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Strategy Planning Visualization Tool (SPVT) for the Air Operations Center (AOC)

Volume II: Information Operations (IO) Planning Enhancements

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14. ABSTRACT

The purpose of this program is to transition innovative work support within the AOC. The idea is to allow decisions to be made and plans to be formulated more quickly by providing users with intuitive, high-level visualizations of mission effects, interrelationships and mechanisms. The end result will be improved planning and assessment within the air tasking order (ATO) cycle.

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PREFACE

The Strategy Planning Visualization Tool (SPVT) project was performed under the direction of Mr. Donald Monk of the Air Force Research Laboratory's 711th Human Performance Wing Human Effectiveness Directorate (711 HPW/RHCP). The effort was accomplished under Contract Number FA8650-04-C-6537, Human Effectiveness in the Air & Space Operations Center (AOC).

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1.0 SUMMARY

The Air Force Research Laboratory's (AFRL) 711th Human Performance Wing Human Effectiveness Directorate (711 HPW/RHCP) created the Human Effectiveness in the Air & Space Operations Center (HE in the AOC) program to address warfighter work challenges experienced in the AOC Strategy Division (SD). The research goal was to develop a thorough understanding of warfighter information and decision requirements within the SD and to organizations within and beyond the AOC in order to better support warfighter decision making, affordances and interactions.

Phase I of HE in the AOC was conducted by ManTech Aegis and involved a decision-focused analysis of AOC SD personnel. The resulting AOC Cognitive Work Requirements product served as a jumpstart for formalizing user information and decision requirements. Phase II of HE in the AOC consisted of parallel efforts. One effort, Strategy Planning Visualization Tool (SPVT), was tasked with bringing decision-centered visualization support to the Strategy Division Strategy Planning Team (SPT), while the parallel effort, Operational Effects Assessment Visualization Tool (OEAVT), was tasked with bringing decision-centered visualization support to the Strategy Division Operational Assessment Team (OAT). OEAVT was performed by Science Applications International Corporation (SAIC) under a separate contract.

SPVT extended the information contained in the AOC SD Phase I Cognitive Task Analysis (CTA) by conducting analyses and performing additional interviews with warfighters. The interaction with warfighters was used to ensure the team had a solid understanding of the CTA, to further develop upon knowledge of work in the AOC SD and to refine concepts and prototypes. The effort yielded an extensive body of knowledge for the AOC SD and resulted in two prototypes, transitioning into Air Force programs of record.

2.0 INTRODUCTION

The primary dimensions addressed under SPVT's decision-centered analysis in the AOC SD included the following:

- How decisions are made in performing work
- How work products are developed
- How work is managed
- The types of collaborations and interactions that are necessary

This knowledge came in part from the Phase I AOC Cognitive Work Requirements which were used as a basis for the cognitive and collaboration work requirements for the work-centered support visualization efforts described herein.

Products from SPVT were designed to operate with the related and envisioned information, applications, systems, and infrastructure planned to be delivered with the AOC Block 10.2 and Joint capabilities, such as:

- Information Warfare Planning Capability (IWPC)
- Information Operations Planning Capability – Joint (IOPC-J)
- Virtual Integrated Support for the Information Operations Environment (VisIOn)
- Global Operations Center Collaborative Environment (GOC-CE)
- Theater Battle Management Core Systems (TBMCS)/Theater Battle Operations Net-centric Environment (TBONE)
- Modernized Integrated Database (MIDB)
- Joint Targeting Tool (JTT)

SPVT was comprised of several tasks. The initial sequence of tasks followed a human-centered systems engineering process from user requirements to system concept and definition through system prototype and evaluation. Volume I of this series describes the entirety of the SPVT tasks in order of their SPVT evolution. Including:

- Section 3.1 User Information and Decision Requirements
- Section 3.2 Common Effects Picture (CEP)
- Section 3.3 Global Effects Management – Synchronization (GEM-S)
- Section 3.4 Joint Air Operations Plan (JAOP) Air Operations Directive (AOD) Status Tool (JAST)
- Section 3.5 COA Sketch
- Section 3.6 TENEO
- Section 3.7 Information Operations Planning Capability – Experiment (IOPC-X)
- Section 3.8 Collaboration in the AOC Context

Ultimately, the combination of requirements elicitation, concept generation and refinement, and prototype development and evaluation resulted in a large body of knowledge for the AOC SD, several conceptual prototypes, one risk reduction, one technology demonstration and two technologies transitioned to United States Air Force (USAF) and United States Strategic Command (USSTRATCOM) programs of record.

The tasks collectively provide a solid work-centered analysis of AOC SD processes and decisions with several technologies designed to support the various aspects of the analysis.

Volume II aggregates the following IO Planning Capability enhancements portions of SPVT:

- Global Effects Management – Synchronization (GEM-S)
- Joint Air Operations Plan (JAOP) Air Operations Directive (AOD) Status Tool (JAST)
- TENEO
- Information Operations Planning Capability – Experiment (IOPC-X)

3.0 METHODS, ASSUMPTIONS, AND PROCEEDINGS

3.1 GLOBAL EFFECTS MANAGEMENT SYNCHRONIZATION

The Joint Information Operations Warfare Command (JIOWC) was interested in exploring visualization concepts for an effects management concept termed GEM-S. Initial concepts were drawn from the Common Effects Picture (CEP) and presented to the JIOWC in February 2006 as a concept supporting the GEM-S. Subsequent design iterations for the GEM-S prototype evolved over several months based on close interaction with operational users and stakeholders from the JIOWC. The following paragraphs describe the features GEM-S is intended to support. The spirit of these design features carry through most aspects of SPVT and thus are described in detail through this section.

GEM-S is a planning, assessment and campaign monitoring capability designed to operate as a thin client over a service oriented architecture. It provides a collaborative environment for users operating at multiple levels of command and across multiple communities of interest. GEM-S provides support for kinetic and non-kinetic operations, and includes unique capabilities which enable users to create and share user-defined displays, develop and modify plans from geospatial and temporal perspectives, and create and assess lines of effect. Innovative views also provide tailored campaign situational awareness for planners, analysts and commanders. The primary visualization and information components unique to GEM-S include Operations, Activities & Actions (OAA), Lines of Effects (LOE), IO Assessment and Information Ticker views and are best described in the following operational context.

Once an operation is underway, operations assessors begin performing assessments at all levels of the campaign. By opening each plan element and associated Measure of Effectiveness (MOEs), planners and assessment analysts document the current plan element state, assessment trend, and assessed effect status. Selecting an assessment status presents the user with two measurements: Magnitude Score and Direction Score. The effect Magnitude refers to the “mass” of the effect achieved when compared to the desired amount. The effect Direction refers to the positive or negative achievement of the desired effect.

Campaign situational awareness is afforded through several innovative views. The OAA view displays an array of information about plan contributions and dependencies as well as current status and trend information (see Figure 1). Each of the strategic prioritized effects is displayed at the top of the screen. The colored circles to the left indicate the current state of each plan element. A green circle indicates operations supporting this effect are currently being executed, yellow indicates operations are planned but not yet in progress, and red indicates the supporting operations have yet to be planned. The colored triangles next to the circles indicate the current status and trend of the plan element. An upward pointing triangle indicates an improvement trend, a downward a worsening trend and to the side indicates no change. The color within the triangle indicates the current assessment of that effect, with gradients of red, yellow and green indicating various degrees of positive or negative effect. This same methodology is repeated for

the other levels of command. Note the triangles in the center matrix also indicate which Prioritized Effects List (PEL) effects they are supporting.

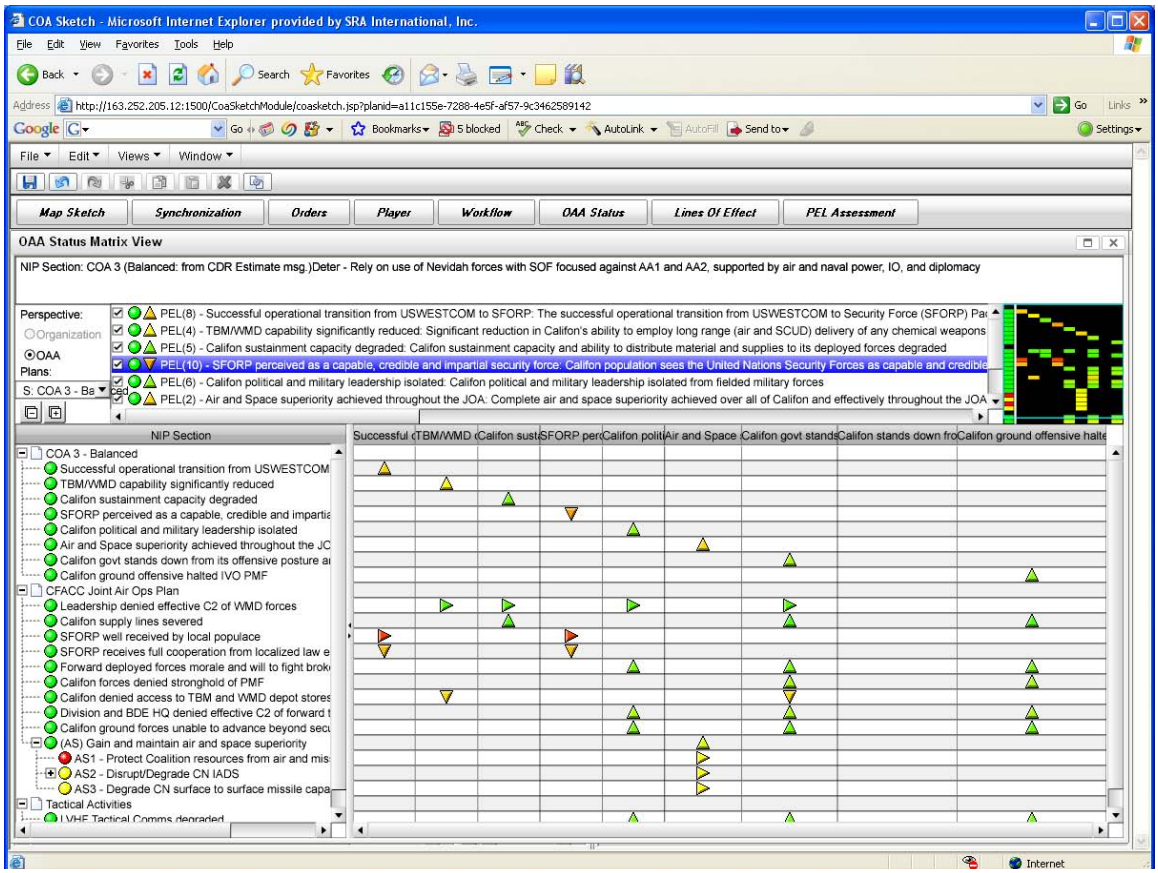


Figure 1 GEM-S Operations, Activities and Actions (OAA) View

The LOE view (see Figure 2) allows the planners to establish supporting relationships that show how each lower level effect, objective or task contributes to the desired effects at the higher level. The LOE view enables one to display these often complex contributions and dependencies. The same four levels of command within the Synchronization View are represented here. Once these relationships have been established joint planners may apply weighting factors to determine the contribution of each supporting effect. This weighting will play a significant role during the ops assessment process by dictating how much each individual lower level assessment is able to influence the success or failure of higher-level effects.

Upon selecting the "Lines of Effect" check box, these relationships are displayed, linking each lower level effect or objective to the high level effect to which it contributes. Note also that the varied line thickness between the elements represents the weighting established earlier in the planning process. A user who wishes to view a single line of effect can simply go to the fly-over view at the top left and mouse over each plan level to select the specific effect of interest. Once the desired element is selected, only the plan elements to which that effect depends or contributes are displayed. This function may be performed at any plan level of the campaign hierarchy. Real

time information updates are capable through the Information Ticker (scrolling text) at the bottom, center of the view.

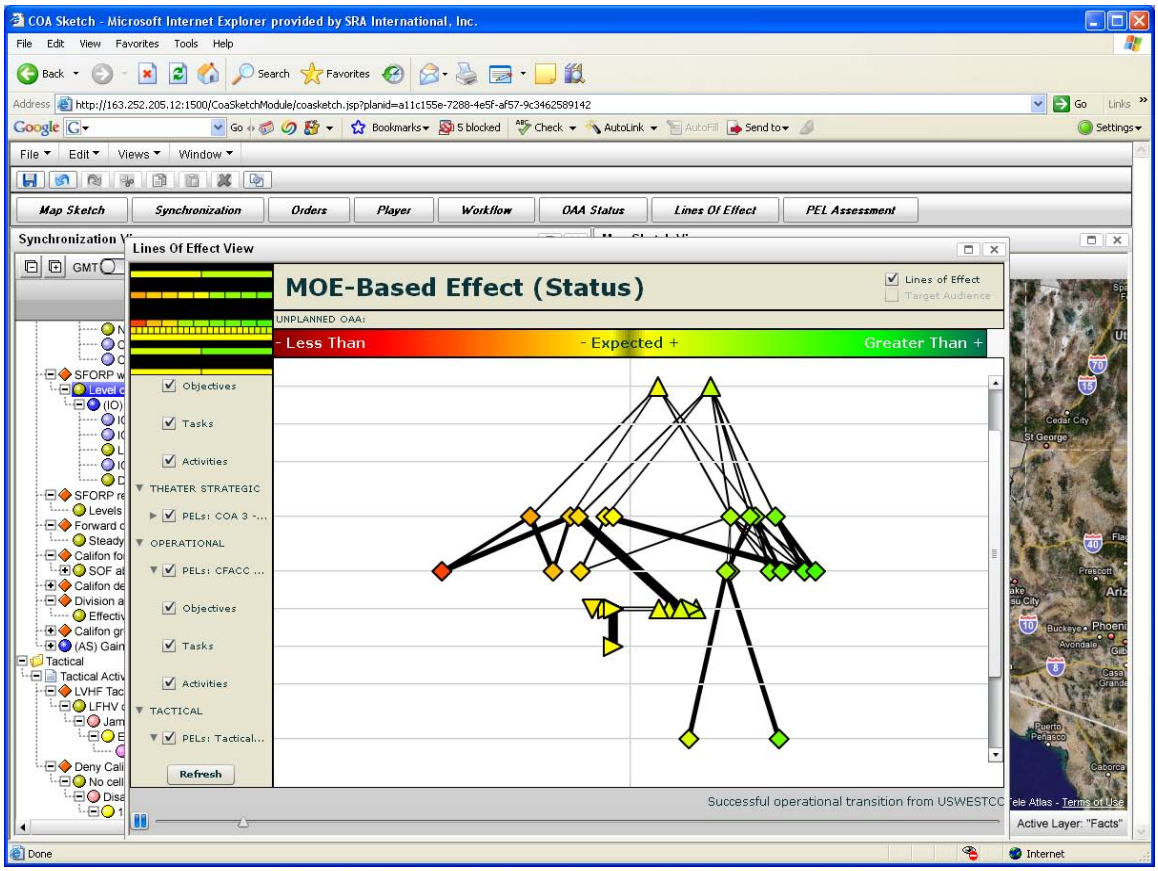


Figure 2 GEM-S Lines of Effect (LOE) View

The view which completes GEM-S is the PEL Assessment (see Figure 3). This view is intended to show a top level status of the entire campaign by displaying the current assessed status of every desired effect in the campaign… at each level of command. The PEL Assessment approach provides a means for commanders to obtain immediate high-level awareness of the success level for each desired effect. At each selected campaign level, diamond shapes represent each effect present. Each effect consists of two values: Effect Magnitude and Effect Direction. The PEL Assessment view captures both values on orthogonal axes.

The vertical axis represents the magnitude score while the horizontal axis represents the direction score. Note the exponential values at the top for the "viral" magnitude score previously discussed. Each of the effects is plotted on this view using the scores found on the status tab of each effect measure. Commanders and other decision makers are quickly able to see which effects are on track and which require further attention.

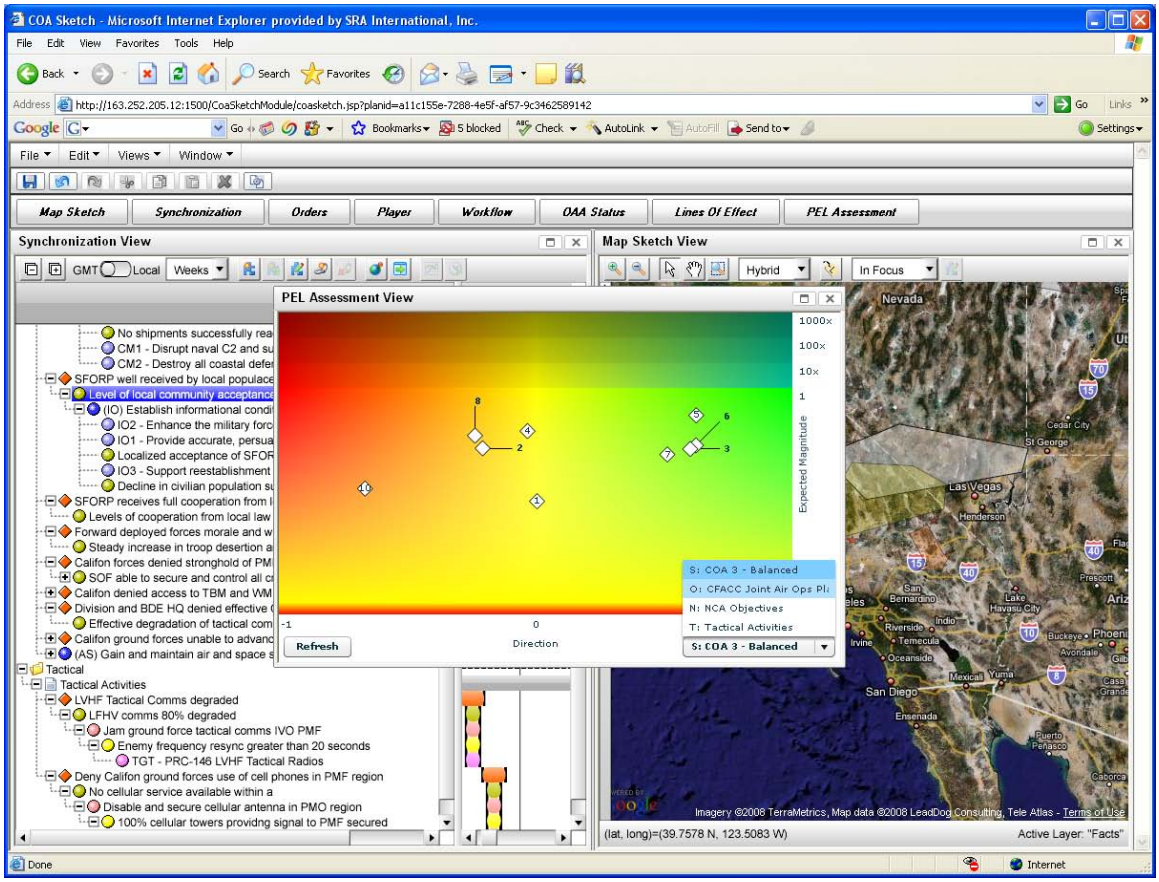


Figure 3 GEM-S PEL Assessment view

Appendix II-A contains detailed theoretical and operational descriptions of the IO Assessment view (developed by SAIC under subcontract to SRA).

3.2 JAOP AOD STATUS TOOL (JAST)

JAST was the product of a need to complete a key feedback path from Combat Operations Division to the Strategy Division. The Planning and Execution Status Bar, as described in the IWPC CPT Software User's Manual (SUM) supports the planning process by providing useful combat planning and execution status data correlated to a published Joint Air Operations Plans (JAOP) and the daily Air Operations Directives (AOD). The SD produces the AOD which is used to develop the daily ATO. Often, information regarding whether a mission on the current ATO is 1) scheduled, and 2) executed, is unknown through SD's next iteration of the AOD. The missing information requires the SD to re-plan a mission or missions whose execution status is unknown in order to ensure the tactical goal (effect) is achieved. The opportunity to complete this feedback path was realized with the inception of TBONE.

The design of IWPC version 4.2b called for TBONE to be (1) a receiver of the JAOP and AODs developed using IWPC and (2) a source of plan status data to include publishing the plan and tracking status for plan elements as they move through targeting, allocation, execution and assessment. JAST was the interface to bring the TBONE combat operations data back into the strategy planning world of IWPC. The IWPC CPT requirements in Table 1 aligned with the JAST requirements analysis.

Table 1. JAST Planning and Execution Status Requirements

Requirement ID	Description
CPT-PE-0001	The application shall provide the user the capability to track the status of Air Tasking Orders (ATO) planned and executed for each Air Operations Directive (AOD) or Joint Air Operations Plan (JAOP).
CPT-PE-0002	The application shall provide the user with the capability to load planning and execution status associated with an AOD.
CPT-PE-0003	The application shall provide the user with the capability to request updates to planning and execution assessment data
CPT-PE-0004	The application shall provide the user with the capability to view planning and execution status data for each effect
CPT-PE-0005	The application shall automatically provide the user with the ability of keeping track of what planning and execution status data has been viewed and unviewed for each effect
CPT-PE-0006	The application shall provide the user with the capability of copying planning and execution status data
CPT-PE-0007	The application shall provide the user with the capability to clear out the tracked unviewed planning and execution status for each and all effects.

The IWPC Execution Status and Assessment data interfaces leverage the TBONE Services and data model. The services and supporting Java 2 Platform Enterprise Edition (J2EE) components for this component of the IWPC interface to TBONE is provided through JAST.

JAST provides the following capabilities back to IWPC:

- JAOP/AOD Element Timing
- JAOP/AOD Associated Target Status
- JAOP/AOD Decision Point Status
- JAOP/AOD Mission Status

These capabilities are shown in Figure 1, where each tabbed section contained detailed information on Timing, Targets, Decision Points and Missions. The data handled by JAST provided interesting user interaction design, in that JAST was intended to provide "updated" information. A user interface, itself, is unaware whether a user has processed new information. Therefore, users were required to acknowledge (interact with JAST) when new information was presented. One example is shown at the bottom of Figure 1, where light blue backgrounds on icons represents an information update is available.

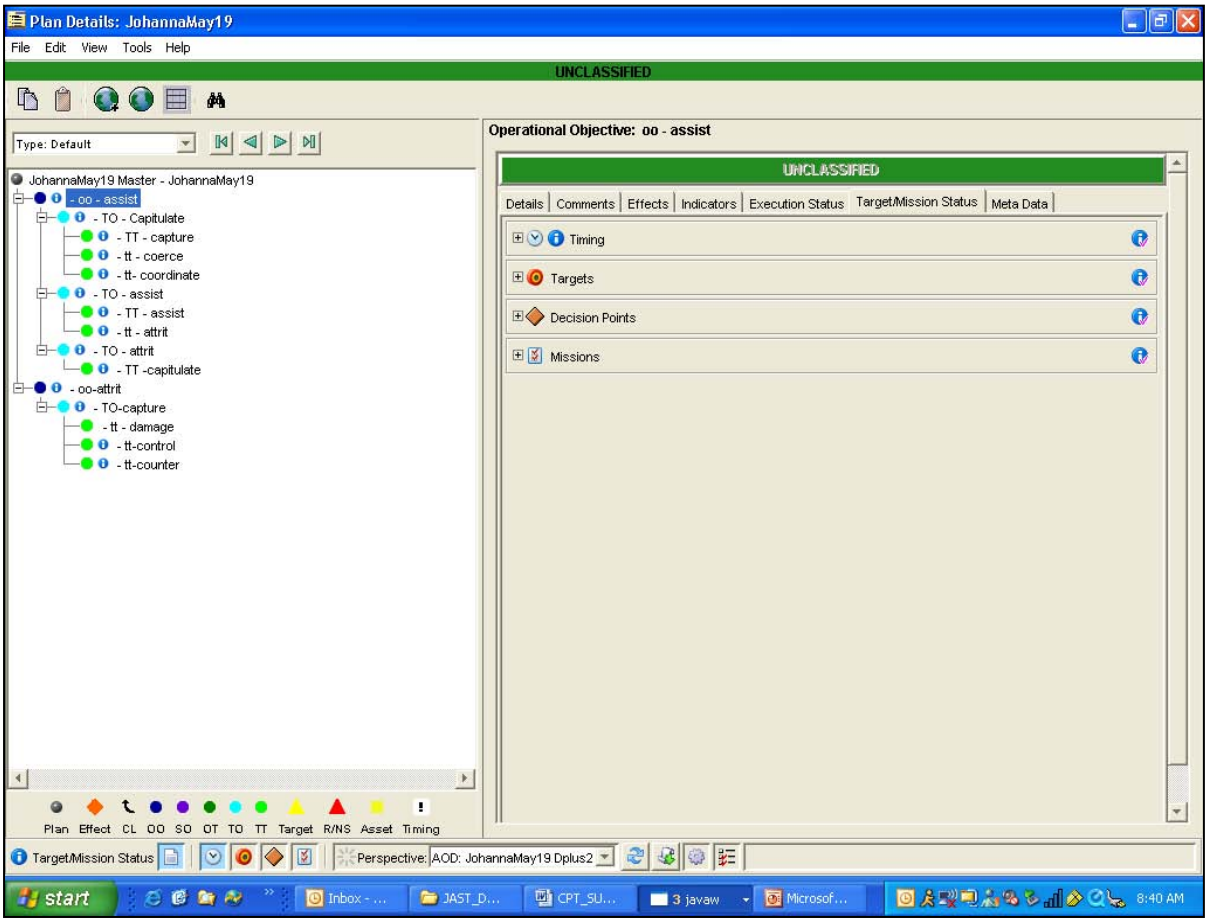


Figure 4 JAST implementation in the IWPC CPT Module

JAST is designed as a Service Oriented Architecture (SOA). JAST complies with the J2EE 1.4 specification and thus is scalable and secure. Termination of the TBONE program, however, just prior to IWPC deployment meant JAST had to be disabled within IWPC 4.2, i.e. no data feed existed to populate JAST. To support JAST integration with IWPC, the following items were delivered initially in October of 2005 with software updates (based on changes to the IWPC Software Developer Toolkit, SDK) as required through December 2006.

- JAST IWPC Client Software
- JAST Software and Subsequent Updates

- Esync/Collaborative Planning Tool (CPT) Software Users Manual (JAST enhanced)
- JAST Code Interface Control Document (ICD) Update

JAST enhancements were included in the CPT SUM (Sections 5.3.8 – 5.3.10.8) and eSync SUM (Sections 5.3.3.8 – 5.3.3.10.10) and are published in separate reports. Each SUM was modified to account for inclusion of JAST-related information within IWPC (Note: these SUMs were provided to the IWPC prime contractor as examples of where JAST reference material best fit, however, additional technical editing was conducted by the prime and thus these documents do not represent the SUMs delivered with IWPC v 4.2e). The SUMs provide an excellent detailed, functional overview of JAST capabilities within the respective IWPC capability module.

3.3 TENEO

The ESC ISRSG/KIS and JIOC teams wanted to explore migrating code from an in-house project to support the maturing Information Operations (IO) Planning Capabilities programs, IWPC and Information Operations Navigator (ION). These programs were being installed at various COCOM locations and specific areas of common capability between current Air Force and future COCOM needs were identified. The common capabilities included Intelligence Preparation of the Battlespace (IPB); IO Strategy and Candidate IO Campaign Targets (Strategy/Targets); IO Mission Planning (IO Missions); and Mission Execution Monitoring and Assessment (Assessment).

The purpose of the code migration was to leverage work already performed in the area of visualizations of Air Operations in support of Strategic Planning to further the IO Planning Capabilities program. The candidate software provided the following functionality in support of Strategy Planning needs:

- Data import and filtering (e.g. ATO, intelligence data, etc)
- Data display on user-selected map backgrounds
- User-selected layering of the capability displays (i.e. ability to de-clutter)
- Visualization of notional operational effects of employing capabilities against specific targets, shown in a time-ordered sequence with playback (e.g. nodes affected and when)
- Visualization of temporal and spatial integration of capabilities into Operation Plan (OPLAN) “What if” analysis by changing some data variables and producing different display results
- On-line help files, some with capability specifications or OPLAN references

The following features were incorporated into the Teneo prototype: 1) launch Teneo from the IWPC main menu, 2) allow the user to view targets from IWPC through a special layer inside Teneo, 3) pass messages from IWPC via a rudimentary publish-subscribe (“pub-sub”) framework using web services, 4) retrieve target data via a web service interface from IWPC and MIDB based on a user-defined geographic area of interest, 5) retrieve ATOs via a web service interface developed from a .NET adapter for TBONE, and 6) repaired the existing United States Message Traffic Format (USMTF) parser to expect any number. Finally, the IWPC architecture

(Teneo enhanced) was evaluated to understand the effectiveness of an integration effort. Modifications to the existing architecture were proposed to improve, for example, web services.

The purpose was to evaluate the client software and the architecture as a whole. The technical (Analysis) Report and Software Product Specification were delivered in June of 2007 and are available separately in Appendix II-B and II-C, respectively.

3.4 INFORMATION OPERATIONS PLANNING CAPABILITY - EXPERIMENT

IOPC-X was a risk reduction capability to develop a modern SOA-based architecture for IWPC and to refine future technical and operational requirements. Primary operational and technical direction was provided by the Joint Forces Command (JFCOM) Engineering Staff Section (J7) VisIOn Technical Integrative Product Team. The IOPC-X environment enabled demonstrating COA Sketch as a plug-in capability to the SOA-based IWPC. The resulting IOPC-X prototype provided the following:

- A software Net-Centric infrastructure prototype enabling integration of new capability modules (CM)
- A pluggable infrastructure of core IWPC tools and IO analysis capabilities
- Alignment with the Net-Enabled Command Capability (NECC) and Net-Centric Core Enterprise Services (NCES) standards and capabilities

A use case diagram is provided in Figure 4. A detailed description of this task is provided in Appendix II-D.

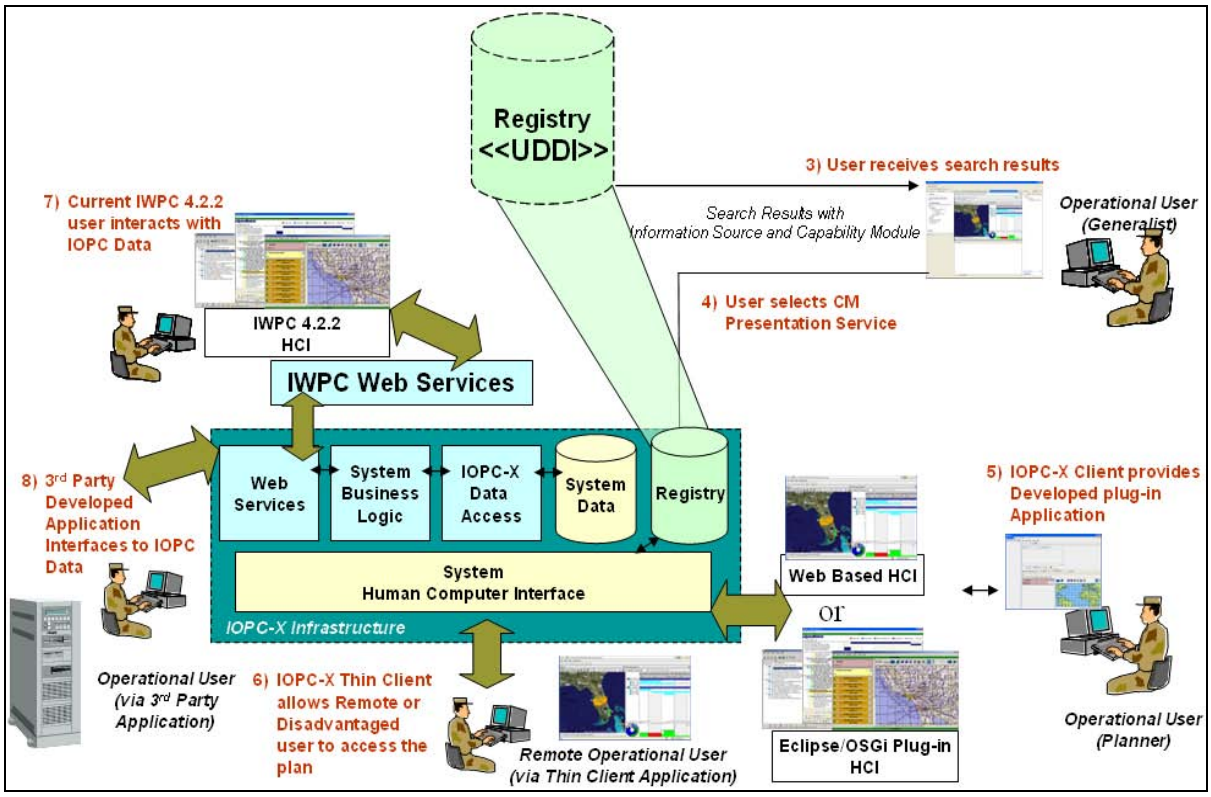


Figure 5 IOPC-X Operational Use Case

The IOPC-X SDK is published as a separate report and contains an overview of the IOPC-X Architecture and summarizes the Net-Centric Standards that were used. The standards for IOPC-X are registered with DoD Information Technology Standards Registry (DISR) and follow the guidance provided in the Net-Centric Operational Warfare Reference Model (NCOW-RM). Reasoning and correlation of the standards followed are detailed in the appropriate sections of the SDK.

The SDK includes a discussion of the Plug-in Infrastructure based on the Eclipse Rich Client Platform (RCP) and Registration of the plug-ins for discovery of the CMs. The SDK moves from the client side to discussion of the J2EE Enterprise JavaBeans™ (EJB™) 3.0 compliant data access tier and its use of the JENA library set and Oracle database for Ontological persistence of information. With understanding of the data access tier, the SDK returns to discussion of the middle tier to cover the IOPC-X Web Services which act as a Façade onto the J2EE™ session bean discussed in the data access tier section.

Security considerations are discussed in their appropriate sections. Throughout the SDK, Sequence diagrams are provided to visually reflect uses of the IOPC-X interfaces being discussed. IOPC-X specific, as well as open source code, examples and tutorials have been provided or referenced to ensure complete understanding of how to properly build IOPC-X

compliant components. The supporting Unified Modeling Language (UML) design diagrams and Javadocs™ have been provided as sections to the SDK.

3.4.1 IOPC-X ARCHITECTURE OVERVIEW

Figure 5 illustrates the IOPC-X architecture components. The IOPC-X architecture is a fully Net-Centric compliant design which leverages a J2EE™ EJB™ 3.0 compliant infrastructure for ease in Authentication, Authorization and Scalability. The J2EE™ session beans are also exposed via Web Service interfaces. The ontology-based backend leverages the JENA library set in order to address the requirements of the Net-Centric Data Strategy.

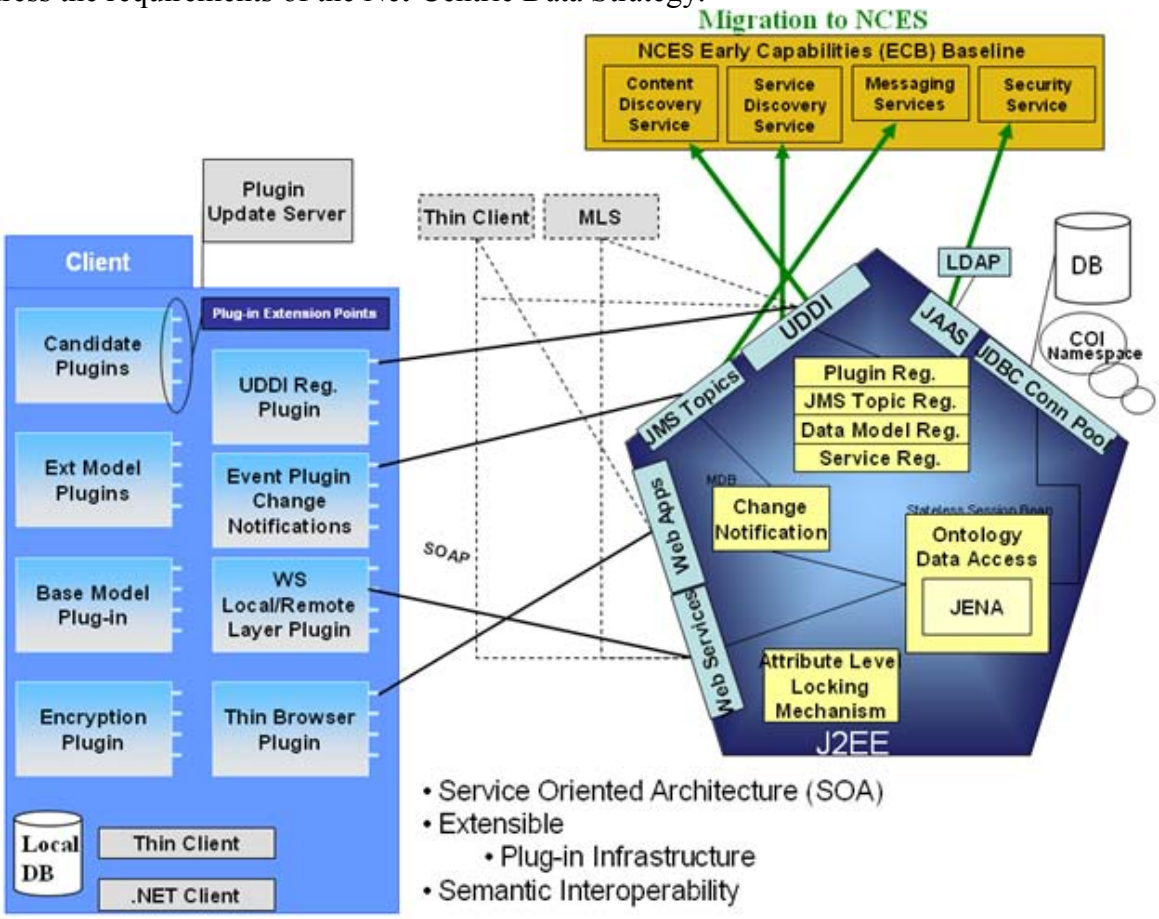


Figure 6 IOPC-X Architecture Components (Migration to NCES)

The client architecture supports an evolutionary development path and re-use of existing Java™ and .Net developed "Fat Clients." The IOPC-X design includes an Open Services Gateway Initiative (OSGi) compliant plug-in infrastructure based upon the Eclipse RCP.

IOPC-X client components included the following:

- IOPC-X RCP Workbench which acts as a ‘baseline’ IOPC-X installation. All client plug-ins will use the workbench as their target platform. The workbench initializes the main client window, menus, and toolbars, providing a predictable environment for the plug-ins.
- The Data Access plug-in provides a locally replicated copy of the ontology in an effort to reduce memory consumption and network traffic. The plug-in has the same interface as the web service, but references its own ontology and prevents all plug-ins from having to maintain a separate instance of the ontology and keep track of updates. However, use of this plug-in is not mandatory and a client plug-in could reference the web service interface directly.
- The Login & Security plug-in provides authentication routines and login handling in the workbench. This plug-in provides the login information to any other plug-ins that need to access it (such as the Data Access plug-in).
- The Dynamic update plug-in provides client updates transparently. No additional software needs to be written to allow dynamic update – this capability is provided by the workbench and the OSGi framework.

