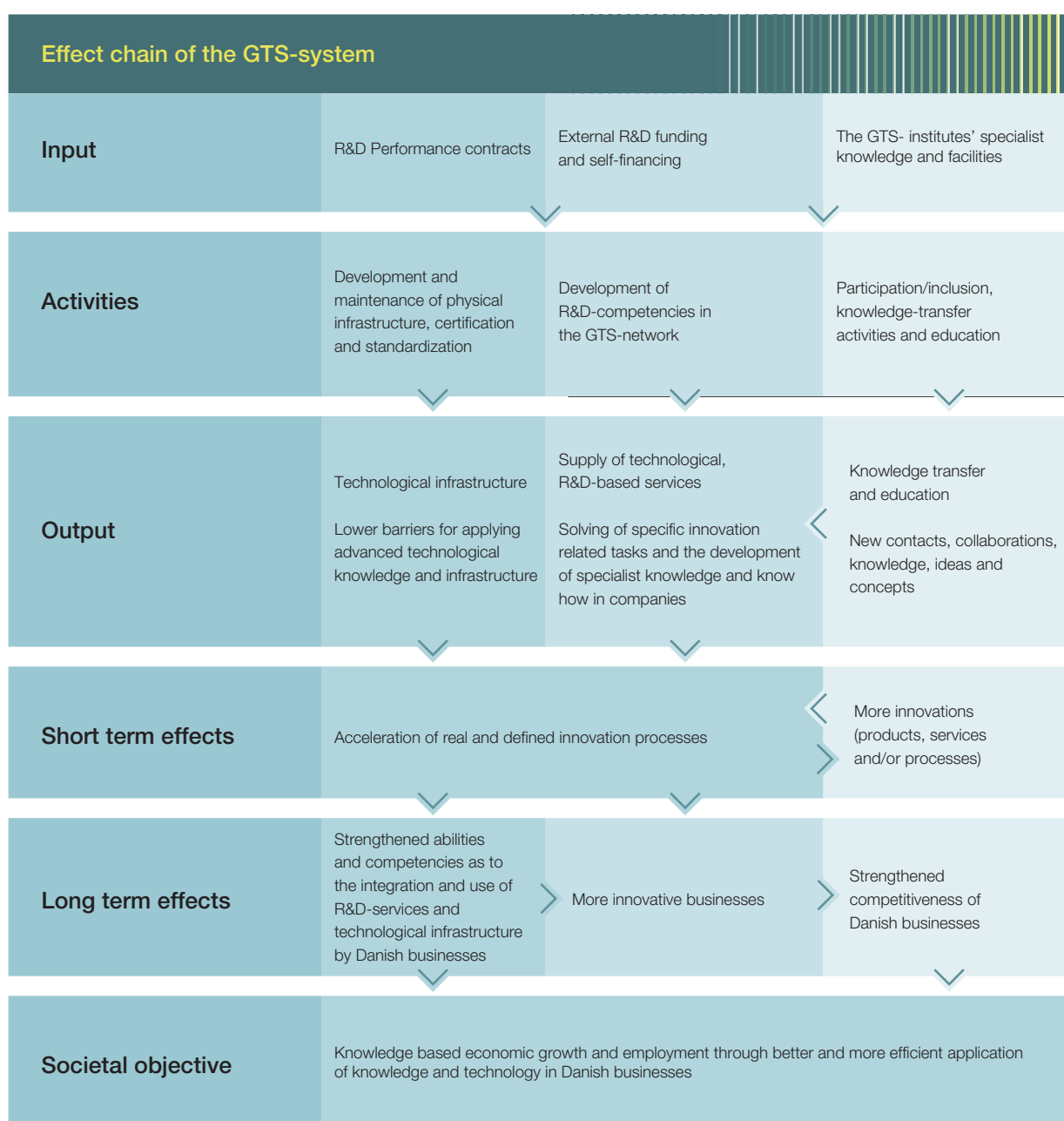
The GTS institutes' work supporting businesses produces both immediate and longer-term effects. An immediate effect can be seen when a GTS institute succeeds in moving a business forward in an innovation process so that the product, service or processes are improved. One indicator of immediate impact of this kind can be gained from asking customers about the value generated in their work with the institutes. Another indicator is case studies, which can demonstrate the effects and the actual results achieved by a particular business. Studies have also documented that

businesses are more innovative when working in partnership with knowledge institutions.

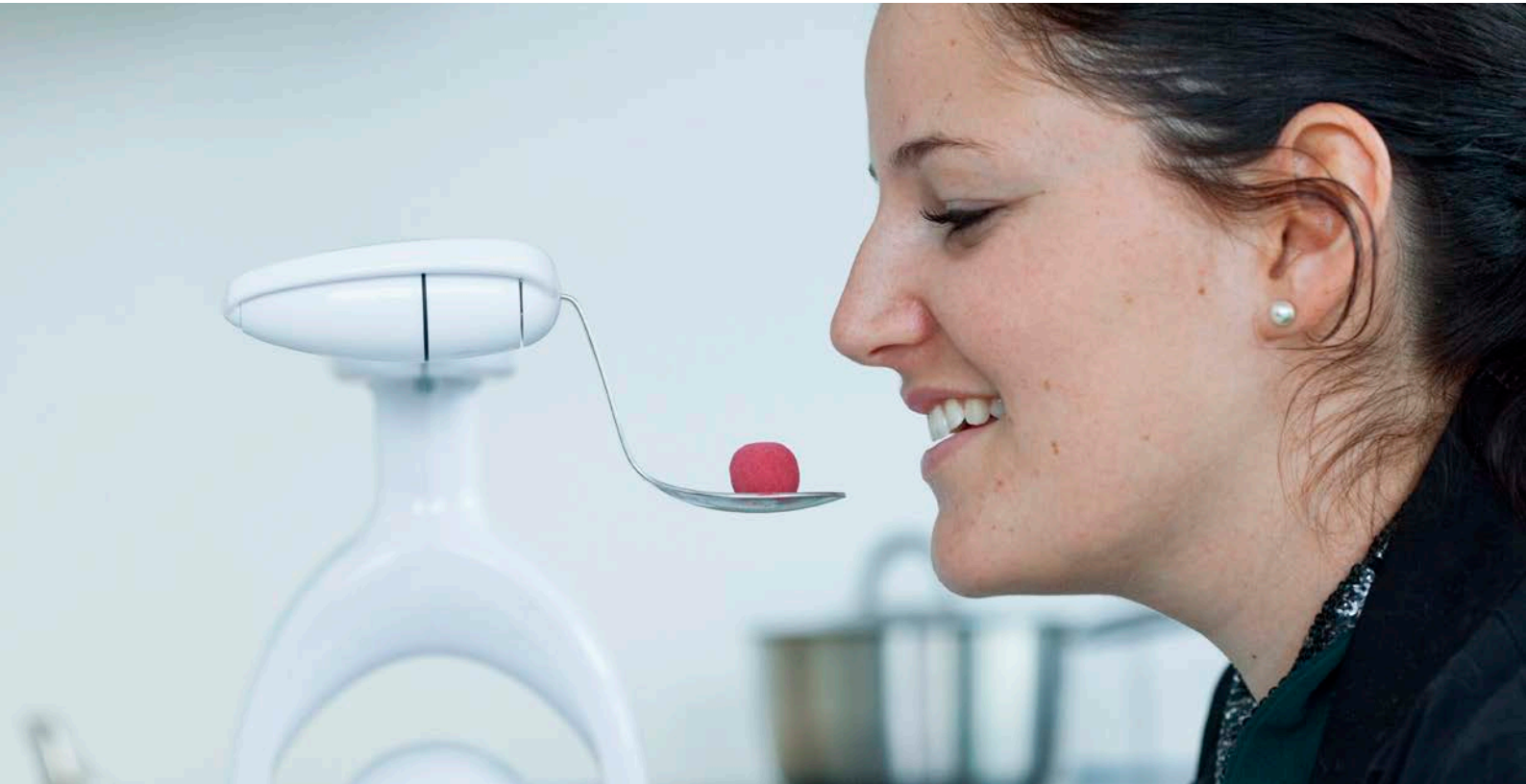
Longer-term effects can be seen when the capacity of Danish businesses in general to incorporate and implement new technologies improves as a result of the institutes' work. Longer-term effects of this kind stimulate growth in overall productivity, make Danish businesses more innovative, and enhance Danish competitiveness.

Impact at overall societal level

The GTS institutes form part of Danish society's endeavour to create knowledge-based growth and employment. It is difficult to isolate and demonstrate the effect of the GTS institutes' activities from such an overall perspective, because a range of factors contribute to this overall societal objective. This means that indicators have not yet been identified that are capable of highlighting the impact of the institutes at societal level.



The figure "Effect chain of the GTS-system" describes the process by which the GTS-institutes work with bringing new research based knowledge and technology into the hands of Danish businesses while also addressing the socio-economic impact.



The Danish Technological Institute created its “CareLab Innovation” facility to help Danish companies develop welfare technologies that can be sold on export markets.

Input

The GTS institutes receive input in the form of performance contracts and grants from competitive funds. They also use self-financing.

As described in the previous chapter, this performance statement is based on the effect chain developed for the GTS institutes. The first link in the chain is input in the form of R&D grants, self-financing, and the extensive infrastructure of technologies, test facilities, laboratories and human resources and competencies on which the institutes draw to perform their activities.

In 2017, total R&D revenue of the institutes was € 123 million.

Performance contracts

Following approval as a GTS institution, institutes can apply for performance contracts administered by the Danish Agency for Institutions and Educational Grants. While only the GTS institutes are eligible for these performance

contracts, they are assigned on a competitive basis. The current performance contract period runs 2016–2018. The total value of performance contracts was € 46 million in 2017, corresponding to 9 per cent of the institutes’ total revenue (Figures 1 and 2, orange pages).

Performance contract funding is crucial for the GTS institutes to develop the skills and competencies that are needed in Denmark. They enable the GTS institutes to work with technologies ahead of market demand and in areas where the market alone cannot or does not perform this task. In their activities the institutes develop technological services targeted to Danish business needs, providing SMEs in particular with access to new and promising technologies and processes in Denmark. The performance contracts also allow for co-financing of

competitive R&D activities within approved areas. For more information about specific performance contract activities, see page 12.

