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# ABSTRACT

Current information systems are difficult to change to produce information that is tailored to the specific needs and context of end users. The information they produce is static, and application reengineering can be complex, costly and time consuming, potentially leading to system downtime. In addition, multiple information systems and sources can produce duplicate or inconsistent information that requires significant human effort to correlate, integrate and understand. The Joint Battlespace Infosphere (JBI) is defined as "a combat information management system that provides individual users with the specific information required for their functional responsibilities" and "provides uniform rules for publishing new and updated objects into the JBI and promptly alerts any JBI clients that have subscribed to such objects."[1] The *transform* core service of the JBI enhances the value of information disseminated by the JBI through information manipulation mechanisms (fuselets) that tailor the information space to the specific needs of the warfighter and mission. This paper describes the results of an experiment that was designed to measure the validity and value of the JBI fuselet concept within the context an Air Operations Center (AOC) and a dynamic collaborative mission replanning scenario.

# 1. INTRODUCTION

## *1.1 Problem Statement*

The information produced by current information systems is typically static in nature. These systems are difficult to change to produce information that is tailored to the specific needs and context of end users since application reengineering can be complex, costly and time consuming, potentially leading to system downtime. Exasperating the problem is the fact that multiple information systems and sources can produce duplicate or inconsistent information that requires significant human effort to correlate, integrate and understand. This can lead to information overload and confusion, inefficient and ineffective decision-making, and cumbersome and error-prone migration of information from one system to another, often requiring manual data reentry.

## *1.2 Joint Battlespace Infosphere (JBI)*

The JBI is a vision of an orchestrated information management environment whose services adapt to the operational needs of joint and coalition enterprises for universal real-time access to tailorable, actionable information. The JBI employs publish, subscribe, query, transform, and control core services to deliver decision-quality information in a secure and assured fashion with the desired Quality of Service (QoS) to all users at all echelons. An instance of the JBI is a dynamic system that is "stood up" for a specific purpose or mission, and is scalable and flexible to the evolving needs over time of a diverse and changing membership set of clients (information producers and consumers).

### 1.3 JBI Fuselets for Information Manipulation

A fuselet is a special-purpose JBI client program that provides value-added information processing functions that are under the control of the JBI. The information processing functions are crafted to take existing information objects as input and manipulate them in some way to produce new value-added information objects. Operationally speaking, fuselets enable information to be manipulated into the form that is required by and useful to the warfighter.

Specifically, the objective of fuselet technology is to augment information systems with a flexible information production capability that is dynamic to the changing needs of end users without requiring any significant changes to legacy systems. The desired operational impact is to improve the efficiency and effectiveness of decision-making by correlating duplicative information, resolving inconsistent information, mediating between information sources, and fusing information together into comprehensible information products. By leveraging the managed information space provided by the JBI, flexible and easy to build decision logic functions in the form of software components (fuselets) can be designed to tailor information for the particular purposes of individuals and Communities of Interest (COIs)[2] so as to improve the speed and effectiveness of command decisions and subsequent actions.

The remainder of this paper describes an experiment designed to measure the validity and value of the JBI fuselet concept within the context an Air Operations Center (AOC) and a dynamic collaborative mission replanning scenario. The name of the experiment is Decision-support Infosphere Services for Collaborative Operations and Virtual Environment Requirements (DISCOVER).

## 2. DISCOVER: A Fuselet Concept Validation Experiment

### 2.1 Overview

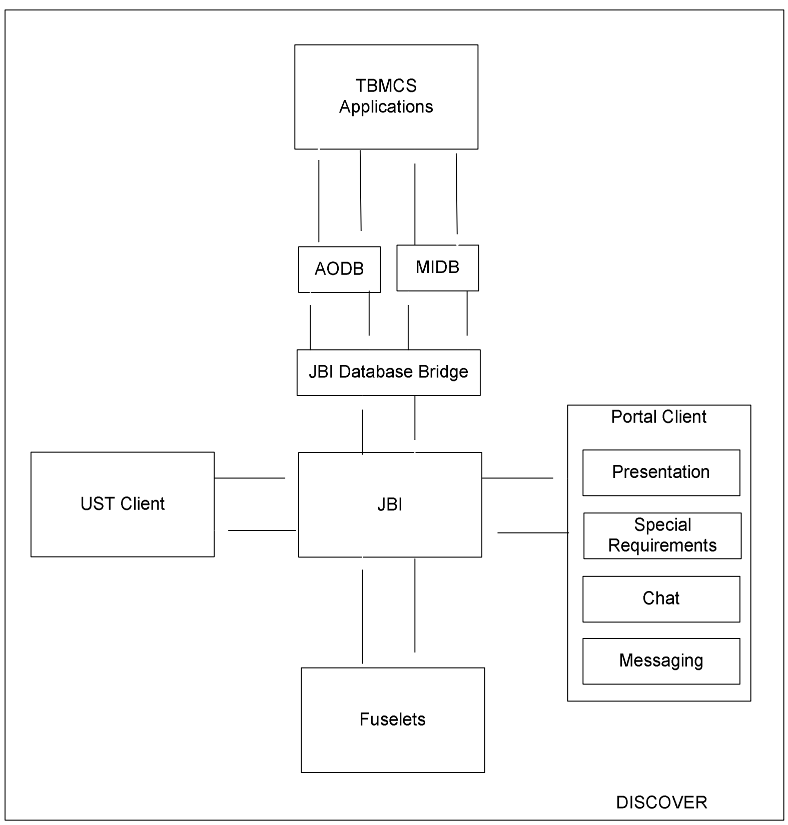
The DISCOVER project is an experiment designed to measure the validity and value of the JBI fuselet technology by applying it to a dynamic replanning scenario within an AOC. In an attempt to do so, we recognized the importance of attempting to adhere to the principles of the scientific method:

1. *Observation* - Dynamic replanning of missions within an AOC involves a great deal of collaboration (person-to-person, person-to-device, and device-to-device) and decision making.
2. *Question* - What information and information sharing capabilities are needed to improve the effectiveness of decision making in this environment?
3. *Hypothesis* - JBI fuselet technology can produce better decision-quality information that will be integral to collaborative processes and workflow.
4. *Prediction* - Fuselet and collaboration capabilities can unobtrusively augment current planning systems and make significant positive improvements to operational effectiveness.

5. *Controlled Experiment* - Compare “as-is” and “to-be” operational processes, the later of which incorporates the aforementioned information management technologies.
6. *Theory/Learn* - Verify or contradict the hypothesis (or elements thereof) based on results of the experiment.

## 2.2 System Architecture and Fuselet Companion Clients

A conscious decision was made to separate the runtime concerns of information production by a fuselet and how that information is ultimately used or presented, and by what/to whom. The runtime responsibility of a fuselet ends with the publication of the information it was intended to produce. In this way, all clients interested in the information produced by a fuselet can subscribe to it and do what they wish with it (provided these clients are authorized to do so). However, the concern over how the output of a fuselet will initially be used is nearly always considered during the development of that fuselet. Recognizing this, there is the notion of a fuselet *companion client* that is designed and developed in conjunction with a fuselet (or set of fuselets). Companion clients subscribe to fuselet outputs and display the information to an end user, or serve as a bridge (adaptor) between the JBI and a legacy application so that fuselets can operate on legacy data. The DISCOVER project involved the development of just such companion clients which are components in the overall system architecture illustrated in Figure 1.



Each of these companion clients within the DISCOVER system architecture is briefly described in turn.

### 2.2.1 JBI Database Bridge

The Theater Battle Management Core Systems (TBMCS) is a collection of tools, utilities and over 50 major applications that have been integrated to support Joint Air Operations. TBMCS provides automated command and control (C2) and decision support tools to improve the planning, preparation, and execution of joint air combat capabilities.[3] From the perspective of the DISCOVER experiment, TBMCS is viewed as a legacy application that plays a part in the operational scenario that the experiment employs. The Air Operations Database (AODB) and Modernized Intelligence Database (MIDB) are relational databases used by TBMCS applications. In order to demonstrate the capability of fuselets to produce information of operational value to AOC operators, data produced by the TBMCS legacy applications had to somehow get published to the JBI so that fuselets could operate on that data. The JBI Database Bridge, developed previously at AFRL, is used as a companion client to publish TBMCS data into the information space of the JBI in support of the DISCOVER experiment's dynamic mission replanning scenario.

### 2.2.2 Unit Status Technician Client

The Unit Status Technician (UST) companion client was developed under the DISCOVER project allows augmentation of TBMCS data with information about the qualifications of military units to handle various munitions. While this information is available at the unit level, it is not currently available in the TBMCS force level applications within an AOC. The significance of this client is that unit qualification information can be published to the JBI along with the legacy TBMCS data published by the JBI Database Bridge. Fuselets then consume this information in support of the experiment's operational scenario.

