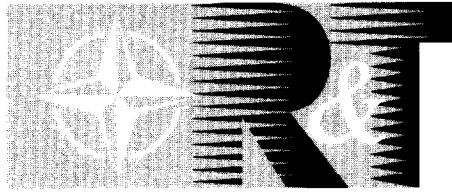


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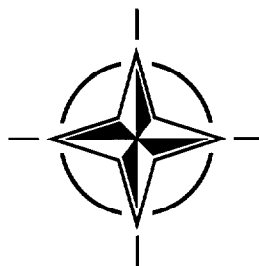
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Non-Cooperative Air Target Identification Using Radar

(l'Identification radar des cibles aériennes non coopératives)

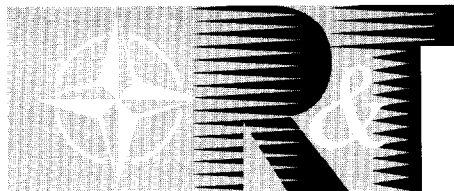
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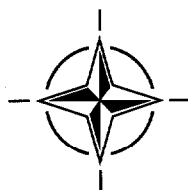
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Non-Cooperative Air Target Identification Using Radar

(RTO MP-6)

Executive Summary

The rapid and reliable identification of (air-) targets at maximum surveillance systems and weapon systems range is still a challenging problem which has a long history in NATO research studies. The different techniques that have been proposed to solve this problem may roughly be divided into two classes: cooperative and non-cooperative techniques. Cooperative techniques (often referred to as IFF - Identification Friend or Foe - techniques) are already operational in the radar domain, e.g. in airborne radars. NATO fighter aircraft are equipped with transponder systems answering on authorized interrogations by transmitting a predetermined coded signal. By this, friendly aircraft may be identified but positive identification of hostile or neutral aircraft is not possible.

This could in principle be achieved by the so-called non-cooperative identification techniques which rely on a comparison between the measured target signature with a reference data base. As one of the most promising techniques with long-range capability, radar based NCTI can be characterized. New developments in radar techniques should allow for major advances in radar based NCTI.

The symposium addressed many aspects of the topic "Non-Cooperative Air Target Identification using Radar". It started with a discussion on system requirements. The question of radar waveforms best suited for the NCTI problem was investigated. Evaluation of micro-Doppler effect and of acoustic signatures were discussed. Some emphasis was laid on the discussion of the benefits of fully polarimetric radar for the signature extraction and on the problems combined with calibration of fully polarimetric radars. The problem to establish and to interpret 2D-ISAR images was given some emphasis. Application of Time-Frequency Distributions in case of manoeuvring aircraft was proposed and different pre-processing steps investigated. Different algorithms and approaches for classification/identification of targets based on HRR or 2D-ISAR imagery were presented. The question which features should be derived from the radar signal information found a broad interest. Real time classification using optical processors was addressed and data fusion algorithms using simultaneous JEM and HRR information. The really challenging question of how to establish reference data bases for the classification/identification process was broadly discussed. There was the common understanding that this task can only be solved by the exploitation of modelling techniques. Besides other advantages this is the only practical way to get access to data of hostile aircraft. Many approaches are considered in different countries, relying on scale-model measurements or on CAD models plus computer prediction respectively. Implementation of the different techniques in real systems seems to be feasible at least as far as the JEM and HRR techniques are concerned. A technical demonstrator for the evaluation of the NCTI algorithms was presented and upgrades of fighter radars that will make the implementation of the above mentioned techniques into existing systems possible.

L'identification radar des cibles aériennes non coopératives

(RTO-MP-6)

Synthèse

L'identification rapide et fiable à distance maximale de cibles aériennes par les systèmes de surveillance et les systèmes d'armes demeure un problème délicat, qui a fait d'ailleurs l'objet de nombreuses études dans l'OTAN. Pour résoudre ce problème, deux grandes catégories existent : les techniques coopératives et non-coopératives. Les premières, souvent appelées IFF (identification ami-ennemi) sont déjà utilisées avec les radars, par exemple aéroportés. Les avions de combat de l'OTAN sont équipés de répondeurs qui, en cas d'interrogation envoient des signaux codés. Ces dispositifs ne permettent d'identifier que les avions amis, mais non les aéronefs ennemis ou neutres.

Ces derniers pourraient, en principe, être repérés avec ce qu'il est convenu d'appeler les techniques d'identification de cibles aériennes non-coopératives (NCTI) qui comparent la signature de la cible et une base de données de référence. La NCTI avec un support radar peut être considérée comme l'une des techniques très prometteuse pour la détection longue portée. Les progrès escomptés dans le domaine des techniques radar devraient amener des avancées importantes pour le principe NCTI.