Grant funding from competitive sources

The GTS institutes received € 43 million from competitive funds in 2017 (Figure 10), including Horizon 2020, Innovation Fund Denmark and the Danish development and demonstration programme, UDP. This corresponds to 9 per cent of the institutes' total turnover (Figure 2, facts and figures). Grant income from available competitive funds has fallen by 31 per cent over the past five years.

Several factors explain this fall. In the first place, between 2007 and 2012 Denmark allocated a "globalisation pool" providing additional funding for R&D projects in this period, which also benefited the GTS institutes. When the pool expired in 2012, these funds were phased out. A further factor is that following major changes in the organisation of the Danish innovation system in 2014, leading to the creation of the Innovation Fund in the same year, some of the funding mechanisms used actively by the GTS institutes were also phased out. In recent years, competition across Europe for EU funds and grants has also increased, representing a further challenge to the GTS institutes.

Self-financing

As the GTS institutes are non-profit organisations, profits are either used to pay for employee time spent on internal and external R&D activities or reinvested in new technology and facilities. The institutes' total self-financing amounted to EUR 33 million in 2017.

An example of self-financing from 2017 is a new and fully automatic force calibration machine in which FORCE Technology invested. The force machine is five times more accurate than existing force calibration equipment on the Danish market. Its high degree of accuracy at large loads is of particular benefit to businesses in the wind turbine, offshore, and construction industries as well as the service sector.

A detailed case study appears on page 24 ("GTS infrastructure opens the doors to Mexico"). Further examples of GTS infrastructure are also given on page 26 and 27.

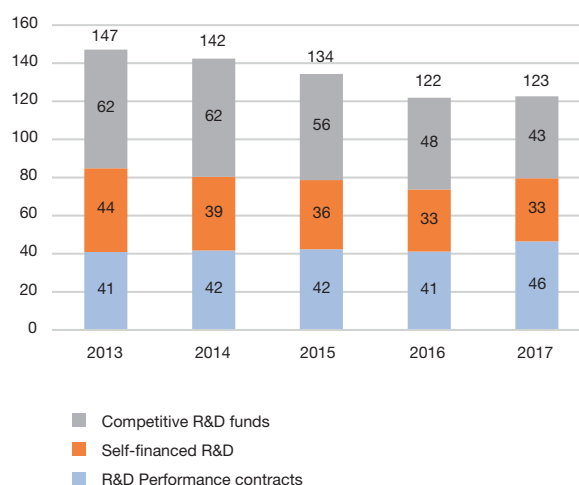
Infrastructure and human competencies

The network of GTS institutes provides a chain of competencies that Danish businesses can draw upon in their work with innovation. Between them, the institutes have more than 150 test facilities and laboratories with a value of at least € 270 billion which can be used by business-

es whenever they are needed. The institutes adapt and develop their technological infrastructure on an ongoing basis so that they can offer Danish businesses uninterrupted access to high-quality facilities in Denmark.

Institute employees also contribute their technological knowledge and specialist knowhow for businesses to use in their development work. While employee numbers have fallen by 5 per cent over the past five years, from 4,013 in 2013 to 3,805 in 2017 (Figure 14, facts and figures), the overall knowledge level in the institutes has risen. There were 474 employees with PhDs in 2017, compared with 428 in 2013 and 312 ten years ago.

Figure 10: Development in R&D activities, million EUR



Competitive funds are from regional, state and international programs (e.g. funds from the Danish Innovation Fund and the EU Horizon 2020).



Bioneer A/S has invested EUR 3.4 million in a gastrointestinal simulation system which allows new pharmaceutical substances for oral use to be analysed.

Activities

New activities are developed on an ongoing basis to facilitate the GTS institutes in initiating the adoption of new technology by Danish businesses.

The second link in the effect chain of the GTS Institutes is the activities initiated by the institutes on the basis of the input they receive. The institutes carry out a wide range of activities ranging from R&D projects to cross-collaborative projects, work with standardisation, and facility building.

Performance contract activities

As described above, the GTS institutes can apply for performance contracts with the Danish Agency for Institutions and Educational Grants to co-finance R&D activities to be conducted by the institutes. Co-financing allows relevant technological services to be developed and targeted directly to the needs of Danish businesses, especially SMEs.

Performance contracts are allocated in two ways. The majority of the contracts are awarded at the beginning of the contract period. This follows a process whereby the institutes put their ideas up for open discussion at www.bedreinnovation.dk. Once businesses, business organisations, public authorities and other interested parties have had the opportunity to openly comment on the suggestions and contribute to developing ideas for future GTS activities, the best proposals are taken forward for funding. In addition to this bottom-up process, a smaller tranche of funds can be granted for special efforts and works at the initiative of the Danish Agency for Institutions and Educational Grants. In the current performance contract period, these special inputs have included drone technology and work on the Fehmarn Belt project.

In the ongoing performance contract period (2016–2018), the main areas of activity for which funds have been allocated are production technology, ICT, and climate and environment. Other areas include food and health, materials technology, energy, building and construction, services and public innovation, and transport and other niche areas. A description of all the projects is available at www.bedreinnovation.dk (in Danish).

An example activity in the ICT area is the development, led by the Alexandra Institute, of interactive Augmented Reality and Virtual Reality systems for industrial training and instruction. This initiative is enabling Danish manufacturing businesses to derive far greater potential from these two technologies for developing solutions and methods than ever before.

In the food and health area, Bioneer is working with immune modulation in drug development and in stem cell therapy. The objective is to develop a range of new skills and services that will meet Danish businesses' needs in the documentation of the immunological effects and safety of drugs, ingredients and medical devices.

Collaborative R&D projects

In their work on R&D projects, the GTS institutes often act as a link between businesses, knowledge institutions and the universities. The institutes' focus is on knowledge-sharing and transfer with the objective of disseminating knowledge developed in specific projects to a wide range of businesses beyond the active participants.

An example in a European context is the AEROMET project, led by DFM A/S, DTI and FORCE Technology with eighteen other partners. The project aims to develop next-generation particle pollution measurement methods, including new methods to characterise contaminants. The project is supported by the joint European research programme EMPIR under the EU Horizon 2020 research and innovation programme.

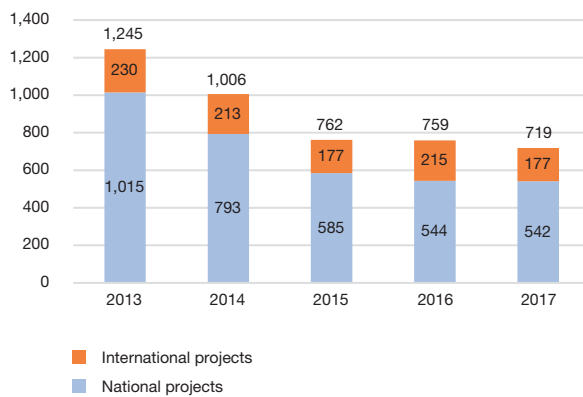
An example in a Danish context is a cross-industry project under the auspices of the Innovation Fund Denmark network to reduce the risk of hospital infections by developing self-cleaning doorknobs. Partners in this project include DTU, Elplatek A/S, Hempel, Aalborg University, Terma, DTI and FORCE Technology. The objective is to



The Danish Technological Institute's promising experiments with drones and injection technology in its R&D have shown that it is possible to target agricultural weed-spraying in fields.

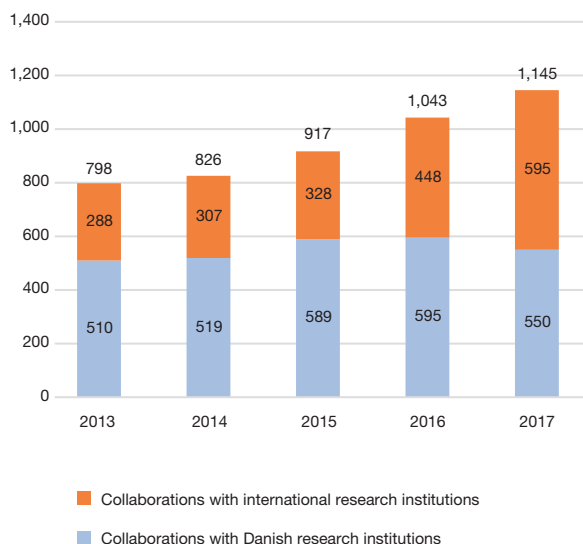


Figure 12: Number of collaborative R&D projects



The figure shows the number of research and development projects where a GTS institute has collaborated with one or more universities, companies or public institutions.

Figure 13: Number of collaborations with other research institutions



A collaboration with a research institution is defined as: a collaboration with Danish and foreign research institutions, where the cooperation is formulated in a written agreement, such as a project, an official framework agreement, an employee exchange agreement or a guest lecturership agreement.

develop new knowledge and new solutions within the area of materials science with a view to improving access to fast and efficient solutions in materials technology.

Another Danish funding programme currently being used by the GTS institutes is InnoBooster, under the umbrella of Innovation Fund Denmark. An example of this kind of R&D partnership is with the manufacturer of glass walls, SKANDI-BO. With support from InnoBooster, this company was able to invest in development work with DBI. They were able to test a brand-new glass element for ship and offshore use in the DBI fire laboratory, and to document that the element met standards and lived up to expectations. The glass element is now ready and on its way to the shipping and offshore market.

Partnership projects and cooperation with research institutions

The GTS institutes collaborate with a broad range of domestic and international research institutions with the objective of fostering and supporting close partnerships with strong specialist knowledge communities. This type of collaboration can be assessed in terms of the number of actual R&D projects financed by Danish and international funding sources (Figure 12) and by the number of partnerships established with institutions in Denmark and abroad (Figure 13).

The GTS institutes took part in 719 Danish and international R&D projects in 2017 and engaged in 1,145 collaborative partnerships. While the number of R&D projects has fallen over the last five years, as indicated in Figures 12 and 13, the number of partnerships has increased. Although it may seem contradictory that the number of international partnerships with research institutions is increasing while the number of projects has decreased, this reflects a general trend within technology development whereby knowledge is becoming increasingly specialised. Teaming up with some of the best domestic and foreign specialists is therefore vital to keep up with international competition.

Developing technological infrastructure

To offer Danish businesses an infrastructure of facilities and technologies ahead of market demand, the GTS institutes develop their technological infrastructure on an ongoing basis. In 2017, FORCE Technology launched a new test facility (FACT-Lab) for use by Danish businesses for testing materials in a realistic environment. In the facility, both liquids and gases can be tested at high pressures and temperatures in aggressive environments.

