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TOPIC: Information Age Transformation

TITLE: IEIST Technologies Enabling TCT Prosecution

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Abstract

Problem

Twelve years after Desert Storm, conduct of Time Critical Target (TCT) operations remains one of the most difficult challenges facing US military forces. While a variety of DoD and DARPA programs are addressing technologies to locate and identify TCTs, finding the target candidate is only one part of the problem. Success will only occur when we shorten the entire "kill chain", and operate within the enemy's maneuver timeline. The automated exchange and processing of battlefield information is critical to achieving viable decision timelines in this arena. The situation demands a secure, robust network backbone supporting automated decision aids designed to execute commander's guidance. Critical decision aids include the ability to monitor and exchange critical tactical information, to evaluate real-time intelligence and generate actionable Target Evidence Files and to re-assign en-route tactical and support assets to higher value tasks.

The Air Force Research Laboratory (AFRL), with support of The Boeing Company, is executing several research initiatives targeted at these information exchange shortfalls. AFRL is developing the Joint Battlespace Infosphere (JBI) as a means to realize information dominance. In effect, the JBI can be viewed as a tactical Internet that provides unprecedented access to data sources. Through this wide-area network connectivity, the JBI can be accessed, searched, and manipulated to create new products.

This paper will discuss the Insertion of Embedded Infosphere Support Technology (IEIST) research in which the Guardian Agent (GA) will be embedded within the Force Template (FT) and transmitted to the appropriate C^2 node(s) over Link 16. The demonstration C^2 node is planned to be the Advanced AWACS Prototype Software, which will host the transmitted GAs as well as the TCT Evidence File Generation Agents, and the Real-time Battle Management system that will match tactical assets to selected TCTs.

Relevance to C2

Whilst the ability to access quantities of data is vital, the essential capability of the JBI is to support the translation of data into actionable information (Figures 1 & 2). This capability directly satisfies the principal need of Command and Control. The AFRL/Boeing Insertion of Embedded Infosphere Support Technologies (IEIST) initiative has already demonstrated dramatic improvements in the exchange of information between deployed tactical elements including airborne C^2 and information nodes worldwide (Figure 3).

