GAN TECHNOLOGY: PUSHING THE ENVELOPE

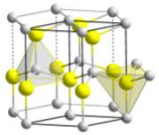
"The Secret of Our Success…"'

Co-funded by Swedish Armed Forces /FMV /EDA /Vinnova

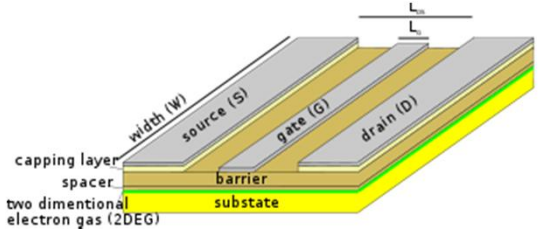
Johan Carlert Saab Surveillance

GAN – NEW BREAKTHROUGH SEMICONDUCTORS

- **GaN = Gallium + Nitride**



- **Semiconductor**
  - **Silicon, Silicon Germanium, Silicon Carbide**
  - **Gallium Arsenide, Gallium Nitride**

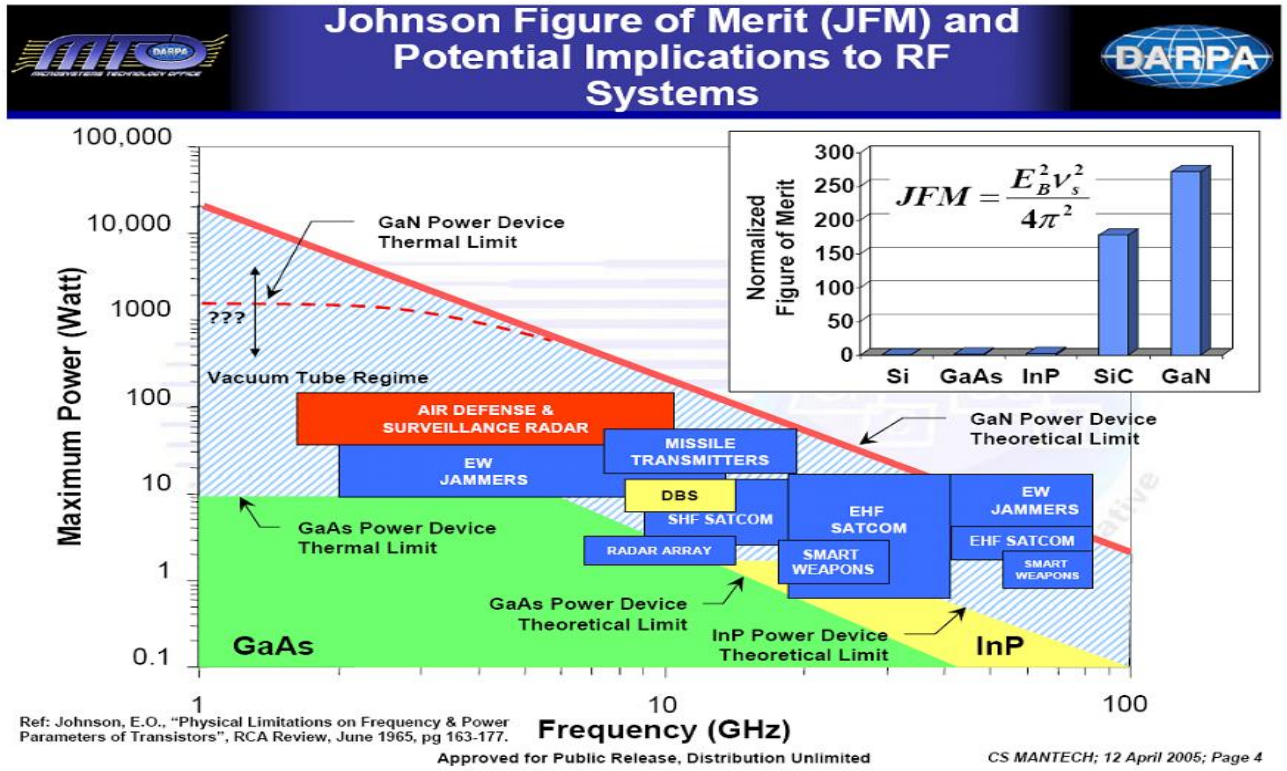


- **Wide bandgap – very high performing**
  - **Robust**
  - **High power**
  - **Large bandwidth**

