INTERSOFT ELECTRONICS

Intersoft Electronics'

NON-ROTATING ANTENNA TECHNOLOGIES

WHITEPAPER

Executive Summary

Non-rotating antennas, (also called Active Electronically Scanned Arrays - AESAs), have been around for some time but mainly as the preserve of expensive military radar systems (typically costing $10mio's).
Intersoft Electronics is developing similar non-rotating antenna technologies, which will provide some of the advanced capabilities of these military systems for the military and civil radar market, but at a competitive cost point.

Intersoft Electronics' non-rotating antenna technologies fit into their modular airport surveillance radar concept (ASR-M®). This concept permits the use of Intersoft's Next Generation Signal Processing (NGSP®) platform to be used as the core of a flexible and potentially phased approach to radar upgrades and replacements integrating with legacy, new or third party PSR transmitters, SSR/IFF interrogators and antenna subsystems. The non-rotating antenna technologies offering a potential last phase replacing the PSR transmitter and antenna in such an approach.

One of the major design goals for Intersoft Electronics is that their non-rotating antenna technologies, are available for the civil market, (e.g. for a non-rotating airport surveillance radars), having a similar capital costs and reduced lifecycle costs compared to conventional mechanically rotating antenna systems.

This whitepaper explains the key concepts of Intersoft Electronics non-rotating antenna technologies.

Intersoft's non-rotating antenna technologies fit into their modular airport surveillance radar concept ASR-M®, which is the next step towards infinite lifetime system support.

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Introduction to intersoft electronics' non-rotating antenna technologies

Intersoft Electronics is developing a range of non-rotating antenna solutions for:

- Operating in L- and S-Band
- Suitable for PSR and SSR/IFF systems
- Both civil and military applications
- Being both modular and scalable

Intersoft Electronics is developing non-rotating antenna technologies for S-Band primary (non-cooperative radar sensors) and L-Band SSR/IFF (cooperative) and L-Band primary (non-cooperative radar sensors).

- *L-IESA® = L Band Intelligent Electronically Scanned Array (PSR & SSR)*
- *S-ESAM® = S Band Electronic Scanning Antenna Module (PSR)*

The Intersoft Electronics non-rotating antenna concept is based on a **circular arrays** 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.

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. Similarly the availability of **low cost, high performance microwave components** permits high precision, electronic scanning, to become affordable.

Intersoft Electronics' ongoing development is providing opportunities for significant improved capabilities.

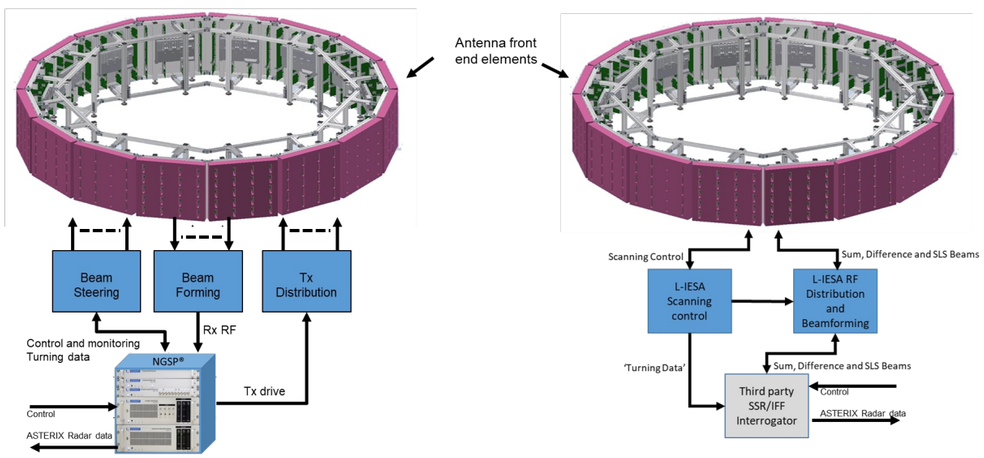

Figure 1 / Intersoft Electronics non-rotating antenna concept Left PSR, Right SSR/IFF

Integrated with the primary non-rotating array is a **distributed transmitter/receive amplifier subsystem**. This integration virtually **eliminates feeder losses** between the normally centralized and remote transmitter and receiver electronics resulting in less **total transmitter power being required** to achieve the same performance as a conventional mechanically rotating antenna radar with many times higher transmitter power output.