4.0 RESULTS AND DISCUSSION

4.1 GLOBAL EFFECTS MANAGEMENT SYNCHRONIZATION

GEM-S resulted in several innovative visualization concepts for effects management on a global scale. Some concepts were based on earlier CEP designs and some concepts evolved from interaction with the JIOWC user community. The GEM-S prototype was developed with a fully interactive user interface, although with no data storage or handling capabilities.

The prototype capabilities were well received and, conceptually, the GEM-S prototype provided an informative view onto operations at a large scale. Of primary operational concern, however, were the data sources required to feed GEM-S. A single data source clearly was not possible across multiple agencies, organizations and programs, and, while a suite of data sources was a more likely scenario, the challenge remained to access numerous stove-piped systems, inconsistent formats and manual records. Ultimately, the data required to support and maintain GEM-S was considered an unattainable task and further development stopped as a standalone capability.

4.2 JAOP AOD STATUS TOOL (JAST)

JAST was the product of a need to complete a significant information feedback path from CO to the SD by providing useful combat planning and execution status data correlated to a published Joint Air Operations Plans (JAOP) and the daily Air Operations Directives (AOD). Termination of the TBONE program, however, just prior to IWPC deployment meant JAST had to be disabled in the IWPC v4.2 (i.e. the required data feed to populate JAST did not exist). JAST was fully integrated with IWPC software and deployed to warfighters, however, the capability was simply never “turned on” and thus users were never made aware that the capability exists should appropriate data feeds become available in the future.

4.3 TENEO

Teneo was a prototype and was not intended for production use. While the concepts that Teneo presented were excellent, the implementation had some problems. Teneo was meant to be a prototype and not intended for release or integration. The software was developed very quickly for a specific audience and, as such, made many assumptions. These assumptions precluded any error handling or concern for the needs of a generic user. Errors were generally handled by application failure and subsequently, exiting the program. As a prototype, code comments were neither present nor expected and the provided documentation reflected the concepts of Electronic Warfare (EW), rather than providing insight into the software development. The evaluation resulted in the recommendation to completely redesign and rewrite Teneo.

4.4 INFORMATION OPERATIONS PLANNING CAPABILITY - EXPERIMENT

IOPC-X was a risk reduction capability to develop a modern SOA-based architecture for IWPC to refine future technical and operational requirements. COA Sketch and SMART were integrated as capabilities within the IOPC-X framework. The IOPC-X prototype was used in the Pirate's Daggers Exercise 2008 to demonstrate the SOA architecture and the plug-in infrastructure.

Determining the best way ahead for COA Sketch/IOPC-X capability framework requires more research. An end-to-end review of COA Sketch/IOPC-X is highly recommended prior to full-scale design for the potential next generation platform, COA Sketch/aXiom. At a minimum the data model, and particularly the date and constraint model, should be reviewed with the goal of expressing queries and pattern matches concisely. This effort should produce a flatter, more redundant, class model with fewer classes and less nesting of objects.

The COA Sketch/IOPC-X Web Service Description Language (WSDL) interface will need to be reviewed along with the data model. The current design is a general purpose Create, Update, Delete model. System-level study is needed to determine if more business-level tasks can be defined at the web service layer. In addition, the serialization constraints inherent in the current data model need to be removed. Many object classes cannot currently be serialized as stand-alone objects – they require additional document portions. This approach must be redesigned so that the data model objects can be used in a more encapsulated fashion.

Finally, the lack of support for ontological data formats (SPARQL and SPARQL result-set XML) in the client application is a shortfall. The data interchange between some plug-ins such as COA Sketch and server is problematic. Pushing the responsibility for query execution and processing to the client tier goes against the theory of N-tiered architectural design and violates the assumption of a course-grained, optimistic system. Expectations for the capabilities of an ontological data access client must be recalibrated and agreed upon. One might consider the COA Sketch service the true ontological client and the COA Sketch thin client merely a display layer. In any case, SPARQL result sets are not ideal for passing data in a client / server system. Other ontological technologies such as RDF/XML may be more suitable, but replacing a well-known and understood technology like WSDL with RDF/XML requires more research.

5.0 SUMMARY

SPVT was a multi-year effort focused on improving warfighter effectiveness in the AOC Strategy Planning context through work-centered understanding of warfighter information and decision requirements. The primary dimensions addressed included: how decisions are made in the Strategy Division in performing work; how work products are developed; how work is managed; and the types of collaborations and interactions that are necessary.

SPVT tasking followed a human-centered, systems engineering process, beginning with defining operational user information and decision making requirements through a combination of modeling work-relevant documentation and interviewing warfighters (on site with warfighter in role and off site with warfighter role playing). Findings from the ***User Requirements Analysis*** drove the next set of activities. (Note the team continued to build on the user information requirements as new documentation and warfighter interviews became available.) Initial concepts focused on developing an effects-based dashboard, ***Common Effects Picture (CEP)***, suitable for the Commander to obtain a quick and accurate assessment of the battlespace. A key characteristic of CEP was transparency from the highest level of information aggregation into the supporting data, methods and analyses.

A logical extension of CEP was to a joint service effects management system, ***Global Effects Management – Synchronization (GEM-S)***, an envisioned single collection point for organizing and deconflicting multi-service global operations. GEM-S provided a venue to explore interface and visualization concepts for the many interactions among agencies, activities and effects.

Following the goal to support the Strategy Division, the next SPVT task focused on enhancing the AOC planning system of record, IWPC, by bringing near real-time ATO execution information from Combat Operations directly to the Strategy Division rather than waiting on slow and sometimes incomplete reports from the Operations Assessment Team. The ***JAOP AOD Status Tool (JAST)*** was integrated with IWPC 4.2.5 eSync/CPT capability modules and instantiated through a series of basic visualizations.

Building on supporting the Strategy Planner, ***Course of Action Sketch (COA Sketch)*** took a previously text-based, manual, single person bottlenecked process and transformed it to a graphical, human-supported automation, collaborative technology. COA Sketch provides a human-focused electronic work environment for the warfighter to flexibly and adaptively collaborate in JAOP development. Strategy planners have the capability to capture the plan as it is developed. And while simple in concept, COA Sketch brought together capabilities warfighters most desired during strategy planning such as Shared awareness; Graphics that are data aware; Collaborative development; and Support for development toward a team mental model. COA Sketch transition to two separate programs provided the validation that decision-centered visualization support to the AOC Strategy Planner was accomplished.

While COA Sketch was an evolving technology, ***TENEO*** was brought to the SPVT program for evaluation as a capability enhancement to IWPC. TENEO included several planning capabilities similar in concept to COA Sketch but much less robust from a software development perspective. The impetus for the project was to determine whether TENEO capabilities were mature enough to integrate with IWPC. The short answer was "no" and the customer, after learning of COA Sketch, proposed the following opportunity.

As COA Sketch continued to mature, more emphasis was placed on developing the underlying data model and architecture. ***Information Operations Planning Capability – Experiment (IOPC-X)*** was a risk reduction effort to develop a net-centric data strategy and architecture. IOPC-X evolved to the JFCOM sponsored VisIOn program and simultaneously was soliciting capabilities to plug into the future architecture. COA Sketch met the desired operational strategy planning requirements and was transitioned.

Maturation of COA Sketch and IOPC-X required access to operationally-relevant, planning mission data sources such as MIDB, JTT and FrOB. The ***External Interfaces*** task explored connection to these databases.

Collaboration in the AOC Context focused on supporting the Strategy Division through improved human-machine and human-human information exchanges. Specifically, the tested capability, LiveSpaces, supports ***Intense Collaboration*** (the type often found in Command and Control environments). The final event for SPVT included application of LiveSpaces during the TTCP C3I TP2 Workshop, in which representatives from three countries engaged in collaboration activities.

The ***Human Effectiveness in the Air & Space Operations Center*** program addressed warfighter work challenges through decision-centered visualization support to the AOC Strategy Division. The program started with developing a thorough understanding of the warfighter information and decision support requirements, individual, machine and team interactions. A strong initial cognitive work analysis set the foundation for subsequent program activities, a series of decision support visualization concepts with increasing capability and fidelity. The effort sponsored by the AFRL 711 Human Performance Wing/Human Effectiveness Directorate yielded an extensive body of knowledge for the AOC SD, numerous concepts available to other USAF and Joint programs, and resulted in three transitioned products, one to the ESC IWPC program, the USSTRATCOM ISPAN program, and one to the JFCOM VisIOn program.

6.0 BIBLIOGRAPHY

Chairman of the Joint Chiefs of Staff (2006). *National Military Strategic Plan for the War on Terrorism.* Retrieved from http://www.defenselink.mil/qdr/docs/2005-01-25-Strategic-Plan.pdf

Cognitive Systems Engineering Center (2004). Strategy Division Working Group Conference Knowledge Elicitation Report.

Cognitive Systems Engineering Center (2004). Spiral 1: Aerospace Command & Control Cognitive Analysis Report.

Cognitive Systems Engineering Center (2004). Spiral 2 Aerospace Command & Control Cognitive Analysis Report.

Cognitive Systems Engineering Center (2004). Next Generation Intelligence Preparation of the Battlespace – Work Domain Analysis Report

Commanders Handbook for Strategic Communications, (2008), JFCOM Joint Warfighting Center.

Croker, S. (2004). Effects Based Assessment. May 2004 PowerPoint presentation.
Croker, S. (2004). Sample AOD – Air Operations Directive for ATO E (begins on D+4). Personal communication 26 June 2004.

Department of Defense (2003). Joint Tactics, Techniques, and Procedures for Intelligence Support to Targeting (Joint Publication 2-01.1).

Department of Defense (2003). Joint Task Force Headquarters Master Training Guide (CJCSM 3500.O5A).

Department of Defense (2003). Joint Task Force Component Commander Master Training Guide (CJCSM 3500.XX).

Department of Defense (2002). Command and Control for Joint Air Operations (Joint Publication 3-30).

Department of Defense (2002). Joint Doctrine for Targeting (Joint Publication 3-60).

Department of Defense (2002). Joint Doctrine for Campaign Planning (Joint Publication 5-00.1).

Department of Defense (2001). Unified Action Armed Forces (UNAAF) (Joint Publication 0-2).

Department of Defense (2001). Doctrine for Joint Operations (Joint Publication 3-0).

Department of Defense (2000). Joint Operations Planning and Execution Systems (JOPES) Volume I: Planning Policies and Procedures (CJCSM 3122.01).

Department of Defense (1999). Joint Doctrine for Countering Air and Missile Threats (Joint Publication 3-01).

Department of Defense (1997). Joint Doctrine Encyclopedia

Department of Defense (1995). Doctrine for Planning Joint Operations (Joint Publication 5-0).

Deputy Chief of Staff, United States Air Force (1994). *JFACC Primer*. United States Air Force Plans and Operations Headquarters: Washington, DC. Retrieved from http://www.fas.org/man/dod-101/usaf/unit/docs/JFACC-94-Complete.pdf

Drew, D.M., & Snow, D. M. (2006). *Making Twenty-First-Century Strategy: An Introduction to Modern National Security Processes and Problems*. Air University Press: Maxwell Air Force Base, Alabama.

Echevarria, A.J. (2002). Clausewitz's Center of Gravity: Changing Our Warfighting Doctrine-Again! Strategic Studies Institute: Carlisle, PA.

Eggleston, R.G. (2003). Work-centered design: A cognitive engineering approach to system design. Proceedings of the Human Factors and Ergonomics Society 47th Annual Meeting.

Elm, W.C., Potter, S.S., Gualtieri, J.W., Roth, E. M., & Easter, J.R. (2003). Applied cognitive work analysis: A pragmatic methodology for designing revolutionary cognitive affordances. In E. Hollnagel (Ed) Handbook for Cognitive Task Design. London: Lawrence Erlbaum Associates

Fayette, D. & McCrabb, M.B. (2003). AFRL/IF Support to AOC Block 30. PowerPoint presentation provide by Don Monk.

Gibson, J. J. (1979). The Ecological Approach to Visual Perception. Boston: Houghton Mifflin.

Gilmour, D.A., McCrabb, M.B., Wagenhals, L. W. & Wentz, L.K. (2003). Developing an Operational Architecture View of an Effects Based Joint Air Estimate Process. Presented at an EBO Workshop at George Mason University, March 2003.

Gualtieri, J. W., Roth, E. M., & Eggleston, R. G. (2000). Utilizing the abstraction hierarchy for role allocation and team structure design. Proceedings of HICS 2000 - 5th International Conference on Human Interaction with Complex Systems (pp. 219-223). Urbana-Champaign, IL: Beckman Institute.

Hunerwadel, J.P. (2002). Planning to Win: A Study in Strategy and Operational Art. Air & Space Power Chronicles.

Joint Chiefs of Staff (1995). *User's Guide for JOPES (Joint Operation Planning and Execution System)*. Retrieved from http://www.dtic.mil/doctrine/jel/other_pubs/jopes.pdf

Joint Chiefs of Staff (2000). *Joint Vision 2020*. Washington, DC: US Government Printing Office. Retrieved from http://www.iwar.org.uk/military/resources/aspc/pubs/jv2020.pdf

Joint Chiefs of Staff (2004). Joint Publication 1-02: Department of Defense Dictionary of Military and Associated Terms. Retrieved from: http://www.asafm.army.mil/pubs/jp1-02/jp1-02.pdf

Joint Chiefs of Staff (2004). *The National Military Strategy of the United States of America: A Strategy for Today; A Vision for Tomorrow.* Retrieved from http://www.defenselink.mil/news/Mar2005/d20050318nms.pdf

Joint Chiefs of Staff (2006). *Joint Publication 3-0: Joint Operations*. Retrieved from http://www.dtic.mil/doctrine/jel/new_pubs/jp3_0.pdf

Joint Chiefs of Staff (2006). *Joint Publication 5-0: Joint Operation Planning*. Retrieved from http://www.dtic.mil/doctrine/jel/new_pubs/jp5_0.pdf

Joint Chiefs of Staff (2008). *Chairman of the Joint Chiefs of Staff Instruction 3100.01B: Joint Strategic Planning System*. Retrieved from http://www.dtic.mil/cjcs_directives/cdata/unlimit/3100_01.pdf

Joint Chiefs of Staff (2008). *Chairman of the Joint Chiefs of Staff Manual 3500.04E*. Retrieved from http://www.dtic.mil/doctrine/training/cjcsm3500_04e.pdf

Joint Warfighting Center (2006). *Commander's Handbook for an Effects-Based Approach to Joint Operations*. Standing Joint Force Headquarters:Norfolk, Va. Retrieved from http://www.au.af.mil/au/awc/awcgate/jfcom/ebo_handbook_2006.pdf

Joint Warfighting Center. (2004). *JWFC Pamphlet 4: Doctrinal Implications of Operational Net Assessment*. Joint Doctrine Series. Suffolk, VA: JFCOM.

Krawchuck, F.T. (2008). Collaborative strategic planning and action: A new approach. *Parameters*. Summer 2008, pp. 67-78.

Maxwell AFB, AL: College of Aerospace Doctrine, Research and Education.

Maybury, M. (2002). Defense Collaborative Tool Suite Description. MITRE Corporation.

McCrabb, M. (2002). Concept of Operations for Effects-Based Operations 2002.

Olschner, C. (2004). Development of Objectives Tasks and Measures of Effectiveness. (STR - 813). 505th Training Squadron: Hurlburt AFB, FL

Olschner, C. (2004). Planning and Assessing Joint Air Operations. (STR - 802). 505th Training Squadron: Hurlburt AFB, FL.

Olschner, C. (2004). Situation and COA Development. (STR - 807). 505th Training Squadron: Hurlburt AFB, FL.

Phillips, M. (2008). Livespaces Technical Overview. AR- 014-287: Command, Control, Communications and Intelligence Division, DSTO Defence Science and Technology Organisation, Australia.

President of the United States (2006). *National Security Strategy of the United States of America*. Retrieved from http://georgewbush-whitehouse.archives.gov/nsc/nss/2006/nss2006.pdf

Pronobis, M., Fayette, D., Starczewski, E., Hubbard, R., & Schuh, D. (2004). AFRL/ESC JEFX04 Initiative: Initial PBA/EBO Integration. PowerPoint presentation provided by Don Monk.

Rasmussen, J. (1986). Information processing and human-machine interaction: An approach to cognitive engineering. North Holland Series in System Science and Engineering, Elsevier Science Publishing Co., Inc., New York, New York.

Rasmussen J., Pejtersen, A. M., & Goodstein, L. P. (1994). Cognitive Systems Engineering. New York: Wiley & Sons.

Roberts, M. (2003). Assessment 101. College of Aerospace Doctrine, Research and Education.

Roth, E. M. & Mumaw, R. J. (1995). Using Cognitive Task Analysis to Define Human Interface Requirements for First-of-a-Kind Systems. Proceedings of the Human Factors and Ergonomics Society 39th Annual Meeting, (pp. 520 – 524). Santa Monica, CA: Human Factors and Ergonomics Society.

Smith, S.D. (2002). Sharpening the Theater Engagement Plan (TEP) focus: The impact of higher order beliefs and values. [Paper.] Newport, RI: Naval War College.

Snodgrass, M. (2003). C4ISR Summit 2003: Transforming C4ISR Into Decision Superiority for Effects Based Operations. PowerPoint presentation provided by Don Monk.

Strange, J. (2004). Center of Gravity Analysis. Presentation at Checkmate Strategy Conference.

Strategic Studies Institute (1995). *World View: The 1995 Strategic Assessment from the Strategic Studies Institute*. Edited by Earl H. Tilford. Retrieved from http://www.strategicstudiesinstitute.army.mil/pubs/display.cfm?pubid=334

Thompson, R. (2004). Planning Construct for Effects-Based Air Operations. Presentation at Checkmate Strategy Conference.

United States Air Force (2000). Air Warfare: Air Force Doctrine Document 2-1. (http://www.epublishing.af.mil/pubfiles/af/dd/afdd2-1/afdd2-1.pdf)

United States Air Force (2002). Operational Procedures – Aerospace Operations Center: Air Force Instruction 13-1AOC. (http://www.e-publishing.af.mil/pubfiles/af/13/afi13-1aocv3/afi13-1aocv3.pdf)

United States Air Force (2002). Air Force Operational Tactics, Techniques and Procedures for an Air and Space Operations Center (AFOTTP 2-3.2).

United States Air Force (2002). Air Force Operational Tactics, Techniques and Procedures for Command and Control Nodes (AFOTTP 2-3.1).

United States Air Force (2002). Air Force Operational Tactics, Techniques and Procedures for an Air and Space Strategy (AFOTTP 2-1.1).

United States Department of Defense (2006). *Quadrennial Defense Review Report*. Retrieved from http://www.defenselink.mil/qdr/report/Report20060203.pdf

United States Intelligence Community (1947). *National Security Act of 1947*. Retrieved from http://www.intelligence.gov/0-natsecact_1947.shtml

United States Marine Corp (1997). Campaigning (MCDP 1-2).

United States Marine Corp (1997). Introduction to the Study of Strategy (MCDP 1-1).

United States Marine Corp (1997). Planning (MCDP 5).

United States of America Department of Defense (2008). *National Defense Strategy of The United States of America*. Retrieved from http://www.defenselink.mil/pubs/2008NationalDefenseStrategy.pdf

USNORTHCOM (2009). About USNORTHCOM. Retrieved from http://www.northcom.mil/About/index.html

Vicente, K. (1999). Cognitive Work Analysis. Mahwah, NJ: Lawrence Erlbaum Associates.

Vicente, K. and Rasmussen, J. (1992). Ecological interface design: Theoretical Foundations. IEEE Transactions on Systems Man and Cybernetics, 22, 589-606.

Warfare Studies Institute (2003). Joint Air Estimate Planning Handbook. College of Aerospace Doctrine, Research and Education: Maxwell AFB, AL.

White, R.C. (2002). AOC Block 10 and 10 +System Baselines. Prepared for AC2ISRC/CC, Langley AFB, VA.

White, R.G. (2001). Concept of Operations for Aerospace Operations Center (AOC). Prepared for AC2ISRC/CC, Langley AFB, VA.

White, R.G. (2002). AOC Block 10 and 10 +System Baselines. PowerPoint presentation provided by Don Monk.

Woods, D. D. and Hollnagel, E. (1987). Mapping cognitive demands in complex problem-solving worlds. International Journal of Man-Machine Studies, 26, pp. 257-275.

Woods, D. D. & Roth, E. M. (1988). Cognitive engineering: Human problem solving with tools. Human Factors, 30 (4), pp. 415-430.

Warfare Studies Institute (2005). *Joint Air Estimate Planning Handbook*.

7.0 ACRONYMS

711 HPW/RHCP	711 Human Performance Wing/Human Engineering Directorate, Warfighter Interfaces Division, Collaborative Interfaces Branch
ACC	Air Combat Command
AFRL	Air Force Research Laboratory
AOC	Air & Space Operations Center
AOD	Air Operations Directive
ATO	Air Tasking Order
BOGSAT	Bunch of Old Guys Sitting Around the Table
CEP	Common Effects Picture
CM	Capability Modules
CO	Combat Operations
COA	Course of Action
COCOM	Combatant Command
CPT	Collaborative Planning Tool
CTA	Cognitive Task Analysis
CWA	Cognitive Work Analysis
DCO	Defense Connect Online
DISR	DoD Information Technology Standards Registry
DoD	Department of Defense
DRDC	Defence Research and Development Canada
DSTO	Defence Science and Technology Organisation
EJB	Enterprise JavaBeans
EW	Electronic Warfare
FrOB	Friendly Order of Battle
GCIC	Global Cyberspace Innovation Center
GEM-S	Global Effects Management-Synchronization
GOC-CE	Global Operations Center Collaborative Environment
HE in the AOC	Human Engineering in the AOC
HPW	Human Performance Wing
ICD	Interface Control Document
IPB	Intelligence Preparation of the Battlespace
IO	Information Operations
ION	Information Operations Navigator
IOPC-J	Information Operations Planning Capability – Joint
IOPC-X	Information Operations Planning Capability – Experiment
ISPAN	Integrated Strategic Planning & Analysis Network
IWPC	Information Warfare Planning Capability
J2EE	Java 2 Platform Enterprise Edition
JAOP	Joint Air Operations Plan
JAST	JAOP AOD Status Tool
JFACC	Joint Forces Air Component Commander

JFCOM	Joint Forces Command
JIOWC	Joint Information Operations Warfare Command
JTT	Joint Targeting Tool
KPP	Key Performance Parameter
LOE	Lines of Effects
MIDB	Modernized Integrated Database
MOE	Measure of Effectiveness
NCES	Net-Centric Core Enterprise Services
NCOW-RM	Net-Centric Operational Warfare Reference Model
NECC	Net-Enabled Command Capability
OAA	Operations, Activities & Actions
OAT	Operational Assessment Team
OEAVT	Operational Effects Assessment Visualization Tool
OPLAN	Operation Plan
OSGi	Open Services Gateway Initiative
PEL	Prioritized Effects List
RCP	Eclipse Rich Client Platform
Ret	Retired
SAIC	Science Applications International Corporation
SD	Strategy Division
SDK	Software Development Toolkit
SGT	Strategy Guidance Team
SME	Subject Matter Expert
SOA	Service Oriented Architecture
SPO	System Program Office
SPT	Strategy Planning Team
SPVT	Strategy Planning Visualization Tool
SUM	Software User's Manual
TBMCS	Theater Battle Management Core Systems
TBONE	Theater Battle Operations Net-centric Environment
TTCP C3I TP2	The Technical Cooperation Program Technical Panel on Command Information Interfaces
UML	Unified Modeling Language
USAF	United States Air Force
USMTF	United State Message Traffic Format
USSTRATCOM	United States Strategic Command
VisIOn	Virtual Integrated Support for the Information Operations Environment
VPN	Virtual Private Network
WAW	Warfighter Assessment Workshop
WSDL	Web Service Description Language

APPENDIX II-A – GEM-S IO ASSESSMENT VISUALIZATION DESIGN

The following report was submitted to SRA through a subcontract to SAIC for GEM-S IO assessment visualization concept development support.

Global Effects Matrix-Sync (GEM-S)

User Interface Design and Use Cases Documentation

Date: 11 August 2008

Developed for performance under
Contract No: 12617.026

Prepared by: Science Applications International Corporation
4031 Colonel Glenn Highway
Beavercreek, Ohio 45431

GEM-S IO Assessment Visualization Design and Prototype

1.0 Introduction

This report summarizes the activity performed in support of the GEM-S IO Assessment Visualization effort, including evaluation of the Adobe Flash prototype with identification of shortcomings and potential improvements.

In addition to the introduction, the report contains the following main sections:

2.0 Background of the effort, including summaries of the elicitation sessions. Unclassified elicitation slides and trip report are contained in Section 6 and Section 7.

3.0 IO Assessment Use Case Study, satisfying the deliverable requirement for defining use cases.

4.0 IO Assessment Prototype Functional Description. This section provides an overview of the basic features of the prototype assessment visualization, with detailed descriptions of the controls and indicators contained in Section 8 (satisfying the requirement for a functional description).

5.0 Identification of prototype tool shortcomings and areas for improvement. Specific areas for improvement are identified and modified display concepts are illustrated. These are based on Subject Matter Expert (SME) and developer peer review of the prototype tool using both random and scenario-driven data. The scenario used to support this evaluation is described in Section 9 and Section 10.

6.0 Assessment concept slides. The following IO assessment concepts slides were presented December 19, 2007 elicitation of IO planners at the Joint Information Operations Warfare Center (JIOWC).

7.0 Trip Report for December 19, 2007 Elicitation at the JIOWC. The following trip report applies to the elicitations of IO planners conducted regarding IO assessment, December 19, 2007 at the Joint Information Operations Warfare Center.

8.0 Visual and Functional Specification of the IO Assessment Prototype. The following details the visual and functional specification of the IO Assessment prototype.

9.0 Fictional Scenario for Prototype Assessment Tool Evaluation. The following details the fictional scenario for the prototype assessment tool evaluation.

10.0 XML Plan File for Operation Healing Voice Scenario. The following is the plan file for Operation Healing Voice scenario in XML format.

2.0 Background of the effort

Development of the GEM-S Assessment Visualization Prototype (the Assessment Tool), was a short-term effort to address a lack of Influence Operations (IFO) assessment visualizations to support broad-ranging, national-level IO goals for the Joint Information Operations Warfare Center (JIOWC). This effort originated at an Air Force Research Laboratory (AFRL) workshop where SAIC's Operational Effect Assessment Visualization Technology (OEAVT) tools for visualizing the assessment of effects-based air operations were demonstrated and observed by Joint Forces Command (JFCOM) personnel.

An initial elicitation trip to the JIOWC on 10 October 2007 introduced the broad scope of IFO activities, and the need for visualizing and assessing the various IFO activities associated with this plan. Classified topics were discussed in the elicitation, which are not further described. A visualization called the Global Effects Matrix-Synchronization (GEM-S), had been constructed using a spreadsheet by the J24 Intelligence Support/SOCOM Team. The spreadsheet implementation of GEM-S, also known as the "horse blanket," mapped national IFO objectives to a Primary Effects List (PEL), and in turn to an activity performed by a U.S. Government (DoD, State or other agency) or non-U.S. government activity. The status of the activity was color-coded to indicate active, planned, or needed. In this manner, the color code cells of the spreadsheet provided a rapid view of who was doing/planning what (at the level of program title), versus the objectives of the NIP. A column labeled "assessment," mapped to objectives, was blank.

An unclassified surrogate of the "horse blanket" is depicted in Figure 1, and summarizes the basic elements of the synchronization matrix using the example of introducing electric vehicles to the U.S.

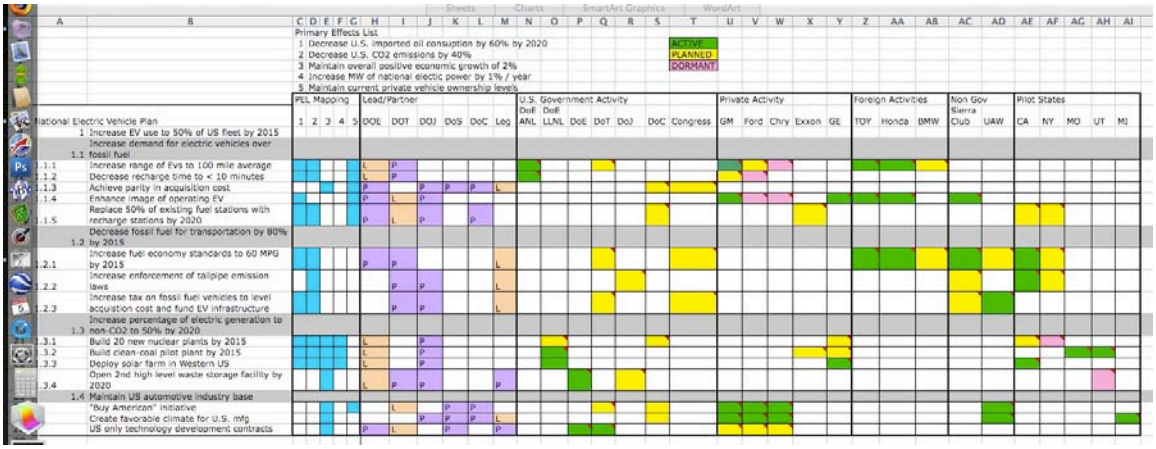


Figure 1: Unclassified surrogate for the GEM-s "Horse Blanket"

Based on this initial elicitation, SRA was tasked to adopt their COA Sketch tool technology to automating the GEM-S, and SAIC was tasked with prototyping visualization techniques for IFO assessment.

A second, unclassified elicitation session was held 19 December 2007 at SRA's San Antonio facilities, and covered specifically the topic of IFO assessment. SAIC presented a small set of slides describing an IFO assessment concept, and received constructive feedback on IFO assessment. Section 6 contains the slides presented by SAIC, and Section 7 includes the trip report for that elicitation session.

The assessment visualization concepts for IFO presented during the second elicitation focused on characterizing the achieved effect of an IFO activity in terms of perception of the delivered message (direction) and penetration of the message in the target population (magnitude). No attempt to plot achieved effect versus expended effort was made due to the difficulty in uniformly quantifying effort across the activity domain of the GEM-S. Unlike kinetic air operations, where effort is fairly uniformly measured in Desired Mean Point of Impact (DMPI) – sortie – equivalents (DSEs), no uniform measure of IFO effort is known to exist. (*For an explanation of DMPIs and DSEs as applied to kinetic planning and assessment, see AFTTO 3-3.AOC, 1 November 2007 FINAL, section 3.3.3.3*).

A final, informal elicitation was conducted on 21 February 2008 at the JIOWC, during SRA's installation of their GEM-S/COA Sketch prototype. Classified topics were discussed along with the general nature of IFO assessment. A USAF Lt Col foreign media analyst and IFO assessor confirmed the utility of the direction/magnitude assessment paradigm and provided samples of typical raw input provided to IFO assessors by commercial foreign media analysts, highlighting the need to refer to files in addition to operator provided comments in justifying assessments. Additional discussions were conducted on IO operations other than IFO. Jamming an adversary's transmitter is an example of such an operation. Currently, the results of such operations are assessed on a "4-D" basis: Disrupt, Deny, Damage, Destroy; which can be thought of in terms of increasing duration and degree of effect on a target system. This discussion prompted the inclusion of what we will describe, for lack of a general term, as an "active" IO display, as opposed to IFO, in the prototype assessment tool.

3.0 IO Assessment Use Case Study

The Prototype Assessment Visualization Tool was designed to support proof-of-concept demonstration to users for the purpose of refining and improving IO assessment displays. As such, it is not designed as a stand-alone tool, but as a visualization "engine," which relies on an external system (COA Sketch) for Operational Plan inputs and underlying database. The Use Cases (Figure 2) presented here are based on this constraint.

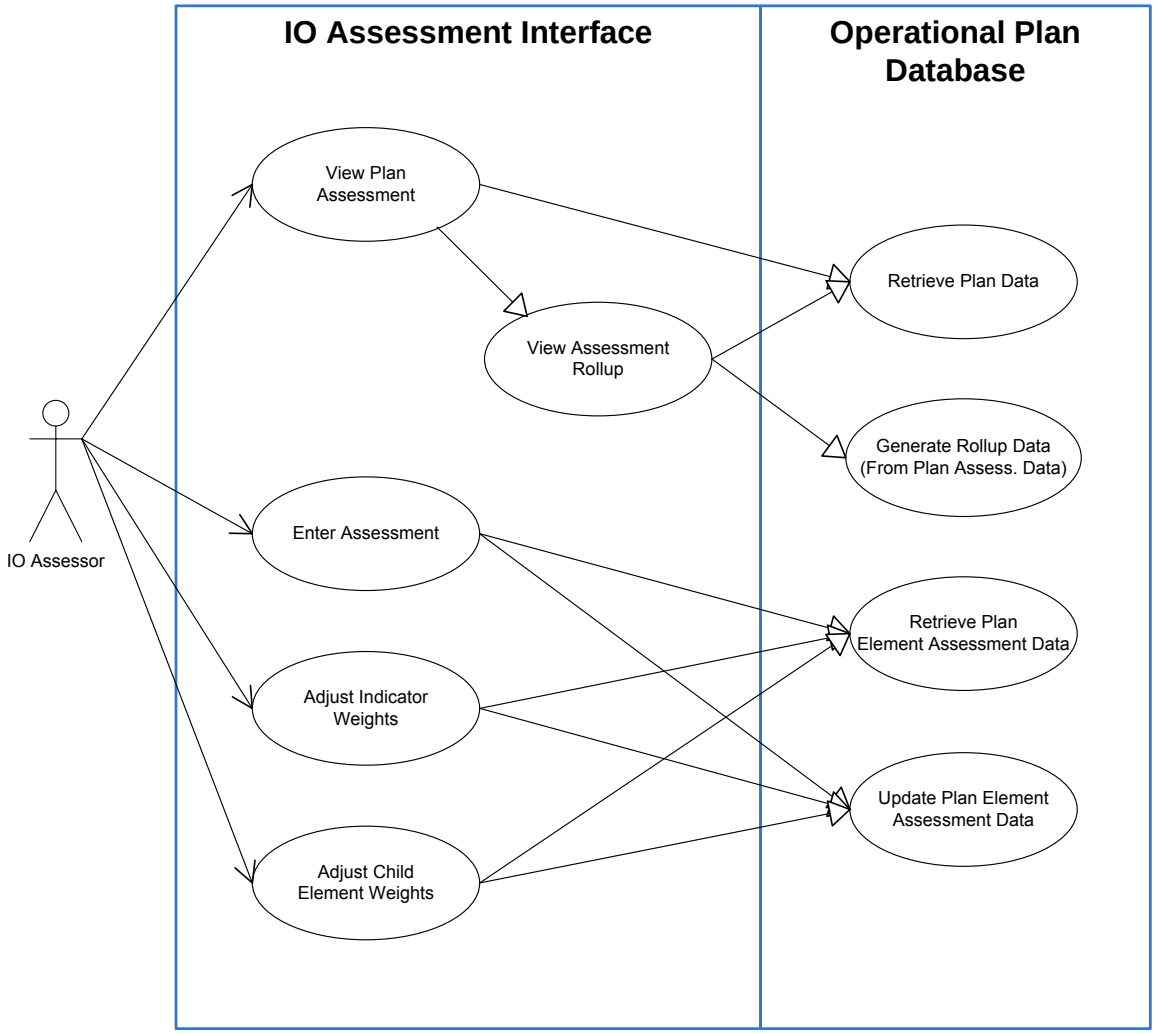


Figure 2: Use Case Diagram

Use Case: View Plan Element Detail

Description: The IO Assessor views the current assessment of an element of the Plan in detail.

Pre-Conditions:

- The IO Assessment tool must be loaded with plan data.

Post-Conditions:

- SUCCESS – The detailed assessment for the selected plan element is displayed.
- FAILURE – None

Steps:

1. IO Assessor scrolls through the plan tree view until the desired plan element is in view.
2. IO Assessor may collapse or expand the tree as needed.
3. IO Assessor clicks on the desired plan element.

<The detailed graph updates to display the graph of the selected plan element's assessment data.>

<The indicator list updates to display the list of the selected plan element's indicators and child plan elements. They are all displayed in their assessment quick view.>

4. IO Assessor may click-hold the assessment plot point to pop up a scatter-plot of the assessed indicators.
5. IO Assessor may scroll through the indicator list if it is longer than the screen height will permit.

Notes/Issues:

- None.

Use Case: Add a new Assessment to an Indicator

Description: The IO Assessor inputs a new assessment for an indicator.

Pre-Conditions:

- The IO Assessment tool must be loaded with plan data.

Post-Conditions:

- SUCCESS – New Assessment added. Display updated.
- FAILURE – Canceled out of Assessment.

Steps:

1. IO Assessor selects a Plan element from the Plan Tree View.

<Plan Element is shown in the detailed graph and indicator list>

2. IO Assessor double-clicks an indicator in the indicator list.

<The Indicator Editor Pops up, populated with the current assessment data.>

3. IO Assessor edits the data as necessary.
4. A justification MUST be entered.
5. IO Assessor clicks the "Commit Changes" button.

<A new indicator assessment for that indicator is created and added to that indicators history.>

<Assessment rollups that are fed by the updated indicator are recalculated.>

<The display is updated, where necessary to reflect the new Assessment and Assessment rollup.>

Notes/Issues:

- None.

Use Case: Adjust Indicator Weights

Description: The IO Assessor modifies the weights for the set of indicators associated to a plan element.

Pre-Conditions:

- The IO Assessment tool must be loaded with plan data.

Post-Conditions:

- SUCCESS – Weights adjusted. Display updated.
- FAILURE – Canceled out of Weight adjustment.

Steps:

1. IO Assessor selects a Plan element from the Plan Tree View.

<Plan Element is shown in the detailed graph and indicator list>

2. IO Assessor clicks the 'Edit Weight Set' button associated with the group of indicators that are to be edited.

<The Weight Set Editor Pops up, populated with a list of the Indicators in the set and their current weightings.>

3. IO Assessor edits the data as necessary.
4. A justification MUST be entered.
5. IO Assessor clicks the "Commit Changes" button.

<A weight for each indicator is created and added to the plan element history.>
<Assessment rollups that are fed by the updated indicator set are recalculated.>
<The display is updated, where necessary to reflect the new weights and Assessment rollup.>

Notes/Issues:

- None.

Use Case: Adjust Plan Element Child Element Weights

Description: The IO Assessor modifies the weights for the set of plan elements that are the children of a plan element.

Pre-Conditions:

- The IO Assessment tool must be loaded with plan data.

Post-Conditions:

- SUCCESS – Weights adjusted. Display updated.
- FAILURE – Canceled out of Weight adjustment.

