Ibex: A Space Situational Awareness Data Fusion Program

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Ibex seeks to provide more timely understanding of the space environment to support course of action implementation in the Joint Space Operations Center (JSpOC). The program will develop and deliver data fusion capabilities into the JSpOC to support sensor tip & cue (surveillance to tasking). Ibex algorithms are compatible for direct integration into the JSPOC Mission System (JMS) products. In this phase of the program, the program will develop and demonstrate algorithms and software to autonomously accept, organize, process and analyze Space Situational Awareness (SSA) data in three primary areas: Dynamic Sensor Tasking (DST), Positive Object Identification (POI) and Rapid Object Characterization (ROC). This paper will discuss those areas in some detail and the systems engineering effort to support interfaces between the three areas. The Ibex program completed a Critical Design Review in July 2012 and will complete its initial demonstration in November 2012. Ibex is a jointly funded DARPA and Air Force program.

Introduction

In February 2011, a Memorandum of Agreement (MOA) between the United States Air Force Space Command (AFSPC) and the Defense Advanced Research Projects Agency (DARPA) establishes the intent to jointly develop Space Situational Awareness (SSA) data fusion capabilities in support of the Joint Space Operations Center (JSpOC). The overall program objects were to develop and demonstrate algorithms and software to autonomously accept, organize, process and analyze space situational awareness (SSA) data in three primary areas: Dynamic Sensor Tasking (DST), Positive Object Identification (POI), and Rapid Object Characterization (ROC). The execution of these programs was to be performed synergistically by the Air Force Research Lab (AFRL) and the Massachusetts Institute of Technology Lincoln Laboratory (MIT/LL) in a fast-paced, 18-month effort. MIT/LL and AFRL also established a systems engineering, technology transition and visualization team which respectively worked the overall architecture, transition and visualization of the fused information.

Overall Ibex System

Two major activities were instituted within Ibex to manage the overall effort. First, a scenario was synergistically created with DARPA and the Air Force prior to the Systems Requirements Review to guide tool-specific requirements. The scenario was specifically used in software tool selection and design. It will also be used to measure end-state performance of the system demonstrations. Second, an overall Ibex system architecture was created to control interactions and interfaces between the three major technical areas of DST, POI and ROC. While the scenario drove tool selection and design, the architecture drove tool implementation. For example, several POI and ROC design choices were impacted by DST's multiple interfaces. Figure 1 shows the Ibex overall architecture.

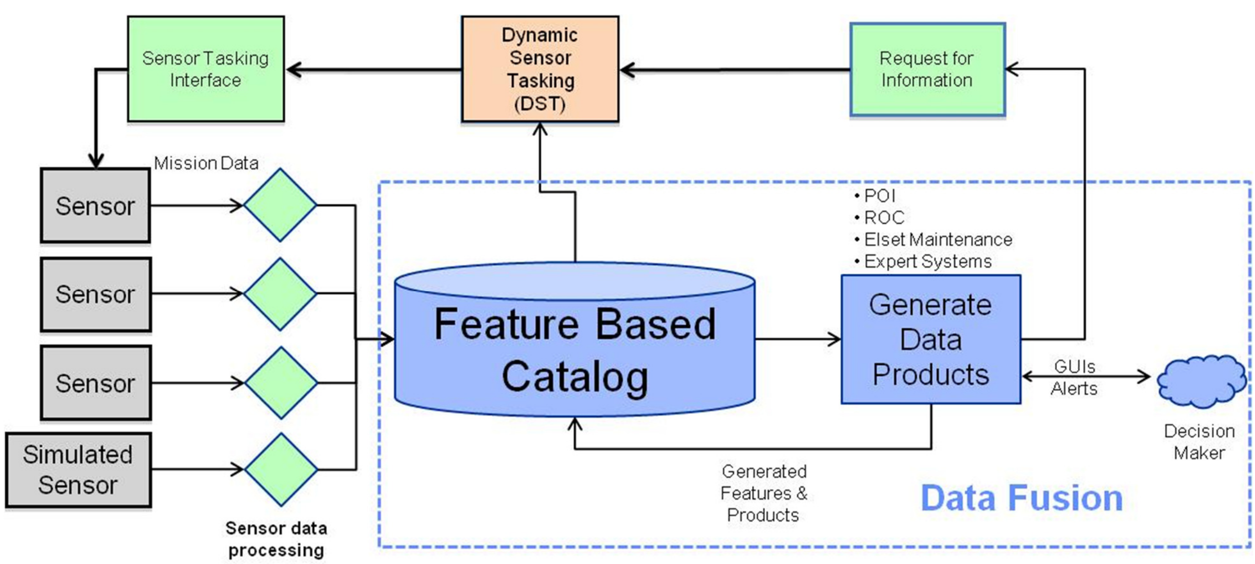

Figure 1. Ibex overall architecture

Starting with the gray boxes, simulated and actual sensor data is fed into sensors-specific data processing systems and then sent to a minable database. The expert systems, POI and ROC tools take the raw data and generate features and products that are subsequently fed into a feature-based catalog. The POI, ROC and expert systems also request additional information from the sensors via an interface with the DST system. DST takes inputs form the feature-based catalog along with the tool information to create a sensor surveillance tasking deck. DST then communicates the task deck to the sensors via an interface. Finally, all of the information is then displayed for a decision maker in an easy-to-understand Graphical User Interface (GUI). The Ibex interface document did not cover sensor-specific interfaces and leveraged other efforts such the Space Surveillance Telescope (SST) program to define tasking and data delivery protocols. Finally, the system interfaces were built with a Service Oriented Architecture (SOA) in mind to make it easier to transition parts of the architecture as needed.

