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NORTH ATLANTIC TREATY ORGANIZATION

RESEARCH AND TECHNOLOGY ORGANIZATION

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RTO MEETING PROCEEDINGS 61

Space-Based Observation Technology

(les Technologies de l'observation spatiale)

Unclassified papers presented at the RTO Sensors and Electronics Technology Panel (SET) Symposium held on the Island of Samos, Greece, 16-18 October 2000.

Published October 2000

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- SCI Systems Concepts and Integration
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- IST Information Systems Technology
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Space-Based Observation Technology

(RTO MP-61)

Executive Summary

Observation of the earth by use of spacebased sensors has a large number of advantages compared with ground-based or airborne sensors. It is, therefore, a primary requirement of future reconnaissance systems, and is thus also a primary requirement of future reconnaissance systems of NATO. There is a tendency worldwide to place in space many reconnaissance functions that have so far been fulfilled by airborne systems.

Spaceborne sensors are in essence optical and radar sensors. Optics have the property of high geometric resolution, but fail during the night and under adverse weather conditions. Radar can penetrate weather, dust and even foliage. The resolution achieved nowadays with Synthetic Aperture Radar (SAR) technology comes close to that of optical resolution. SAR offers additional features such as classification based on Doppler or polarimetry, moving target detection, 3D-imaging etc.

Sensors installed on a spacecraft have to fulfill various conditions which have to do with the space environment. Light weight, low-power power consumption, small size are prerequisites. Moreover, components have to be space-proof. Signal and image processing techniques and technology for on-board real-time processing have to be considered as well.

Starting from operational requirements this symposium summarizes aspects of spaceborne radar, including the required technology as well as special features, signal and data processing, optronics instrumentation and detector technology, so as to cover the whole range of spacebased observation technology based on radar and optronics. Various existing or planned observation satellite projects are described.

les Technologies de l’observation spatiale

(RTO MP-61)

Synthèse

La technique de l’observation de la terre à partir de capteurs spatiaux offre de nombreux avantages par rapport à l’observation à partir de capteurs terrestres ou aériens. Elle est, par conséquent, l’une des premières caractéristiques souhaitées pour les futurs systèmes de reconnaissance et à fortiori pour les futurs systèmes de reconnaissance de l’OTAN. Il existe une tendance universelle à faire réaliser des fonctions de reconnaissance remplies jusqu’ici par des systèmes aéroportés, par des systèmes spatiaux.

Les capteurs spatiaux sont des capteurs radar et optiques. Les capteurs optiques offrent une haute résolution géométrique, mais ils sont inexploitables de nuit et par mauvais temps. Le radar peut pénétrer les nuages, la poussière et même les feuillages. La résolution obtenue par les radars à ouverture synthétique (SAR) aujourd’hui est presque aussi bonne que la résolution optique. Le SAR a également d’autres fonctionnalités telles que la classification basée sur les techniques Doppler ou la polarimétrie, la détection des cibles mobiles, l’imagerie 3D etc...

Les capteurs installés sur les véhicules spatiaux doivent remplir certaines conditions en relation avec l’environnement spatial. Légèreté, dimensions réduites et faible puissance absorbée sont des éléments indispensables. En outre, les composants doivent être résistants à l’environnement spatial. Il faut également considérer les techniques et technologies de traitement de l’image pour le traitement embarqué en temps réel.

Prenant comme point de départ les besoins opérationnels, ce symposium fait le point des différents aspects des radars spatiaux, y compris les technologies, les fonctionnalités spéciales, le traitement du signal et le traitement des données, l’instrumentation optronique et les technologies de détection, de façon à couvrir l’éventail des technologies d’observation spatiale basées sur le radar et l’optronique. Différents projets de satellites d’observation, existants ou prévus, sont décrits.

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Theme

For many years, spaceborne observation and reconnaissance systems have been of high importance to NATO countries. The military and political changes of the past years lead to a situation where precise and fast reconnaissance is a primary requirement. Moreover, verification of disarmament treaties will become a major task in future years. This RTO-SET symposium will cover the specific aspects of space-based observation technology with emphasis on both radar and optronics systems.

Currently many high performance satellites use optronics technology for applications such as meteorology, terrain mapping, environmental monitoring, surveillance, reconnaissance etc. The rapid evolution of optronics technology in the fields of optics, detectors, and image processing will have significant influence on the design of the next generation of satellites. In addition to high-resolution target identification, optronics even allow the nature of their materials to be identified. While passive optronics detection systems are more or less “stealthy” in nature, active optronics may be used to distinguish real targets from false targets and decoys.

Compared with optical and IR sensors, radar technologies offer complementary capabilities such as all-weather, day/night operation, long range performance, penetration of obscurants such as dust, fog and smokes. Multispectral and multipolarization operation in the microwave domain are additional options for detection and classification. Geometrical resolution of less than 1m has been demonstrated by synthetic aperture techniques. The next generation of spaceborne radar will include active phased array antennas in conjunction with synthetic aperture processing, thus offering high efficiency, reliability and the potential of spatial signal processing for image enhancement, MTI, ECCM.