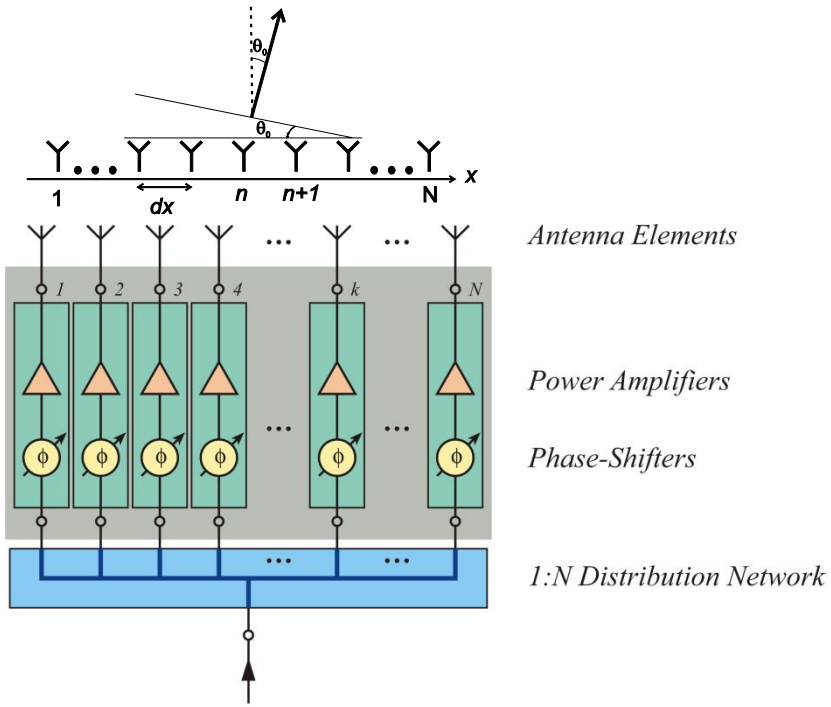
- **Applications**

WHY GAN?

- GaAs and Si are already pushing their limits
  - No room for real improvements (power vs. efficiency vs. size vs. reliability)
- GaN has proved its superiority
  - power & efficiency & size & reliability



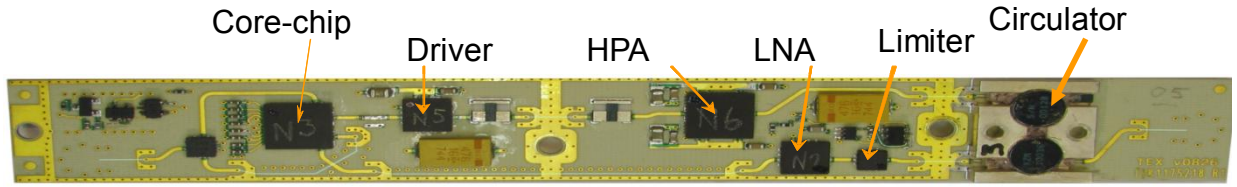
AESA; THE BASICS



- AESA – Active Electronically Scanned Array
  - Active=One transmitter (power amplifier) and receiver (low noise amplifier) per element/module
  - Electronically Scanned=Beam scan using phase gradient
  - Antenna/Array

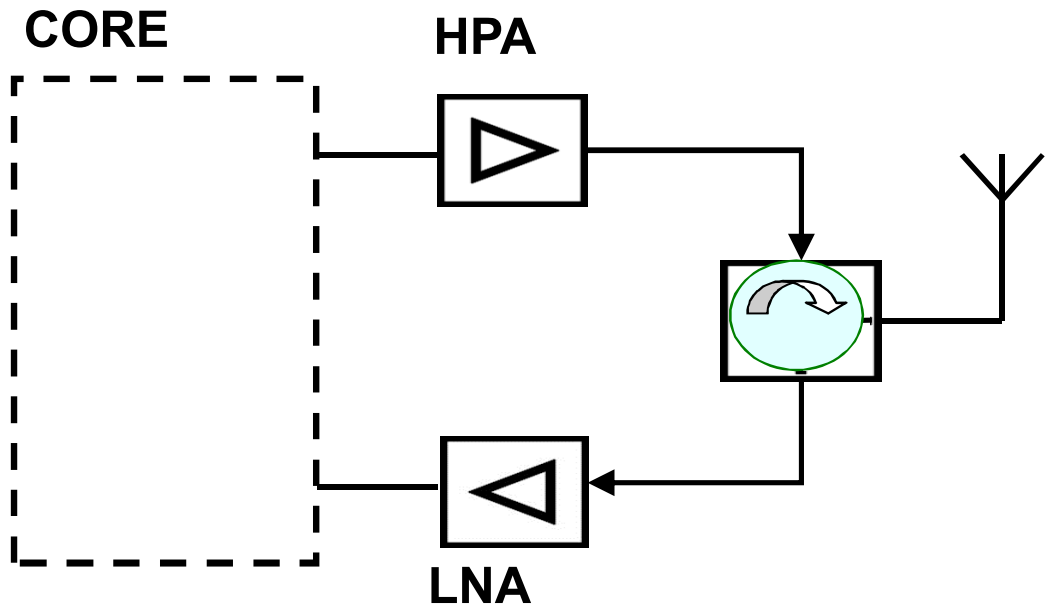
TRANSMIT/RECEIVE (T/R) MODULE

Defines the performance (and cost!) of the whole system



Key building blocks

- **Core-functionality: amplitude and phase control (steering of antenna lobe)**
- **High Power Amplifier (HPA): sets the output power (and thus the range)**
- **Low Noise amplifier (LNA): sets the noise level (and thus the sensitivity)**



