Document #	TUS-FIN-0001
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ONR Transparent Urban Structures: Decision Aids Using Heterogeneous Intelligence Analysis Base Effort (Year 1)

Final Report

Contract #: N00014-08-C-0244

Submittal Revision: -

Date: 18 August 2009

Prepared for:

ONR
Revolutionary Research ... Relevant Results

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Table of Contents

List of Figures

List of Tables

DOCUMENT NUMBER:	RELEASE/REVISION:	RELEASE/REVISION DATE:
TUS-FIN-0001	-	08/18/09

Table 1-1 Revisions

1 Documentation Roadmap

This Final Report is organized into the following sections:

- **Section 1 ("Documentation Roadmap")** provides information about this document and its intended audience. It provides the document overview and describes the content of each section.
- **Section 2 ("Program Overview/Review")** provides a summary of schedules and milestones achieved during the year by phase.
- **Section 3 ("Base Year Technical Overview/Review")** a technical overview of each phase, from an architectural and implementation perspective. Interaction with other ONR performers and testing accomplished in each phase are also summarized.
- **Section 4 ("Results, Conclusions and Next Steps")** summarizes overall status, lessons learned and presents goals and objectives for the first option year.
- **Section 5 ("Directory")** provides reference information, including a glossary and acronym list.

1.1 Document Management and Configuration Control Information

- Revision Number: -
- Revision Release Date: 08/14/09
- Purpose of Revision: Initial Release
- Scope of Revision: N/A

1.2 Purpose and Scope

This Final Report provides a summary of work done under the ONR Transparent Urban Structures contract in the Base Year of the Transparent Urban Structures program by the team comprised of Natural Selection Inc, the U.S. Army Engineering Research and Development Center (ERDC), Textron Defense Systems and the anthropologist Liam Murphy. The effort was divided into 3 phases, and the programmatic and technical discussions will address each phase individually.

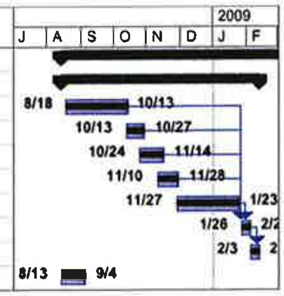
2 Program Overview/Review

2.1 Schedules

Figure 1 shows the executed schedule per phase for the Base year.

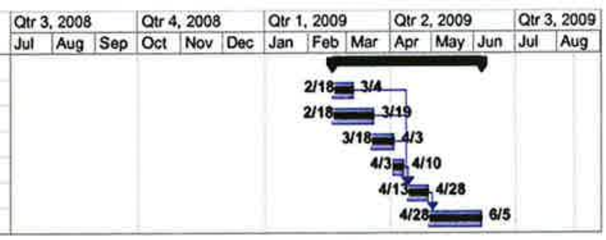
ONR Transparent Urban Structures (YEAR 1)
Phase I
System Engineering and Design

ID	% Complete	Start	Finish	Task Name
1	**81%**	**Wed 8/13/08**	**Mon 8/24/09**	**ONR Transparent Urban Structures (YEAR 1)**
2	**100%**	**Wed 8/13/08**	**Wed 2/11/09**	**Phase I System Engineering and Design**
3	100%	Mon 8/18/08	Mon 10/13/08	System Architecture Development
4	100%	Mon 10/13/08	Mon 10/27/08	Experiment Development
5	100%	Fri 10/24/08	Fri 11/14/08	Sensor Information Collection Service
6	100%	Mon 11/10/08	Fri 11/28/08	CAF Module Development
7	100%	Thu 11/27/08	Fri 1/23/09	Simulation Environment Devlopment
8	100%	Mon 1/26/09	Mon 2/2/09	Integration and Experimentation
9	100%	Tue 2/3/09	Wed 2/11/09	Technical Interchange Meeting I
10	100%	Wed 8/13/08	Thu 9/4/08	System Engineering



