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Program Overview of the Multi-Spectral Sensor Surveillance System (M4S)

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ABSTRACT

Over the years a great deal of multi-sensor fusion research has been conducted. While the potential military value of such research is considered high, there have been few fielded examples in the tactical arena. The objective of the Multi-Spectral Sensor Surveillance System (M4S) program is to transition high-payoff, low risk multi-sensor fusion technology from the research and development phase into practical user-oriented systems applications.

The primary application focus of M4S is toward a robust and highly integrated autonomous littoral surveillance capability for either manned or unmanned surveillance aircraft. Sensor data from various organic, i.e. on-board, sensors as well as off-board sources is used to provide superior battlespace awareness. Specific operational payoffs from M4S include reduced manning requirements, improved detection, classification, and geo-location accuracy, and reduced prosecution timelines against time-critical targets.

This objective and focus has led to the selection of a suite of notional sensors and a data fusion architecture consistent with the limited space and computational capabilities of airborne platforms. The four non-developmental organic sensors chosen for M4S include the PLAID ESM system, AN/APS-137B

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1.0 INTRODUCTION

Over the years a great deal of multi-sensor fusion research has been conducted. While the potential military value of such research is considered high, there have been few fielded examples in the tactical arena. The objective of the Multi-Spectral Sensor Surveillance System (M4S) program is to demonstrate the operational utility of such of such a system, quantifying improvements to the maximum extent possible. In this context, M4S is addressing not only the information fusion from the outputs of a suite of dissimilar sensors, but also a closely integrated interaction of these sensors, as typified by human sensor processes. As an example, it’s one sensor telling another in which general geographic area to search for a target, as well as give it some idea of what it’s looking for. Or, as another example, M4S realizing it needs a particular piece of critical information to make a positive ID on a target. It’s our belief that there are some significant gains in ISR capability that are available even with our existing sensor inventory... if we can get these sensors to interact more synergistically.

To implement this concept in an airborne surveillance context, M4S has selected a notional airborne surveillance platform (see figure 1) which could be either a manned or unmanned aircraft, and identified four off-the-shelf sensors, including an ESM, SAR, FLIR, and LADAR, which will be later described in further detail. While M4S could also take advantage of off-board sensor information as well, the initial efforts have focused on the use of these organic sensors in littoral environments, as might be the case with an organic surveillance asset under the control of a joint theatre commander.