### 2.2.3 Collaboration and Visualization Portal Client

In addition to the information produced by fuselets, the DISCOVER project recognized the requirement to visualize (present) this information to human operators within an AOC and the ability for teams of operators to collaborate over this information. The DISCOVER project utilizes portal, messaging, and chat technology to support presentation and collaboration requirements. Fuselets perform information manipulation functions on data stored in the JBI's managed information space in order to produce value added information that can be visualized within a Portal Client. Figure 2 shows a notional screen shot of the Portal Client, a principal DISCOVER fuselet companion client. This client provides the primary human-machine interface to AOC operators in support of DISCOVER's dynamic mission replanning process. The Portal Client provides information visualization spaces that are shared by multiple AOC operators, a shared space for entering special requirements for a target, and Chat and Messaging services.

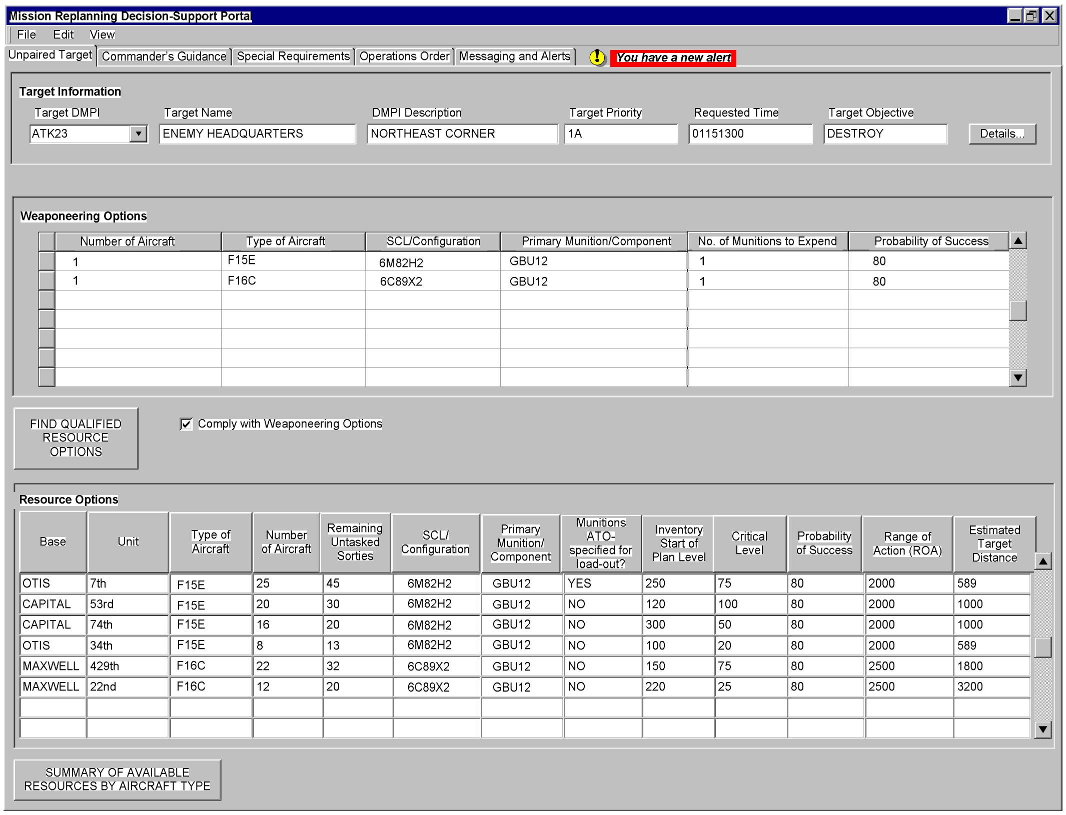



*Figure 2 –Portal Client Screen Shots*

## 2.3 Experimentation Methodology

### 2.3.1 Capture and Analyze an "As-Is" Operational Scenario & Process

The first thing we did was consult with a Subject Matter Expert (SME) who was both a retired Air Force pilot and AOC operator to identify an operational domain where information management technology could be applied with a potentially significant return on investment. After some dialog, the SME suggested the area of dynamic mission replanning within an AOC, since that is an area ripe with collaborative and rapid decision-making activities that are less sufficiently supported by existing C2 systems than are normal mission planning activities. It seemed that fuselets might go a long way to execute the decision logic to derive information that human operators now have to find manually using current C2 systems, such as TBMCS (see Figure 3).

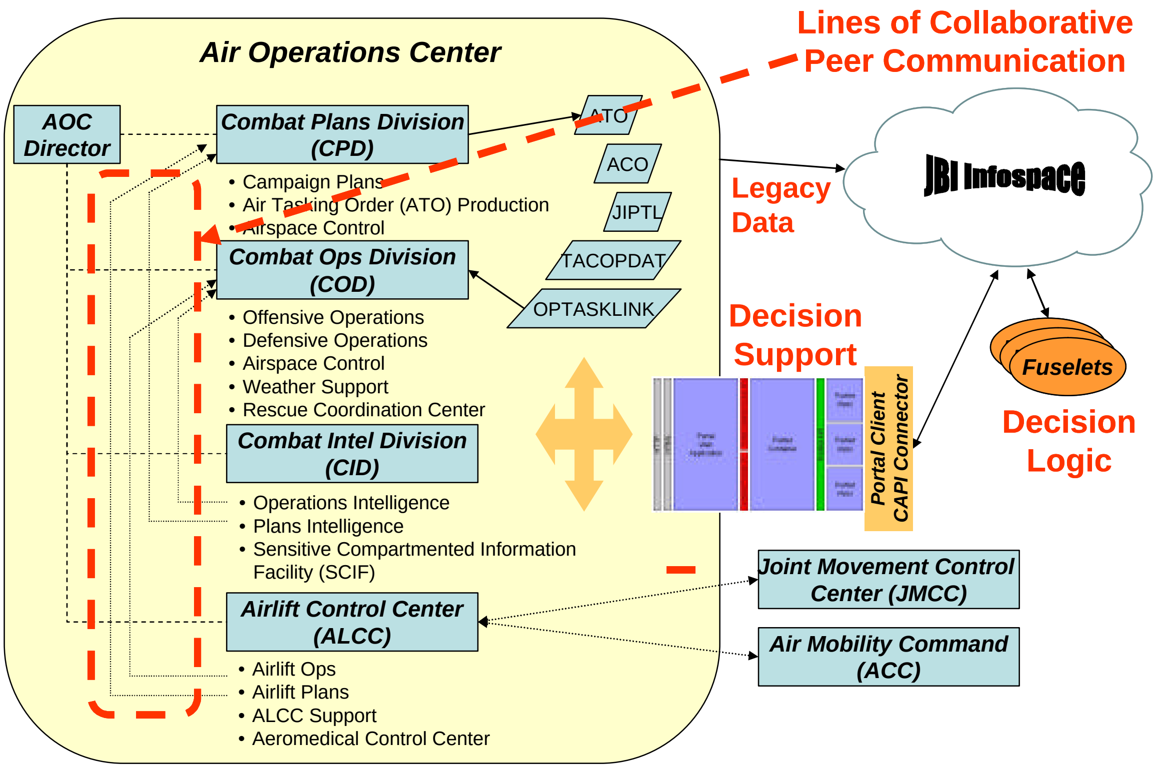



*Figure 3 - AOC Collaborative Decision-Making Support*

Once convinced that dynamic mission replanning within an AOC was a good candidate for our experiment, we (in conjunction with the SME) wrote a textual description of the scenario that started with the identification of a new high priority target for which no missions were planned against. In the scenario, this eventually led to the requirement for an F-15E Fighter Duty Officer (FIDO) to choose and re-roll a mission of lower priority to attack the new target. We were surprised how complex such a seemingly straight forward activity actually is – warfighting is by no means a paltry affair.

We then transformed the text-based scenario into a well-defined process model (Figure 4 captures a small portion of the as-is process model that we defined). We used Software Business Success's Processworks process modeling tools and problem solving methodology to develop the model. In Processworks, a problem (scenario) is transformed into a process – that is, the problem is decomposed into a series of activities (bubbles) and tasks (text in bubbles), which are then related together by lines and arrows designating data (information) and control flow throughout the process. In Processworks, the specification of actors relates roles to responsibilities (process activities and tasks), and interfaces to systems that are responsible for the production and storage of information produced and consumed in the process are also defined. The reason an as-is process was developed in Processworks is, first and foremost, to provide the basis for reasoning about how the existing process works and how it can be improved.