ONR Transparent Urban Structures (YEAR 1)
Phase II
Development

ID	% Comp	Start	Finish	Task Name
11	**100'**	**Wed 2/18**	**Fri 6/5/**	**Phase II Development**
12	100'	Wed 2/18	Wed 3/4	Geo-Cultural Service Emulator
13	100'	Wed 2/18	Thu 3/19	Inferencing Engine Development
14	100'	Wed 3/18	Fri 4/3/	CAF Module Implementation & Testing
15	100'	Fri 4/3/	Fri 4/10	Scenario Development & Implementation
16	100'	Mon 4/13	Tue 4/28	Experimentation
17	100'	Tue 4/28	Fri 6/5/	Technical Interchange Meeting II



ONR Transparent Urban Structures (YEAR 1)
Phase III
Integration and Test

ID	% Complete	Start	Finish	Task Name
18	**100%**	**Mon 9/8/08**	**Mon 8/24/09**	**Phase III Integration and Test**
19	100%	Mon 9/8/08	Tue 5/12/09	Geo-Cultural Service
20	100%	Mon 6/8/09	Mon 6/8/09	Architecture
21	100%	Mon 6/8/09	Tue 8/11/09	Design & Development
22	100%	Mon 6/8/09	Fri 8/14/09	Integration & Test
23	100%	Mon 8/10/09	Mon 8/24/09	Technical Interchange Meeting III (DEMO)

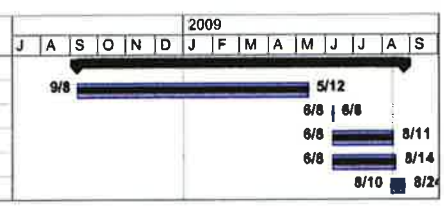


Figure 2-1 Schedules by Phase

Table 2.1 Summarizes statused milestones for the program Base year.

Tasks	Baseline	Planned	Completed
Deliverables			
Program Plan	SEP	SEP	SEP
Software Architecture	OCT	OCT	OCT
Phase 1 TIM and minutes	FEB	FEB	FEB
Phase 1 Experimentation and Test Plan	DEC	JAN	JAN
Phase 2 TIM and minutes	MAY	JUNE	JUNE
Phase 2 Experimentation and Test Plan	APR	MAY	AUG
Phase 3 TIM and minutes	AUG	AUG	AUG
Phase 3 Experimentation and Test Plan	AUG	AUG	AUG
Monthly Technical and Financial Reports	Monthly	Monthly	Monthly
Final Report	AUG	AUG	AUG
Other Technical Milestones			
Phase I Tasks			
Defined Services & Interfaces (Architecture)	SEP	OCT	OCT
PDR	OCT	OCT	OCT
Sensor Information Collection DB	NOV	OCT	OCT
Developed Service Adapters	NOV	DEC	DEC
Model Requirements/Design	DEC	NOV	NOV
Implement Models	JAN	DEC	DEC
Integrate System Test/Experiment	FEB	JAN	JAN
Phase II Tasks	--	--	--
Develop Geo Cultural Emulator and Service	MAY	MAY	MAY
Develop Inference Engine	MAY	MAY	MAY
CAF Module Implementation & Test	APR	MAY	MAY
Scenario Development and Implementation	APR	MAY	MAY
Phase III Tasks	--	--	--
Geo Cultural Service	MAY	AUG	AUG
Architecture	JULY	JULY	JULY
Design and Development	AUG	AUG	AUG
Integration and Test	AUG	AUG	AUG

Table 2-1 Statused Milestones

2.2 Meetings Summary

The base year program had a defined set of periodic meetings that are all documented with meeting minutes. These meetings included:

- Weekly Team meetings with subcontractors

- Weekly program meeting
- Monthly program review with Textron Senior management
- Monthly Teleconference with ONR: Minutes have been distributed to ONR
- 3 Technical Interchange Meetings with ONR: Minutes have been distributed to ONR
- Bi-weekly anthropology meetings in Phase 3 with subject matter experts (SMEs) and development team
- Daily integration meetings towards the end of each phase

2.3 Documents

Monthly

- Monthly Spend Report 9/2008 - 7/2009
- Monthly Financial Report 9/2008 - 7/2009
- Monthly Internal Review Slides and Meeting Minutes 9/2008 - 7/2009

