NOVEL ASR DESIGN CONCEPTS

How modular systems and non-rotating antenna technologies will change ASR design fundamentally

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National Airspace environments are changing. Wind farms, 4G/5G telecom systems and the increasing air traffic density pose new challenges to air surveillance. New technologies offer solutions, but fast-evolving technologies pose another challenge themselves.

New system developments take time and it's hard for manufacturers to keep the installed base on track with state-of-the-art technologies. To guarantee service lifetimes of 20 years and more, a novel radar system design is needed. One that allows to introduce new technologies stepwise and that eliminates the shortcomings of legacy designs. Modular system designs and non-rotating antennas have the potential to become the new standard towards infinite system lifetime.

Fig 1: Modular ASR-M integration with NGSP technology and optional non-rotating antenna subsystem for infinite system lifetime

The real challenges

The so-called emerging challenges are not so emerging anymore. Windfarms have been around for decades by now. Not only recent 4G/5G but also 3G base stations and other high frequency sources interfered with S- and L-band surveillance systems, already many years ago. The increasing air traffic density – and with that the higher need for air traffic safety awareness – can hardly be called an emerging issue either. So, what is the *real* emerging challenge for contemporary air surveillance?

Air surveillance systems are complex. They integrate Radio Frequency (RF) power electronics, gigahertz microelectronics and advanced processing algorithms. The development of such systems requires a lot of complementary skills. For instance, due to the expanding mobile phone base station market, low-cost microwave transmitter and receiver modules are now available. This brings distributed transmit/receive based systems within the budgets of civil primary radar users, but it takes time for manufacturers to integrate, test and validate new components in safety critical systems such as Airport Surveillance Radar (ASR). The same challenge occurs in soft- and firmware development. It takes years, and very clever minds to develop smart algorithms and get them integrated into and certified for air surveillance systems.

Don't underestimate the mechanical engineering of a complete radar system either. Both, Primary (PSR) and Secondary (SSR) Surveillance Radar typically have a rotating antenna. Rotary joints, cabling and waveguide configurations are off the shelf available from multiple suppliers, but those components do require periodic maintenance and inspection. And that's a critical point, as the connection with the antenna is a single point of failure.

The mechanics have their preventive maintenance schedule, but also the electronics need monitoring and servicing. Modern systems are interconnected and require frequent firmware and security updates. A lot can be done from remote locations, although local support is often required, just in case something goes wrong and immediate action is required. Unforeseen downtimes have great impact on Air Traffic Management (ATM). The same local support from system savvy engineers and technicians is desired when doing performance analysis for certification. Bringing an operational system under test can be a stressful endeavor if the right competencies are not on site.

Wind farms, telecom interference, air traffic density… those are not the real challenges for ATM. They are changing environmental factors. The real challenges

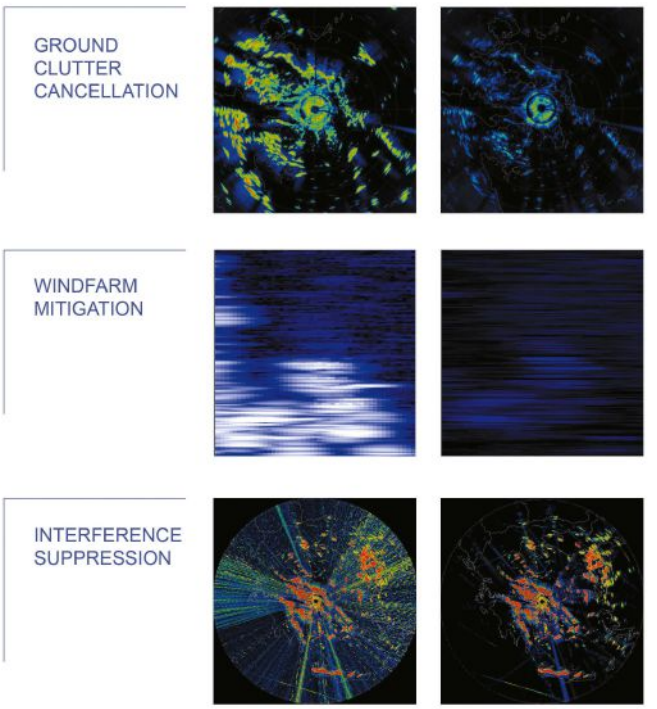


Fig 2: ASR-M Next Generation Signal Processing (NGSP) algorithms – before (left) and after (right)

lay with the radar manufacturer's R&D departments. How will they deal with the continuous change of National Air Space (NAS) environments? How will they design new systems that can keep pace with advancing technology?

State-of-the-art modular system solutions

Intersoft Electronics' ASR-M concept offers modular solutions for radar manufacturers and ANSPs. The modular radar subsystems can be integrated in both, brand new and legacy radar. ASR-M comprises modular blocks for every subsystem, from transmitter/receiver to signal processor to non-rotating antennas.