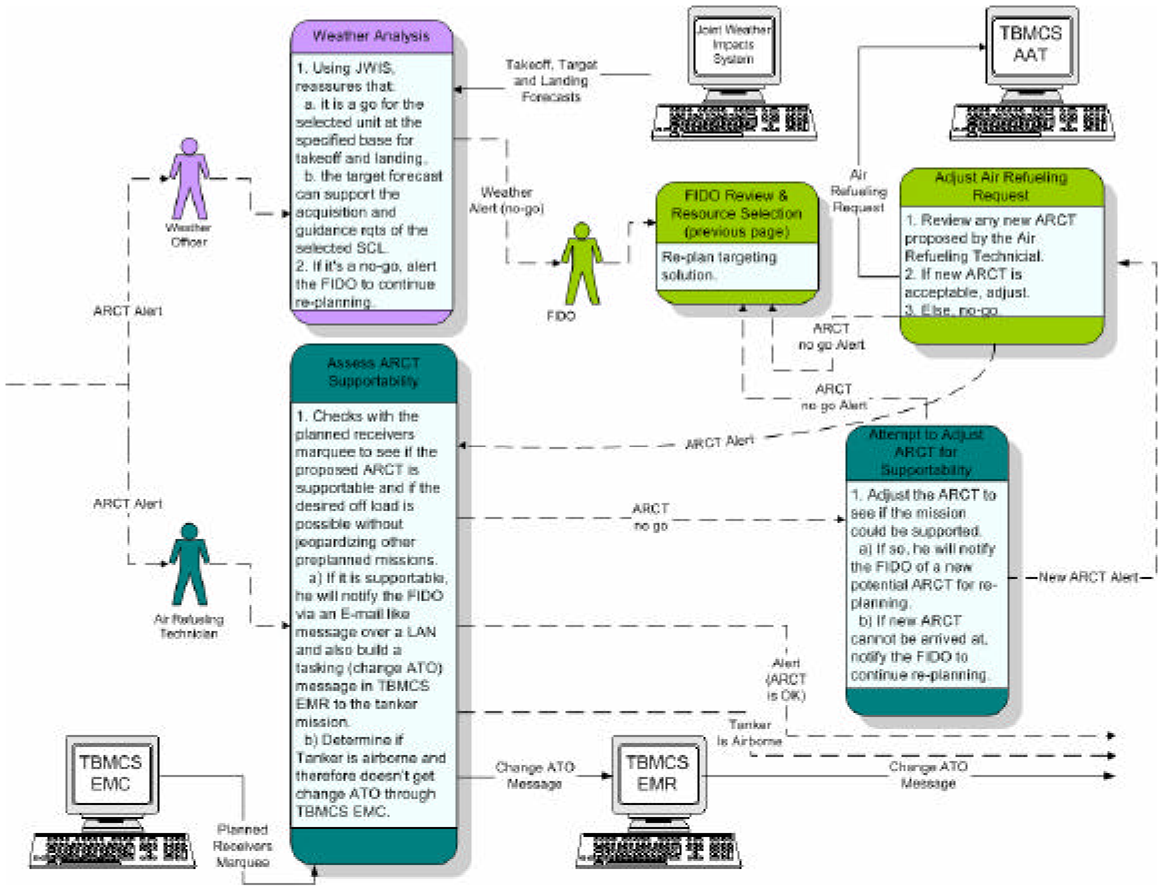



*Figure 4 – Dynamic Collaborative Mission Replanning Scenario*

## 2.3.2 Analyze "As-Is" Process for Informational Deficiencies

We next went into an analysis of the process we defined and the C2 systems that AOC operators interact with. As can be seen in Figure 4, there are many lines of communication between people and systems. Today, much of the person-to-person communication is done by "tennis shoe" interfaces, which makes distributed AOC operations difficult and centralized operations vulnerable to attack. Therefore, automation for collaborative capabilities provided by chat, instant messaging, and portal technology would in theory be beneficial to speeding up communication between operators and enable it to be done in a distributed way.

Another one of the problems that we identified is that TBMCS is largely a sophisticated database query-response system. For example, a FIDO could select a mission to re-roll and attempt to submit it to the system only to have the database constraint checking mechanisms tell him that his choice is ineligible for re-roll. The FIDO might have to do this any number of times before he finds a valid option that passes the system checks. Therefore, we postulated that a combination of fuselets could be developed to derive a list of valid resource options to attack the specified target, and provide other supporting information to the warfighter to help the FIDO make an informed decision about the resource he should select. Fuselets would provide a proactive decision-support capability, as opposed to a reactive one where there is a high potential for no-go decisions where replanning has to back up and repeat itself.

### 2.3.3 Develop a "To-Be" Operational Scenario Process

The as-is scenario that we arrived at was fairly large, and our time and budget constraints relatively limited. Therefore, we chose to narrow the scope of our experiment to a small slice of the as-is process for technology application. We decided to focus on supporting the FIDO for the decisions he has to make, the activities he has to perform, and the collaborations he has with other duty officers. Figure 5 illustrates the as-is slice of the process that we defined. Red lines indicate potential no-go decisions in the as-is process that our technology is intended to help minimize.

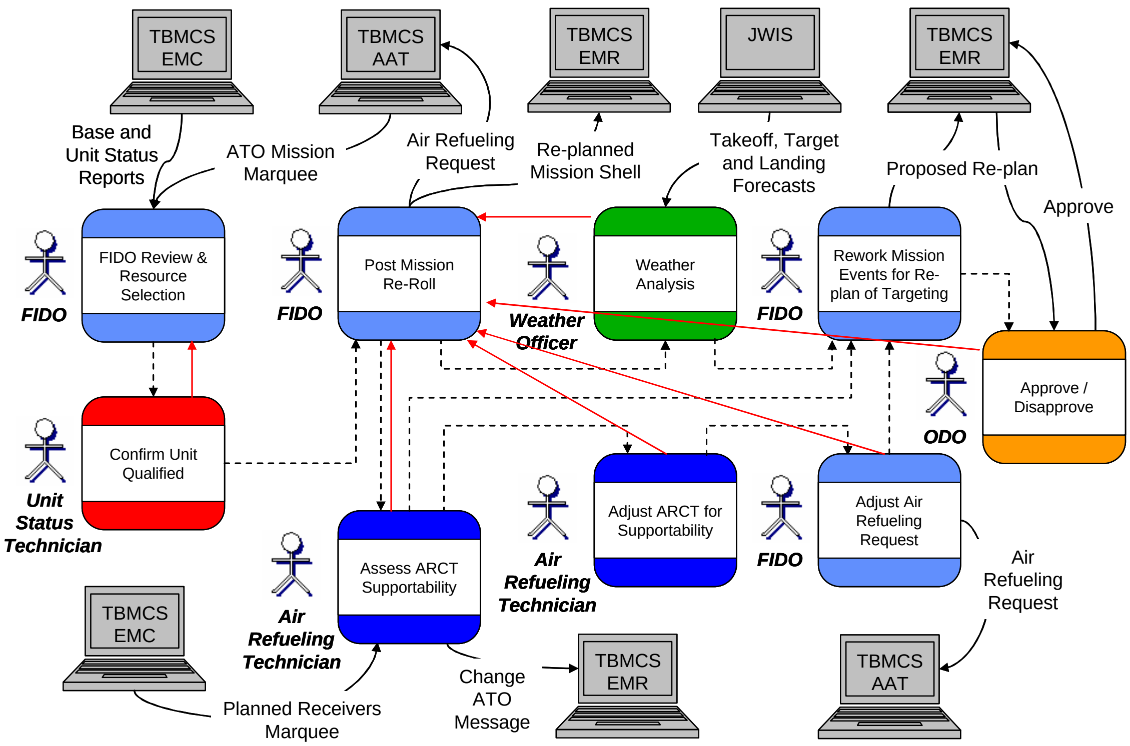



*Figure 5 – Subset of "As-Is" Dynamic Mission Replanning Process*

Figure 6 depicts our to-be operational scenario where JBI, JBI fuselet, and collaborative fuselet companion clients are injected into the overall dynamic mission replanning scenario. AOC operators have access to all of the same legacy C2 systems and tools that they are accustomed to using, as well as the capabilities that DISCOVER affords them.