Contractual

- Textron /ONR SOW TS-W8C03 (AV04) 8/12/2008
- Contract No. N00014-08-C-0244 MOD-1-NONE-Initial 8/14/2008
- Contract MOD 2-P00001-Initial -1/15/2009
- Contract MOD 3-P00002-Final-6/16/2009

Technical Interchange Meetings

- TIM I – Presentation and Meeting Minutes 2/18/2009
- TIM II – Presentation and Meeting Minutes 6/5/2009
  - RBIE- Trade Study 6/10/2009
  - Ramadi Scenario Playbook 3 6/10/2009
- TIM III – ISR Data Analysis Workshop Slides and Meeting Minutes 8/5/2009

Deliverables

- ONR TUS Software Architecture Specifications, TUS-SAD-0001, 10/13/2008
- Experiment Test Plan -Phase I, TUS-ETP-0001-Initial, 1/19/2009
- Experiment Test Plan-Phase II TUS-ETP-0001-REV B- 8/14/2009
- Experiment Test Plan Phase III TUS-ETP-00011-REV C-8/14/2009
- ONR TUS Integrated Program Plan TUS-IPP-01Initial- 9/12/2008
- Textron Base Year Final Report, TUS-FIN-0001, 8/14/2009

3 Base Year Technical Overview/Review

The system being developed by the Textron team on the Transparent Urban Structures Program is comprise of a software framework infrastructure that integrates three key services and a simulation environment into a blended Service Oriented Architecture, Event Driven Architecture (SOA/EDA) software communications architecture.

The base year effort is comprised of 3 phases of development with increasing functionality and interoperability of the system.

3.1 Requirements

The following are the high-level technical requirements:

1. Interoperability with DoD Frameworks and Architectures
   - a Develop a blend of EDA and SOA architectural approaches. EDA will allow for near real time messaging in the system while the SOA paradigm enables a pull back feature that will allow the request of data via a XML/SOAP web service interfaces.
   - b Implement a common messaging bus for data communications amongst services in the system
   - c Expose datasets via extensible markup language, simple object access protocol (XML/SOAP) web services
2. Geo-Cultural service to provide context and actionability to sensor data and intelligence
   - d Data collection
   - e Possible data fusion for heterogeneous data sources
   - f Inferencing engine to determine if data is actionable
3. Integrate with multiple sensor systems and technologies
   - g Develop M&S environment
     - i Urban
     - ii Multiple sensor modalities
4. Scalable to option years

3.2 Requirements Coverage

These requirements have been addressed in the following fashion:

1. Web based semantic web technologies were used to facilitate data query and dissemination. Protégé, SPARQL, Sesame and JAVA are technologies implemented on this program. These technologies provide SOA tools to encourage interoperability. Common messaging bus (ActiveMQ) was implemented to aid data flow between components of the systems. This bus satisfied the EDA requirement of the system.

2. Geo-cultural components were implemented. This includes a geo-database, ontology, instance data and an inferencing engine. Additionally the ontology is being expanded to encompass anthropological relationships. The inferencing engine (Drools) chosen for our system is able to produce output on ac-

tionable data. Future iterations of the system may have more robust Bayesian fusion rules integrated into the platform.

3. Integrated simulation system in phase 1 that mimicked urban sensors in a tailored scenario. Showed the ability to use sensor data in real time, which could be fused with the ontological and geographic data. As work continues with other ONR performers, leveraging of more live data is expected.
4. *Scalable to option years* implies two philosophies. First, that the architecture for the system builds on itself over time in a fashion that can support a wide range of inputs and interfaces to other systems in an environment of increasing complexity and functionality. Second, that the Textron system comply with the architectural guidelines and implementation standards posed by ONR, while providing information services to other performers and ultimately the warfighter. Both of these have been firm tenants of this design and priority has been given to working with other performers and understanding the objective ONR architecture.

3.3 Phase 1

Figure 3-1 shows the system architecture. The colored components will be developed under the Base Year of the current contract. The grayed-out components are Option Year development efforts. As shown with dotted lines, some components developed in the Option Years will replace components developed in the Base Year. The colored components in the red rectangle were developed and tested in Phase 1. The following section describes these components.