Dynamic Sensor Tasking

The goals of the DST system were to provide synergistic and cooperative cueing for systems such as Space Based Space Surveillance (SBSS) and Space Surveillance Telescope (SST). Although the software was built to be extensible, the SBSS and SST sensors were chosen to focus the program goals to realizable objectives. Performance metrics of the DST system were built around the top-level objectives of scheduling more efficiently to build a complete object database, to meet accuracy requirements, and free up sensor resources to enable monitoring of high-interest satellites.

Positive Object Identification

The goals of POI were to reduce SSA ambiguity through positive identification of space objects to maintain custody of all detectable objects. Performance metrics focused on eliminating cross-tags and detection of lost or maneuvered objects of interest. The effort focused primarily on the Uncorrelated Target (UCT) mission. Figure 2 shows an example POI “waterfall” GUI where simulated UCT observations were identified and highlighted. Once multiple UCTs were identified and determined to be from a single satellite, they were associated together to form a so-called “discovery object”. “Discovery objects” can be added to the catalog as an object and those observations removed from the UCT bin. Key parts of POI were also built to be compliant with the astrodynamics standards.

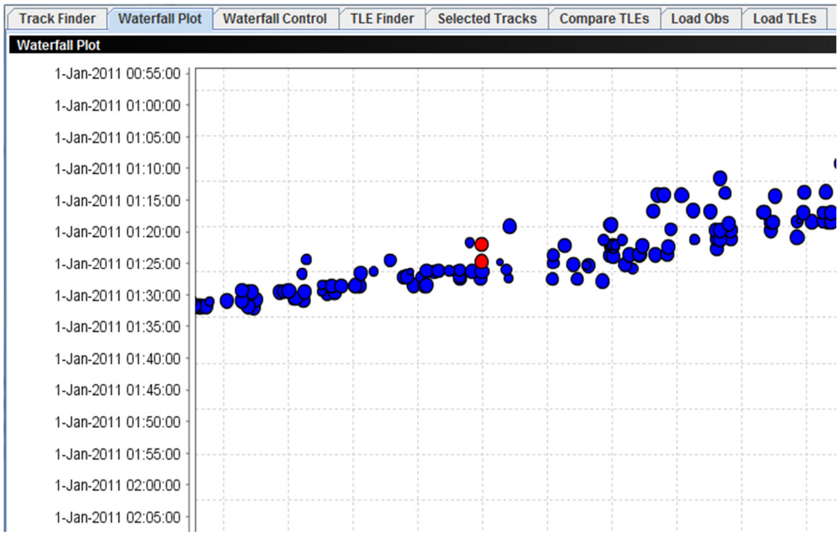

Figure 2. Example POI GUI were a UCT has been identified in red

Rapid Object Characterization

ROC supports quicker sensor response and object of interest (OOI) identification from uncorrelated targets. ROC also supported satellite change detection via temporal techniques and brightness information. Object characterization and identification was performed via a variety of techniques including color properties. Figure 3 shows an example of such information.

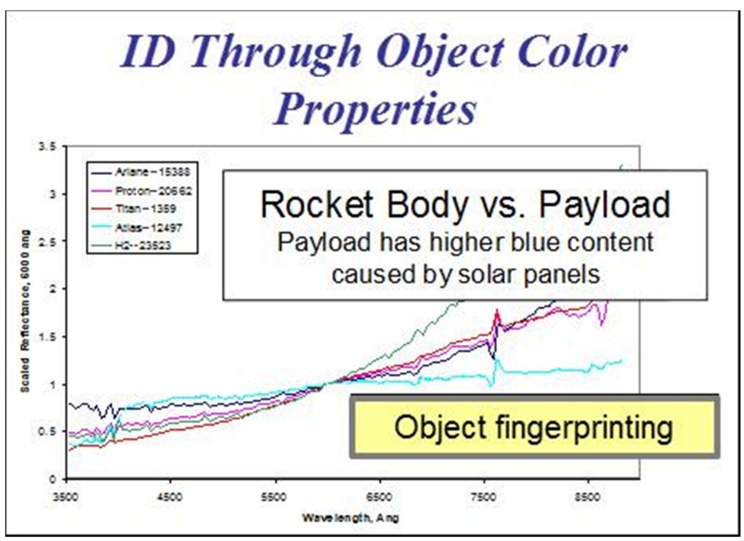

Figure 3. Example identification of objects through color.

Conclusion

The Ibex program is a jointly funded DARPA and Air Force program investigating fusion of information focused on supporting Joint Space Operations Center (JSpOC) activities. Advanced Positive Object Identification (POI) and Rapid Object Characterization (ROC) tools were fused together with innovative Dynamic Sensor Tasker algorithms to understand the benefits of multiple systems working together. The Space Based Space Surveillance (SBSS) and Space Surveillance Telescope (SST) sensors were used as example sensors within the Ibex architecture with the goal of demonstrating synergistic and cooperative cueing. The Ibex program completed a Critical Design Review in June 2012 and will complete its initial demonstration in September 2012.

Acknowledgements

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