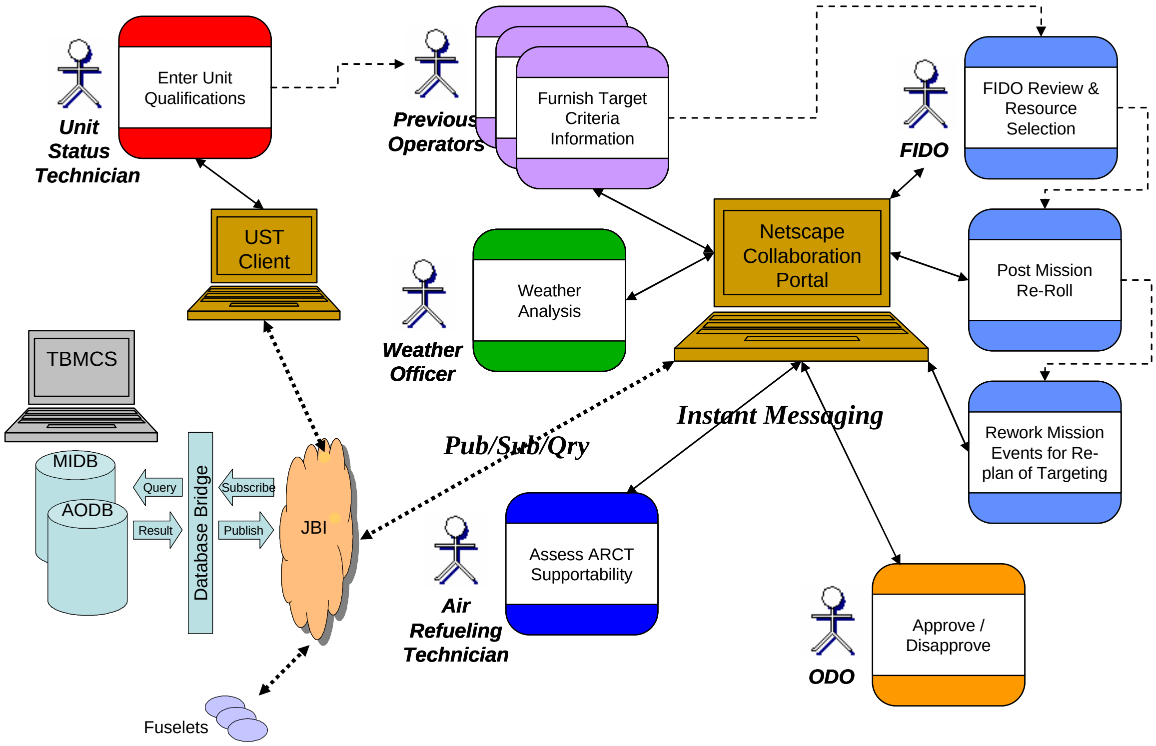



*Figure 6 –"To-Be" Dynamic Mission Replanning Process*

## 2.3.4 Requirements Specification and Design of the Solution

Once we had a handle on the operational domain to which we were to apply our technology, we had to define the requirements for each of the system components within our architecture. This involved legacy system data modeling to understand the relationships between the various pieces of information utilized within the as-is process, storyboarding to come up with the Graphical User Interfaces (GUIs) that our collaboration portal client would present to the end user, defining use cases for the various interactions between the users and the system, specifying functional descriptions of the system components, developing sequence diagrams showing the flow of JBI information object publications, subscriptions and queries, and finally engineering the information object schemas for the objects identified in the sequence diagrams. Each of these activities is described with representative examples.

### 2.3.4.1 Legacy System Data Modeling

We test drove TBMCS applications and studied the documentation for that system to derive a relational data model using Microsoft Access. This data model, shown in Figure 7, proved essential in better understanding the as-is process, and in determining what information we needed to extract from TBMCS via the database bridge and publish to the JBI in support of our to-be process. It also allowed us to prototype how fuselets would correlate various information objects based on slices through the data model, and also helped us to determine what additional information would be needed to augment TBMCS in the to-be process (see Figure 8).

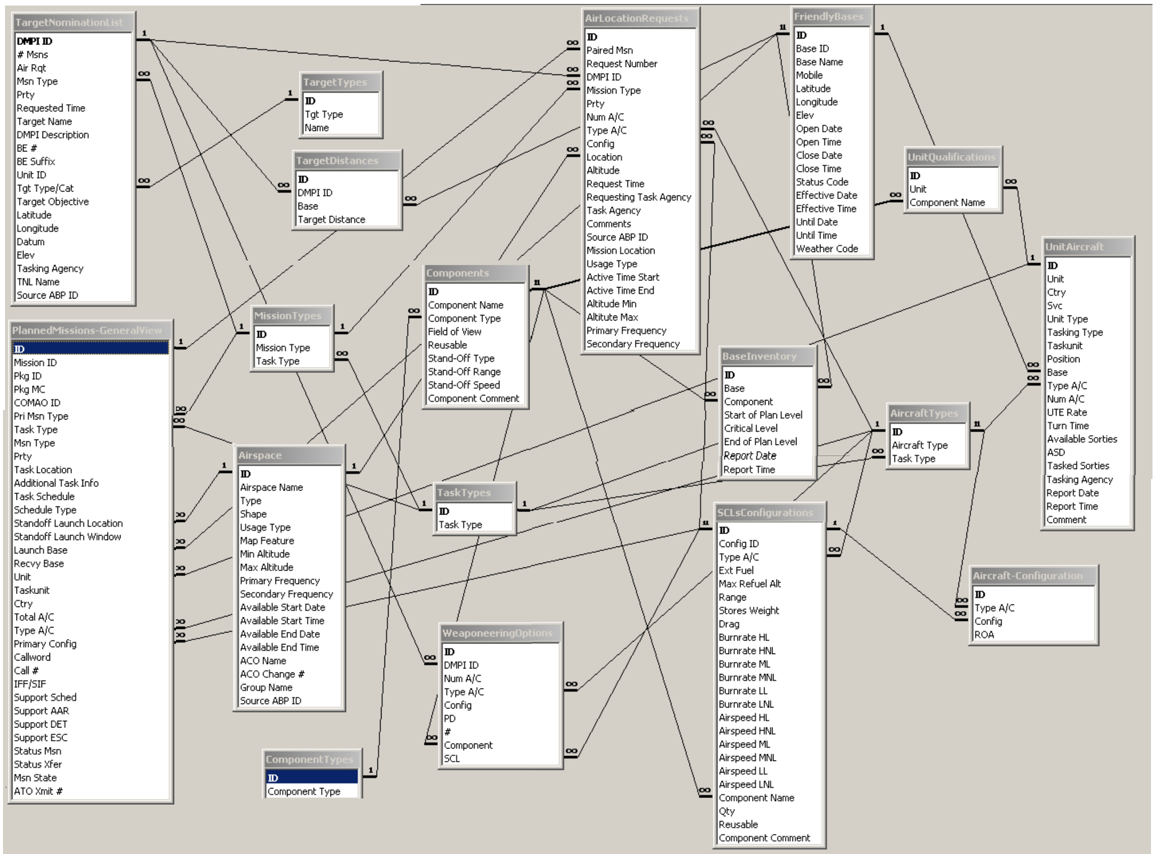



*Figure 7 – Legacy System Data Modeling*

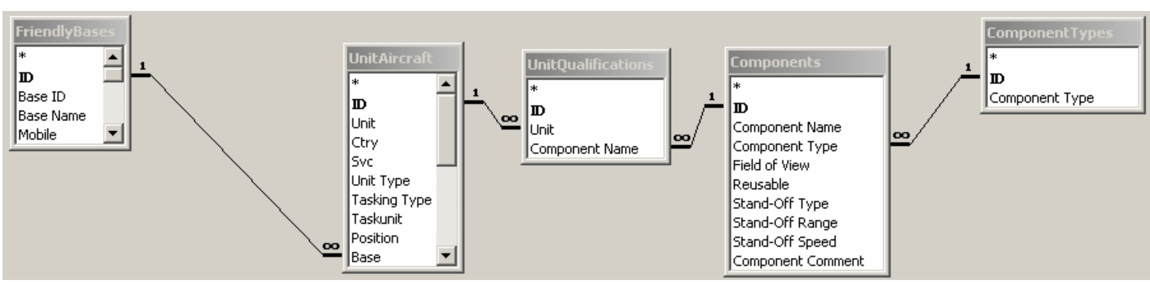



*Figure 8 – Relational Slice through the Data Model*

### 2.3.4.2 Storyboarding

We used Microsoft Visio to develop some notional GUIs for the collaboration and visualization capabilities to be provided by the Portal Client of our system. Figure 9 shows one of these screens.