Due to the modular construction, the **arrays are scalable in size** (array diameter) giving a choice in antenna aperture and total transmit power. This in turn determines the accuracies/resolutions and detection range capabilities.

Typical scalability:

- 16-64+ 'Antenna front end elements'
- 3-12m diameter
- Transmit power 2kW to 32kW per beam

For both primary and secondary radar applications, **azimuth monopulse** is utilized for **increased azimuth accuracy**.

Depending on the operating band and array diameter the antenna front-end elements may be flat panels or multibeam 'cassettes' as shown below.

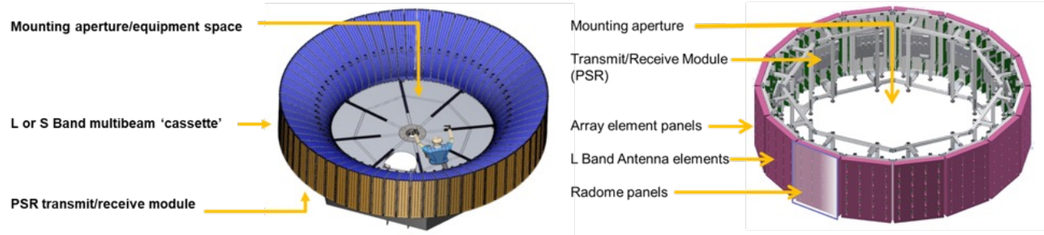

Figure 2 / Multibeam 'cassette' (Left) and Flat panel (Right) antenna front-end elements

CONCEPT	BENEFIT
Circular arrays	» Less beam degradation
Expanding mobile phone basestations market	» Low cost, high performance microwave components
Integrated TX/RX power amplifier	» Eliminate feeder losses
Modular design	» Scalable arrays
Azimuth monopulse	» Increased azimuth accuracy

Concept of scanning operation

The Intersoft Electronics non-rotating antenna technology typically utilizes 90° of the full array for single beam. In the typical example shown below, for continuous circular ‘beam’ rotation, the beam is electronically scanned ±22.5° about the current antenna boresight (compared with flat panel AESA systems that typically scans >±60° about boresight). After this fine electronic scanning the quarter array is advanced, ‘stepped’ one array element in the direction of the ‘beam’ rotation and the fine electronic scanning repeated. For non-continuous circular ‘beam’ rotation, (see later), the quarter array can be instantly directed to a new boresight and the electronic scanning can point the beam to any point within that quarter array direction.

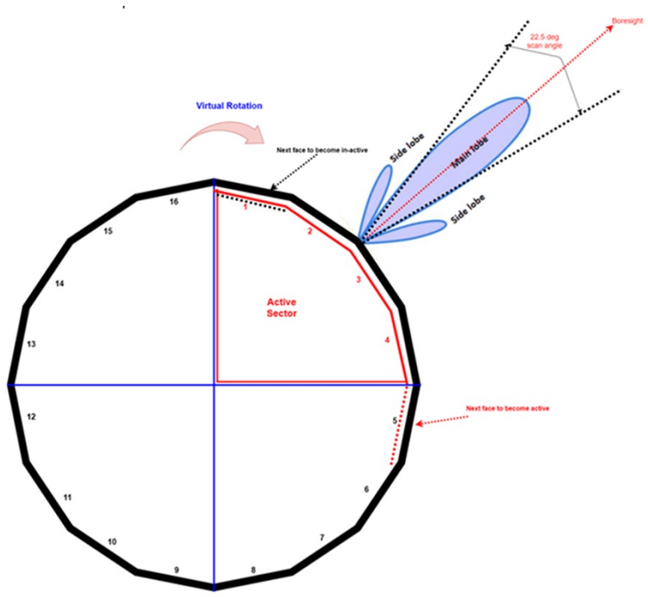

Figure 3 / Beam concept of scanning operation

Multiple elevation beams

Similarly to the scalability in array size (diameter), the arrays can be scaled in elevation to provide two or more elevation beams.