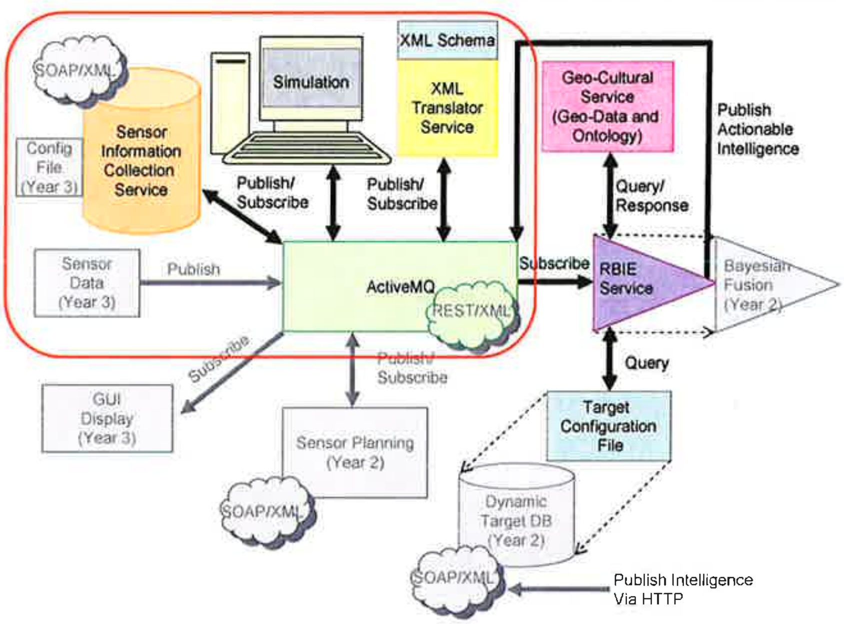


Figure 3-1 Phase 1 Architecture

ActiveMQ Message Bus – Provides the coupling of all the disparate services through topic-based publish and subscribe capabilities.

Simulation – A High Level Architecture (HLA) based environment that models & simulates an urban geographic area, including building, roads, foliage, people, vehicles, sensor systems, and more. The sensors in this environment publish data to the ActiveMQ Message Bus via an adapter. In the future, the simulation will be able to subscribe to topic data on the ActiveMQ Message Bus.

Sensor Information Collection (SIC) Service – Subscribes to formatted sensor data topics on the ActiveMQ Message Bus and stores the data for other uses. There is a flat configuration file that contains the database schema. In the future, the SIC will publish data to the ActiveMQ Message Bus as well as through an SOAP/XML web service interface.

XML Translator Service – Subscribes to, and translates, raw sensor data into standard XML formats and then publishes formatted data to the ActiveMQ Message Bus

3.4 Phase 2

Figure 3-2 shows the Phase 2 system architecture. The colored components will be developed under the base year of the current contract. The grayed-out components are option year development efforts. As shown with dotted lines, some components developed in the option years will replace components developed in the base year. The colored components in the red rectangle were developed and tested in Phase 1. The colored components in the blue rectangle were developed and tested in Phase 2 and are described below.