FIRST GENERATION AESA-BASED RADARS

X-Band

~20 T/R-modules

Early 90´s

S-Band

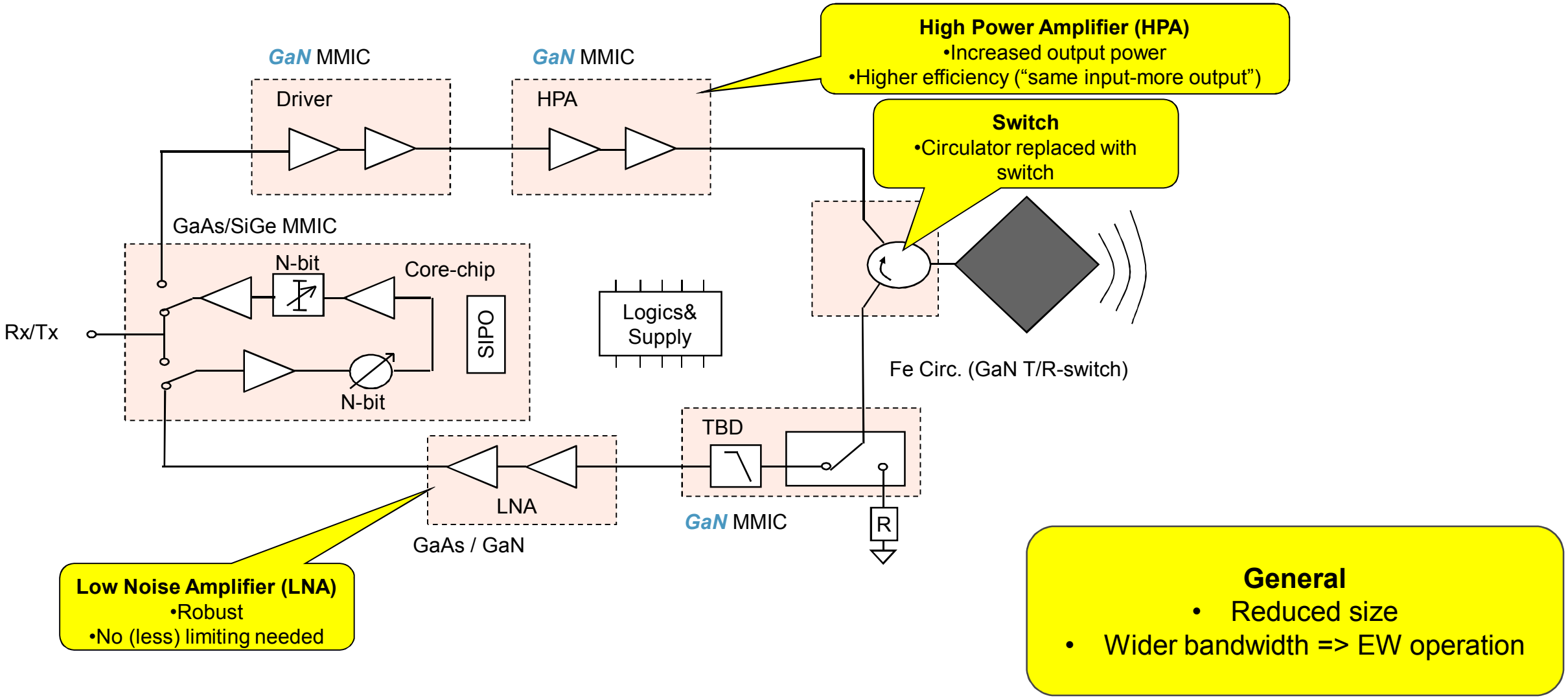
~200 T/R-modules

~2010

X-Band

~1000 T/R-modules

T/R MODULE (R-)EVOLUTION



General

- Reduced size
- Wider bandwidth => EW operation

BREAKING NEWS

Aviation Week May 26/June 2, 2014

”Saab has unveiled a previously closely held program that puts the company ahead of most its larger rivals in the race to field active AESAs based on GaN… The company is deploying GaN in new and expanded range of land- and sea-based radars and EW systems…”

DEFENSE

Material Gains

Saab claims lead in gallium-nitride use

Bill Sweetman Gothenburg, Sweden

Saab has unveiled a previously closely held program that puts the company ahead of most of its larger rivals in the race to field active electronically scanned array radars and electronic warfare (EW) systems based on gallium-nitride (GaN) technology. The company is deploying GaN in a new and expanded range of land- and sea-based radars and in the EW system of the JAS 39E Gripen fighter.

Longer-range [illegible] using GaN are expected to show much better detection performance against stealthy targets than current products, and—in a follow-on development—Saab technologists are looking at teaming active long-range radars with passive receivers, further improving counter-stealth capability. GaN technology likely will also be used in future upgrades of the ErieEye airborne warning and control system.

The first of the new products, the S-band, medium-range Giraffe 4A multi-purpose mobile radar designed for air defense and to provide tracking and warning of artillery, rocket and mortar fire, is already in full-scale development for an unidentified customer, and due for delivery in 2016. One Giraffe 4A has been completed and is undergoing live testing at Gothenburg and on Swedish artillery ranges, and the first tactically configured version will be assembled later this year.

The family will be joined by the long-range Giraffe 8A, designed to detect low radar-cross-section (RCS) targets and tactical ballistic missiles, and the X-band Giraffe 1X, smaller and more mobile than the company's current Giraffe AMB (agile multi-beam) radar. Maritime versions of the 4A and 1X radars are also on offer.