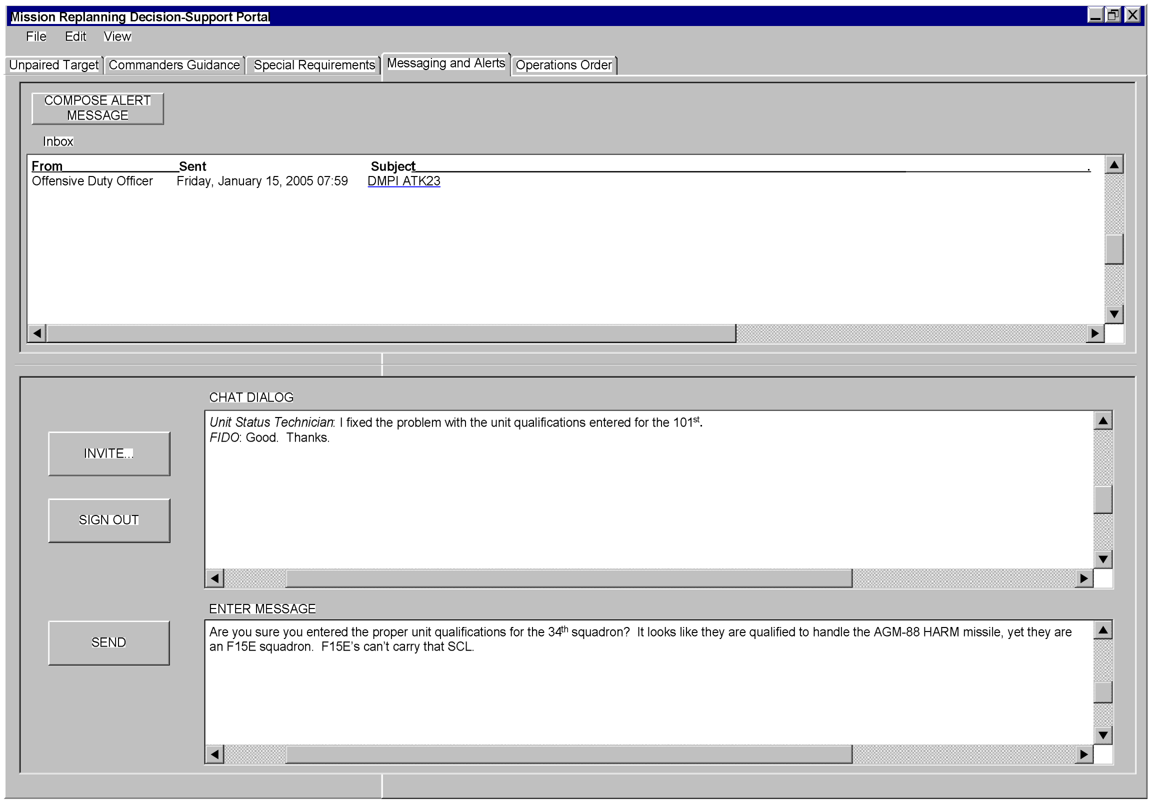
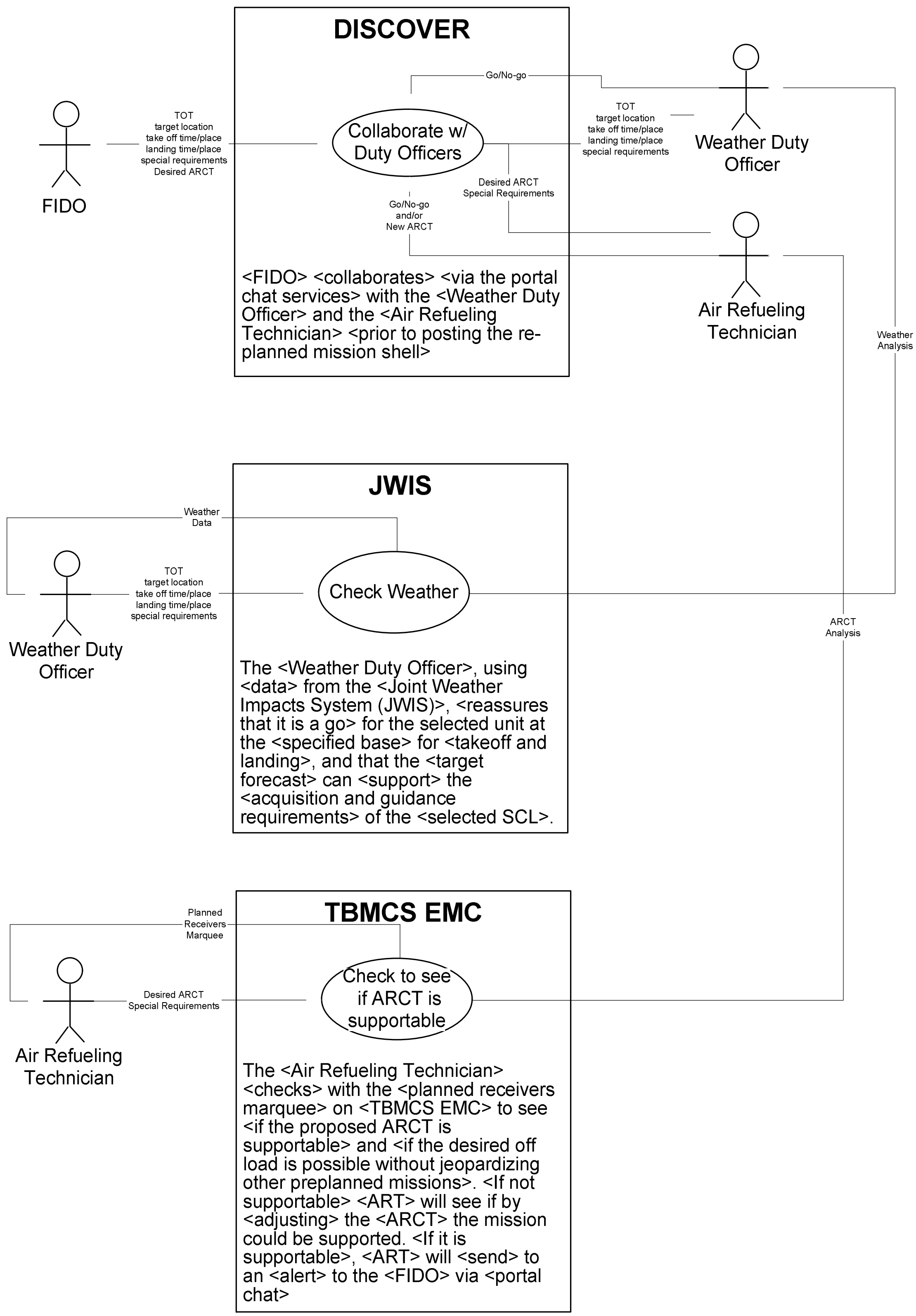



*Figure 9 – Storyboarding a GUI for Messaging and Chat Collaborations*

It should be noted that the actual screens developed will probably look somewhat different from those that we have storyboarded. At the time of this writing, we are only two-thirds of the way through the project.

### 2.3.4.3 Use Cases

We also used Microsoft Visio to define various use cases tied to our to-be process. Figure 10 illustrates some of these Unified Modeling Language (UML) use case diagrams. We were able to capture snippets of the as-is process within the system box of each use case, allowing us to map each use case back to the operational scenario.


DISCOVER
Go/No-go
FIDO
TOT
target location
take off time/place
landing time/place
special requirements
Desired ARCT
Collaborate w/ Duty Officers
TOT
target location
take off time/place
landing time/place
special requirements
Weather Duty Officer
Desired ARCT
Special Requirements
Go/No-go
and/or
New ARCT
Air Refueling Technician
<FIDO> <collaborates> <via the portal chat services> with the <Weather Duty Officer> and the <Air Refueling Technician> <prior to posting the re-planned mission shell>
Weather Analysis
JWIS
Weather Data
TOT
target location
take off time/place
landing time/place
special requirements
Check Weather
Weather Duty Officer
ARCT Analysis
The <Weather Duty Officer>, using <data> from the <Joint Weather Impacts System (JWIS)>, <reassures that it is a go> for the selected unit at the <specified base> for <takeoff and landing>, and that the <target forecast> can <support> the <acquisition and guidance requirements> of the <selected SCL>.
TBMCS EMC
Planned
Receivers
Marquee
Desired ARCT
Special Requirements
Check to see if ARCT is supportable
Air Refueling Technician
The <Air Refueling Technician> <checks> with the <planned receivers marquee> on <TBMCS EMC> to see <if the proposed ARCT is supportable> and <if the desired off load is possible without jeopardizing other preplanned missions>. <If not supportable> <ART> will see if by <adjusting> the <ARCT> the mission could be supported. <If it is supportable>, <ART> will <send> to an <alert> to the <FIDO> via <portal chat>

### 2.3.4.4 Functional Descriptions

We developed functional descriptions, such as the following example: "The portal application shall allow for text messaging between the various duty officers so that they can collaborate on the targeting information and special requirements that are presented in the portal application. Note that users shall be able to collaborate via asynchronous Email-like alert messages as well as via synchronous multi-party chat sessions."[4]

### 2.3.4.5 Sequence Diagrams

In order to understand how to coordinate the sequence of information object publications, subscriptions, and queries by the UST Client, Database Bridge, Fuselets, and the Portal Client, we developed UML sequence diagrams using TogetherSoft to illustrate the passing of information objects within the system, all of which occurs transparently to the end user. Figure 11 illustrates one such sequence diagram.