Le symposium a examiné les aspects de l'identification radar des cibles aériennes non-coopératives. Les spécifications du système ont d'abord été passées en revue avant d'étudier les formes d'onde les mieux adaptées au NCTI. L'évaluation de l'effet micro-Doppler et des signatures acoustiques a été, ensuite, discutée. Une place importante a été accordée à la discussion des avantages que pourraient apporter les radars entièrement polarimétriques pour l'extraction de la signature, sans oublier les problèmes soulevés par leur étalonnage. La conférence s'est penchée également sur la prise d'images et l'interprétation ISAR-2D. Une proposition d'attribution temps-fréquence aux aéronefs en évolution a été émise ainsi que les différentes étapes possibles pour un pré-traitement. Différentes approches et algorithmes de la classification/identification des cibles, basés sur l'imagerie HRR et ISAR-2D, ont été présentés. La question de savoir quelles caractéristiques devaient être extraites des informations radar a été suivie avec grand intérêt. La classification en temps réel à l'aide de processeurs optiques ainsi que les algorithmes de fusionnement des données à base d'informations JEM et HRR simultanées a également fait l'objet de discussions.

Le délicat problème de l'établissement de bases de données de référence pour établir une classification/identification a été évoquée dans ses grandes lignes. Un consensus s'est dégagé sur le fait qu'il ne pouvait être résolu que par le biais des techniques de modélisation qui, seules permettent, de façon pratique, d'accéder aux données concernant des avions ennemis. De nombreuses études sont en cours à l'heure actuelle dans différents pays, basées sur des calculs à partir de modèles à l'échelle, de modèles CAO couplés à des prédictions de modèles informatiques. L'installation de ces techniques sur des systèmes existants semble possible, du moins en ce qui concerne les techniques JEM et HRR. Un démonstrateur technologique pour l'évaluation des algorithmes NCTI a été présenté, ainsi que des versions améliorées de radars d'avions de combat qui permettront l'installation de ces techniques.

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Preface

Identification of aircraft is a critical function in both command and control (C 2) and weapon systems. Since many years work is going on in a variety of NATO countries to develop an identification system which will allow for reliable identification of friendly, hostile and neutral aircraft at maximum surveillance systems and weapon systems range. Different sources could in principle be exploited for the identification process, one of which is the so called "cooperative" component, often addressed as IFF (Identification Friend Foe) systems. This source relies on the response of an interrogated aircraft via a transponder and a predefined code, by this identifying an aircraft as a friendly one. Missing response is an indication for a hostile or neutral aircraft but there is no positive hostile/neutral aircraft identification. An incorrect identification can result in fratricide or engagement of civilian aircraft, both of which happened in recent conflicts.

Systems having the potential for identification of friendly, hostile and neutral aircraft are elements of the so-called "Non-Co-operative Target Identification (NCTI)" system class. These systems operate by comparing the received signatures (radar, infrared, acoustic, etc.) of an aircraft against a database of known signatures. As one of the most promising techniques with long-range capability, radar based NCTI can be characterized. Recent developments in radar techniques improving e.g. the resolution capabilities of the radar systems and new more advanced processing techniques should allow for major advances in radar based NCTI.

There is no doubt that a future identification system will be a "system of systems" where different entries will be used for the final declaration of a target as friend, foe or neutral. In this system the cooperative IFF mode and the non-co-operative mode together with auxiliary informations from other sources (ESM, intelligence, flight/mission plans, airspace control procedures, track by origin, flight profile and target behaviour, etc.) will form the input information in a data combining process (see proposed NATO Identification Data Combining Process (IDCP)).

This Symposium will concentrate on the discussion of the non-co-operative component. Its scope is to serve as a forum where experts from the whole alliance will be able to present and discuss novel technical solutions and novel processing techniques to the NCTI problem, and by that will help to explore current capabilities in all topics that are of relevance to the problem of non-co-operative air target identification using radar and even beyond this special application.

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14. Abstract Contains the unclassified papers presented at a Symposium on Non-Cooperative Air Target Identification using Radar organised by the Systems Concepts and Integration Panel (SCI) of RTO, in Mannheim, Germany, 22-24 April 1998. Novel solutions to the Non-Cooperative Target Identification (NCTI) Problem, using radar are proposed. The papers are presented under the following headings: • System requirements • Target characterisation • Radar measurements and feature extraction • Target classification • Scattering techniques, target modelling and validation					



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