Steps:

1. IO Assessor selects a Plan element from the Plan Tree View.

<Plan Element is shown in the detailed graph and indicator list>

2. IO Assessor clicks the 'Edit Weight Set' button associated with list of child elements of that plan element.

<The Weight Set Editor Pops up, populated with a list of the Indicators in the set and their current weightings. There is also an item that represents the weight to portion to the plan elements Direct Indicators.>

3. IO Assessor edits the data as necessary.
4. A justification MUST be entered.
5. IO Assessor clicks the "Commit Changes" button.

<A weight for each child plan element is created and added to the plan element history.>

<Assessment rollups that are fed by the updated plan elements are recalculated.>

<The display is updated, where necessary to reflect the new weights and Assessment rollup.>

Notes/Issues:

- None.

4.0 IO Assessment Prototype Functional Description

The original concept graphics were revised based on internal peer-review and IO SME review to depict two different basic assessment displays: one for IFO, and a second for "active" IO. These are depicted in Figure 3 and Figure 4 respectively. The functional capability and visual specification for the interface is described in greater detail in Section 8.

Note that no interface is provided to manipulate the IO plan: this is created outside this tool and imported for display. Controls are available to set:

1) Assessment values associated with IFO direction
2) Assessment values associated with IFO magnitude
3) Assessment values for duration for both desired and collateral indicators for active IO.
4) Assessment values for percent reduction in capability for both desired and collateral indicators for active IO.
5) Confidence for all indicators, both IFO and active IO.
6) Weights for all indicators and subordinate operations.

Figure 3: Basic IFO assessment display, with a direction/magnitude grid.

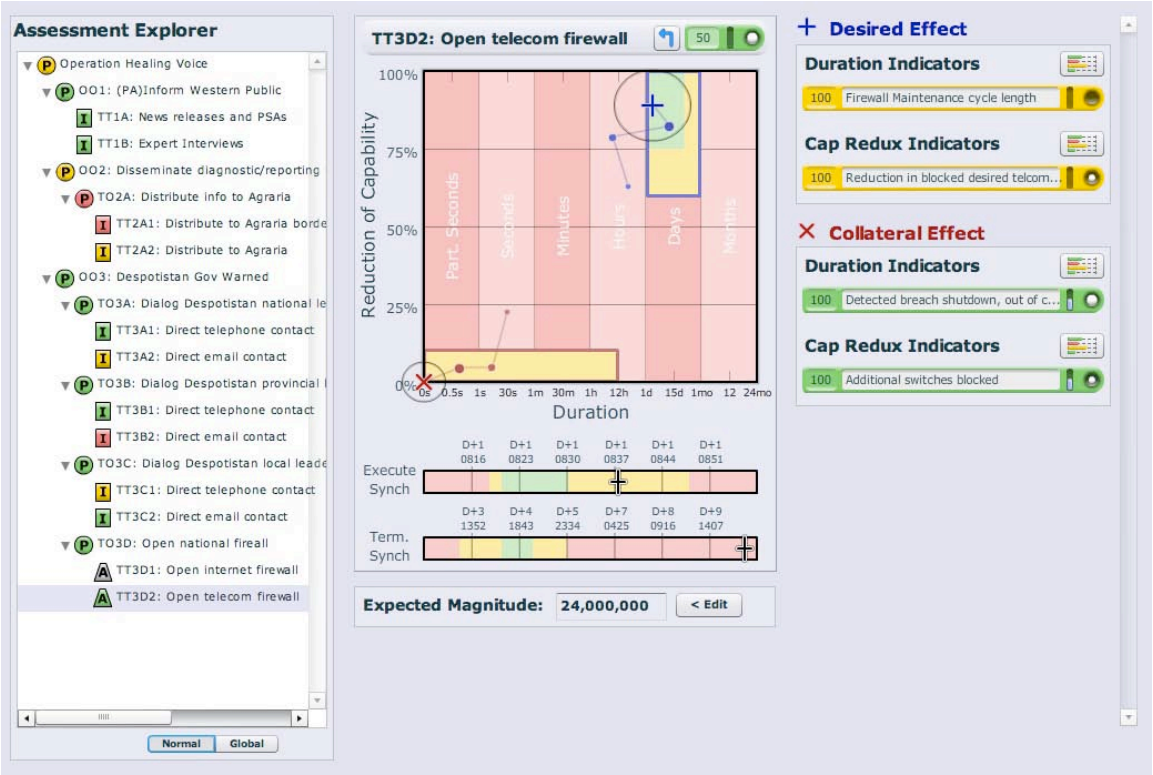


Figure 4: Basic Active IO assessment Display, with a duration/degree capacity reduction graph

5.0 Identification of prototype tool shortcomings and areas for improvement

The prototype assessment tool was evaluated internally by a mix of human factors engineers and by IO SMEs currently supporting the JIOWC and familiar with the IO assessment process. Overall findings were quite positive, with several general comments on good features:

1) The direction/magnitude display for IFO makes sense and is intuitive to understand.
2) The "active" display is also intuitive to understand and allows rapid characterization of the success of planned operations.
3) Supporting the mix/match of indicators and subordinate operations is flexible and supports real-world needs.
4) Controls and displays for assessed values, confidence, weights, and age are clear to understand and easy to use.
5) After an initial walkthrough, experienced IO assessors found the overall tool intuitive to use.

The evaluation also solicited specific weaknesses in the tool. To support the evaluation, a fictional IO scenario was constructed, "Operation Healing Voice," and an XML file was built to provide an assessment snapshot of this operation. This allowed SMEs and engineers performing the evaluation to see how the tool worked in context with an operation. The scenario used for evaluation and the XML file used to initialize the tool can be found in Sections 9 and 10, respectively. Several areas for potential future improvement were identified in this process, and are discussed below:

1. Implement a capability to allow assessment of performance/effort.
2. Provide help reference to IO TTPs.
3. Provide mechanism for operator to define the indicator sampling technique.
4. Allow for review of justification history.
5. Display multiple collateral damage effects on the active IO display.
6. Improve the Operator Interface.
7. Alter the depiction of active IO desired or collateral effects to ovals.
8. Provide a detailed "analyst's view" toggle for the active IO display to include point & click editing of effects bounds.
9. Provide a stand-alone capability, including local Op/effect input screens and database.
10. Allow expected magnitude to be set by indicator, rather than by effect.

Implement a capability to allow assessment of performance/effort

Current EBO doctrine calls for establishing both Measures of Performance (MoPs), and Measures of Effectiveness (MoEs). The prototype tool focuses exclusively on MoEs and their indicators. As discussed earlier, this design decision

was based on the observation that performance (i.e., effort), especially for IFO, is difficult to measure in a uniform, repeatable fashion. Displays can certainly be added to evaluate MoPs, but the fundamental issue of uniform measurement must be addressed at the level of IO Tactics, Techniques and Procedures (TTP), in order to allow a meaningful comparison either within or between IO operations. This will require significant SME input, and subsequent acceptance by the IO community.

Provide help reference to IO TTPs

Within the realm of effects, the criteria for evaluating effects based on indicators follows TTPs (business process rules), that range from global to operation specific. Recognizing that assessors will vary in background and skill, and that the assessment of IFO in particular is subjective, help screens or windows that allow the operator to review these process rules in context to setting assessment values, confidences, and weights would aid in maintaining consistent assessments.

Provide mechanism for operator to define the indicator sampling technique

Equally important to assessment as selecting a measureable indicator is specifying the sampling method to be used. No provision currently exists for in COA Sketch or the assessment tool prototype to specify sampling method for an indicator. A related issue is the generation of an Assessment Information Request (AIR) needed to task collection assets under the tactical control of other commands to generate the data needed to satisfy the sampling method.

There is also an opportunity to apply statistical theory as a quality control measure to the sampling method. By describing the stochastic nature of an indicator and the sampling method and frequency applied, it is possible to predict the confidence yielded by a given sampling technique. This is currently a standard procedure in opinion polling, but is not routinely applied to other sample gathering techniques such as employing ISRD assets. This can be used to determine if a given indicator is being sufficiently sampled, and just as usefully, when it is being over-sampled and squandering a scarce collection asset. This metric does not address whether an indicator is appropriate or useful, but only that it is being sufficiently sampled to reach a given level of statistical confidence.

Allow for review of justification history

As currently implemented, the Assessment Tool requires that a user enter text or attach documents to justify each change in assessment, but provides no ability to review past justifications. Such review is essential to allow an analyst to review trend data. Suggested functionality includes:

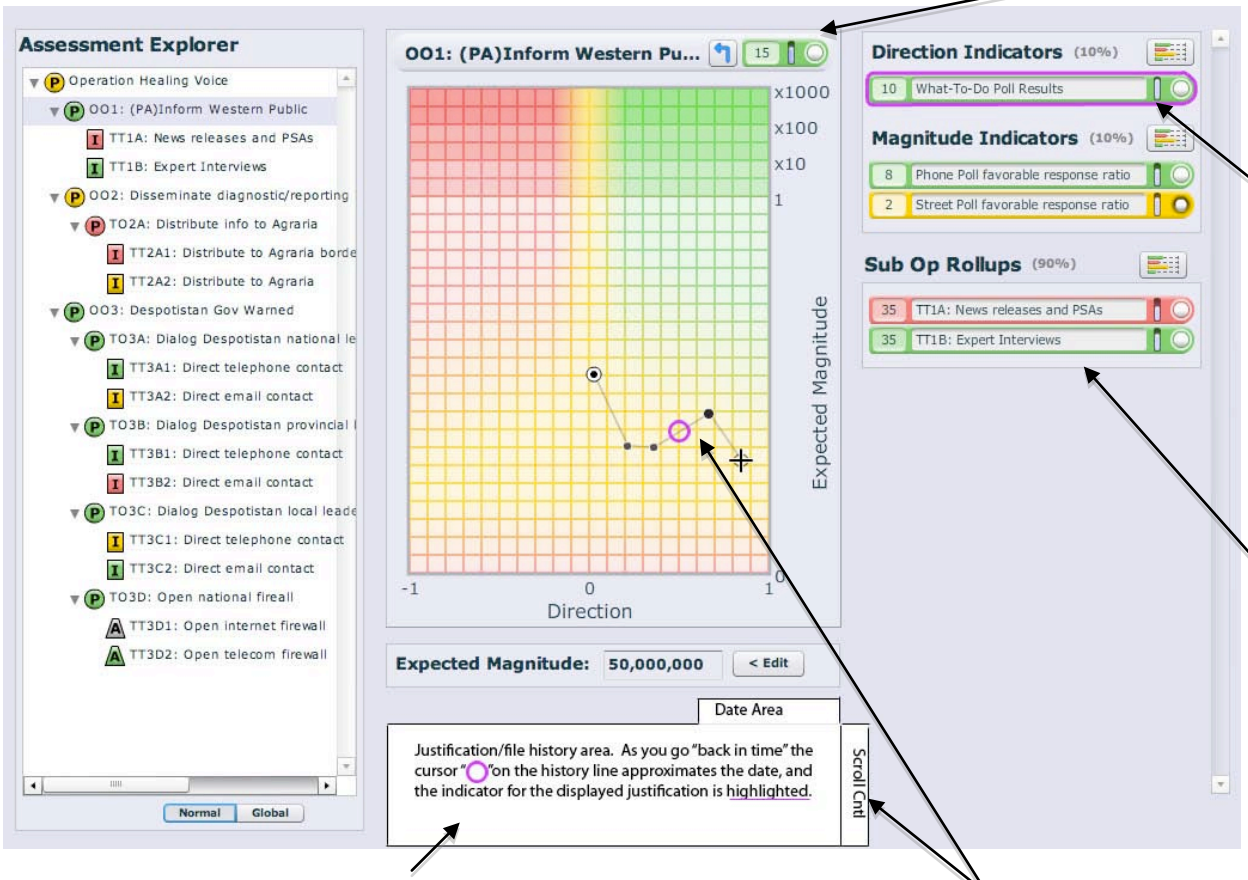
- Scroll backwards in time through assessment justifications, showing each justification or attached file in chronological order.
- Provide symbols on the assessment display to show the approximate position of the displayed justification on the assessment trend-line.

- Display the actual date of the justification.
- Update the displayed indicator values (weight, assessed value, color) consistent with the point in time, and provide an indication of which indicator's justification is being displayed.

A concept for the history review interface is shown in Figure 5. Note that this should be a modal display: The user may review the history of indicator changes, but cannot adjust indicator values or alter roll-up assessments while in this mode.

Display multiple collateral damage effects on the active IO display

Based on user feedback, multiple collateral effects may result from IO actions. The most significant effects, not just a single effect, should be viewed on the Active IO display. To avoid rarely used complexity, it is suggested that the maximum number



The roll-up assessment display should not be affected by the indicator history (grayed out). It needs to be clear to the user that this is a review of indicator assessments.

As justifications move backwards in time, the indicator being displayed should be highlighted, and its data reflect the changes. Scrolling back and forth in the history window should allow toggling between the older and newer states/data.

Subordinate operation roll-ups should not be affected by the history scroll-back. History reviews only indicator justifications and values. In fact, these roll-ups should be grayed out to avoid confusion.

Justification history should also allow attached files used for justifications to be opened in another window for review

The location of the history cursor on the trendline should vary with scroll control – start out on current, then slide back to show the approximate point on the trendline when an update occurred.

Figure 5: Indicator History Concept

of collateral effects displayed for a single IO task be three. This does not mean that the user may only choose three collateral effects. Multiple indicators may be assigned and weighted to allow a sum of minor effects be displayed as a single summary effect. In fact, with the display limit of three, a useful convention may be to display the two most significant collateral effects, and a summary for remaining minor effects. The presence of multiple effects requires that a weighting scheme be implemented to summarize collateral effects for the purpose of roll-up.

A possible method of display for multiple collateral indicators is depicted in Figure 6. In the concept shown, collateral effect bounds and assessed points are shown as transparent over-lays, with the degree of transparency shown by the order in the stack. The currently selected collateral effect area is displayed as a solid fill. Non-selected areas are displayed as partially transparent fills behind this solid layer. Non-selected assessed points are depicted as partially transparent foreground symbols.

With these characteristics, this has a weakness in obscuring a smaller "background" allowable effect area under the foreground area, but preserves the "background" assessment "X" to indicate the presence of another assessment for review.

Improve the Operator Interface:

Several minor changes to the user interface were suggested based on a human engineering review. These include:

1) It is not obvious that the indicator bars on the right side of the display can be double-clicked to adjust an indicator. To improve their affordance, it is recommended to make them single-click to open and give them some mild hover effect when moused-over, possibly a background color change. Incorporating this difference will also let the user know when it can be clicked on or not since it is not always interact-able, e.g., in the edit weight set window.

2) Subordinate operation bars on the right side of this display necessarily behave differently than the indicator bars. It is recommended that subordinate operation bars should be represented somewhat differently to avoid confusion by the operator. A separate control could be provided; however, the tradeoff between adding an additional control versus increasing display clutter would need evaluated. Additional feedback from actual operators can refine this.

3) It has been recommended that the operation level displayed in the center graphic, whether IFO or active IO, should be highlighted in the Assessment

"Background" collateral effects (effects for which indicators are not currently displayed on the balance of the window), are depicted by transparent underlays.

"Background" assessments are displayed using partially transparent "X" symbols in the foreground of the graphic. They should not be obscured by the foreground fill of the selected collateral effect.

Clicking a "background" assessment symbol should select the collateral

The currently selected collateral effect (who's indicators are displayed and may be altered), is displayed as an outlined solid foreground fill

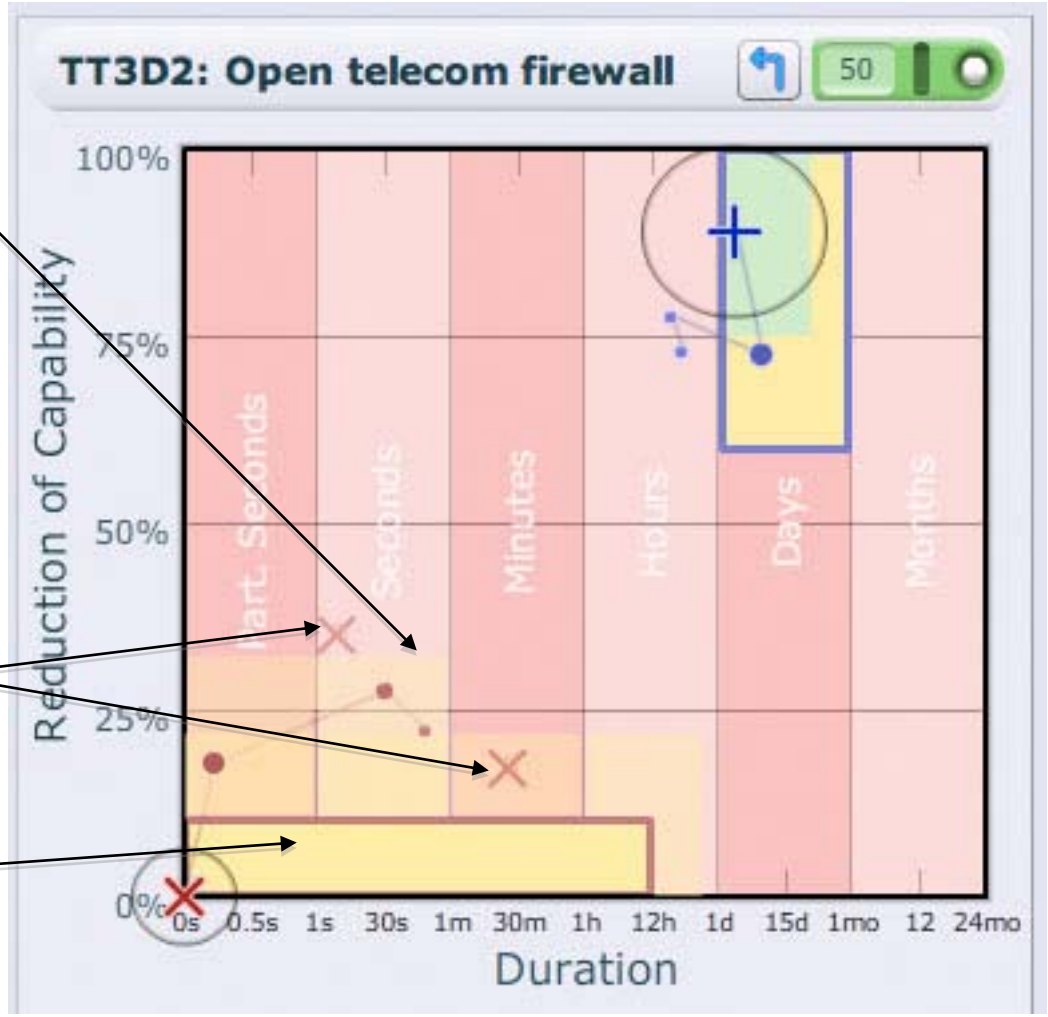


Figure 6: Multiple Collateral Effects Concept for Active IO

Explorer. Currently, the prototype initializes by showing the summary operation level, "Operation Healing Voice," but this is not highlighted in Assessment Explorer.

4) It is recommended to remove the “X” for closing the window from the "Edit Weight Set" window to prevent the operator from clicking the X rather than using the Commit Changes button and thinking they actually made changes.

5) When there is only one indicator, the edit weight selection is irrelevant; thus, it is recommended to disable the edit weight selection button under this circumstance, to avoid confusion and frustration on the part of an operator who may not understand why the button exists but does not work.

Alter the depiction of active IO desired or collateral effects to ovals.

(SME input required) Currently, rectangular regions are used to display desired and collateral effects bounds in terms of duration and degree of effect. It is likely that this may overstate the limits of these bounds near the corners of the rectangle when both factors are approaching their limits. An alternate to this display is an oval region defined at a minimum by semi-major/minor bounds that correspond to duration/degree of effect. However, as effects bounds are not necessarily symmetrical, the mathematically attractive solution of displaying a simple ellipse is insufficient. This is an area for mathematical exploration before committing to graphics prototypes, as a rigorous solution that lends itself to roll-up calculations may prove quite complex. The class of shapes known as Cassini ellipses and also Super ellipses may be useful, though the rigorous solution probably falls into the complex area of general elliptical curves.

Provide a detailed “analyst’s view” toggle for the active IO display to include point & click editing of effects bounds.

The current active IO display uses multiple x-axis time scales on a single display to provide at-a-glance *comparison* of the rough durations of effects between IO tasks. However, this same display poorly supports the precise interpretation of durations by an analyst – at the right side of the display, the difference of a few pixels is a large change in duration.

This display should be able to be toggled to a single, uniform scale, selected by the user. If the collateral area on the scale selected extends beyond the display limits, either a pan control to move the windowed area of the display on the scale or a scale change should be implemented. Implementing this “analysts’ view” would potentially allow a click-and-drag interface for setting or modifying effect boundaries.

Provide a stand-alone capability, including local Op/effect input screens and database.

As alluded to in the paragraph above, a stand-alone capability to enter at least a rudimentary IO plan, designating effects and indicators, is desired to support smaller operations, locally controlled IO operations, and compartmented activities. Ideally, this interface should be simple, with immediate feedback of the result. One suggested interface is to start with a blank tree view, that contains a single, blank "Operation." Right-clicking on this blank operation would allow a user to enter:

- Descriptive information for the selected element.
- Creation of a new operational effect subordinate to the selected level (tactical objective, IFO or IO tactical task, etc.).
- Creation of a new indicator subordinate to the selected level.

In this manner, a user familiar with the conventions of the display could rapidly construct a small plan from a blank tree, populating it with related indicators and subordinate tasks, by building and describing effects and indicators subordinate to a selected level.

Paired with this capability would be a locally resident database capable of storing both the plan and its history data.

Allow expected magnitude to be set by indicator, rather than by effect.

In the Despotistan scenario, a desired IFO effect was to influence the government to allow NGO workers supported by foreign military to enter the country unmolested by either national troops or local militias. Since the desired effect impacted the entire country, the magnitude assigned was equal to the population (24,000,000). However, the magnitude indicators used to determine the effect are numerically much smaller: detection of messages urging cooperation on official Despotistan broadcast channels (say five channels possible), and observation of the withdraw of heavy brigades from the border (say twelve brigades).

In this case, the expected magnitude for each indicator differs from the expected magnitude of the effect: it can be argued that this is not an exceptional instance, but a normal occurrence in IFO assessment. It would be simpler for the assessor if indicator-specific expected magnitudes could be assigned and displayed for each indicator, so that the assessor is entering real-word numbers for the indicator rather than scaling the value in their head: the software can scale and weight the indicators for display in the overall effect summary.

Essentially, IFO assessment can be characterized as describing a population through a sort of clustered sampling method, using one or more sample frames and sampling weights. Thus in the example above, we are attempting to describe the receptivity

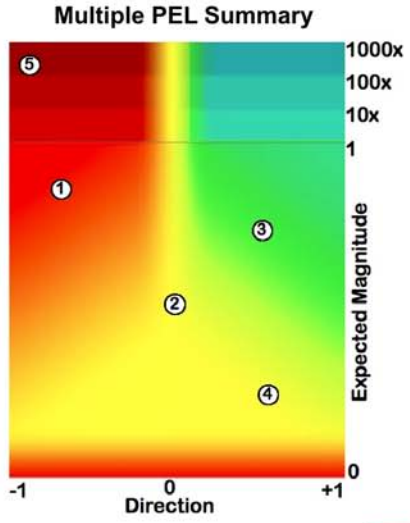
of the population of Despotistan to foreign intervention by using two different sampling frames: 1) the content of government-controlled broadcasts, and 2) the behavior of forward based troops. Within these frames, the assessor will need to articulate a sampling strategy (e.g., When do I listen? How often do I look?). The recommended change recognizes that these two frames, while assumed to have a correlation to the affected population, in reality have their own individual magnitude. With this approach, if the assessor can fully characterize the size and distribution of the sample frame, it is possible to evaluate his selected sample strategy and assign a confidence limit,

6.0 Assessment concept slides

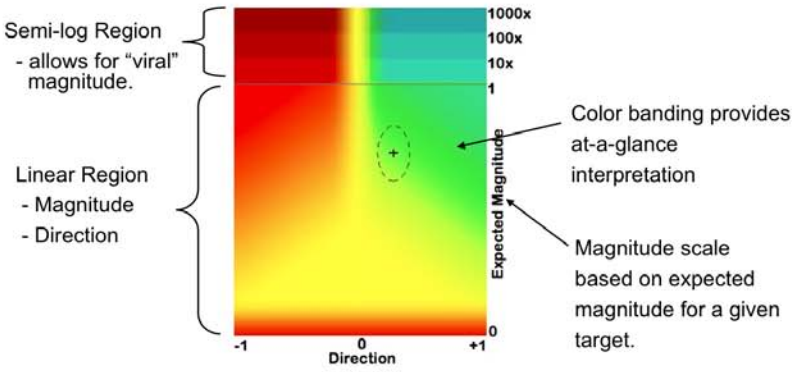
The following IO assessment concepts slides were presented December 19, 2007 elicitation of IO planners at the Joint Information Operations Warfare Center (JIOWC).

Effect Assessment Concept

- Based off media analysis concept, with two components:
  - Direction: Perceived positive or negative effect
  - Magnitude: Portion of target population influenced

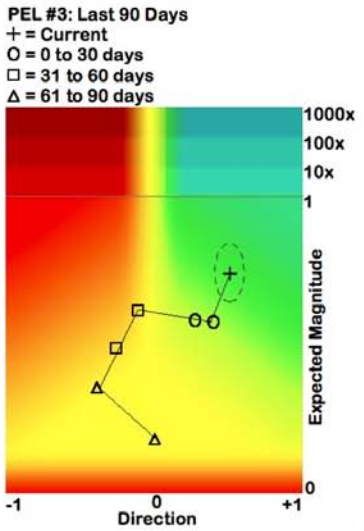


Basic Features



Single PEL Display

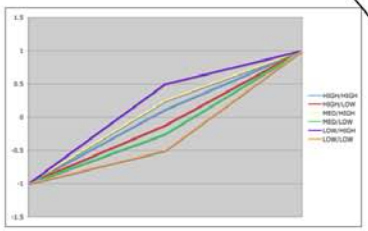
- Drill-down to single PEL provides:
  - Confidence bound for most recent data
  - Trend over time
    - User selected period
    - Symbols denote approximate data age

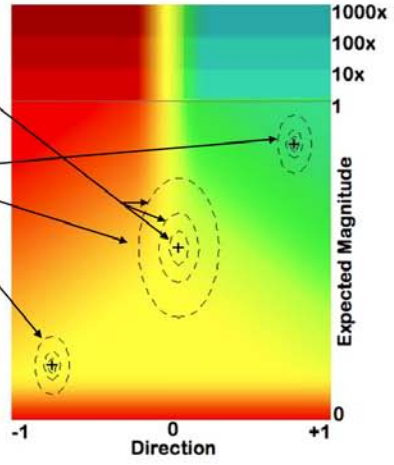


Confidence Presentation

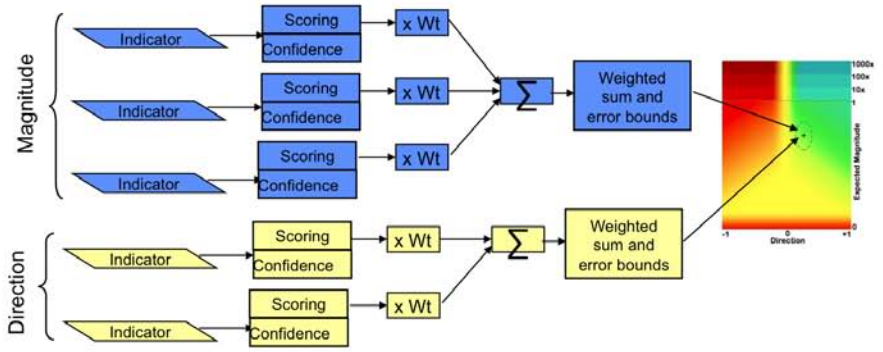
Low, Med, High confidence bounds

Perceived confidence is reduced for mid-scale (assumed ambiguous) assessment values.





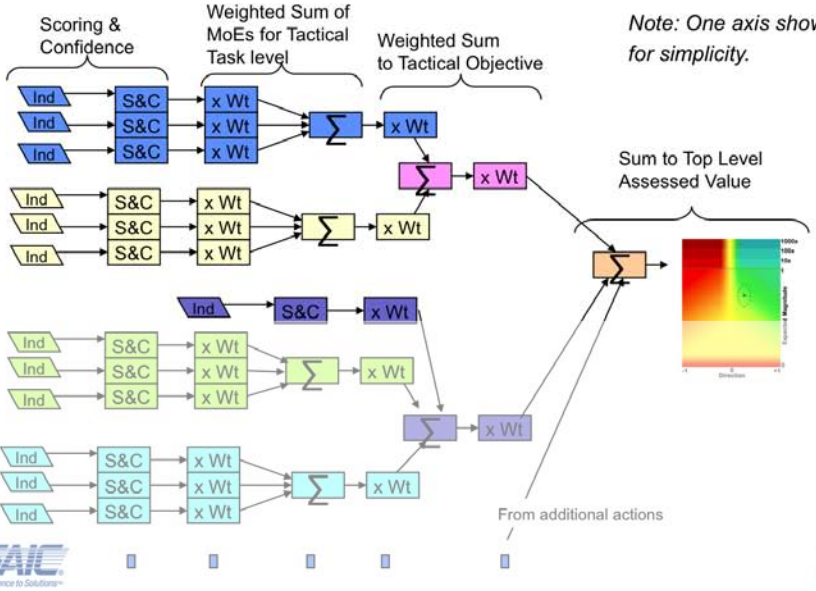
Value Model for Effect Computation



For a given PEL:

- **Analyst collects raw indicators**
- **Analyst assigns normalized score in direction or magnitude**
- **Analyst assigns weight for computed roll-up to summary level**
- **Analyst assigns confidence in individual assessment for bounds**

Model is extensible to multi-tiered efforts



Indicator Considerations

- Cultural understanding is critical to accurate assessment
  - A very positive message to one community may be neutral or negative to another.
    - e.g., U.S. border security and immigration laws
- Indicators for an effort are not limited to media sources
  - Internal reports regarding behavioral changes in populations, e.g. rally turn out.
  - Campaign donations/trends
  - Voter registrations
  - Poll results/trends
- Non media indicators may contribute to either magnitude or direction, as the analyst determines

7.0 Trip Report for December 19, 2007 Elicitation at the JIOWC

The following trip report applies to the elicitations of IO planners conducted regarding IO assessment, December 19, 2007 at the Joint Information Operations Warfare Center.

Dec. 19, 2007.

JIOWC leadership opened with an overview of the GEM-S, and described VisIOn as a marriage of JIAPSE and IOPC-J/X. The two take-away messages from the current horse-blanket is a lack of synchronization and a lack of activity. Goal for January is some stand-alone capability to mechanize the horse-blanket. A parallel activity is to obtain data for entry into the tool. From January to June, try to connect the tool to other COCOMs, others.

The elicitation was conducted at the unclassified level.

Participant background:
1. Career Army Intel, planning Intel OPS. Last 7 years in I/O. Currently working Joint OPS and Plans. Mix of Intel and I/O operations. Characterized I/O in the following manner:

EW alone is not I/O
CNO alone is not I/O
PSYOPS alone is not I/O

I/O is a combination of techniques to achieve an effect. Also characterized the bulk of the horse blanket activities as Influence OPS, and in large part, not a DoD mission. DoD controlled activities are very minor. Others lead the influence area, in particular DoS. Was very clear that in order to make GEM-S "work", it needed direction from the NCA level for multiple departments and agencies to play together. Build it and they will come – perhaps not. "Hope is not a strategy".
Read between the lines (but not by much): Regards the author of the horse blanket, as a smart guy who sees the "big picture", but is reaching beyond his ability in attempting to bring the horse blanket as an integrated, active, multi-agency effort to fruition. Thinks it will die on the vine – which he states is not our problem.

2. Ten years in USAF Intel, including past assignment to NSA. First tour in I/O. Focus is on assessing current I/O Ops. Current activity is on Operation Assured Voice, out of EUCOM, focused on Africa. Current state of I/O assessment is haphazard and *ad hoc*. Have started developing their own assessment tools (JEMA, Joint Effects Modeling and Assessment) – see separate hard copy. They are reach back for EUCOM.

Use EBO methodology, with assessment tied to MoEs and indicators. Things they are running into:

- Lots of dependency on OSINT: commercial polls, websites, and foreign media analysis.
- Traditional Intel reports and collections don't meet needs. Example: an indicator may be the portion of inter-sect marriages. Intel shop shrugs and asks, How do we collect against that? May rely on NGO sources.
- Blue Force OSINT – walking around observsations.
- Many stove pipes for collected data, obstacles to sharing

- Difficulty in correlating the data (data volume issue), and how to weight the data – what is the importance of any individual item?

Commissioning commercial polls: See below, from an email with unclassified end-state and indicators examples:

"Here's the document I would like you to pass to Tom. Treat the blue as"end state", the red as PELs and the black as MOE and indicators (we've collapsed them here and taken them out of their MOE and indicator categories for sanitization purposes). It's rudimentary b/c I had to eliminate a lot of detail but gives you the idea of how the process trickles down. If you provide me a SIPR email I can send down the actually PELs and provide more detail.

Intent: Minimize violent extremist ideology in the region of interest

Goal: Influential host nation "moderates" speak out against extremism (Influential host nation population actively opposes extremism in their country; they speak out again extremist ideology. Potential communicators can be religious and political leaders, media personalities and outlets, business leaders and celebrities)

Potential Measurements:
- Increase/Decrease (I/D) of instances of moderate statements in the host nation media
- Increase/Decrease (I/D) Size of moderate media audience
- Increase/Decrease (I/D) in population's belief that extremism is damaging to their country or a threat to their culture
- Increase/Decrease (I/D) leadership effort to police extremist organizations
- Increase/Decrease (I/D) civic / non-profit organizations that promote moderate ideology (or oppose radical / extremist ideology)
- Increase/Decrease (I/D) population "turn in" or "reporting" of radicals or extremist activity (assists security services)
- Increase/Decrease (I/D) in successful anti-extremist operations by local forces (arrests, breaking up cells, foiling plots etc.)

Goal: Extremist / radical organizations and/or their leaders are discredited (Extremist organizations or their leaders are no longer seen as effective or reputable; they are no respected by their followers, the host nation population or other extremist organizations)

Potential Measurements
- Increase/Decrease (I/D) Instances of "desertion" or "reform" of operatives from extremist organizations

- Increase/Decrease (I/D) internal conflicts within extremist organizations, such as splinter groups forming or power struggles between factions or rival leaders vying for group / population loyalty
- Increase/Decrease (I/D) in negative mass media coverage of violent extremist organizations
- Increase/Decrease (I/D) in name recognition of extremist leadership
- Increase/Decrease (I/D) in passive support within population for extremist organizations
- Increase/Decrease (I/D) Instances of monetary / in kind donations to extremist groups
- Increase/Decrease (I/D) population "turn in" or "reporting" of radicals or extremist activity (assists security services)
- Increase/Decrease (I/D) in successful anti-extremist operations by local forces (arrests, breaking up cells, foiling plots etc.)

Goal: Host nation governments collaborate with external partners on counter-extremist initiatives
(Host nation governments collaborate with external / regional partners; cooperative efforts with regard to illegal trafficking and other criminal activity)

Potential Measurements:
- Host nation participates in regional security related information sharing or security agreements
- Host nation participates in international agreements and treaties on anti-terrorist issues (i.e. extraditions, assistance, border security cooperation, exercises etc.)

Goal: Host nation population adopts an anti-extremist, anti-radical ideology
(Population actively opposes extremism in their country; they speak out again extremist ideology)

Potential Measurements:
- Increase/Decrease (I/D) of instances of moderate statements in the host nation media, to include anti-extremist editorials
- Increase/Decrease (I/D) Size of moderate media audience
- Increase/Decrease (I/D) of Instances of moderate communication forums, ie. Web sites, blogs, clubs
- Increase/Decrease (I/D) Instances of moderate messages in civic/public forums, to include demonstrations, civic action groups
- Increase/Decrease (I/D) in moderate / anti-extremist positions in educational institutions/curriculums
- Increase/Decrease (I/D) in Evidence of moderate message in religious discourse, schools, or places of worship
- Increase/Decrease (I/D) in Instances of the "normalization" of extremist / radical viewpoints through incorporation into mainstream political organizations / parties, vice terrorist platforms

- Increase/Decrease (I/D) in youth or college student opposition to extremist ideology
- Increase/Decrease (I/D) in population's belief that extremism is damaging to their country or a threat to their culture
- Increase/Decrease (I/D) in Evidence that host nation leaders make effort to police extremist organizations
- Increase/Decrease (I/D) in Evidence of civic / non-profit organizations that promote moderate ideology (or oppose radical / extremist ideology)
- Increase/Decrease (I/D) in Evidence that host nation population is inclined to "turn in" or "report" radicals or extremists (assists security services)
- Increase/Decrease (I/D) in Evidence that host nation is successful in anti-extremist operations (arrests, breaking up cells, foiling plots etc.)
- Increase/Decrease (I/D) in religious tolerance
- Increase/Decrease (I/D) in Instances of sectarian violence
- Increase/Decrease (I/D) in inter-sect, inter-faith or inter-ethnic marriage
- Increase/Decrease (I/D) in religiously / ethnically mixed neighborhoods, schools

Goal: Extremist organizations' cyber presence is diminished
(Extremist groups cyber activity is non-productive, presence on the web is reduced; creation of training resources is minimized)

Potential Measurements:
- Evidence of extremist presence on the web
- Instances of extremist ideology in moderate, mainstream web sites

Constructing Operation Assured Voice (OAV):

Used SIAM (http://www.inet.saic.com/inet-public/), to construct a nodal analysis, create effects, MoEs, and indicators. SIAM generates the PEL. (Note that SIAM is now an SAIC company, and this is Java-based software – need to see if we can get documentation/API).

Big problem comes in attempting to link information to indicators. Information that comes in is rated on:

- a scale of 1:10 for applicability.
- Good/Bad/Neutral
- L/M/H confidence

All of these ratings are "judgment calls".
One critical aspect of evaluating an operation is obtaining a baseline of the indicators prior to the start of the operation, as a point of comparison: are you making things better, worse?

May be 100 web sites influencing an area, be we are monitoring perhaps 2. Everything we are dealing with is a soft target. You are rarely sure of the effect.

Doing assessment right is more expensive in resources and manpower than conducting the I/O operation.

When coordinating with kinetic folks, need to warp the EBO constructs used in Intel to the strat-to-task constructs still being used by others.

The desired end-state should be driving both the OP and assessment. The end-state consists of 3-4 sentences.

Outside of a major DoD operation (OEF, OIF, etc.), then influence OPS and I/O in general is worked through the embassy, thus DoS and other agency coordination come into play. No evidence of EBO planning, or anything the DoD recognizes as formal planning on the DoS side. Notes that the NIP was done at the NCA level – and that to achieve the vision of GEM-S, that direction will have to come from that level as well. For GEM-S to achieve even DoD acceptance, it must have clear utility for a commander. COCOMs work tactical I/O in their theatres – not necessarily coordinated with JIOWC. (From the Army 1st I/O, notes that they have developed I/O specific icons, a la MIL-STD-2525, for internal use).

