INFORMATION ANALYSIS IN AIR DEFENCE SURVEILLANCE IN CONNECTION WITH THE NCW PROGRESS

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Abstract: *The contemporary radar data processing methods are not sufficient enough for demands of air defence fire units for the enemy aircraft goal analysis and the target pointing aberration measurement. This paper analyses new possibilities of radar data processing in connection with the Network Centric Warfare progress.*

Keywords: *Air defence surveillance, primary surveillance radar, secondary surveillance radar, passive surveillance system, visual observer, radar data fusion, target pointing aberration, radar data delay, information analysis, stereoscopic projection, primary information source, complementary information source.*

Introduction

The basic element of successful air defence system is quality information about air situation. The information is obtained both by radars, and passive surveillance systems. The main information source is primary surveillance radar, which is able to acquire information about air situation independently on weather, time of day and radio-electronic emission of the air objects. The supplemental information source is secondary surveillance radar, which is able to identify air objects and say to us, if the object is friend or foe. In case of friendly objects, the secondary surveillance radar is able to say, what it is (number of fly) and provide the information about height of flight, and a lot of other information. The data volume transfer is increasing using new “mode S” and “mode 5”.

The complementary information source could be a passive surveillance system, which is able to tell us more information about an enemy air object. On the base of received radio signal analysis it is able to define aircraft type and, if the information is registered in the passive surveillance system database, it is able to define aircraft registration number. The main precondition for a quality such analyses are databases keeping in actual status.

Further complementary information source is visual observer of air situation. The observer is depended on weather and day time indeed, but his information is indispensable. Only the observer is able to acquire the first information about new aircraft, if such information in passive surveillance system database is missing. On the basis of this information the database is actualised and kept in actual status.

But the most important phase in the air situation recognizing process is information analysis and the enemy aircraft purpose investigation. On basic results of this step the C4ISR[1] system sets the target priority and target engagement order. All success of air defence system depend on this step .

The present-day systems asses the potential dangerousness ratio only, but the next assessment people do. The result of this assessment depends on their practice, education, training and experience. In stress and time deficiency conditions of this process there is a great danger of mistake and in that event the after-effects may be unforeseeable. The possible way to improve this situation lies in automation of assessment with the data utilization from all possible information sources.

The Network Centric Warfare (NCW) gives to us new challenges to improve this surveillance system. From the point of view of the new requirements to network all systems on the war theatre comes up a possibility to combine all information from all possible sources. But initial limitation for air surveillance systems is data transfer delay. The C4ISR systems connecting possibility of air forces, ground forces and navy gives the opportunity of reciprocal information exchange about actual status in separate kind of forces, and possibility to create joint environment picture. But information regeneration requirements are different for every kind of forces. The quickest information regeneration concerns air situation because the air means have the highest speed. Accordingly to this fact the air message transfer has the highest priority.

Process of air targets classification

Any air defence system in the whole world's history has not been able to destroy every aircraft on the air strike. Main significance of these systems consists in potential possibility to destroy part of enemy aircrafts and repulsing the others from a planed strike. The SAM[2] fire possibilities have limitations in number of fire channels and rockets available. Every air defence system has limitation in number of fighters, too. Consequently, the most important question is to determine which target has to be destroyed and which not, and which target is more dangerous and which one less.

From complementary information source we are able to obtain information about the aircraft type. This information is important for next prognosis about what this aircraft is able to do, and what will it probably do. On the basis of knowledge about our own situation, defended point location and enemy aircrafts flight course we are able, with certain probability, to estimate which defended point the attacker want to destroy. On this basis we are able to estimate the dangerousness factor of the particular aircraft and estimate preferences for the engagement order of enemy's air attack means.