The welfare sector in Denmark primarily have made use



At FORCE Technology, Danish businesses can use a fully automatic force calibration machine with five times greater accuracy than existing force calibration equipment on the Danish market.

of existing technologies developed internationally, such as robot vacuum cleaners and intelligent medication dosage systems. Moving forward, DTI is looking to boost the development of Danish welfare technology. In DTI's new innovation lab, CareLab Innovation, businesses can work closely with end-users from the welfare system to develop new welfare technologies for both Danish and international markets.

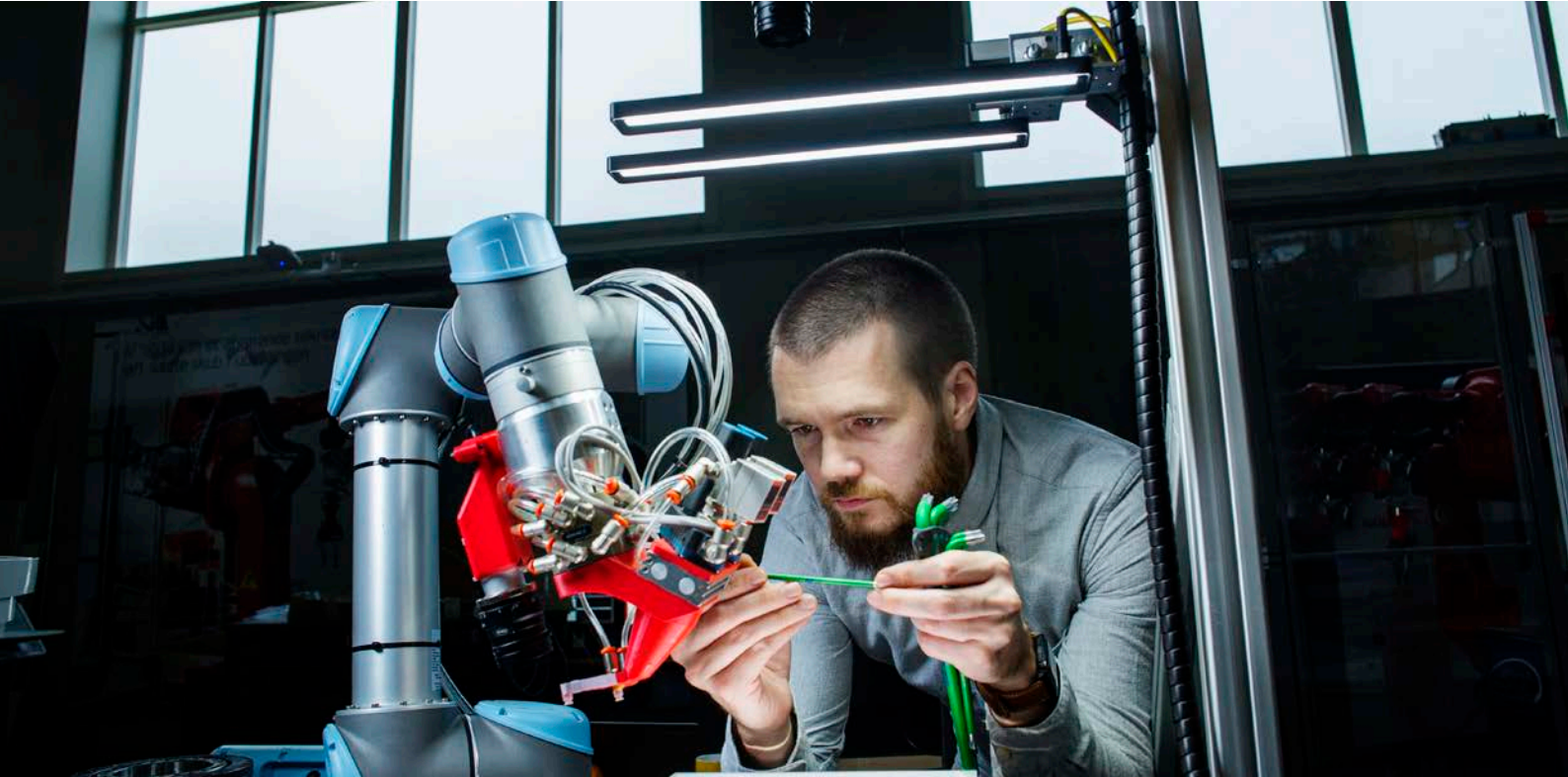
Standardisation and external activities

The GTS institutes are active in a large number of international standardisation committees. Their participation safeguards Danish interests and at the same time contributes Danish practice and experience. Work on standardisation also provides Danish industry with useful knowledge about current international developments. The majority of these activities are funded by performance contracts. 450 GTS employees took part in external activities in 2017 (Figure 15, facts and figures), compared with 396 in 2016, an increase of 14 per cent.

The GTS institutes are currently active in 82 standardisation committees, according to Danish Standards Foundation figures. FORCE Technology and DTI are particu-

larly active in these committees, sometimes with several employees. DBI, DHI, FORCE Technology and DTI are also active in a number of professional working groups.

The market for collaborative robots working in close contact with people is expected to grow dramatically in the years ahead. Legislation and standards in this area, however, have yet to catch up. This is a challenge that could slow development. For this reason five European RTOs, led by DTI, have joined forces in the EU-funded initiative, COVR. COVR will deliver a clear framework for safety approval of collaborative robots. It consists of DTI, the Italian National Research Council, the German Fraunhofer IFF, the French Alternative Energies and Atomic Energy Commission, and the Dutch Roessingh Research and Development.



More than 500 small and medium-sized enterprises have developed new robotic solutions in recent years through their work with the Technological Institute's Centre for Robot Technology.

Output

The activities of the GTS institutes underpin their development of a wide range of innovation programmes tailored to Danish businesses. The dissemination of these programmes increases innovation and competition in the Danish business sector.

The third link in the effect chain of the GTS institutes is the services supplied by the institutes to Danish businesses and the knowledge-sharing initiatives that these establish. These include technological services as well as courses, education and training. Several indicators can be used to assess the breadth of the knowledge transfer effected by the institutes, such as the number of customers buying institute services and their revenue. The GTS network had 19,139 Danish business customers in 2017 (Figure 6, facts and figures), consisting of 1,156 public institutions, 1,816 private individuals and associations, and 16,167 private-sector businesses.

An illustrative example of the institutes' work with public-sector customers is DTI's partnership with a municipality to develop welfare technology solutions. Another is FORCE Technology's partnership with Vordingborg Harbour to develop a harbour extension. The institutes also provide services to private individuals and associations. An example here is mould detection systems for housing associations and private individuals.

The principal objective of the GTS institutes is to contribute to innovation and growth in the private sector. The following sections therefore focus on how the institutes approach this task with reference to Danish businesses.

Figure 4: Distribution of Danish, commercial turnover, private sector, million EUR

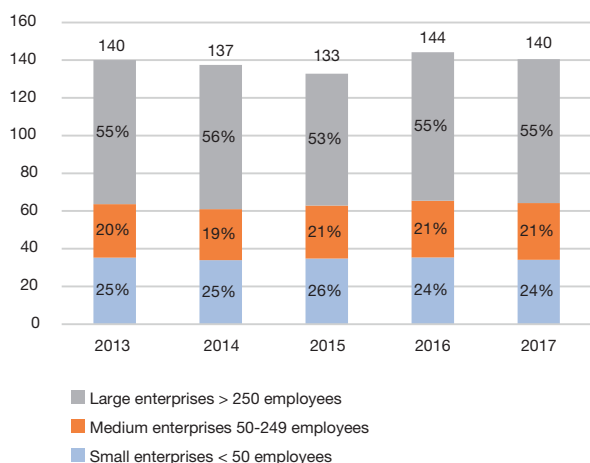
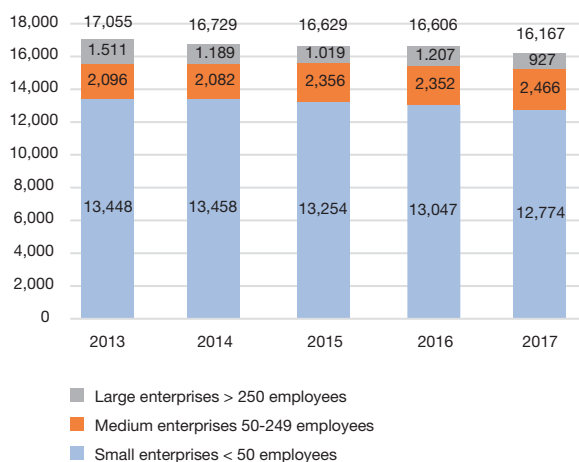


Figure 5: Number of Danish private customers sorted by size



In the unique customer account, all customers have been filtered so they only count as one regardless of how many institutes they have purchases services from.

Private-sector customer numbers

Figure 5 shows that unique private-sector business customers numbered 16,167 in 2017 compared with 17,055 in 2013, a fall of 5 per cent over the past five years.

Private-sector customer turnover

Private-sector customer turnover was € 140 million in total in 2017. Large businesses made up 55 per cent of this total, medium-sized enterprises 21 per cent, and small businesses 24 per cent. This distribution of business turnover has remained largely unchanged over the past five years.



Danish businesses can use DHI's special wind turbine to test the performance of offshore structures such as floating windmills in severe wave and wind conditions.



What services do Danish businesses buy?

The turnover of the GTS institutes falls into five categories: consultancy services; testing and calibration; education, training and courses; product sales; and commercial R&D (Figure 9, facts and figures). These categories vary greatly in scale and complexity. Cooperation can include everything from small-scale testing to major innovation tasks. There have been only minor fluctuations in the distribution of these five types of service category over the past five years.

Some of these services categories are derived from performance contract activities that have evolved over a longer period into concrete business-related services. Others are purely commercial and not supported by performance contract activities.

As shown in Figure 9, the majority of customer purchases are in the categories of advisory and consultancy services, and testing and calibration.



Advisory and consultancy services

In 2017, 39 per cent of the commercial turnover of the GTS institutes from Danish businesses was derived from research based advisory and consultancy services. These services involve the development of technologies and innovation methods in collaboration with businesses, and they are typically initiated when a business requires critical feedback and discussion on product development or production methods.



