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**RTO EDUCATIONAL NOTES** **EN-SET-063**

# Knowledge-Based Radar Signal and Data Processing

(Le traitement du signal et des données radar basé sur les connaissances)

The material in this publication was assembled to support a Lecture Series under the sponsorship of the Sensors and Electronics Technology Panel (SET) presented on 3-4 November 2003 in Stockholm, Sweden; 6-7 November 2003 in Rome, Italy; 10-11 November 2003 in Budapest, Hungary; 28-29 October 2004 in Madrid, Spain and 4-5 November 2004 in Gdansk, Poland.

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RTO is the single focus in NATO for Defence Research and Technology activities. Its mission is to conduct and promote co-operative research and information exchange. The objective is to support the development and effective use of national defence research and technology and to meet the military needs of the Alliance, to maintain a technological lead, and to provide advice to NATO and national decision makers. The RTO performs its mission with the support of an extensive network of national experts. It also ensures effective co-ordination with other NATO bodies involved in R&T activities.

RTO reports both to the Military Committee of NATO and to the Conference of National Armament Directors. It comprises a Research and Technology Board (RTB) as the highest level of national representation and the Research and Technology Agency (RTA), a dedicated staff with its headquarters in Neuilly, near Paris, France. In order to facilitate contacts with the military users and other NATO activities, a small part of the RTA staff is located in NATO Headquarters in Brussels. The Brussels staff also co-ordinates RTO's co-operation with nations in Middle and Eastern Europe, to which RTO attaches particular importance especially as working together in the field of research is one of the more promising areas of co-operation.

The total spectrum of R&T activities is covered by the following 7 bodies:

- AVT Applied Vehicle Technology Panel
- HFM Human Factors and Medicine Panel
- IST Information Systems Technology Panel
- NMSG NATO Modelling and Simulation Group
- SAS Studies, Analysis and Simulation Panel
- SCI Systems Concepts and Integration Panel
- SET Sensors and Electronics Technology Panel

These bodies are made up of national representatives as well as generally recognised 'world class' scientists. They also provide a communication link to military users and other NATO bodies. RTO's scientific and technological work is carried out by Technical Teams, created for specific activities and with a specific duration. Such Technical Teams can organise workshops, symposia, field trials, lecture series and training courses. An important function of these Technical Teams is to ensure the continuity of the expert networks.

RTO builds upon earlier co-operation in defence research and technology as set-up under the Advisory Group for Aerospace Research and Development (AGARD) and the Defence Research Group (DRG). AGARD and the DRG share common roots in that they were both established at the initiative of Dr Theodore von Kármán, a leading aerospace scientist, who early on recognised the importance of scientific support for the Allied Armed Forces. RTO is capitalising on these common roots in order to provide the Alliance and the NATO nations with a strong scientific and technological basis that will guarantee a solid base for the future.



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# Knowledge-Based Radar Signal and Data Processing

## (RTO-EN-SET-063)

# Executive Summary

Radar systems are an important component of NATO military operations. In response to increasingly severe threats from military targets with reduced radar cross sections, slow moving and low flying targets, targets hidden in foliage and under trees, and in environments with large numbers of targets, knowledge-based (KB) signal and data processing techniques offer promise of significantly improved performance of NATO operated radar systems. In addition, radar systems under knowledge-based control can be deployed to better utilize valuable resources such as air space and runways and aid human operators in carrying out their missions. As battlefield scenarios become more complex with ever growing numbers of sensors and weapon systems, the challenge will be to effectively use already available information to enhance radar performance. Knowledge-based processing fills this need and helps meet the challenge.

This Lecture Series presents a state-of-the-art assessment of knowledge-based radar signal and data processing techniques, and thereby increase awareness of their value to the NATO scientific community. It reviews current developments in the area, and presents examples of improved radar performance for augmented and upgraded systems. In addition, the impact of KB technology on future systems is discussed.