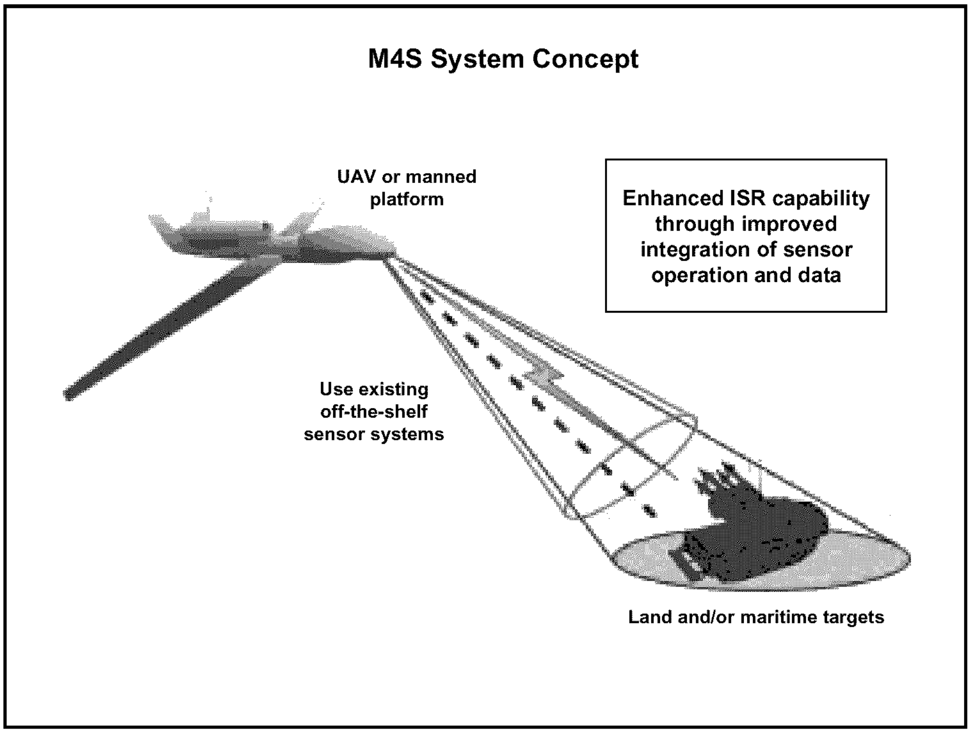

Figure 1 Multi-Spectral Sensor Surveillance System (M4S) Concept

2.0 OPERATIONAL IMPACT

Operational benefits that can be achieved through implementation of this data fusion technology in an operational context include: Enhanced real-time awareness of friendly, neutral, and adversary forces; improved detection, classification, identification and battle damage assessment; Reduced operator workload by increasing automation of information processing and sensor/flight control; improved prosecution of time critical targets, i.e. tighter sensor to shooter connectivity; and reduced off-board communication bandwidth requirements through increased on-board processing.

3.0 TECHNICAL APPROACH

The M4S technical approach is to use data fusion technology to exploit the synergy of our four-sensor suite. That synergism comes from a number of factors, including the broad spectral coverage, as well as measurement of different target phonologies. Indeed, M4S covers not only the EM and EO portions of the spectrum, but also the acoustic end via the vibrometry information obtained from the LADAR. That allows not only the ability to take full advantage of any emissions or characteristics of a particular target, but also allows mitigation of adverse environmental or propagation effects. Additionally, the M4S concept can be extended to include multiple distributed platforms and sensor systems.

4.0 SELECTED SENSORS

Figure 2 depicts the specific sensors chosen for the M4S sensor suite. They include, starting in the upper left and working clockwise: the multimode AN/APS-137 Synthetic Aperture Radar; a 2-18 GHz Passive Location and Identification ESM system currently being procured by the Air Force, and which provides passive ranging and SEI capability; an AN/AAQ-49 mid-wave FLIR used by the LAMPS helicopter; and a coherent 10.6 micron CO2 LADAR that provides target vibration information.