Testing and calibration

Testing and calibration services formed 41 per cent of GTS service sales to Danish business customers in 2017. This is the largest category of services supplied by the institutes to Danish businesses, and they generally take their point of departure directly in the institutes' extensive technological infrastructure as well as their standardised services.



Education, training and courses

The GTS institutes are among Denmark's largest education, training and course providers. Training amounted to 12 per cent of the institutes' sales to Danish business customers in 2017. A wide variety of courses are offered, including both short refresher courses and longer training courses.



Product sales

Product sales amounted to 5 per cent of the GTS institutes' Danish commercial turnover in 2017.



Commercial R&D

Commercial R&D from the GTS institutes amounted to 3 per cent of the institutes' Danish commercial turnover in 2017. This level has been consistent over the past five years. Here the service purchased is an R&D collaboration intended to address a specific challenge defined by the business. Intellectual property rights (IPR) are transferred to the company in services of this type.

Volume of customer purchases

The distribution by category of GTS (commercial) turnover has remained broadly consistent over the past five years.

Table 3 shows the size of the GTS institutes' Danish commercial turnover in 2017. 16,046 customers (78 per cent of the customer base) made purchases of less than € 3,400 in value, accounting for 10 per cent of total turnover. At the other end of the scale, 296 customers (2 per cent of the customer base) made purchases of more than € 67,200 in value, accounting for more than 55 per cent of total turnover.

The large number of small purchases reflects the GTS institutes' mandate to develop standardised afforda-

ble services that can be readily accessed by multiple businesses at the same time. Examples include analysis of chemical substances in a given product, or inspection of a process to check compliance with current standards or norms.

At the other end of the scale are the large and complex R&D collaborative partnerships that form the more expensive purchases of GTS services.

The distribution of turnover from Danish business category indicates that the GTS institutes cater to the whole range of Danish businesses, giving equal priority to supplying large and complex services and simple but just as necessary services.

Table 3: Danish, private business customers (not unique) distributed by size of purchase

Size of purchase in 1000 €	Number of customers	Percentage of customers	Million EUR	Percentage of turnover
<0.7 k€	8,369	41%	3	2%
0.7 – 3.4 k€	7,677	37%	12	8%
3.4 – 6.7 k€	1,836	9%	9	6%
6.7 – 13.4 k€	1,168	6%	11	8%
13.4 – 33.6 k€	843	4%	18	12%
33.6 – 67.2 k€	312	2%	15	10%
67.2 – 134.4 k€	171	1%	16	12%
134.4 k€ <	125	1%	59	42%
	20,501	100%	141	100%

Knowledge-sharing activities

The GTS institutes participate in a diverse range of knowledge-sharing activities to service Danish business as a whole. These knowledge-sharing activities frequently take place in collaboration with other players within the innovation system, including universities and educational institutions. The institutes also play an active part in the Innovation Networks Denmark initiative.

Collaboration with universities and educational institutions

As stated above, the GTS institutes collaborate with universities in R&D projects. Some facilities are managed jointly by the Danish universities and the GTS institutes. Bioneer Pharma, a business unit of Bioneer based in the Department of Pharmacy at the University of Copenhagen, is an example. Bioneer Pharma was established in

2007 in cooperation with the University of Copenhagen and offers R&D based consultancy and services to pharma and biotech businesses.

Additionally, a strategic partnership agreement was signed in 2017 between the GTS institutes and the University of Copenhagen with the objective of strengthening knowledge-sharing between these two institutions and Danish business. The agreement runs for five years, during which the University of Copenhagen and the GTS institutes will identify new areas in which joint activities can be launched. At the same time, the many connections that already exist between the two institutions will be strengthened and expanded.

A range of partnerships have also been established with educational institutions including university colleges and



business academies to collaborate in training and updating both teachers and students in the latest technological advances.

Innovation Networks Denmark

The Innovation Networks Denmark system acts as a cluster that brings all the players in a given field or sector together. Participants include businesses, universities, knowledge and educational institutions, and public-sector authorities. The objective is to create a space where businesses come together to access the latest knowledge.

Innovation Networks Denmark assists businesses in starting up new development projects, matches businesses with relevant Danish and international partners, and takes overall responsibility for general knowledge transfer.

Denmark had 22 innovation networks in 2017, with about 11,000 businesses taking part in activities annually. The GTS institutes are actively involved in all but one of these innovation networks, and frequently several GTS institutes take part in a specific innovation network. The GTS institutes contribute specialist and technological competencies and participate in the networks at every level, sometimes as partner, sometimes managing the network.

For example, DTI is project manager for the innovation network InnoBYG, whose vision is to contribute to sustainable development in the construction industry. Here the focus is on environmental, social and economic conditions within both new construction and renovation sectors. Under DTI's project management, the central partners include DBI, AAU, DTU, the Danish Construction Association, the BAT Cartel, the Danish Association of Construction Clients (DACO), Danish architects, the Confederation of Danish Industry (Construction), the Danish Energy Agency, FRI, Tekniq, and Velux. Some sixty Danish businesses are affiliated with InnoBYG.

Another example is the InfinIT network, led by the Alexandra Institute. InfinIT is Denmark's only nationwide IT network working at the interface between researchers and businesses. Businesses gain access to the latest IT knowledge and receive support for applying it, while researchers gain the opportunity to try new ideas in practice and obtain valuable insights into new research areas.

The GTS institutes' engagement with the innovation networks allows them to get into contact with new businesses and keep track of developments within the networks' specific fields.

Innovation Agents

The special "Innovation Agents" scheme has been in operation for the past ten years. Under this scheme, a number of technology specialists from the GTS institutes seek to proactively support Danish SMEs which lack knowledge of the possibilities offered by the innovation system. These businesses are offered an innovation check-up at no charge. The SMEs gain access to specific knowledge and knowhow about technological opportunities and possible partnerships with private consultants, universities or the GTS institutes. The objective is to motivate SMEs to grasp the opportunities represented by new technology so that they can launch their own innovation processes.

Since the establishment of the scheme in 2007, Innovation Agents have conducted 4,540 innovation check-ups for Danish SMEs across the country. In 2017 alone, Innovation Agents carried out 480 check-ups for businesses nationwide. 290 of these SMEs took action on the basis of the recommendations made by partnering with a private consultant, a knowledge institute or a GTS institute. Of those that received an innovation check-up in 2017, 91 per cent of SMEs were either satisfied or very satisfied with the service and would recommend it to other businesses.

One SME that received an innovation check-up was a.h. Nichro Haardchrom A/S, located in Hvidovre, close to Copenhagen. This company specialises in surface treatment of hard chrome. Its basic technology was developed in the 1920s, and the company had expressed a strong desire for help in developing this further. The Innovation Agents assisted in the preparation of an application for 'InnoBooster' funding, leading to a partnership with materials experts from DTU. The company is currently investigating the possibilities for an EU project to enable pulse chromium testing within specific applications.

The Innovation Agents scheme is financed by a performance contract with the Danish Agency for Institutions and Educational Grants. It expires at the end of 2018.

Publications and newsletters

A part of the GTS institutes' knowledge transfer mandate is fulfilled in the form of publications, academic articles and news distributed in the institutes' newsletters.

Publications by the GTS institutes include:

- Scientific dissertations
- Articles in scientific journals
- Conference papers (articles written as presentations in connection with academic conferences).

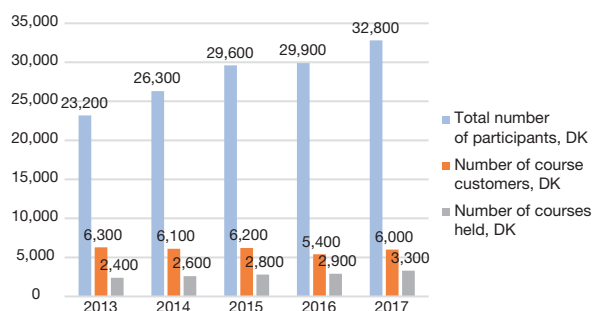
In 2017, the GTS institutes produced 284 publications (Figure 17, facts and figures). These included six PhD theses, 173 articles in scientific journals, and 105 conference papers.

The volume of publications is closely linked to levels of research funding. High research funding levels positively affect publication levels, and vice versa.

The newsletters published by the GTS institutes constitute a comprehensive method of knowledge transfer. The newsletters had a total circulation of 103,000 subscribers in 2017.

One example is the newsletter produced by DTI's Agro-Tech division. The primary target group here is decision-makers and employees in the agro and food industry. The objective is to keep the industry updated on current topics within field trials, bio-resources, bio-refinement, and plant and food technology by drawing on the services, laboratories and pilot facilities of DTI. The newsletter is distributed to 1,400 recipients fortnightly or monthly.

Figure 16: Course activities



Courses and seminars

The GTS institutes held a grand total of 3,300 courses in 2017 (Figure 16). There were 32,800 attendees, representing 6,000 business customers. As one of Denmark's largest training and course providers, DTI's experience is that the demand for courses increases when Danish businesses are doing well.

DBI is another GTS institute offering a wide range of courses and theme days providing participants with knowledge on fire safety. As a spin-off of the performance contract project Prototype Fire Lab (PROFIL), DBI organised a demonstration day for door manufacturers during 2017. Fifty participating businesses were brought up to date on EU standards, minor fire tests and simulations at the event. During the day these businesses were given good advice and specific knowledge and experience that they can apply in their own product development.

DHI's courses are targeted to specialists in planning and dealing with water and the environment. DHI offered flexible courses for the first time in 2017 aimed at employees who find it a challenge to find sufficient time for training and knowledge updating during busy workdays. DHI introduced free online courses and 1–2 hour seminars which can be taken as self-study courses when time permits. Another possibility is attending an online course run by a teacher at scheduled times for a course fee.



Every year the GTS institutes work closely with Danish businesses and the GTS staff set their specialist technological knowledge to work to build Danish innovation.

Effects

What is the actual effect of the GTS institutes' collaboration and partnership with Danish businesses? A number of indicators and case studies can be useful here in shedding light on the results obtained.

The fourth link in the effect chain for the GTS institutes becomes visible when Danish businesses, through their work with an institute, achieve results in the form of product and process improvements.

Measuring the direct and long-term effects of the work of the GTS institutes is a challenge. There are currently no methods for directly measuring the specific value of Danish society's investment in the GTS institutes, for instance in terms of growth and jobs created.

A few recent studies have examined the effects of the GTS institutes' work, however, and these studies are

briefly reviewed in this chapter. The chapter also focuses on the experiences of businesses partnering with the institutes. These experiences are presented by the businesses' executives in four case studies below.