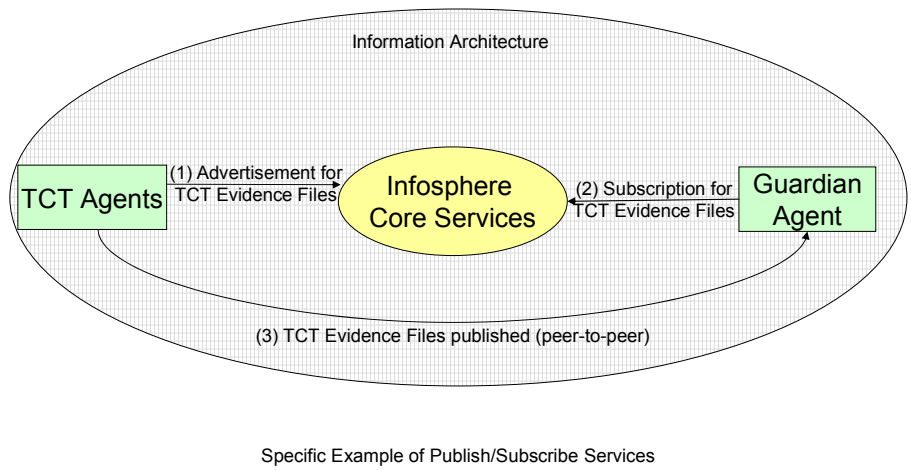

Figure 1 – JBI Core Service Architecture

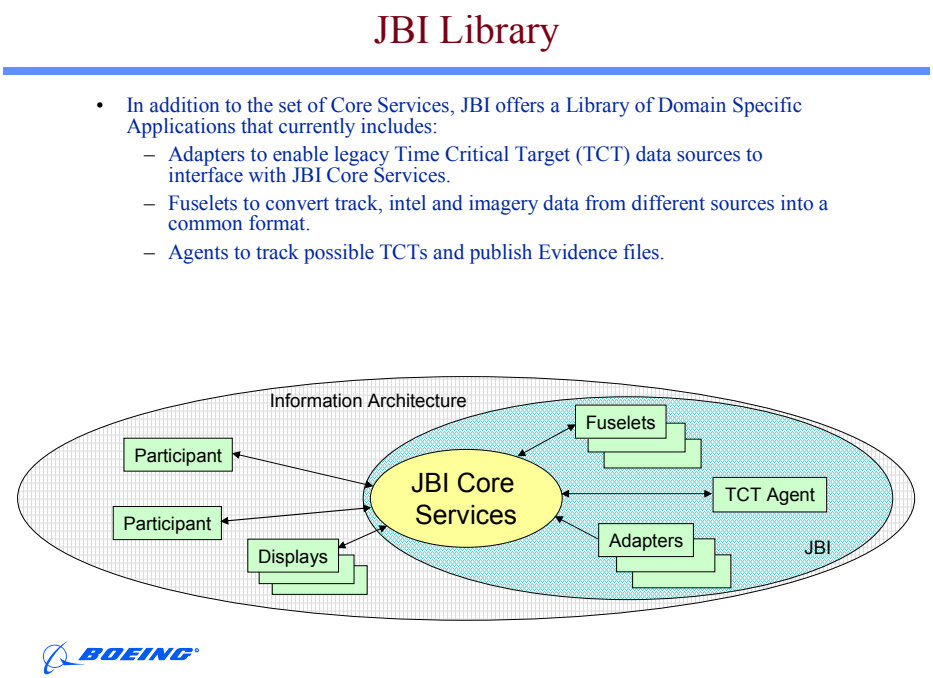

Figure 2 – JBI Library

IEIST focuses on the integration and requirements for off-board software agents, designed to augment embedded tactical systems and plug into the evolving JBI, while still providing interoperability with legacy systems and communication links. The essence of IEIST is to understand the information needs and collection capabilities of the

platform and to match these against information sources and destinations in the JBI. Key elements of the IEIST Architecture include the Guardian Agent (GA), the Host Agent (HA) and the Force Template (FT). The GA identifies and accesses information of interest across the JBI, evaluates the tactical utility of the accessed information, and transmits the information to the tactical element (aircraft) using available communications. The HA is a relatively small software entity, which resides on the tactical node and operates in conjunction with the Operational Flight Software. The Host Agent will provide an interface between extant tactical systems and Guardian Agents, using legacy tactical data links for communications. The FT is an Information Object that defines the information generation capabilities and information need of the tactical platform. IEIST has already demonstrated integration of GAs and HAs for multiple tactical assets and C^2 nodes communicating using JBI protocols and services over a simulated Link 16 interface. Other agents within the IEIST demo scenario have automatically generated TCT Evidence Files, which were transmitted to and exhibited on the cockpit displays of assigned prosecution assets.

