The Desirability of a NATO-central Database for Non-Cooperative Target Recognition of Aircraft

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ABSTRACT

For a decade, NATO nations, both on their own and within NATO groups have performed studies in the field of Twodimensional Inverse Synthetic Aperture Radar (2D-ISAR) and High Resolution Radar (HRR) Range Profiles. During that work high-quality radar imagery data of aircraft has become available through measurement campaigns. It was shown that the acquisition of a sufficiently large and representative reference database is a difficult and laborious process. Other database properties, such as its contents, size, upgradability, retrieval speed, operational use, etcetera have not received sufficient attention within these studies. In the future, NATO may be playing a major role in maintaining a NATO central database of radar signatures. This paper provides an initial understanding of the operational implications for performing such a task. It argues that, instead of providing a central database to NATO nations, NATO should stimulate the use of decentralized classifiers and databases and ensure that coalition partners can access them via a data network in operational situations.

1. INTRODUCTION

Target identification is essential for any combat command and control and weapon system. Effective response to threats can be generated only if the ability exists to rapidly detect, track and identify targets present. Cooperative identification techniques play an important role. These techniques include IFF and the use of airspace control procedures.

A serious drawback of these methods is that they require the cooperation of the targets. This can lead to serious consequences if friendly or neutral targets fail to cooperate. In the extreme case, the target will be marked hostile and will be engaged by own fire. Furthermore, enemy units can exploit cooperative identification to mask their identity. Nevertheless, cooperative identification methods remain crucial for the positive identification of own troops.

Positive identification of neutral or enemy troops under all operational circumstances, however, remains a deficiency in NATO's air defence capability. In fact, it is acknowledged that it is the most serious deficiency and one that impacts almost every aspect of air command and control and weapon system employment. The lack of timely and reliable means to identify all air vehicles at all aspect ranges necessitates the use of very restrictive airspace and weapon control orders. This limits the effective use of advanced weapon systems, specifically of beyond visual range systems.

To improve identification capabilities and to ensure high confidence in positive air target identification, more advanced techniques and additional information sources have been proposed (see for example STANAG 4162 on the "*Technical Characteristics of the NATO Identification System (NIS)*"). These include Non-Cooperative Target Identification (NCTI) by radar.

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Radar based NCTI techniques include modulation techniques (like Jet Engine Modulation (JEM), Helicopter Rotor Modulation (HERM) and Propeller Rotor Modulation (PRRM)) and imaging techniques, either one-dimensional (High Range Resolution (HRR) profiles) or two-dimensional Inverse Synthetic Aperture Radar (2D-ISAR)). Under the Sensors and Electronics Technology (SET) Panel of the Research and Technology Organization (RTO) of NATO, extensive research has been conducted over the past two decades to establish and enhance the benefits of these techniques.

At the end of the eighties, JEM was regarded as most promising but limited only to nose-on aspects. Nowadays, modern tracking radars generally have JEM capabilities. HRR was also looked upon as promising but required further development. The past decade, research within NATO focused on classifying HRR profiles and on the generation of synthetic databases for HRR classifiers. It is foreseen that next-generation radars generally will possess means of generating HRR profiles. HRR classification means are expected on a longer term though.

While considerable attention has been paid to the development of NCTI classifiers, only limited attention has been paid to issues concerning their operational use. These issues include the desirability and the definition of requirements for a possible future NATO database for NCTI.

This paper discusses some of the issues related to the operational deployment of NCTI classifiers. It attempts to develop a coherent view on the future operational use of NCTI classifiers, specifically HRR based ones. Therefore, the second and third section current trends in concepts of operations and technological trends, respectively, to the foreseeable future. The fourth section then formulates general requirements for NCTI databases. Finally, the fifth section combines the results from the previous chapters and formulates a coherent view on the future use of NCTI classifier and databases within NATO.

2. OPERATIONAL CONSIDERATIONS

It is imperative to understand that the next military operation where NATO is involved in differs from the last one and that making statements about any future conflict therefore is quite hazardous. However, it is safe to say that the probability of NATO having to respond to large-scale aggression against one or more of the members is low. Instead, potential threats to Alliance security are more likely to result from regional conflicts, ethnic strife or other crises beyond Alliance territory, as well as the proliferation of weapons of mass destruction and their means of delivery.