Productivity gains through partnering with the GTS institutes

In 2017, the Ministry of Higher Education and Science published "Business investments in R&D in Denmark 2017." This publication maps business investments in R&D covering the period 2008–2015, and investigates whether there is a correlation between businesses' research partnerships and their productivity.

The mapping shows a positive correlation between research cooperation and productivity growth compared with other businesses that are active in R&D. The study looked at three forms of cooperation:

- R&D active businesses working with one GTS institute showed a productivity gain of 3.7 percentage points higher than R&D active businesses that did not partner with a GTS institute
- R&D active businesses working with both a university and a GTS institute showed an average productivity gain of 2.2 percentage points
- R&D active businesses working only with a university showed a productivity gain of 2.9 percentage points

The study therefore documents measurable gains in productivity resulting from partnering with the GTS institutes.

European study documents the GTS institutes' impact

An economic study conducted by the Belgian consulting firm IDEA Consult – “Economic Footprint Study: Impact of 9 RTOs in 2016” – shows that across the European countries, four additional jobs are created for each employee of an independent research and technology organisation (RTO).

The study was published by EARTO, an umbrella organisation of 350 non-profit European RTOs focusing on

the economic footprint of nine of the largest members of EARTO, of which DTI is one. The study is based on an input–output model calculating how the effects of one industry spread to other sectors and industries in the economy. The total number of employees in the nine participating RTOs was 54,191 in 2016. A total of 284,000 jobs can be linked to their activities.

DTI had 1,074 employees in 2016. However, the spin-off effects of the activities of these employees are calculated to have helped create more than 6,000 jobs in Europe. Thus the job creation factor for DTI is an astonishing 4.73.

Applied to all 350 members of EARTO, the model suggests that this sector is responsible for the creation of between 322,000 and 400,000 jobs across Europe. If non-core activities such as contract research and spin-offs are included, the effect increases to between 730,000 and 900,000 jobs.

Assuming that this study is also representative of Denmark, and extrapolating the results of the study to the Danish GTS institutes, the GTS activities will help to create some 20,000 additional jobs in 2018, both within the institutes and in other industries and sectors, in addition to a total economic effect of approximately € 2,420 million.

User analysis of the GTS institutes

In 2016, a comprehensive user analysis of the GTS institutes' technological services was carried out at the initiative of the Danish Agency for Institutions and Educational Grants. The user analysis showed that:

- GTS institute users gain added value in terms of gaining new skills, solving specific technical issues, more certainty of compliance with regulation, and improving the quality of their own services and products. More than 60 per cent of the users experienced that the GTS institutes were significant or highly significant in these areas.
- 54 per cent of GTS institute users estimated that partnering with the GTS institutes had some or a major impact on their company's innovation or business development.

- 69 per cent of GTS institute users found that the GTS services had a positive impact on company productivity and overall efficiency.
- Among users participating in a publicly co-funded research, development and innovation project in collaboration with one or more GTS institutes in 2015, considerable satisfaction was generally noted with the GTS institutes' specialist contribution.
- The GTS institutes often play a decisive role in initiating projects and handling overall project management. This is especially important for SMEs.

Case studies

The following four company case studies provide insight into how the GTS institutes work concretely to apply technology and work in partnership with Danish businesses to build innovation and growth.

GTS competencies were the launching pad for a new company

CerCell is a twelve-employee business producing single-use bioreactors for the biotechnology industry. A combination of project funds and access to Bioneer's laboratories helped the business to launch in 2010.

CerCell was founded by Per Stobbe, the CEO. From day one his aim was to design, manufacture and supply specialised single-use equipment for biotechnological production of recombinant proteins and cell therapies. Today, CerCell produces bioreactors ranging in size from 500 ml to 30 l for use by the biotechnology industry in R&D.

"Ten years ago, a research project with Bioneer enabled me to move into their laboratories for a period of two years. During that time, I had the

best possible conditions for developing my bioreactors further. I brought eight years of experience from DTU with me, but getting the chance to move in with Bioneer and access their facilities and competencies within the field of cell biology was vital. It also produced an enormous amount of useful experience," says Stobbe.

The cooperation with Bioneer boosted ongoing development efforts. Today the product has matured and is patented in both the EU and the



United States. Thirty EU and US businesses now use it, and CerCell expects market growth of 75 per cent in 2018 and a doubling of sales in 2019.

"As a GTS institute, Bioneer gave us access to facilities we could not afford as a new company. The smart link between project funds, access to the Bioneer labs, and our work with advanced bioreactors gave us the chance to become a global company and to sell our products worldwide."

GTS infrastructure opens the doors to Mexico

Last year, FORCE Technology invested in a fully automatic force calibration machine, the largest of its kind in Denmark. This investment has greatly benefited Eilersen Electric A/S, a 27-person business that has sold robust road cells to customers in Denmark and beyond for some fifty years.

When one of the world's leading food manufacturers decided to replace all its weighing sensors from a Swiss supplier in their Mexican assembly plant with digital weighing sensors manufactured by Eilersen Electric A/S, part of the reasoning behind the decision was that the weighing cells are calibrated by FORCE Technology. After each calibration, FORCE Technology issues an individualised certificate recognised by the International Laboratory Accreditation Cooperation (ILAC).

"A certificate from FORCE Technology adds credibility to the quality of our products. So access to FORCE

Technology's pool of knowledge and competencies boosts our ability to sell our products on export markets, including Mexico," says Frederik Juul Eilersen, Eilersen Electric's General Manager.

Juul Eilersen reports that customers are increasingly demanding fast delivery. This means that proximity to the FORCE Technology test facilities is of vital importance. "FORCE Technology's investment in new facilities that will enable testing and certification in Denmark in future is extremely important to us. Without this investment, this knowhow would disappear from Denmark. That would make it hard

for us to maintain a high level of flexibility towards our customers," says Juul Eilersen.

The first fifty weighing cells have already been delivered to the production site in Mexico, following their calibration at FORCE Technology. There is potential for a total of 300 weighing cells over the next one to two years.



SMEs get to share valuable resources

Hit hard by the economic crisis, the family business Thürmer Tools rethought itself from scratch and has now regained a strong position in the market for tools. The company has worked closely with the GTS institutes.

Thürmer Tools is a family business that was founded in 1898. After taking a hit in the recent economic crisis, the company bet everything on a radical digitisation and reorganisation of their entire production. In the process, the company benefited from the GTS institutes' vast knowledge of 3-D print, tribology and computer flow analyses – all areas where the GTS institutes deploy international-level expertise, according to Erick Thürmer, who heads the company.

“Two factors have put Thürmer Tools back on the map: the GTS institutes,

and some of the public schemes available, for instance the knowledge pilot scheme. The GTS institutes are experts in pinpointing and solving the challenges that emerge during a development process,” says Thürmer.

“If not for the GTS institutes, small Danish businesses would not be able to innovate at all. The GTS institutes give SMEs a valuable shared platform, where it's all about sharing facilities and competencies that multiple businesses can use at the same time. SMEs can't afford to develop the competencies that already exist

in the GTS institutes on an individual basis.”

For Thürmer Tools, digitisation was a huge expansion. The company went from employing researchers as 5 per cent of their staff to more than 80 per cent today. This change was essential, in Thürmer's view, for success in digitisation. “Disrupting the business has been nothing short of crazy – even crazier than I expected. We've met the objectives we set ourselves four years ago. But it's a never-ending journey,” says Thürmer.

Silo manufacturer builds success with robots

“Just dive in, waiting won't help” and “Say yes to all the feedback and ideas you can get.” For Dorte Martinsen, CEO of BM Silo, these are the two key messages behind BM Silo's robot success.

Start out with a pilot project involving selected employees. Gain some experience, and say yes to all the external sparring you can get,” says Martinsen, who bought a used British robot for her employees to play with at the beginning of the project.

This was the starting-point for what subsequently developed into fully automated silo production at the company premises in Holstebro. The result has been more competitive products on the global market, while employees have been freed of a significant amount of heavy lifting of steel and concrete.

Martinsen says, “Six employees at-

tended a course at DTI to learn how to use the British robot. Two of them opted to continue working on the project. After completing a year's pilot project, we had gained sufficient experience and knowledge to look at a big solution ... Previously, five employees were handling this part of our production, which now requires the attention of just one. This means that the robots are taking care of everything that is heavy and hard to handle, whereas the manual line is used to work on small elements that the robots cannot handle.”

BM Silo's robot experiment project ran for four to five years. Without external support and assistance, the



project might never have got off the ground. The company collaborated with a wide range of partners, including robot experts from DTI. BM Silo also got an innovation check-up from the GTS Innovation Agents.

Martinsen's recommendation is that SMEs should take the maximum possible advantage of external co-operation opportunities – particularly because small businesses cannot develop a full range of competencies in house.



State-of-the-art facilities

The GTS institutes represent Denmark's technological infrastructure, consisting of test facilities, appliances, laboratories, and human skills and competencies. These facilities give businesses the space to confront their ideas with reality – whether this involves testing and documentation or developing processes and products. Here follows a short presentation of some of the state-of-the-art facilities deployed in the GTS institutes.

Centre for Robot Technology

DTI has consolidated its position as one of Europe's leading robot innovation centres over the past five years. In the Centre for Robot Technology, domestic and international robot technologies, prototypes, and mock-ups are presented. The Centre combines hands-on demonstrations with testing of various types of technologies, while also advising businesses on the use of robots. The robot technology in use in the Centre stems from projects undertaken by DTI itself and as several of its partners which place their equipment at the disposal of interested businesses and others. The equipment and the technologies therefore form part of a dynamic process in which everything is replaced and updated on an ongoing basis.

Component and structural test centre

In the former shipyard at Lindø, near Odense, Funen, there is a component and structural test centre built for advanced full-scale testing. The centre is tailored to the offshore industry and ship and tanker manufacturers. Inside the climate chamber and on the mechanical test bench, businesses are assisted in performing highly reliable longevity tests. Measuring a total of 8 x 8 x 14 m, the climate chamber is large enough to perform functional tests of air conditioners for wind turbines. The centre is the result of a strategic partnership between FORCE Technology and LORC, the Lindø Offshore Renewables Centre. Day-to-day operations are managed by FORCE Technology.

