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Adapting C2 to the 21st Century
Effects Based Assessment: Near-Real time insight into Combat Objectives
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Effects Based Assessment 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 by relating near-real time mission information, obtained from data links and other sources, to operational and tactical objectives.

Typically the Operational Assessment Team (OAT) is forced to wait several days before obtaining an understanding of what tasks were accomplished and how they contributed to the operational and tactical objectives. It is, however, possible to provide the Operational Assessment Team and others in the Air Operations Center (AOC) with near real time insight into the status of the operational objectives by inferring the status of missions and targets during execution. The challenges are to collect the information, relate it to the operational objectives, display it, and disseminate it to the widest possible audience. We have worked with operators at the Air Force's 505th Training Squadron and the Command and Control Battle Lab to identify relevant execution information for collection and to develop a graphic user interface that displays and updates the status of the combat objectives during mission execution. In order to disseminate the information we have developed interfaces to FalconView and Google Earth to plot assets on a map along with their mission status and Air Tasking Order call sign. We have also provided a dynamic query capability that lets users define ad hoc queries during mission execution to get answers on the fly. Although our prototype provides useful information during the current 48-72+ hour black out when Battle Damage Assessment (BDA) is being conducted, it does so at the cost of increased uncertainty. The information we provide is a 'first look' that can be augmented with mission reports and later with formal BDA.

Functional Decomposition from Operational Objectives to Tactical Tasks

A brief overview of Crisis Action Planning will help elucidate the relationship between target prosecution and operational objectives. 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 a Crisis Action Plan (CAP). Although our research focuses specifically on armed combat, it is extensible to the full range of military activities.

During Crisis Action Planning the Joint (or Coalition) Force Air Component Commander (JFACC) defines Operational Objectives that will achieve 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 Tasks that are prioritized in order to place greater weight on those tasks that are crucial to the success of the Operational Objectives. The prioritized targets are then handed off to the Master Air Attack Plan (MAAP) operators and eventually executed as part of an Air Tasking Order (ATO). When the Tactical Tasks are prioritized, a Measure of Effectiveness (MOE) is defined for each Tactical Task. These MOEs are used by operators in the Intelligence, Surveillance, and Reconnaissance (ISR) division to complete Assessment Information Requirements (AIRs) which provide information on the status of the Tactical Tasks after the (non) kinetic effects associated with them have been applied.

During Operational Assessment, this decomposition process gets reversed and information on the execution of the Tactical Tasks (i.e. did we do what we planned to do?) and the AIRs (i.e. did it have the intended effect?) gets “rolled up” into a formal assessment. In the Effects Based Approach to Operations methodology, Tactical Tasks are aggregated into Tactical Missions. Tactical Missions are related to the Tactical Objectives insofar as the success of the Tactical Mission are related to Tactical Objectives via a causal linkage which explicitly states why the planner believed that the success of the Tactical Mission would lead to the desired outcome, or Tactical Objective. The successful completion of the Tactical Objectives, in turn, is aggregated and supports the Operational Objectives.

It is worth noting that the relationship between Tactical Tasks and Tactical Missions is the only one that is truly causal in the sense that successful completion of the Tactical Tasks guarantees that the Tactical Mission is successful. The relationship between Tactical Missions and Tactical Objectives is different in that successful completion of the Tactical Missions gives one reason to believe that the Tactical Objectives will be met, but does not guarantee it. Rather than merely aggregating the Tactical Missions, the AIRs are used to provide independent verification that the desired effects have been met. Similarly, achieving the Tactical Objectives gives one reason to believe that the Operational Objectives will be met, but does not guarantee it. The fact that Tactical Tasks can be summed in order to demonstrate that a Tactical Mission is successful makes it a prime candidate for automation. While the other relationships require a trained operator to assess the evidence and draw a conclusion, demonstrating

the success of a Tactical Mission is a matter of accounting only, and as such can be automated.

Typically, the Operational Assessment can take several days to complete. One problem is that during ATO execution there is no efficient means to associate target status during execution with the Operational and Tactical Objectives 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 the Theater Battle Operations Net-Centric Environment (TBONE). DLARS started as an initiative and the C2 Battle Lab, and was subsequently transitioned to the acquisition community at Langley. DLARS monitors the Tadi-J link system, infers mission events such as take-off, landing, and munitions drops, and associates those events with the ATO in order to provide insight into mission status during execution. TBONE, scheduled to be part of the Theater Battle Management. Core Systems (TBMCS) 1.1.4, is working to import the Strategy-to-Task hierarchy from the Information Warfare Planning Capability (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 as a framework to provide a near real-time “assessment first-look” capability. If mission events, like munitions drops, are associated with ATO targets, and the targets with Tactical Tasks, 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 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 insight into our progress towards Operational and Tactical Objectives within the current 72 hour waiting period for traditional Battle Damage Assessment.