Future NATO operations are therefore likely to be smaller in scale, they may be longer in duration, extend multinational co-operation to lower levels and take place concurrently with other NATO operations. The operations possibly will include contributions from Partnership for Peace (PfP) nations or even from other non-allied nations.

These developments will make their demands on the combined NCTI capability. The next few sections will develop some of the interoperability issues a little bit more. The final section exemplifies the foreseen use of NCTI capabilities.

2.1 Types of Conflict and Anti Fratricide

The types of conflict NATO nations have been and will continue to be involved in, can be divided into non-combat and combat operations. Non-combat operations typically have the aim to promote or to keep peace. They may include contributions from many nations, not necessarily allied with NATO. The level of force applied is relatively low and one might argue that these operations don’t have the need for extremely accurate non-cooperative identification means. Combat type operations typically have the aim to resolve conflicts, to deter war or even to fight and win war. The level of force applied is higher than in non-combat operations, and consequently the need for accurate and complete NCTI means may be more urgent.

Operational analysis has demonstrated that when the Blue Force has an overwhelming superiority over the Red Force, with all other factors being equal, the ratio of fratricide to the total number of Blue casualties can be greater than the fratricide rate in situations where Blue and Red are more evenly matched. The ratio indeed approaches 100 percent, even if the Blue losses are much lower [1, 2]. The accelerated operational tempo, the increased accuracy, lethality and speed/range of modern weapons, the lack of common tactics, techniques and procedures, and the absence of combined training of the coalition partners can explain the apparently increasing fratricide rates [2].

These factors contribute to augment both the likelihood and adverse consequences of human error, particularly in a coalition that consists of forces with varying degrees of interoperability, i.e. a coalition that is more likely to be found with no-combat, peace keeping operations. If we start from the idea that better means of identification can significantly decrease the number of friendly fire casualties, it is inevitable that both in non-combat operations as well as in combat operations, non-cooperative identification means have to be as accurate as possible, even though the level of force differs. In all situations, an NCTI database should therefore at least contain signatures of every allied platform in theatre and preferably a vast number of enemy platforms.

2.2 A Networked Force

Information technology is undergoing a fundamental shift from platform-centric computing to network-centric computing. This shift is most obvious in the explosive growth of the internet, intranets and extranets. Information can now be distributed, and exploited across the extremely heterogeneous global computing environment.

Evidently, the technology that enables network-centric computing is also available in military environments. The use of networks of (weapon)platforms in military operations stirred the imagination of military thinkers. In fact, they have embraced the new technology and developed theories like Network-Centric Warfare (NCW), Network Centric Operations (NCO) and Network Enabled Capabilities (NEC). In theory, NCW, or NCO and NEC for that matter, will result in a revolutionary change in the way we think about and conduct warfare [3]. In reality, it is more likely to result in incremental, evolutionary changes in military capabilities and doctrines.

Whatever the outcome of these developments will be, it is safe to assume that platform operators have access to relevant information via, or contained by the network, and that they have knowledge, or have access to knowledge, about the location and capabilities of other platforms in the network.

2.3 Identification within a Networked Force

As an example of how platforms could behave in a networked force, consider the air superiority mission.

In a conventional force, each fighter pilot is able to develop situational awareness by three means: firstly, by direct visual observation, secondly by indirect observation using on-board sensors and thirdly, via voice or Link-16 communications with other fighter pilots. If a pilot is to establish ID on a threat, he relies solely on his own sensors, classifiers and databases.

In a networked force, the pilot has a fourth means to develop situational awareness, namely digital information that is exchanged with external sources, such as other fighter aircraft or airborne surveillance and C2 aircraft, over a network. At the time of the information request, the information can already be contained by the network, or can be generated by other platforms. Specifically, the pilot can ask the airborne surveillance aircraft to establish ID on the threat he is currently facing. Alternatively, he can use his own sensors to measure a HRR profile of the threat and ask a central classifier to classify the profile using a central database.

In these examples, the platform operator (the pilot) only uses the network to communicate with other platforms. However, he still needs to know where the information that he needs can be obtained. Although the platforms can communicate via a data network, the environment can still be characterized as Platform-Centric.

In Network-Centric environments, the pilot approaches the network as a separate entity. If he needs ID on a threat he queries the network rather than the individual platforms. The network then takes care of the selection and deployment of resources (platforms, sensors, classifiers, and databases) to answer the query.

