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TECHNICAL
REPORT

A RAND Analysis Tool for Intelligence, Surveillance, and Reconnaissance

The Collections Operations Model

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Prepared for the United States Air Force

RAND PROJECT AIR FORCE

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Summary

This report is an introduction to the Collection Operations Model (COM), a stochastic, agent-based analysis tool for C3ISR written for the System Effectiveness Analysis Simulation (SEAS) modeling environment. SEAS is a multiagent, theater-operations simulation environment sponsored by the Air Force Space Command, Space and Missile Systems Center, Directorate of Developmental Planning, SEAS Program Office (SMC/XRIM) (see pp. 13–16).

The COM grew out of ISR tasking and employment studies conducted by Project AIR FORCE in fiscal years 2005 and 2006. It has since been used to support further research, notably to investigate the utility of the Global Hawk as a maritime surveillance platform.[2] The COM is designed for the study of processes that require the real-time interaction of many players, such as ad hoc collection, dynamic retasking, and resource allocation. The COM can provide analytical support to questions regarding force mix, system effectiveness, concepts of operations, basing and logistics, and capability-based assessment.

The COM is designed to be a universal model that can be adapted to support almost any scenario. It can represent thousands of autonomous, interacting platforms on all sides of a conflict that employ a wide variety of sensor packages and communications devices and execute individual behaviors of arbitrary complexity (see pp. 3–6). The COM can explore the capabilities of a wide range of ISR assets, including manned platforms, unmanned aerial vehicles, unattended ground sensors, special operations forces, and virtually any air, land, or sea system. The model accepts as input a wide array of sensor capabilities, target properties, terrain analysis, weather effects, resource limitations, communications delays, and command and control delays. Its final output is a minute-by-minute account of each agent's changing operational picture.

As an agent-based construct, the COM supports interactive behaviors that link the actions of agents to environmental conditions, to the perceived activity of other agents, and to commanders' orders. Examples of such behaviors are maintaining a surveillance orbit around a moving ship, attempting to provoke an enemy vessel by repeatedly approaching and retreating, and reorienting sensors in response to revised tasking orders.

The COM's sensor models (see pp. 9–11), which are categorized according to the type of intelligence they collect, are its most detailed components. The signals intelligence (SIGINT) model is the COM's most sophisticated individual model. Many aspects of emitters and receivers are represented: field of regard (FOR), including main and side lobes where appropriate; scan cycle, emission interval, or emission probability; frequency bands; relative angular size of

[2] Carl Rhodes, Jeff Hagen, and Mark Westergren, *A Strategies-to-Tasks Framework for Planning and Executing Intelligence, Surveillance, and Reconnaissance (ISR) Operations*, Santa Monica, Calif.: RAND Corporation, TR-434-AF, 2007; Lingel et al., 2007.

main and side lobes (for directional signals); and the effective radiated power of each radiative lobe. The COM's related communications intelligence exploitation model, which involves further processing, may result in target identification.

The imagery intelligence model estimates the quality of electro-optical, infrared, and synthetic aperture radar images. For each individual sensor, an empirical formula relates target range to expected image quality on the National Imagery Interpretability Rating Scale. In the maritime environment, detection and classification are performed by inverse synthetic aperture radar. Ground moving target indicator (GMTI) and maritime moving target indicator (MMTI) models are inherently complex, and currently the COM does not incorporate tracking algorithms per se for either mode. For GMTI, the COM estimates and monitors the percentage of available sensor resources required to track a given target. For MMTI, maintenance of track is approximated by repeated radar contact.

For fiscal year 2008, RAND has invested in the addition of space-based assets to the COM, including relevant space weather and atmospheric effects (see p. 17). Other planned upgrades include a more robust model of sensor data fusion, communications modules that more accurately represent the advantages of a networked force, a more realistic representation of workflow within the air operations center and the deployable ground station, the capability of sensors to generate spurious reports (i.e., false positives) on their own, and the capability of agents to deliberately induce such reports (i.e., deception) (see pp. 17–18). The larger goal of these extensions and enhancements is to create a COM that can represent the entire C3ISR process specifically and network-centric operations in general.