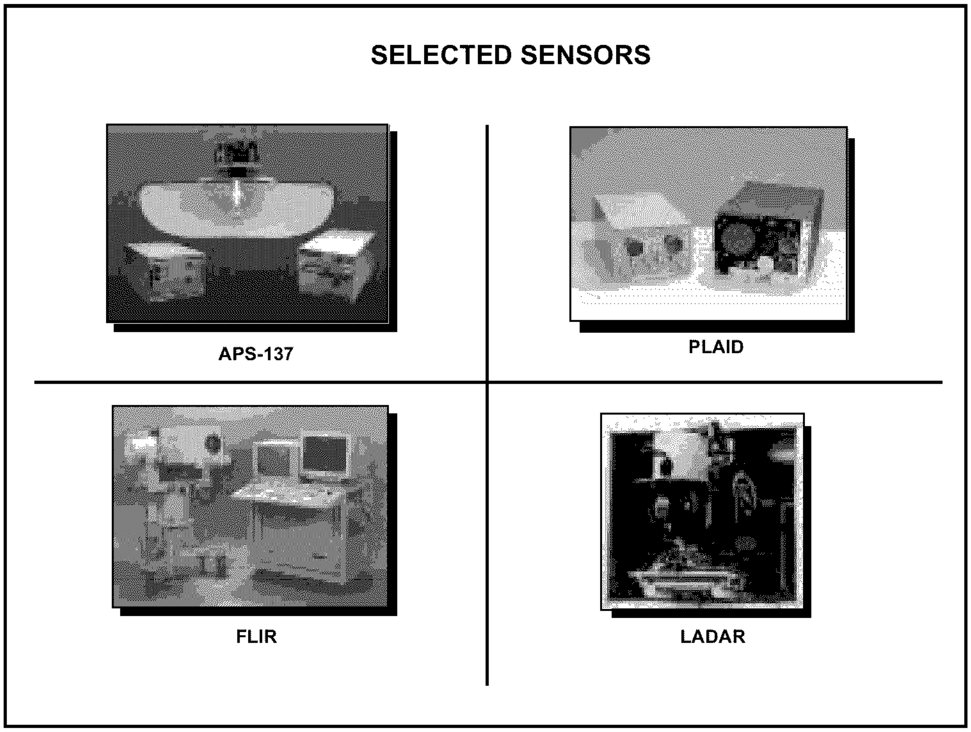

Figure 2 Selected M4S Sensor Suite

5.0 M4S ARCHITECTURE

Figure 3 provides a graphical depiction of the overall M4S system architecture. At the far left in the graphic are the individual sensors, which each feed their own Sensor Processor. The Sensor Processor provides both a software and hardware interface between the individual sensors and the M4S system, allowing the transfer of sensor data into M4S, as well as sensor operation, i.e. pointing and mode control, by the resource manager. Additionally, it provides a large measure of the system's plug and play capability, should additional or alternative sensors be used with M4S.

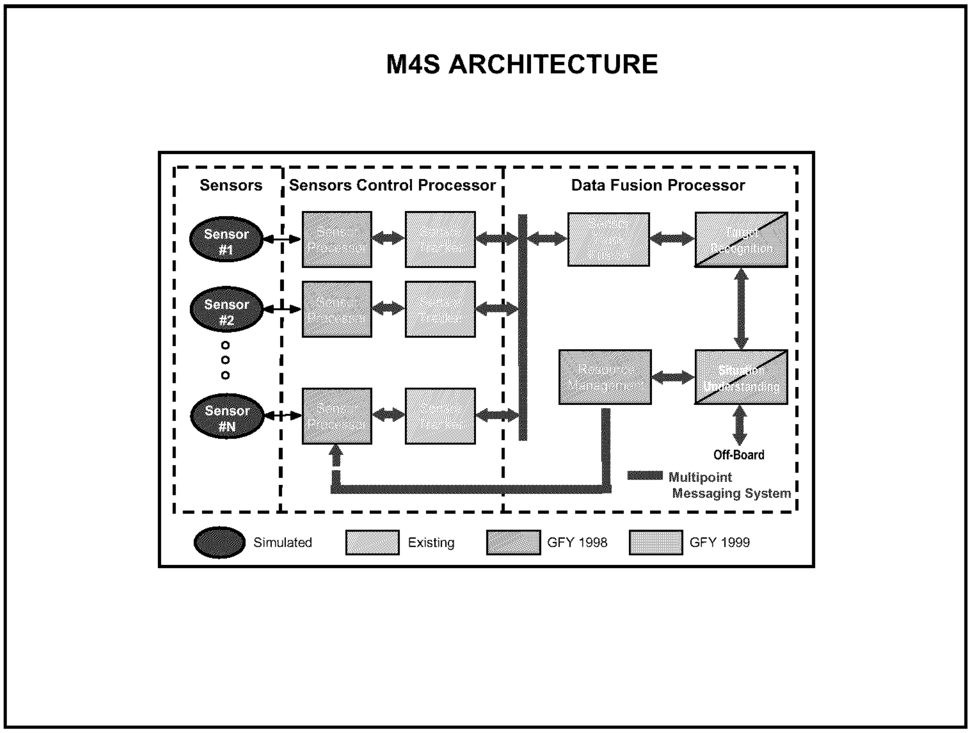

Figure 3 M4S Architecture

The outputs of the Sensor Processors each feed individual Sensor Trackers. Each Sensor Tracker takes individual sensor detections and observed target characteristics, and attempts to establish mature tracklets, or short track segments, which include not only target positional information, but target characteristics such as target length or vibration spectrum.