Reverberation chamber ensuring products against radiation

FORCE Technology is home to the largest reverberation chamber in Northern Europe. This is a test facility designed to test whether electronics and machines are affected by electromagnetic noise – a type of noise that is increasingly causing problems due to the increase in the number of mobile phones and wireless devices. By using a reverberation chamber, it is possible to test fields of

unprecedented size in Denmark, ensuring the intended functionality of these products in question even against a background of electromagnetic noise.

DHI WaterData

DHI WaterData is a portal that makes data on aquatic environments and water available to Danish businesses. This data is valuable for model development and forecasting. DHI WaterData combines access to a wide range of high-quality data for aquatic environments with data ready for use in specific projects. Water data can be used to predict floods in urban areas and to minimise their impact. The price for this service varies depending on whether businesses can use data on their own or require expert assistance from DHI. Some parts of the portal can be accessed and used free of charge. The portal is used primarily by consulting engineers.

Concrete testing

In DTI's Concrete Centre, accredited tests can be carried out on most products and materials related to concrete production and construction. The tests can be carried out according to Danish or international standards. This service is specifically targeted to the needs of concrete manufacturers and contractors who use the tests to document actual concrete properties, and also to advisers who use the tests to investigate the condition and durability of concrete structures.

High-pressure calibration facilities

FORCE Technology's department in Vejen, Denmark, is the world's largest closed-loop facility for high-pressure calibration of natural gas meters. This unique facility is the only one of its kind in the world. Using natural gas as its medium, it is built as a closed calibration loop in which giant natural gas meters from anywhere in the world can be calibrated at maximum flow and all year round – 24/7/365. Customers can monitor the calibration on their own meters, either live or via remote access and camera.

Fire lab

DBI has one of the most modern fire laboratories in Europe, performing all types of fire tests of up to 4.48 m high components. Materials, components and fire extinguishers for buildings and for ships can all be tested in the lab. DBI also offers fire testing of materials for cars, aircraft, trains and furniture upholstery. Tests are performed using DBI's expert knowledge of testing methods and rules and guidelines to which products are subject. DBI conducts more than a thousand fire tests annually.

Test facility for safety products

DBI has established a test facility for verification of physical safety products. The facility gives installation personnel, decision-makers, and day-to-day users of physical safety products the opportunity to test how a specific safety solution will perform in real life.

Facility for production and storage of stem cells

Bioneer has established new facilities for the production and storage of stem cells and of tissue cells produced by stem cells. The Bioneer infrastructure can transform cells from patient samples to patient-specific stem cells, and subsequently to nerve cells or cells from the blood-vessel system. Bioneer can also "DNA engineer" the cells in such a way that diseased cells are transformed into normal-profile cells. This facility allows businesses and hospitals access to advanced models that can be used to analyse new trial substances.

Interactive Spaces Lab

Interactive Spaces Lab, located in IT City in Aarhus's Katrinebjerg, is an R&D laboratory for future rooms and products involving IT. In the lab, Aarhus University and the Alexandra Institute are working together to develop the latest interaction and sensor technologies in close cooperation with businesses. Concept development, prototyping, implementation, and testing can all take place here.

Biomarker facility

Bioneer operates a biomarker facility for the analysis of disease markers. Tissue samples can be analysed here for the investigation of diseases and to explore the effects of drug trial substances at molecular level. The facility enables visualisation (colouring) of specific biomarker molecules in tissue sections. These are subsequently analysed, using robotic image-processing to determine the effectiveness of a given trial substance. This service allows businesses to document the performance of trial substances within the body. The facility is used by hospitals both in Denmark and internationally.

Nordic IoT Centre

A wide range of technical and commercial skills are required for the development of successful IoT products and systems. FORCE Technology and the Alexandra Institute have therefore teamed up to form the Nordic IoT Centre, where the GTS institutes have brought together all the relevant multidisciplinary competencies. This constitutes a one-stop-shop for the industry for the development and practical implementation of IoT solutions. Expert assistance is at hand here for concept development, development of wireless products with artificial intelligence, advising on IoT security, and product approvals.

Surface characterisation

DFM operates a range of facilities for calibration and measurement support within high-technology industry and research. One example is surface characterisation facilities. These include both tactile and optical methods and cover a wide range of dimensions from nm to μm . Tactile methods available include atomic force microscopy (AFM) and roughness gauges. Optical methods consist of scatterometry and microscopy. DFM's leading role in the field of surface characterisation is highlighted by the self-developed scatterometer, which is used for characterising periodic nanostructures, including at sufficiently high speeds for use on production lines with injection moulding.



DFM provides reliable measurement technology that together with new drone-based technology will improve wind turbine owners' ability to monitor blade conditions. Wind-turbine blade section under the microscope.

The work of the GTS-institutes

The GTS institutes offer an extremely rich resource of activities tailored to Danish businesses. This section summarises the most important of these, as well as the various means and possibilities for working together.

R&D tasks

Here a GTS institutes work to solve a concrete R&D task for a particular business, so as to strengthen the technological and knowledge content of the products offered by this particular business.

Collaborative R&D projects

Here the GTS institutes collaborate with businesses and with universities, both within Denmark and internationally. Activities in this category may include both public-sector institutions and private citizens. New knowledge and methods are developed to the benefit of the participating business and strengthening the general knowledge base of the industry.

Technological partnerships

The GTS institutes partner businesses up with Danish and international technology experts capable of solving complex concrete challenges in connection with R&D activities.

Innovation Network Denmark

The GTS institutes are strongly represented in Innovation Network Denmark. They are active players in all but one of the 22 innovation networks in the system. The innovation networks bring together Danish businesses, universities and the GTS institutes within academic and scientific areas of importance to Danish businesses.

Business-oriented education and training courses

The GTS institutes are among the largest education, training and course providers in Denmark. Six thousand

customers purchased courses from the GTS institutes in 2017, with more than 32,000 course participants joining the very extensive range of course offerings. The institutes prioritise meeting the market's needs and requirements, with education and training closely connected to the overall GTS objective of ensuring widespread, yet in-depth knowledge transfer to Danish businesses.

Technology assessments and innovation maturity

The GTS institutes help to bring technology and technological platforms home, often in close cooperation with companies and universities. The technologies are then further developed to reach a higher level of innovation maturity. This in turn makes them accessible to Danish businesses as they develop new products and services.

Innovation check-ups for businesses with innovation potential

The GTS institutes' "Innovation Agents" scheme deploys experts in a range of technologies who proactively offer innovation check-ups to SMEs at no charge. Check-ups evaluate a company's development and innovation potential, develop an action plan, and provide suggestions for potential partners, such as private advisers.

Organisational, strategic and leadership development

Many businesses need help with optimising and streamlining their production and processes. The GTS institutes advise businesses on any and all operational and development aspects.

Inspection and control

Several of the GTS institutes offer independent inspections that can be performed, including regular fire inspections, inspection and control of production facilities and equipment. In addition the institutes carry out multiple statutory and voluntary checks.

Measurement and calibration

Thanks to their status as primary reference laboratories, several of the GTS institutes are able to provide businesses with traceable measurements and accredited calibration within many fields.

Certification and testing

Products and ideas can be thoroughly tested prior to product development, as well as for documentation and marketing purposes.

Standardisation

Businesses receive assistance in implementing and complying with the latest standards. In addition, the GTS institutes participate in several international standardisation entities and committees.

Cooperation with public institutions

The GTS institutes work to address a broad cross-section of challenges for public-sector institutions and for the Danish authorities. They act as a knowledge hub in relation to governmental tasks, including advisory services on environmental issues and adaptation to climate change.

Facts about the GTS-institutes

Below you find a brief presentation of the seven GTS institutes and their key figures for 2017. On the following pages, you find an overview of 5-Year Key Figures for the GTS-institutes merged.

Find more information about GTS on: www.gts-net.dk



The **Alexandra Institute** helps public and private organizations develop innovative, IT-based products and services based on cutting-edge IT research.

www.alexandra.dk

Turnover, million EUR.	9
Danish turnover, million EUR.	8,5
R&D activities, million EUR.	5,1
R&D Performance contracts, million EUR.	3,2
Number of employees	87



Bioneer offers research based on services to companies in the areas of biomedicine, pharma, biotechnology and medico technology.

www.bioneer.dk

Turnover, million EUR.	7,4
Danish turnover, million EUR.	4,5
R&D activities, million EUR.	5,3
R&D Performance contracts, million EUR.	1,9
Number of employees	37



DBI is Denmark's leading centre of knowledge within security, fire safety engineering and fire prevention. DBI's mission is to secure life and property.

www.dbi-net.dk

Turnover, million EUR.	23
Danish turnover, million EUR.	19,2
R&D activities, million EUR.	4,9
R&D Performance contracts, million EUR.	1,7
Number of employees	171



DFM is Denmark's National Metrology Institute and offers accredited calibration services and consultancy on metrology at the highest international level.

www.dfm.dk

Turnover, million EUR.	4,3
Danish turnover, million EUR.	3,6
R&D activities, million EUR.	4,1
R&D Performance contracts, million EUR.	2,6
Number of employees	31



DHI is a research-based company focusing on the development and application of advanced technologies in the fields of water and related disciplines. Our focus areas are inland, marine and urban waters and industry.

www.dhigroup.com

Turnover, million EUR.	112,3
Danish turnover, million EUR.	21,4
R&D activities, million EUR.	16,2
R&D Performance contracts, million EUR.	4,5
Number of employees	1,061



FORCE Technology particularly services the maritime and construction industries, life science and processing industries, oil and gas industry, electronics industry, energy and environmental industries as well as the public sector.

www.forcetechnology.dk

Turnover, million EUR.	180,9
Danish turnover, million EUR.	81,3
R&D activities, million EUR.	24,9
R&D Performance contracts, million EUR.	11,9
Number of employees	1,377



**TEKNOLOGISK
INSTITUT**

The **Danish Technological Institute (DTI)** offers consultancy and services within a wide range of business areas, such as building and construction, production, materials, life science, energy, agrotechnology and meat research.

www.teknologisk.dk

Turnover, million EUR.	151
Danish turnover, million EUR.	109,9
R&D activities, million EUR.	60,9
R&D Performance contracts, million EUR.	19,5
Number of employees	1,041

Note: There is a slight difference of 1 million EUR when one compares the allocated performance contract funds (€46m) to the sum of funds used by the institutes (€45m). This is due to displacements in activities related to the performance contracts..