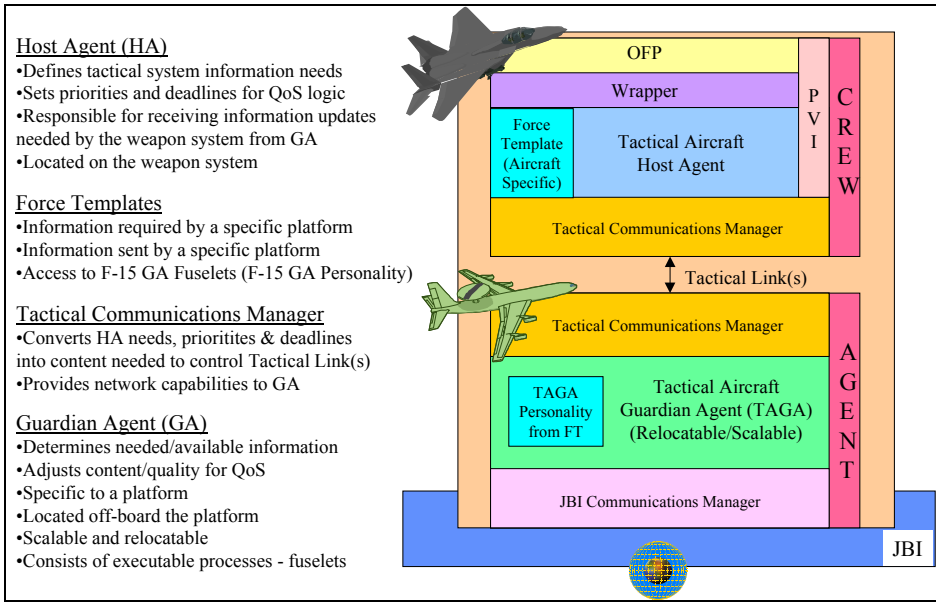

Figure 3 – Insertion of Embedded Infosphere Support Technology (IEIST) Architecture

The IEIST Demonstration Scenario

The IEIST Demonstration features a 2 hour 50 minute Kosovo based scenario with two F-15 and two pairs of unmanned combat air vehicles (UCAVs) performing search and destroy missions and one additional UCAV proceeding to a pre-defined target. Since the scenario is based on real-time, the simulation is sped up 5 times, without loss of the fidelity of the important activities. This shortens the demonstration's run-time to about 30 minutes. Within the scenario a total of five TCTs appear – a SCUD-style Transporter/Erector Launcher (TEL), an armored vehicle and three Surface-to-air-

missiles (SAMs). All are detected by airborne sensors and confirmed by human intelligence (HUMINT). In each case intelligence sufficient to satisfy the Commander's Guidance is generated and the TCT Agents are able to communicate the existence, location and identification of the TCTs to Multi-systems Operations Manager (MOM). Accordingly, MOM selects from among the modeled tactical assets and the targets are prosecuted. For the two targets assigned to the F-15s, Target Evidence Files are generated and communicated to the aircraft for display in the cockpit. In addition, one of the F-15 GAs detects an eminent threat along the aircraft route and vectors the aircraft to a safer ingress area. Figure 4 shows an Open Map display of the scenario, about halfway through. The first F-15 has been assigned to the TEL, routed to engage the TEL, and also notified of a pop-up SAM along its route. UCAVs 1 and 2 as assigned to the pop-up SAM that is in the first F-15's route.

