Defense Innovation Technologies

Team Sweden Case Studies

SOFF

Team Sweden – a trusted technology partner

Cover photo: SOFF, Försvarsmakten

THE UNITED STATES provides the gold standard of the defense technology sector and is determind to continue to do so well into the future. As it embarks on a third offset strategy – commonly referred to as the Defense Innovation Initiative – to maintain and advance its preeminence in military affairs, Team Sweden stands ready to assist with knowledge and technology to the extent that the United States finds it useful.

This is in our enlightened self-interest, as the strengths and resources of the United States are a force for good in world affairs. The United States plays an indispensable role to uphold the values and principles of a liberal international order and remains the bedrock of the European security structure. Due to the deteriorating security environment in Europe's eastern and southern neighborhoods, the role of the United States as a European power is more important now than ever before in the post-Cold War era. Thus a forward-looking approach from the United States to defense innovation is clearly in Sweden's interest.

Being a small country of only 10 million people, Sweden is rather well adept to be a partner for innovations in general and for defense innovations in particular. We like to think that we punch above our weight in this sector.

Innovation starts with ideas and knowledge. To support it, Sweden has the most PhDs in the world per capita, in technical and natural-science subjects and the second most who work in this area.[1] Sweden also tends to score well in international comparative surveys on innovation.[2]

The Defense Innovation Initiative emphasizes the importance of of engagement with the commercial sector. In this regard, Sweden has a rather unique industrial landscape. No other country of a similar size, possibly with the exceptions of Switzerland and Israel, has so many large high-tech multinational companies. ABB, Atlas Copco, Electrolux, Ericsson, Saab, Scania, Securitas, SKF and Volvo are cases in point.

The resource limitations that come from being a small country has led us to work very closely within the Triple Helix model where industry, academia and government agencies work hand in hand on cost-efficient innovation models. Within this Triple Helix, there is

Anti-Access/Area Denial

Anti-Access/Area Denial capabilities reinforce the need for defense innovations to counter the development of advanced systems or, as the satellite images shows, activities that change the balance of power.

Sweden's ranking

- **#1** in the **Knowledge Index 2012** (The World Bank)
- **#1** in the **Innovation Capacity Index 2011** (European Business School)
- **#1** in the **Innovation Union Scoreboard 2013** (EU Commission)
- **#1** in the **Global Creativity Index 2011** (Martin Prosperity Institute)
- **#2** in the **Global Innovation Index 2013** (INSEAD)
- **#3** in **World Economic Forum's Global Information Technology Report 2013**, which measures how well countries take advantage of ICT and new networking technologies. More than 90% of Swedes are connected to the internet.

Sweden is one of the top foreign direct investors calculated per capita.

Photo: Willbrasil21/iStock/Thinkstock

intensive collaboration on the technologies connected to the Fourth Industrial Revolution such as artificial intelligence, robotics, Big Data and the Internet of Things.