Although the distinction between a networked Platform-Centric environment and a Network-Centric environment is small to the platform operator, it is a large one to the network technology. We shall see, however, that the distinction has only fractional impact on the requirements on NCTI databases.

3. TECHNICAL CONSIDERATIONS

3.1 Radar Technology

Implementations of HRR and 2D-ISAR techniques in radar systems require that those radars be wideband and coherent. The most important requirements for NCTI relate to the geometrical resolutions (range resolutions in HRR, range and cross-range resolution in 2D-ISAR). Resolution requirements impose radar system bandwidth requirements, and bandwidth is a key parameter which is usually limited by the transmitter or antenna technology for a given radar design.

The Final Report of the Task Group (TG) 09 of the Sensors and Electronics Technology Panel (SET) lists a comprehensive set of requirements for radar imaging techniques [4]. These requirements are not very stringent, apart maybe from the motion compensation requirements for ISAR. The latter is, however, more a processing/algorithmic requirement than a system requirement. A number of existing radars already have the required bandwidth and some of these even could support NCTI modes.

It is the expectation that many future radar systems will have a HRR and/or ISAR mode if such a mode fits into their operational scope. Motion compensation for ISAR will remain a different task that requires a lot of processing power. Meeting this requirement, however, will be a matter of availability of motion compensation algorithms, rather than processing power.

The required bandwidth can be achieved relatively easily by the transmitter technology, even within a single pulse. X-band will be the preferred choice for the operational frequency. The growing use of phased array antennas might limit the HRR capabilities to stepped frequency waveforms (SFWs) if phase shifters are applied. Since these waveforms require longer dwell times, the use of an HRR classification dwell must be seriously considered in an operational situation as to not consume too much time budget. Furthermore, HRR classifiers should be able to handle HRR profiles obtained with SFWs and be robust for subtle differences. Phased array antennas using time-delay steering can handle larger bandwidths though.

3.2 Classifiers

The process of identifying aircraft based upon its JEM, HRR or ISAR signature can be separated in a number of stages. These include motion compensation, other pre-processing (like range alignment, dynamic range compression and dimension reduction), feature extraction and finally classification. Apart from the motion compensation, these stages can be considered an integral part of the classifiers.

Classifiers for radar NCTI can be divided into three groups. The first group comprises of classifiers based on *correlation techniques*. The nearest neighbour (NN) classifier is perhaps the most widely known. Since an NN-classifier does not incorporate statistical distributions, its use in the (Bayesian) IDCP framework (see section 3.3) is not straightforward. Another type of classifier based on correlation techniques is the Template Matching (TM) classifier. Its theoretical basis is well-established and the algorithm can be made as robust as in the NN case. Moreover, the template allows for information about the statistical distribution of the feature vectors and the incorporation in an IDCP framework much easier.

A second group of classifiers uses *neural networks*. The most elementary classifier that uses a neural net is the Radial Basis Functions (RBF) classifier. Radial Basis Functions provide a way to construct a smooth, non-linear mapping from a high dimensional feature vector space to a lower dimensional space, in which the class labels are defined. The important advantage, as opposed to many neural network types, is that the fitting is done in a well-defined linear way. There is no need for tuning the learning rate nor the size of the network, and there is no danger of slipping into a local optimum instead of a global one. As in the nearest neighbour case, the only quantities that enter the classifier are, as in the NN case, profile to profile distances. Incorporation into an IDCP framework is possible but not straightforward.

A final group of classifiers consist of *model* or *feature based classifiers*. While the actual classification step might very well consist of Radial Basis Functions, Nearest Neighbour, Template Matching or other previously mentioned classifier, they distinguish themselves by the presence of a feature extraction step. JEM classification algorithms all make use of simple features, such as the number of blades on a compressor stage and the blade chopping frequency. For HHR, recent investigation showed that positions of peaks in an HRR profile can be used as class discriminating features.

From this overview, it is clear that the databases belonging to these very divergent types of classifier are also very different in their nature. It is safe to say that the type of classifier defines the database and vice-versa. Therefore, classifiers and databases cannot be viewed separately.

3.3 IDCP

No single identification sensor or source is capable of providing positive identification of all friend, foe and neutral platforms under all conditions (e.g. countermeasures). The combination, however, of more than one identification sensor or source can increase the probability of correct identification. The Identification Data Combining Process (IDCP) is a component of the NATO Identification System (NIS) and it provides a standardized process for using, combining and exchanging identification data, in order to improve identification accuracy and timelines.