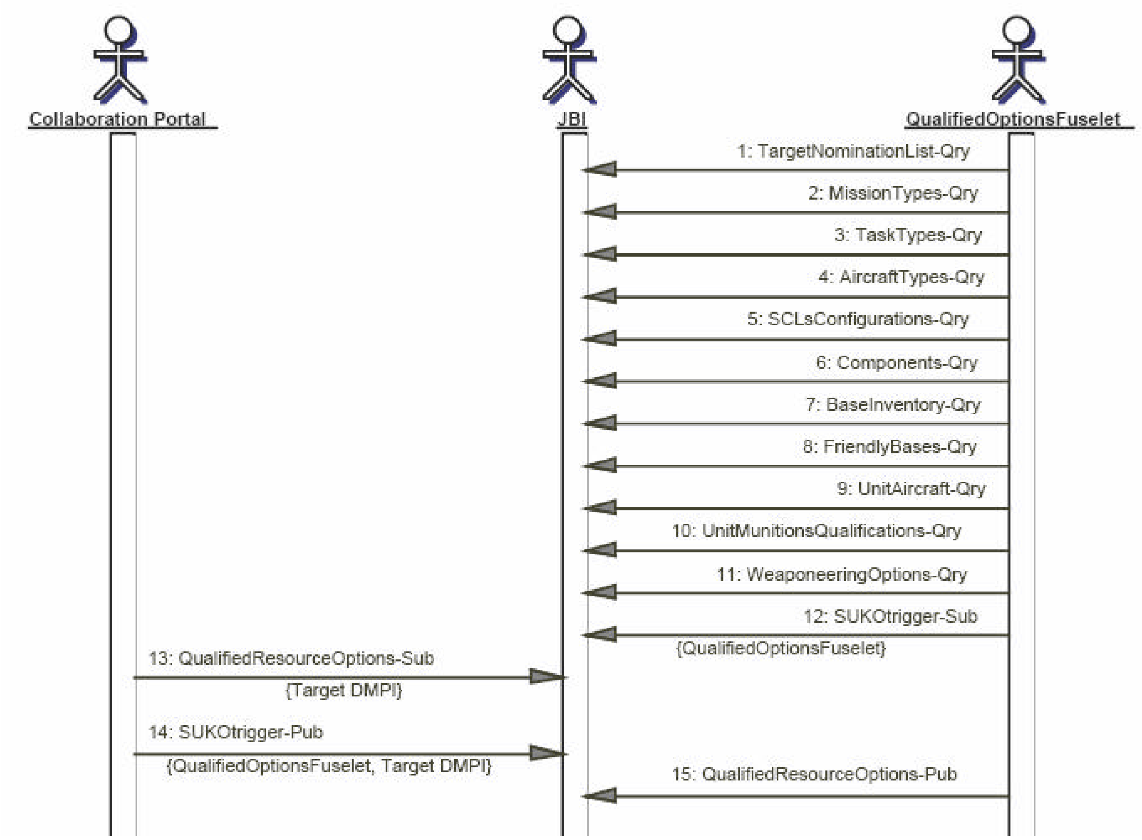



***Figure 11 – An Example of a UML Sequence Diagram***

### 2.3.4.6 Information Engineering

Once we had identified in our sequence diagrams the information objects required to support our system, we needed to specify the schemas for each information object type. We used XMLSpy for XML schema development. Figure 12 depicts a graphical representation of the XML Schema for one of our information object types.

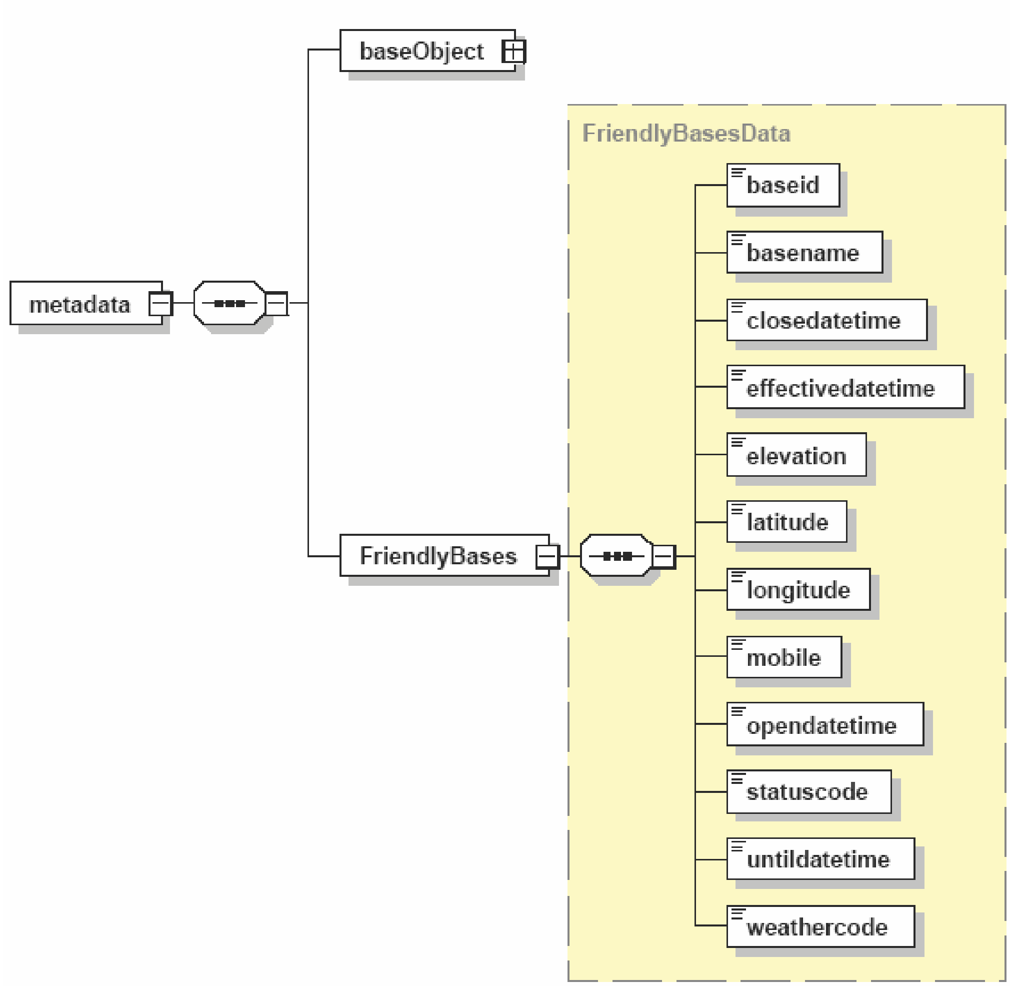



***Figure 12 – Graphical View of an Information Object Schema***

This particular example is the output of one fuselet that is later consumed as the input to another, and that is where the sequence diagrams become an important tool in understanding workflow dependencies between the various system components.

## 2.3.5 Portal and UST Client Design and Development

We hope to tie together all the collaboration and information sharing needs of AOC operators within a flexible and extensible portal framework. Ultimately, in our view, this portal is all about collaboration. The JBI is one mechanism for sharing specific kinds of information between users while collaboration features like text messaging allow other kinds of (usually ad-hoc) information sharing.[5] The initial DISCOVER client suite that InfoDynamics is assembling consists of these primary components:

- Jabber Inc. Messaging Server & Web Client
- Jakarta Jetspeed Portal (v. 1.5)
- Tomcat 5.x
- Apache 1.3x Web Server

The UST Client for populating the JBI information space with military unit munition-handling qualifications is a simpler client to develop than the Portal Client. Figure 13 shows a notional look-and-feel for this client.

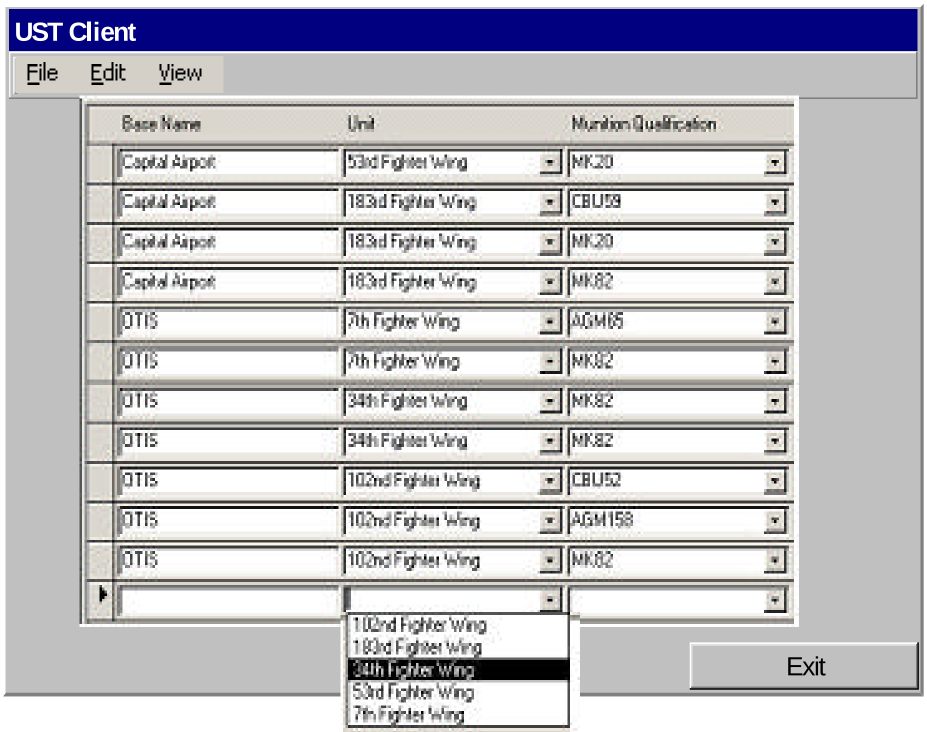



***Figure 13 – Unit Status Technician (UST) Client***

## 2.3.6 SUKO Fuselet Design & Fuselet Development

Fuselets that maintain information about their internal state over the passage of time are called "stateful" fuselets. While the internal state of a fuselet cannot be queried directly by other JBI clients, the fuselet can provide a "snap-shot" of this information by publishing it to the JBI as an immutable information object. A stateful fuselet that maintains state information based on inputs received from multiple information sources (via the JBI) and publishes this information periodically according to some business logic for consumption by multiple clients with a common interest in (and possible contribution to) that information is what is known as a "Shared Updateable Knowledge Object" (SUKO).[6]