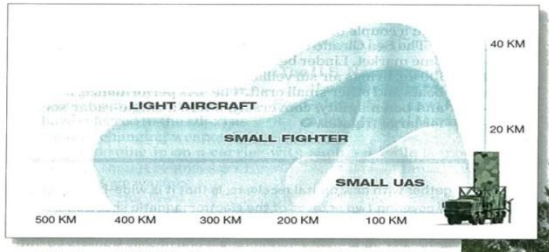
Saab states that the 1X will be available in 2016 if a customer is found, and that the 8A—which is basically a double-sized 4A—could be delivered in 2017. The more technologically challenging electronic attack subsystem for the JAS 39E will be in service in 2023, according to current plans.

All the new radars are due to be available before the first planned U.S.-made GaN radar, the upgraded Northrop Grumman TPS-80 Ground/Air Task Oriented Radar, is scheduled to become operational. (Airbus Defense's TRS-4D is under development for Germany's F125 frigates, the first of which is to be commissioned in 2016.)

GaN-based transmit-receive modules are inherently more efficient than the gallium arsenide (GaAs) components used in today's active electronically scanned array radars, because GaN can run at higher voltages without overheating. The result is greater power and lower noise, increasing range and sensitivity, as well as higher temperature margins, which are expected to improve reliability. GaN also permits wider operating wavebands, which can improve radar resistance to jamming.

The Giraffe 4A and 8A radars are technically very similar: The former has a 2 X 2-meter (6.5 X 6.5 ft.) antenna with 2,000 modules, and the latter is a double-sized derivative with 4,000 modules and a larger power supply. All the radio-frequency components are inside the antenna housings, which have closed-loop primary air cooling (to avoid ingesting dust and salt) with a liquid cooling loop inside the antenna electronics. The antennas have electronic stabilization: because the market for naval radars is small, Saab's strategy is to design its radars to operate on ships with few or no changes.

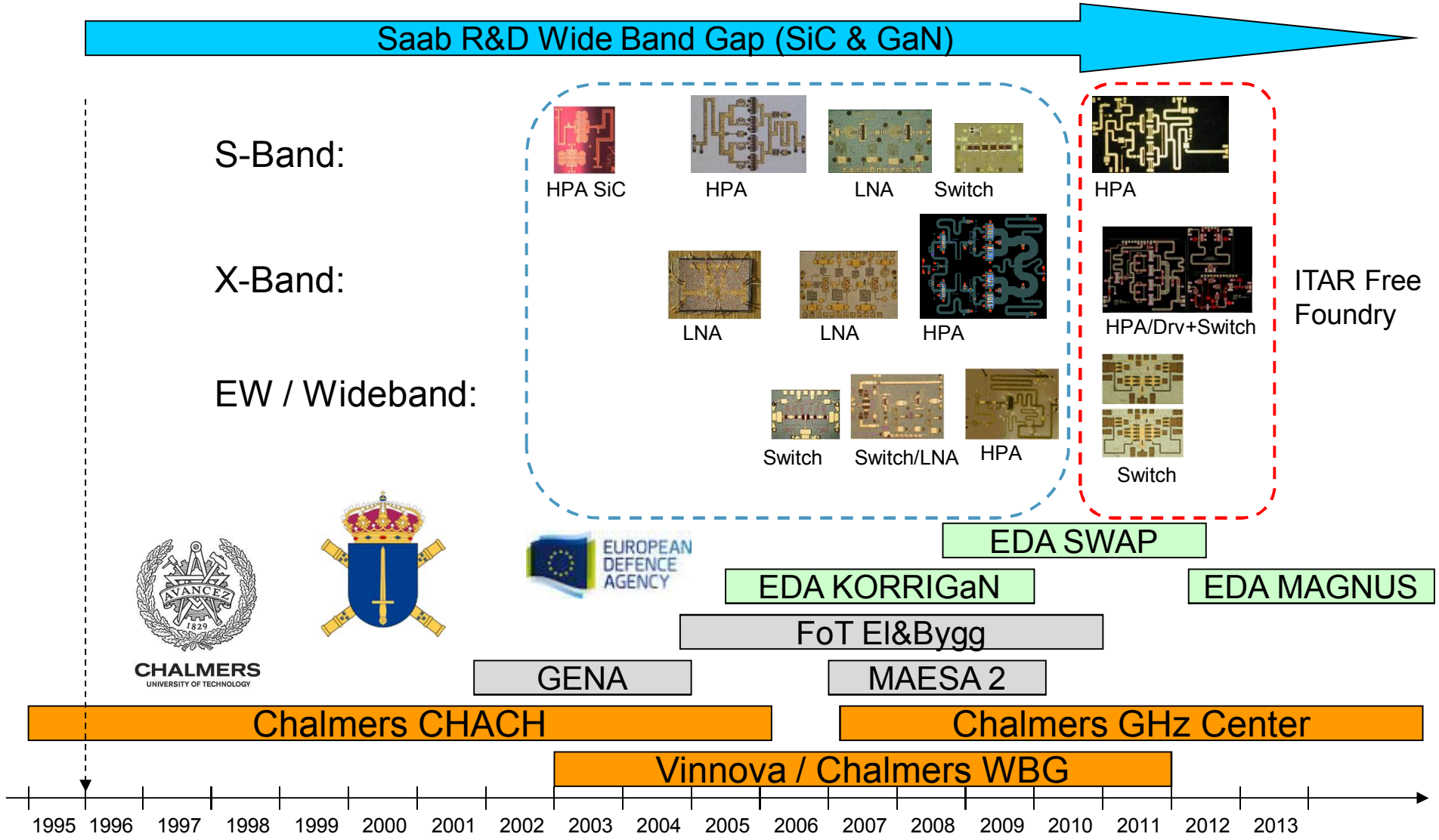
Mobility is important for the Giraffe 4A/8A. The smaller radar is intended to be carried on a standard 6 X 6 truck as a self-contained unit that can be dismounted in the field. It fits in the same envelope as a 16-ft. ISO container. The basic unit



The "small UAS" reference target for the Giraffe 8A radar is also representative of some stealth aircraft. The smaller 4A radar is already under test (right).