Turnover and customer base		2017	2016	2015	2014	2013
Turnover	Total turnover, m €	489	486	507	513	498
	Total Danish turnover, m €	250	251	245	256	253
	R&D turnover, m €	89	89	98	104	103
	... Thereof R&D performance contracts, m €	46	41	42	42	41
	... Thereof international-funded R&D, m €	10	14	17	19	20
	Commercial turnover, m €	400	397	409	409	394
	Danish commercial turnover, m €	170	175	164	172	170
	Danish commercial turnover, private sector, m €	140	144	133	137	140
	... Thereof small enterprises, m €	34	35	35	34	35
	... Thereof medium enterprises, m €	30	30	28	27	28
	... Thereof large enterprises, m €	76	79	70	77	76
	Danish commercial turnover, public sector, m €	30	31	31	34	30
	International commercial turnover, m €	230	222	245	238	225
	Customer base	Danish customers, number of enterprises, private and public (gross) ¹	23,630	23,938	23,958	24,095
Danish customers, number of enterprises, private and public (unique) ²		17,323	17,693	17,842	18,024	18,522
Danish private customers, number of enterprises (unique)		16,167	16,606	16,629	16,729	17,055
... Hereof small enterprises		12,774	13,047	13,254	13,458	13,448
... Hereof medium enterprises		2,466	2,352	2,356	2,082	2,096
... Hereof large enterprises		927	1,207	1,019	1,189	1,511
Danish public customers (unique)		1,156	1,087	1,213	1,295	1,467
Productivity		Turnover per employee, €	128,549	123,672	126,145	124,845
	Profit per employee, €	2,429	1,482	2,909	2,523	1,648

Research, development and innovation		2017	2016	2015	2014	2013
Research and development	R&D activity, FTEs	686	701	747	794	792
	R&D activity, m €	123	122	134	142	147
	Self-financed R&D, m €	33	33	36	39	44
	Research intensity, percent	18	18	19	20	21
	R&D collaboration projects, number of	719	759	762	1,006	1,245
	... Hereof Danish projects	542	493	585	793	1,015
	... Hereof international projects	177	266	177	213	230
Human resources	Employees, number of	3,805	3,930	4,021	4,110	4,013
	Dr. & Ph.D.	474	480	444	435	428
	Masters degree or comparable, longer education	1,743	1,698	1,724	1,825	1,843
	Other technical personel	1,096	1,193	1,285	1,388	1,280
Publications	Other, non-technical personel	493	560	569	462	461
	Dissertations, number of	6	8	11	13	7
	Articles in scientific journals, number of	173	250	249	260	229
Other professional activities	Conference papers, number of	105	110	154	135	156
	Education/tutoring, number of engaged employees	140	144	132	131	153
	External technical activities, number of engaged employees	450	396	447	419	445
	... Hereof engaged in international activities	173	130	184	168	199

Benefit to society		2017	2016	2015	2014	2013
Efficiency	Degree of knowledge transfer ³	11	12	12	12	12
	R&D-factor ⁴	3	3	3	3	4
Spin-offs	Spin-offs	8	3	2	5	2
Patents	Patent families, number of	91	100	106	82	95
	Patent applications, number of	10	15	16	13	11
	Licenses	30	43	45	53	47
Course activities	Combined Danish turnover from course activities, m €	21	20	17	17	16
	Total number of Danish course participants	32,752	29,921	29,575	26,252	23,239
	Number of course customers in Denmark	5,966	5,413	6,201	6,127	6,306
Visibility	Number of subscribers to the newsletters of the GTS-institutes	103,000	108,000	78,000	82,000	62,000

Notes:

- 1) Sum of all the customers registered by each GTS-institute. This number does not take into account that some customers have collaborated with more than one GTS-institute.
- 2) Sum of all the customers removed of duplicates. Every customers is counted only once, regardless of how many GTS institutions the customer has purchased services from.
- 3) Degree of knowledge transfer is defined as the total turnover divided by the funds allocated for performance contracts. The number represents the overall benefit of the performance contracts.
- 4) The R&D-factor is defined as the R&D activities divided by the funds allocated for performance contracts. The number represents the R&D activities that are generated from each EUR. spent on the performance contracts.

Customer base and turnover

Figure 1: Development in total turnover, million EUR (current prices)

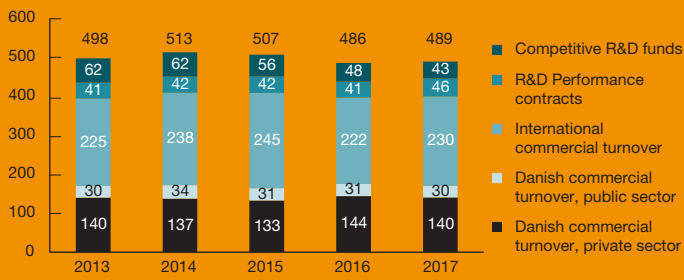
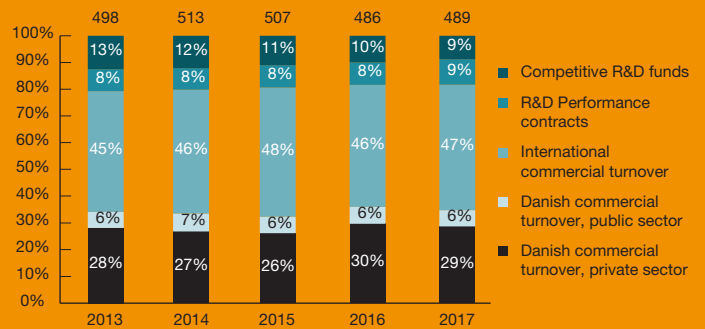
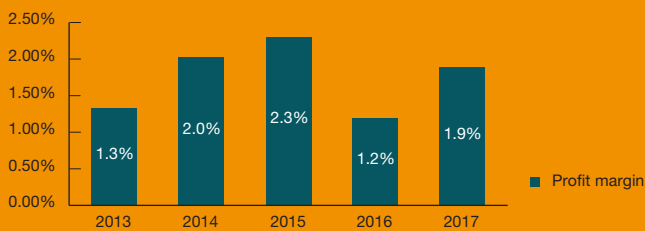


Figure 2: Development in the distribution of total turnover, %



Competitive funds are from regional, state and international programs (e.g. funds from the Danish Innovation Fund and the EU Horizon 2020).

Figure 3: Profit margin of the GTS-institutes, 2013-2017, %



The profit margin is defined as the profit divided by the turnover as a percentage. The profit in 2017 was 9.3 million € and total turnover was 489 million €

Figure 4: Distribution of Danish, commercial turnover, private sector, million EUR

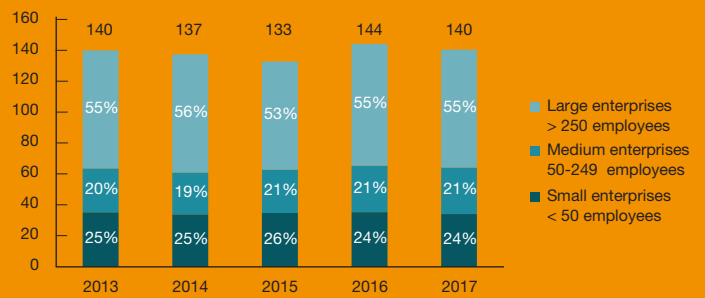
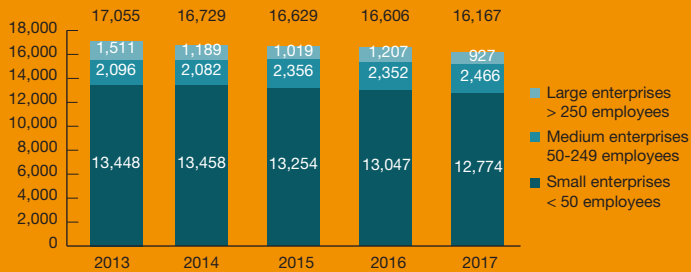


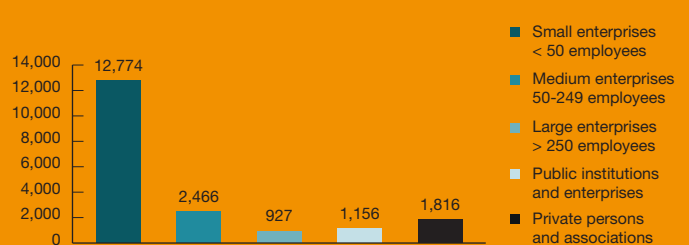
Figure 5: Number of Danish private customers sorted by size



In the unique customer account, all customers have been filtered so they only count as one regardless of how many institutes they have purchases services from.

A unique customer is counted using the businesses D-U-N-S® number. D-U-N-S® number is a unique nine-digit identifier for companies, as well as legal entities such as subsidiaries. This means, that for example large businesses that have multiple subsidiaries can act as a unique customer several times, if multiple subsidiaries have made use of the GTS institutions services.

Figure 6: Distribution of unique customers in 2017, 19,139

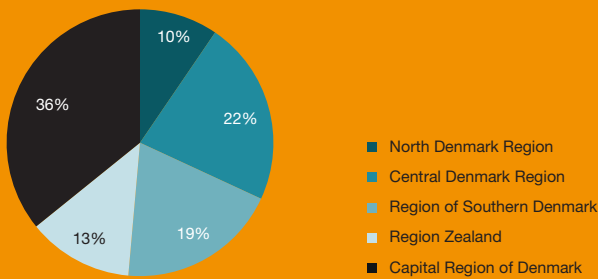


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Customer base and turnover

Figure 7: Regional distribution of public and private customers (unique), %



Private persons and associations are not included in this figure/table.