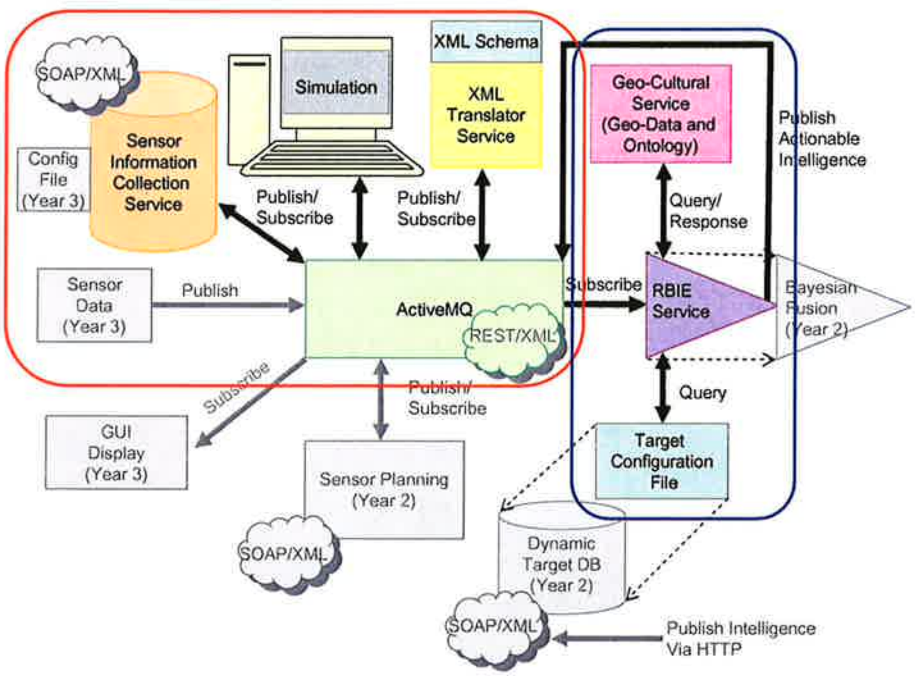


Figure 3-2 Phase 2 Architecture

Geo-Cultural Service – this service has three building blocks:

Geo-Cultural Ontology – The geo-cultural ontology was created prior to this project and is undergoing constant improvement or enhancement. It is a Web Ontology Language

(OWL) file containing relationships between geographic entities and cultural practices, including activities and events.

Geo-Cultural Knowledge Store – The knowledge store contains instance data (dates, times, etc.) for when particular activities and events occur in the geo-cultural area of interest. While the OWL file could represent instances of the data, the knowledge store decouples the instance data from the ontology to improve scalability of the system.

Geo-Database – The geo-database for Ramadi, Iraq was provided by the Navy Research Lab (NRL). It is used in conjunction with the Ontology and Knowledge Store to provide the rule-based inferencing engine with contextual data.

Protégé Utility to convert ONR ontologies into Java classes – The existing ONR ontologies represent a common framework for performers to interpret the interaction of data. It is necessary to leverage these ontologies, so as to contain the same information when interacting with other performers. Protégé contains a utility that allows a user to export an OWL file to Java classes. These classes follow a format such that the name of the ontology (e.g., "Person") will be an interface, and the implemented ontology containing the properties specific to that ontology will be contained within the "impl" package of the high-level ontology package, with the same name except preceded by "Default" (e.g., "DefaultPerson").

Scenario Configuration Environment – This file contains all events associated with a given scenario, including events that generate potential targets and threats for the scenario. This file also contains periphery information such as date, time, weather, and interfaces with the System/Graphical User Interface.

System/Graphical User Interface – The User Interface performs the essential function of presenting data to the user in a visually condensed but intuitive fashion. This is achieved by performing as many actions on the backend as possible, such as loading all scenarios and rules immediately on startup, as well as displaying each asserted fact and fired rule (and potential threats and targets) in the appropriate text box at the appropriate time (immediately following the user's assertion of the next fact).

Scenario Configuration Input Utility – This utility is responsible for correctly configuring the initial setup conditions of the system by reading in all buildings and scenarios contained within the scenario playbook.

Rule-Based Inferencing Engine (RBIE) – The RBIE contains rules derived from military and anthropological subject matter experts. The inferences made based on these rules help create lists of targets and threats for a given scenario, and will provide alerts when a threshold threat level (or similar) is reached.

Resource Description Framework (RDF) Statement Generator – This utility is responsible for correctly assembling and publishing RDF statements to a specified server.

3.4.1 Phase 2 System Usage

Figure 3.3 illustrates the usage of the Phase 2 system. The accompanying text will summarize the functionality of each box in the diagram in terms of inputs and user interface.

