OPPORTUNITIES OF ACTIVE ELECTRONICALLY STEERED ARRAY RADAR FOR AIR TRAFFIC MANAGEMENT

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Abstract: *The paper considerate the opportunities and advantages that AESA radar ensures for the ATM system. Air traffic in Balkan region grows with a rate of 5 to 7 % annually and that requires implementation of new technologies in radar systems.*

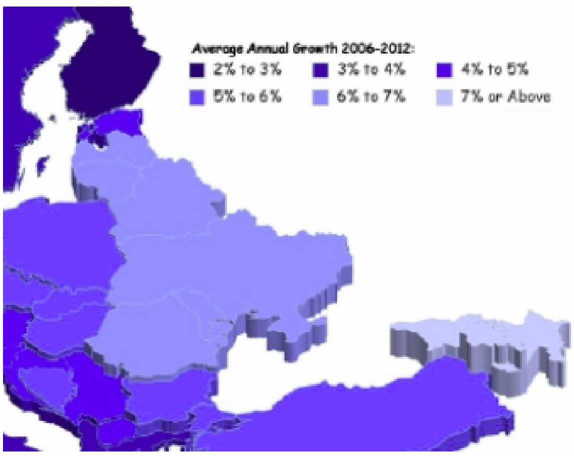
Keywords: *ATM, PSR, SSR, AESA, Mode S.*

1. INTRODUCTION

Despite 11 September events the air traffic increases and continues to grow with an average annual rate of 3.4 %.

The forecast is that it will be doubled in next 20 years in European airspace and even in our region – South Eastern Europe increases faster with an average annual growth of 5 up to 7 percentages [5].

Safe and efficient use of airspace will be main challenge in next decades and can only be achieved through implementation of new technologies and approaches in air traffic management (ATM) system [4].



Enhancing of the air traffic set some new requirements for the radar systems used in ATM in respond of new loading of controlled areas and sectors.

2. AESA RADARS AND ATM

Functions of ATM radars

Two types of Air Traffic Management radars are used today – Primary Surveillance Radar (PSR) and Secondary Surveillance Radar (SSR) [2]. The main functions of PSR are: surveillance in En-route airspace and major terminal areas, 2D location of the target (range and azimuth) [3]. The main function of SSR are: aircraft identification, aircraft height determination, providing of mode S data link. Combined PSR and SSR provide the separation of aircraft throughout en-route airspace and in major terminal areas and ensure the efficient handling of increasing traffic volumes in a safe, orderly and expeditious manner [3].

The additional sensors are needed to survey and track the aircraft on the ground in airport area.

ATM radars use mechanical steered antennas and PSR and SSR antennas are rotated on together to provide co-operation between radars. Thus the requirements to the mechanical elements and electromagnetic compatibility increase. The revolution rate of these antennas is relatively low and it is from 4 to 15 revolutions per minute. The time during a target is within antenna beam is limited by the scanning with relatively low rate. In this period the PSR have to detect target and locate it and SSR have to carry out communication with airborne transponder. It is necessary to increase interrogation frequency in order to provide reliable receiving and decoding of airborne transponder respond in SSR. These is result from air traffic bunching in sectors, particularly in approaches to airports. In such cases the majority of targets that require interrogation will lie in narrow approach and departure corridors. For a rotating system this leads to very high peaks in the interrogation rates required, placing a very high demand on the transmitter for a short period.

Additional difficulty when mechanical steered antennas are used is providing of data exchange between SSR and airborne transponder in Mode S. Data link messages have to be scheduled along with surveillance interrogations; data link messages however do not arrive in a time period related to the position of a rotating antenna. This means that, in the worst case, messages could be delayed by a period related to an antenna scan revolution. Adding data link messages that are much longer than surveillance messages leads to a requirement for an instantaneous duty of about 70%.

The problems mentioned above could be resolved if active electronically steered antenna (AESA) radar is used as an ATM radar.

Features of AESA radars

The AESA radars are the most promising practical solution for further rise of multifunctional ATM radars in terminal areas. In these radars each element of antenna array is directly connected with its own transmit/receive module (TRM). Thus these modules are inherent parts of the antenna array. Such array architecture provide an opportunity to control each TRM separately and consequently adaptive beam forming could be realized. The basic structure of AESA radar is shown in Figure 1.