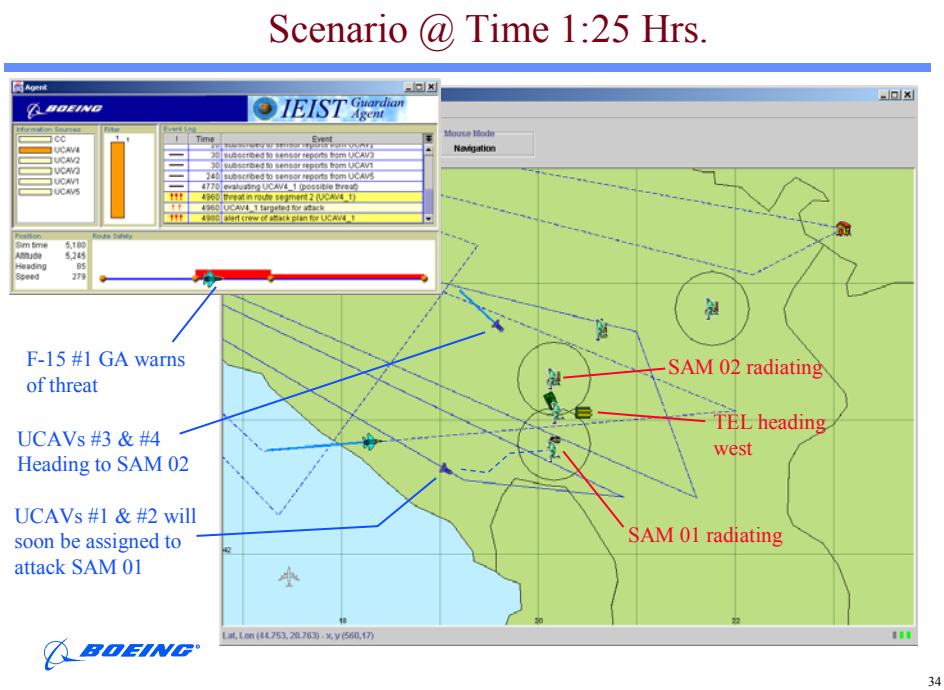

Figure 4 – IEIST Demonstration Scenario

The IEIST Tactical Node Architecture

The IEIST architecture has been expanded to receive inputs (subscriptions) from entities such as an Air Operations Center (AOC). This allows the AOC to assign tactical weapon systems to the targets that it has tracked and validated as legitimate TCTs. The inclusion of these features was made possible by building JBI Capabilities into the IEIST Tactical Node Architecture (Figure 5). This new feature literally builds an evidence file of a potential target, based on the theater commander's guidance for what qualifies as a TCT. When the TCT evidence file is complete, a weapons pairing is made, and a tactical asset is assigned to the TCT.

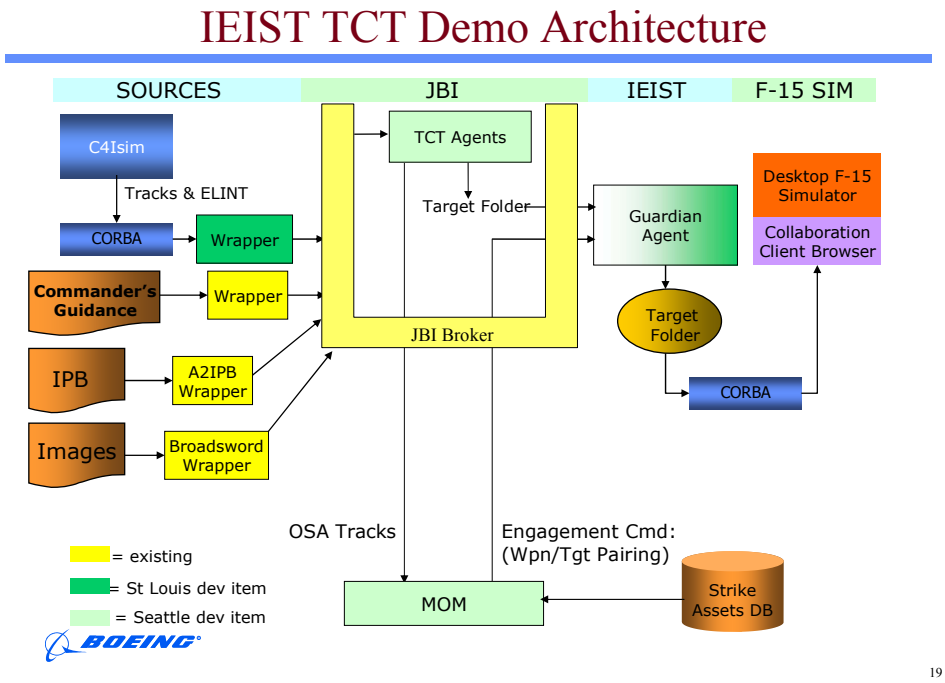

Figure 5 -The IEIST Tactical Node Architecture

TCT Evidence File Generation

The TCT Agents are created by a TCT Agent Factory. The factory evaluates each sensor report as an indication of TCT activity. When the first potential TCT indication is received, a TCT Agent is created corresponding to that report. After each subsequent TCT indication is received, it is passed on to any existing TCT Agent for correlation with their candidate target. If the new indication correlates, that TCT Agent incorporates the new report. If no existing TCT Agent is able to correlate the new indication, an additional TCT Agent is created. Each TCT Agent continues to assimilate new reports until it has sufficient information to confirm the existence, location, and type of TCT. In performing this function, the TCT Agents follow a set of Commander's Guidance. Once a TCT is confirmed its existence is reported to MOM for target assignment to the appropriate tactical evidence and the TCT information is gathered into a target folder. The existence of the target folder is advertised to potential consumers throughout the JBI.