This Lecture Series will present all relevant aspects of knowledge-based techniques as they apply to modern radar signal and data processing. The lectures cover:

- Introduction to Radar Signal & Data Processing – the Opportunity.
- Fundamentals of relevant knowledge-based techniques.
- Detailed characterization of the general radar problem in terms amenable to KB solution applications.
- Expert system application to constant false alarm rate processor.
- Knowledge-based control for space time adaptive processing.
- KB techniques applied to performance improvement of existing radar systems.
- Impact of KB techniques for emerging technologies (multi-phased arrays, electronically agile beam forming, waveform diversity).
- Integrated end-to-end radar signal & data processing with overarching KB control.

# Le traitement du signal et des données radar basé sur les connaissances

## (RTO-EN-SET-063)

# Synthèse

Les systèmes radar constituent un élément important des opérations militaires de l'OTAN. Les techniques de traitement du signal et des données radar basées sur les connaissances (KB) permettront d'améliorer considérablement les performances des systèmes radar de l'OTAN, afin de répondre aux menaces de plus en plus sérieuses présentées par des objectifs militaires à surface équivalente radar réduite, des objectifs évoluant à basse vitesse et à basse altitude, des objectifs masqués par le feuillage et les arbres, ainsi que par des environnements contenant un grand nombre d'objectifs. En outre, des systèmes radar contrôlés par des systèmes basés sur les connaissances peuvent être déployés afin de mieux utiliser les moyens précieux que sont l'espace aérien et les pistes d'envol, ainsi que pour aider les opérateurs dans l'exécution de leurs missions. Avec la complexité croissante des scénarios de champ de bataille, intégrant de plus en plus de capteurs et de systèmes d'armes, l'accent sera mis sur l'exploitation efficace des informations déjà disponibles pour améliorer les performances des systèmes radar. Le traitement basé sur les connaissances répond à ces critères et permet de relever le défi qui est posé.

Ce cycle de conférences a pour objectif de présenter une évaluation de l'état actuel des connaissances dans le domaine des techniques de traitement des données et du signal radar basées sur les connaissances, afin de mieux sensibiliser les scientifiques de l'OTAN aux possibilités offertes par ces techniques. On y examinera les développements actuels dans ce domaine, et on y présentera des exemples d'amélioration de performances dans des systèmes augmentés et améliorés. Les conférences couvriront en outre l'impact des technologies KB sur les systèmes futurs.

Ce cycle de conférences présentera tous les aspects des techniques basées sur les connaissances dans la mesure où elles sont applicables au traitement du signal et des données d'aujourd'hui. Les conférences couvrent :

- Une introduction au traitement du signal et des données radar – les possibilités.
- L'essentiel des techniques basées sur les connaissances appropriées.
- La caractérisation détaillée du problème général du radar présentée dans des termes se prêtant à des applications KB.
- L'application des systèmes experts aux processeurs de taux de fausse alarme constant.
- Le contrôle basé sur les connaissances pour le traitement spatiotemporel adaptatif.
- Les techniques KB appliquées à l'amélioration des performances des systèmes radar existants.
- L'impact des techniques KB sur les technologies émergentes (antennes réseaux multiphases, formation de faisceaux agiles, diversité des formes d'ondes).
- Le traitement intégré du signal et des données radar de bout en bout avec contrôle global KB.

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**14. Abstract**

The objective of this Lecture Series was to present a state-of-the-art assessment of knowledge-based (KB) radar signal and data processing techniques, and thereby increase awareness of their value to the NATO scientific community. The Lecture Series covered: Fundamentals of Relevant Knowledge-Based Techniques; Detailed Characterization of the General Radar Problem; Expert System Application to Constant False Alarm Rate Processor; Knowledge-Based Control for Space Time Adaptive Processing; KB Techniques Applied to Performance Improvement of Existing Radar Systems; Impact of KB Techniques for Emerging Technologies; Integrated End-to-End Radar Signal & Data Processing with Over-Arching KB Control. The Lecture Series reviewed the current developments in the area and present examples of improved radar performance for augmented and upgraded systems. In addition, the series projected the impact of KB technology on future systems.

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