Figure 8: Regional distribution of Danish commercial turnover, %

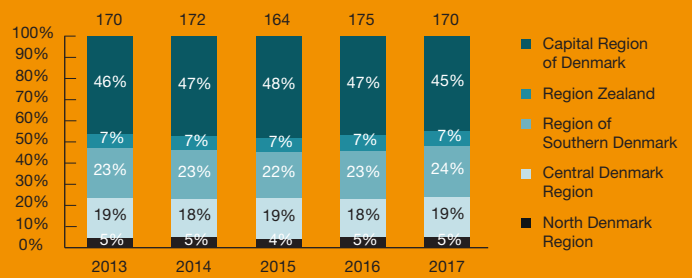


Figure 9: Danish commercial turnover distributed by types of services, million EUR

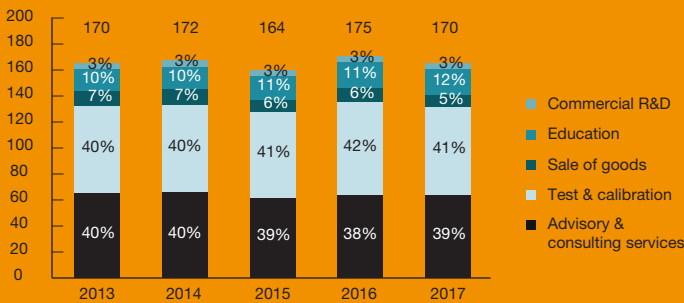


Table 1: Unique Danish customers distributed between industries

Industries	Number of enterprises	Percent
Agriculture, forestry & fishing	213	1%
Industry	3,291	19%
Construction	1,747	10%
Commerce & transportation	4,264	25%
Information & communication	583	3%
Finance & insurance	335	2%
Real estate & rental business	1,244	7%
Business service	2,414	14%
Public administration, education & health	1,792	10%
Culture, recreation & other services	1,268	7%
Unknown activity	172	1%
Total	17,323	100%

Table 2: Danish turnover distributed between industries

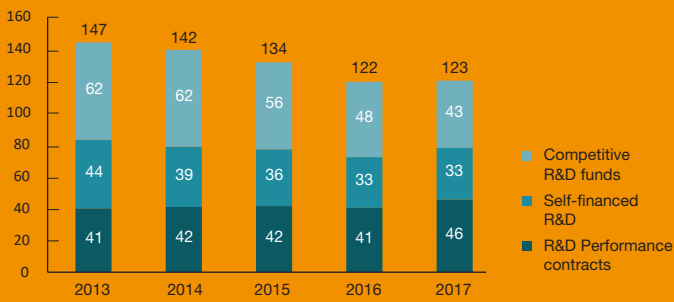
Distribution of turnover between industries	Million EUR	Percent
Agriculture, forestry & fishing	1	1%
Industry	71	42%
Construction	7	4%
Commerce & transportation	19	11%
Information & communication	4	2%
Finance & insurance	3	2%
Real estate & rental business	5	3%
Business service	29	17%
Public administration, education & health	25	15%
Culture, recreation & other services	6	3%
Unknown activity	0	0%
Total	170	100%

Table 3: Danish, private business customers (not unique) distributed by size of purchase

Size of purchase in 1000 €	Number of customers	Percentage of customers	Million EUR	Percentage of turnover
<0,7 k€	8,369	41%	3	2%
0,7 – 3,4 k€	7,677	37%	12	8%
3,4 – 6,7 k€	1,836	9%	9	6%
6,7 – 13,4 k€	1,168	6%	11	8%
13,4 – 33,6 k€	843	4%	18	12%
33,6 – 67,2 k€	312	2%	15	10%
67,2 – 134,4 k€	171	1%	16	12%
134,4 k€ <	125	1%	59	42%
Total	20,501	100%	141	100%

Table 3 is based on non-unique customer records. A single company can thus show up more times if the company has purchased services from more than one GTS institute. Private persons and associations also show up in this account of customers, because their turnover is categorized as Danish commercial turnover from the private sector.

Figure 10: Development in R&D activities, million EUR



Competitive funds are from regional, state and international programs (e.g. funds from the Danish Innovation Fund and the EU Horizon 2020).

Figure 11: R&D's share of the total turnover, %

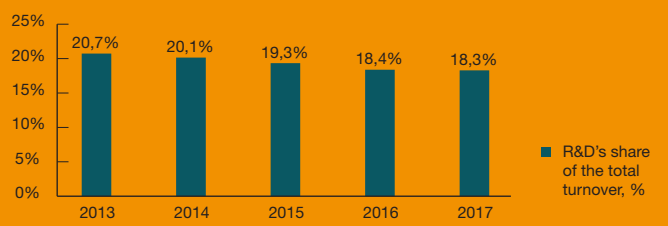
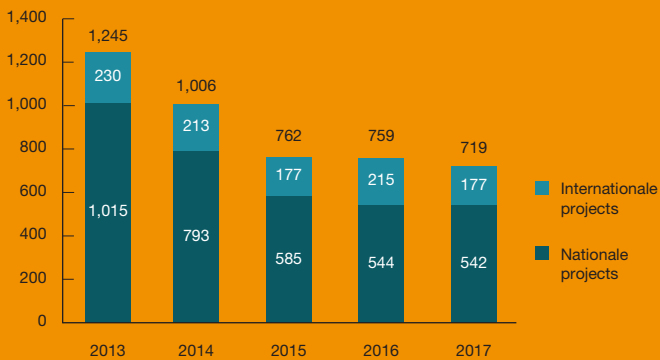
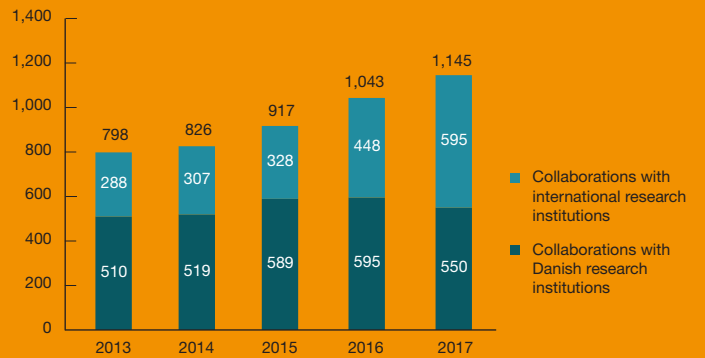


Figure 12: Number of collaborative R&D projects



The figure shows the number of research and development projects where a GTS institute has collaborated with one or more universities, companies or public institutions.

Figure 13: Number of collaborations with other research institutions



A collaboration with a research institution is defined as: a collaboration with Danish and foreign research institutions, where the cooperation is formulated in a written agreement, such as a project, an official framework agreement, an employee exchange agreement or a guest lectureships agreement.

Figure 14: Employees distributed by educational background

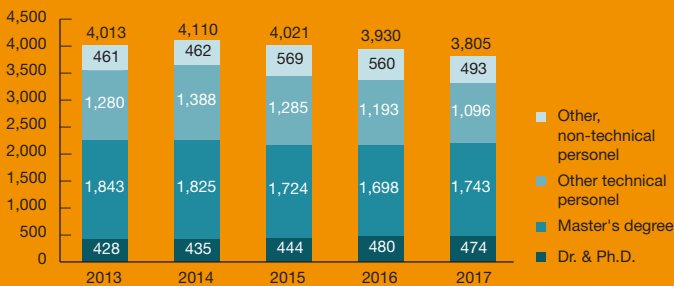
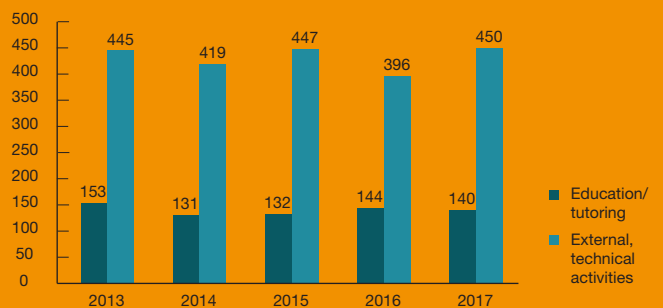
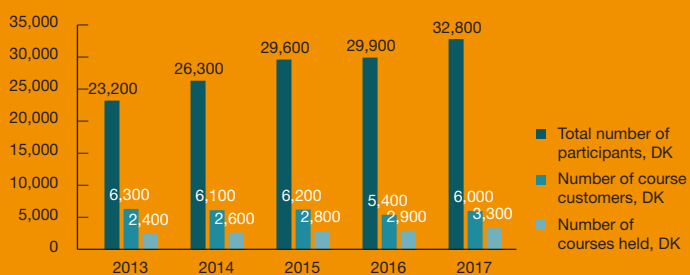


Figure 15: external activities, number of engaged employees



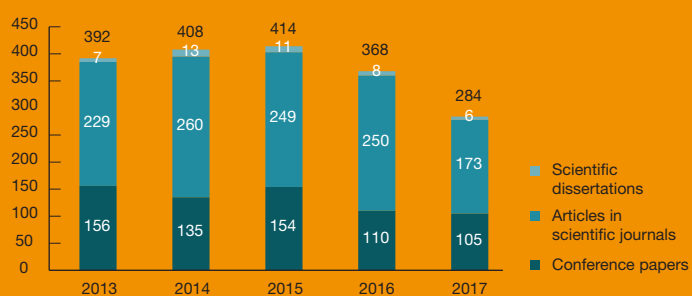
Courses

Figure 16: Course activities



Visibility and publications

Figure 17: Number of publications



Conference papers include articles written for and presented at academic conferences. The articles can subsequently become articles in journals. Articles in scientific journals have been evaluated by a scientific committee. Scientific dissertations include PhD dissertations and doctoral theses.

Patents, licenses and spin-offs

Table 4: Number of patents, patent-applications, licenses & spin-offs

	2013	2014	2015	2016	2017
Number of patent-families	95	82	106	100	91
Patent applications	11	13	16	15	10
Licenses	47	53	45	43	30
Spin-offs	2	5	2	3	8

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The seven Danish Research and Technology Organization (GTS-institutes) play an indispensable role in the Danish innovation system. Their core function is to deliver technological knowhow and expertise to private businesses and to public institutions, thereby increasing the innovation and competitive power of both business and society through the accelerated adoption of technology.

This performance statement offers an introduction to the GTS institutes and their key role within the innovation system, as well as an insight into the work of the institutes and their performance over the past five years. Key statistics and case studies illustrate in concrete terms how the GTS institutes work in collaboration with Danish businesses.

The performance statement is structured in terms of an effect chain which emphasises how the GTS institutes' work accelerates technology adoption in Danish businesses at all levels – from knowledge building, to developing new technological services, and ultimately to creating results by driving societal and business change in Denmark.

This document is a translation of the Performance Statement of the GTS Institutes 2018, derived from the GTS institutes' Annual Report to the Danish Agency for Institutions and Educational Grants. It is a shortened and adapted version intended for an international audience.

We wish you a pleasant reading experience.

For additional information on the GTS institutes, please go to:

www.gts-net.dk
www.ufm.dk
www.bedreinnovation.dk

The GTS institutes are:

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