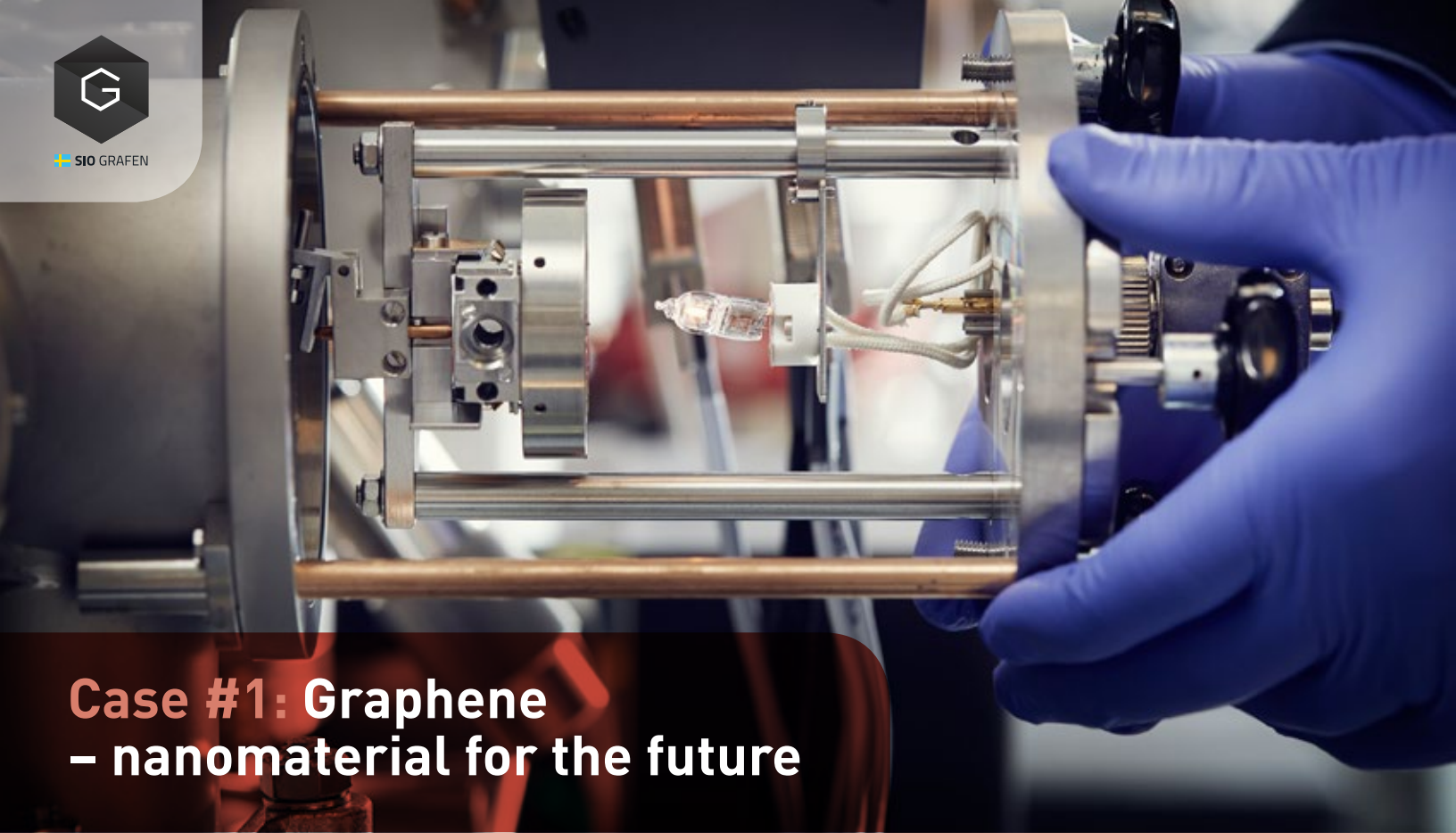
Neither is there any other country in the world of comparative size with a defense industrial base that can design and produce platforms such submarine, advanced radar systems and fighter aircrafts. However, none of this would be possible if it were not for the strong transatlantic link that Sweden maintains with the United States. A strong bond across the Atlantic and technology transfer have been indispensable parts of the Swedish defense industrial base. Sweden has also been fortunate to enjoy strong US support in this area. After the United Kingdom and Germany, Sweden has been the largest recipient of funding from the Foreign Comparative Testing Program during the last decades.

Now, as the United States is in part entering a new chapter by launching the Defense Innovation Initiative, Team Sweden stands ready to support it. We think that the ability to provide a combination of strong commercial and defense sectors puts us in a good situation to do so. The short presentations enclosed intend to provide innovation snapshots, and we hope to contribute with evermore – as a trusted technology partner to the United States. The technology areas has been selected by their ability to match up to the Defense Innovation Initiative particularly in the areas nanotechnology/miniaturization, automation and Big Data.

Early partner

On April 3, 1773, Benjamin Franklin and King Gustav III of Sweden signed The Treaty of Amity and Commerce, which was the first treaty signed by the U.S. with any nation not directly involved in the Revolutionary War. Therefore, Sweden became the first neutral nation to officially recognize the young American republic.

1 OECD Science Monitor 2012.
2 Sweden placed number one in the world in recent time on all of the following global surveys: Innovation Union Scoreboard, Global Innovation Index, Innovation Capacity Index, Knowledge Economy Index, Networked Readiness Index, Global Creativity Index.



Case #1: Graphene – nanomaterial for the future

Photo: Chalmers

What is this technology area all about?
The wondermaterial graphene is an atom-thick layer of carbon which was awarded with the Nobel Prize in 2010. It has a number of extraordinary properties: graphene is transparent, impermeable to gases and moister, bendable, strong, super thin, electrically and thermally conductive.

How could this technology be applied?
The startling properties of graphene could impose a variety of solutions for technical challanges like bendable transparent electronics including displays and batteries, multifunctional composites with thermal and electrical conductivity, high-performance sensors, barrier layers in packaging materials, biomedical electrodes, water purification, to mention a few. One specific area is multifunctional light composites that is of high interest for airplanes and other vehicles, where added functionality could be aniti-icing, heat dissipation, protection towards lightning and radiation, sensors, etc. Graphene is an emerging technology and it is most likely that the main impacts will be in the form of applications in other areas such as Life Science, Energy and ICT.

