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Adapting C2 to the 21st Century

Effects Based Assessment: Near-Real time insight into Combat Objectives

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Our research relates near-real time mission information, obtained from data links and other sources, to the strategy-to-task associations. Although far short of an actual assessment, it is possible to provide near real-time insight into the status of combat objectives by inferring the status of missions and targets during execution. We have developed a graphic user interface, with guidance from operators at the 505th AF and the C2 Battle Lab, which displays and updates the status of the combat objectives during mission execution. Interfaces to FalconView and Google Earth are used to plot assets on a map along with their mission status and Air Tasking Order call sign. The proof-of-concept prototype also provides a dynamic query capability that lets users generate ad hoc queries during mission execution. By inferring the status of missions during execution, and relating that information to the strategy-to-task associations, it is possible to provide Operational Assessment (OA) insight into the near real-time status of missions during execution. Typically the Operational Assessment Team (OAT) is forced to wait a couple days or more before obtaining an understanding of what tasks were accomplished any how they contributed to the Operational and Tactical Objectives. Although our prototype provides useful information during that 48-72+ hour 'black out' period, it does so at the expense of increased uncertainty, as compared to a formal assessment. Implementing Effects Based Operations requires that we answer two key questions, have we met our combat objectives and, if so, has it had the desired effect? Our goal in this research is to make progress towards the former question by prototyping an Effects Based Assessment capability.

<u>Functional Decomposition from Strategy to Task</u>

In preparation for military actions, such as armed combat, Non-combatant Evacuation Operations (NEO) and other humanitarian efforts, the Strategy Division is responsible for incorporating high level guidance to produce an actionable plan that achieves the desired effects. Although this process is used for the full range of military activities, our research focuses specifically on armed combat scenarios. The general principles of the research, however, can be extended to these other applications.

During Crisis Action Planning (CAP) the Joint (or Coalition) Force Air Component Commander (JFACC) defines Operational Objectives that constitute the over-all goals for the air component, such as “gain and maintain air superiority”, or “isolate enemy Command and Control from their forces”. These Operational Objectives are then decomposed into Tactical Objectives, such as “destroy enemy Integrated Air Defense Systems (IADS)” or “restrict mobility of enemy leaders”. Tactical Objectives get decomposed into Tactical Missions such as “destroy enemy RADAR installations” or “conduct a strong ISR presence in Zone II”. Tactical Missions subsequently get decomposed into Tactical Tasks that are defined by a target set that gets grouped into missions as part of the Master Air Attack Plan (MAAP) and eventually executed as part of an ATO.

During Operational Assessment, this decomposition process gets reversed and “rolled up”. The Battle Damage Assessment (BDA) for the targets is conducted, and the results are associated with their respective Tactical Missions. In the Effects Based Assessment methodology, Tactical Missions are related to Tactical Objectives via a causal linkage, which explicitly states why the planner believed that accomplishing the specified tasks would support the successful completion of the Tactical Objective. The successful completion of the Tactical Objectives, in turn, leads to effects that support the Operational Objectives.

Typically, the Operational Assessment can take several days to complete. The problem is that during ATO execution there is no efficient means to associate aircraft mission status during execution, with the Operational and Tactical Objectives and Tactical Missions that lead to their creation. Recently, pieces of this disconnect have been addressed by developing capabilities such as the Dynamic Link and Reporting System (DLARS) and TBONE. DLARS started as an initiative and the C2 Battle Lab, and was subsequently transitioned to the acquisition community at Langley. DLARS monitors the Tadil-J link system, infers mission events such as take-off, landing, and munitions drops, and associates those events with the ATO callsign in order to provide insight into mission status during execution. TBONE, scheduled to be part of TBMCS 1.1.4, is working to import the Strategy-to-Task hierarchy from IWPC, a developing system that provides capabilities to the planners in the Strategy Division. With additional work, the new capabilities in DLARS, TBONE, and IWPC can be used to form a framework to provide a near real-time "assessment first-look" capability, and that is the goal of our research.