In DISCOVER, we came up with an initial design for a SUKO fuselet and how one would be triggered to publish the information it maintains. In addition to subscribing for inputs from multiple clients for information transformation according to some business logic, a SUKO fuselet can also subscribe for a "trigger" information object that is published by an external client as an instruction to the fuselet when to publish and what to publish. Figure 14 illustrates how this works.

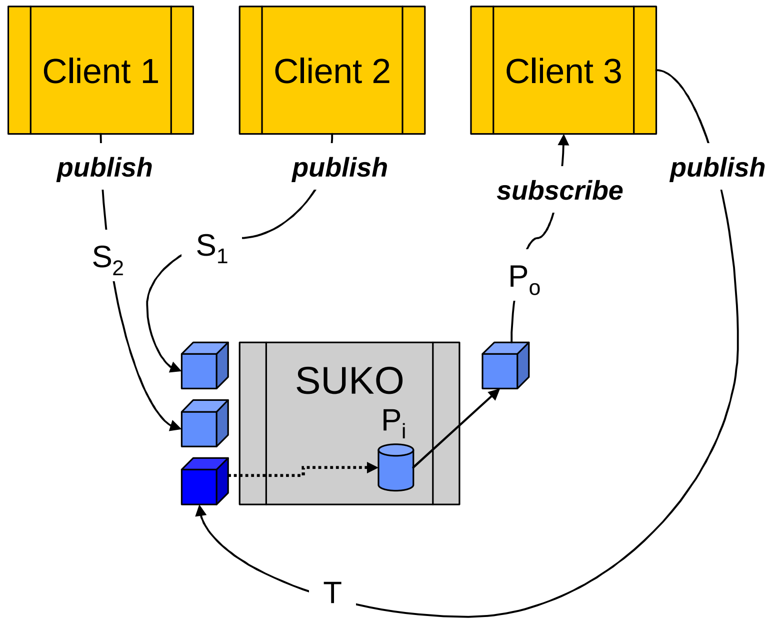



***Figure 14 – Triggering a SUKO Fuselet***

What is depicted in Figure 14 is a SUKO that is subscribing to information objects $S_1$ and $S_2$ that are published to the JBI by *Client 1* and *Client 2*, respectively. Based on these inputs and the manipulations performed on them, the SUKO internally maintains the result $P_i$. The SUKO also subscribes to a trigger information object type *T*. In this example, *Client 3* publishes *T* to trigger the fuselet to publish the output information object $P_o$ which represents the current state of $P_i$. The JBI then delivers $P_o$ to *Client 3* based on its subscription to that information object. The SUKO trigger information object that we designed is shown in Figure 15. It tells the SUKO what information object(s) it should publish, and includes optional parameterization that can be used to prescribe what exactly the fuselet is to produce as information in its publication.

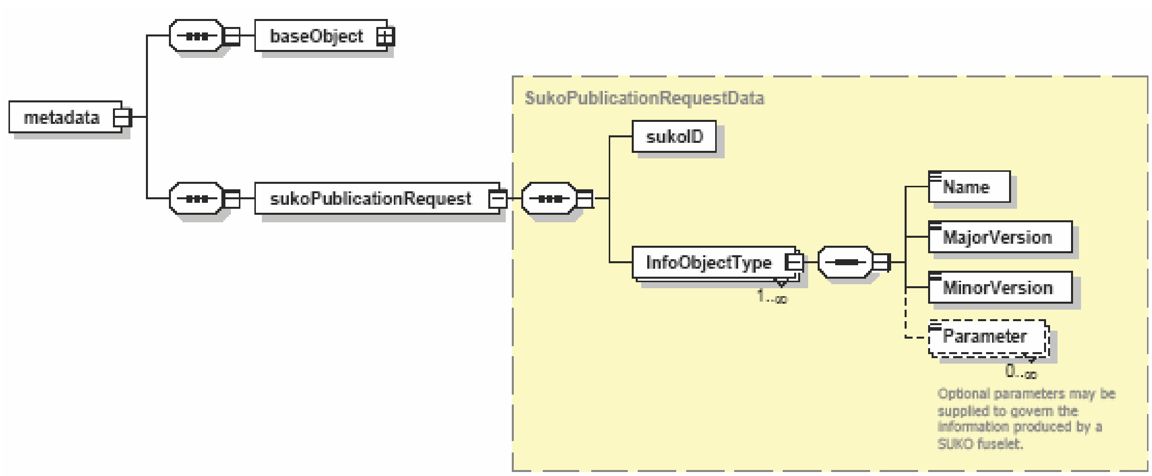



***Figure 15 – Schema of a SUKO Trigger Information Object***

In DISCOVER, the SUKOs we are developing manipulate inputs from each of the major TBMCS databases (via the bridge), the UST Client, and other fuselets. They then publish their results to the JBI for consumption by the Portal Client when a SUKO trigger information object is received, and this is usually associated with an end user action such as a button click. While not utilized in the DISCOVER project, another kind of SUKO maintains trigger information internally based on business logic that dictates when and what the fuselet should publish – that is, with this kind of a SUKO, trigger information objects are not needed to invoke fuselet publications.

Not all of the fuselets being developed for the DISCOVER project are SUKOs. Some are stateless fuselets that perform rather simple functions. All of the fuselets, including SUKOs, are developed using the Fuselet Development Environment (FDE) created by General Electric and ISX Corporation under a previous contract to AFRL in support of a congressionally funded effort called Information Management for Crisis Response (IMCR), another JBI experiment focused on homeland security. The FDE provides not only an Interactive Development Environment (IDE) for authoring fuselets, but also a runtime "sandbox" for testing, debugging, and executing fuselets. AFRL is currently porting this sandbox into the AFRL JBI fuselet runtime infrastructure that is itself under development at the time of this writing.[7]

## 2.3.7 Controlled Experimentation

### 2.3.7.1 Quantitative and Qualitative Metrics

The DISCOVER experiment utilizes the Goal Question Metric (GQM) method as its measurement system.[8] The GQM method was originally developed by V. Basili and D. Weiss[9], and expanded with many other concepts by D. Rombach.[10] We are using the GQM method to define measurement on the DISCOVER project, process, and products in such a way that the resulting metrics will be tailored to the goals of dynamic mission replanning within an AOC. GQM defines a measurement model on three levels:

- Conceptual level (goal): A goal is defined.
- Operational level (question): A set of questions is used to characterize the assessment or achievement of a specific goal.
- Quantitative level (metric): A set of metrics is associated with every question in order to answer it in a measurable way.

Some of the goals for DISCOVER are:

- Operators spend less time looking for information and more time on warfighting and decision making.
- Operators can respond more quickly with reduced effort, fewer errors and optimized solutions.
- AOC operations can be distributed and less vulnerable to attack than are centralized AOC operations.