Clear that both officers are attempting to interpret and correlate the information contained in separate panes of the PowerPoint, and are getting confused in chart inconsistencies. This is not intuitive (four panel chart). Confusion on the 3D icons presented as well – what did it mean? Need to walk through a consistent use-case and build that case from slide-to-slide.

-- Concurrence on assessment concept. Checking for alternate terms for "direction" and "magnitude" -- nothing is standardized here, so lets adopt whatever is closest to current terminology.

- no heartburn with fixed gradient. It made sense to them
- concurrence on widening the confidence "bubble" for center-scale assessments. Confirmed that analyst often place things they are uncertain about center-scale.
- Need to have a user-defined time period for the trend display. Binning of periods and mapping to a sparse set of symbols seems OK.
- Need to separately display the "baseline" point of an assessment.
- Magnitude as a relative measure: Objective may be a single leader. May be an entire population. No heartburn with the semi-log "viral" area.

On observing the value-model slide, looked at it for a few moments, and then correctly indicated what it meant (before I briefed it), saying yep, that makes sense. Also concurred on the continuation of the roll-up.

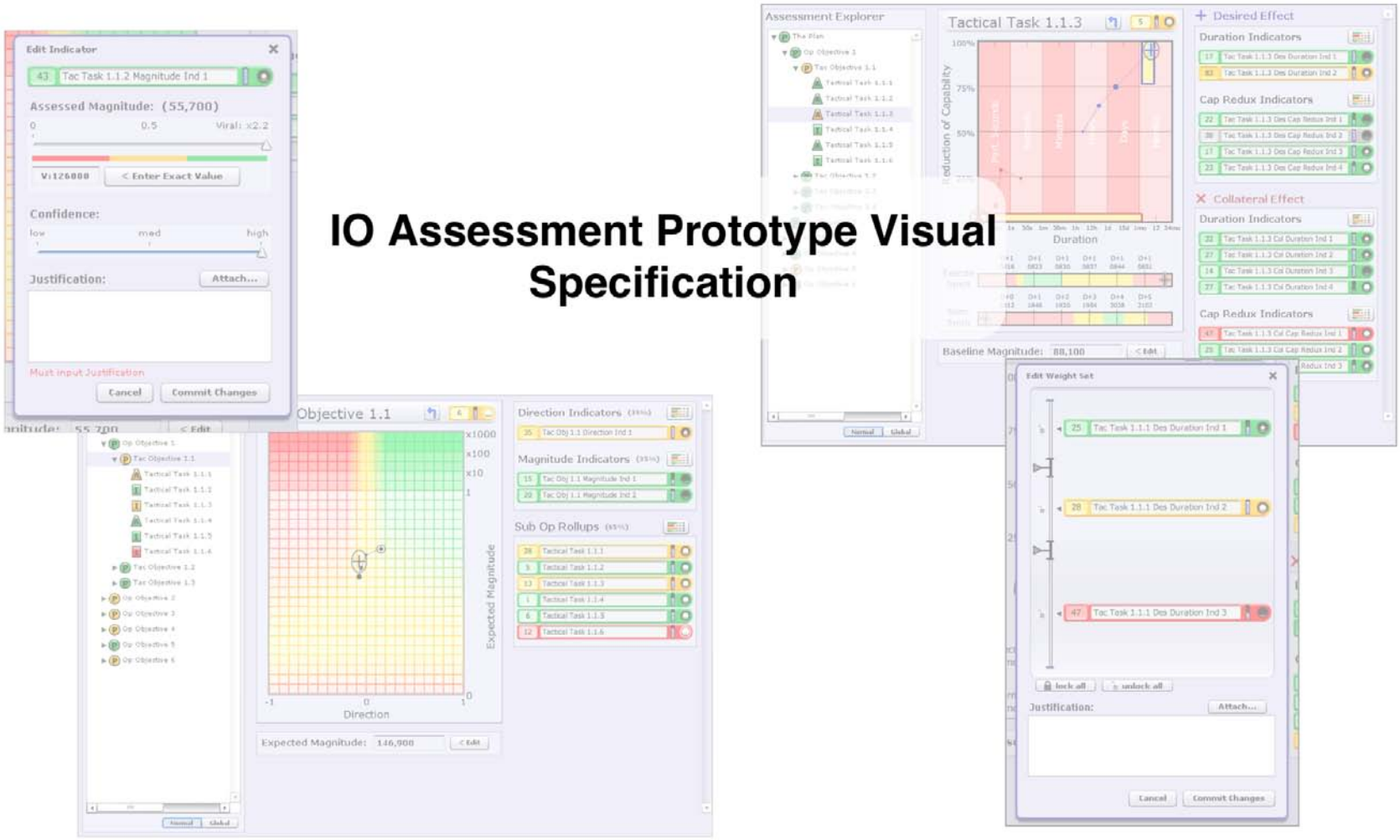
Overall – assessment concept seems to be pretty much on. Need to check terminology, and need to add a baseline symbol.

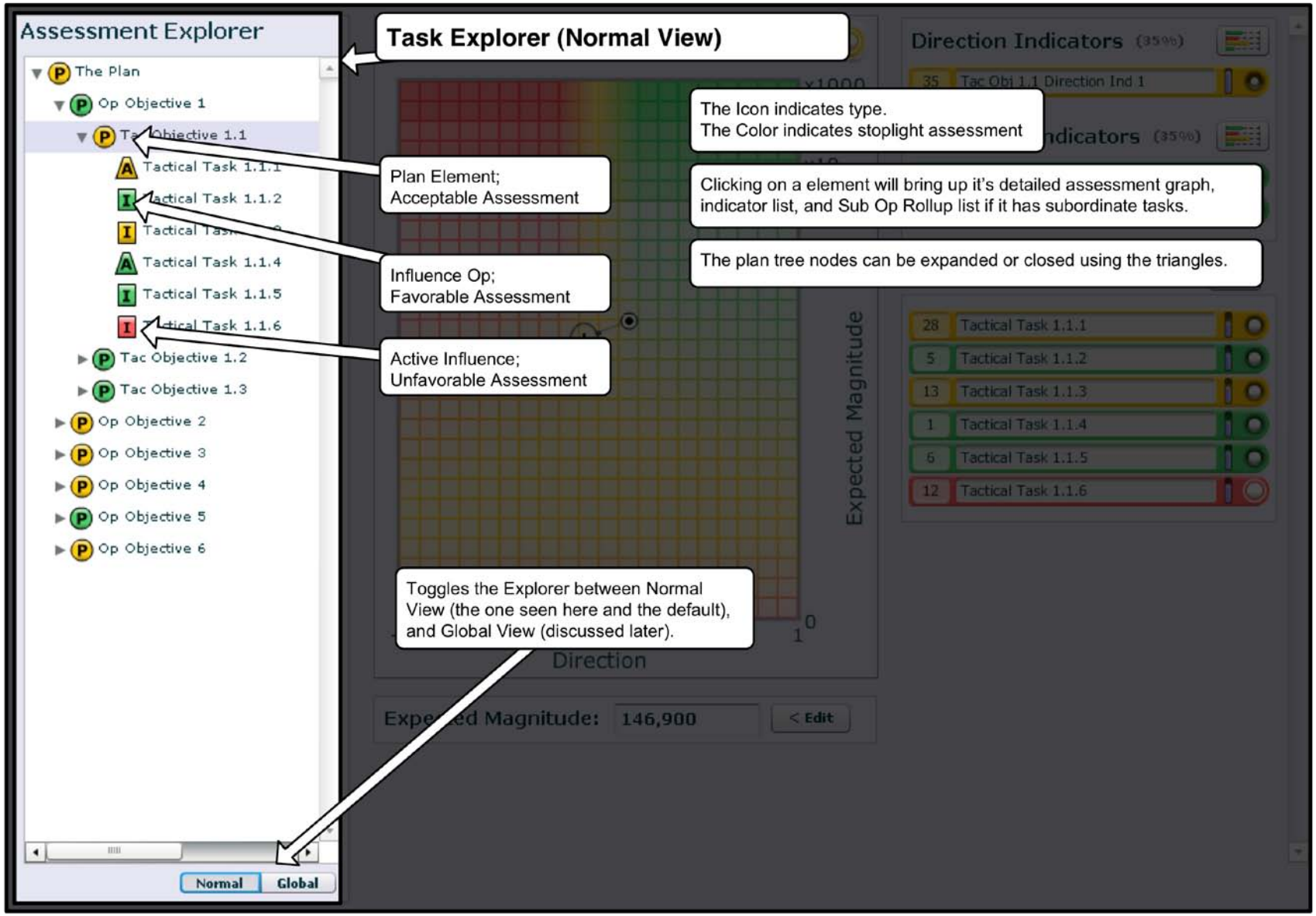
Also, need to see if we can directly import assessment info from JEMA – Seems silly to develop yet another assessment interface if one exists already.

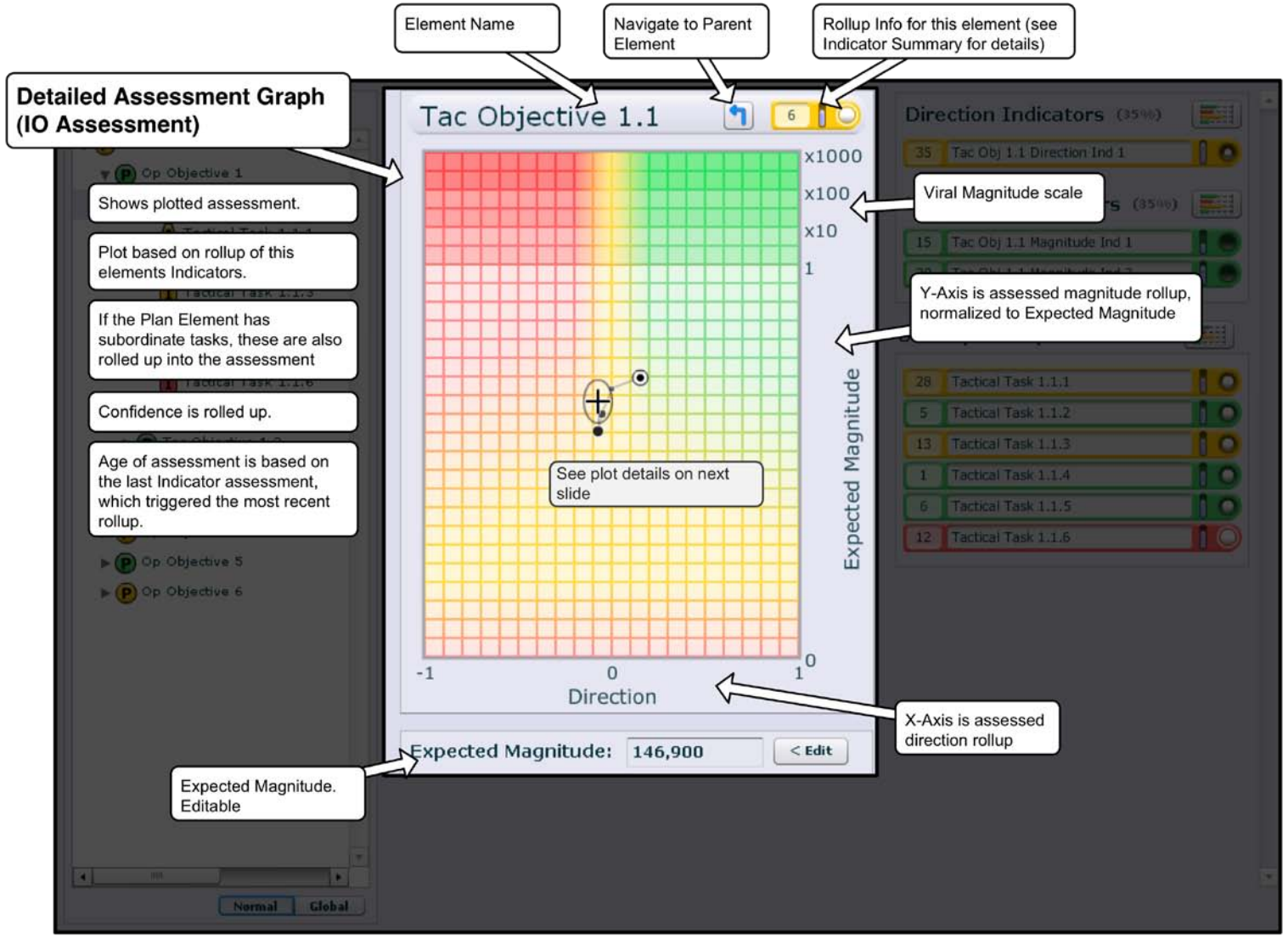
8.0 Visual and Functional Specification of the IO Assessment Prototype

The following details the visual and functional specification of the IO Assessment prototype.

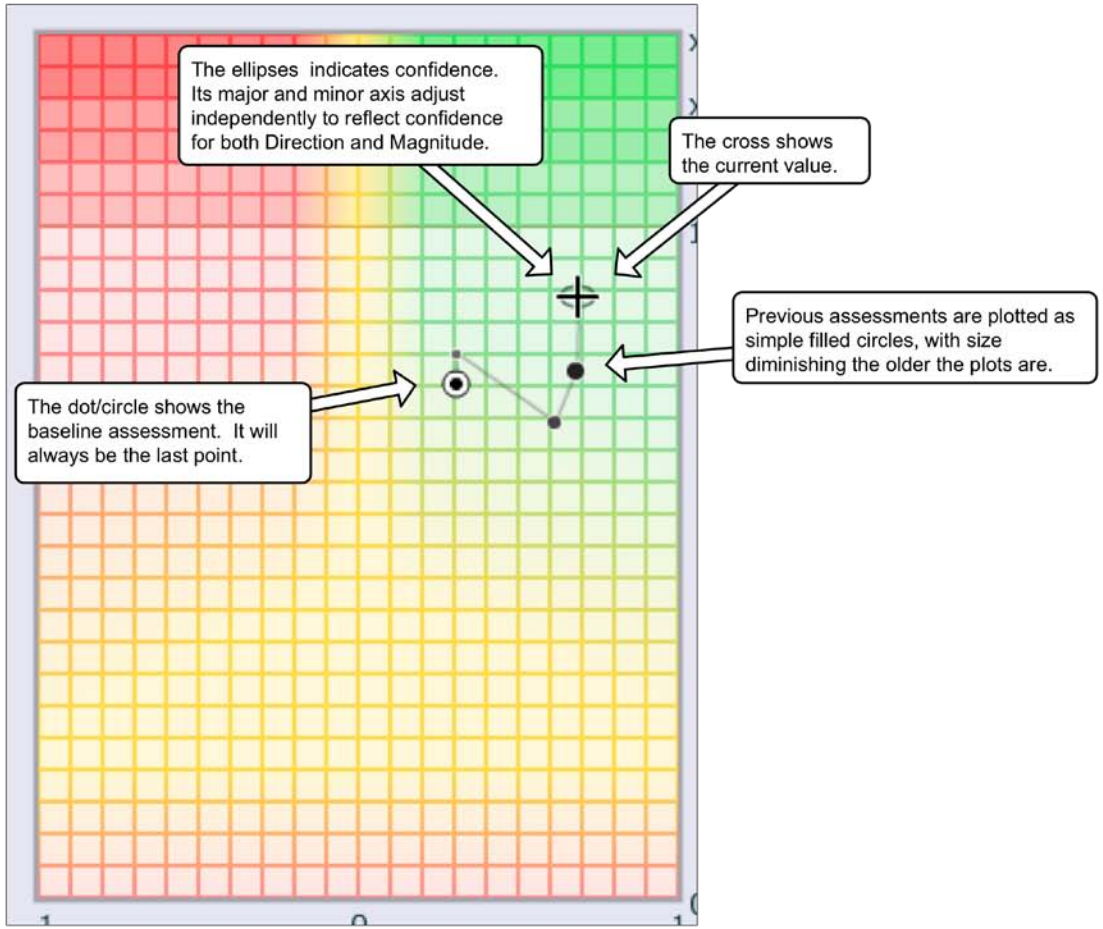
IO Assessment Prototype Visual Specification



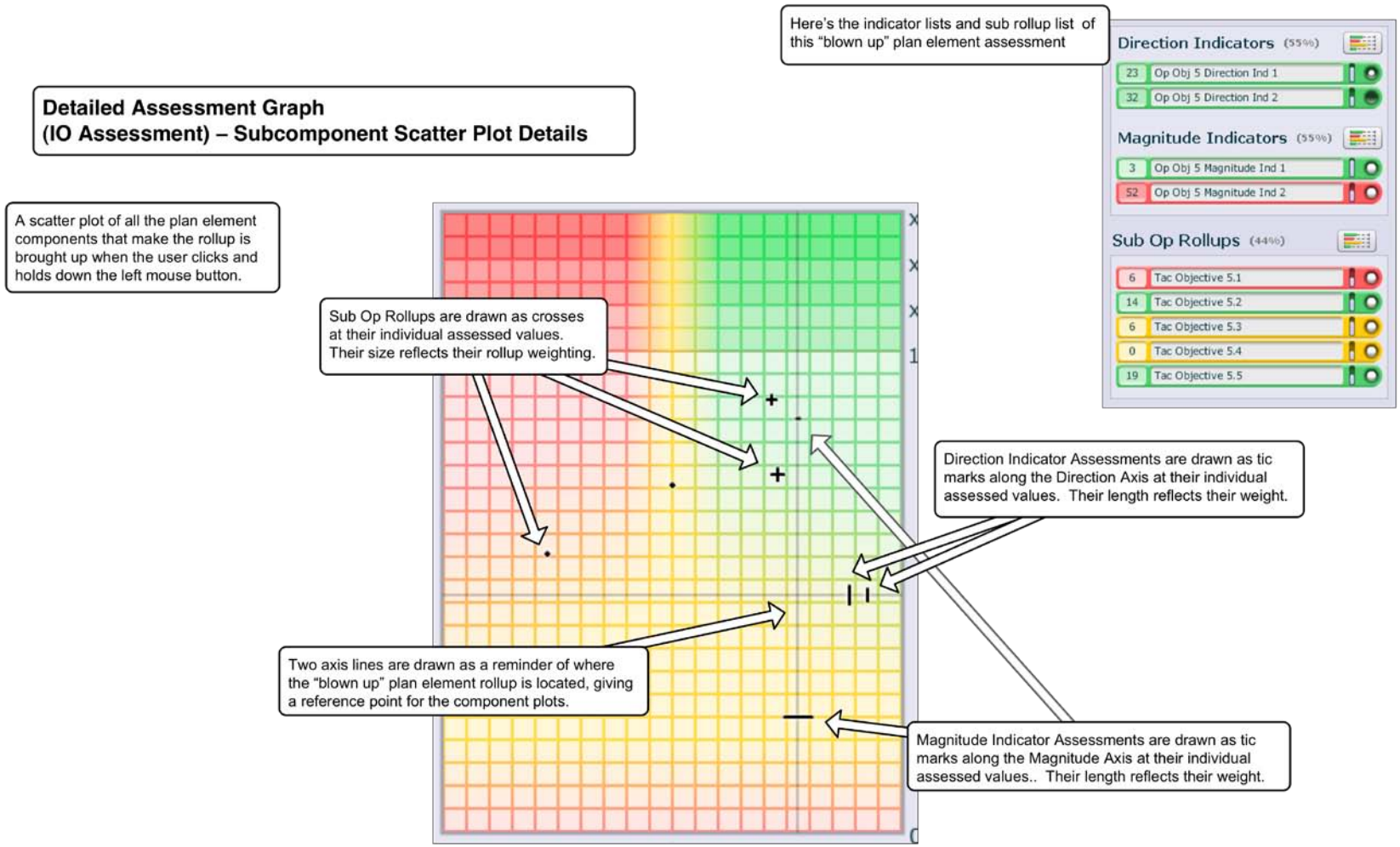


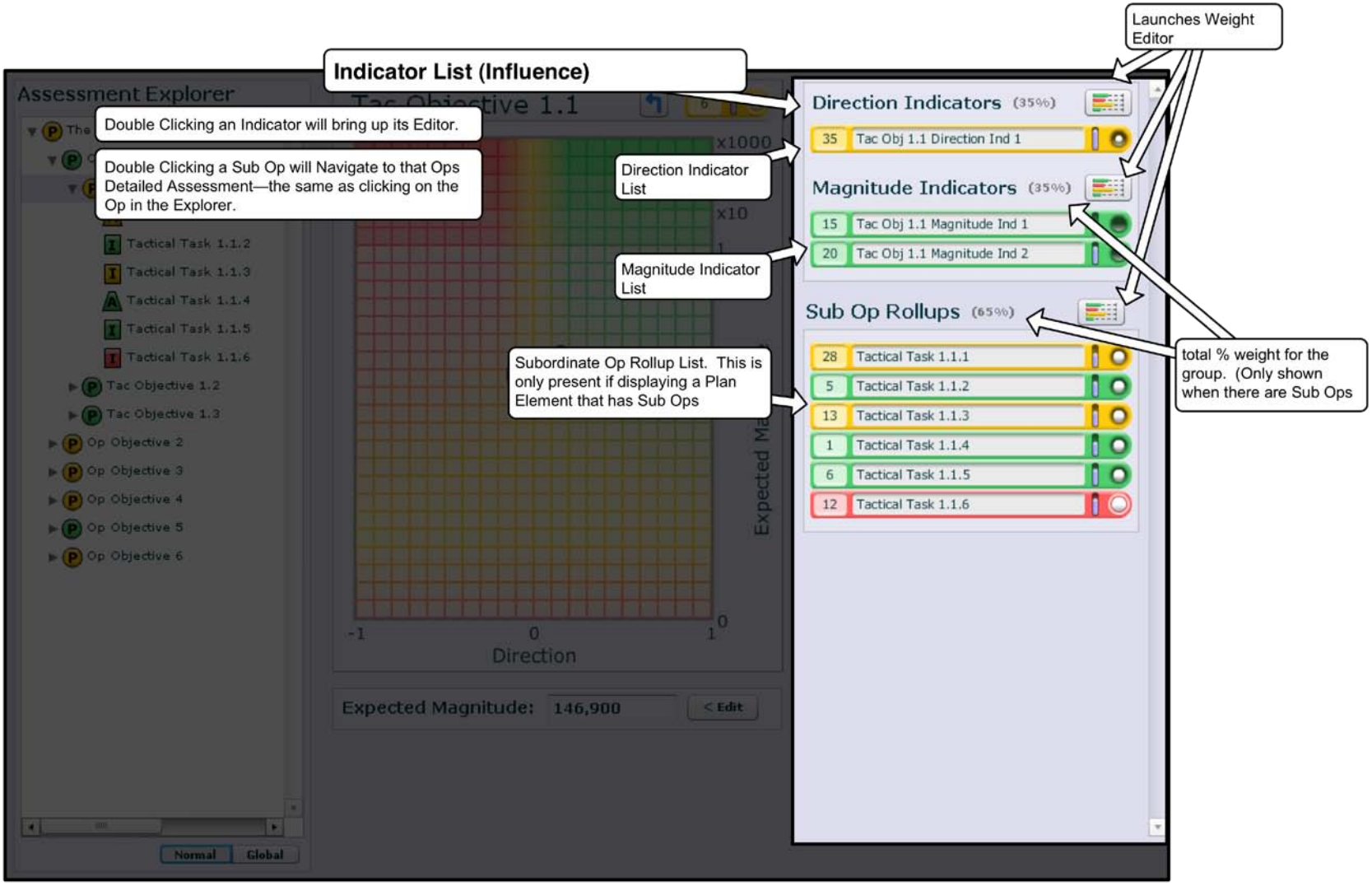


Detailed Assessment Graph (IO Assessment) – Plot Details

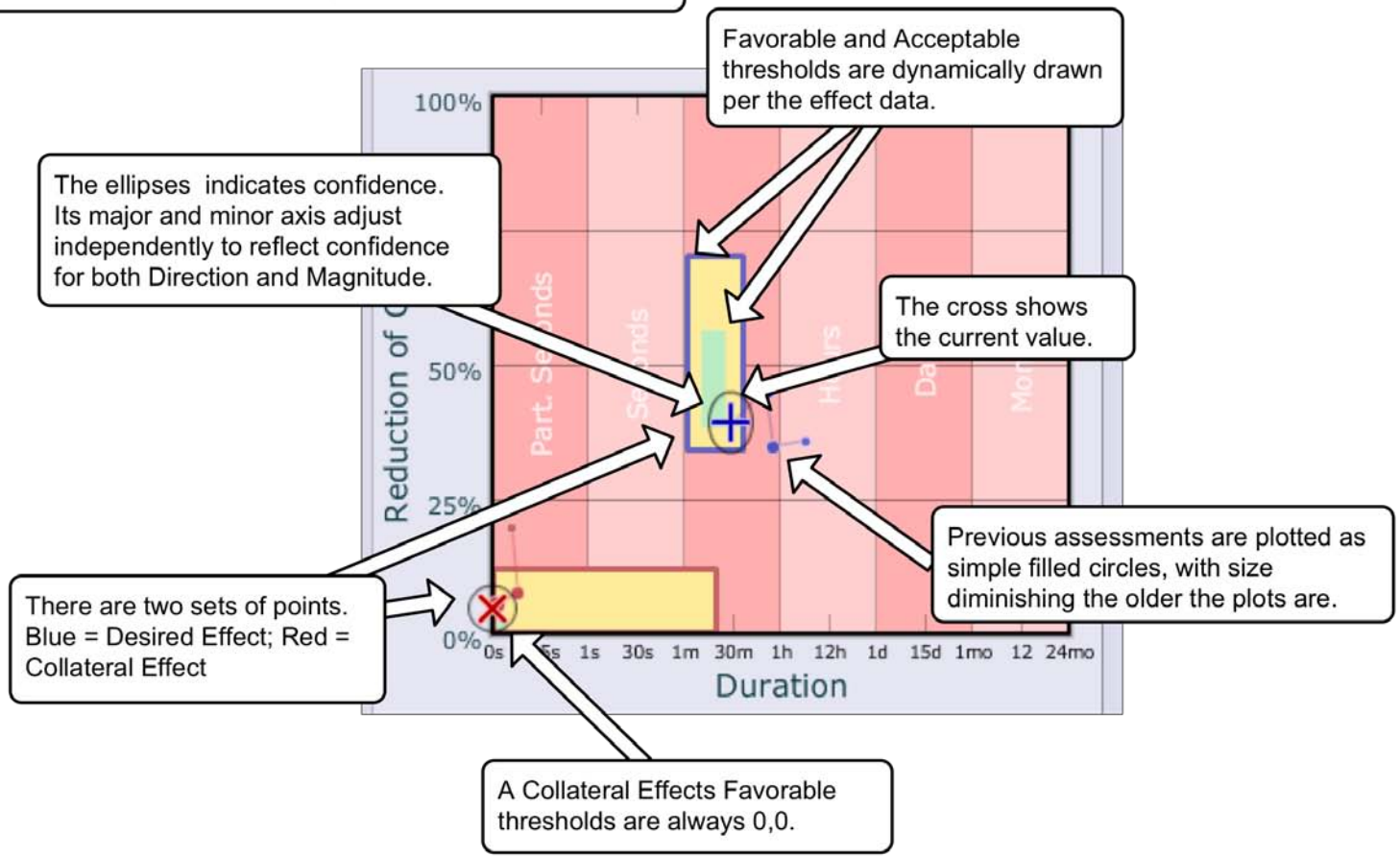


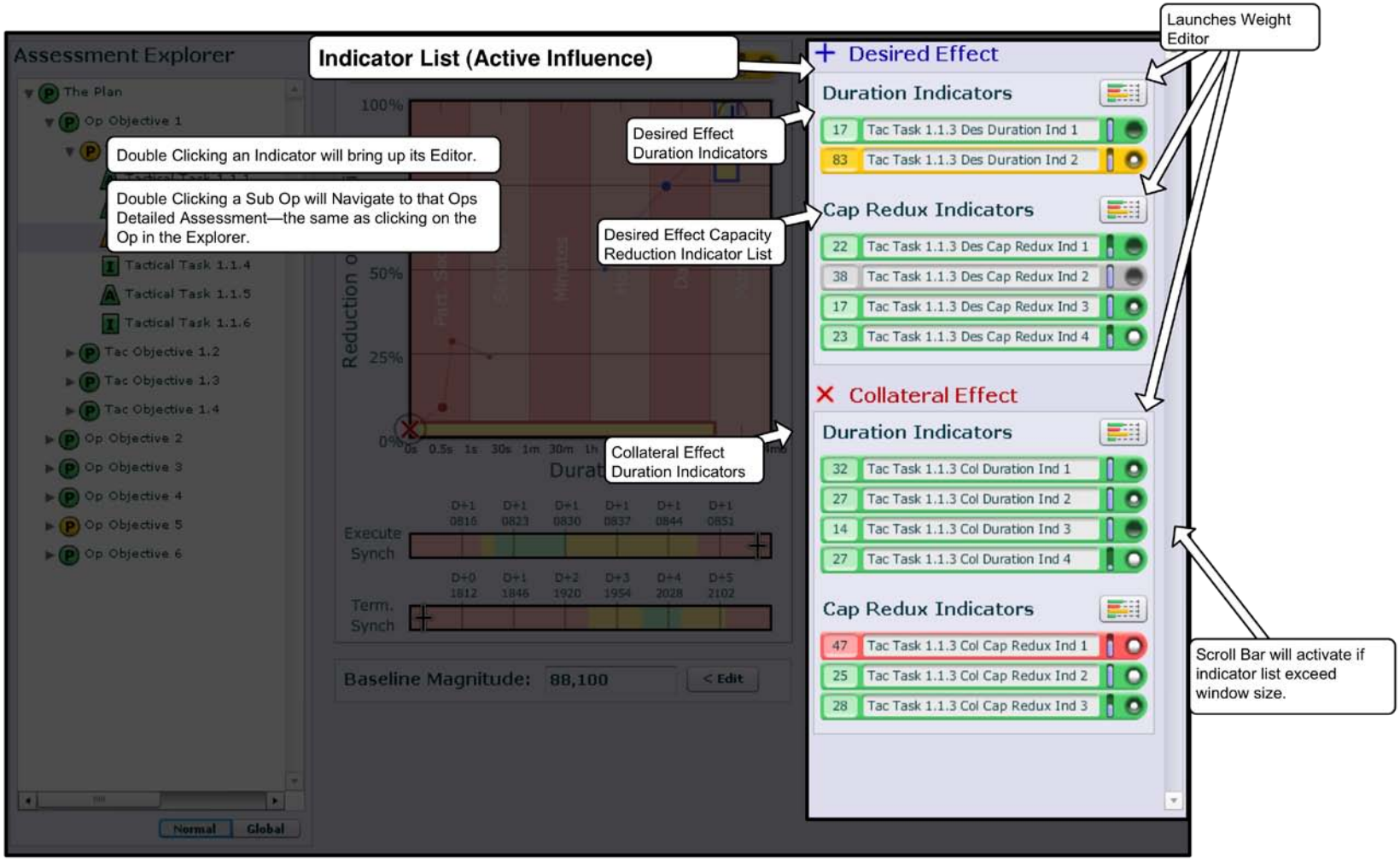
Detailed Assessment Graph
(IO Assessment) – Subcomponent Scatter Plot Details



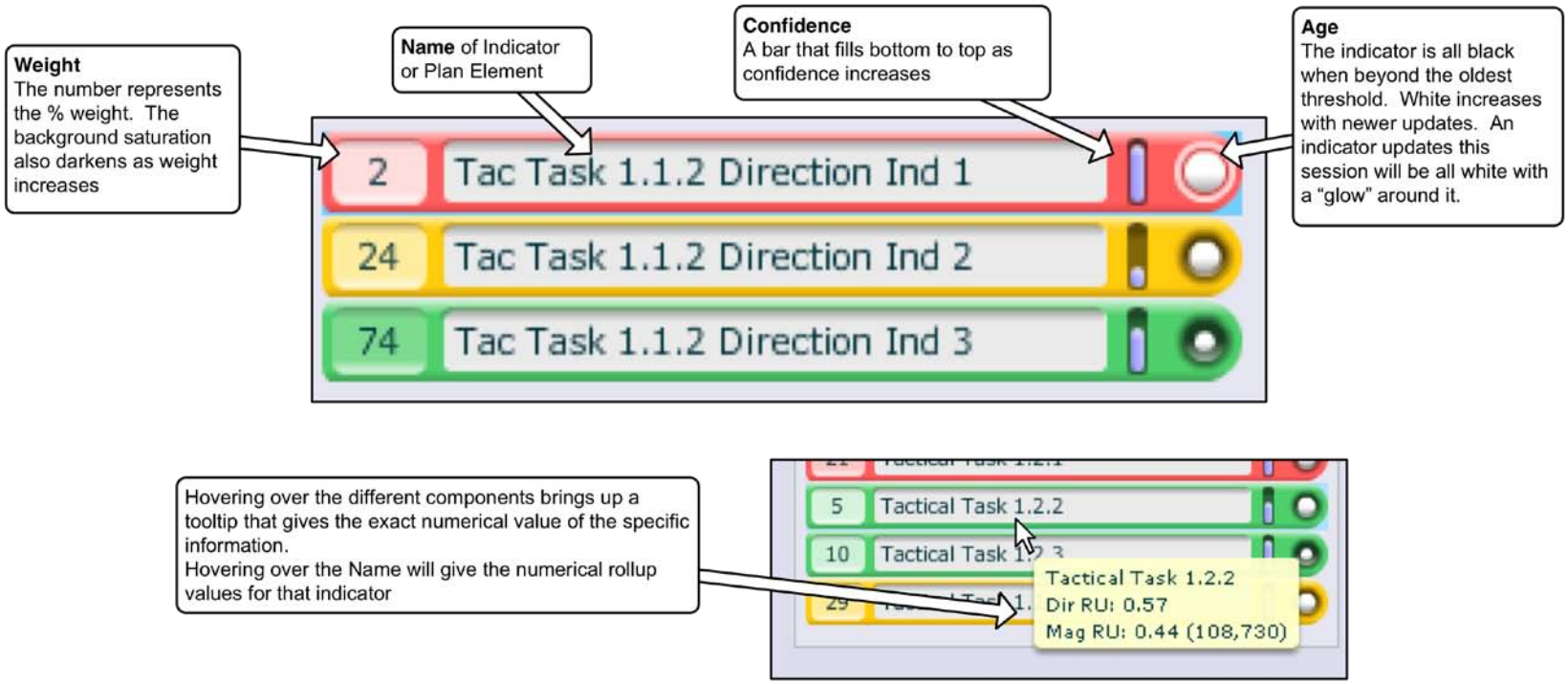

Indicator List (Influence)
Launches Weight Editor
Assessment Explorer
Tac Objective 1.1
Double Clicking an Indicator will bring up its Editor.
Double Clicking a Sub Op will Navigate to that Ops Detailed Assessment—the same as clicking on the Op in the Explorer.
Direction Indicator List
Magnitude Indicator List
Subordinate Op Rollup List. This is only present if displaying a Plan Element that has Sub Ops
total % weight for the group. (Only shown when there are Sub Ops
Direction Indicators (35%)
35 Tac Obj 1.1 Direction Ind 1
Magnitude Indicators (35%)
15 Tac Obj 1.1 Magnitude Ind 1
20 Tac Obj 1.1 Magnitude Ind 2
Sub Op Rollups (65%)
28 Tactical Task 1.1.1
5 Tactical Task 1.1.2
13 Tactical Task 1.1.3
1 Tactical Task 1.1.4
6 Tactical Task 1.1.5
12 Tactical Task 1.1.6
Tactical Task 1.1.2
Tactical Task 1.1.3
Tactical Task 1.1.4
Tactical Task 1.1.5
Tactical Task 1.1.6
Tac Objective 1.2
Tac Objective 1.3
Op Objective 2
Op Objective 3
Op Objective 4
Op Objective 5
Op Objective 6
x1000
x10
1
0
-1
0
1
Direction
Expected Magnitude: 146,900
< Edit
Normal
Global

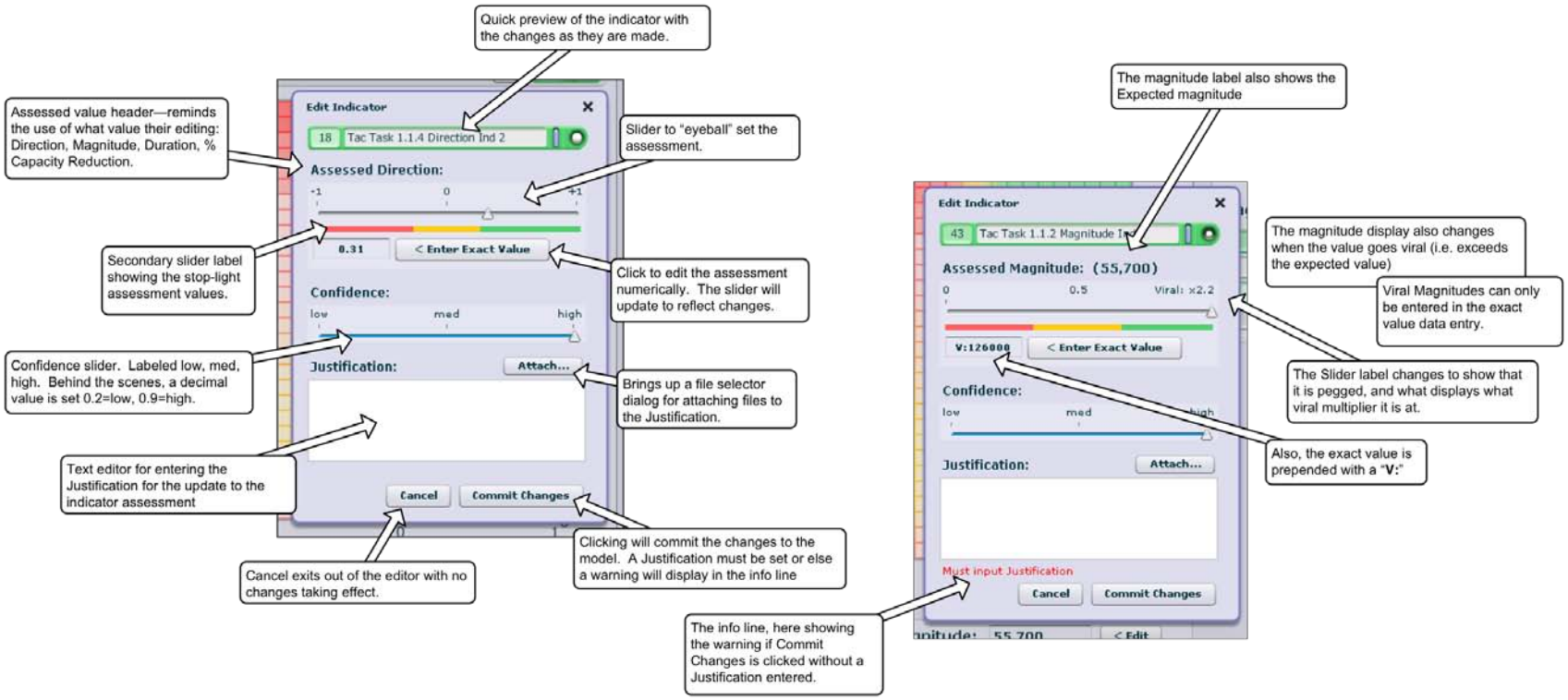
Detailed Assessment Graph (Active IO Assessment) – Plot Details