How could this technology be applied to the defense sector?
Possible product segments in the security and defense areas are:

- Lightweight electronics, displays and batteries;
- Signature management in IR region;
- Multifunctional composites – leightweight, anti-icing coating, protective coatings, sensors;
- Ultrafast and highly sensitive sensors;
- Lightweight vehicles;
- Protective equipment, ballistic vests.

How does this technology match up against the Defense Innovation Initiative?
The Defense Innovation Initiative has identified miniaturization and nanotechnologies as especially relevant for future defense technologies. Sweden has a world-leading position in this area. We are the host of the European Graphene Flagship Project due to our advanced research and development in this area. Sweden also has a strong industry base eager to collaborate with researchers to use the material in future products.

What Technology Readiness Level are we talking about?
Most effort in the graphene area so far lies in TRL 1–6. There are a lot of ongoing activities in companies where graphene is a part of demonstrator projects, in Europe as well as in the US and Asia. Displays, coatings, composites and sensors is among those areas where we believe that most products will appear in the near future.

What are the thresholds against further advancement?
Industry and academia need to be working closer together, scaling up the academic results into real products and industrial production. Standardization – characterization of different graphene materials and grades is needed (and ongoing). This will help both buyers to find the right material and suppliers to start manufacturing in a larger scaler.

Health and environment knowledge (making sure graphene-based materials are not toxic/harmful) is ongoing work, but needs to be further investigated for each new product.

Helena Theander, Director, SIO Grafen

Case #2: Detection of nuclear activities using noble gases

Photo: Tolga TEZCAN/iStock/Thinkstock

What is this technology area all about?
The ability to remotely monitor nuclear activities is vital to national and international security. All activities involving nuclear fission, such as nuclear explosions or reactor operation, produce significant amounts of radioactive noble gases, which are much more difficult to contain than other radioactive substances. Technologies to detect these gases can therefore provide useful information. The technology involves remote detection, location, and characterization of activities involving nuclear fission, or handling of material containing fission products.

How could this technology be applied?
Any activities involving nuclear fission can be monitored. The technique can for example be used in emergency preparedness, and to monitor normal reactor operation. It can be used to detect sources up to several thousands of kilometers away. This is achieved through very sensitive measurement equipment in combination with analysis of state-of-the-art atmospheric transport calculations and modelling of release scenarios. Sensor equipment, and to some extent location and source characterization methods, are already being used in the area of nuclear explosion detection. But if further developed, it has the potential of being used in other applications. Future development plans at FOI include small and mobile detection units, and improvement of analysis algorithms.

How could this technology be applied to the defense sector?
No other technology exists that can show the nuclear nature of an underground explosion. For this reason, it is used in treaty verification on a global scale. Systems developed by FOI and marketed by the company Scienta SAUNA Systems AB are deployed at more than 30 sites globally, including several in the US. In 2006, it was used by FOI to prove the nuclear nature of the first test explosion performed by the DPRK. The development of smaller and more robust units would improve the possibility to more effectively target specific facilities, suspected to contain reactor operation of special interest, production of certain radioactive materials, or reprocessing of nuclear fuel.

How does this technology match up against the Defense Innovation Initiative?
Detection of nuclear activities is crucial in the work against the proliferation of WMD. The Defense Innovation Initiative emphasizes the integration of relatively mature technologies that could be applied to the defense sector in a short time frame. This could be an example of such a technology. Source location and characterization analysis would benefit from techniques such as pattern recognition and neural networks.

What Technology Readiness Level are we talking about?
The stationary detection systems are around TRL 8. The mobile detection units are at TRL 3–4. The associated analysis algorithms need further development to improve from a current TRL of 5–6.

What are the thresholds against further advancement?
Data-analysis techniques need more R&D compared to the detection systems themselves. The main challenges include obtaining better source location techniques in combination with an optimized measurement strategy. This requires cooperation between the nuclear detection community and meteorological expertise. A better understanding of the basic physics related to nuclear signatures is also needed.

Anders Ringbom, Research Director, FOI

Case #3: Autonomous systems – heterogeneous interacting smart systems

Photo: Saab

What is this technology area all about?
Autonomy includes, in a wide sense, the development of continuously smarter computer systems and their interaction with their environment. Important areas are:

- Observation by combination of information from various sources;
- Planning and analysis of possibilities to act;
- Reasoning and decision making in collaboration between system and humans;
- Acting such as autonomous driving of a vehicle, unmanned aircraft, mining activity, or tactile interaction with a human user.