Modularity

The modular system design enables fast and easy integration and reconfiguration of modules for multiple radar systems, even of a different make or type. That reduces the need for spare parts and significantly eases obsolescence management. Line Replacement Units (LRUs) can be swapped by a site technician and configured by a system engineer remotely. Downtime is minimal or even non-existent, depending on which LRU needs replacement. And that's not only the hardware story. A-SRM is modular at system level. That means that firm- and software building blocks are designed according to the principles of modularity as well. That way, it's possible to configure the same hardware for completely different functions.

Modularity enables far-reaching optimization of program management. Similar hardware platforms are used in different modules and similar modules can be configured to execute different functions. Consequently, costs are reduced throughout the entire value chain, from production to integration, training, maintenance and support.

Advanced technologies

Intersoft Electronics' ASRM incorporates patented algorithms that address the so-called emerging challenges. Ground clutter cancellation, wind farm mitigation and interference suppression are processed in an unrivalled way.

ASR-M also features 3D processing, even to legacy 2D PSRs when being installed as part of a service life extension program (SLEP). Height information from PSRs increases the rejection efficiency of false targets and in addition provides a significant operational advantage as it is possible to report the height of targets with a malfunctioning or disabled transponder.

Both, the radar manufacturer – or system integrator in the case of a SLEP – and the Air Navigation Service Providers (ANSPs) benefit from Intersoft Electronics' state-of-the-art modular system solutions.

Non-rotating antenna solutions

The same modular concepts are applied to Intersoft Electronics' non-rotating S- and L-band Intelligent Electronic Scanning Array antennas, S-ESAM and L-IESA. Non-rotating antennas have been around for some time, mainly as military radar systems, with operational limitations and an extremely expensive price tag. Intersoft Electronics' non-rotating antenna technologies provide advanced capabilities for the civil radar market at a competitive cost.Non-rotating antenna technologies become competitive in the civil market and significantly reduce lifecycle costs compared to conventional mechanically rotating antenna systems.

Capabilities of Non-Rotating Antenna Systems

The Intersoft Electronics non-rotating antenna concept is based on a circular array, rather than the more common multi-faced planar flat arrays. This results in less beam degradation when the electronically scanned beam is pointed off the antenna boresight, maintaining near equal performance at all azimuths.

The integration of a distributed transmitter/receiver amplifier subsystem virtually eliminates feeder losses between the normally centralized and remote transmitter and receiver electronics. That results in less transmitter output power being required to achieve the same performance as a conventional mechanically rotating antenna radar.

Due to the modular construction, the arrays are scalable in diameter, giving a choice in antenna aperture and total transmit power. This in turn determines the accuracies and detection range capabilities. The arrays can be scaled in elevation as well, to provide two or more elevation beams, making it a real 3D system that provides accurate height information.

Optional operational modes

The circular array design allows for beam scanning options which are not possible with conventional ASR antennas. Apart from the continuous electronic rotation mode, confirmation lookbacks and sector scanning are possible. These modes permit confirmation of a target with unusual features by giving it more time-on-target.

Another optional mode is to operate multiple simultaneous beams. Alongside the regularly scanned operation volume of airspace from a single surveillance beam, S-ESAM and L-IESA can have a second beam which operates as an additional surveillance beam or as a tracking beam. An additional surveillance beam permits double the dwell time for increased detection capability while also maintaining the update interval.

Alternatively, maintaining the original update interval of a single surveillance beam with a second beam scanning back-to-back at the same rate, the combined update interval would be halved. Having a single surveillance beam and a second tracking

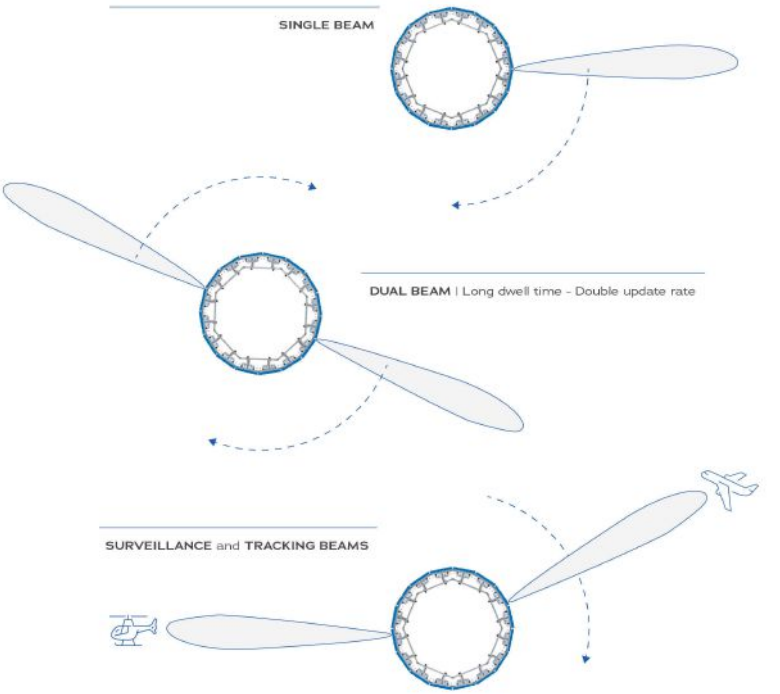


Fig 3: LIESA non-rotating antenna prototype **Fig 4:** Beam concepts of operation of non-rotating ASR

beam with the ability to have much more time-on-target greatly improves the levels of airspace awareness that is possible to deliver.