As of November 1996 there are (completed) parts of STANAG 4162 Annex D which cover the processing of the following identification sensor and source types: IFF, ESM, Flight Plans, Procedural Routing, Track Behaviour, Identification by point of Origin, Link 16 PPLI Messages, Nationally Sensitive Sources, and Discrete Events (e.g. target is jamming a friendly radar). A first draft of the NCTI part just covers the JEM NCTI technique, as imaging radar was considered insufficiently mature to be included at that time. Nevertheless, the general principles covering the addition of radar imaging sensors to the IDCP framework are clear, even if the details remain to be defined.

The IDCP specifies Bayes' theorem to fuse the information from different types of sensors. Fusion can be carried out in the Platform Object Class (e.g. F-14, F-15, Tornado, etc.) and/or the Basic Identity Object Class (i.e. Own Forces, Enemy Forces, Non-Aligned), depending on the sensor type. It is appropriate to convert the declaration from a radar JEM, or imaging sensor into a Likelihood Vector of the Platform Object Class.

Given the operational trend from platform-centric towards network-centric, the IDCP concept will only gain in importance. To be able to fuse ID information from different radar NCTI sensors (e.g. classifiers) it is essential that they provide a measure of reliability with their declarations. The databases coupled to these classifiers should allow for this (extra) information.

3.4 Information and Communication Technology

Information and communication technology and the networks they enable play a fundamental role in future military operations. Consequently, understanding the underlying trends that govern technology and influence the value-creation potential of networks is important to understanding the potential power of network-centric operations.

Military operations employ commercial information technologies, as well as military specific information technologies. In general, the primary difference between the networks used by deployed warfighters and the networks used by non-mobile entities, is the characteristics of the links. The primary transmission path for the deployed warfighter is radio frequency communications enabled by radio, data link, or satellite. Furthermore, military operations typically require special link features, such as anti-jam properties, which to date have not been priorities for commercial users.

There are a number of fundamental business and technology trends that shape the future of networks and the future of network-centric operations [5].

- *Moore's law*: *Computer chip performance doubles every eighteen months*. The same technology trends which have enabled the performance-cost ratio for personal computers to double approximately every 18 months have also enabled relatively small, powerful chips to be deployed in a wide variety of devices, such as personal digital assistants (PDAs). Analogous trends are being played out in warfare as we make the shift to network-centric operations.
- *Data storage capacity doubles every twelve months.* Like silicon integrated circuits, data storage devices has put on a spurt of their own, first matching the pace of chip developments but over the few years surpassing it. Since the giant magnetoresistive head (GMR) reached the market in 1997, density has been doubling each year. At the same time, costs of data storage device has fallen from approximately 1 dollar per megabyte to only a few tenths of a cent per megabyte and is now well below the cost of paper [6].
- *Transmission Capacity doubles every twelve months.* Currently, the primary backbone of advanced networks (both voice and data) is fiber optic cable. Recent and ongoing developments in the field of optical communications have resulted in the doubling of the transmission capacity of fiber optic cable every 12 months. This performance trend in fiber optical communications is key to enabling the significant capacity increase of the Internet. The last ten years has seen a rapid evolution of radio communication systems, GSM systems in particular. To maintain competitive advantage, equipment manufacturers are being driven to develop low cost and high volume products with increasing levels of functionality and miniaturization. In addition, companies are pursuing efforts to launch large constellations of satellites to provide high capacity bandwidth worldwide over radio frequency. In February 2002, regulatory approval for the development of Ultra Wideband (UWB) Communications was granted. As a result, the IEEE is expected to announce the use of UWB in their new communications standard. UWB technology allows systems to operate across a range of frequency bands, without interfering with existing systems. UWB signals appear as very low background noise to an unauthorized receiver. This radically reduces the probability of interception or detection and provides high physical security benefits compared with more conventional technologies. The operating range of current systems is, however, still limited to tens of metres.

- *Confluence of Trends—Network-Centric computing.* The consequences of these mutually reinforcing trends have been profound. The combination of increasing performance and cost suppression has resulted in the widespread adoption of computers in business and in the home which, when combined with trends in communications, has set the stage for network-centric computing and network-centric operations. The combination of digital communications capabilities and breakthroughs in software technology has enabled information interactions among entities of virtually any size that can be connected to the network.