If mission events, like munitions drops, are associated with ATO targets, and the targets with Tactical Missions, we have a rudimentary framework for creating near real-time assessment of Operational Objectives. In order to build on this rudimentary framework, it is necessary to factor in the effectiveness of the munitions against the target, the uncertainty in the data, the timing of the mission events as compared to the planned times, and the manner in which the data is graphically represented and disseminated, to name but a few. The goal of our research is to explore this space in order to provide an assessment capability that graphically displays the current status, not of targets, but of Operational and Tactical Objectives during execution. Although less certain than a full-blown Assessment, this capability would provide the information during execution, and would provide some insight into our progress towards Operational and Tactical Objectives inside the current 72 hour Operational Assessment cycle.

<u>Execution data</u>

In order to provide insight into the status of missions during execution, we are mining data available in the Tadil-J network. We have endeavored to minimize the overlap with DLARS by focusing on capabilities that could be used to enhance the functionality provided by that system. To date, all of the systems that use Tadil-J information input the messages in their original binary format, filter out the messages of interest, and discard the remaining messages. As a result, the effort of translating the binary messages and parsing them needs to be re-invented by every new system that wants to make use of the information available on Link-16. We have explored an alternative approach to this problem. We have worked with the Multi-Tadil Display System (MTDS) program to develop middleware that translates the binary format into XML and outputs via RSS. Other users on the local area network (LAN) can then subscribe to the feed specifying the Tadil messages in which they are interested. Those messages are then sent to them in the XML format. By making our work compliant with the Task Post Process Use (TPPU) model we can save the government money and speed program development time, because it is no longer necessary to reinvent the wheel by translating and filtering the binary messages.

By monitoring the Tadil-J messages, it is possible to determine, as DLARS does, events such as take-off, approach, munitions drops, etc. Further exploitation of these messages, however, allows one to determine the munitions type that was loaded on the asset, and in some cases the target location associated with the munitions drop.

In keeping with TPPU model, we store the link-16 messages in which we are interested in the DB. Missions in link-16 are associated via a JU number, while missions in the ATO are grouped by mission number and callsign. In order to bridge this gap, the JU number must be associated with the ATO missions and callsigns, which can be accomplished in one of two ways. The first involves IFF codes, which are reported in both the ATO, and in some of the Tadil messages. The second approach involves callsigns, which are reported in full in the ATO, but only in an abbreviated format in link-16. Because the link-16 abbreviations are computed in a consistent manner, it is possible to reverse engineer the process by checking to see which full callsigns in the ATO abbreviate to the format reported in link-16. We know in advance that the callsign approach does not always yield unique solutions, since more than ATO callsign can map to the same abbreviated form. Ties can be broken in a number of ways, by comparing IFF codes, take-off times, asset type, or other identifying information.

Once the association between the link-16 messages and the ATO is made, the mission data culled from link-16 can be associated with ATO missions. One can, for example, record planned take-off time versus the reported take-off time. Mission status, such as speed, heading, fuel, number of munitions, and so forth can be computed and associated with ATO missions. We maintain both a current status for each asset, and a history of events of interest, such as take-off time, landing time, re-fueling times, munitions drops, etc. By maintaining a current status, it is possible to compare the assets actions to the plan in order to determine where the asset is relative to the plan. It is possible, for example, to determine that a given asset is halfway through the planned mission, is 30 minutes behind schedule, and has a half a tank of fuel. While our ultimate objective is to associate this with the Strategy-to-Task hierarchy for a near-real time 'assessment', the information is also of use to other cells in the AOC.

Data dissemination

The mission data obtained by comparing the link-16 messages to the ATO can be used by numerous cells in the AOC. For example, if a mission is behind schedule by 45 minutes, it might be possible to change the ISR collections in order to make more efficient use of the assets. By keeping of track of assets that have completed their missions, but still have munitions on their wing, it is possible to provide the Dynamic Targeting and Time Sensitive Targeting cells with a list of assets that can be used to prosecute pop-up targets, but without impacting the planned missions. Once the link-16 messages have been associated with the ATO missions and the Strategy-to-Task hierarchy, it is possible to provide the TST and Dynamic Targeting cells with insight into which Operational and Tactical Objectives will be impacted by diverting an asset.

Because there are multiple operators and cells in the AOC that might be interested in this data, it is very difficult to determine how the data should be structured and presented. Listing all of the potential parties and designing a custom set of queries and interfaces for each seems unlikely to succeed. In addition, it is quite likely that the kinds of quieries that are made will change based upon the theater of operations and as new systems and capabilities are added to the AOC. It is also possible that this system might be used in the event that a system of record should crash, or be rendered momentarily unavailable. The challenge, then, is to design the system so that it provides enough flexibility to remain useful in varying theaters with different resident capabilities.