Execution data

In order to provide insight into the status of missions during execution, we are mining data available in the TadiJ 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. By monitoring the TadiJ messages, it is possible to determine, as DLARS does, events such as take-off, approach, munitions drops, etc. Further exploitation of these messages, however, permits one to determine the munitions type that was loaded on the asset, and in some cases the coordinates that were targeted when the munitions were released.

Again, one of the primary challenges in this endeavor is to associate targets back to the Tactical Task they are meant to accomplish so that the real time status of operational objectives can be provided. Messages in link-16 are associated via a JU number, thus all active messages with the same JU number belong to the same asset. However, 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 a number of ways.

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 and back to the operational objectives. One can, for example, record planned take-off time versus the reported take-off time. Events of interest such as mission status, speed, heading, fuel, munitions types, 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. 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, 30 minutes behind schedule, and has a half a tank of fuel. While our ultimate objective is to associate this with the operational objectives for a near-real time assessment, this information is also of use to other cells in the AOC.

Data dissemination

While our primary goal is to provide a real time status report on operational objectives, the mission data obtained by comparing the link-16 messages to the ATO is useful to numerous cells in the AOC. To that end, a brief digression in order to discuss the value of this information to Combat Operations might be useful. For example, if a mission has been scrubbed because of weather or maintenance, it might be possible to change the ISR collections in order to make more efficient use of the ISR 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 without impacting

the planned missions. Once the link-16 messages have been associated with the ATO missions and the operational objectives, it is possible to provide the Time Sensitive and Dynamic Targeting cells with insight into the impact on the plan of diverting an ISR or strike asset. Currently the ISR and TST cells base their decisions on the priority of the planned target, but the target priority does not provide an understanding of how the plan as a whole, will be impacted by a decision. By disseminating the status of the combat objectives in relation to planned targets, it is possible to provide operators in Combat Operations with a 'big picture' understanding of how their decisions impact the plan.

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 queries 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 that permits the creation of user defined 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 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 bounding box that are at or above a given altitude. 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 two 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 be 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.

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 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 interests 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. Our graphic user interface displays the Operational Objectives, 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 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.