MOM is a decision aid that provides specific weapon assignments in response to a set of rules, which embody the Commander's Guidance. MOM is Java-based and uses JBI publish/subscribe protocols as an integration mechanism among cooperating components. The scope for application components is in support of planning and decision-making by a commander or decision maker, where the decision maker has responsibility for a group of resources across an area of interest such as a geographic/political region or theater of battle. MOM uses a heuristic technique called Simulated Annealing to optimize weapon assignment very rapidly. Recommendations can be generated in seconds (rather than the minutes, hours, or days) that straightforward linear programming would use for theater

level problems, providing rapid re-planning in response to time-critical (TCT) / time-sensitive (TST) targets, insufficient damage to targets, or loss of platforms that have disrupted the original mission plan.

The weapon assignment recommendations are filtered for appropriateness of weapons, range from platform to target and back to base, and, in the case of TCTs, time to reach target while still effective. A platform may be assigned to multiple targets without a return to base. Each recommendation identifies the platform, what and how many weapons to employ, and what percent kill is expected. The set of recommendations maximizes the expected percent kill across all known possible targets. In a resource-poor situation, targets with low priorities or very low probability of successful prosecution will not appear in the set of recommendations. Targets are grouped together in order to minimize effects on an existing attack plan.

In the IEIST demonstration, the JBI Broker is used as a means of communications. The JBI offers a set of Core Services, which include Publish (make data available for sharing), Subscribe (make a request to the Infosphere for future data) and Advertise (send a message to the Infosphere describing the data to be published), which are sufficient for the demonstration needs. Figure 6 depicts the IEIST Demonstration use of the JBI to communicate between the TCT and Guardian Agents.