Taken together, this means that various (heterogeneous) systems are interacting to solve tasks in a smart way together with humans.

How could this technology be applied?
Applications of interest include:

- Smart city – better support to the society regarding, for instance, green and efficient transports and logistics, efficient infrastructural maintenance and coping with emergency situations;
- Smart industry – more efficient development and production of products and enhanced quality through detailed monitoring and control;
- Smart mining – efficient mining without staff below ground level.

How could this technology be applied to the defense sector?
The technology area is of great importance for development of command-and-control systems, managing systems of systems, as well as various types of unmanned systems. Expected progress the next few years includes, for example, how sensors best could be used to support command-and-control decisions; for instance, how sensors onboard unmanned vehicles can be repositioned to provide optimal information for a decision at hand. This implies reasoning between human users and systems concerning possibilities to act and what corresponding consequences that the action leads to.

How does this technology match up against the Defense Innovation Initiative?
The development of autonomous systems is central to managing future complex conflict situations and is, hence, pointed out as a primary area in the defence innovation initiative. Today's development is primarly focused on efforts for civil applications. An important example is WASP, where management of public safety and emergency situations is of high civil relevance, and also generates knowledge and solutions with military relevance.

What Technology Readiness Level are we talking about?
Solutions exist on every TRL level. We will see several generations of autonomy pass through all the TRL levels for the coming 25 years.

What are the thresholds against further advancement?
Aspects such as security, availability, robustness, and resilience need to be handled differently to make full use of the technological possibilities. Enhanced cooperation between the system cognition and human intelligence, regarding potential benefits and costs, is important – for example enabling manned and unmanned air traffic to share airspace in a safe and efficient manner.

Lennart Sindahl, Deputy CEO, Saab

Recorded Future

Case #4: Big data analytics for the future

Photo: Ahmed Abd El-Fatah from Egypt [CC BY 2.0 (http://creativecommons.org/licenses/by/2.0)], via Wikimedia Commons, Recorded Future

What is this technology area all about?
Big Data Analytics is an area that focuses on applying techniques from statistics, mathematics and computer science (in particular artificial intelligence) to create actionable insight from very large data sets, acquired from various sources. It also includes the tools and techniques such as natural language processing that are necessary to transform open source intelligence into structured data suitable for Big Data Analytics.

How could this technology be applied?
Big Data Analytics is already transforming all aspects of how both governments and industry manage their business. In particular, we believe it will have enormous impact on the area of threat intelligence, allowing defenders to anticipate threats and act proactively, rather than reacting to current threats and ongoing attacks.

How could this technology be applied to the defense sector?
The defence and security community has for a long time understood the value of intelligence. What BDA brings to this community is the ability to analyze data – both open source and other – at a new scale, and to leverage artificial intelligence/machine learning to create predictive threat intelligence. In the cyber-threat intelligence space, these technologies will be necessary to keep up with the dramatic increase in volume and sophistication of the attackers. For geopolitics, the technology can be key in tracking terrorist organizations like ISIL.

How does this technology match up against the Defense Innovation Initiative?
Big Data has been singled out as areas of great potential to the Defense Innovation Initiative. Big Data Analytics and in particular its applications in threat intelligence are key in giving the US and its allies an advantage in intelligence in the coming decade. As information technology is becoming increasingly accessible to adversaries of all kinds, even more resources need to be spent to keep that advantage. The technology could be used for example to provide intelligence against hybrid threats.

What Technology Readiness Level are we talking about?
Big Data Analytics products exist all across the upper TRL scale today, from 5 to 9. Research (TRL 1–4) is continuing to provide new technology which will further improve the capabilities of BDA.

What are the thresholds against further advancement?
During the last 4–5 years we have seen the first full-scale systems for Big-Data-Analytics-based Threat Intelligence. Cloud computing and advances in distributed algorithms and storage has reached a level where these systems are feasible to build, but for the next 10x improvement in capability, further advances in database technology, analytics, and information visualization are necessary. For open-source-based threat intelligence, further advances in natural language processing, machine translation, and unsupervised machine learning are also very important.

Staffan Truvé, CTO, Recorded Future

SOFF – the Swedish Security and Defence Association – promotes the common interests of the security and defence industry in order to achieve the best possible preconditions for future business.

SIO GRAFEN

SIO Grafen is a strategic innovation program supporting the industrial graphene development in Sweden.

FOI

FOI is one of Europe's leading research institutes for applied research in the areas of defence and security.

SAAB

Saab serves the global market with world-leading products, services and solutions from military defence to civil security

Recorded Future

Recorded Future is a provider of real-time threat intelligence that helps organizations defend against cyber attacks and other significant threats.