Our approach to handling this challenge was to design middleware code that permits the user to create ad hoc queries. The atomic elements in the database are individual pieces of information like speed, heading, munitions, fuel, status, JU number, callsign, latitude, longitude, altitude, frequency, etc. The middleware code developed permits users to flexibly combine these elements during execution. For example, one might request all of the assets containing certain munitions, or the current position of an asset based on callsign or JU number. Or again, all the assets within X miles of a specific point, or all the assets within a certain box. We are also working to incorporate queries that would provide a list of all missions or assets that are more than X minutes behind schedule.

Currently the atomic elements are combined using logical and mathematical operators such as AND, OR, NOT, >, <, =. !=, and so forth. We plan to design to types of interfaces, one for advanced users that provides greater control over the queries, and a more basic interface that would provide a more user-friendly interface requiring less technical expertise in creating the rules, but with corresponding limits on the range of queries that can made. In addition, we plan to provide demonstrations of the capability to operators in various AOC cells in order to get additional insights into their particular needs, the kinds of query capabilities they would find most helpful, and their feedback on the graphic user interface.

At this point it should be noted that the Dynamic Query capability, like most of the components in our system, is web enabled. The middleware software that translates the user query into SQL resides on the same server as the DB. As a result, any operator on the LAN can access the system from their desktop using their resident Web Browser.

Although many operators may want only a static snapshot of the data, such as a list of assets within a given area carrying specific munitions, others might want a real-time update on specific types of information. For those users we are developing an RSS feed that works in conjunction with the Dynamic Query capability. One might, for example, want information want information to scroll across the bottom of their screens like the ticker tapes on news channels and financial reports. Operators in the Strategy cell might, for example, want to see the current status of specific missions, while operators in the ISR cell might want to see a list of missions that are more than X minutes behind schedule. Like the Dynamic Query capability, we expect that there are a wide variety of users with unique interest who might benefit from this capability.

Graphic User Interface for Operational Assessment

The events monitored during mission execution, as associated with ATO missions, are then associated with the Strategy-to-Task hierarchy that lead to their genesis. Our graphic user interface displays the Operational Objectives, their Tactical Objectives, Tactical Missions, and finally the supporting targets. The interface permits the hierarchy to be collapsed or expanded to show the current status at any level: Operational, Tactical, or Target. A stop light charts shows the status of targets based on the schedule, current status inferred from the Link messages, MISREPs, and finally the BDA. In the current Beta version, the stop light charts are turned green, yellow, or red to indicate that the status is successful, partially successful, or failed. As the information for targets is received it is rolled up to the Tactical and Operational levels where a corresponding stop light chart is displayed.