The high resolution of today’s optronics and radar technology makes the application of novel pattern recognition techniques such as artificial intelligence or neural networks possible. The complementarity nature of radar and optronics should be exploited for detection, localization and identification of targets in hostile environments, and should lead to highly reliable automatic or automated recognition systems. This symposium is proposed for Fall 2000. At that time several new space-based systems are expected to be in operation: SEAWIFS (USA) together with MOS on IRS (DLR); SRTM (Shuttle Radar Topography Mission, USA, Germany); ENVISAT/ASAR (ESA) together with ERS-2 (interferometric), SPOT5 (F+D). Fruitful interactions between these experiments and the proposed symposium can be expected.

The symposium will deal with all aspects of space-based observation including the satellite, support systems, sensors, data handling etc.

Topics to be covered include:

- Operational requirements/trade-offs
- Specific space systems issues
- Spaceborne radar technology
- Special features of spaceborne radar
- Spaceborne optronics technology
- Special features of optronics systems
- On-board/real-time processing

Thème

Une grande importance est accordée aux systèmes d'observation et de reconnaissance spatiaux par les pays membres de l'OTAN depuis de nombreuses années. Les changements politiques et militaires qui sont survenus ces dernières années ont conduit à une situation où il est impératif de disposer de données de reconnaissance précises et à jour. De plus, la tâche de vérification des traités de désarmement est appelée à s'amplifier dans les années à venir. Ce symposium RTO-SET traitera d'aspects spécifiques des technologies de l'observation spatiale, en mettant l'accent sur les systèmes radar et optroniques.

Aujourd'hui, bon nombre de satellites à hautes performances font appel aux technologies de l'optronique pour des applications telles que la météorologie, la cartographie de terrain, la surveillance de l'environnement, la surveillance, la reconnaissance, etc... L'évolution rapide des technologies de l'optronique dans des domaines tels que l'optique, les dispositifs de détection et le traitement de l'image aura une influence non négligeable sur la conception de la prochaine génération de satellites. L'optronique, en plus de sa haute résolution, permet d'identifier la nature des matériaux constitutifs des cibles. A la différence des systèmes de détection optroniques passifs, qui sont par nature plus ou moins « furtifs », l'optronique active est capable de distinguer entre « vraies », « fausses » cibles et leurres.

Comparé aux senseurs optiques et infrarouges, le radar offre des performances complémentaires telles qu'un fonctionnement tous temps, jour et nuit, une longue portée et la capacité de voir au travers d'obscurcissants tels que la fumée, le brouillard et la poussière. Le fonctionnement multispectre avec multipolarisation dans le domaine des hyperfréquences sont des options supplémentaires pour la détection et la classification. Des résolutions de moins d'un mètre ont été démontrées par le biais des techniques d'ouverture synthétique. La prochaine génération de radars spatiaux sera dotée de radars à antenne réseau active associés au traitement d'ouverture synthétique, de façon à assurer un haut niveau d'efficacité et de fiabilité avec la possibilité d'un traitement du signal spatial pour l'amélioration de l'image, ainsi que des capacités MTI et CCME.

La haute résolution autorisée par les technologies actuelles de l'optronique et du radar permet la mise en oeuvre de techniques novatrices de reconnaissance de formes, telles que l'intelligence artificielle et les réseaux neuronaux. Le caractère complémentaire du radar et de l'optronique doit être exploité pour la détection, la localisation et l'identification de cibles en environnement hostile, et devrait conduire à la réalisation de systèmes de reconnaissance automatiques ou automatisés hautement fiables. Ce symposium est proposé pour l'automne 2000. L'entrée en service de plusieurs nouveaux systèmes spatiaux est prévue avant cette date, à savoir : le SEAWIFS (USA) avec le MOS sur IRS (DLR); le SRTM (mission de topographie radar par la navette spatiale, USA, Germany); l'ENVISAT/ASAR (ESA) avec l'ERS-2 (interferométrique), le SPOT5 (F+D). Des interactions fructueuses entre ces expériences et le symposium proposé sont à prévoir.

Le symposium traitera de tous les aspects de l'observation spatiale, y compris les satellites, les systèmes de soutien, le senseurs, le traitement des données etc..

SUJETS A TRAITER :

- besoins opérationnels/compromis
- questions spécifiques à l'utilisation des systèmes spatiaux
- technologies des radars spatiaux
- caractéristiques particulières des radars spatiaux
- technologies de l'optronique spatial
- caractéristiques particulières des systèmes optroniques
- traitement embarqué en temps réel

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Target acquisition	Optronics
Target recognition	SBR (Space Based Radar)
Artificial satellites	Remote sensing
Real time operations	

14. Abstract

This volume contains the unclassified papers presented at the Sensors and Electronics Technology Panel symposium held on the Island of Samos, Greece on 16, 17 and 18 October 2000.

All aspects of space-based observation including the satellite, support systems, sensors, data handling etc.

Topics covered included:
- Operational requirements/trade-offs
- Spaceborne radar technology
- On-board/real-time processing
- Specific space systems issues
- Special features of optronics systems

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