

Denmark, a **Powerhouse** of Robotics and Automation

By Carsten Steno
& Malene Grouleff



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By Carsten Steno and Malene Grouleff, 2020

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Design, cover illustration, infographics and production: Helene Ingerslev, Wet DesignerDog

Translation: Rikke and Bill Fryman

Printing: Toptryk Grafisk A/S, Denmark

1. edition, 1. print

Published by Robot Books I/S

On comission with Forlaget Underskoven

ISBN : 978-87-93804-16-6

Authors' Foreword

Denmark is a small country with a population just shy of six million people. Yet within the last 10 years, Denmark has become home to one of the world's most successful robotics and automation industries.

The cluster of robotics and automation companies in Denmark has achieved critical mass and competes toe to toe with the giants of the robotics world in the USA, Germany, Korea and Japan. Danish robot manufacturers, integrator companies and suppliers work very well together. Moreover, unlike many of the other clusters around the world, the Danish robotics cluster is not specialized to support any one particular industry, such as automotive manufacturing.

This means that Danish robotics companies are in a strong position to provide flexible, complete solutions for production companies around the globe and in any industry. In addition, Danish companies are developing service robots for use outside the factory floor.

Robotics as an industry is growing in Denmark and the rest of the world as new robotics technologies are gaining momentum in multiple disciplines and a variety of industries.

As edits to this book were concluding in March of 2020, the robotics industry in Denmark and internationally was experiencing a slowdown in demand, especially from the automotive industry, which is making the switch to electric cars. At the same time, China, which is both a major purchaser of robots and a supplier of components to the robotics industry, was experiencing an economic contraction as it struggled to stop the spread of the corona virus.

The infection later spread to Europe and the rest of the world with significant societal and business consequences. Obviously, the robotics industry was also affected.

And while short term forecasts for robotics technology sales had to be adjusted, most analysts agree that, even with a long-term recession, demand for flexible robotics technologies will increase, so that production could respond to fluctuating demand. This could be beneficial for the Danish robotics industry in particular. In the years following the financial crisis, the number of robots increased significantly in Denmark.

How has Denmark created such a strong robotics and automation industry? What are the strengths and weaknesses of the Danish robotics cluster? What companies and institutions make up the cluster, and how do they contribute to its success? These are questions being asked more and more around the world. This book intends to provide the answers.

The book came to fruition after many conversations with the cluster's most important players and industry experts and exhaustive research. We are extremely grateful for all their input and time. The opinions expressed within these pages are solely those of the authors.

We hope that the book will be enlightening and inspiring for anyone interested in the international robotics and automation industry.

Copenhagen / Aarhus on the 6th of March 2020
Carsten Steno and Malene Grouleff

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Three hundred companies – \$4.5 billion

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The fear that robots will completely take over our jobs is groundless. In Denmark, trade unions are asking for more robots. Businesses and the Danish government have answered by playing an active role in developing the robotics cluster.

A self-driving disinfection robot is positioned in the center of a hospital room. The robot is white with a prominent vertical column of four bright blue UV-C light tubes. It has a low profile and is on wheels. The room is dimly lit, with the primary light source being the robot's UV-C lamps. In the background, a hospital bed is visible, along with medical equipment and a window with curtains. The floor is a light-colored, polished surface that reflects the robot's lights. A white text box with a thin black border is overlaid on the left side of the image, containing text about the robot's use in hospitals. A white line points from the text box to the robot.

Self-driving Danish disinfection robots are used at hospitals in 40+ countries. The invention increases the safety of both staff, patients and their relatives by reducing the risk of contact with bacteria, viruses and other harmful microorganisms.

The Robots Are Coming - From Denmark!

In less than 10 years, a Danish cluster of automation and robotics companies has captured a strong position on the world map. How did a small nation with only six million citizens manage such a feat? The secret lies in an interdisciplinary approach, mutual trust, demanding customers, creativity and a very pro-robot population.

On May 22, 2019, a jubilant Dane, Claus Risager, stepped down from the stage at Palais des Congrès in Montreal, Canada. At the Innovation and Entrepreneurship in Robotics and Automation (IERA) Awards honoring science-industry collaborations in the field of robotics, his company, Blue Ocean Robotics, had just won the award of the year. Who wouldn't be happy? The IERA Award is awarded by The International Federation of Robotics (IFR) and The IEEE Robotics & Automation Society (RAS), the world's largest professional technical organization with some 420,000 members in more than 160 countries.