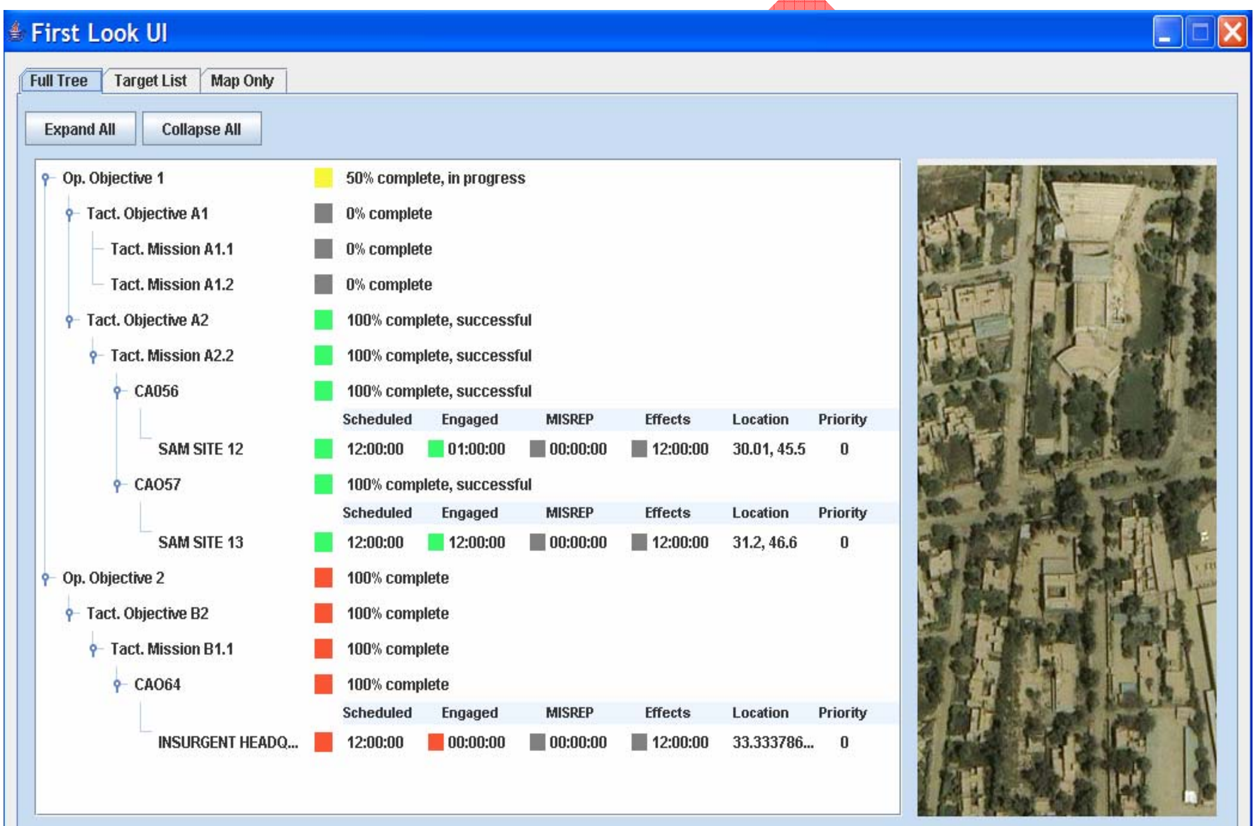

Figure 1: Strategy-to-Task hierarchy updated during mission execution. Stop light roll-up.

In this way it is possible to view the real time status of the ATO being executed, not just in terms of targets, but in terms of their contribution to the Operational and Tactical Objectives. The Air Operations Directive (AOD) which defines the goals that are to be achieved for the given ATO period, can be assessed during execution. It is thus possible to determine how the current status of the missions compares to the plan, and how the progress made thus far contributes to the objectives for that period.

One of the biggest challenges was representing uncertainty in the roll-up. The Beta version simply assessed the constituent parts, if all of them were green then the objective at that was green, if all of the subordinate goals were red, then that objective was red, otherwise it was yellow. Clearly this provides, at best, only a crude roll-up capability. We are in the process of altering this roll-up so that Operational and Tactical Objectives show the percentage of subordinate tasks that are succeeding on schedule, those that are only partially successful, and the percentage that are unmet. In addition, we are working to represent where we are in execution compared to where we were scheduled to be in the plan. That is, we are currently able to represent the fact that 50% of the targets have been struck, or 50% of the Tactical objectives have been met, but what we need to do is show what percentage should have been completed by this point in the ATO.

Another challenge is the certainty that can be associated with the assessment. Operator interviews has revealed that some operators are willing to be convinced that a target was successfully prosecuted if presented with the coordinates of the munitions drop, the munitions type, and the probabilities obtained from the Joint Munitions Effectiveness Manual (JMEM). Other operators are reluctant to place much faith in the success of the mission until a Mission Report (MISREP) is received. Other operators have quipped that they never met a pilot who didn't hit his target, and they would prefer to wait for a BDA assessment. Our current strategy is to have separate columns for each data source, as depicted in Figure 1, with the planned prosecution time on the far left, followed by the

Link-16 data, the MisRep, and BDA assessments. As time passes, and additional sources of assessment are made available, greater confidence can be placed in the assessment. In addition, we provide notes for the Tadil column. So, for example, if we turn the stoplight box for a given target green in the "Engaged" column, we provide notes that specify the exact events that lead us to that conclusion, so that the operators can decide for themselves whether or not the data is compelling. Like most of the components in the prototype, the Assessment GUI is web accessible.