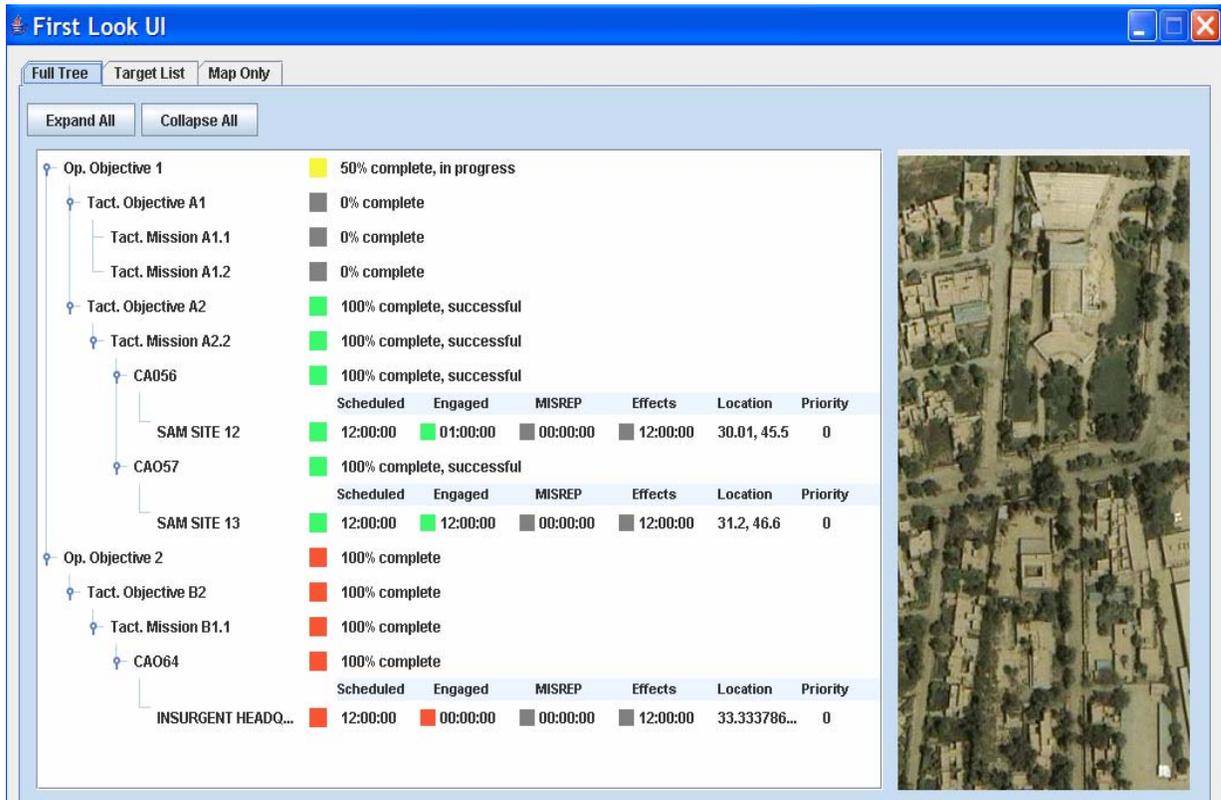


Figure 1: Strategy-to-Task hierarchy updated during mission execution. Stop light roll-up.

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. 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 our challenges was finding an acceptable way to “roll up” target information to the tactical and operational objectives. The current version tracks the targets that have been prosecuted, as indicated by the link-16 messages, and rolls that information up to show the percentage of the tactical and operational objective that have been met. If all of the subordinate tasks have been accomplished the stoplight chart is coded green, if none of the subordinate goals were met it is colored red, otherwise it was yellow. Clearly this provides, at best, only a crude roll-up capability. We are in the process of amending the display 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 as 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 munitions drop. Operator interviews has revealed that some operators are willing to believe 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. Still 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.

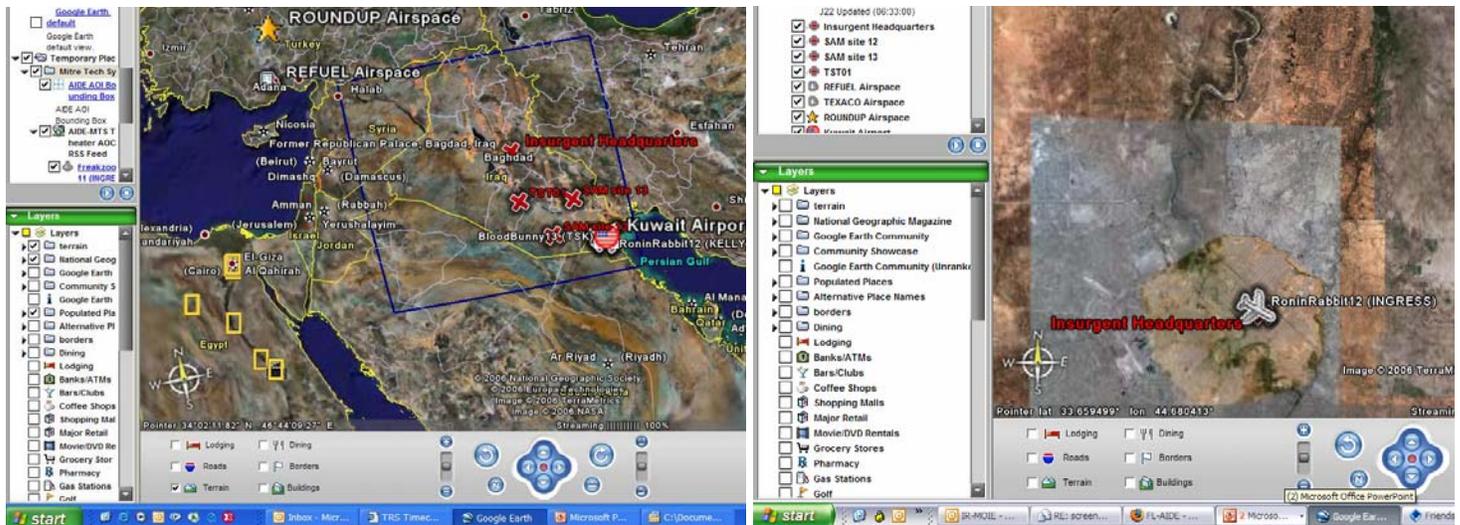


Figure 2: Google Earth Display of assets labeled with ATO callsign and mission status

Summary

Our goal is to provide insight 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, not what it means. To know that, one must often wait 2-3 days (or more) to get responses to the Assessment Information Requirements (AIRs), and even then the information is associated with targets and must be manually associated with Operational and Tactical Objectives through a painstaking process. Developing capabilities such as DLARS, TBONE, and IWPC contain the raw material with which to construct a rudimentary framework for a near real-time assessment capability. We have endeavored to look out into the future and determine what additional capabilities would be required to flesh out this developing framework. Our work seeks to augment these capabilities by developing new inference 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 mechanisms to disseminate it.