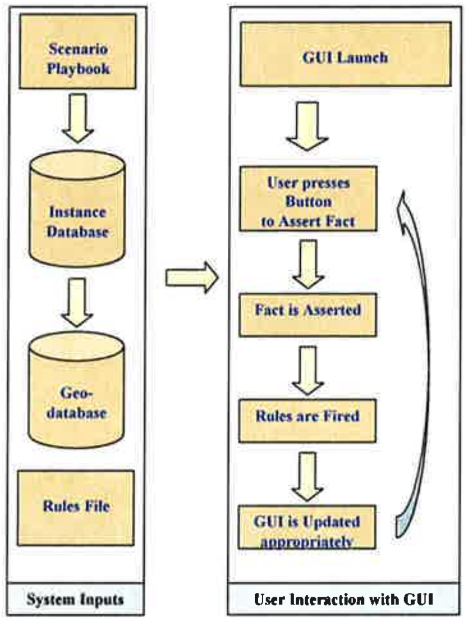


Figure 3-3 Phase 2 System Usage

System Inputs

The input components of the Phase 2 System, illustrated above, are solely responsible for providing context to the system. These components drive the system functionality and their interactions are displayed on the Graphical User Interface (GUI) :

Scenario Playbook

The scenario playbook, shown in figure 3-1, contains contextual events, such as socio-economic status, military support, or non-insurgent illegal activity, and intelligence events, such as arrests and recorded sensor events (i.e. Metallic Anomaly). This provides a way to script scenario history, events and detections for testing the system.

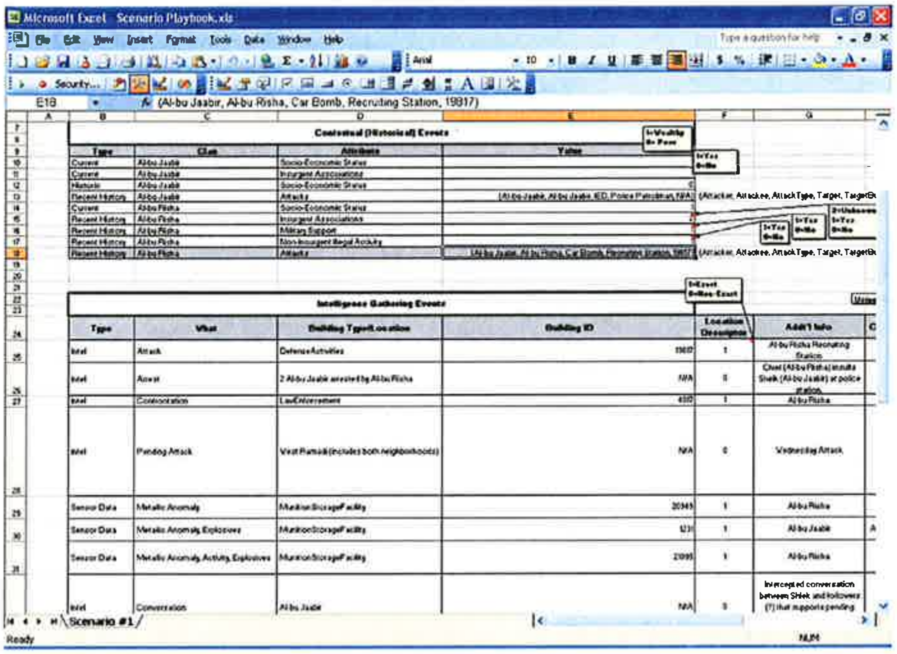


Figure 3-4 Scenario Playbook

The Contextual Events are past events that serve to give context to the current Scenario, and Intelligence Events are meant to simulate events that occur in real-time. Each Intelligence Event contains the following fields (table 3-1):

Field	Description
Type	Intel or Sensor Data event
What	Event sub-types, such as Pending Attack or Metallic Anomaly
Building Type/Location	Building Type/Location
Building ID	Building ID
Location Descriptor	Exact or Non-Exact
Addt'l Info	Additional Comments pertaining to Intelligence Event
Classification	Further Classification of the Intelligence Event
Date	Date
Time	Time
State Change	This field reflects the what the output of the Intelligence Event should be, and is not processed as input.

Table 3-1 Event Fields

Instance Database
The instance database contains local geo-cultural information for the specified region: in this case, Ramadi, Iraq. This data and its inter-relationships are described by the geo-cultural ontology. Instance data can be queried by the inferencing engine as part of its execution thread or ultimately by outside users and services.