The location of assets on the Link-16 system can be displayed on either Google Earth or FalconView. As shown in Figure 2, we label each asset with its ATO callsign and, in parenthesis, its current status. We are also able to display bases, refueling tankers, targets, and other points of interest. We are currently working on a filter capability that would permit operators to view assets based on their association with Operational and Tactical Objectives. Once again, we have web enabled this capability so that operators can view it remotely on their PCs without needing to load additional software.

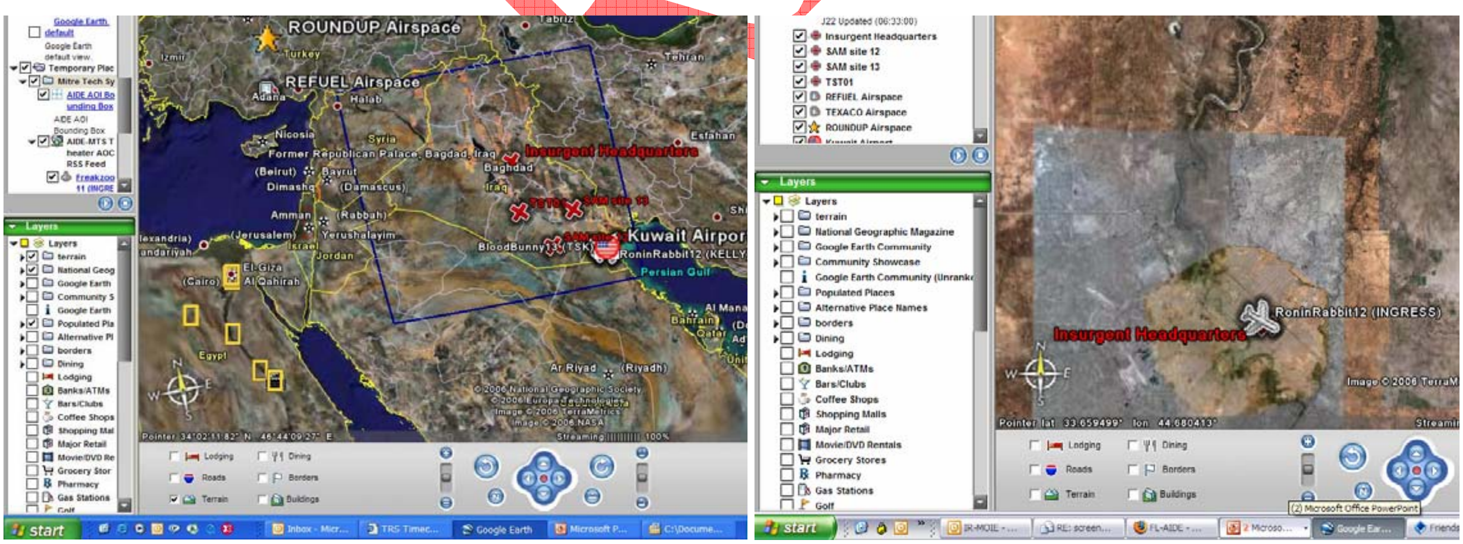

Figure 2: Google Earth Display of assets labeled with ATO callsign and mission status

<u>Summary</u>

Our goal is to develop the capability to provide a glimpse into the status of missions during execution and to associate this information back to the Operational and Tactical Objectives that they support. Such a capability allows the warfighter to answer the simple question “how goes the war?” Currently, we are able to provide information about the number of targets prosecuted shortly after an Air Tasking Order (ATO) cycle ends, but the number of targets prosecuted tells us what has happened, but not what it means. To know that, one must wait 2-3 days (or more) to get Battle Damage Assessment information, and even then the information is associated with targets and must be manually associated with Operational and Tacticial Objectives through a painstaking process. Developing capabilities such as DLARS, TBONE, and IWPC contain the raw material with which one might construct a rudimentary framework for a near real-time assessment capability. We have endeavored to look out into the future and bit, and determine what additional capabilities would be required to flesh out this developing framework. Our work seeks to augment these capabilities by developing new rules for assessing mission status, new techniques for associating mission status with the Operational and Tactical Objectives, new Graphic User Interfaces for displaying the information, and additional mechanisms for disseminating it.