The Sensor Track Fuser, which is based upon the Advanced Tactical Workstation, is where all the dissimilar sensor source information is first brought together. There the fuser attempts to correlate, both spatially and temporally, tracklet information originating from any single type sensor, or cross correlate information from dissimilar type sensors. The output from this process is a track database that provides a complete description of the time history, target characteristics, and possible identification of all maintained tracks. The fuser is a statistical tracker that makes soft decisions, and as such is able to go back and revise merge/demerge decisions, or handle out-of-order data.

Providing a situation understanding capability in M4S is a new effort just getting started. Here again M4S uses a database, this time of known enemy scenarios and behaviors, to infer a higher level of understanding of the threat's intent and possible future actions.

The last block in the M4S architecture is the Resource Manager, which provides pointing and mode control of the individual sensors, as well as flight path waypoint updates. It should be noted that all communications within M4S take place via a Multipoint Messaging System – an ask/answer messaging format that throttles the flow of information within the M4S system.

6.0 Simulation

Since M4S is a development program, it was realized early that a virtual or synthetic environment was needed to support M4S. Such an environment could support software development, integration and laboratory testing before heading out into the much more complex real world. It would also permit the conduct of highly repeatable Intelligence, Surveillance, and Reconnaissance (ISR) missions in any desired area of the world in support of Monte Carlo evaluation of Measures of Effectiveness (MOE) or Measures of Performance (MOP). The capabilities listed in figure 4 identify some of the present and future planned M4S sensor modeling capabilities.

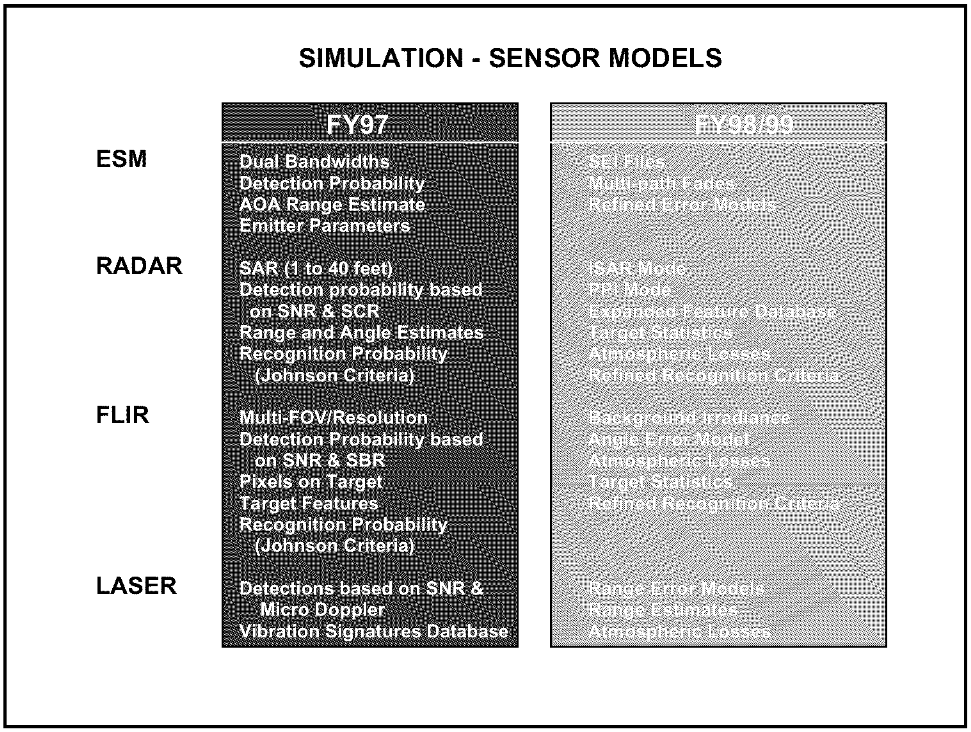

Figure 4 Sensor Modeling Capabilities

In addition to modeling the sensors themselves, M4S has also developed all the necessary components to conduct and evaluate, again through Monte Carlo techniques, several typical ISR missions. These modeled components include the earth, various target arrays, the airborne surveillance platform, and atmospheric phenomenon such as weather effects. These components are listed in figure 5.