The award went to the company's UV Disinfection (UVD) Robot; a mobile disinfecting robot that increases patient safety in hospitals by reducing the risk of contracting infections. It won after fending off an effort by Mobile Industrial Robots (MiR); another Danish-based robot manufacturer with a mobile transport robot that automates internal logistics in the healthcare, manufacturing and logistics industry. The UVD Robot that won actually uses a mobile platform component developed by MiR.

MiR has received numerous other international awards, the likes of which have rained down on automation companies and robot manufacturers from the small Scandinavian country way up north.

Not just directed at service robots like the UVD and MiR, but also robots and automation solutions for industrial companies working hard to rapidly digitize their production according to the concepts of Industry 4.0.

This is also true for one of the Danish flagships, Universal Robots (UR), whose six-axis flexible col-

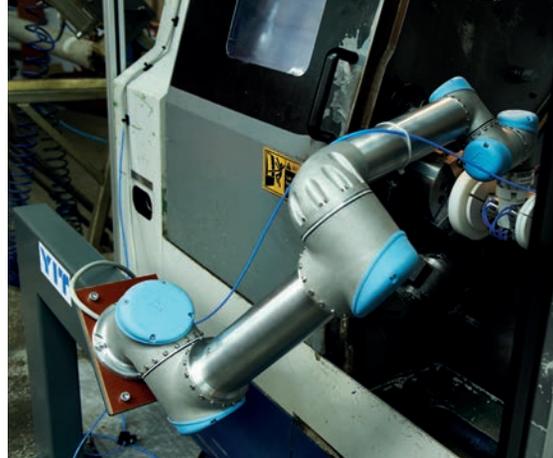


Photo: Universal Robots

In 2008, Linatex installed the first robot from Universal Robots - UR5.

laborative robot was the first to be installed in the world. The flexible collaborative UR robot was installed in 2008 at a Danish manufacturer of plastic components, Linatex, when the company wanted to automate the feed of its CNC machines.

Only this time, instead of installing the robot behind a safety fence, shielded from humans (as has been the case with industrial robots for decades), the UR robot was working side-by-side with the employees. And instead of hiring external programmers for complex programming, Linatex's employees were able to program the robot themselves via a touch-sensitive screen without any prior programming experience.

The UR robots have since been developed and are now called "cobots," short for collaborative robots, noting the concept of the robots working alongside humans. Universal Robots has received many awards, including the internationally recognized magazine, Automation World's "Leadership in Automation First Team Honoree" for three consecutive years. Co-founder and technical director Esben Østergaard won the IERA Award in 2012.

Even the Danish integrator-companies that build complete automation solutions and the Danish research within robot technology receive recognition worldwide.

The integrator aspect in Denmark goes all the way back to the late 1800s when industrialization took off. It was companies such as ProInvent that delivered award-winning automation equipment to a large number of big Danish companies, and Jorgensen Engineering that helped automate international giants in the food industry, e.g. Nestlé and Danone.

Within research and development at higher education institutions, Danish universities have excelled significantly in recent years. For instance,

in October of 2018, Team Robotics from the University of Southern Denmark (SDU) won the unofficial World Cup in industrial robotics, the World Robot Challenge in Japan. They had created their bid for the future flexible robot cell for production. It consisted of two robots from Universal Robots working together on each side of a cobot workbench, developed by Danish Technicon.

Since then, SDU has invested more than \$15 million on a so-called Industry 4.0 Lab that will be part of new groundbreaking research projects and help Danish companies to advance their automation proficiencies.

Other Danish higher education institutions, such as the Technical University of Denmark (DTU), Aalborg