The requirements for assuring undisturbed surveillance put in the first place a priority to destroy the

1 Command, Control, Communication, Computer, Interoperability, Surveillance and Reconnaissance
2 Surface to Air Missile

air barrage jamming means and secondly the air defence counteraction means. Third priority has main forces's attack and after it escort assurance means, which are created from fighters, lure groups and rescue means. The main attack forces are created by strike aircrafts and marking aircrafts. The assessment of the survey aircraft dangerousness depends on the war situation conditions. Sometimes it may be very important, but sometimes their dangerousness is less important and the preferences have the other targets.

The jamming means assessment is very simple. More difficult is their observation by radars. If we have means without frequency agility, than the only possible surveillance method for the jammer position estimation is a triangular plotting. Consequently, it is important to have a complementary information from passive surveillance systems, which worked on the signal receive basis. These systems are able to estimate the jamming characteristics and on this basis we are able to prognosticate the jamming influence on the radar cover.

The assessment of air defence counteraction means is more difficult. But they generally fly at the front of the air attack group, on low flight level, and they are created by strike aircrafts. Using information from radars we obtain their location and from passive surveillance systems we are able to obtain the aircraft type. On this basis we are able to determine their intention and assess their dangerousness.

The main attack forces are created by combat aircrafts and marking aircrafts. Their position is in the middle of the attacking group and they usually fly at the middle or low flight level. Above combat aircrafts generally fly the marking aircrafts and above and around them fly all the escort assurance means, created by fighters. From passive surveillance systems information we are able to obtain an aircraft type. Therefore, estimation of the fighters is not very difficult. Assessment of strike aircraft purposes must be established on the basis of fly direction, and location of the defended point.

More difficult is the case, when the attack group is created by multi-purpose aircraft of the same type. In this situation passive surveillance systems are not able to generate the air target dangerousness ratio and the analytic system must start only from tactical attack principles. The probability of mistake in this case increases, thus the task of the operational staff is to control the analysing process for to minimising the possibility of mistake.

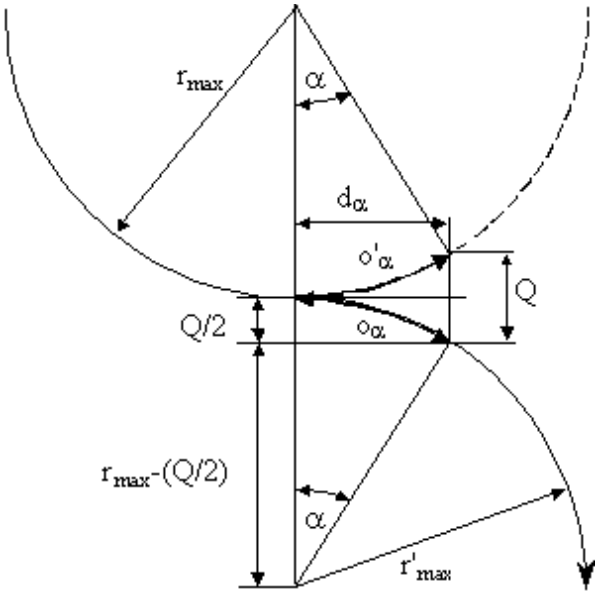
The role of visual observer is very important too. Only he/she is able to detect accurately the aircraft type, registration number, carrying weaponry and damage status. If the observer is equipped with binoculars with laser range finder, he is able to give the accurate information about target location too. Very important is the transfer of this information immediately from the observer post to the command post. The best way of transfer is via computer network and if the binocular allows connecting with computer, the simplest way is to equip the observer with pocket computer and

radio connection. This information may be ciphered, thus the network security is assured. For this purposes is not suitable radio with the Field Internet connection type (for example as MRR[3]), because this type of connection has not warranted the response time and in this event the *on time* information transfer is not assured.