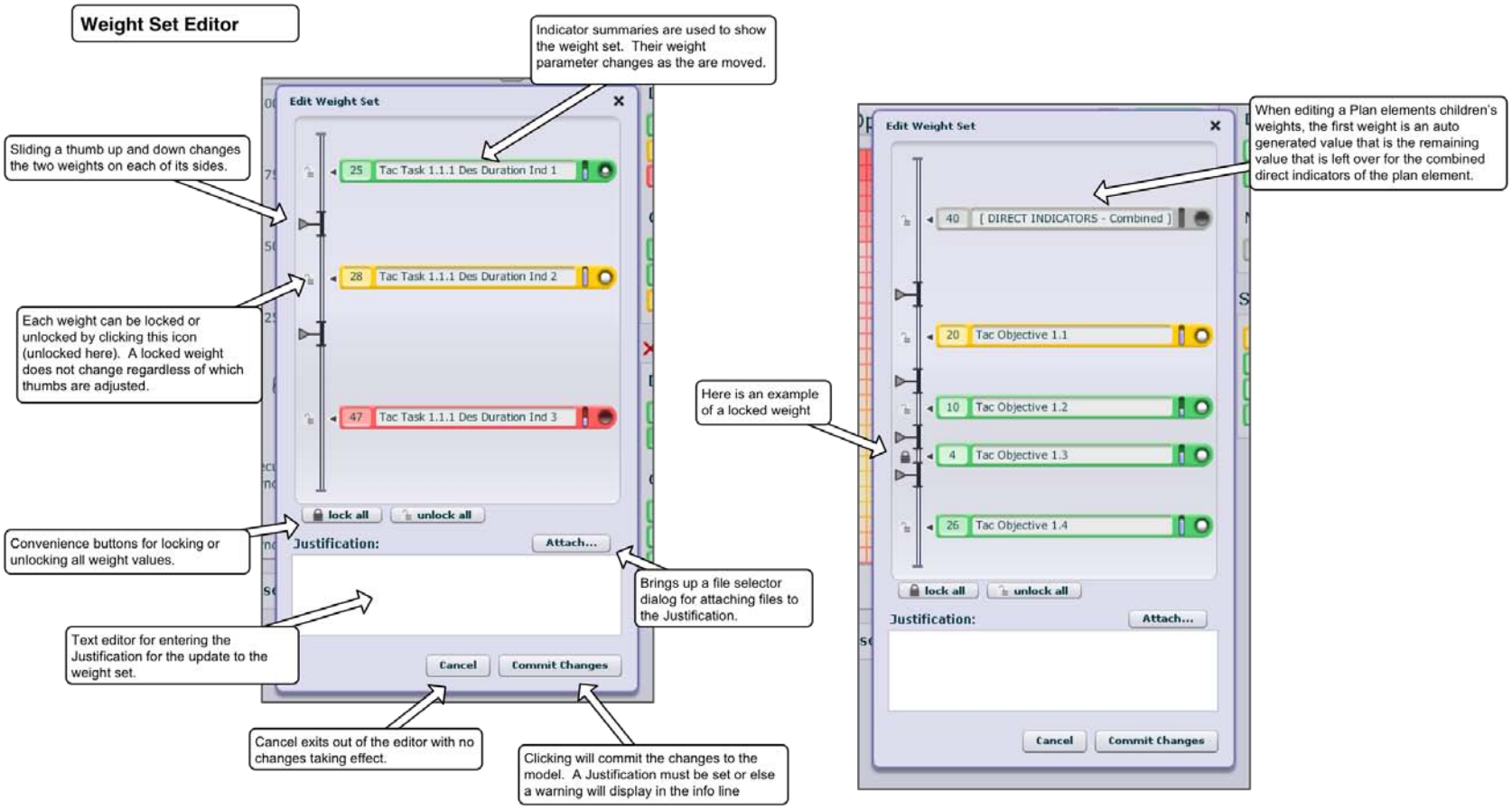


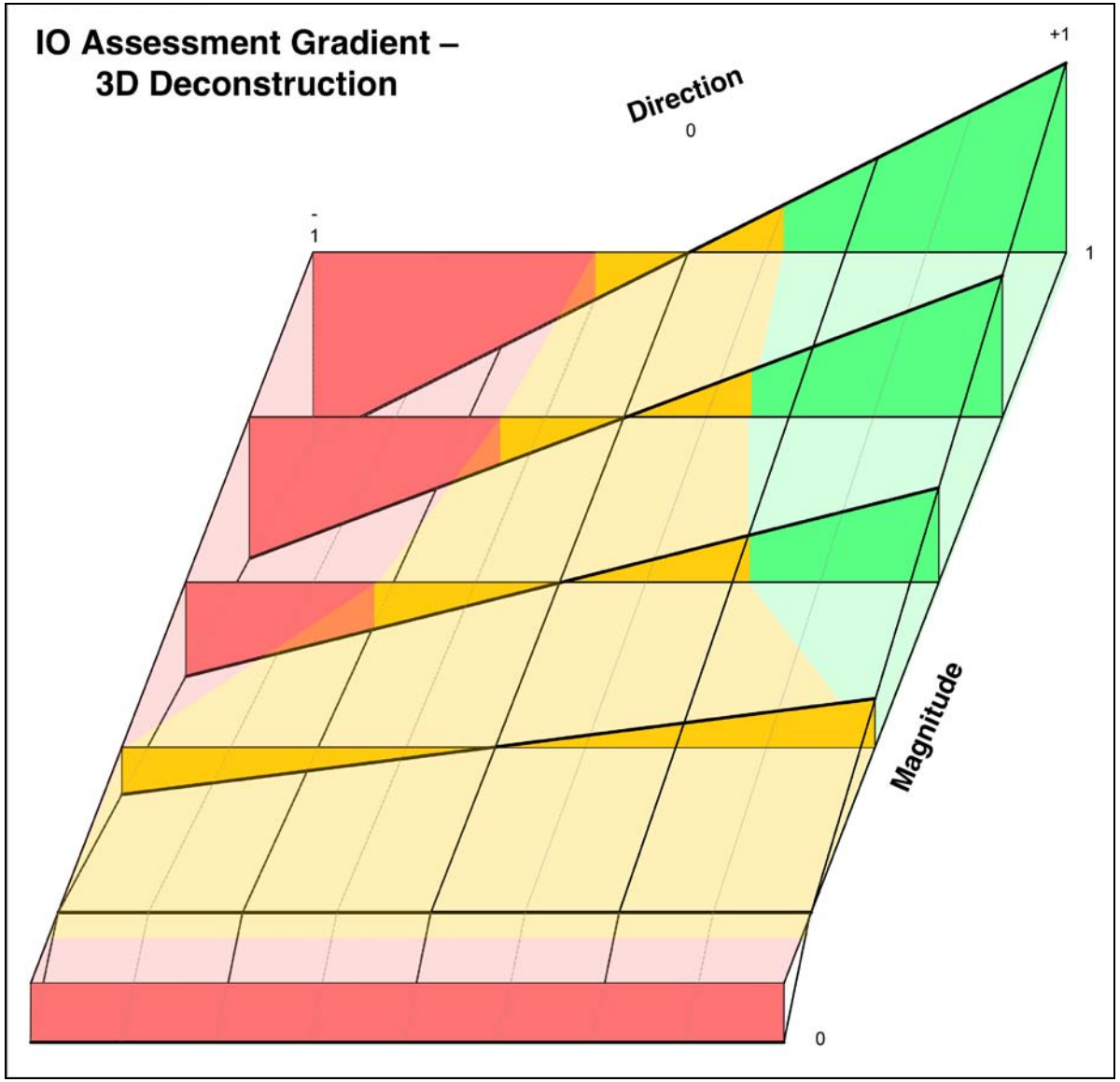


Indicator Summary




Quick preview of the indicator with the changes as they are made.
Assessed value header—reminds the use of what value their editing: Direction, Magnitude, Duration, % Capacity Reduction.
Slider to "eyeball" set the assessment.
Secondary slider label showing the stop-light assessment values.
Click to edit the assessment numerically. The slider will update to reflect changes.
Confidence slider. Labeled low, med, high. Behind the scenes, a decimal value is set 0.2=low, 0.9=high.
Brings up a file selector dialog for attaching files to the Justification.
Text editor for entering the Justification for the update to the indicator assessment
Cancel exits out of the editor with no changes taking effect.
Clicking will commit the changes to the model. A Justification must be set or else a warning will display in the info line
Edit Indicator
18
Tac Task 1.1.4 Direction Ind 2
Assessed Direction:
-1
0
+1
0.31
< Enter Exact Value
Confidence:
low
med
high
Justification:
Attach...
Cancel
Commit Changes
The magnitude label also shows the Expected magnitude
The magnitude display also changes when the value goes viral (i.e. exceeds the expected value)
Viral Magnitudes can only be entered in the exact value data entry.
The Slider label changes to show that it is pegged, and what displays what viral multiplier it is at.
Also, the exact value is prepended with a "V:"
The info line, here showing the warning if Commit Changes is clicked without a Justification entered.
Edit Indicator
43
Tac Task 1.1.2 Magnitude
Assessed Magnitude: (55,700)
0
0.5
Viral: x2.2
V:126000
< Enter Exact Value
Confidence:
low
med
high
Justification:
Attach...
Must input Justification
Cancel
Commit Changes





9.0 Fictional Scenario for Prototype Assessment Tool Evaluation

The following details the fictional scenario for the prototype assessment tool evaluation.

Operation Healing Voice -- Fictional Scenario

Background:

The country of Despotistan has been a closed society since the overthrow of the monarchy by a military junta some forty years ago. Since that time, the junta has controlled all media within the country, and has efficiently jammed foreign broadcasts. For their own part, they have offered a national message of total independence and self-reliance, in keeping with the principles animalistic state religion. The message also portrays all foreigners as enemies and usurpers, to be turned back at every sighting.

This has not prevented the junta from benefiting from the global economy. While most of the country is agrarian, they have trained in the three major urban areas, a core labor force in both electronic assembly and small-scale pharmaceutical production (mostly counterfeit versions of drugs still under patent), and offer low cost outsourcing to foreign manufacturers in Europe and Asia – with all contacts, and profits, strictly controlled by the ruling junta.

To aid in educating and maintaining this workforce, the junta has allowed the introduction of computer technology, including limited Internet access, to the civilian population. While private ownership is officially banned, Internet kiosks are common in the urban areas, and are spreading into the rural area. Intranet communication within the country is monitored, but otherwise unencumbered. The external Internet and telecommunications circuits are effectively firewalled and monitored by the junta to prevent external contacts. Official government communications within the country are routinely and effectively encrypted. Only radio and television broadcasts targeting the local population are made in the clear.

There is limited trade of goods and exchange of information across the guarded, but porous mountainous border with neighboring Agraria, which while tolerant of the Despotistan government, maintains good ties with the West.

Despotistan lacks an effective air force, having a roughly 20 EMB-314 Super Tucano propeller attack aircraft and another 20 MI-17 transport helicopters, some of which are believed to be operated as light gunships.

Air defense capability consists of Chinese manufactured AAA and QW-4 MANPAD missiles deployed with ground units.

Despotistant ground forces are formidable for the region, centered on a force of 100 Chinese Type 88B main battle tanks, and an additional 150 infantry fighting vehicles: 30 ZSD89 tracked APCs, and 90 wheeled ZSU-92s IFVs, and 30,

ZFB05 lightly armored 4x4s. Heavy units are tightly controlled by the central government, with ZSU and ZFB equipment found in local garrisons.

Crisis timeline:

Rumors of a plague in Despotistan have been communicated by border traders and smugglers in the neighboring country of Agraria. Twenty six days ago, a series of unsecured communications were intercepted from the Despotistan town of Varicelle, concerning an outbreak of disease among workers living near a pharmaceutical factory. Subsequently encrypted government communications within Despotistan increased dramatically, and satellite imagery shows that troops have deployed towards the border region. Despotistan public broadcast channels called for a nationwide travel ban enforced by the military for "reasons of national sovereignty and security", but offered little additional insight.

Twenty days ago, a contact was lost with a small mountain border village in Agraria. Agraria government workers investigating the village confirmed that all of the villagers were dead, with symptoms of an hemorrhagic illness combined with blackened skin on the face and extremities and in the more recent dead, red eyes. NGO medical personnel recognized the symptoms as classic hemorrhagic smallpox, and used vaccinated workers to quarantine the government workers and obtain samples that were sent to the Centers for Disease Control. Six days ago the CDC confirmed that the samples were a partial match to the *Rahima* strain of smallpox – a strain found in the WHO repositories. Four days ago, the government workers died, and the vaccinated NGO medical personnel caring for them developed first-stage symptoms of hemorrhagic small pox. Two days ago, the CDC informed the NCA that the smallpox was a genetically modified, weaponized version of the *Rahima* strain (GMPOX), that included a human interleukin 4 (IL-4) gene, rendering conventional vaccination therapy ineffective for containment. An experimental former-Soviet vaccine from the Biopreparat program is known to have greater efficacy against this modified virus.

Intel summary:

1) High confidence: With or without the knowledge of the Despotistan government, a pharmaceutical plant in the town of Varicelle was producing IL-4 modified smallpox as a biological weapon. The disease escaped containment and began uncontrolled spread in the local population.
2) Fact: IL-4 modified smallpox is highly contagious, with an incubation period of twelve days from contact to first symptoms (headache and fever). Death typically occurs within seven days of the onset of symptoms, with modern supportive therapy. The dried scabs of a victim are infectious for weeks to potentially years after death, depending on environmental conditions. The morbidity and mortality rate of the disease varies with the vaccination status of the victim as shown below:
    a. Unvaccinated: 100% mortality within 21 days of contact
    b. Conventional vaccination
        i. > 90 days after vaccination: 95% morbidity, 80% mortality
        ii. At least 14 days prior to exposure, but within 90 days of vaccination : 80% morbidity, 50% mortality
    c. Biopreparat vaccine at least14 days prior to exposure : 25% morbidity, 10% mortality
3) High confidence: Despotistan does not have the medical means to contain the disease, and are relying on physical quarantine to let the virus "burn itself out" in infected cities. Satellite imagery finds military roadblocks ringing the Varicelle area, with evidence of a shoot-on-approach policy. Border checkpoints and military hard points are configured against an outward threat.
4) Moderate confidence: IMINT evidence of roadblocks and civil disruption near the central hospital in the capital city of Despotistan indicate that the contagion may have spread there, in spite of the roadblocks.
5) Moderate confidence: Limitation of the availability of the Biopreparat-Moscow vaccine precludes preventative vaccination of the general population of the West. A crisis effort is underway, but suitable stocks for mass-vaccination in the West are estimated to be 18 to 24 months away.
6) High Confidence: Suitable stocks are available to attempt ring-vaccination containment methods at the Despotistan border and urban areas, and have been offered by former Soviet governments.
7) Estimated death toll if the virus is not contained to Despotistan ranges from 40 million to 340 million depending upon the assumptions used in the estimate.

CAP Objectives

A) Contain GMPOX to Despotistan until the epidemic burns itself out, with UN approval to.

1) Support NGO medical teams to contain the GMPOX epidemic within Despotistan.
2) Insert NGO or military medical teams into Despotistan to perform ring-vaccination containment of the GMPOX epidemic to urban areas, with or without Government approval.
3) Prevent by blockade and civil travel bans, travel out of the afflicted regions.
4) Maintain a reserve rapid response capability to perform ring-vaccination and diagnostics of suspected cases of GMPOX outside of Despotistan.

B) Sequal:

1) Support Despotistan in performing decontamination of urban areas after containment.

C) Branch:

1) In order to stave of a pandemic, former Soviet and Western forces have agreed to cooperate in sterilizing afflicted regions using appropriate weapons if containment proves ineffective.

IO / Assessment plan

Operation Healing Voice (IO support to CAP):

Operation Level Indicator (evaluate for direction and magnitude):
-- Despotistan public announcements on 5 national broadcast channels supporting western NGO and military support teams entering the country and encouraging assistance. Expected magnitude is all five channels, repeated every hour.

1) Operational Objective: Western public is informed of the risk of travel by personal from the plague area, and military & NGO efforts to contain the disease, without inducing panic (Public Affairs activity).
    a. Objective level Indicators:
        i. Polling indicating understanding of what-to-look-for, what-to-do in targeted areas (evaluate for direction, i.e., correct understanding, and magnitude). Expected magnitude is ≈ 25% of population.
    b. Tactical Objective
        i. Provide official news releases & PSAs (Public Affairs activity).
            1. Indicators (evaluate for both direction and magnitude)

a. Accurate, non-sensational stories appearing on US broadcast, CNN, BBC, Fox, and SkyNews.
b. Accurate, non-sensational stories appearing in print media (including mainstream electronic print media)

ii. Provide experts for background and on-air interviews to counter misconceptions (Public Affairs activity).
1. Indicators (evaluate for both direction and magnitude)
a. Accurate interviews US broadcast, CNN, BBC, Fox, and SkyNews

2) Operational Objective: Agraria civilian medical authorities are informed of the need to accurately isolate and report new cases through military channels.
a. Indicators (Evaluate for Direction and Magnitude based on all clinics reporting daily)
i. False-alarm reports (Chicken-pox & other benign rashes) are traced to facilities/physicians who have not received diagnostic guides.
b. Tactical Objective
i. Translate and distribute differential diagnosis and reporting guides to 1800 physicians, 124 clinics and 3 hospitals in targeted Agraria areas.
1. Tactical Task: Distribute to 200 physicians in border region.
a. Magnitude Indicators
i. Polling indicates >100% availability of diagnostic and reporting guides in medical facilities in Agraria border regions.
b. Direction Indicators
i. Medical education teams assess understanding and application of materials.
2. Tactical Task: Distribute to 1600 physicians in balance of Agraria.
a. Magnitude Indicators
i. Polling indicates >80% availability of diagnostic and reporting guides in medical facilities in Agraria.
b. Direction Indicators
i. Medical education teams assess understanding and application of materials.

3) Operational Objective: Despotistan government officials at national, regional and local levels are apprised of United Nations intent to insert medical teams, urged to cooperate to achieve containment, and warned of the certain consequences of containment failure.
    a. Indicators
        i. NGO teams, with Western military security and logistics, are unchallenged by organized military or police resistance in effecting ring vaccination (Direction only).
        ii. Public Despotistan broadcasts urging cooperation with Western NGO and military teams are detected (Evaluate for direction & magnitude (24 million/5 channels)
        iii. All five Despotistan heavy brigades return/remain in garrison (Direction & Magnitude)
    b. Tactical Objective: Influence National leadership (key 3 Generals)
        i. Tactical Task: Direct telephone contact
            1. Indicators (evaluate for magnitude & direction)
                a. Dialog established with 5 key national leaders (24 million total population)
        ii. Tactical Task: Direct email contact
            1. Indicators (evaluate for magnitude & direction)
                a. Dialog established with 5 key national leaders (24 million total population)
    c. Tactical Objective: Influence Provincial leadership (24 military governors)
        i. Tactical Task: Direct telephone contact
            1. Indicators (evaluate for magnitude & direction)
                a. Dialog established with 24 military governors (24 million total population)

        ii. Tactical Task: Direct email contact
            1. Indicators (evaluate for magnitude & direction)
                a. Dialog established with 24 military governors (24 million total population)
    d. Tactical Objective: Influence local urban leadership (city mayors, police chiefs, 12 total)
        i. Tactical Task: Direct telephone contact
            1. Indicators (evaluate for magnitude & direction)
                a. Dialog established with 12 local leaders
        ii. Tactical Task: Direct email contact
            1. Indicators (evaluate for magnitude & direction)
                a. Dialog established with 12 local leaders
    e. Tactical Objective: Open national firewall to allow outside contact from selected sources
        i. Tactical Task: Open Internet firewall
            1. Duration Indicators (3 to 21 days desired)

        a. Firewall opening remains for standard maintenance cycle length of seven days.
    2. Degree indicators (75 to 100% selected servers desired)
        a. Ping response on previously blocked ports on selected servers indicating reduction in firewall effectiveness.
    3. Collateral Duration Indicators: On detection of breach, firewall is locked down, typically in < 12 hours.
    4. Collateral Degree Indicators: Loss of contact to > 10% of normally opened ports

ii. Tactical Task: Open telecomm firewall
    1. Duration Indicators (3 to 21 days desired)
        a. Firewall opening remains for standard maintenance cycle length of seven days.
    2. Degree indicators (75 to 100% selected switches desired)
        a. Connection response on selected switches indicating reduction in firewall effectiveness.
    3. Collateral Duration Indicators: On detection of breach, firewall is locked down, typically in < 12 hours.
    4. Collateral Degree Indicators: Loss of contact to > 10% of normally opened ports

10.0 XML Plan File for Operation Healing Voice Scenario

The following is the plan file for Operation Healing Voice scenario in XML format.

```
<node ID="1" infopType="P" desc="Operation Healing Voice"
      longDesc="IO support to contain GM smallpox to Despotistan"
      baseMag="24000000" indWeight=".3" weight="1" weightLock="" confidence=".4"
age="99999" ass="N">
   <dirindis>
      <item ID="63" parentID="1" indiType="Dir" desired="true" desc="Chan A Public
broadcast analysis"
            longDesc="Influence Analysis Report on Despotistan public broadcast of
Channel A supporting western NGO and military support teams entering the country."
            weight=".334" weightLock="false" confidence=".5" age="1" ass="F"
assVal=".7"/>
      <item ID="64" parentID="1" indiType="Dir" desired="true" desc="Chan B Public
broadcast analysis"
            longDesc="Influence Analysis Report on Despotistan public broadcast of
Channel B supporting western NGO and military support teams entering the country."
            weight=".333" weightLock="false" confidence=".3" age="1"
ass="F"assVal=".3"/>
      <item ID="65" parentID="1" indiType="Dir" desired="true" desc="Chan C,D,E Public
broadcast analysis"
            longDesc="Influence Analysis Report on Despotistan public broadcast of
Channels C,D, and E (combined) supporting western NGO and military support teams
entering the country."
            weight=".333" weightLock="false" confidence=".6" age="3" ass="F"
assVal=".5"/>
   </dirindis>
   <magindis>
      <item ID="66" parentID="1" indiType="Mag" desired="true" desc="Chan A viewership
size"
            longDesc="Despotistan public broadcast Channel A viewership size
estimate."
            weight="0.334" weightLock="false" confidence=".5" age="5" ass="U"
assVal="5000000"/>
      <item ID="67" parentID="1" indiType="Mag" desired="true" desc="Chan B viewership
size"
            longDesc="Despotistan public broadcast Channel B viewership size
estimate."
            weight="0.333" weightLock="false" confidence=".5" age="5" ass="U"
assVal="2000000"/>
      <item ID="68" parentID="1" indiType="Mag" desired="true" desc="Chan C,D,E
viewership size"
            longDesc="Despotistan public broadcast Channel C,D, and E combined
viewership size estimate."
            weight="0.333" weightLock="false" confidence=".8" age="5" ass="U"
assVal="1000000"/>
   </magindis>
   <node ID="2" parentID="1" infopType="P" desc="OO1: (PA)Inform Western Public"
         longDesc="Western public is informed of the risk of travel by personal from
the plague area, and military and NGO efforts to contain the disease, without inducing
panic."
         baseMag="50000000" indWeight=".1" weight=".15" weightLock="false"
confidence="0" age="99999" ass="N" >
      <dirindis>
         <item ID="22" parentID="2" indiType="Dir" desired="true" desc="What-To-Do
Poll Results"
               longDesc="Polling results need to indicate understanding of what-to-
look-for, what-to-do in targeted areas."
               weight="1.0" weightLock="false" confidence=".9" age="0" ass="F"
assVal=".8"/>
      </dirindis>
      <magindis>
         <item ID="23" parentID="2" indiType="Mag" desired="true" desc="Phone Poll
favorable response ratio"
```

```
               weight="0.8" weightLock="false" confidence=".75" age="0" ass="F"
assVal="45000000"/>
         <item ID="24" parentID="2" indiType="Mag" desired="true" desc="Street Poll
favorable response ratio"
               weight="0.2" weightLock="false" confidence=".8" age="1" ass="A"
assVal="18000000"/>
      </magindis>
      <node ID="5" parentID="2" infopType="I" desc="TT1A: News releases and PSAs"
            longDesc="Provide official news releases and PSAs."
            baseMag="150000000" indWeight="1" weight=".35" weightLock="false"
confidence="0" age="99999" ass="N">
         <dirindis>
            <item ID="25" parentID="5" indiType="Dir" desired="true" desc="TV News
Analysis"
                  longDesc="Accurate, non-sensational stories appearing on US
broadcast, CNN, BBC, Fox, and SkyNews."
                  weight="0.7" weightLock="false" confidence=".6" age="0" ass="F"
assVal=".8"/>
            <item ID="26" parentID="5" indiType="Dir" desired="true" desc="Print News
Analysis"
                  longDesc="Accurate, non-sensational stories appearing in print media
(including mainstream electronic)."
                  weight="0.3" weightLock="false" confidence=".8" age="0" ass="F"
assVal=".9"/>
         </dirindis>
         <magindis>
            <item ID="27" parentID="5" indiType="Mag" desired="true" desc="TV News
audience size"
                  longDesc="US broadcast viewership size--CNN, BBC, Fox, and SkyNews
combined."
                  weight="0.7" weightLock="false" confidence=".9" age="5" ass="U"
assVal="6000000"/>
            <item ID="28" parentID="5" indiType="Mag" desired="true" desc="Print News
audience size"
                  longDesc="Source print media (including mainstream electronic)
distrubtion size."
                  weight="0.3" weightLock="false" confidence=".7" age="5" ass="U"
assVal="1800000"/>
         </magindis>
      </node>
      <node ID="6" parentID="2" infopType="I" desc="TT1B: Expert Interviews"
            longDesc="Provide experts for background and on-air interviews to counter
misconceptions."
            baseMag="35000000" indWeight="1" weight=".35" weightLock="false"
confidence="0" age="0" ass="N">
         <dirindis>
            <item ID="29" parentID="6" indiType="Dir" desired="true" desc="Interview
Assessment" weight="1.0" weightLock="false" confidence=".75" age="0" ass="F"
assVal=".9"/>
         </dirindis>
         <magindis>
            <item ID="30" parentID="6" indiType="Mag" desired="true" desc="Interview
Audience" weight="1.0" weightLock="false" confidence=".9" age="0" ass="A"
assVal="15000000"/>
         </magindis>
      </node>
   </node>
   <node ID="3" parentID="1" infopType="P" desc="OO2: Disseminate diagnostic/reporting
info"
         longDesc="Agraria civilian medical authorities are informed of the need to
accurately isolate and report new cases through military channels."
         baseMag="2000" indWeight=".2" weight=".25" weightLock="false" confidence="0"
age="99999" ass="N">
```

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APPENDIX II-B – TENEO ANALYSIS REPORT

Teneo

Interim Report – Teneo Analysis

30 March 2007

Project Title: Air Operations Center Strategy Planning Visualization Toolkit (AOC SPVT)
Contract No: FA8650-04-C-6537
Document ID: IR_12730.001_Teneo_21Jun07_V1.0

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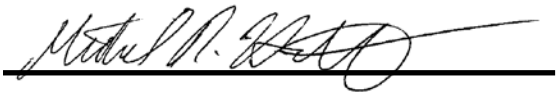

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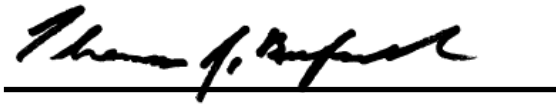

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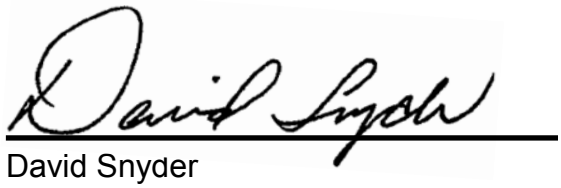

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Introduction

This final report will give an overview of the work accomplished by the SRA Teneo team. This report will include the initial feature set, appeal, and drawbacks of the Teneo software. All work performed by SRA is also documented here. Finally, recommendations on how to proceed are discussed.

Teneo Software Overview

Major Features

In analyzing the software, the source code, and the available documentation, the major functional features of Teneo have been identified. Please refer to Figure 1, "Teneo Screenshot", for a visual depiction of the features.

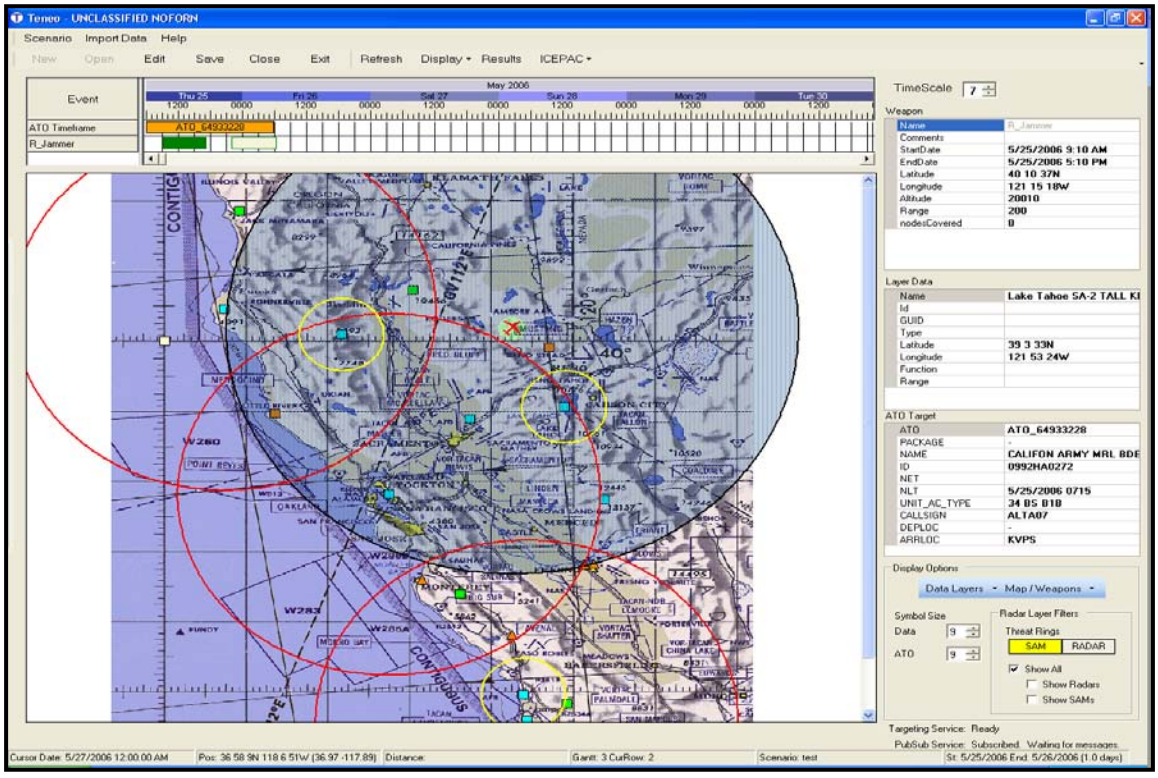

Figure 1: Teneo Screenshot

A map view with a customizable background is used to display targets, weapons, and Air Tasking Order (ATO) nodes. The different categories of items that are displayed are separated into layers that can be toggled on or off. Each layer contains a collection of nodes and each node contains detailed information that can be quickly shown to the user. If the node is a ranged weapon or a missile site, it will have a circle drawn around it that indicates its range. At any point, a snapshot of the map shown on the screen can be saved to a JPEG picture file.

A timeline, in the form of a Gantt chart, shows the period of activity of the ATO and weapons systems. This timeline is displayed in close proximity of the map view. A scenario playback feature can be used to show the advancement of time through the timeline. A 'current time' marker on the timeline shows the state of the scenario in hourly intervals. When a weapon system is active at the time indicated by this marker, its entry on the timeline is highlighted. Also, if it is a ranged weapon, the surrounding ring depicting the weapon's range becomes visible. Any target nodes that are affected by any active weapon are highlighted on the map and listed in a grid view.

Layer data can be imported from outside data sources. ATO target data can be imported from United States Message Text Format (USMTF) files. General layer data can be imported from Links and Nodes (".ln") files.

Teneo also includes an ATO viewer. This can be used to view any ATO entries in the current scenario or to preview an ATO that is stored in a file. The ATO is organized into four customizable grids: 'Ground targets,' 'Aircraft,' 'Missile targets,' and 'Units.' The grid can be successively grouped by any field in the ATO. It can also be sorted by any field.

Teneo's Appeal

Teneo's overall concept was well received by the user community. In particular, scenario playback and a temporal synchronization display in the form of a Gantt chart were identified as useful features. Also, having a selectable background allows the user to customize the view to suit their particular needs, and the detailed display of object (node) data gives easy access to a greater depth of information.

From a more technical perspective, USMTF support and the ATO grid are valuable assets. The ability to import directly from USMTF text format allows for standard information exchange with other systems and the grid control is easy to use and excels at sorting/grouping this type of tabular data.

Identified Issues/Drawbacks

While the concept that Teneo presents is excellent, the implementation has a lot of problems. The reason for this is that Teneo was meant to be a prototype not intended for release. It was developed very quickly for a specific audience and, as such, makes many assumptions. These assumptions preclude any error handling or concern for what a generic user may want. Errors are generally handled by failing and exiting the program. As a prototype, code comments are neither present nor expected and the provided documentation reflects the concepts of electronic warfare (EW), rather than providing insight into the software.

The code is not modular and is, in general, very fragile and inflexible. Because of this, the software is very resistant to modification, as mild changes can have catastrophic effects. The lack of modularity creates some confusing interdependencies between seemingly unrelated source files. Even moderate tasks (in either using the software or changing the code) become exceedingly difficult due to the design of the system.

Hard coded values in the source code make the final software difficult to use. For example, the software must be installed to 'C:\Teneo' with the data directory installed to 'C:\TeneoTargetData' or many things break. The saved scenarios cannot be easily transferred to another machine, or even another directory, easily. This is because the scenario files have links to many other files using absolute paths. Unless all of the referenced files are in exactly the same directories on both machines, the scenario cannot be read. The available weapons are also hard coded, so no new weapons can be added without modification of the source code (covered in the previous paragraph). The effects of the weapons are limited to layers, rather than nodes. For example, the 'R_Jammer' weapon affects only nodes in a layer specifically called 'Nodes_Radar'. If a radar site were located on another layer, the R_Jammer would not recognize it.

The graphical interface is not fully implemented. The user can do many things that the software allows, but is not equipped to handle. For example, trying to reorder the rows of the Gantt chart by dragging them with the mouse crashes the program. The windows are not designed to scale well and lower resolution screens are not shown crucial parts of the interface.

It should also be noted that objects do not move during animation (planes, etc). The only thing that moves is the 'current time' marker on the Gantt chart.

The technology behind the map view is ESRI (Environmental Systems Research Institute) MapObjects 2.3, which is quite old and is being phased out in favor of ArcObjects. ArcObjects is not backwards compatible with MapObjects and is considerably more expensive.

Due to the fact that Teneo is written in .NET directly bonds it to Microsoft Windows machines only, immediately eliminating the possibility of porting the software to other platforms, such as Solaris.

SRA Enhancements to Teneo

SRA incorporated the features discussed here into the Teneo prototype.

Launch Teneo from IWPC

SRA integrated Teneo to launch from the Information Warfare Planning Capability (IWPC) main menu. This involved minor modifications to the IWPC source code and the inclusion of a new source file in the IWPC code base.

Functionality was also added so as to import an ATO directly from Theatre Battle Operations Net-Centric Environment (TBONE) using a web services interface.

A 'wizard' interface was added to Teneo (accessible from the 'Import Data' menu), that walks the user through importing an ATO stored in TBONE. The user enters a username, a password, and a date range. Any ATO entries that start or end in the specified date range are returned for the user to select.

View IWPC Targets In Teneo

SRA enhanced Teneo to allow the user to view targets from IWPC through a special layer inside Teneo. The client is setup to retrieve any targets in the currently viewable map area automatically. These targets are retrieved from a web service on the application server. The functionality to pull targets from the IWPC database and the Modernized Integrated Data Base (MIDB) Data Access Layer (MDAL) was developed. Final integration testing against a copy of the MIDB was not performed due to the unavailability of a copy of the MIDB to SRA at the time.

Message Passing From IWPC Via Pub-Sub Web Service

SRA created a rudimentary publish-subscribe ("pub-sub") framework using web services in order to facilitate message passing from IWPC. This publish-subscribe framework follows the event driven model. An event driven model is present when changes to data by any client are then automatically reflected in all other clients. Publish-Subscribe accomplishes this by having each client "subscribe" to listen for changes to data, while the server will publish all changes to those who have subscribed.

This framework uses web service based registration of an endpoint. In this instance, the endpoints used a direct socket connection. Messages can be targeted at specific 'topics' or sent as broadcast messages. This framework was intended as a temporary implementation that would fit the needs of the project and should not be considered for a production level environment.

Target Data Retrieval from IWPC and MIDB

SRA created a web service to allow for the retrieval of target data from IWPC and the MDAL/MIDB based on a user-defined geographic area of interest. The service accepts latitude and longitude coordinates as rectangular bounds. Any targets that are located

within the bounds are returned in a list. The IWPC database and the MDAL/MIDB are used as data sources.

ATO Retrieval Via TBONE .NET Adapter

SRA developed a .NET adapter for TBONE to enable the retrieval of ATOs via a web service interface. The adapter makes both communication with TBONE and manipulation of TBONE data easier.

USMTF Parser

SRA repaired the existing USMTF parser. As Teneo was originally developed for the Korean area of the globe, certain assumptions were made about coordinate data and the format of timestamps. Because Korea is located in the first quadrant of the coordinate plane, all of its coordinate data will be positive numbers. To make the importer more generic, it was modified to expect any number.