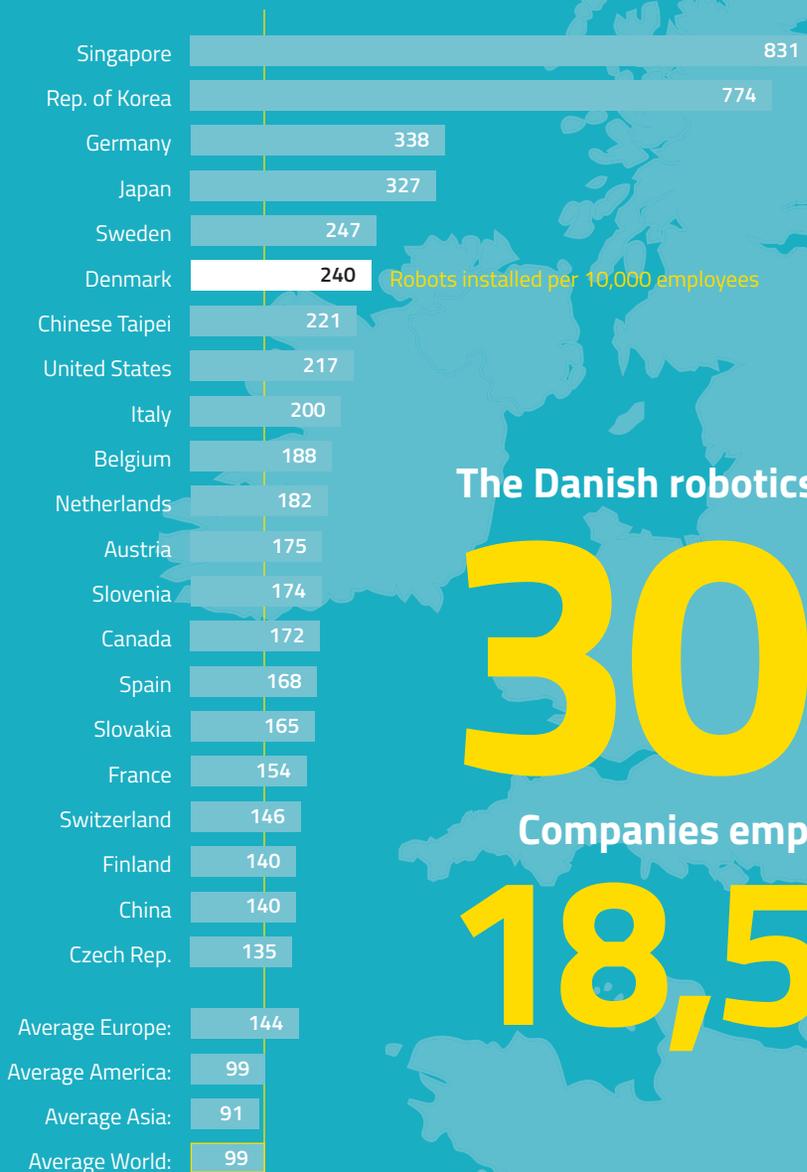


Photo: MiR

Thomas Visti (b. 1974), CEO of MiR

Thomas Visti is a trained electrical engineer and started his career as sales director at Sauer-Danfoss. Subsequently, he has twice shown that he can develop and continuously execute on an ambitious growth strategy. First, as a VP of Sales and Marketing, he played a key role in Universal Robots from 2009 to 2014. During that time, he soon established an international distribution network and offices worldwide and the company's global revenue grew from \$.5 million \$15 million. He was well prepared when he joined the newly established MiR in 2014 as CEO and principal shareholder, and in a few years, he and his team geared the company to global success. Teradyne saw the potential in MiR and bought the Danish company for \$256 million in 2018.

Robot density in the manufacturing industry 2018



DENMARK

6 million inhabitants

16,600 square miles

● 335 square miles of airspace dedicated to drone flights

The Danish robotics industry:

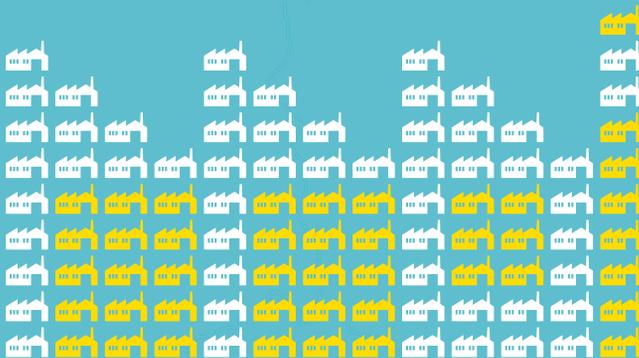
300+
companies

Companies employing
18,500
people

Danes Embrace Robot Technology

Danish workplaces automate at breakneck speed. There are 240 robots per 10,000 employees in Denmark. The world average is 99. Denmark has one of the most pro-robot nations in the world.

44% of all Danish manufacturing companies use robots, according to the Danish Technological Institute.



University, and Aarhus University are also focused on researching robots and automation.

At DTU, experts are on the cutting edge of developing fault-tolerant control, a way to calculate algorithms in the control loop so that they can withstand a sensor failure without the control itself lapsing. This is a mission-critical step in the development of autonomous vehicles, for example.

At Aalborg University, a research team has developed a whole new robot type, that moves about on a ball. It should get all the app developers jumping to contribute with ideas for how the robot can help with directions, searching and more.

It is a far cry from a traditional development program identifying a project or a problem that a robot needs to solve, and then developing an application that can solve that particular task. Instead, the goal of their project is to develop an app-based platform that has to solve two well-known challenges with apps and robots.