SAAB PHOTOS

SAAB WIDE BAND GAP DEVELOPMENT



GigaHertz Centre 2007-2016

An international consortium between Chalmers and leading companies for bringing research advances in microwave engineering and components faster to industry

- **Research topics:**
  - **Si-based transmitters for mm-wave arrays**
  - **Dispersion-free GaN HEMTs**
  - **Low phase-noise integrated GaN oscillators**
  - **THz and very low-noise components**

- **System targets:**
  - **Cellular radio base stations for 5G**
  - **Microwave/mm-wave radio links**
  - **Defense radar systems**
  - **Satellite radiometers**

www.chalmers.se/ghz

MORE FROM THE PRESS…

AVIATION WEEK

- ”One thing we always have been good at is not being hesitant about taking substantial technology steps. We wanted to take a step beyond the first generation AESA. Fortunately, we had a good relationship with Chalmers University of Technology (Sweden´s leading research institute, based in Gothenburg) so we were quite prepared.”

FIRST PERSON

SAAB

MICAEL JOHANSSON

Senior vice president and head of electronic defense systems business area, Saab Group.

Education: Degrees in mathematics and computer science, University of Uppsala.

Background: Joined the former Ericsson Radio Systems as a systems engineer in 1985. Became president of Saab Avitronics, South Africa, in 2008. Appointed to current position in January 2010.

Speed of Light

Radar operations have been part of Saab's business since 2006, when Saab acquired Ericsson's defense division. In 2010, it was combined with Saab's electronic warfare and avionics business to establish today's Electronic Defense Systems (EDS) unit. EDS produces the Giraffe multipurpose radar family and the Arthur weapon-locating radar, as well as electronic warfare systems for the JAS 39 Gripen. In May, Saab revealed a new range of radars based on gallium nitride (GaN) technology (AW&ST *May 26/June 2, p. 65). Senior International Editor Bill Sweetman talked to the electronic unit's leader, Micael Johansson, at the group's headquarters in Gothenburg Sweden.*

Defense Technology Edition: What's the strategy behind the new product line?

Johansson: In 2006, when Saab acquired Ericsson's defense side, the reasoning behind that was a strategic realization that control over sensor technology and situational awareness would be crucial on many of the platforms Saab already had, like the Gripen and the Saab 2000 EriEye. But one leg that was missing was the sensors that would be complementary to the air defense systems on the Saab Dynamics side.

But the "harvest period" for the earlier systems had started, and that delayed investment that should have started a couple or three years earlier than it actually did. One of my first initiatives was to review where we were going with these systems, and how to complement them with new technology and better performance.

We started to see that sometimes technology becomes the customer's key question: Is it a TWT (traveling wave tube) or AESA (active, electronically scanned array)? Even though there may be systems on the solid-state side that are not as good as the TWT systems, it became evident that this was a step we must take.

One thing we always have been good at is not being hesitant about taking substantial technology steps. We wanted to take a step beyond the first-generation AESA. Fortunately, we had a good relationship with Chalmers University of Technology (Sweden's leading research institute, based in Gothenburg) so we were quite prepared.

Will there be future product rollouts on this scale?

You'll see incremental steps every year or every other year. Big steps like this will come in 4-5-year cycles. We continue to work with our sensor developers on the passive side and active side, to see what we can accomplish. There are always things boiling.

Saab as a whole has made a huge change to become export-driven. How has that worked for your products?

The Swedish government challenged us early [after the Cold War] and said: "You have to transform and show that you are competitive on the world market, because we will not be able to support you in the way other countries have supported their defense industries." Of course, we complained a bit in the beginning. But this has been very healthy for us, and we have shown we are very competitive in the international area. Saab sells up to 70% of its products outside Sweden, and certain business areas, like mine, are 85% export. That has generated a lot of income, but also positioned us to help Sweden react quickly when it comes to increasing capability.

How has Saab moved to turn products into technology?

We have a combination of industrial competence from the big Swedish industrial companies, end-user competence and innovative engineers. We focus enormously on modularity, so we not only can build scalable systems but also reuse products, sharing between EriEye and ground-based radars and even the fighter radar technology.

What is the secret to what—from the outside—looks like remarkably rapid product development?

It's teamwork, it's not rocket science. You have to take small steps, using modern development methods such as model-based systems engineering. It sounds like a cliche, but you have to make sure that everyone knows on a daily, weekly and monthly basis what we have to achieve to meet our goals. We have stand-up meetings all the time and we're prepared to change direction and modify our spending if needed. We don't have programs that completely derail. That's because we don't use brute force. We don't throw bunches of engineers into things that are not progressing. You have to have transparency on the team, in terms of who is meeting targets on an individual level. We have an integrated project team, everyone has the plan in their head, and there is no one that can escape from being part of the team. If they're not contributing, they don't have to have a manager telling someone they are not contributing—the team, 99% of the time, will organize themselves.