Architecture View

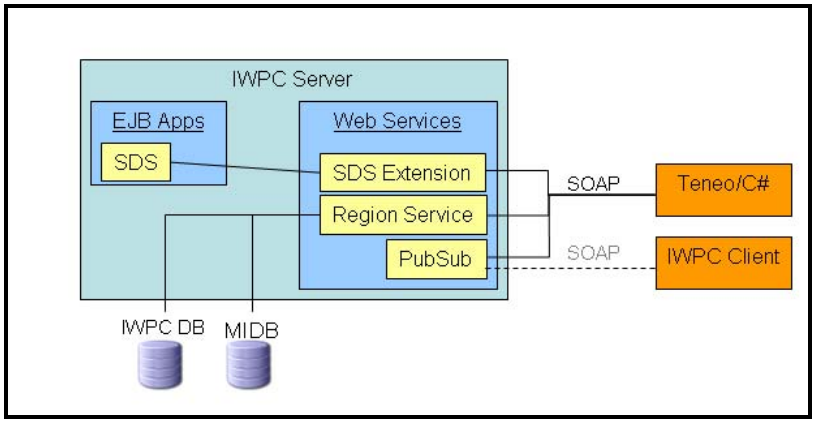

Figure 2: Basic Message Passing Structure.

The 'Region Service' in Figure 2, "Basic Message Passing Structure", is the service that retrieves targets from the IWPC database and MDAL/MIDB based on a geographic area. The 'SDS Extension' service acts essentially as a pass-through to the regular Strategy Development Service (SDS) EJB (Enterprise Java Bean).

Any links connecting to the pub-sub service are using the custom Publish-Subscribe implementation created by SRA. In the future, a standard WS-Notification/WS-Eventing (or other method) based solution can be used. At this time, no web service based approaches are usable. The IWPC client's connection to this web service was planned, but not implemented because the hour-by-hour granularity of Teneo does not fit with the day-by-day approach of IWPC.

Figure 3, "Message Passing Sequence", shows the sequence of events in utilizing the services to retrieve a list of targets and also retrieving an ATO from IWPC/TBONE.

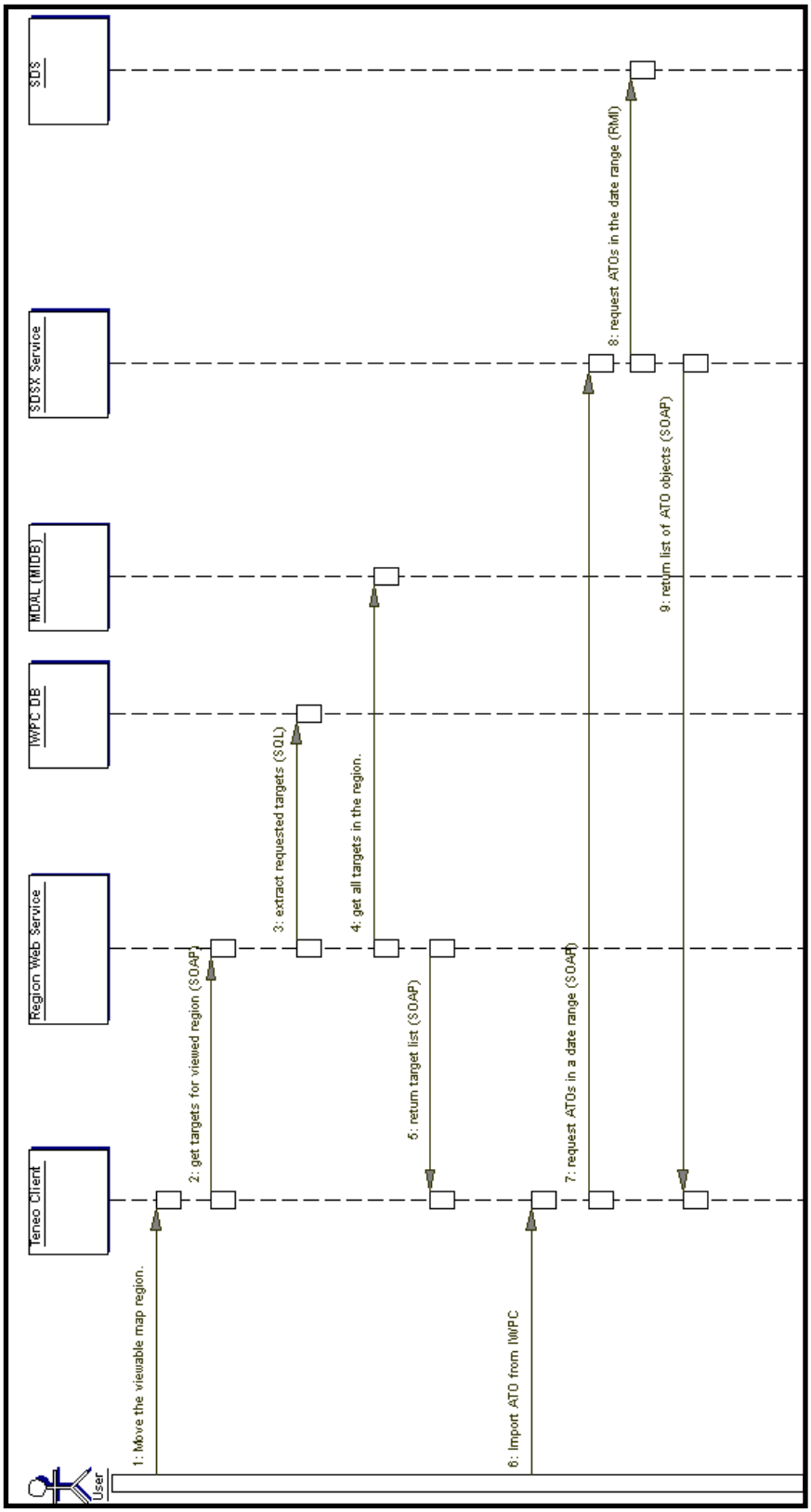

Figure 3: Message Passing Sequence

Recommendations

The existing implementation can be used to elicit quick user feedback that will reveal the requirements that it fulfills. These requirements can be added to the IOPC effort.

Due to the EW focus of Teneo, a functional comparison and operational workflow analysis should be performed with respect to Builder, IMOM, and Dynamic Course of Action Development (DCOAD). This comparison can be used to de-conflict the Teneo functionality with the DCOAD and other lab functionality being developed.

If a demonstrable prototype is required short term, a shift in technologies should be applied. Using the completed requirements list, moving to Java and BBN's OpenMap would provide a number of advantages. Using Java would allow for easier integration with the existing tools and OpenMap is already being used by most current systems, providing consistency for the interface.

If a prototype is not required short term, the Teneo feature set could be a focus of future technology prototyping.

The time required to develop a stable Java + OpenMap implementation is estimated at roughly 115 days, including 95 days to stabilize (re-engineer) the code base, with all of the features of Teneo as it was delivered to SRA, plus another 20 days to add in the enhanced connections to IWPC.

IWPC/SDS Integration Analysis

Current IWPC Architecture

IWPC is currently laid out around a Java 2 Enterprise Edition (J2EE) fat-client architecture with web services bolted on. There is nothing intrinsically wrong with IWPC using the faster, more reliable Java Remote Method Invocation (RMI) protocols to access the server, but the same functionality should be available to other users and applications through web services and thin web applications.

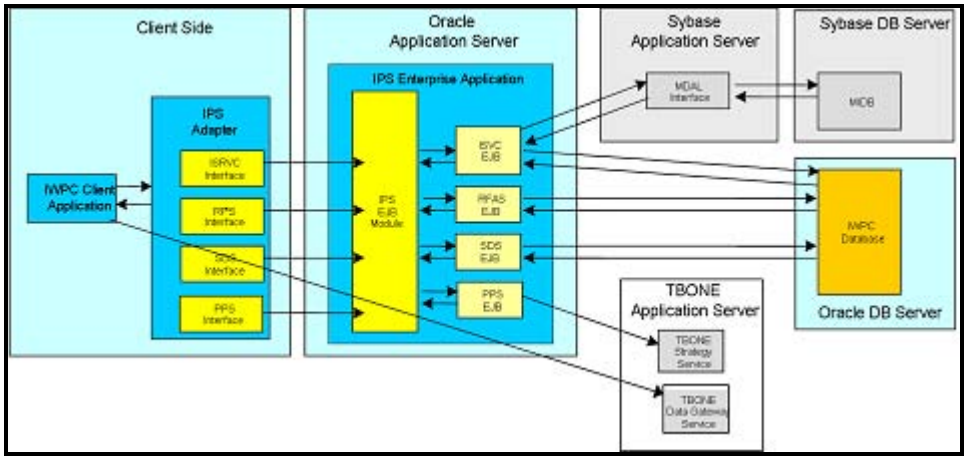

Figure 4: Current IWPC Fat-Client and J2EE Server-Side Applications

As noted in Figure 4, “Current IWPC Fat-Client and J2EE Server-Side Applications”, IPS serves as a wrapper for a number of other services within IWPC, these being as follows:

- ***IPS - Integrated Planning Service***

Wraps other service implementations. Strictly call-through.

- ***SDS - Strategy Development Service***

View, modify, lock and delete plan elements.

- ***ISVC - Intel Service***

Searches and retrieves data from MIDB.

- ***RFS/RFA - Request for Analysis Service***

Make and view requests, communicate results.

- ***PPS - Plan Publication Services***

Sends plan to TBONE in Collaborative Planning Tool (CPT)-XML format.

- ***BCS - Briefing Composer Service***

Browses database of briefing templates (based of off source code analysis and not actual documentation).

So far, we have identified SDS and ISVC as services that critically need to be updated for TENEO and IOPC-X. These two services provide access to the plan (SDS) and targets associated with the plan (ISVC). They also compose the bulk of the methods in IPS.

Below, we analyze the current state of the IWPC services before discussing how they may be improved.

IPS

The IPS web service deployment does not work at all. The Axis deployment descriptor appears to be duplicated from an earlier version of SDS. It is pointed at the wrong Java implementation class and attempting to browse the Web Service Description Language (WSDL) page caused Axis to crash with a classpath error. (missing i18n (internationalization) resource).

SDS

Unfortunately, SDS exposes the IWPC BaseEBOData model directly. The BaseEBOData model has a number of methods that expose the raw Java Object type. These types cannot be mapped correctly to Simple Object Access Protocol (SOAP).

SDS provides limited interoperability even if the configuration problems are corrected. It uses an Axis generated WSDL. These WSDLs are never fully WS-I compliant (even when Axis is using Document-Literal encoding). SDS is deployed at /SDS_RC/services and is a functional part of the IPSWeb service.

ISVC

ISVC does not have its own web service interface. It relies on the IPSWeb interface to expose a WSDL.

Proposed IWPC Architecture

Technologies

- ***WS-****

The WS-I Basic Profile defines a basic starting point for web service interoperability and most SOAP frameworks now support the basic interoperability and security profiles. These basic standards ensure that services can authenticate and exchange SOAP messages with other WS-I compliant systems. It is vital that any Net-Centric system follow these standards. J2EE 1.4 incorporates these standards and makes it much easier for developers to expose truly interoperable web services.

There are also a number of emerging WS-* standards that support interoperable ways of making security and message delivery guarantees. These advanced standards should be followed wherever possible; they allow clients and services to make assertions about the messaging system state that could not be done with the basic SOAP/HTTP protocol.

- ***Castor***

Castor is a data binding framework for Java objects. It has never been popular to the point of achieving standardization, but it is one of the oldest frameworks for marshaling Java to XML or Software Query Language (SQL). Castor is already being used within the IWPC client for importing and exporting plans and Courses of Action (COAs) to XML documents with well-defined schemas.

- ***Apache Axis***

IWPC currently uses Apache Axis 1.2.1 to export a web service endpoint to the IWPC service applications. Axis's default configuration is not suitable for interoperable, WS-I compliant web services. However, it does have built in support for Castor as an alternate framework for marshaling SOAP messages.

With a substantial configuration change and a limited amount of coding, we hope to leverage the existing Castor mappings from the IWPC client and export these schemas as the base data types for an interoperable web service. The focus of this plan is repairing and updating SDS in a relatively short timeframe to achieve SDS integration with other web service consumers, including Global Strike Pilot (GSP).

Tasks

This section lists the tasks needed to update the SDS web service to integrate the existing BaseEBOData Castor bindings from CPT with Axis and create a new deployment for Axis 1.x and OC4J 10.1.2.

Again, these tasks are based on an early June drop of the IWPC code and may not totally reflect the current status of IWPC 4.2.

a. Provide build scripts such that a deployable application can be generated in an automated way.

Risk: Low. Probably the easiest way to set up SDS is to provide an Ant script. If we encounter dependency cycles, we will have to configure the master build to do a partial pre-build.

b. Construct WSDL that defines methods for at least the following functionality:

- Listing available plans
- Retrieving available plans
- Creating new plans

Risk: Low. WSDL development is a generic and well documented process. Already have good understanding of XML, WSDL and XSD. CPT schema for BaseEBOData types is already defined. A schema for a limited number of SDS-specific classes (i.e. UniqueId and SdsUser) will need to be created. Need to understand Castor requirements and limitations for schema definitions. New schemas will need to be tested for compatibility with Castor.

c. Configure Axis deployment to leverage existing Castor bindings.

Risk: Medium. Castor/Axis integration is not well documented and Axis deployment problems can be difficult to debug. Also, IWPC services are deployed on Axis 1.2.1. Apache has put out significant bug fixes and Axis is currently at version 1.4. Many of these fixes focus on interoperability issues and it is possible that some of them will be relevant here. We may need to consider upgrading Axis.

d. Integrate new deployment into some kind of deployable patch, including:

- Review patch design options and coordinate with integrators. There are a number of unanswered questions about this task. Do we want a pre-install or a post-install patch? Can we patch the install directory and redeploy the application to the app server? Do we need to provide updates to the InstallAnywhere installer?
- Implement and bundle patch.
- Test patch bundle installer.

Risk: Unknown. Depends on the implementation chosen. The best option for a post-install patch is to provide a new SDS WAR to drop into the install directory and redeploy. This will not work if we need to make actual functional changes to SDS. The SDS EJB is deployed as part of IPS EAR. We may then need to provide functionality to update the EAR directly.

e. Testing and documentation, including:

- Unit tests, Functional tests.
- Compatibility tests. (WS-I, .NET, etc.)
- Updates to SDS/IPS VDDs.
- Document web service external interface.
- Support for security accreditation.

Risk: Medium. SDS provides very few unit tests, and testing will be difficult. SDS must be deployed to a container and have a real plan available in the database before it can operate. Tests and drivers will need to be developed for such functional tests.

f. Spiral in additional functionality, to include modifying any existing plans.

Risk: Medium. Adding functionality to lock and update should mostly consist of updating the WSDL. However, in order to make things safe for concurrent users, need to ensure that object modification time is easily available so GSP can lock, refresh, edit, unlock.

Issues

This section lists operational issues which would need to be addressed before pursuing any further efforts:

a. Axis Documentation

Detailed documentation on Axis serializers/deserializers is limited. In theory, changing Axis over to use the Castor serializer should be easy. In practice, problems with the deployment descriptor are difficult to debug. Fortunately, Axis is an open source product and we can refer to the original sources.

b. IWPC Build Management

General Dynamics has never provided an automated master build for IWPC. SRA has done some internal work on integrating the builds, and the SRA master build does produce an IPC services EAR. However, the SDS build is set up to be driven by the Maven3 build tool and so it was never integrated into the master build.

One would need to either get Maven set up and running or provide an Ant build for SDS. In either case, one will have to work within the constraints of a build that has been badly cross-coupled.

c. IWPC Installers

Either a new installer would need to be provided, or one would need to update the original IWPC installer. Some of this depends on deployment – will the SDS changes be deployed as a post-install patch, or as an update to IWPC 4.2?

Other Explored Technologies

Adobe Flex Data Services 2

Flex is a 'Rich Internet Application' (RIA) framework that uses standard J2EE server technologies and the Flash browser plug-in. It includes a transport mechanism to facilitate communication between web browsers and the server.

Flex has the ability to communicate asynchronously with a flash object embedded in a web page. It also has the ability to translate it's communications with the web page into messages using the Java Messaging Service (JMS). JMS is a stable communications interface with robust implementations available from all major application server vendors. Most vendors also provide a C interface to allow other languages to utilize the benefits of their publish-subscribe framework. This allows seamless communication between browser based applications and virtually any other platform. This communication method is depicted in Figure 5, "Architectural Use of Flex", below.

It should be noted that these capabilities could also be achieved with the Java plug-in using a regular applet. A deeper analysis would need to be performed.

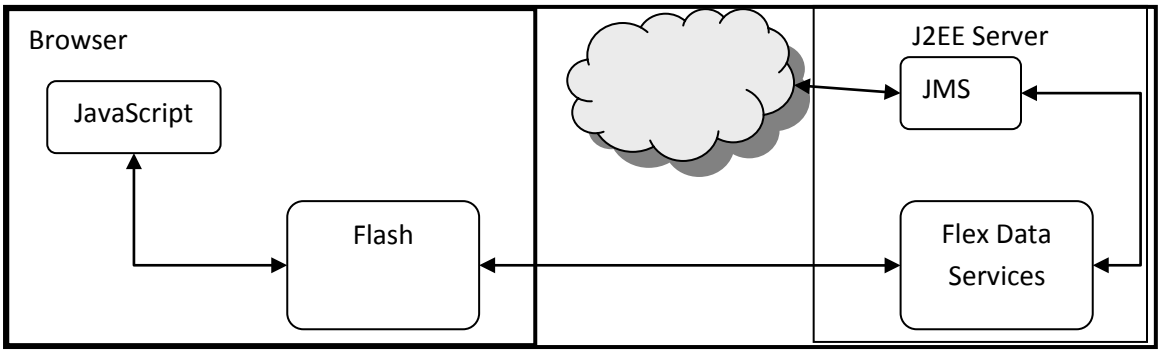

Figure 5: Architecture Use of Flex

Alternate JMS Implementations

Using the native calling interface to any particular application server will tie a non-Java client to that application server. However, alternate JMS implementations exist which are portable across many server platforms and provide a standard, stable interface to all clients. Examples of such implementations are ActiveMQ (www.activemq.org) and MantaRay (www.coridan.com) (among others).

Yahoo! User Interface Library

In order to ease the transition from fat client based solutions to thin client, web based solutions, Yahoo! Inc. created a set of JavaScript widget libraries that allow a web app to appear more like a desktop app. This library abstracts away the difficulties in creating a consistent layout across browsers and platforms. In removing these obstacles, the developer can concentrate on solving real problems, instead of wrestling with the technology.

More information can be found at http://developer.yahoo.com/yui

Summary

The analysis that was completed by SRA has shown that the current state of the Teneo prototype software has some fundamental problems. While the Teneo concept was well received and had many excellent features, the implementation was intended to be a prototype.

As such, Teneo in its present form is unstable and unusable in a real-world environment.

Teneo's appealing features including:

- a map view that can be customized with different backgrounds
- nodes can be displayed on the map view
- a map view that can be layered (introducing the ability to 'de-clutter' a display)
- the ability to save the map view as a picture file (JPEG)
- a Gantt chart timeline showing the ATO activity
- a 'playback' feature, that allows the user to advance through the timeline, showing the current state on the map view
- 'Threat Rings' showing the range of weapons on the map
- data import capability from USMTF and Links and Nodes formatted files
- a sorting and grouping capability for the data in the ATO in a grid format.

The appeal of Teneo is overshadowed by its frailty and the level of difficulty in maintaining the code. Moving forward with the current source code base is not recommended. Recommendations on how to proceed include performing a functional comparison between Teneo and existing lab technology in order to reduce duplicated functionality. A demonstrable short term prototype could be constructed using Java and OpenMap technologies. In lieu of a short term prototype, the Teneo feature set could be a focus for future technology prototyping.

Acronyms and Abbreviations

AOC	Air Operations Center
AOC SPVT	AOC Strategy Planning Visualization Toolkit
ATO	Air Tasking Order
BBN	BBN Technologies
BCS	Briefing Composer Service
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
COA	Course of Action
CPT	Collaboration Planning Tool
DCOAD	Dynamic Course of Action Development
EAR	Enterprise Archive File
EJB	Enterprise Java Bean
ESRI	Environmental Systems Research Institute
EW	Electronic Warfare
GSP	Global Strike Pilot
IMOM	Improved Many to Many
IO	Information Operations
IOPC-J	IO Planning Capability – Joint
IOPC-X	Integrated Operations Planning Capability – Prototype
IPC	Inter-Process Communications
IPS	Integrated Planning Service
ISVC	Intelligence Service (web service)
IWPC	Information Warfare Planning Capability
J2EE	Java 2 Enterprise Edition (Sun Microsystems, Inc.)
JPEG	Joint Photographic Experts Group
MDAL	MIDB Data Access Layer
MIDB	Modernized Integrated Data Base
.NET	XML Web Services Platform (Microsoft Corp.)
PPS	Plan Publication Services
Pub-Sub	Publish-Subscribe Service
RFS/RFA	Request for Analysis Service
RIA	Rich Internet Application
RMI	Java Remote Method Invocation
SDS	Strategy Development Service
SOAP	Simple Object Access Protocol
SRA	SRA International, Inc.
TBONE	Theatre Battle Operations Net-Centric Environment
USMTF	United States Message Text Format
VDD	Version Description Document
WS	Web Service(s)
WSDL	WS Description Language, WS Definition Language
XML	Extensible Markup Language
XSD	XML Schema Definition

APPENDIX II-C – TENEO SOFTWARE PRODUCT SPECIFICATION

Teneo

Software Product Specification

21 June 2007

Project Title: Air Operations Center
Strategy Planning Visualization Toolkit
(AOC SPVT)
Contract No: FA8650-04-C-6537
Document ID: SPS_12730.001_Teneo_21Jun07_V1.0

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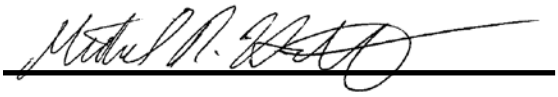

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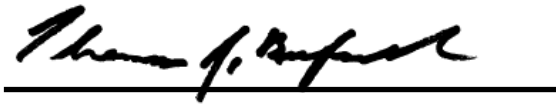

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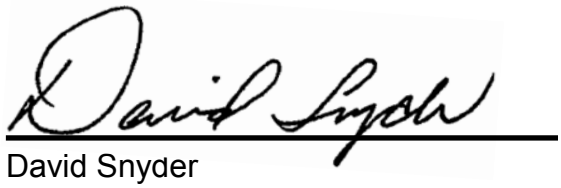

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Table of Contents

Scope

Identification

This document applies to the Teneo software. Teneo is a prototype and does not have a valid version number. References to the Information Warfare Planning Capability (IWPC) apply to version 4.2, delivered on June 21, 2006.

System Overview

Discussions with the Electronic Systems Center (ESC) Intelligence Surveillance and Reconnaissance Systems Group (ISRSG) indicated a potential for migrating code from the in-house "Teneo" prototyping project conducted by MITRE Corporation to support the maturing Information Operations (IO) Planning Capabilities program. The purpose of this code migration would be to leverage work already performed in the area of visualizations of air operations in support of strategic planning to further the IO Planning Capabilities program.

The system is comprised of the IWPC server software running on the Oracle application server (OAS), the IWPC client software, and the Teneo software. Communication from Teneo to the IWPC server was accomplished using standard web services. The Teneo software requests plans and targets from IWPC, which it then displays on its own screen. It acts like a viewer for the data inside IWPC without actually being built into the original system.

This was a prototyping effort, so there are no current or planned operating sites or support agencies. There is also no planned maintenance.

Document Overview

The purpose of this document is to serve as a companion to the contents of the delivered software disc. It will show what the software is supposed to accomplish, its environmental requirements are, and how to work with the disc's contents.

This document is unclassified and does not have any security or privacy considerations.

Referenced Documents

None.

Requirements

Executable Software

The disc that was delivered contains the following files that are necessary for execution:

/software

/client

/Teneo

AGCSN20.dll
ESRI.MapObjects2.Control.dll
ESRI.MapObjects2.Core.dll
ESRI.MapObjects2.Custom.dll
InputTrace.webinfo
Interop.MapObjects2.dll
Lic.rtf
OutputTrace.webinfo
SandBar.dll
Teneo.application
Teneo.exe
Teneo.exe.config
Teneo.exe.manifest
TeneoPubSub.dll
TeneoService.dll
iwpc-region-stub-1.0.dll
log4net.dll
log4net.xml
preferences.xml
teneo-data-1.0.dll
teneo-tbone-net-stub-1.0.dll
teneo-tbone-net.dll
wse3policyCache.config

/Scenario

/Califon_UNC/

7_11_2006_2_29_20_PM.jpg
CDScheduleObjects.xml
R_JammerScheduleObjects.xml
SandstormScheduleObjects.xml
TACMSPScheduleObjects.xml
ag.xml
deadnodes.xml
eventList.xml
scenario.xml
taskScheduleObjects.xml
thermoBaricScheduleObjects.xml

/TeneoTargetData

/ATOs

/Maps

GNC_N34_33_W125_38_F
GNC_N34_33_W125_38_F
ONC_Base.tfw
ONC_Base.tif

/ShapeFiles

CMTUtil.dll
CoreUtil.dll
CxImage.dll
Links_COAX.dbf
Links_COAX.shp
Links_COAX.shx
Links_FIBER.dbf
Links_FIBER.shp
Links_FIBER.shx
Links_LOS.dbf
Links_LOS.shp
Links_LOS.shx
Nodes_COAX.dbf
Nodes_COAX.shp
Nodes_COAX.shx
Nodes_FIBER.dbf
Nodes_FIBER.shp
Nodes_FIBER.shx
Nodes_LOS.dbf
Nodes_LOS.shp
Nodes_LOS.shx
Nodes_Radar.dbf
Nodes_Radar.shp
Nodes_Radar.shx
XMLArchive.dll
califon.fcn
califon.ln
califon.xml
expat_wrapper.dll
gdal12.dll
libexpat.dll
proj.dll
run.bat

/rpf

/IWPC

/app

/mainmenu

/bin

mainmenu.jar
mmthreads.jar

/bin
images.jar

/properties
mainmenu.properties

/server
iwpc-region-app-1.0.ear
iwpc-sdsx-app-1.0.ear
iwpc-xfmproxy-app-1.0.ear
teneo_service.war

Additional files are necessary in order to get the IWPC client running properly. The files included on the disc are only the files that were modified for this project. The four files for IWPC (mainmenu.jar, mmthreads.jar, images.jar, and mainmenu.properties) should be copied over an existing IWPC client installation with the same directory structure as the disc.

Source Files

The source files are located in the disc in the following directory structure under /source (files modified by SRA are listed in **bold** and files that were not modified/added by SRA are shown in grey):

/client
/IWPC
README.txt
build_all.xml
/ACE/common/com/btg/ace/util
Encrypt.java
/Database/iwpc/database/oracle/data
PlanData.java
/Main_Menu
/mmthreads
/applications:
/teneo
TeneoThreadMain.java
/threadmanager
ApplicationIDs.java
ThreadManager.java
/properties:
mainmenu.properties
/src
/mainmenu
MainMenuCOATabPanel.java
MainMenuFrame.java
/images
Teneo_Icon.png
/Teneo
/TeneoTargetData
/ATOs
/Maps
GNC_N34_33_W125_38_File.tfw

GNC_N34_33_W125_38_File.tif
ONC_Base.tfw
ONC_Base.tif
/ShapeFiles
CMTUtil.dll
CoreUtil.dll
CxImage.dll
Links_COAX.dbf
Links_COAX.shp
Links_COAX.shx
Links_FIBER.dbf
Links_FIBER.shp
Links_FIBER.shx
Links_LOS.dbf
Links_LOS.shp
Links_LOS.shx
Nodes_COAX.dbf
Nodes_COAX.shp
Nodes_COAX.shx
Nodes_FIBER.dbf
Nodes_FIBER.shp
Nodes_FIBER.shx
Nodes_LOS.dbf
Nodes_LOS.shp
Nodes_LOS.shx
XMLArchive.dll
califon.fcn
califon.ln
califon.xml
expat_wrapper.dll
gdal12.dll
libexpat.dll
proj.dll
run.bat
/rpf
/Teneo_Unclass:
DISCLAIMER.rtf
DTimer.ocx
ProductKeys.RTF
Readme.rtf
Teneo.csproj
Teneo.csproj.user
Teneo.ico
Teneo.sln
Teneo.suo
Teneo_TemporaryKey.pfx
UIDateTimeEditor.cs
UIDateTimeEditor.resx
UILongString.cs
UILongString.resx
app.config
fATO.cs
fATO.resx
fAbout.cs
fAbout.resx
fDeploying.cs

fDeploying.resx
fImporter.cs
fImporter.resx
fMain.cs
fMain.resx
fPreferences.cs
fPreferences.resx
fPropertyGrid.cs
fPropertyGrid.resx
fResultsNew.cs
fResultsNew.resx
fRow.cs
fRow.resx
fScenario.cs
fScenario.resx
fSplash.cs
fSplash.resx
fTboneAto.Designer.cs
fTboneAto.cs
fTboneAto.resx
fTboneAtoLogin.Designer.cs
fTboneAtoLogin.cs
fTboneAtoLogin.resx
licenses.licx
preferences.xml
splash.jpg
squareBlack.bmp
squareBlue.bmp
squareCyan.bmp
squareDarkGreen.bmp
squareGreen.bmp
squareGrey.bmp
squareMagenta.bmp
squareNavy.bmp
squareOrange.bmp
squareOrange_actual.bmp
squarePurple.bmp
squareRed.bmp
squareWhite.bmp
squareYellow.bmp
vcrEnd.bmp
vcrEnd1.bmp
vcrNext.bmp
vcrPrev.bmp
vcrReset.bmp
vcrStart.bmp
wse3policyCache.config
/BIOImporterDLL
- **BIOImporterDLL.dll**
- **BIOImporterTest.exe**

/Class Files
- **AssemblyInfo.cs**
- **CustomAxMap.cs**
- **DevicePropertySort.cs**
- **Devices.cs**
- **LongStringEditor.cs**

RegionHandler.cs
WSMessageListener.cs
init.cs
/Properties
Resources.Designer.cs
Resources.resx
Settings.Designer.cs
Settings.settings
/Scenario
/Califon_UNC
CDScheduleObjects.xml
R_JammerScheduleObjects.xml
SandstormScheduleObjects.xml
TACMSPScheduleObjects.xml
ag.xml
deadnodes.xml
eventList.xml
scenario.xml
taskScheduleObjects.xml
thermoBaricScheduleObjects.xml
/Teneo
Lic.rtf
/support software
Microsoft.Web.Services3.dll
SandBar.dll
TeneoPubSub.dll
TeneoService.dll
Xceed.Editors.dll
Xceed.Grid.UIStyle.dll.backup
Xceed.Grid.dll
Xceed.Grid.dll.backup
Xceed.UI.dll
iwpc-region-stub-1.0.dll
iwpc-region-stub-1.0.pdb
log4net.dll
log4net.pdb
log4net.xml
teneo-data-1.0.dll
teneo-data-1.0.pdb
teneo-tbone-net-stub-1.0.dll
teneo-tbone-net-stub-1.0.pdb
teneo-tbone-net.dll
teneo-tbone-net.pdb
wse3policyCache.config

/support software:
/TeneoPubSub
TeneoPubSub.csproj
TeneoPubSub.csproj.user
TeneoPubSub.sln
TeneoPubSub.suo
TeneoSubscriber
TeneoSubscriber.cs
/TeneoService
TeneoService.csproj
app.config
/Properties

Settings.Designer.cs
Settings.settings
/Web References
teneo.ws
/teneo.ws:
Reference.cs
Reference.map
TeneoService.wsdl
/TeneoSubscriber
TeneoHttpListener.cs
TeneoMessageListener.cs
TeneoSubscriber.cs
/Tester
Main.cs
TeneoMessageListenerTest.cs
TeneoService.dll
Tester.csproj
/Properties
AssemblyInfo.cs
/tbone
build.xml
/teneo-data
build.xml
project.properties
teneo-data.csproj
teneo-data.sln
teneo-data.suo
/Properties
AssemblyInfo.cs
/src/cs/mil/af/teneo/
/adapters
AdapterSourceException.cs
DataSource.cs
/tbone
AxisTBONEAdapter.cs
TBONEAdapter.cs
/data
ATO.cs
AbstractATO.cs
IWPCObject.cs
TBONEObject.cs
TeneoObject.cs
/tbone
TBONEATO.cs
/teneo-tbone-axis
BUILD.txt
CONTENTS.txt
axis-tbone-adapter.nunit
build.xml
classpath.xml
jtools.jardesc
local.properties
project.properties
teneo-tbone-axis.csproj
teneo-tbone-axis.csproj.user
teneo-tbone-axis.sln

teneo-tbone-axis.suo
/Properties
AssemblyInfo.cs
/TestCaseDriver:
Program.cs
TestCaseDriver.csproj
TestCaseDriver.csproj.user
/Properties
AssemblyInfo.cs
/lib
System.Xml.jar
System.jar
TboneGatewayXmlBeans-20060630.jar
XmlSchema-1.0.2.jar
activation-1.0.2.jar
axiom-api-1.0.jar
axiom-impl-1.0.jar
axis2-kernel-1.0.jar
backport-util-concurrent-2.2.jar
bcprov-jdk13-132.jar
commons-beanutils-core-1.7.0.jar
commons-codec-1.3.jar
commons-httpclient-3.0.jar
commons-logging-1.0.4.jar
gatewayXmlBeans-20060630.jar
javamail-1.3.2.jar
jaxen-1.1-beta-7.jar
log4j-1.2.11.jar
mscorlib.jar
neethi-1.0.1.jar
stax-1.1.2-dev.jar
stax-api-1.0.jar
teneo-data-1.0.jar
tools
wsdl4j-1.5.2.jar
wss4j-1.5.0.jar
xbean-2.1.0.jar
xmlsec-1.3.0.jar
/tools
asm-2.2.1.jar
axis-ant.jar
checkstyle
checkstyle-all-4.1.jar
cobertura.jar
commons-cli-1.0.jar
commons-lang-2.1.jar
easymock-2.2.jar
jakarta-oro-2.0.8.jar
jakarta-regexp-1.3.jar
jaxen-1.1-beta-7.jar
jdepend
jdepend-2.9.jar
lint4j.jar
log4j-config.jar
pmd
pmd-3.7.jar

pmd-config.jar
svnClientAdapter.jar
svnant.jar
svnjavahl.jar
/checkstyle
checkstyle-frames.xsl
checkstyle-importcontrol.xml
checkstyle-sun.xml
checkstyle-suppressions.xml
checkstyle-text.xsl
/jdepend
jdepend-frames.xsl
/pmd
arrow_down.gif
arrow_up.gif
corley-pmd-report.xslt
fcoltable.css
fcoltable.js
only-prio1.xslt
only-prio2.xslt
only-prio3.xslt
only-prio4.xslt
only-prio5.xslt
pmd-report-per-class.xslt
pmd-report.xslt
sorttable.js
wz-pmd-report.xslt

/src
/cs/mil/af/teneo/adapters/tbone
CAxisTBONEAdapterImpl.cs
/ctest/mil/af/teneo/adapters/tbone
TestCAxisTBONEAdapterImpl.cs
/dot
project-deps.dot
/java
log4j.xml
tbone-types.properties
/mil/af
/spvt/tbone
/converters:
ConversionException.java
Converter.java
LocalObject.java
package.html
/dal
AdapterSourceException.java
ConfigurationException.java
DataMaintenanceDAL.java
DataMaintenanceDALImpl.java
DataMaintenanceStub.java
DownloadInterruptedException.java
IdTranslator.java
LocalObjectCache.java
LocalObjectCacheImpl.java
LocalObjectNotFoundException.java
MappedRelationshipProxy.java

RelationshipProxy.java
TASObjectCache.java
TASObjectNotFoundException.java
TBONEConnectionConstants.java
TBONEQuery.java
XMLBeansDataMaintenanceStub.java
package.html
/state
DALState.java
DataMaintenanceDALImplState.java
LocalObjectCacheState.java
MappedRelationshipProxyState.java
StatefulCache.java
TASObjectCacheState.java
package.html
/gnuclasspath
PromiscuousCertificateHandler.java
package.html
/loaders
AbstractLoader.java
DefaultATOLoader.java
Loader.java
package.html
/types
ATOType.java
TasType.java
UnknownType.java
package.html
/utils
ArrayUtils.java
EqualsBuilder.java
HashCodeBuilder.java
PropertyUtils.java
PropertyUtilsBean.java
StringUtils.java
XMLSafePropertyBean.java
package.html
/teneo/adapters/tbone:
JAxisTBONEAdapterImpl.java
JExceptionHelper.java
package.html
/converters
ATOConverter.java
AbstractConverter.java
LocalObjectWrapper.java
package.html
/loaders
ATOLoader.java
package.html
/test/mil/af:
BaseTest.java
/spvt/tbone:
/dal:
TestAdapterSourceException.java
TestDataMaintenanceDAL.java
TestDataMaintenanceStub.java
TestIdTranslator.java

TestLocalObjectCache.java
TestRelationshipProxy.java
TestTASObjectCache.java
TestTBONEQuery.java

/loaders

TestAbstractLoader.java
TestDefaultATOLoader.java

/types

TestATOType.java
TestTasType.java
TestUnknownType.java

/utils

TestPropertyUtils.java
TestXMLSafePropertyBean.java

/tools/org/apache/log4j

AppenderSkeletonBeanInfo.java
ConsoleAppenderBeanInfo.java
LayoutBeanInfo.java
PatternLayoutBeanInfo.java
WriterAppenderBeanInfo.java

/tools

CONTENTS.txt
ikvmc.exe.config
ikvmstub.exe.config

/teneo-tbone-net

app.config
build.xml
classpath.xml
local.properties
project.properties
tbone-types.Designer.cs
tbone-types.resx
teneo-tbone-net.csproj
teneo-tbone-net.csproj.user
teneo-tbone-net.nunit
teneo-tbone-net.sln
teneo-tbone-net.suo
wse3policyCache.config

/Properties:

AssemblyInfo.cs
Settings.Designer.cs
Settings.settings

/TestCaseDriver

Program.cs
TestCaseDriver.csproj

/Properties

AssemblyInfo.cs

/lib

Microsoft.Web.Services3.dll
log4net.dll
log4net.pdb
log4net.xml
teneo-data-1.0.dll
teneo-data-1.0.pdb

/tools

NMock2.dll

nunit.common.dll
nunit.core.dll
nunit.framework.dll

/src

/cs/mil/af

/spvt/tbone

/converters:

ConversionException.cs
Converter.cs
LocalObject.cs

/dal

AdapterSourceException.cs
ConfigurationException.cs
DataMaintenanceDAL.cs
DataMaintenanceDALImpl.cs
DataMaintenanceStub.cs
DownloadInterruptedException.cs
IdTranslator.cs
LocalObjectCache.cs
LocalObjectCacheImpl.cs
LocalObjectNotFoundException.cs
MappedRelationshipProxy.cs
RelationshipProxy.cs
Security.cs
TASObjectCache.cs
TASObjectNotFoundException.cs
TBONEConnectionConstants.cs
TBONEQuery.cs
WSE3DataMaintenanceStub.cs

/state

DALState.cs
DataMaintenanceDALImplState.cs
LocalObjectCacheState.cs
MappedRelationshipProxyState.cs
StatefulCache.cs
TASObjectCacheState.cs