Geo-database
The geo-database contains information regarding locations with the ability to represent objects, buildings, roads and attributes associated with them. Each location contains a unique index (the Scenario Playbook assumes that the location has been identified via some external means), with a location or building functionality, such as 'DefenseActivities' or 'MunitionsSupplyFactory'. This particular geo-database is derived from one received from NRL for Ramadi Iraq. It has been enhanced for the South West portions of Ramadi in support of this particular scenario.

Rules File
The Rules file contains inferencing 'rules' that contain a subject and a predicate. Each rule represents a cause-effect relationship between the inputs to the system, contextual and intelligence events, and the outputs of the system, threat and target levels. In this light, the subject is the input to the system, such as a metallic anomaly occurring at a recorded location, and via the associations drawn from the instance database and geo-database, the predicate, or output of the event, is that the threat level for the given location is increased.

For the Phase 2 System, the RBIE selected was a JAVA based solution named Jess, based on it's interoperability with Protege. Issues occurred in Phase 2 with Jess's ability to handle complex data types. This issue is addressed in Phase 3.

User Interaction with the GUI

These components provide the user with the means of asserting facts into the Inferencing Engine, and provide back to the user the result of a subset of rules firing. See figure 3-5.

User Presses Button to Assert Fact
The following figure represents the Jess GUI:

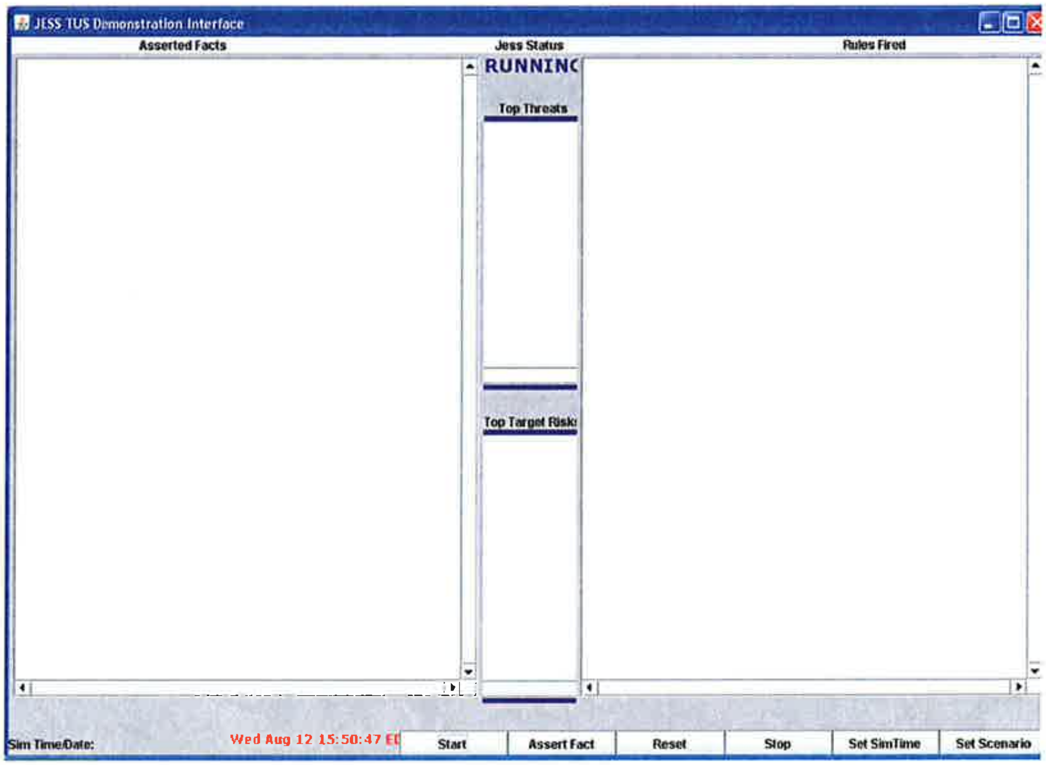


Figure 3-5 Jess GUI

The user must first press the "Start" button to start the Rete algorithm based Jess engine, and then can press the "Assert Fact" button as desired to observe assertion of facts and the firing of rules.