THE SWEDISH GAN CLUSTER

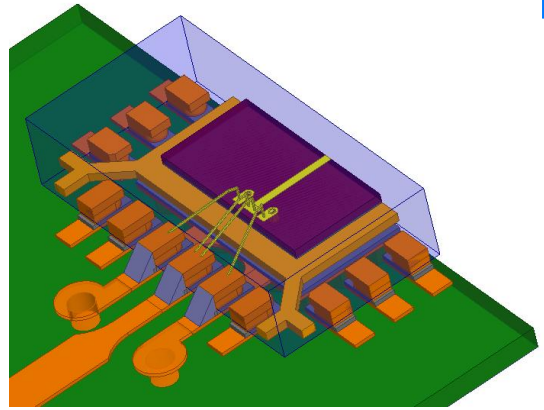
ERICSSON

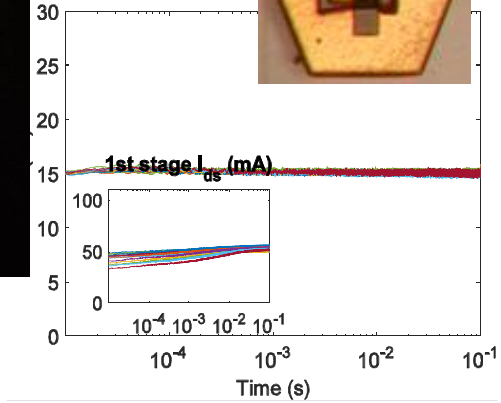
SAAB

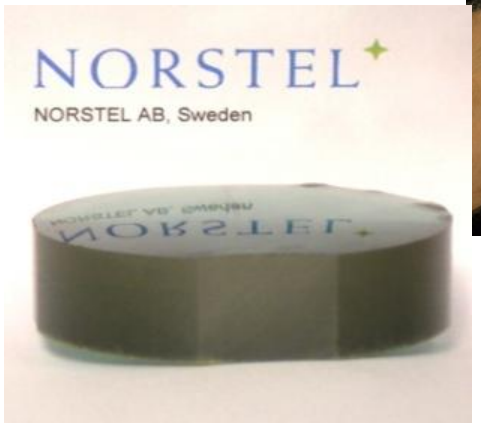
LINKÖPINGS UNIVERSITET

CHALMERS
UNIVERSITY OF TECHNOLOGY

RUAG







ums

Laureate Awards

HOME | ABOUT THE AWARDS | GUIDELINES & NOMINATIONS | FINALISTS & PAST RECIPIENTS | SPONSORS | ATTEND THE AWARDS | CONTACT US

http://aviationweek.com/technology/aviation-week-laureate-award-winners-announced

AVIATION WEEK

Laureate Awards

AVIATION WEEK'S 58TH ANNUAL LAUREATE AWARDS
MARCH 5, 2015 | NATIONAL BUILDING MUSEUM | WASHINGTON, DC

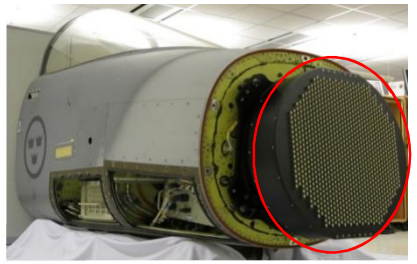
Innovation

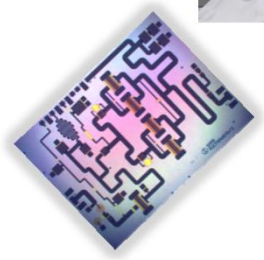
WINNER – Saab and Raytheon!

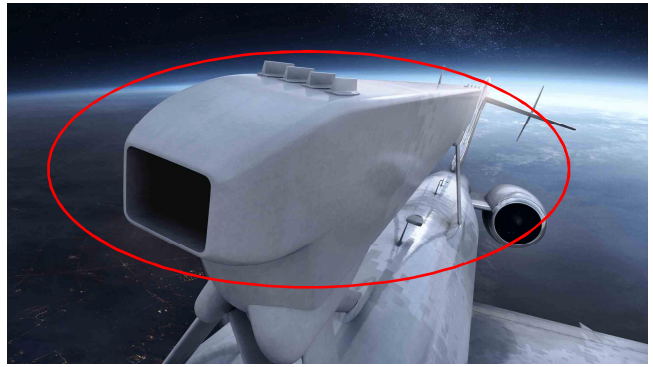
- **Paramount Group**, for development of the first fully indigenous African-designed and -built military aircraft
- **Raytheon and Saab**, for their different approaches to bringing gallium nitride power electronics to military radar and electronic-warfare systems
- **Rockwell Collins**, for expansion of its Pro Line Fusion civil avionics system into military aircraft and unmanned aerial systems
- **Textron**, for business innovation, led by private-venture development of the Textron AirLand Scorpion military jet

UNPARALLELED PARALLEL GaN DEVELOPMENT

- Robust and rapid development based on long term synergistic Swedish development AND early adaption in system/sub-system development
- AESA GaN MMIC introduction enables significantly
  - Improved Performance (Power and efficiency)
  - Miniaturization (size and weight)
  - Improved robustness (temperature and MTBF)