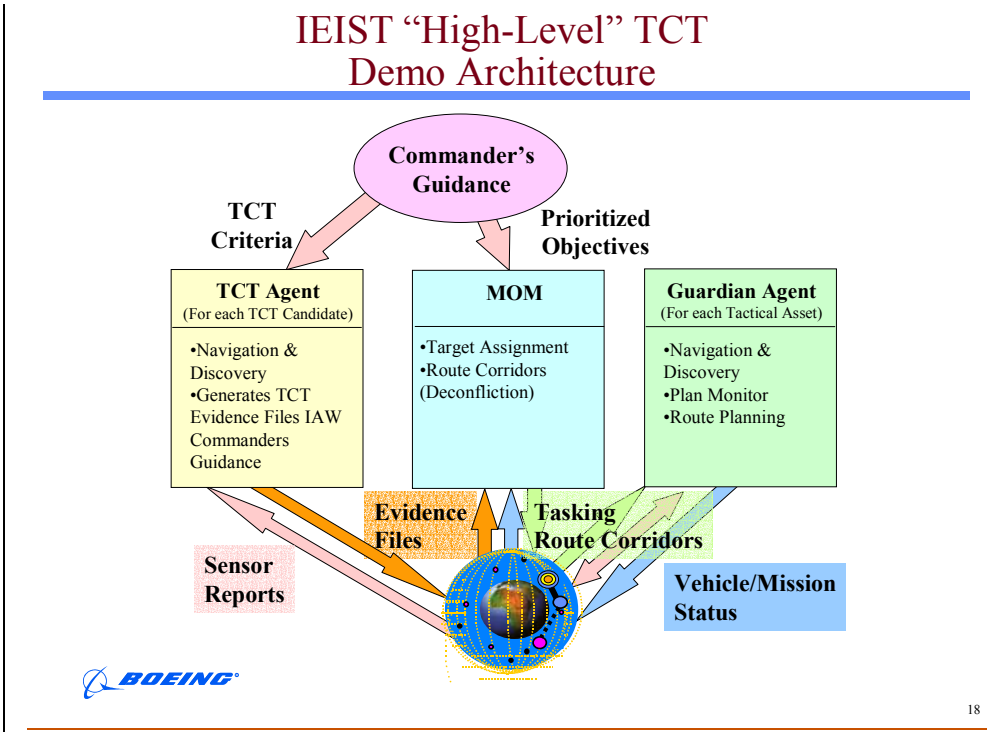

Figure 6 - TCT Evidence File Generation

Summary and Conclusions

The primary goal of IEIST research is to explore means of delivering tactical utility from exploitation of the evolving JBI. This goal is sensitive to the reality that the tactical system will remain communications and processing bandwidth limited relative to the growing need for information exchange and processing. In response IEIST has partitioned the tactical system information challenge into a small on-board requirement with the bulk of the effort located off-board of the tactical system. The GA is the off-board surrogate for the tactical platform. To date IEIST demonstrations have shown exceptional merit in this functional partitioning choice. As an advocate for the tactical system the GA is able to access and process volumes of data and pass on only the essential elements of information to the tactical platform. It is positioned to act as a surrogate for the platform in bidding for emerging high value TCTs and to intelligently filter realtime threat data such that only the critical items require attention from the crew.

The evolving JBI protocols have provided a responsive and easily implemented method to find key information providers and to allow the tactical platform to advertise its capabilities to other potential subscribers. The remaining tasks are to "productionize" the GA by making its functionality more robust and portable and to integrate the IEIST system into a suitable transition platform. The plans are in place and the final transition is targeted for the latter half of CY04.

Feedback to the IEIST Demonstration has been quite positive. Integration with the prototype JBI Broker, the TCT Agents and the target weapon pairing decision aid proved to be straightforward. The resultant demonstration is a powerful endorsement of the value of Network Centric Operations in facilitating battlefield decision making and accelerating the tempo of the battle. Evaluation of the IEIST Program progress against goals indicates that the primary area of focus for the Final Demonstration should be integration into the operation C^2 infrastructure. It was also felt that the IEIST CONOPS would benefit from the use of relocateable (mobile code). It is envisioned that the force template (FT) would be generated as part of the mission planning process and would be passed to the C^2 platform as the tactical platform enters the theater. A reasonable approach would be to incorporate the GA into the FT such that the ingressing platform would provide its GA to the C^2 as part of the FT.

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References

[USAF, 1999] United States Air Force Scientific Advisory Board Report on "Building the Joint Battlespace Infosphere", Volume 1: Summary, SAB-TR-99-02, December 17,1999.

[USAF, 1999] *United States Air Force Aerospace Command Control Intelligence, Reconnaissance (C2ISR) Campaign Plan 2000*, December 23, 1999.

[USAF, 1997] *Chairman of the Joint Chiefs of Staff, "Joint Vision 2010",* May, 1997.

[USAF, 2000] *Chairman of the Joint Chiefs of Staff, "Joint Vision 2020",* June, 2000.

Satterthwaite, C. P., *Space Surveillance And Early Warning Radars: Buried Treasure For The Information Grid*, 5th International Command and Control Research and Technology Symposium, Naval Post Graduate School, Monterey, CA., June 2000.

Satterthwaite, C. P., Corman, D. E., and Herm, T. S., *Transforming Legacy Systems To Obtain Information Superiority,* 6th International Command and Control Research and Technology Symposium, U. S. Naval Academy, Annapolis, MD., June 2001.

Satterthwaite, C. P., , Corman, D. E., and Herm, T. S*., Real-time Information Extraction for Homeland Defense*, 7th International Command and Control Research and Technology Symposium, Naval Post Graduate School, Monterey, CA., June 2002.