Thanks to directly placing TRMs into antenna array the losses in RF signal between the transmitters and the antenna, and between the antenna and the receivers are significantly lower in AESA radars than in other radars. Less than 50% of effective transmitter power in Passive Phased Array radars is radiated whereas in AESA radar this percentage is much more. This feature lead to enhance of target detection capabilities.

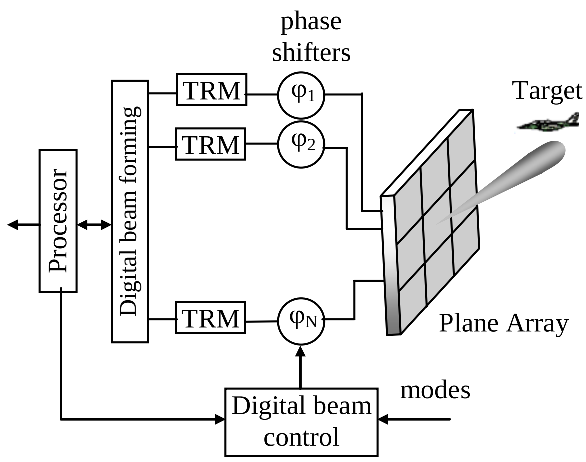


Fig. 1 AESA radar structure

The requirements to power supply in AESA radar decrease because of low power TRMs use. Figure 1 shows that the beam forming and beam control are separated which enhance radar flexibility.

The control of the radiation and receiver parameters of an active-array radar in real time provides ability to adapt radar performance as the situation changes. Adding adapting function to radar it becomes adaptive AESA radar. Features that can be adapted include [1]:

- digital beamforming;
- waveform generation and selection;
- beam management;
- frequency selection;
- task scheduling;
- multi target tracking.

These functions provide the radar with ability to optimize its parameters to meet environmental effects as they occur. This could be accomplished by human operators or the system can be programmed to adapt automatically.

The adaptive AESA radars can provide different operating modes to scan the surveillance volumes. In the same time the energy usage is optimized to maximize the probability of target detection by management of the radar waveforms and beams

Volume surveillance can be managed by different priority. For instans low priority long range tasks can be traded for higher priority tasks such as short-range. Separate tracking beams can be used to maintain target positions and velocity data. Targets with low manoeuvring capability may be tracked using trackwhile-scanning techniques during normal surveillance.

A look-back beam using the position data derived from the detection beam can immediately confirm each detection that is not associated with a target already in the current track file, thus significantly reducing the track confirmation delay.

In order to carry out digital adaptive beamforming more than one receiver channel is required. Normally the number of receiver channels are limited to the low tens. In order to do this the TRMs are grouped into subarrays by the use of traditional RF beamforming techniques. The subarrays are generally randomised in shape, i.e. in height and width, but have a similar area. This improves the operation of the digital adaptive beamforming and breaks up any correlation effects.

The signals of subarray channels can simply be summed to form the normal or quiescent antenna pattern. In the adaptive beamformer each subarray receiver signal is adjusted in amplitude and phase (weighted) before summing to form the desired radiation pattern.

The radar management system is designed to control and optimise the radar process to perform tasks at the correct time. When peak loading causes short-term problems with radar resources, the managment program is designed to act on task priorities, rescheduling tasks to maximise the value of the radar data and making optimum use of the radar performances.

The radar management function has to co-ordinate the process of signal generation, beam pointing, dwell, transmission, reception, signal processing and data extraction to ensure that the correct parameters are applied through each process to carry out the task demanded.

Use of AESA radar for ATM

It is possible an AESA radar to carry out the following ATM roles:

- terminal area surveillance;
- medium-range/en-route surveillance;
- general movement and tracking;
- Monopulse Secondary Surveillance Radar;
- Mode S data link;
- Airport Surface Detection Equipment;
- precision parallel runway monitoring;
- weather surveillance;
- wake vortex detection.

The wide-band nature of the AESA radar architecture makes it possible to integrate the SSR into the primary radar. Mode S of SSR is a selective addressing system and the ability of an AESA radar to arbitrarily scan the beam simplifies the target scheduling compared to that required by a rotating system. The use of electronic scanning in the selective addressing process has the secondary benefit that it effectively smoothes out the interrogation rate peaks that occur in a conventional rotating system. An AESA radar can operate with an effectively constant interrogation rate, resulting in a constant transmitter duty. This is particularly important when a Mode S data link is used. Adding data link messages [3] that are much longer than surveillance messages leads to a requirement for an instantaneous duty of about 70% for a rotating system. Electronic scanning can be used to smooth out the interrogations in time, leading to a much lower duty of less than 10%.