SHEPHARD

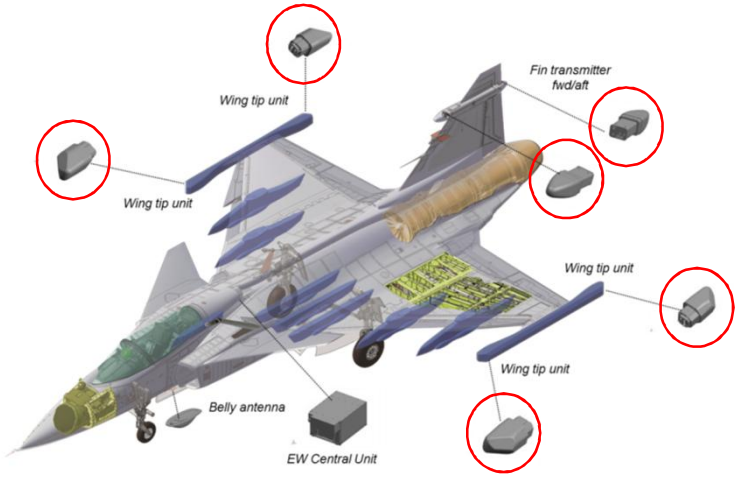
DIGITAL BATTLESPACE

Saab expands Giraffe radar family

13 May 2014 - 8:11 *by* ***Beth Stevenson*** *in Gothenburg*

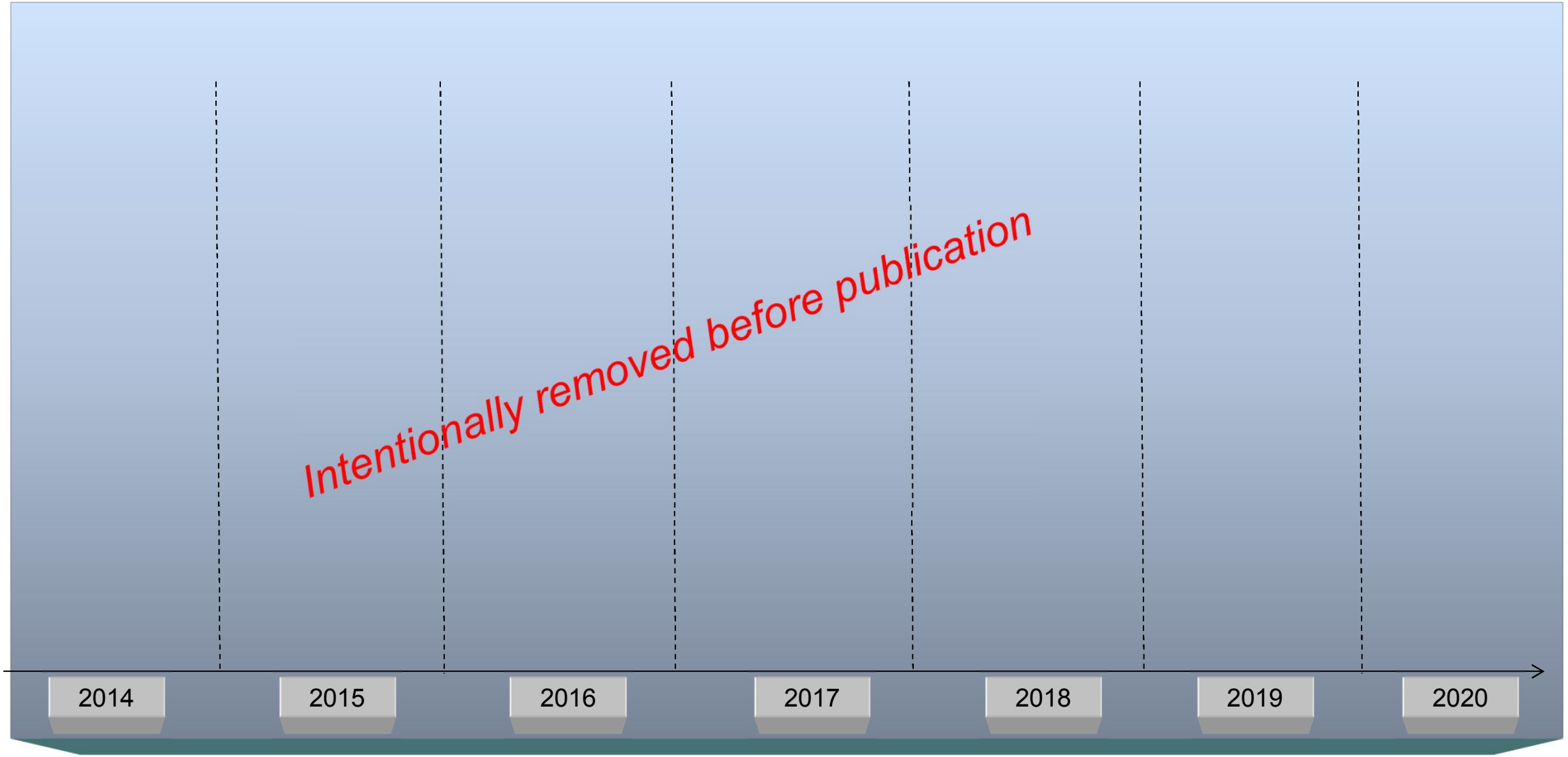
Saab has introduced five new additions to its Giraffe surface radar family, including AESA technology for sea and land applications, the company has revealed.