The first challenge is to get users to actually use the services already developed into apps. The ball robot, whose face is a tablet computer, simply brings the app directly to users, such as customers at a mall or relatives visiting patients at a hospital looking for directions.

The second challenge is the lack of engineers with a knowledge of robot development. In creating a platform, that challenge is overcome by making the project available to app developers on a large scale.

Danish universities and colleges are also trying to solve the lack of robotic and automation engineers and forecast for future needs by educating an increased number of engineers and technicians with cutting edge skills. Universities and colleges are therefore also included in the Danish robotics cluster.

A cluster with deep roots and strong growth

The robotics cluster has roots far back in Danish industrial history, but has experienced exponential growth within the past decade.

Today, the cluster consists of around 300 companies throughout Denmark. Research, development, and production for the global market has already created 8,500 jobs. With an annual \$2.7 billion in revenue and exports accounting for more than \$1.5 billion, Denmark is in prime position to expand its dominance in this business sector.

Including subcontractors, the cluster employs even more: 18,500 employees, with a revenue of \$4.4 billion. With mobile and industrial robots working beside people, Danish companies command an impressive global market share of more than 50 percent.

In addition to the 300 companies in the cluster, there's also a growing number of business angels and institutional investors who are interested in scaling Danish robotics companies to gain critical mass on the rest of the world stage. They are keeping a close eye on the Danish startup scene, where robotics and automation companies have become more prevalent, even though industrial and service robots are costly and harder to introduce globally.

than software robots. This is due, in part, to robots and automation requiring deep skills in multiple facets, including software, electronics and mechanics. Sales and service also require a significant setup effort.

An example of a business angel and venture fund-investment is the drone startup QuadSat. The company has developed a technology that can reduce the noise from the many satellites in space, allowing the navigation systems in aircraft, ships and cars that rely on proper and fast satellite communication, to work optimally.

QuadSat's technology allows drones to test and calibrate antennas for satellite communications autonomously, thus ensuring a constant flow of high-speed Internet.

QuadSat utilizes the University of Southern Denmark's new drone lab as part of the Hans Christian Andersen Airport near Odense on the island of Funen. At the facility, researchers are able to experiment with drones in the surrounding airspace reserved for testing drones as part of Denmark's national drone strategy with its 327 square miles of its airspace dedicated to drone flying. The airspace is one-of-a-kind internationally as it gives drone companies the opportunity to fly farther and fly above the sea.

The national drone strategy, in part, answers why the robot and automation industry in Denmark has grown dramatically in recent years. This important development is backed by competent and flexible authorities playing a significant role in the environment that has helped shape the industry.



Photo: Combine

Polaris, an interactive robot that moves about on a ball, was developed to offer a new way to assist customers as a guide or provide information in public facilities, such as airports. Six entities are collaborating on the development of the ball robot: Combine, MapsPeople, Det Gode Firma, The Danish Technological Institute and the University of Aalborg.

The full answer to the questions remain elusive. Just how did a small country like Denmark achieve a leading role in a drastically growing global robot and automation market? How is the Danish robot industry able to keep ahead of the rapid technology development of artificial intelligence (AI), machine learning, 3D printing and big data? How long can translating opportunities into solutions that provide the global industry with the tools needed



Eleven robotics researchers from University of Southern Denmark are among the world's best in industry robots. The team, SDU Robotics, won within the category of industry robots at the World Robot Challenge in Japan in 2019. Together, they have created their proposition for the robot production cell of the future. And they have done this so persuasively that among 250 applicants from all over the world then won the competition. The Winning Team from SDU Robotics is Christian Schlette, Christoffer Sloth, Iñigo Iturrate San Juan, Henrik Gordon Petersen, Dirk Kraft, Frederik Hagelskjær, Simon Mathiesen, Thomas Nicky Thulesen, Anders Prier Lindvig, Aljaz Kramberger and Mads Høi Rasmussen.

to produce this kind of flexibility be sustained as a business model?

The benefits of a small country

Nigel Edmondson is the head of the association MADE (Manufacturing Academy of Denmark), a national network of advanced production conducting research and innovation within the usability of flexible automation and robots.

He points out that Danish universities and colleges have an application-oriented approach to research

in advanced production. Moreover, Danish society is built on a high degree of trust, which makes it easier to share knowledge.

At MADE, big and small companies work together to develop new automation solutions using inspiration from the research community. Also, Denmark does not have one dominant industry, in which big companies are watchful competitors, e.g. Germany's automotive industry. The majority of Danish companies operate in global niches. It makes it easier for them to collaborate.