Military information and communication technology generally follows commercial technology with a delay of several years and thus the same evolution rate can be assumed. This implies that future military platforms will possess networking capabilities comparable to today's commercially available capabilities.

4. DATABASE REQUIREMENTS

Basic requirements for NCTI databases include requirements for the following properties: type of information, size, retrieval speed, maintenance, data sources, aircraft types and configurations, etc. Requirements for these properties are not universal but depend heavily on technical possibilities, on their operational use, i.e. on the type of conflict in which they are deployed and, most importantly, on the classifier they are used with.

Furthermore, practical issues may restrict their contents. It will be impossible to build an NCTI database based upon measurements of all possible aircraft that can be encountered in theatre. While measurements of every friendly aircraft may be available, this is certainly not the case for neutral, let alone for hostile aircraft. Databases based upon synthetic data might relief this problem partly.

However, even the availability of friendly signatures (either measured or synthetic) might be limited, especially in multinational operations. It is not unthinkable that NATO members are reluctant to share signatures of some of their national aircraft with other members, let alone with possible non-NATO members within a certain coalition.

While technical requirements, like speed and size, can (eventually) be met by the ever-increasing technological possibilities, the issues related to classifier dependence and to database contents (i.e. signature availability and proliferation) need to be solved explicitly.

4.1 Dependence on NCTI Technique and NCTI Classifier

The precise information required in an operational database clearly depends on the imaging technique and the classification algorithm. The database for a JEM classifier will typically comprise JEM features like the blade-chopping frequency, the number of blades per compressor and the number of compressor stages of individual jet engines.

The database for an HRR profile classifier will typically comprise either individual range profiles, averaged range profiles, templates that are similar to averaged range profiles, or of features that are extracted from range profiles. If the classification algorithm is preceded by a pre-processing stage, for example a power law transformation, the same pre-processing of the reference profiles in the database will be required. Furthermore, depending on the classification algorithm, it may be computationally more efficient to store the Fourier Transformed range profiles, instead of the profiles themselves.

The contents of an operational ISAR database will also depend on the feature extraction and classification algorithms employed. Database for ISAR may comprise of 3D peak locations of carefully selected scatterers that are visible at each aspect angle of interest. Other recognition algorithms proposed for ISAR require databases consisting of sets of moments of the ISAR image intensity.

It is clear that NCTI databases depend heavily on the classifier they belong to. Indeed, it is impossible to view them separately. The type of classifier defines the database and vice-versa. This means that if there are to be NATO databases for NCTI, then there have to be corresponding NATO classifiers as well. This would require a lot of extra research and development efforts to co-ordinate the development and maintenance of such a classifier/database combination.

4.2 Nationally Sensitive Contents

The concept of a NATO NCTI central database, or rather NATO-central NCTI classifiers including databases, suffers from the problem of data availability. Since the database of signatures depends on the classifier, dedicated measurement campaigns have to be organized, or dedicated synthetic signatures have to be generated. Clearly, operational aircraft from non-NATO nations will never participate in such a measurement campaign. NATO intelligence sources, however will be able to provide detailed CAD models of hostile aircraft, and therefore the generation of synthetic signatures is feasible in principle.

While using synthetic signatures might relieve the need for signatures of neutral and hostile aircraft, the real challenge might be the availability of signatures of aircraft of individual member nations, to other NATO nations. It is not unthinkable that nations will be very reluctant to share such sensitive information as HRR or ISAR signature to every other NATO nation.

A possible way to diminish this reluctance is to ensure confidentiality by encrypting the information in the database and to offer the NATO classifier/database combination on a operation-by-operation basis as a black box to nations that participate in the operation. However, next to the research and development overhead caused by the classifier/database generation, this would require additional administrative overhead. Even if confidentiality within a NATO central office is guaranteed, it is still questionable if every nation can be convinced to release signature data of their most modern aircraft.

4.3 The Network Enabled Approach

The two previous sections roughly sketched the difficulties related to a NATO NCTI database with the aim to provide it to nations if circumstances call for it. Firstly, it is useless to provide databases to member nations without a corresponding classifier and secondly, it may be very hard to obtain relevant signature data. Solving these difficulties seems to implicate such a lot of effort that it may be sensible to look for alternatives for a centralized database.