For information delay estimation, we must start from requirements of the SAM fire unit information accuracy. The main fire unit requirement is to obtain precise information about target without necessity its additional searching. If the fire unit tracking radar antenna has the main beam width about one degree, the aberration of target pointing may be only a half of degree. In the medium range air defence unit in distance 25 km from the external area efficient activity border (D_{AEA}) the deviation may be only:

$$Q = D_{AEA}.tg\left(\frac{\Theta}{2}\right) = 25000.tg\left(\frac{1[^{o}]}{2}\right) = 218{,}172\,[m]$$

In this case we are able to define an estimating delay. For this event we may extrapolate the target location by delay, but only up to that moment, when the possible target location may exceed the tolerable error. Considering the extrapolation done on the flight history basis, the most adverse event is the moment, when we re-compute delay by maximal curve route at one side and the aircraft changes the route to the other side.



If we define the delay (see picture) in which the target route achieve $\boldsymbol{o_\alpha}$ distance, so this delay will be:

3 Multi Role Radio – from Ericcson comp.

$$t_{delay} = \frac{r_{\max} \cdot \frac{\pi}{180} \cdot \arccos\left(\frac{r_{\max} - \frac{Q}{2}}{r_{\max}}\right)}{v_{target}}$$

For the contemporary aircraft (v_{target} = 0,8 M; r_{max}= 1300 m) we obtain:

$$t_{delay} = \frac{r_{\max} \cdot \frac{\pi}{180} \cdot \arccos\left(\frac{r_{\max} - \frac{Q}{2}}{r_{\max}}\right)}{v_{target}} = \frac{1300 \cdot \frac{3.14}{180} \cdot \arccos\left(\frac{1300 - \frac{218}{2}}{1300}\right)}{0.8.330} = 2{,}03\,[s]$$

To take into consideration the whole means chain the information passes through (a source and four processing centre), and the time for fire unit aiming (1 s) the delay on one processing point can be 200 ms only. Therefore, the information transfer delay from the visual observer, radar or another information sources to the next processing centre may be no more than 200 ms.

In the point of view the requested SAM units target pointing aberration we have to consider the data fusion processing. First phase of this process is to transform coordinates from the polar to the planar system of coordinates. The generally used stereoscopic projection is not suitable for requested aberration, because its error is too high. On the transversal target distance 300 km the error of computing is equal about 40 m. This difference between real and computed target position is too high. The better method is direct transformation into the WGS-84 geodetic coordinates. Contemporary computer's performance is already at our disposal.

Conclusion

With the warfare networking the information analysis process provide new possibilities. The number of available information sources is increasing. The new computer technology is able to fulfil the fire unit tactical requirements for information accuracy and without any significant delay. The radar data processing systems must be able to evaluate the air target dangerousness and prompt it to operators solving the air situation.

The realization of predominant requirement is very simple. We must utilize passive surveillance systems capabilities and integrate their information into the radar data processing systems. But always we must be aware, that a primary radar information source is only primary surveillance radar, and a passive surveillance system is only complementary information source. If an aircraft turn all the board radio transmitters off (as a for example Japanese in the Pearl Harbour operation

did), then passive surveillance systems is blind. So, there are new passive surveillance systems developed today on basis of receiving a spurious reflecting signal.

The other information sources have informational value too. We must be able to transfer them into radar data processing system from all sources. The visual observer must be equipped with net radio-connection and he must be able sending the air situation information via pocket computer with absolute transfer priority. The airborne radar information must be connected to ground network and must be able to send the air situation information with absolute priority transfer too. And last, but not least we must connect all other radars on the aerodromes, within the ground forces, EW means, etc. into the informational network The information about air situation must be always transferred with absolute priority.

The next development must be aimed on the process of air targets classification. Contemporary requirements for to decrease the number of military personal can be implemented only by additional means transferring human work onto computer. It does not represent, that human may be replaced by computers at all. The human factor in radar data processing is not fungible. But computer processing can compute the target dangerousness variants quickly and one can offer to human the computed variants for choosing. But C4ISR systems must be able to work automatically too. This work mode is most difficult, but in this mode the operator can decide, what will computer do and what will be done by him/her personally.