Four AESA, plased on the sides of piramidal piadestal, can be used to ensure 360° surveilance. This provide ability to syrvey volume in 4 sectors simultaneously. Besides the digital beam forming allows in each sector to shape several beam at the same time. Thus the great flexibility of volume surveillance is achieved. For example the interrogations of targets that has already exchange data with radar in Mode S can be realized by pointing beam to each target consecutively without scanning. Thus the interrogation frequency can be decreased without increasing of probability of respond shortage from transponders.

Signals from different RF channels can be combined to provide monopulse operation mode. Block diagram of this mode is shown in Figure 2.

Digital control allows to implement common control algorithm for adjacent AESA radars that have overlapping surveilance volumes and indentical indentefication codes.

Thus different radars won't irradiate the same sectors in the same tame.

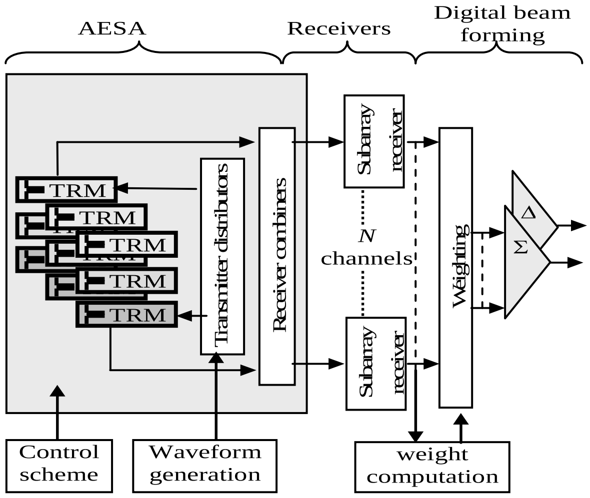


Fig. 2 Monopulse mode of AESA radar

In this way RF interference could be lowered in uplink as well as in downlink. Such control of iterrogation from adjacent sensors will increase numbers of servicing aircraft.

General opportunities of AESA radar for ATM are shown in Figure 3.

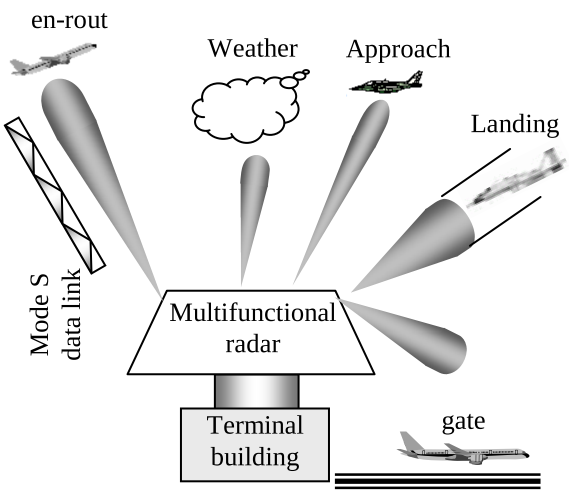


Fig. 3 Opportunities of AESA radar for ATM

One limiting factor of ASEA radar using for ATM is the layout of the airport.

Unlike milityary radars, which can be sited in an optimum position, airport radars have to fit the existing site layout.

This generally bounds the possible use of a multifunction radar due to shadowing and the relative positions of the runways, flight paths etc.

However, with the rise in air traffic and the need for new green field airport sites the possibility now exists for siting a multifunction radar in an optimum position. Such a radar could be capable of true ‘gate to en-route’ operation.

3. CONCLUSION

The optimization of radar infrastructure with AESA radars will improve operability and reliability of ATM systems. Modernizing of the airport and en-route radars with such technology will raise the level of safety, efficiency and airspace capacity, which is crucial for the future development of ATM system.

Despite the significant annual growth in air traffic, implementation of AESA radars in a common network will ensure capacity, while providing the required safety and quality levels of air navigation services.

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