The individual elevation beam vertical polar diagrams (VPD) are application selectable but fixed per system.

Primary transmission can occur on the low beam or low and high beams. The latter supporting beamforming in space and the Intersoft Electronics advanced vertical clutter cancellation (VCC^2) technique (figure 4).

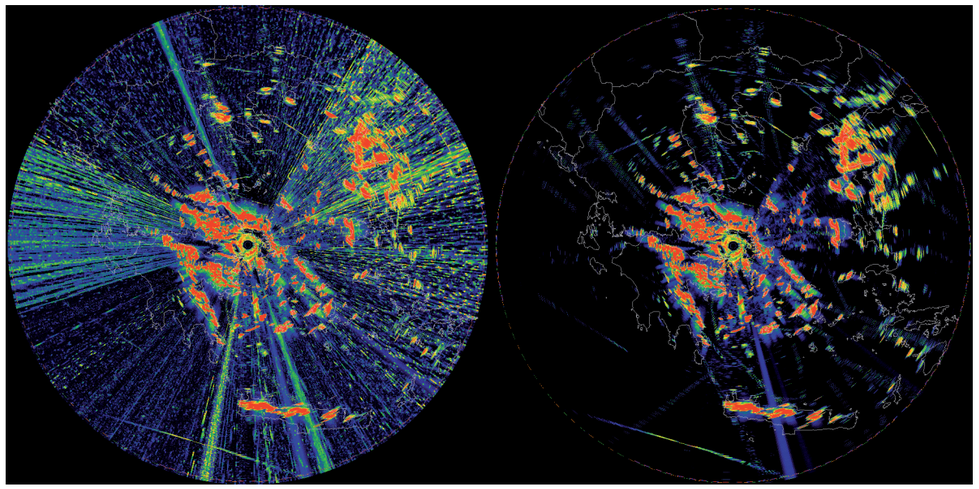

Figure 4 / Cluttermap of a multi-beam system before (left) and after (right) filtering

Azimuth/horizontal beam scanning options

The flexibility in beam scanning and near instantaneous beam pointing permits a wide range of scanning regimes to be employed

These include:

- Continuous rotation – akin to a conventional scanning primary or secondary airport surveillance radar
- Continuous rotation with ‘confirmation’ look-backs, this is typically used in military AESA primary radars to ‘confirm’ a potential detection or for a more rapid track report or clarify whether an initial detection is not a false detection
- Sector scanning – this permits focusing the radars time/energy in a small sector to improve detectability or increase the reporting (update) rate on a particular aircraft (such as a highly maneuvering aircraft)

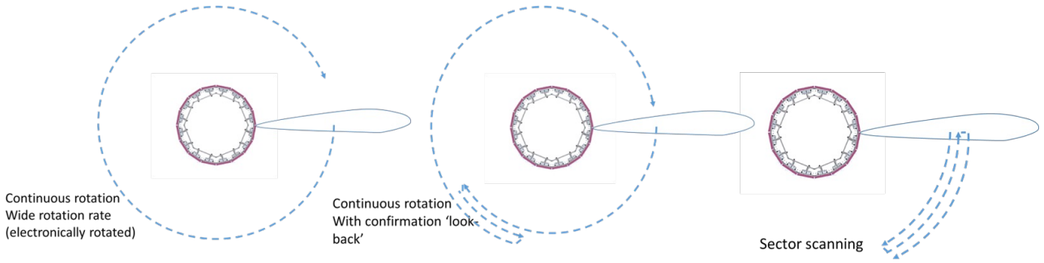

Figure 5 / Beam concept of operation

Multiple simultaneous beams

One of the key benefits of the Intersoft Electronics non-rotating antenna technology is the potential to have multiple simultaneous beams, alongside the regularly scanned operation volume of airspace from a single surveillance beam we can have additional beams, such as a second surveillance beam which could:

- Permits double the dwell time for increased detection capability but maintaining the update/reporting interval (e.g. 4/5/10/12 seconds being typical)
- Alternatively maintaining the original update/reporting interval of a single surveillance beam with a second beam scanning at the same rate, due to the back-to-back nature of operation the combined update/reporting interval would be halved (e.g., 2/2.5/15/16 seconds)
- Or having a single surveillance beam and a second ‘tracking’ beam with the ability to have much more ‘time-on-target’ for a number of targets of interest such as small and/or slow targets or highly maneuvering targets

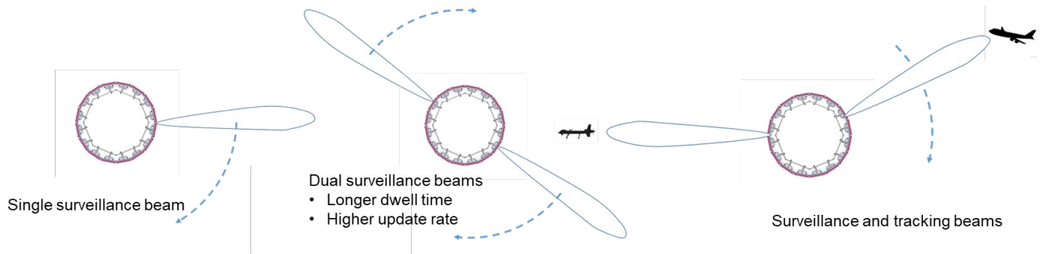

Figure 6 / Beam concept of operation

Benefits and advantages

The Intersoft Electronics non-rotating antenna technologies have a number of benefits and advantages over radar systems incorporating mechanically rotating antennas.

These include:

- **Capital cost** being similar to a mechanical rotating antenna and primary radar transmitter subsystem
- Lower **lifecycle costs** as there are no mechanical moving parts which wear and have ‘lifed’ items such as bearings, rotary joints and motors which will require replacement a number of times during the planned lifetime of the system. Thus reducing lifecycle costs and requiring reduced preventative maintenance
- Light **weight** for ease of transportation and installation and reduced antenna mast/tower requirements
- Having a high level of redundancy with **no single points of failure** e.g. bearings, feeders, Rotary joints etc.
- Modular design, **reducing LRU stock** needs and allowing **easy access for maintenance**
- Lower overall power requirements including **reduced transmit power requirement**
- Multiple simultaneous beams e.g. **dual scan, scan & track, scan and reinforce**
- Potentially high scanning/beam pointing rate allowing for **improved update rate**
- **Customizable beam patterns** designed for specific operational coverage needs
- Use of azimuth monopulse techniques to improve **azimuth accuracy**
- Improved performance and a wider **range of applications**

System Integration

As a final key benefit, the system integration capabilities of Intersoft Electronics' non-rotating antenna technologies should be highlighted. Thanks to the modular design, not only of the antenna, but whole the ASR-M® concept, non-rotating antennas offer a potential last phase in a service life extension program.

Primary radar systems, used in conjunction with the Intersoft Electronics Next Generation Signal Processor (NGSP®) will fully realize the processing benefits available from the Intersoft Electronics processing platform.

For secondary radar systems can integrate the Intersoft Electronics non-rotating antenna with virtually any standard SSR/IFF interrogator.

Intersoft Electronics' non-rotating antenna technologies add unprecedented value to operators of primary and secondary radar operators and system integrators.

- By eliminating mechanical antenna rotation, single points of failure such as bearings, feeders and rotary joints are removed.
- New scanning modes of operation become available for better target detection, addressing the challenges of a changing National Air Space environment.
- The non-rotating antenna technologies offer a potential last phase replacing the PSR transmitter and antenna in service life extension programs, based on the modular airport surveillance radar concept (ASR-M®), improving a system's performance with the Next Generation Signal Processing (NGSP®) platform.

Non-rotating antenna technologies and ASR-M®...

To change Air Surveillance Radar fundamentally

INTERSOFT ELECTRONICS

Together we make the sky safer