Benefits of Non-Rotating Antenna Systems

The extended capabilities and optional modes of Intersoft Electronics' non-rotating antenna technologies result in particular operational benefits. The advantages in terms of integration, maintainability, availability and support may even be called a real game changer. By removing single points of failures such as rotary joints, non-rotational antennas deliver a high level of redundancy. The need for mechanical maintenance is scaled back significantly, as there are no more rotating parts prone to degradation.

Non-rotating antenna technologies are innovative in terms of integration, maintainability, availability and support. S-ESAM and L-IESA antenna modules can be stored as LRU parts, just as the modules of NGSP and transmitter/receiver modules. Having a spare conventional parabolic or flat array antenna is unrealistic, but a modular non-rotating antenna can be serviced with spare parts on site. If one antenna module would fail, the system can remain operational while the adjacent modules fill the gap of the failed module, with only minor local degradation in performance. That redundancy significantly improves the system's availability.

Another advantage of the modular non-rotating design is that logistics for installation and operation are eased. Requirements for transport, cranes or platform loads are relaxed thanks to the modules being compact and lightweight.

S-ESAM, the non-rotating antenna technology for systems operating in the S-band, is the logical next steps to upgrade an ASR system with a modular antenna system. The combination with ASR-M processing technology offers unrivalled detection capabilities.

L-IESA technology is available for PSR systems operating in the L-band, typically long-range en-route radar. Non-rotating L-IESA technology is also used for Secondary Surveillance Radar (SSR) and Identification Friend or Foe (IFF). Primary and secondary antennas can even be integrated in a single antenna construction.

Infinite service lifetime

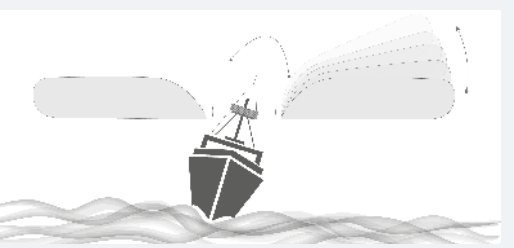
Modular systems and non-rotating antenna technologies will change ASR design fundamentally – and all PSR by extension. They have the potential to address not only the so-called emerging challenges of the changing NAS environment, but also the *real* challenges radar manufacturers and integrators struggle with: keeping a complex and safety-critical system on track with rapidly advancing technologies.

When we succeed in doing just that, ANSPs will enjoy infinite system lifetimes. The need to replace outdated monolith sensors will disappear. Instead, a modular sensor will remain up to date, by replacing LRUs and updating the software with the newest versions and releases. To ensure Quality of Service (QoS) on infinite lifetime support, Intersoft Electronics deploys local field technicians that are ATSEP (Air Traffic Safety Electronics Personnel) certified.

So, how would you design an ASR system? ❖

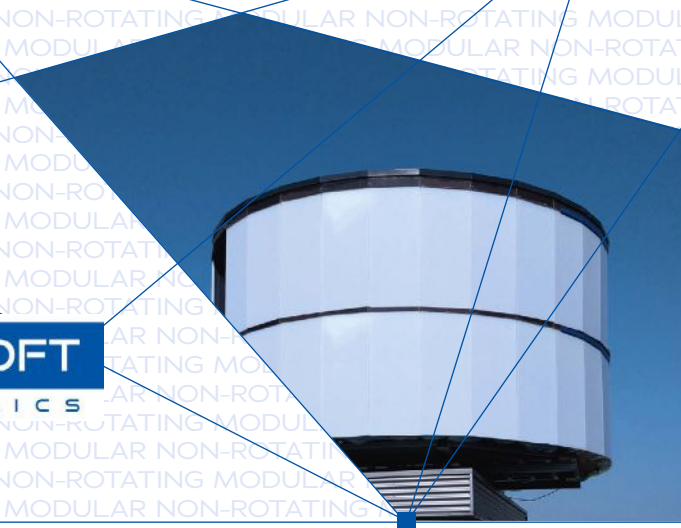
L-IESA NR-IFF NAVAL APPLICATION

The specific design and capabilities of L-IESA make it ideally suited for naval applications as well. The platform space on a ship is often limited to the mast, and every Communication, Navigation and Surveillance (CNS) system claims the top position. The circular design allows to wrap the antenna around the mast, ensuring 360˚ coverage while leaving the top position vacant for other CNS systems.



L-IESA non-rotating IFF features beam agility in elevation to compensate ship rolling movements

Another feature that comes in very handy for naval applications is the beam pointing agility in elevation. That allows to electronically correct in real time for the rolling movements of the ship.



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NON-ROTATING

HOW WOULD YOU DESIGN AN AIRPORT SURVEILLANCE RADAR ?

MODULAR