/loaders

AbstractLoader.cs
DefaultATOLoader.cs
Loader.cs

/types

ATOType.cs
TasType.cs
UnknownType.cs

/utils

EqualsBuilder.cs
HashCodeBuilder.cs
Log4NetLogger.cs
LogFactory.cs
Logger.cs
NullLogger.cs
PropertyUtils.cs
PropertyUtilsBean.cs
StringUtils.cs

/teneo/adapters/tbone

WSE3TBONEAdapter.cs

/converters
ATOConverter.cs
AbstractConverter.cs
LocalObjectWrapper.cs
/loaders
ATOLoader.cs
/ctest/mil/af/
BaseTest.cs
/spvt/tbone
/dal:
TestDataMaintenanceDAL.cs
TestIdTranslator.cs
TestLocalObjectCache.cs
TestRelationshipProxy.cs
TestTASObjectCache.cs
TestTBONEQuery.cs
/loaders
TestAbstractLoader.cs
TestDefaultATOLoader.cs
/types
TestATOType.cs
TestTasType.cs
TestUnknownType.cs
/wsdl
DataMaintenanceService.wsdl
/xsd
GatewayServices.xsd
TBONE.xsd

./server
/Region
Region.jpx
Region.jpx.local
Region.jpx.local~
build.xml
classpath.xml
lib.library
local.properties
project.properties
stubs.library
/client/mil/af/iwpc/region/client
ClientTest.java
/lib
MDALobjects.jar
UtilsCoreData.jar
UtilsStorageAdapters.jar
activation-1.0.2.jar
axis-1.4.jar
castor-1.0.1-xml.jar
commons-discovery-0.2.jar
commons-logging.jar
iwpcdb2.jar
javamail-1.3.2.jar
jaxrpc-1.1.jar
jaxrpc.jar
jug.jar
log4j-1.2.11.jar

saaj-1.2.jar
tools
utils.jar
wsdl4j-1.5.1.jar
xercesImpl-2.8.0.jar
xml-apis.jar
zonule-utils-1.0.jar
/tools
asm-2.2.1.jar
axis-ant.jar
checkstyle-all-4.1.jar
cobertura.jar
commons-cli-1.0.jar
commons-lang-2.1.jar
jakarta-oro-2.0.8.jar
jakarta-regexp-1.3.jar
jaxen-1.1-beta-7.jar
jdepend-2.9.jar
lint4j.jar
log4j-config.jar
pmd-3.7.jar
pmd-config.jar
svnClientAdapter.jar
svnant.jar
svnjavahl.jar
/checkstyle
checkstyle-frames.xsl
checkstyle-importcontrol.xml
checkstyle-sun.xml
checkstyle-suppressions.xml
checkstyle-text.xsl
/jdepend
jdepend-frames.xsl
/pmd
arrow_down.gif
arrow_up.gif
corley-pmd-report.xslt
fcoltable.css
fcoltable.js
only-prio1.xslt
only-prio2.xslt
only-prio3.xslt
only-prio4.xslt
only-prio5.xslt
pmd-report-per-class.xslt
pmd-report.xslt
sorttable.js
wz-pmd-report.xslt
/src
/java:
log4j.xml
/mil/af/iwpc/
/region/service
RegionExtensionWrapper.java
/axis/wrappers
GetTargetRequest.java

Target.java
TargetResults.java
TargetsList.java

/sds/axis

CastorDeserializer.java
CastorDeserializerFactory.java
CastorSerializer.java
CastorSerializerFactory.java
MappingSingleton.java

/latex

GNCI-ROM-Assessment.tex
GSP-IOPCX-plan.tex
GSP-IWPC-plan.tex
IPS-interface.tex
ISVC-interface.tex
SDS-interface.tex
iwpc.eps
iwpc.orig.png
iwpc.png
technology-assessment.tex

/map

RegionTypeMapping.xml

/stub-test/mil/af/iwpc/sdsx/client

LiveServiceTest.java
TestGetEffect.java
TestGetPlan.java
TestGetTarget.java

/test/mil/af/iwpc

AllTests.java

/region/castor

AllTests.java
BindingTest.java
TestGetTargetRequestBinding.java
TestGetTargetResponseBinding.java

/sds/castor

AllTests.java
BindingTest.java
TestLockBinding.java
TestLockRequestBinding.java
TestStratPlanBinding.java

/wsdd

server-config.wsdd

/wsdl

Region.wsdl

/xsd

Region-Types.xsd

/SDSX

build.xml
classpath.xml
local.properties
project.properties

/lib

SdsCommon.jar
SdsWebService.jar
UtilsCoreData.jar
UtilsStorageAdapters.jar

activation-1.0.2.jar
axis-1.4.jar
castor-1.0.1-xml.jar
commons-discovery-0.2.jar
commons-logging.jar
javamail-1.3.2.jar
jaxrpc-1.1.jar
jaxrpc.jar
jug.jar
log4j-1.2.11.jar
saaj-1.2.jar
utils.jar
wsdl4j-1.5.1.jar
xercesImpl-2.8.0.jar
xml-apis.jar
zonule-utils-1.0.jar
/tools
- **asm-2.2.1.jar**
- **axis-ant.jar**
- **checkstyle**
- **checkstyle-all-4.1.jar**
- **cobertura.jar**
- **commons-cli-1.0.jar**
- **commons-lang-2.1.jar**
- **jakarta-oro-2.0.8.jar**
- **jakarta-regexp-1.3.jar**
- **jaxen-1.1-beta-7.jar**
- **jdepend**
- **jdepend-2.9.jar**
- **lint4j.jar**
- **log4j-config.jar**
- **pmd**
- **pmd-3.7.jar**
- **pmd-config.jar**
- **svnClientAdapter.jar**
- **svnant.jar**
- **svnjavahl.jar**
- /checkstyle
  - **checkstyle-frames.xsl**
  - **checkstyle-importcontrol.xml**
  - **checkstyle-sun.xml**
  - **checkstyle-suppressions.xml**
  - **checkstyle-text.xsl**
- /jdepend
  - **jdepend-frames.xsl**
- /pmd
  - **arrow_down.gif**
  - **arrow_up.gif**
  - **corley-pmd-report.xslt**
  - **fcoltable.css**
  - **fcoltable.js**
  - **only-prio1.xslt**
  - **only-prio2.xslt**
  - **only-prio3.xslt**
  - **only-prio4.xslt**
  - **only-prio5.xslt**

pmd-report-per-class.xslt
pmd-report.xslt
sorttable.js
wz-pmd-report.xslt

/src

/java

log4j.xml

/mil/af/iwpc

/client/axis/utils

ClientConfigUtils.java

/data/ebodata

StratPlanWrapper.java

/castor/handlers

CPTBooleanHandler.java
CPTDateHandler.java
CPTDayHandler.java

/sdsx

/service

SDSExtensionWrapper.java
TargetType.java

/axis:

/encoding

CastorDeserializer.java
CastorDeserializerFactory.java
CastorSerializer.java
CastorSerializerFactory.java
MappingSingleton.java

/wrappers

GetBaseEBODataRequest.java
GetBaseEBODataResponse.java
GetEffectRequest.java
GetEffectResponse.java
GetPlanRequest.java
GetPlanResponse.java
GetTargetRequest.java
GetTargetResponse.java

/latex

GNCI-ROM-Assessment.tex
GSP-IOPCX-plan.tex
GSP-IWPC-plan.tex
IPS-interface.tex
ISVC-interface.tex
SDS-interface.tex
iwpc.eps
iwpc.orig.png
iwpc.png
technology-assessment.tex

/map

CoaMapping.xml
SDSEBOTypeMapping.xml
SDSTypeMapping.xml
SDSXTypeMapping.xml
StratPlanMapping.xml

/stub-test/mil/af/iwpc/sdsx/client

LiveServiceTest.java
TestGetEffect.java

TestGetPlan.java
TestGetTarget.java

/test/mil/af/iwpc

AllTests.java

/cpt/castor

AllTests.java
BindingTest.java
TestCapabilityBinding.java
TestCausalLinkBinding.java
TestEffectBinding.java
TestFacilityTargetBinding.java
TestGenericAssetBinding.java
TestGenericTargetBinding.java
TestIndicatorBinding.java
TestObsOppBinding.java
TestPhaseBinding.java
TestPlanElementBinding.java
TestStratPlanBinding.java
TestUnitTargetBinding.java

/sds/castor

AllTests.java
BindingTest.java
TestLockBinding.java
TestLockRequestBinding.java
TestSdsUserBinding.java
TestStratPlanBinding.java
TestUniqueIdBinding.java

/sdsx/castor

AllTests.java
BindingTest.java
TestGetEffectRequestBinding.java
TestGetEffectResponseBinding.java
TestGetPlanRequestBinding.java
TestGetPlanResponseBinding.java
TestGetTargetRequestBinding.java
TestGetTargetResponseBinding.java

/wsdd

sdsx-client-config.wsdd
server-config.wsdd

/wsdl

SDSX.wsdl

/xsd

SDS-Types.xsd
SDSX-Types.xsd
V42_AssetElement.xsd
V42_Asset_List.xsd
V42_Asset_List_Structure.xsd
V42_BaseEBOData.xsd
V42_CapabilityCollection.xsd
V42_EffectElement.xsd
V42_IO_Plan.xsd
V42_IO_Plan_Basic.xsd
V42_IO_Plan_Intermediate.xsd
V42_IO_Plan_Structure.xsd
V42_IO_Plan_TargetAndAsset.xsd
V42_IndicatorCollection.xsd

V42_IndicatorStatus.xsd
V42_JTTTargetList.xsd
V42_LinkElement.xsd
V42_ObsOpsCollection.xsd
V42_PlanElement.xsd
V42_Plan_Basic.xsd
V42_Plan_CC.xsd
V42_StratPlan.xsd
V42_TargetElement.xsd
V42_Target_List.xsd
V42_Target_List_Structure.xsd

/XFMProxy

build.xml
classpath.xml
local.properties
project.properties

/lib:

activation-1.0.2.jar
axis-1.4.jar
castor-1.0.1-xml.jar
commons-discovery-0.2.jar
commons-logging.jar
javamail-1.3.2.jar
jaxrpc-1.1.jar
jaxrpc.jar
jug.jar
log4j-1.2.11.jar
saaj-1.2.jar
wsdl4j-1.5.1.jar
wss4j-1.5.0.jar
xercesImpl-2.8.0.jar
xml-apis.jar

/src

/java

log4j.xml

/mil/af/iwpc/xfmproxy

Constants.java

/service

XFMProxy.java

/axis

AxisFaultHandler.java
PWCallback.java

/transforms

SoapFilter.java
WSAddressingVersionFix.java

/wsdd

server-config.wsdd

/wsdl

DataMaintenanceService.wsdl

/xsd

GatewayServices.xsd
TBONE.xsd

/teneo_service

build.xml

/lib:

/axis:

axis-ant.jar
axis-schema.jar
axis.jar
commons-discovery-0.2.jar
commons-logging-1.0.4.jar
jaxrpc.jar
log4j-1.2.8.jar
log4j.properties
saaj.jar
wsdl4j-1.5.1.jar

/xml

xercesImpl.jar
xml-apis.jar

/src/mil/af/teneo

TeneoService.java

/client

TeneoMessageHandler.java
TeneoSubscriber.java

/exceptions

MalformedEndpointException.java

/publisher

AbstractPublisher.java
TcpPublisher.java

/test

ServiceTest.java

/support files

/axis _template_

fingerprint.jsp
happyaxis.jsp
i18nLib.jsp
index.html
index.jsp

/WEB-INF

server-config.wsdd
users.lst
web.xml

/classes

i18n.properties
i18n_ja.properties

/lib

axis-ant.jar
axis-schema.jar
axis.jar
commons-discovery-0.2.jar
commons-logging-1.0.4.jar
jaxrpc.jar
log4j-1.2.8.jar
saaj.jar
wsdl4j-1.5.1.jar

The source code for a proof-of-concept demo is also included on the disc under the '*flex demo*' directory:

/java client
- **build.bat**
- **README.txt**
- **run.bat**
- /lib
  - **flex-bootstrap.jar**
  - **flex-messaging-common.jar**
  - **flex-messaging-opt.jar**
  - **flex-messaging-req.jar**
  - **flex-messaging.jar**
  - **javax77.jar**
  - **jms.jar**
  - **oc4j.jar**
  - **oc4jclient.jar**
  - **servlet.jar**
  - **xercesImpl.jar**
- /src
  - /demo
    - **Test.java**

/web client
- **application.xml**
- **build.xml**
- **chat.css**
- **chat_placeholder.html**
- **index.html**
- **README.txt**
- **xindex.html**
- /bridge
  - **FABridge.as**
  - **FABridge.js**
- /images
  - **blinddown.gif**
  - **blindup.gif**
  - **resize_gripper.gif**
  - **version.swf**
- /js
  - **xmlutility.js**
  - /scriptaculous
    - **builder.js**
    - **controls.js**
    - **dragdrop.js**
    - **effects.js**
    - **js_utils.js**

prototype.js
scriptaculous.js
slider.js
unittest.js

/messageservice

/dashboard

Chat.mxml
dashboard.mxml
main.css
README.html

/META-INF

/WEB-INF

jrun-web.xml
web.xml

/classes/samples/dashboard

JMSChat.class

/flex

data-management-config.xml
flash-unicode-table.xml
flex-config.xml
flex-webtier-config.xml
global.css
jgroups-default.xml
license.properties
localFonts.ser
macFonts.ser
messaging-config.xml
mxml-manifest.xml
proxy-config.xml
remoting-config.xml
services-config.xml
winFonts.ser

/jars

asc.jar
batik-awt-util.jar
batik-bridge.jar
batik-css.jar
batik-dom.jar
batik-ext.jar
batik-gvt.jar
batik-parser.jar
batik-script.jar
batik-svg-dom.jar
batik-svggen.jar
batik-transcoder.jar
batik-util.jar

batik-xml.jar
commons-collections.jar
commons-discovery.jar
commons-logging.jar
commons-logging.properties
flex-messaging-common.jar
flex-webtier.jar
license.jar
mm-velocity-1.4.jar
mxmlc.jar
oscache.jar
swfkit.jar
xercesImpl.jar
xercesPatch.jar
xmlParserAPIs.jar

/libs

charts.swc
fds.swc
flex.swc
framework.swc
playerglobal.swc
rpc.swc
utilities.swc

/locale/en_US

charts_rb.swc
fds_rb.swc
framework_rb.swc

/themes

haloclassic.swc

/lib

backport-util-concurrent.jar
cfdataservicesadapter.jar
cfgatewayadapter.jar
commons-codec.jar
commons-httpclient.jar
commons-logging.jar
concurrent.jar
flex-bootstrap.jar
flex-messaging-common.jar
flex-messaging-opt.jar
flex-messaging-req.jar
flex-messaging.jar

/src/samples/dashboard

JMSChat.java

Packaging Requirements

No special packaging or marking must be made for copies of the Teneo software.

Qualification Provisions

To validate that a body of software is a valid copy of Teneo, verify that each executable file referenced in section 3.1 under the */Teneo* directory (not including the encapsulated *Scenario* directory) has an identical counterpart in the software in question.

A valid copy of the source will contain all of the files listed in section 3.2.

Software Support Information

"As Built" Software Design

Teneo, as it was received, was a 'rapid prototype' style software package. As such, Teneo was never scrutinized via formal design review, and no formal documentation for Teneo (e.g., detailed design document) was generated, or at least provided by the developer. SRA completed an evaluation of the Teneo software and the architecture of the system to which it was to be integrated through proof-of-concept testing and prototyping.

The Teneo software is integrated into the main menu of IWPC by minor modifications to the IWPC source code that includes a system call to launch the Teneo executable. A custom web service is used to more easily integrate the .NET environment with the J2EE (Java 2 Enterprise Edition) architecture. This web service utilizes a standard 'callback' approach for the server to asynchronously pass messages to a subscribing client.

Compilation/Build Procedures

To build Teneo, the following tools must be acquired:

1. Ant 1.6.5
2. Java Development Kit 1.4.2
3. JDepend 2.9.1
4. Microsoft C# Compiler (CSC)

Before beginning, set the environment variable 'JAVA_HOME' to point to the installation directory in which the Java Development Kit is installed.

1. Under the source directory, in the client/IWPC directory, unzip the June 21, 2006, release of IWPC 4.2. Do not replace the files that are already in this directory. The files that are already there are our modifications to the base IWPC source code. Run the command 'ant –f build_all.xml' to produce all of the jar files in IWPC. The jar files that are important are the 'images.jar' located in the bin directory and 'mainmenu.jar' and 'mmthreads.jar' located in the Main_Menu/bin directory. These jars can replace the jars of the same name in an IWPC installation.

2. The Teneo client can be compiled using Microsoft Visual Studio by opening the *Teneo.sln* file located under the source directory in the *client/Teneo/Teneo_Unclass* folder. Teneo's publish-subscribe client libraries can also be built using Microsoft Visual Studio by opening the *TeneoPubSub.sln* file under the source directory in the *client/support software/TeneoPubSub* folder.
3. Under the '*source/client/support software*' directory, run ant to build the TBONE adapters for C#.
4. Under the '*source/server/Region*' directory, run *ant* to build the region service. This will create *iwpc-region-app-1.0.ear* in the dist directory which can be deployed to the application server using the enterprise manager (console).
5. Under the '*source/server/SDSX*' directory, run '*ant dist ear*' to build the SDS extension service. This will create *iwpc-sdsx-app-1.0.ear* in the dist directory which can be deployed to the application server using the enterprise manager (console). Run *ant cstub* to create the C# stub classes for this service.
6. Under the '*source/server/XFMProxy*' directory, run '*ant dist ear*' to build the XFM Proxy service. This will create *iwpc-xfmproxy-app-1.0.ear* in the dist directory which can be deployed to the application server using the enterprise manager (console).
7. Under the '*source/server/teneo_service*' directory, run '*ant compile make_service_war*' to build the Teneo publish-subscribe service. This will create *teneo_service.war* in the base directory which can be deployed to the application server using the enterprise manager (console).

The proof-of-concept code is intended to be used more as a reference point for how browser-to-JMS (Java Messaging System) messaging can occur, but the code can be compiled. In order to satisfy all of the dependencies, it must be compiled on a machine that has Oracle Containers for Java (OC4J) installed, as well as the base Adobe Flex service installed on that OC4J instance.

To compile the web client, run *ant* in the '*flex demo/web client*' directory after modifying the build.xml to point the 'oracle-home' property at base directory of the Oracle/OC4J installation. Also, make sure that the OC4J instance has the following JNDI setup: *jms/amqfactory* and *jms/flex/TopicConnectionFactory* as JMS topic connection factories, and *jms/amqtopic* as a JMS topic. To compile the Java client for this proof of concept, run *ant* in the *flex demo/java client* directory.

Modification Procedures

None.

Computer Hardware Resource Utilization

Teneo will run on a standard personal computer under the .NET environment. No special considerations need to be made in order to utilize this software.

Requirements Traceability

Not applicable.

Notes

Teneo is a prototype and is not intended for production use. The purpose of SRA's work was to evaluate the client software and the architecture as a whole, with this evaluation resulting in the recommendation to completely redesign and rewrite Teneo.

Acronyms and Abbreviations

AOC	Air Operations Center
AOC SPVT	AOC Strategy Planning Visualization Toolkit
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
EAR	Enterprise Archive File
EJB	Enterprise Java Bean
ESRI	Environmental Systems Research Institute
IOPC-J	Information Operations Planning Capability – Joint
IOPC-X	Integrated Operations Planning Capability – Prototype
IPS	Integrated Planning Service
ISVC	Intelligence Service (web service)
IWPC	Information Warfare Planning Capability
J2EE	Java 2 Enterprise Edition (Sun Microsystems Inc.)
MDAL	MIDB Data Access Layer
MIDB	Modernized Integrated Data Base
.NET	Microsoft XML Web Services platform
SDS	Strategy Development Service
SOAP	Simple Object Access Protocol
SRA	SRA International, Inc.
WS	Web Service(s)
WSDL	Web Services Description Language, Web Services Definition Language
XML	Extensible Markup Language
XSD	XML Schema Definition

APPENDIX II-D – IOPCX REPORT

Final Report

Information Operations Planning Capability – Experiment (IOPC-X)

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FINAL REPORT
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Summary

The Information Operations Planning Capability - Experiment (IOPC-X) task was a risk reduction effort to help refine future technical and operational net-centric requirements. The primary goals of IOPC-X were to:

- Design and develop a software net-centric infrastructure prototype enabling rapid integration of new capability modules (CM)
- Demonstrate a pluggable infrastructure of core Information Warfare Planning Capability (IWPC) tools and Information Operations (IO) analysis capabilities
- Align with the Net-Enabled Command Capability (NECC) and Net-Centric Core Enterprise Services (NCES) standards and capabilities

IOPC-X was developed under the Strategy Planning Visualization Tool (SVPT) contract for the 711 Human Performance Wing Human Effectiveness Directorate (RH). Primary Operational and Technical direction for this task was provided by the Joint Forces Command (JFCOM) Engineering Staff Section (J7) Virtual Integrated Support for the Information Operations Environment (VisIOn) Technical Integrative Product Team.

Introduction

The Information Operations Planning Capability - Experiment (IOPC-X) task was a risk reduction effort to help refine future technical and operational net-centric requirements. The primary goals of IOPC-X were to:

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- Align with the Net-Enabled Command Capability (NECC) and Net-Centric Core Enterprise Services (NCES) standards and capabilities

The standards used for the IOPC-X architecture were Department of Defense (DoD) Information Technology Standards Registry (DISR) registered standards. The architecture also followed the guidance provided in the Net-Centric Operational Warfare Reference Model (NCOW-RM). The Architecture was based on the use of a Web Service Oriented Architecture leveraging a J2EE middle tier. In order to address the requirements of the Net-Centric Data Strategy, a data access service leveraging the Jena Ontology Library was developed to allow capabilities to register Ontologies for persistence and querying of their data model elements via SPARQL queries.

This experiment also tested the use of new thin client technologies such as Flex/Flash, ActionScript and JavaScript as well as the potential for discovery and distribution of Eclipse Rich Client Platform Open Services Gateway Initiative (OSGi) compliant fat client plug-in modules by leveraging the NCES UDDI registry. Authentication and authorization proof-of-concepts were performed in order to test the ability of the infrastructure to leverage the NCES security services. In addition, in order to look at potentials for better cross security boundary handling of data, the Intelligence Community Security Markup Standard was applied to the data model of one of the capabilities. Finally, this experiment investigated the requirements for the development of an OPSWARE compliant installer for the infrastructure and select capabilities in order to ensure compliance with DODIIS requirements.

Refer to the IOPC-X Software Developer Kit (SDK) for a thorough review of all technical specifications.

Methods, Assumptions and Procedures

Information Operations Planning Capability - Experiment (IOPC-X) was developed, demonstrated and vetted through a series of tight spirals which constituted the initial AOC SPVT "reference architecture."

Spiral development was based on the results of capabilities-based needs and requirements analyses to derive the AOC Strategy Division and Joint Information Operations (IO) communities notional reference architecture system requirements appropriate with the anticipated future level of the hardware and software constraints facing the AOC and Joint IO communities.

Operational and system design knowledge (understanding)

Operational and system design knowledge (understanding) was obtained through a collaborative effort between the contractor and the JFCOM and JIOWC VisIOn team. First, the team attended operational user forums for demonstration of planned IOPC-X user interfaces and functionality and attended government-specified Combatant Command (COCOM) and air component meetings to support development of Operational and System Views (SVs) for the IOPC-X reference architecture in parrallel. Second, at the Government's direction, the team conducted data collection trips to determine the current processes, source data, inputs/outputs, decisions, visualization elements and software features critical to the AOC and Joint IO community. These two information elicitation approaches generated artifacts from which the team could derive the capabilities-based needs and requirements for the IOPC-X system "reference architecture". The derived requirements were communicated to both industry and Government stakeholders to include the AOC and Joint IO community to validate the operational effectiveness of the analysis. Story boards or semi-operational prototype screens were used to present capability and functionality "look and feel" for the approach to the client prototypes to be developed in conjunction with the reference architecture.

Special focus was given to those activities specific to the performance of "Adaptive Planning" and the "Time Sensitive Planning" (TSP) process to include the cognitive requirements, perception requirements, comprehension and projection and their impact on information display, ordering, retrieval and other aspects of information presentation that impact cognitive capabilities.

AOC and Joint IO requirements collected focused on :

- system performance;
- process control;
- process decision points;
- strategy analysis in the context of work;
- functional capability;
- software systems;
- software applications;

- collaboration technologies;
- information flow between internal and external processes;
- information flow between associated systems.

The Software Development Kit for the reference architecture included appropriate reference(s) to each system requirement and was maintained to capture the incremental findings identified during each IOPC-X spiral.

Trade Studies

In establishing the IOPC-X development/prototype environment, the team performed trade studies to evaluate candidate software for potential inclusion in the IOPC-X reference architecture and IOPC-X prototypes. The results of the trade studies were communicated to the government stakeholder.

The team began by researching existing sources of pertinent scientific and technical information (STINFO) to determine the state-of-the-art capabilities in that task area to avoid duplication of effort and to conserve scientific and technical resources.

The team started with the IWPC Version 4.2 baseline, the AOC Strategy and IO planning system of record, to provide trade studies and follow-on implementations including an ability to send and receive the necessary operational data, through interoperability of IOPC-X with both interfacing systems and internal integration of candidate operational prototype modules.

The team maintained DODAF compliant SVs, high-level designs, use cases, and IOPC-X reference architecture source code for the approved architecture changes to the Government-designated IWPC Version 4.2 GFE baseline. The system design and interface definitions were maintained and published in the IOPC-X Software Development Kit document. This document and the supporting version controlled binary distribution of the framework were distributed to all stakeholders on a regular basis. Backward compatibility was supported throughout the spiral evolutions.

Where feasible, user comments were incorporated into each prototype and the final reference architecture to obtain the best blend of user acceptance while still adhering to the development schedule.

The team evaluated industry wide accessible tools identified by Government and 711 HPW/RHC and trade study results associated with expected critical infrastructure or architecture elements of the IOPC-X reference architecture including the following in Table 1.

Trade Study Results for Critical Infrastructure and Architectural Elements.

Technology Risk	**Specific Technical Area**	**Candidates (not limited to)**
Net Centricity	SOAP and Enterprise Service Bus (ESB) tools, UDDI components, candidate Web portal and “Web 2.0”	SONIC ESB 7.0; Systinet UDDI (DISA/ NESI project); Flex 2.0

	technologies	AquaLogic Websphere DCGS (GOTS)
Application Server and Database Extensibility	Security extensions, OWL & RDF	OWL; RDF;
Security	SAML; WS-Security;	NCES Security Service, Layer 7
Advanced Query, Data Manipulation Tools, and Common Data Sharing	XML Schema transformations; unstructured to structured transformation	XML Spy; DIA program (name?) Documentum
Plug-in Architecture	Ease of Integration and/or interoperability with candidate Operational Tools	ECLIPSE; Oracle Server modifications, JAVA enterprise changes and updating of IWPC 4.2 architecture
Multi-Level Security	Evaluation of technologies applicable to both Coalition and system-high solutions that enable PL-4 accreditable solutions, enabling machine-machine interaction and multi-level collaboration of strategy plans, COAs and supporting analytical data	Oracle OLS & Data Vault, TNE, etc.

The team developed automated interfaces capable of satisfying the required functions documented in the IOPC-X system "reference architecture" . Each automated interface that was developed employed common data types and formats, building towards, and consistent with, the master IOPC-X "reference architecture."

Prototypes considered included automated interfaces to systems such as:

- TBMCS
- MIDB
- JTT
- IWPC

The automated interfaces were also developed and configured to other COTS and GOTS identified through industry-proposed connections, or module inclusions to the IOPC-X baseline. Changing interfaces to these external components unfortunately quickly obsoleted much of the progress in this area.

Integrate IOPC-X Enhancements into IWPC

Potential high value IOPC-X enhancements and problem resolution issues for potential near-term inclusion in the IWPC 4.2 operational baseline were identified early and delivered to the IWPC SPO. Subsequent to customer prioritization and approval, the team developed, tested, and integrated these high value modifications with the IWPC 4.2 operational baseline. The primary

contribution developed during this effort was a web service interface for the existing IWPC 4.2 system.

The team provided recommended markups to GFE-provided IWPC 4.2 Technical Data to support Interim Authority To Operate in classified test environments as well as document the above mentioned enhancements.

Results and Discussion

Throughout the project the IOPC-X architecture was produced refined and integrated with two clients: the COA Sketch flex based thin client, and a OSGI client framework to support migration of existing capabilities. Select components from the Information Warefare Planning Capability (IWPC) were used as a sample codebase for migration. The results of the IWPC port to the new architecture included porting the clients to the OSGI Rich Client Platform front end and converting the persistence tier to a JENA ontology data store accessed via a newly developed web service. This experiment proved that legacy systems could be ported to the architecture. The three IWPC applications selected were ported at about a 90% completion state. The rest of this section discusses the results of integrating the COA Sketch Visualization tool with the IOPC-X architecture.

Intelligence Community (IC) Information Security Markings (ISM) for Security Labeling

To address security labeling, IOPC-X investigated security level tagging at the data object level in accordance with the IC ISM standard. An advantage of the IC ISM approach is that it supports a tear-line model for both untagged text and tagged data objects. Under a tear-line model, a document is broken up into sections that are classified at different security levels. By creating the core content at the lowest classification level while amplifying information is contained as extensions at higher classification levels, the more sensitive information is marked and can be stripped off by trusted, automated processes. This facilitates automated data exchange and permits wider dissemination while accommodating releasability guidelines for the sensitive information below the tear-line.

Results

The first lesson learned in our attempt to incorporate IC ISM markings for every attribute of the COA Sketch data model is the need to only bring across the classification marking itself and allow user interaction to trigger querying for the rest of the IC ISM details via a lazy-loading paradigm. This is largely due to analysis results showing less operator immediate need for the detailed classification data. Given the size of the XML data associated with the additional information, further compression would also be recommended.

IOPC-X Client Architecture

In support of an evolutionary development path and re-use of existing Java™ and .Net developed "Fat Clients"; The IOPC-X design included an Open Services Gateway Initiative (OSGi) compliant plug-in infrastructure based upon the Eclipse Rich Client Platform. Efforts included proof-of-concepts for inclusion of .Net clients and Java™ client plug-in development.

Client Components

- IOPC-X RCP Workbench: The workbench acts as a 'baseline' IOPC-X installation. All client plug-ins use the workbench as their target platform. It initializes the main client window, menus, and toolbars, providing a predictable environment for the plug-ins.
- Data Access plug-in: In an effort to reduce memory consumption and network traffic, the data access plug-in provides a single interface through which the ontologies can be

manipulated. Use of this plug-in is not mandatory and a client plug-in could reference the web service interface directly if so desired.

- Login & Security plug-in: Authentication routines and login handling are integrated into the workbench through a separate plug-in. This plug-in provides the login information to any other plug-ins that need to access it (such as the Data Access plug-in).
- Dynamic Update plug-in: Client plug-ins can be updated transparently by an update plug-in. No additional code needs to be written to allow dynamic update – this capability is provided by the workbench and the OSGi framework.

Client Component Results

- The Service-Oriented Architecture (SOA) enhanced Eclipse RCP based workbench and discoverable plug-in architecture proved to be a viable alternative method for handling user interfaces vs. strictly thin client alternatives. The deployment of the workbench is recommended to be from a discoverable URL. The download time for the lightweight plug-ins was reasonable for operational use.
- The use of the login and security plug-in still requires further investigation to ensure it would pass accreditation.
- The dynamic update plug-in unfortunately was not used or tested during the Limited utility Assessment or Pirates Dagger event but shows promise in supporting the plug-in UI approach.
- It should also be noted that 2.5 Dimensional interfaces are not easily supported at this time via thin client technologies. The plug-in architecture used here is a viable approach to support these types of user interfaces.

Internationalization

In context of IOPC-X, internationalization is focused on the support of different lexicons for different COIs. IOPC-X leveraged its Ontology support in order to allow Ontological capturing of lexicons/Vocabularies/Taxonomies from different COIs into it's knowledgebase. IOPC-X required that each integrating module externalize its strings into Key Value pairs. The Keys and default value strings from each module were provided in Ontological form for correlation to the COI ontologies mentioned above. Integrating modules then accessed a listing of COIs using IOPC-X convenience methods and provide IOPC-X with a user selected COI namespace as well as the unique module namespace. In return IOPC-X provided the user the COI overridden "Internationalized" Key Value pair list for instantiation within the integrating module.

Results

- While the designed and implemented handling for this feature worked as expected, it is questionable as to whether or not the additional loading overhead is worth the limited enhancement gained.
- To test this feature easier administrative views for manipulation of the underlying ontologies is necessary and potentially would need to be kept in context of the tools being manipulated.
- The handling of this feature should be broken out into a separate Web Service from the IOPC-X data service.

OPSWARE Compliant Installer

In discussions with DoDIIS and OPSWARE representatives it was determined that the only real requirement to work with OPSWARE and be DoDIIS compliant was to be callable as a "command file" no user interaction installer. IOPC-X leveraged Installshield as well as some custom scripts and queries in order to not only install the IOPC-X software itself, but the supporting Weblogic Application server and Oracle Database.

Results

- The combined use of both an interactive as well as command file driven installer, allowed for easier debug of the command file version installation.
- Early development of the installer greatly eased potential greater pressures and demands on developers.
- The installer also allowed for consistency in system configuration, making duplication of issues easier.

IOPC-X Web Service and Data Access Tier Architecture

Web Ontology Language (OWL) utilized by IOPC-X

All Data Storage in IOPC-X was in Ontology form in order to align with the DoD Net-Centric Data Strategy. The data standard followed was the Web Ontology Language (OWL) specification. More information on the Ontology and OWL specifications can be obtained from http://www.w3.org/2004/OWL/. OWL is a Web Ontology Language that can define a semantic vocabulary as well as information stored within that vocabulary. OWL builds on the RDF schema (http://www.w3.org/RDF/) which is an XML (eXtensible Markup Language) representation of a vocabulary or ontology that contains classes and properties. OWL adds the ability to describe relationships between classes within any ontology. OWL is a way to represent data models and data stored within data models with all the data descriptions of XML schema, all the resource definitions of RDF, and the ability to tie data models together with the OWL specifications

Results

- The use of this standard did not present any major issues in and of itself, but the supporting tools and libraries for working with this standard have proven to still be immature at this point in time.
- The specification for the ontology technology sets are well thought out but still maturing themselves. (Such as the XML SPARQL result specification that came out this year)

Ontology Libraries utilized by IOPC-X

The project researched JENA and SESAME Open source library kits for Ontology data. These were the two forefront standards compliant libraries for ontology data at the time. JENA outperformed SESAME on a couple of fronts including persistence to an Oracle database.

The open source JENA (version 2.5.4) library is used within the IOPCDataAccessBean to store, load and manipulate Ontology data models and their data. More information on the JENA library can be obtained here: http://jena.sourceforge.net/. The license for the JENA library can be obtained here: http://jena.sourceforge.net/license.html . Jena is built on top of other sub-systems or libraries, the information on the libraries and their respective licenses can be obtained here: http://jena.sourceforge.net/Licenses/index.html .

Results

- The Jena open source library was used for the Ontology data manipulation and persistence. This library persist the ontology data models within a SQL database, but the normalization and table setup for Jena to persist data was not optimum and caused delays in retrieving and querying models.
- These open source libraries cannot compete when it comes to data persistence to the likes of a Relational Database (RDB) that has had years to mature and optimize response time. These ontology technology implemented library solution sets proved immature. One key area in which they are lacking is in easy support for data validation. Another area is in handling cascading deletes and orphaned nodes.
- The commercial world continues to work these issues. Bringing to bear its resources and some time to optimize the Ontology persistence and querying capabilities, the use of these technologies will most likely be viable in the next several years. Early implementers of this technology will take on large risks unless potential alternate fallback paths at appropriate abstraction layers are maintained.

Stateless Session Enterprise Java Bean (EJB)™

The IOPCDataAccessBean is deployed to a Bea WebLogic Application Server version 10 maintenance pack 1 or higher. The Sun 1.5 Java Development Kit™ (JDK™) and J2EE™ 5 with EJB™ 3.0 are used to create and run the IOPCDataAccessBean EJB™. The Sun licenses for these can be obtained here: (http://www.java.com/en/download/license.jsp). The bean also utilizes the Apache XML Xerces library (xercesImpl.jar) version 2.7.1 to perform data manipulation from ontology OWL format to a plain XML form when necessary. More information on the Apache XML Xerces project can be obtained here: http://xerces.apache.org/xerces2-j/. The license for this Apache library can be obtained here: http://www.apache.org/licenses/LICENSE-2.0.html.

The IOPC-X IOPCDataAccessBean was developed as a Stateless Session EJB™. This bean adheres to the J2EE™ 5 and EJB™ 3.0 specification utilizing annotations in place of deployment descriptors (http://java.sun.com/produ cts/ejb/docs.html). This EJB™ will run within a Bea WebLogic Application Server version 10 maintenance pack 1 or higher (http://www.bea.com/framework.jsp?CNT=index.htm&FP=/content/products/weblogic&WT.ac=topnav_products_weblogic). This application server utilizes the Sun Java™ Runtime Environment (JRE) 1.5 and the Sun J2EE™ 5 with EJB™ 3.0 specifications. This EJB™ will theoretically deploy to any J2EE™ application server that supports the aforementioned specifications although all testing has been done with the WebLogic Application Server. The IOPCDataAccessBean is accessible via RMI and can be looked up on the application servers Java Naming and Directory Interface (JNDI) with the JNDI name of: IOPCDataAcess/remote for outside the J2EE™ container and IOPCDataAccess/local for within the J2EE™ container. This

EJB is the actual core of the IOPC Data tier where the IOPC-X web service interface is a Façade onto this interface.

Results

- The Stateless nature and proven use over many years for scalability proved to be fairly crippled in use due to the lack of a solid optimized query handling in the backend. Due to the deficiencies found in the Jena solution set discussed above, client access to data was slow at best.
- The use of this part of a well known n-Tiered architecture did continue to provide benefits from the hosting application server in authentication and authorization handling, connection pool handling and potentials for clustering for scalability.

Data Storage

The IOPCDataAccessBean utilizes a JDBC™ Data Source within the application server to store the ontology's and data into a JDBC™ compliant database. All testing has been done with MySQL® 5 and Oracle 10g databases. The IOPCDataAccess JDBC™ data source is configured within the J2EE™ application server. More information on J2EE™ Data Sources can be obtained from the Sun J2EE™ 1.5 specifications.

Results

The data storage performed as expected, however, the lack of optimization in data handling by JENA impacted the performance of retrieval.

IOPC Data Access Web Services

The IOPC Data Access Web Services programming model centers on Java™ Web Service *(*JWS) files and annotations. The standard @WebService, @WebMethod, and @SOAPBinding JWS annotations are used (annotations were introduced in Version 5.0 of the JDK™, specified by JSR-175), and include annotations defined by the Web Services Metadata for the Java Platform specification JSR 181 (Web Services Metadata for Java Platform).