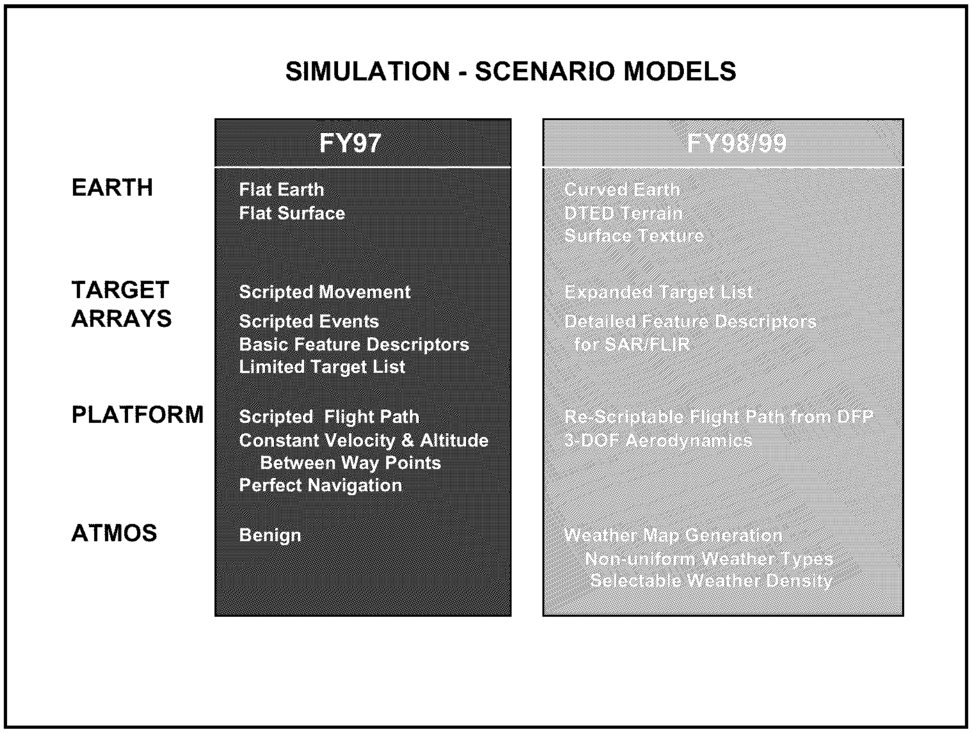

Figure 5 Scenario Modeling Capabilities

7.0 System Integration Lab (SIL)

Figure 6 is a photograph of the M4S System Integration Lab, or SIL, where software development and test takes place, and virtual ISR missions are conducted. The M4S architecture is implemented using a Windows NT operating system hosted on Pentium class machines, networked together over an Ethernet. Also noted in the graphic there is a test controller that conducts the Monte Carlo simulations, and records appropriate data for post mission MOE/MOP analysis.

SYSTEM INTEGRATION LAB (SIL)
IS UP AND RUNNING

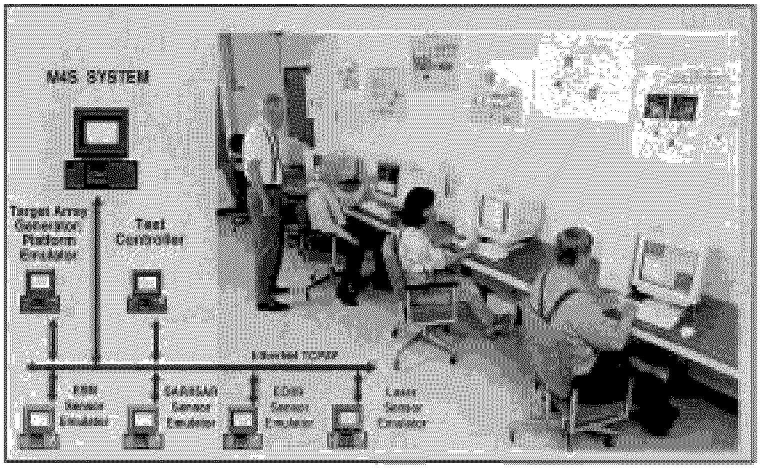

Figure 6 System Integration Lab (SIL)