Launched during a media event in Gothenburg, Sweden on 12 May, the new systems include three land-based Giraffe radars and two naval Sea Giraffe systems.



SO, WHERE DO WE GO FROM HERE?

GAN EXPLOITATION ROADMAP



WIDEBAND CHIPSET OVERVIEW

Intentionally removed before publication

WB Transceiver MMIC

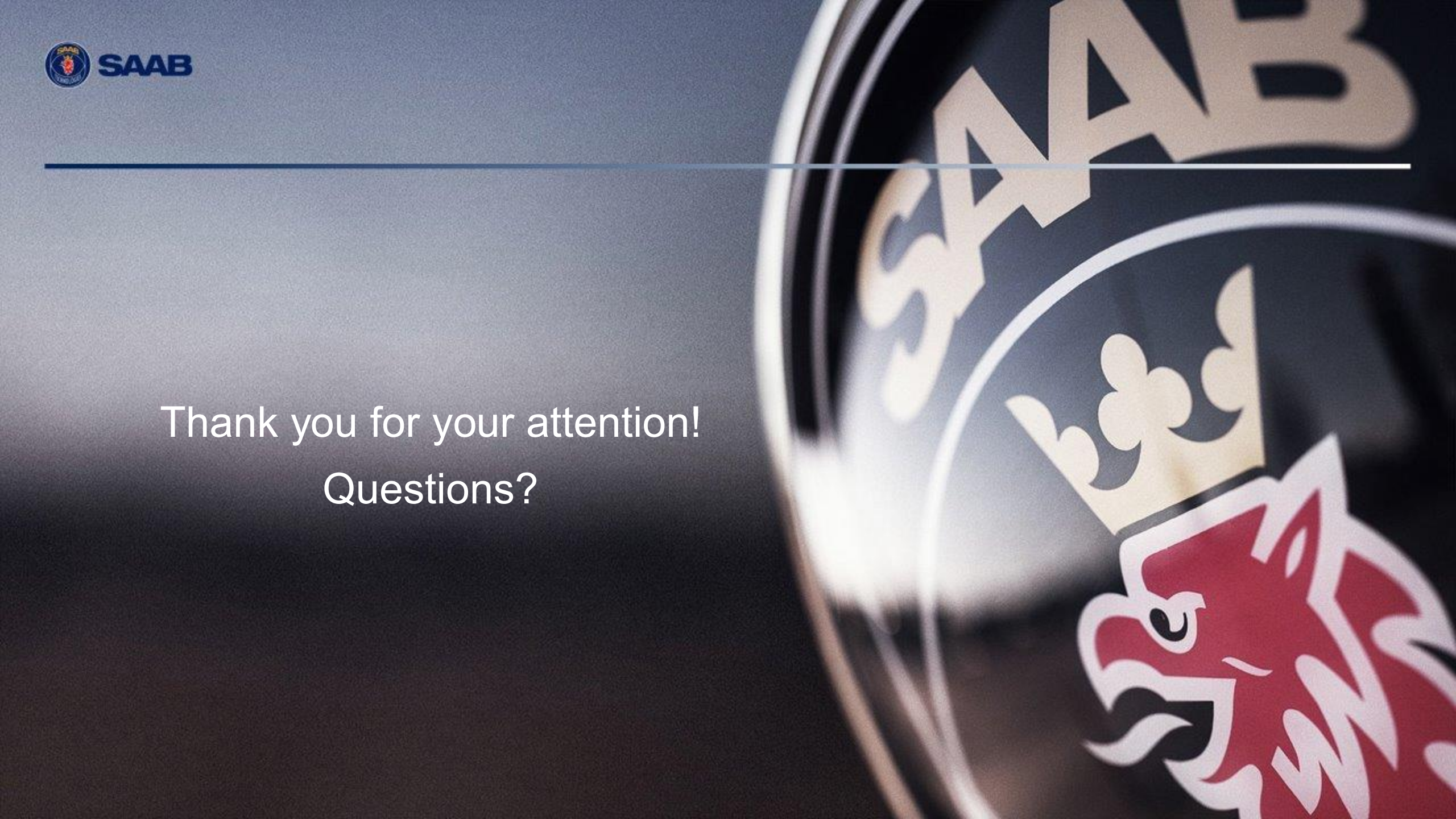
Intentionally removed before publication

WIDE BAND TRANSCEIVER MMIC

- Measured Performance On Wafer

CONCLUSIONS

- 15 years of focused R&D have put us ahead of our competition
  - Exploitation of new semiconductor materials requires perseverance
- The GHz Centre has built one of the strongest GaN-clusters in Europe
  - LiU, Norstel, SweGaN, Chalmers, UMS, Saab, Ericsson…
- We are still only scratching the surface of what benefits GaN can give us
  - “GaN opportunities will grow,… GaN still has a lot of untapped potential”, DARPA sept 2015
- If we play the cards right we have (at least) 20 years of world leading innovation ahead of us


SAAB
Thank you for your attention!
Questions?