The Web Service is hosted in Axis2 and is implemented using standard J2EE™ components, as defined by the Implementing Enterprise Web Services 1.1 specification JSR-921, which is the 1.1 maintenance release of JSR-109. See Enterprise Web Services 1.1.

Currently, the web service is targeted to run inside of Axis2, but it could compile and run under any standard J2EE™ application server that supports *JWS files* and annotations.

For the mapping of the web service to the SOAP Message Protocol the JWS file uses the standard @SOAPBinding annotation, at the class level, to specify the SOAP bindings of the web service, such as 'RPC-encoded' or 'document-literal/wrapped'. The IOPC Data Access web service uses the 'document-literal/wrapped' style encoding. Document/literal is WS-I compliant, *and* the wrapped pattern meets the WS-I restriction that the SOAP message's "soap:body" has only one child.

Axis2 web services use SOAP as the message format and Hypertext Transfer Protocol as the connection protocol; both versions 1.1 and 1.2 are supported. See SOAP 1.1 and 1.2.

The IOPC-X web service uses WSDL 1.1. See the WSDL 1.1 specification.

Results

- This standardized approach to Web Service Implementation has proven to be a solid approach.
- Automated tools for WSDL generation are still lacking in their performance and it is highly recommended that WSDLs be created by hand in order to ensure proper generation.

Model Registration

Data storage and data manipulation within the IOPC-X software suite go through the IOPCDataAccess interface. Each application, upon installation into the suite, needs to register their data model with the IOPCDataAccess interface. The data model is registered by providing, in ontology form, an OWL formatted description of that model. Each application will has a unique model name under which the model is registered. This model name is almost synonymous with a database schema name and is used by clients when obtaining and manipulating data within the model.
Model registration (upon application installation) is performed through a call to the IOPCDataAccessBean. Each application's model or general ontology vocabulary can be loaded into the IOPCDataAccess bean via the registerModel method. This method takes the Ontology OWL XML (model) description within a String parameter, as well as the ontology name for it to be stored under, and a String parameter indicating the Semantic Language the ontology is in. The languages the ontology can be described in are "RDF/XML", "N-TRIPLE" and "N3". More information on any of these ontology data formats can be found here: http://www.w3.org/TR/2004/REC-rdf-testcases-20040210/#ntriples , or here: http://jena.sourceforge.net/tutorial/RDF_API/index.html.

Results

- While this approach worked, it lead to a centralized knowledge store and processing point for the infrastructure and thus increased latency.
- While ontology retrieval from disparate end points is supported by the standards and libraries, decentralized processing of queries is not supported.

XML-Legacy Model Registration

For legacy XML based applications or applications not using any semantic ontology capabilities a process has been established that can take plain XML Schema Definition (XSD) and convert it to an OWL representation of that XSD that can then be registered with the IOPCDataAccess bean. This way the data for that system can be stored within the IOPC Data Store in an ontology form that can be utilized by other applications while the application can utilize the XML data model that the application was built around. The application can perform data manipulation and receive change data notifications via JMS in an XML format.

Results

- This process entails using one of the many Graphical User Interface (GUI) tools on the market that can take XSD and create a simplistic OWL representation of that XSD. One tool that has this functionality is the TopBraid Composer. There are other applications that have this functionality. For more information on the TopBraid Composer visit the website at: http://www.topbraidcomposer.com/.
- These tools will create a first cut of the OWL representation of the model. These tools do not convert all of the XML syntax over to OWL accurately. The developer will have to go through the ontology that is built in an ontology editor and fix the ontology to accurately reflect the model. (i.e. the xs:choice XML sytax doe not convert well into ontology form with these tools)

Data Retrieval

Once a data model for an application is registered, data retrieval or loading existing data from a data model is accomplished with the getData method in the IOPCDataAccessBean. This method will return a String XML representation of the requested data in the result set format specified by the dataXMLLanguage parameter. The getData method will take a SPARQL query that will be used to query the data from the existing data model. More information on the SPARQL query language can be obtained here: http://www.w3.org/TR/rdf-sparql-query/ and a good tutorial for the SPARQL query language can be found here http://jena.sourceforge.net/ARQ/Tutorial

The getData method has the following parameters: modelName, SparqlQuery, dataXMLLanguage, and User Identification (userid). The modelName is a String parameter that holds the name of the model to retrieve data from. The SparqlQuery String parameter in the getData method is the query. The dataXMLLanguage parameter is a String that defines what format the result set string that is returned is in. Valid formats are: "XML", "RDF/XML", "N-TRIPLE", and "N3". "RDF/XML" is the preferred format**.** More information on any of these ontology data formats can be found here: http://www.w3.org/TR/2004/REC-rdf-testcases-20040210/#ntriples , or here: http://jena.sourceforge.net/tutorial/RDF_API/index.html. The userid is a String holding the userid of the user that is requesting the data.

The other getData method takes all the above methods parameters, except a string array of object GUID's replaces the SPARQL query parameter. This getData method will return an ontology model triplet form of the data instead of a result set form of the data.

Results

- IOPC-X attempts to compile a simplistic translation to XML in the IOPC DataAccess layer was a resounding failure. The interface could not be kept generic enough. It became exceedingly difficult to support all the xml specified elements such as key refs, refs, etc.
- COA Sketch attempted to translate the SPARQL query XML result sets into a coa sketch XML so the clients could understand the data. This prohibited the clients from using any of the power of the ontology technology, created a time consuming middle tier to go through, and defeated the purpose of utilizing the ontology data formats. If you're

writing a client to persist the data in ontology format you need to make the client understand the ontology formats.

- There is a difference between SparQL Result set and an ontology model. When a client retrieved a SparQL result set in any format xml, rdf or java object resource, it didn't have any of the model information just a result set from a query. Jena had no way of adding this result set into an existing ontology model for use by the client. In order to load an ontology into memory you have to retrieve the whole model and load it up into a Jena memory ontology and then, using java ontology objects, add or merge the two. Solving this issue will be key to using SparQL result sets for data handling especially when middle tier business logic needs to be applied and expecting to have all the power of the semantic specs.
- Creating each set of saved data as its own stand alone ontology would allow your client to have a JENA like library in it and utilize all the aspects of an ontology library, but this makes linking data from one applications data model to another's exceedingly difficult and querying the data even slower.

Data Manipulation and Transaction Handling

Data manipulation is done through the manipulation methods within the IOPCDataAccessBean. The interface accepts dataXML, userid, modelName, parentGUID, and dataXMLLanguage and returns an XML String. The dataXML is a String parameter that holds the data to be stored, modified or deleted. The userid is a String parameter used by the bean to verify that the user has the attribute lock for the data to be modified. The modelName is a String parameter that holds the name of the model, this is the same name the application registered the data model with in the model registration process during initial installation. The parentGUID parameter is a String holding the GUID of the parent data object of the data being added to the model. This parameter is only used in the addElement method and is only needed if the parent relationship is not held within the dataXML. The dataXML String can contain any number of data objects and these can be related to an already existing data object in the IOPC Data Store. The dataXMLLanguage parameter is a String that defines what format the dataXML is in. Valid formats are: "XML", "RDF/XML", "N-TRIPLE","N3", and XML. "RDF/XML" is the preferred format.

The GUID or unique resource identifier for each data object to be stored is an important attribute in the dataXML. For each data object element contained in the dataXML there is a GUID that must be generated by the client and must adhere to the specifications in the IOPC-X SDK for correlation to the register model.

Upon successful completion, the add and modify methods return the String XML representation of the objects passed into the method in the format specified by the dataXMLLanguage parameter. The delete method returns a Boolean TRUE upon successful completion of the delete. Both methods throw an exception if the data manipulation is not successful. The methods throw an IOPCPropertyLockException if there was a data lock issue.

The Update Tripplets service is a transactional data manipulation that can add, modify and delete Ontology triplets in the IOPC-X Datastore. As with the other data manipulation services the name of the model to be manipulated is passed in as well as a XML String describing the

requested transaction. A client can perform any number of data manipulations within one transaction. The method will return a transaction number which is referenced in update notifications sent out by the IOPC-X server.

Results

- The IOPC-X transactional XML that allowed one to add mod and del in one call was simple XML. Unlike in JDBC where you can have a java object called a prepared statement this XML didn't do enough validation on what went into it so information in a text box such as < > and other xml characters could corrupt the transaction. JDBC to a RDB deals with this by utilizing the prepared statement class. IOPCX ended up doing it at the client Level in IWPC checking over the input before it went into the transaction xml but it would be nice to have a small connectivity kit that would have done this for you. This kit would have to be available for all supported Web Service programming languages

- String being passed around between client and server for web service. At some point you will Reach the limit of String and have problems passing data. So when passing Strings back from a web service you'd need a way to stream it or cover this limit on what size of serializable String

- The locking mechanism was relatively simple in nature but performed well at the PD Event. The simplistic locking mechanism that included a timer on an entity bean with a web service call to lock and unlock worked very well in various ways by different clients. This was an easy effective cheap way to implement locking.

- Further investigation into the benefits or detriments of attribute level locking on a collaborative interface has yet to be accomplished.

Data Change Notification

IOPC-X investigated the use of the NCES Web Service Eventing (WSE) based messaging system for data propagation. As an interim solution, Data Change notifications were sent from the IOPCDataAccessBean via Java Message System messages in the form of OWL Triplets and in the form of plain XML. More information on JMS can be obtained here: http://java.sun.com/products/jms/.

The Data Change Notification JMS messages mimic the document literal Web Service interfaces by sending JMS TextMessages with the following properties:

Change Notification JMS TextMessages Properties

modelName	the model name the data manipulation took place in.
Userid	the userid for the user that modified the data
Type	'ADD','DELETED','MODIFICATION'.

When subscribed to the JMS/IOPCDataAccessOWLTopic the text message in the JMS TextMessage contains the added or modified data in the RDF/XML format. When subscribed to

the JMS/IOPCDataAccessXMLTopic, the text message in the JMS TextMessage contains the XML representation of the added or modified data objects that adheres to that models original XML XSD. In the delete case both messages depict the data objects that have been deleted in their respective formats.

Results

- The use of JMS within IOPC-X proved fairly reliable with the exception of some duplicate messages being accidently generated due to a few coding errors.
- The NCES WSE messaging interface proved feasible, but due to instability of the development network could not be fully tested

Change History

The getChangeHistory method returns an xml representation of the change history on the guids passed into the method via the guids string array parameter.

Results

- The change history interface was not robust enough to fully support Data Versioning
- Data Versioning, the bad words on any software projects that has a relational data setup already up and running requires further investigation with regard to handling using an ontology store. Using the change history feature to obtain Data Versioning would have been costly.
- Data Versioning should be a well thought out approach at the early stages of the infrastructure design and warrants early proof-of-concepts
- Key human factors in the areas of Undo/Redo as well as legacy and future version support hinge on this capability

IOPC-X WebService Security

IOPC-X investigated the use of the NCES recommended WebService Security as provided by the Layer 7 solution. All testing was performed using the NCES developmental test network.

According to NCES policy, service providers will need to provide the notions of Policy Enforcement Point (PEP), a Policy Decision Service (PDS), a Policy Retrieval Service (PRS), and an optional local Attribute Service (AS) with the support of Attribute Based Access Control (ABAC).

A PEP (NCES Service Security Interface Specification for Service Security v0.4.6, August, 13, 2007) is a SOAP Node that enforces policy between a service consumer and a service provider. The PEP is responsible for requesting authorization decisions from a PDS and enforcing them. The PDS could be located locally as a function of the PEP. The PEP is also responsible for rejecting service provider service requests that are unknown, that contain improperly formulated SOAP message security headers, or that contain unverifiable digital signatures. The PEP is the point of presence for access control and must be able to intercept all service requests between service consumers and IOPC-X service providers and cannot be bypassed.

A PDS (NCES Service Security Interface Specification for Service Security v0.4.6, August, 13, 2007) ensures that a consumer can consume all services controlled by the PDS. The PDS is the implementation of the policy engine, it works based on policy. Policy is key because it is used to determine whether a consumer is authorized to consume a service. The PDS serves as a Security Assertion Markup Language (SAML) authorization authority for service providers who choose to use an external Policy Decision Point (PDP). It accepts authorization queries and returns authorization decision assertions, all conforming to the SAML Protocol. The heart of the service is a policy evaluation engine, which applies policies based on a variety of inputs such as the target resource, the action (operation) requested, and the identity of the requester.

The PRS (NCES Service Security Interface Specification for Service Security v0.4.6, August, 13, 2007) exposes security policies in Extensible Access Control Markup Language (XACML) format.

The NCES AS, based on Joint Enterprise Directory Service, provides attributes on consumers of IOPC-X web services which can be consumed by PDP and PDS.

ABAC (NCES Sercice Security ABAC Policy Tool v0.2 User Guide, October 5, 2007) can not only encompass Role Based Access Control rules but also Identity Based Access Control. ABAC is supported by NCES through two enterprise level services which are the Robust Certificate Validation Services (RCVS) and the AS. RCVS provides consumers with the ability to validate certificates which have been presented for authentication. The AS provides attributes on people which can be consumed by a PDP or PDS. These two enterprise level services provide capabilities which when used with a PDS or PDP support ABAC.

As a critical part of the NCES Service Security capability, a PEP has historically been provided in the form of a software component known as NCES Service Security Development Kit. Until a couple of years ago, hardware based solutions to implement the functionality of a PEP were not available. Then vendors like IBM, Jericho Systems, Layer7 came up with devices that are, SOAP and XML aware firewalls which support standards based web service message authentication and authorization, encryption functions, content validation and transformation, and message routing.

These hardware devices sit in the path of the request, thereby allowing them to act as the PEP. This is a hardware implementation of a PEP, whereas the preceding implementation of the PEP, the NCES Service Security Development Kit, was a software PEP. The Security Development Kit achieves the same effect by deploying message handlers in front of the protected service, each message handler then communicates request data to the Service Security services to establish authentication and authorization decisions.

NCES is leaning more towards Commercial Off-The-Shelf (COTS) vs. Government Off-The-Shelf (GOTS) products or solutions. They are also recommending the use of PEP firewalls as compared to software component based PEP. NCES has learned that NCES Service Security PEP firewall hardware configurations exceed the software based PEPs developed using the NCES Service Security Development Kit. Using the NCES Conformance Test Kit and the NCES Service Security PEP specification, NCES has experienced potential performance gains by

implementing the NCES Service Security PEP on a separate dedicated device with hardware support for common Web service security, verification, and processing functions.

As a result, NCES has deprecated its NCES Service Security Development Kit, and is encouraging the use of COTS solutions instead. NCES is also leaning towards using PEP firewall vs. software component based PEP for the following reasons:

- The PEP firewall implements a common PEP instead of each provider having its own integrated PEP
    - Instead of service consumers accessing service providers directly, consumers access providers through the PEP firewall
- Separating the PEP from the service providers allows a much greater degree of freedom in creating and deploying services
- Service providers can be implemented on any software platform and are no longer restricted to the platforms for which PEP components are provided

Following NCES policies IOPC-X web services end points whether on AXIS and/or Weblogic require a hardware based PEP SOAP and XML aware firewall to enforce authentication and authorization.

Results

- Though the documentation for use of the NCES security and other services was lacking at the time, the IOPC-X team was able to work with the infrastructure.
- The key problem in the proposed Layer 7 product was that it did not properly support imported WSDLs as realized upon using this product against the NCES UDDI registry. A separate report holding details of these findings is available.
- Another identified issue with the proposed NCES solution is that it is system focused and thus does not allow for user transaction handling by default.
- For event experimentation purposes, the NCES environment was not available. IOPC-X was rapidly redesigned to leverage the Authentication services provided by the Weblogic Application server. This design would need stringent review to ensure accreditation requirements are met, however, the capabilities provided by the application server show potential for compliance.

Conclusions

The intention of this section is to discuss design issues surrounding the integration of ontological data stores into enterprise applications. The Java 2 Enterprise Edition (J2EE) platform is the primary focus for integration issues. Design recommendations are based on the project's experiences with IOPC-X/COASketch as well as industry best practices.

Data Integrity

Any data store that provides concurrent access to multiple clients must be able to isolate client transactions from one another. If two clients try to access the same field simultaneously, the data store must provide an arbitration mechanism. The alternative is a "last input wins" system, which has serious risks for data integrity.

The simplest approach to managing concurrency and exclusivity is to require the client application to explicitly request exclusive access or "lock" a resource. This approach is difficult to apply in complex situations where large numbers of resources may need to be accessed. Transaction management is a more sophisticated approach that shifts some of the resource management burden from the client to the data store.

Explicit Locking

Explicit locking of objects or object attributes possibly the simplest approach to managing concurrency. In most implementations, a lock is associated with every individual lockable resource. Multiple locking levels are defined on the lock to provide multiple levels of constraints on concurrent access.

For example, if an object is "read-locked" by a process, other processes may be able to acquire read-locks. However, no process could acquire the ability to write to the object using a "write-lock". In other words, read-locks provide a non-exclusive guarantee that the data being read will not change while the read-lock is held. Write-locks provide an exclusive guarantee that only the holder of the lock can change the data while the lock is held. This is a simplified example; locking constructs are both complex and subtle.

The primary disadvantage of explicit locking is that client software must acquire and manage locks. When the system of objects and interactions becomes complex, lock design and management becomes difficult to implement in client code. Lock management quickly becomes an excessive burden unless the structure of the locks is tightly coupled to the business logic by providing special-purpose locks for specific business tasks. Obviously, this approach is not feasible for general-purpose data stores or applications where scalability is an issue.

Transaction Management

A more efficient and flexible approach to concurrency is for the data store to provide a transaction interface. The client sends multiple requests to the data store to read or write data in the context of a single transaction. The data store manages a private set of locks at a row or object level that provide certain guarantees of isolation for all the requests in the transaction. If at any point a request fails, the client or the server can issue a "roll-back" command, which guarantees that no changes to the data store are recorded as a consequence of the transaction.

Transaction management and processing has become a standard feature of enterprise applications. This is in part because it greatly simplifies data access. Clients need only manage a single transaction object rather than a plethora of locks and locking levels.

As described below in Section 0, the Java 2 Enterprise Edition (J2EE) platform specifies the Java Transaction API (JTA) as the standard interface for transaction management. By implementing the JTA interfaces, a data source allows both the application server and client applications to manage transactions in a standardized fashion. The application server can often manage JTA transactions without any explicit direction on the part of client applications, leading to clean separations between business logic and resource allocation code.

The JTA incorporates the XA two-phase commit standard. Two-phase commit is a transaction algorithm that permits multiple data stores to participate in a single transaction. At the end of the transaction, when all the data stores have been updated, the client sends a "prepare" request. Data stores respond to the prepare request be committing the transaction, but leaving the possibility of readily rolling it back. If any data store fails to prepare the changes, the transaction manager sends the roll back command. Otherwise, a final commit message is sent, ending the transaction. Implementation of the XA portion of the JTA interface is vital for an enterprise data store. Without two-phase commit capability, transactions cannot span multiple data stores and applications will be hindered from accessing multiple data sources.

Transaction Optimism and Granularity

In general, best practice indicates that optimistic concurrency (use of unlocked reads) is favored over pessimistic concurrency (locked reads) in distributed systems because of the high latency and risk of client failure. Obviously, this is true up to a point, but mission-critical applications must rigorously enforce data integrity. Fortunately, the rational for optimistic concurrency on the part of clients dove-tails nicely with another principle of distributed client design – the task- or document-oriented service interface. This suggests that servers should expose coarse-grained interfaces for specific business tasks. Network latency is then less of an issue when submitting one large request instead of multiple small requests. We note that this architecture also allows the coarse-grained service to execute the coarse task as a single transaction without exposing a transaction object to the client.

Although the assumption in an optimistic system is that transactions will succeed, this must not be taken for granted. There must be a clearly specified method of notification for informing clients when an optimistic transaction fails. This can be more problematic to design when

communications between the client and server are truly asynchronous. The client must retain a record of all pending transactions until they are confirmed by the server. User interface design is also affected; the system must unobtrusive user feedback about the state of transactions as well as methods for recovering work from failed transactions, so that the user does not have to re-enter any lost data.

Data Integrity for COA Sketch

COA Sketch/IOPC-X is dependent on the current IOPC-X interface. The only type of lock provided is an exclusive attribute level lock. It may be possible with a significant level of effort to create a lock management system based on these locks. However, it must be clearly understood that if data is not locked before it is read from the database, then, without exception, business logic may be operating on inconsistent data. For example, one suggestion for limiting the scope of locking required during complex operations was to add change listeners that would monitor the COA Sketch JMS change notification topic for changes related to objects in use by the current process. This design would not eliminate data integrity problems – it would simply limit the duration of the race condition for data collisions.

A better option of COA Sketch/IOPC-X would be to explore the possibility of providing a transaction management interface. This approach would necessarily be limited, because IOPC-X is not currently being actively developed. In addition, transaction propagation over web services is difficult and error prone. COA Sketch would need to access the transactional IOPC-X service using RMI instead of SOAP.

COA Sketch/aXiom is still undergoing design and has greater scope for change. The ideal data integrity solution would be implementation of a transaction management interface using the Java Connector Architecture (JCA) as described in Section 0, below.

Rule/Knowledge-Based Programming

Rules- or Knowledge-based programming is a paradigm where objects representing facts and rules are inserted into a “Rules Engine”. The rules engine applies pattern-matching techniques to determine which rules apply to which facts. As rules are matched, they are executed and the consequences of their execution are matched iteratively against other rules.

Rules-oriented programming is commonly positioned as a dynamic solution. In theory, business rules can be written or altered, tested and deployed rapidly in order to change the behavior of a rules-based system. In addition, it is commonly asserted that rules provide greater transparency in processing by virtue of their terseness and declarative nature. However, it should be realized that rule development is still programming, albeit at a level closer to actual business operations. The ability to develop effective rules will be closely related to the expressive power of the data model used to represent facts in the knowledge base. It will be difficult to formulate rules to reason over an overly simplified or deeply nested data model. Also, best practices indicate that rules should be atomic; one rule should apply to one condition and have one consequence. This means that rules must be designed to work together in compatible sets. Persons who are not

subject matter experts in both the business and rule-development domains will probably have difficulty writing effective rules.

The use of rules and rule engines do provide some clear benefits in dealing with complex problems. The rules engine assembles facts and dependencies for rules. This provides an inversion-of-control (IoC) system for the procedural code in rule consequences because dependencies are automatically managed by the engine. The concise, declarative, nature of rules in conjunction with this self-organizing behavior means that complex constraint problems can often be expressed and solved using a few relatively simple rules.

Data Access for Rule-Based Systems

Generally, rule engines and other inference systems are assumed to have access to all the data that they will use to reason. Conversely, distributed systems must make explicit calls to the data store in order to retrieve data. For complex rule sets, it may not always be clear what data will be required to execute the rules until run time. There are a variety of issues surrounding this problem, but if data sets do need to be retrieved for reasoning in conjunction with client requests, it is vital that data integrity be preserved. Rule engines cannot reason over in-memory data that may be concurrently changing in the data store. In addition, code in rule consequences may need to access the data store directly. In these cases, explicit lock management is particularly awkward – rules are designed to be orthogonal to the procedural allocation of resources such as locks. A transaction API for the data store would greatly reduce the impact of these problems.

The pattern-matching nature of rules drives at a second point-ontologies are generally populated with normalized, object-oriented, structures. Conversely, experience with SQL data stores has shown that efficient queries often require a somewhat de-normalized view of the data. This need for flattening and de-normalization will apply to the representation of objects in both the data store and the rule engine working memory. Based on this, we believe that ontology data model design must take into consideration the types of rules and queries that will be applied as well as capturing the semantics of the business domain. In fact, one might consider designing multiple ontological representations – one for data storage and access, and one for pure business object representations – ideally with a well-defined transformation between the two.

Data Access for COA Sketch

COA Sketch/IOPC-X's business rules system has several fundamental flaws that severely limit its capabilities and potential for expansion. This is, in part, due to flaws in the rules and rules engine design. However, the COA Sketch data model is also problematic.

Data Access Issues

The COA Sketch/IOPC-X rules engine is designed to make a single pass to match rules, then to execute those rules sequentially. Flaws within the matcher mean some data is missed and the two-pass design does not allow reentrance, so the code that can be executed as part of a rule consequence is extremely limited. The design team agrees that the engine implementation needs

to be replaced. However, examining the code for the individual rules points to some problems in the COA Sketch data model as well.

Many of the COA Sketch rules deal with managing timing dependencies. For example, when adding a new object that has a time object, a number of default values must be imported from the parent object. Accessing the parent object's timing information is painful, because the rule code may have to work its way up the object tree through multiple layers of indirection and intermediary objects to access the "real" parent object.

Some work has already been done to simplify data access using the COA Sketch data model, but it has been ad hoc and a full review of the data model and web service interface is needed. The initial design of the COA Sketch data model was developed before the COA Sketch client/server and COA Sketch/IOPC-X interaction use cases were well defined. In addition, the model definition was maintained using ontology tools and code generators. As a consequence, front-line developers had difficulty updating the data model because doing so required altering multiple schemas in multiple locations using multiple definition languages. This inflexible approach amplified the problems of the initial design by creating a major incentive to "work around" data model problems rather than revisiting the design.

The model for date and timing information has been particularly problematic. The data model does not make effective use of inheritance or interfaces. Instead, multiple attributes representing various offsets and base times are publicly exposed. Defining queries and matching patterns to work with these structures quickly leads to heavily nested conditionals that are difficult to implement, test and maintain. In addition, the schema mixes requirements for serialization with data representation, leading to confusion on both parts.

Recommendations

Determining the best way ahead for COA Sketch/IOPC-X will require more research. It is highly recommended that an end-to-end review of COA Sketch/IOPC-X be conducted before full-scale design for COA Sketch/aXiom begins. At a minimum, we recommend that the data model and particularly the date and constraint model be reviewed with the goal of expressing queries and pattern matches concisely. We believe this may result in a flatter, more redundant, class model with fewer classes and less nesting of objects.

Some new classes may need to be added to express some system-level concepts. For example, the current COA Sketch/IOPC-X use cases discuss rules for handling change requests according to user-specific preferences. However, the data model does not define any classes that represent change requests or users. Adding classes such as deferred promise objects that can act as handles to concurrent request, change objects that can represent user requests to the system will simplify the syntax required for implementing these use cases.

The COA Sketch/IOPC-X Web Service Description Language (WSDL) interface will need to be reviewed at the same time as the data model. The current design is a general purpose Create, Update, Delete model. Some work is on going to add higher-level tasks such as object creation methods for specific use cases. However, system-level study is needed to determine if more business-level tasks can be defined at the web service layer. In addition, the serialization constraints inherent in the current data model need to be removed. Many object classes cannot currently be serialized as stand-alone objects – they require additional document portions. This must be redesigned so that the data model objects can be used in a more encapsulated fashion.

Finally, the IOPC-X Results and discussions identified the lack of support for ontological data formats (SPARQL and SPARQL result-set XML) in the client application as a shortfall. Admittedly, the data interchange between the COA Sketch/IOPC-X client and server was problematic. However, pushing the responsibility for query execution and processing up to the client tier goes against the theory of N-tiered architectural design and violates the assumption of a course-grained, optimistic system described in Section 0 above. Obviously, expectations for the capabilities of an ontological data access client must be recalibrated and agreed upon. One might well consider the COA Sketch service the true ontological client and the COA Sketch thin client merely a display layer. In any case, SPARQL result sets are not ideal for passing data in a client / server system. Other ontological technologies such as RDF/XML may be more suitable, but replacing a well-know and understood technology like WSDL with RDF/XML requires much more research before a decision should be made to pursue this design path.

Integration with J2EE Applications

The Java 2 Enterprise Edition (J2EE) framework was designed for accessing transactional data stores. Obviously, the most common type of data store is a Structured Query Language (SQL) Relational Database Management System (RDBMS). However, there are specific previsions for non-SQL data sources. The Java Connector Architecture (JCA) shown in Figure 1 is designed to

provide a point of integration for any transactional data store or Enterprise Information System (EIS).

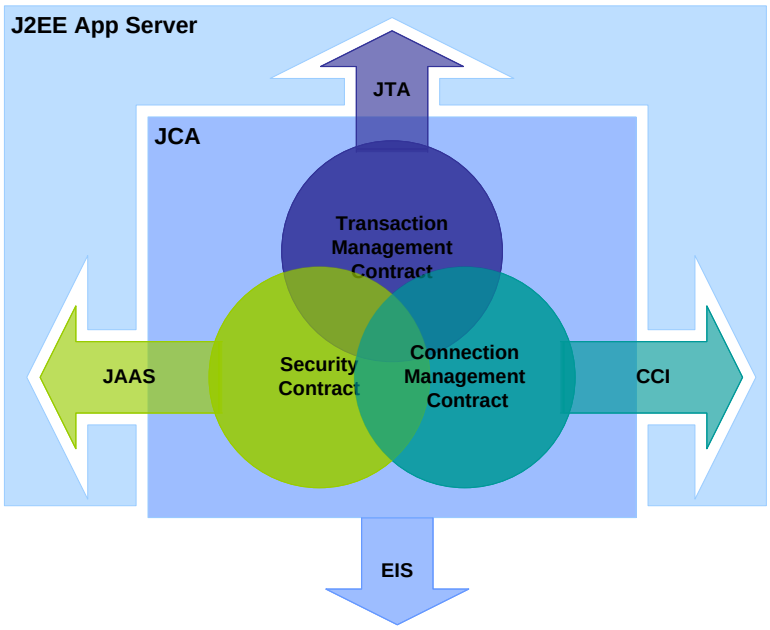

Figure 1: The Java Connector Architecture for integrating external Enterprise Information Systems with J2EE application servers.

A JCA resource adapter implements three main interfaces for data access:

- Authentication and authorization for the data store are provided through the Java Authentication and Authorization Service (JAAS) interface.
- Connection management is provided through the Common Client Interface (CCI).
- Transaction management is provided through the Java Transaction API (JTA).

The J2EE application server is designed to use these interfaces to provide managed connections and transactions to client applications. It is possible to communicate with external data sources without using a JCA resource adapter. However, by implementing the JCA resource adapter interface, a data store works with the J2EE architecture rather than against it. J2EE objects have highly specific lifecycles and management constraints. Only resource adapter objects have the lifecycle and coding constraints to be truly suitable for implementing an adapter to an external data store.

Data integrity must be part of the design of a distributed knowledge system. Providing a data store that supports transactions and two-phase commits is the least burdensome approach and has the most potential for integrating into complex systems.

The Java Connector Architecture is designed specifically for the purpose of providing access to arbitrary data stores. It provides three well-known interface contracts for security, transactions and connection management with which client developers are already familiar. Ontological data sources should be accessed through JCA resource adapters. This will facilitate clean and flexible designs for client applications.

The semantics of ontologies in the data store and rule engine working memory take into account the rules and queries they are designed to support. This may lead to a de-normalized, less object-oriented, design than ontology theory might suggest.

References

Microsoft Corporation (2009). Smart Client Architecture and Design Guide [Computer software and manual]. Available from Microsoft Web site, http://msdn.microsoft.com/en-us/library/ms998506.aspx

Red Hat Middleware, LLC (2009). Drools Documentation Library [Computer software manual]. Available from Drools Web site, http://www.jboss.org/drools/documentation.html

Sriganesh, R.P., Brose, G. Silverman, M. (2006). *Mastering Enterprise Java Beans 3.0* (3rd ed.). Indianapolis: Wiley.

Sun Microsystems, Inc. (2000). Java 2 SDK, Enterprise Edition Documentation Bundle [Computer software manual]. Available at Sun Microsystems Web site, http://java.sun.com/j2ee/sdk_1.2.1/techdocs/index.html

Abbreviations, Acronyms, Trademarks & Copyrights

ABAC	Attribute Based Access Control
ACE	Advanced Collaborative Environments
AFRL	Air Force Research Laboratory
AOC	Air and Space Operations Center
API	Application Programming Interface
AS	Attribute Service
ASAP	Asynchronous Service Access Protocol
ATM	Asynchronous Transfer Mode
AVDL	Application Vulnerability Description Language
BPEL	Business Process Execution Language
BSP	Basic Security Profile
CES	Core Enterprise Services
CGS-WG	CIM based Grid Schema WG
CM	Capability Module
COA	Course of Action
COCOM	Combatant Command
COI	Community-of-Interest
CORBA	Common Object Request Broker Architecture
CORE	Controlled Requirements Expression
CoreTax	Core Taxonomy
COTS	Commercial Off-The-Shelf
CPIM	Common Presence and Instant Messaging
CSS	Cascading Style Sheets
DARPA	Defense Advanced Research Projects Agency
DB	Database
DDMS	Department of Defense Discovery Metadata Specification
DECC	Defense Enterprise Computing Centers
DiffServ	Differential Services
DISR	DoD IT Standards Registry
DoD	Department of Defense
DODAF	Department of Defense Architecture Framework
DoDISS	Department of Defense Intelligence Information System
DOM	Document Object Model
DSS	Digital Signature Services
ECB	Early Capabilities Baseline
EJB™	Enterprise JavaBeans™
FTP	File Transfer Protocol
GFE	Government Furnished Equipment
GGF	Global Grid Forum
GIG	Global Information Grid
GOC-CE	Global Operations Center – Collaborative Environment
GOTS	Government Off-The-Shelf
GUI	Graphical User Interface

GUID	Globally Unique ID
HAIPE	High Assurance Internet Protocol Encryptor
HCI	Human Computer Interface
HPW	Human Performance Wing
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol
IA	Information Assurance
IAW	In Accordance With
IC	Intelligence Community
ICMPv6	Internet Control Message Protocol Version 6
ID-FF	Identity Federation Framework
ID-SIS	Identity Services Interface Specifications
ID-WSF	Identity Web Services Framework
IETF	Internet Engineering Task Force
IMP	Instant Messaging and Presence
IMPP	Instant Messaging and Presence Protocol
Infoset	Information Set
IO	Information Operations
IOPC	Information Operations Planning Capability
IOPC-X	Information Operations Planning Capability - Experiment
IP	Internet Protocol
IPT	PAGE 4
IPTEL	IP Telephony
IPTO	Information Processing Technology Office
IPv6	Internet Protocol Version 6
IRI	Internationalized Resource Identifiers
ISM	Information Security Markings
IT	Information Technology
IWPC	Information Warfare Planning Capability
J2EE™	Java 2 Enterprise Edition™
J7	Engineering Staff Section
JAAS	Java Authentication and Authorization Service™
JDBC™	Java Database Connectivity™
JDK™	Java Development Kit™
JEFX	Joint Effects Force Experiment
JFCOM	Joint Forces Command
JMS	Java Message Service™
JNDI	Java Naming and Directory Interface™
JTT	Joint Targeting Toolkit
JVM™	Java Virtual Machine™
JWS	Java Web Start™
KOS	Knowledge Organization Systems
KPP	Key Performance Parameter
LDAP	Lightweight Directory Access Protocol
MDB	Message Driven Bean

MIB	Management Information Base
MIDB	Militarized Intelligence Database
MIPv6	Mobility for IPv6
MLS	Multilevel Security
MWG	Metadata Working Group
NCE	Net Control Element
NCES	Net-Centric Core Enterprise Services
NCOW-RM	Net-Centric Operational Warfare Reference Model
NECC	Net-Enabled Command Capability
NIP	National Implementation Plan
NSA	National Security Agency
OASIS	Organization for the Advancement of Structured Information Standards
OGSA	Open Grid Services Architecture
OGSI	Open Grid Services Infrastructure
OSGi	Open Services Gateway Initiative
OWL	Web Ontology Language
PDS	Policy Decision Service
PDP	Policy Decision Point
PEP	Policy Enforcement Point
PKI	Public Key Infrastructure
PPP	Point-to-Point Protocol
PRS	Policy Retrieval Service
PSTN	Public Switched Telephone Network
RCP	Rich Client Platform
RCVS	Robust Certificate Validation Services
RDF	Resource Description Framework
RDF-S	Resource Descriptoin Framework Schema
REST	Representational State
RFC	Request For Comments
RH	Human Effectiveness Directorate
RMI	Remote Method Invocation
RSVP	ReSerVation Protocol
SAML	Security Assertion Markup Language
SAPIENT	PAGE 12
SDK	Software Development Kit
SIGTRAN	Signaling Transport
SIMPLE	SIP for Instant Messaging and Presence Leveraging Extensions
SIP	Session Initiation Protocol
SIPPING	SIP Project Investigation
SIT	Simple Internet Transition
SKOS	Simple Knowledge Organization System
SMIL	Synchronized Multimedia Integration Language
SMTP	Simple Mail Transfer Protocol

SOA	Service Oriented Architecture
SOAP	Simple Object Access Protocol
SPARQL	Protocol and RDF Query Language
SVG	Scalable Vector Graphics
SPVT	Strategy Planning Visualization Tool
STINFO	Scientific and Technical Information
SWT	Standard Widget Toolkit
TAG	Technical Architecture Group
TBMCS	Theatre Battle Management Core System
TC	Technical Committee
TSP	Time Sensitive Planning
UDDI	Universal Description, Discovery, and Integration
UI	User Interface
UML	Unified Modeling Language
URI	Uniform Resource Identifier
URL	Uniform Resourse Locator
USERID	User Identification
VisIOn	Virtual Integrated Support for the Information Operations Environment
VoIP	Voice Over IP
VPIM	Voice Profile for Internet Mail
W3C	World Wide Web Consortium
WAS	Web Application Security
WG	Working Groups
WS	Web Services
WSDL	Web Services Definition Language
WS-I	Web Services-Interoperability
WS-I18N	Web Services-Internationalization
WS-S	Web Services-Security
WSO	Web Services Orchestration
WSRF	Web Services Resource Framework
WSRF-BF	WS-BaseFaults
WSRF-RL	WS-ResourceLifetime
WSRF-RP	WS-ResourceProperties
WSRF-SG	WS-ServiceGroup
WSRP	WS Remote Portlet
WSS	Web Services Security
XACML	Extensible Access Control Markup Language
XCBF	XML Common Biometric Format
XHTML	Extensible Hypertext Markup Language
XLIFF	XML Localization Interchange File Format
XMI	XML Metadata Interchange
XML	eXtensible Markup Language
XMPP	XML Messaging and Presence Protocol
XSD	XML Schema Definition

XSL	eXtensible Stylesheet Language
XSLT	Extensible Stylesheet Language Transformation

API	Application Programming Interface
CM	Capability Modules
EJB	Enterprise Java Bean
IC	Intelligence Community
IOPC-X	Information Operations Planning Capability - Experiment
ISM	Information Security Markings
IWPC	Information Warfare Planning Capability
JDBC	Java Database Connectivity
JPA	Java Persistence API
JPQL	Java Persistence Query Language
OV	Operational View
OWL	Web Ontology Language
SQL	Structured Query Language
SV	Systems View
XML	eXtensible Markup Language
XSD	XML Schema Definition