Three ISR scenarios have been implemented in the SIL to demonstrate various M4S functional capabilities. These scenarios include 1) An ocean surveillance scenario which demonstrates the handoff from off-board to onboard sensors, the ability to track multiple targets, and target identification; 2) An armored column scenario which demonstrates the integration of intelligence information, and dynamic flight path control; and 3) A site assessment scenario which demonstrates the ability to separate and identify closely spaced targets, and operate in the presence of a surface to air missile threat. All of these scenarios take place in the Persian Gulf near the Straight of Hormuz.

8.0 M4S Program Schedule

Figure 7 provides the overall M4S program schedule. As can be noted, M4S is still in laboratory development, but is aiming for an actual flight test of the system in a manned aircraft, such as a P-3, in the FY01 timeframe.

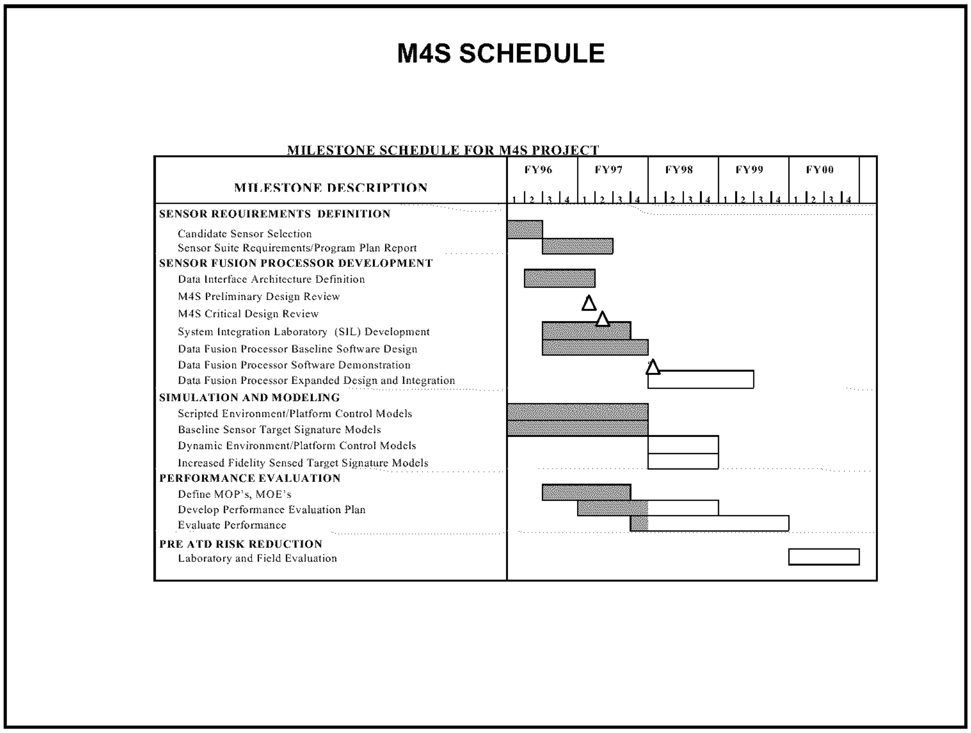

Figure 7 M4S Program Schedule

9.0 Summary

In summary, M4S is a unique program that can provide significant improvements in ISR capability, baselined using existing sensors, while at the same time reducing current operator workload. A critical next step for the M4S program is to start receiving feedback from the operational user community, especially regarding their thoughts on measures of performance and measures of effectiveness.

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