As the experiment progresses, we will formulate the questions and metrics associated with these and other project goals (see Figure 16 for more).

| Goal | Question | Metric |
|---|---|---|
| **Mission Replanning** | | |
| Improve Mission Replanning Process Effectiveness | Does the JBI and fuselets lead to a greater number of successfully rerolled mission? | % improvement in missions rerolled successfully |
| Improve Mission Replanning Process Efficiency | Does the JBI and fuselets lead to less time to reroll a missions? | % reduction in time to reroll a complete mission |
| Improve Mission Replanning Process Value | Does the JBI and fuselets improve mission replanning value [I.e fewer missons to reroll faster]? | % improvement in missions rerolled successfully/% reduction in time to reroll a misison |
| **Decision-Making** | | |
| Improve Decision-Making Effectiveness | Does the JBI and fuselets make mission planners successful in choosing qualified missions to reroll? | % reduction in unqualified missions to reroll |
| Improve Decision-Making Efficiency | Does the JBI and fuselets help mission planners choose qualified missions to reroll faster? | % reduction in time to select a qualified mission to reroll |
| Improve Decision-Making Value | Can mission planner make select qualified missions to reroll-faster with the JBI and fuselets? | % reduction in negative missions to reroll/% reduction in time to select a qualified mission to reroll |
| **Information Value** | | |
| Improve Information Effectiveness | Does the JBI and fuselets produce more effective information? | If you agree that the JBI and fuselets produce more effective information and hence improve your ability to reroll mission - by what percent would rate the improvement in information effectiveness? |
| Improve Information Efficiency | Does the information JBI and fuselets produce lead to increased process and decision-making effeciency? | If you agree that the information JBI and fuselets produce leads to decreases the time you need to reroll mission - by what percent would rate the improvement? |
| Improve Information Value | Does the JBI and fuselets produce higher value information? | If you agree that the information JBI and fuselets produce helps you make more effective decision faster - by what percent would rate the improvement? |
| **Collaborative Communications** | | |
| Improve Communications Effectiveness | Does the JBI and fuselets improve communications effectiveness? | (1) % increase in machine to machine communications; (2) % reduction in person to person communication; (3) Would you say that the JBI and fuselets improve you abilitiy to communicate - if so by what percent? |
| Improve Communications Efficiency | Does the JBI and fuselets reduce the time mission planners spend communicating? | (1) % reduction in the time mission planners spend communicating;(2) Would you say that the JBI and fuselets the time you spend communicating - if so by what percent? |
| Improve Communications Value | Does the JBI and fuselets improve communications value? | If you agree that the JBI and fuselets improve your ability to communicate and also save you time - by what percent would rate the improvement in communications value? |
| | | |

***Figure 16 – DISCOVER Goals, Questions, and Metrics (GQM)***

### 2.3.7.2 Experiment Execution and Measurement

We will be running our fuselets and portal software within an unclassified AOC setting here at AFRL and against an instrumented JBI platform. The instrumentation capability was developed at AFRL as a general purpose JBI status and health monitoring system.[11] Therefore, we should be able to gain some insight into the runtime characteristics with regard to information object production and consumption rates (e.g., fuselet efficiency).

However, the most important measurements will be with respect to the quantitative and qualitative metrics related to DISCOVER's goals for information accuracy and operational value. Measurement will be based on the metrics that we derive through the application of the GQM method.

### 2.3.7.3 Experimentation Data Assessment and Reporting

The GQM method will provide us with a measurement plan that deals with the particular set of problems we are attempting to solve and the set of rules for obtaining, interpreting, assessing and reporting data from the experiment. The interpretation should give us the answers we are looking for if the project goals are attained. Figure 17 provides some of the assessment metrics associated with the questions that are related to project goals.

| Question | TBMCS | DISCOVER | Assessment Metric |
|---|---|---|---|
| Mission Replanning | | | |
| Does the JBI and fuselets lead to a greater number of successfully rerolled mission? | (1) number of missions rerolled; (2) number of missions rerolled successfully | (1) number of missions rerolled; (2) number of missions rerolled successfully | % of DISCOVER missions rerolled successfully - % of TBMCS missions rerolled successfully |
| Does the JBI and fuselets lead to less time to reroll a missions? | Mean time to reroll a complete TBMCS mission | Mean time to reroll a complete DISCOVER mission | [Mean time to reroll a complete TBMCS mission - Mean time to reroll a complete DISCOVER mission] / Mean time to reroll a complete TBMCS mission |
| Does the JBI and fuselets improve mission replanning value [I.e fewer missons to reroll faster]? | (1) % TBMCS missions rerolled successfully; (2) Mean time to reroll a TBMCS mission | (1) % DISCOVER missions rerolled successfully; (2) Mean time to reroll a DISCOVER mission | [% of DISCOVER missions rerolled successfully - % of TBMCS missions rerolled successfully] / [Mean time to reroll a complete TBMCS mission - Mean time to reroll a complete DISCOVER mission] / Mean time to reroll a complete TBMCS mission |
| Decision-Making | | | |
| Does the JBI and fuselets make mission planners successful in choosing qualified missions to reroll? | (1) number of TBMCS missions selected rerolled; (2) number of unqualified TBMCS missions selected to rerolled | (1) number of DISCOVER missions selected rerolled; (2) number of unqualified DISCOVER missions selected to rerolled | [number of unqualified TBMCS missions selected to rerolled - number of unqualified DISCOVER missions selected to rerolled] / [number of TBMCS missions selected reroll] |
| Does the JBI and fuselets help mission planners choose qualified missions to reroll faster? | Mean time to choose a qualified TBMCS mission to reroll | Mean time to choose a qualified DISCOVER mission to reroll | [Mean time to choose a qualified TBMCS mission to reroll - Mean time to choose a qualified DISCOVER mission to reroll] / [Mean time to choose a qualified TBMCS mission to reroll] |
| Can mission planner select more qualified missions to reroll-faster with the JBI and fuselets? | (1) number of unqualified TBMCS missions to reroll selected / total number of TBMCS missions to reroll selected; (2) Mean time to select a qualified TBMCS mission to reroll | (1) number of unqualified DISCOVER missions to reroll selected / total number of DISCOVER missions to reroll selected; (2) Mean time to select a qualified DISCOVER mission to reroll | [number of unqualified TBMCS missions to reroll selected] - [number of unqualified DISCOVER missions to reroll selected] / [total number of TBMCS missions to reroll selected] / [Mean time to select a qualified TBMCS mission to reroll] - [Mean time to select a qualified DISCOVER mission to reroll] / [Mean time to select a qualified TBMCS mission to reroll] |
| Information Value | | | |
| Does the JBI and fuselets produce more effective information? | What percent would you rate TBMCS's information effectiveness? | What percent would you rate DISCOVER's information effectiveness? | [DISCOVER's % information effectiveness] - [% TBMCS's information effectiveness] / [% TBMCS's information effectiveness] |
| Does the information JBI and fuselets produce lead to increased process and decision-making effeciency? | What percent would you rate TBMCS's process and decision-making effeciency? | What percent would you rate DISCOVER's process and decision-making effeciency? | [DISCOVER's process and decision-making effeciency] - [TBMCS's process and decision-making effeciency] / [TBMCS's process and decision-making effeciency] |
| Does the JBI and fuselets produce higher value information? | What percent would you rate TBMCS's information value? | What percent would you rate DISCOVER's information value? | [DISCOVER's information value] - [TBMCS's information value] / [TBMCS's information value] |
| Collaborative Communications | | | |
| Does the JBI and fuselets improve communications effectiveness? | What percent would you rate TBMCS's communications effectiveness? | What percent would you rate DISCOVER's communications effectiveness? | [DISCOVER's communications effectiveness] - [TBMCS's communications effectiveness] / [TBMCS's communications effectiveness] |
| Does the JBI and fuselets reduce the time mission planners spend communicating? | What percent of the mission replanning time do TBMCS's planners spend communicationing? | What percent of the mission replanning time do DISCOVER's planners spend communicationing? | [% TBMCS's mission replanning time communicating] - [% DISCOVER's mission replanning time communicating] / [% TBMCS's mission replanning time communicating] |
| Does the JBI and fuselets improve communications value? | What percent would you rate TBMCS's communications value? | What percent would you rate DISCOVER's communications value? | [DISCOVER's communications value] - [TBMCS's communications value] / [TBMCS's communications value] |
| | | | |

***Figure 17 – DISCOVER Assessment Metrics***

## 2.4 Results and Lessons Learned

While the DISCOVER project has not yet completed as of the date of this writing, we have already learned that a great deal of application domain knowledge needs to be assimilated before an understanding of problems and the development of potential solutions can be embarked upon.  It seems there will always be is a fairly steep learning curve, either for the fuselet developer to understand the problem domain, or for the subject matter expert to learn how to build fuselets and companion clients.

One of the objectives (not the primary one) of the DISCOVER experiment is to evaluate the graphical fuselet authoring capabilities provided by the GE/ISX Fuselet Development Environment (FDE) for ease of use by people that are not proficient programmers. The intent of developing the FDE's graphical fuselet authoring capabilities was to empower non-programmer domain experts with the ability to craft fuselets that capture the business logic for which they have the best understanding. What we learn in this regard will help shape future research and development in fuselet production environment technology.

The primary lessons to be learned, however, have yet to be revealed since the results of the experiment are not yet available. It is the expectation at this time that results and lessons learned will be ready to be unveiled in time for the 10th International Command and Control Research and Technology Symposium (ICCRTS).

# 3. Conclusion

In this paper, we have presented the work that has been done to date in an experiment designed to evaluate and validate the value of JBI publish/subscribe infrastructure, JBI fuselet, and collaboration technology to the real-world operational domain of joint air operations, specifically dynamic mission replanning. We hypothesize that the technology can make positive contributions to better and faster decision making and communication through the production of high-value, decision-quality information while doing so unobtrusively and affordably. Following the principles of the scientific method, we hope to execute a controlled experiment to validate our hypothesis, and be able to present the results.

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