A possible solution to solve the main difficulties would be to stimulate the use of decentralized classifier/database combinations. Each nation that participates in a multi-national operation is responsible for providing means to classify their own aircraft using their own classifier / database combinations. This way, signatures of their own aircraft do not have to be distributed to other nations. Of course, other nations would need access to the classifier/database combinations. This can be achieved by using a network.

Consider for instance the individual fighter aircraft that operates in a multi-national war-like operation. In the previous chapters we have established that future fighter aircraft will possess the following resources:

- Sensors that allow for the measurement of NCTI signatures, being JEM spectra, HRR profiles and/or ISAR imagery.
- A classifier that accepts these measurements as input and classifies them against a database, which, at the least, contains their own national aircraft and possibly other friendly, neutral or hostile aircraft in theatre.
- A communication link, which connects to a network. This communication channel allows for the distribution of NCTI signatures to other linked platforms.

Now suppose the platform operator (the pilot) needs ID on a threat he is facing. His first action will be to query the network for an ID on the threat. If this is not available or if it is unreliable, he uses his own sensors to obtain a JEM, HRR or ISAR signature of the threat. He then offers this signature to his classifier and at the same time sends out a request to other platforms to classify the signature using their classifiers. All classifiers in the network will prioritize and schedule this request and possibly come up with an answer that gets sent back to the requesting platform. Finally, the requesting platform combines the ID information, preferably using the IDCP protocol, and stores the ID for immediate and future use.

5. DISCUSSION AND CONCLUSIONS

Accurate identification has always been a requirement on the battlefield and has nowadays become even more stringent when military operations involve multi-national coalitions. Better means of identification significantly reduces the risk of fratricide and –partly therefore– enhances the effectiveness of advanced weapon systems, especially of those that can be employed beyond visual range.

In the past few decades, considerable attention has been paid to the development of non-cooperative identification systems and algorithms. As a result, the majority of future radar systems will possess a HRR and/or ISAR mode if such a mode fits into their operational scope. Contrarily, only limited attention has been paid to the operational use of NCTI classifiers, including the desirability and the requirements for a possible NATO central database for use with NCTI systems.

To assess if a NATO-central NCTI database is desirable, the previous chapters highlighted some operational and technological trends and projected them into the foreseeable future. The analysis of these trends seems to indicate that the answer to the question whether a NATO-central database is desirable is a negative.

There are a two serious impediments to the idea of a NATO-central NCTI database, that cannot be circumvented in practice. Firstly, we have established that NCTI classifiers and NCTI databases cannot be separated (see section 3.2 and 4.1). The availability of a NATO-central database implies the availability of a NATO-central NCTI classifier, which would require a lot of research and development in NATO panels. Efforts that are much more effective when conducted within the NATO nations themselves.

Secondly, Section 2 argued that both in non-combat and in combat operations, non-cooperative identification means have to be as accurate as possible, even though the level of force differs from the one type to the other. An NCTI database should therefore at least contain signatures of every allied platform in theatre and preferably a vast number of enemy platforms. While using synthetic signatures might relieve the need for signatures of hostile and neutral aircraft, security considerations might restrain NATO nations from sharing signatures of their own aircraft with other NATO nations. Confidentially guaranteed via NATO encryption and procedures might not convince every nation to release signature data of their most modern aircraft.

The alternative to enhance identification within multi-national coalitions is to stimulate the use of decentralized classifiers and to use a network to offer access within the coalition. Each nation that participates in a multi-national operation is responsible for providing means to classify their own aircraft using their own classifier / database combinations. This way, signatures of their own aircraft do not have to be distributed to other nations. This concept is further specified in section 0. In concreto, next to the non-trivial issues related to a networked force (which lie beyond the scope of this report), this approach would require NATO to:

- Stimulate nations to develop and maintain classifiers that report a measure of reliability with their declarations.

- Stimulate nations to develop and maintain classifier/database combinations that allow for the identification of at least their own national aircraft.
- Stimulate nations to include foreseeable neutral and hostile aircraft as well, by organizing measurement campaigns that include neutral / civil aircraft and by providing CAD models of non allied fighter aircraft.
- Specify a data format for the exchange of HRR and ISAR signatures, as well as for the exchange of ID classification results.

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