Fact is Asserted

When the user pressed the "Assert Fact" button, the next Intelligence Event in the 'IntelligenceEventVector' is asserted into the Jess RETE engine. This use case allows the user to see the output of each rule (or rules) firing, and how that impacts the overall system.

Rules are Fired

For a given fact, a subset of the total number of rules will fire, where that subset is between 0 and the total number of rules. Thus, though unlikely, an asserted fact could cause every single rule to fire, or could cause none. When a fact is asserted that meets the criteria of the subject of a rule, then the predicate of the rule is executed. For instance, if an 'Arrest' event occurs (subject), then the Threat Level of that person's organization, based on their Socio-Economic Status and previous attack history will be elevated (predicate). The output of a subset of rules firing is updating the GUI to correctly represent the underlying information.

GUI is Updated appropriately

The process between the assertion of facts and firing of rules is transparent to the user. The user simply clicks "Assert Fact" and the system responds accordingly. See figure 3-6:

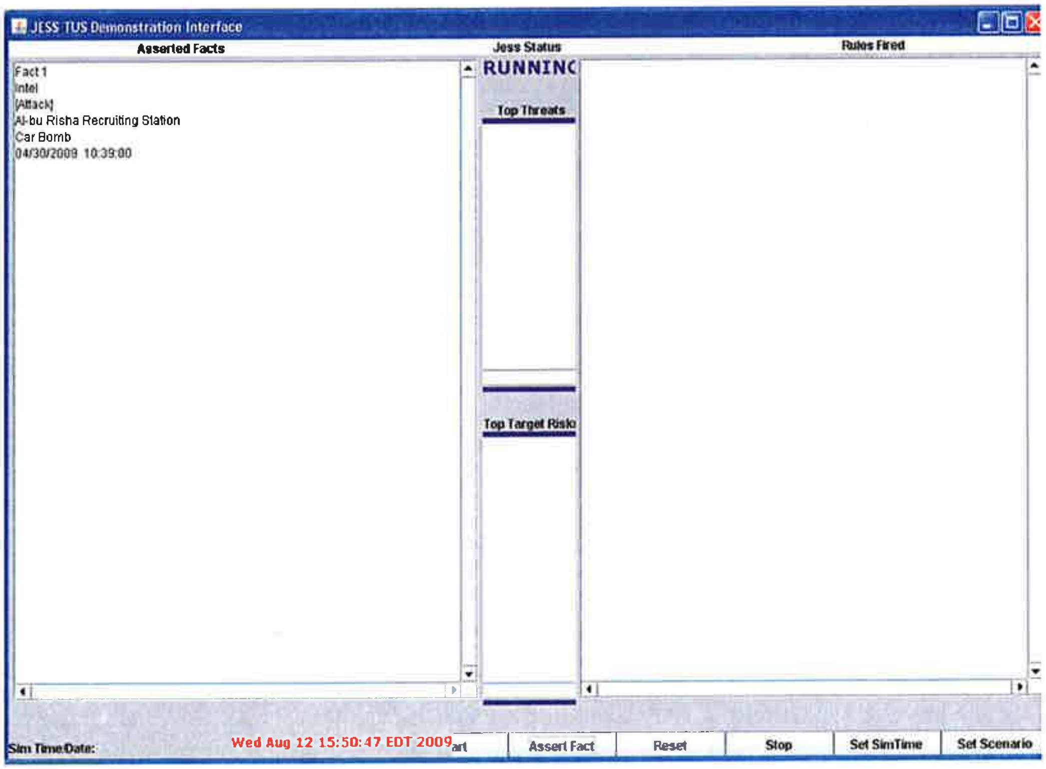


Figure 3-6 Asserted Fact in Jess GUI

Though the "Top Threats," "Top Target Risks," and "Rules Fired" panels have not updated in the above view, they would serve to represent the top Target and Threat Levels that have been deduced by the rule-based inferencing engine and the report of which rules have been fired would appear in the "Rules Fired" panel.

3.5 Phase 3

Efforts in Phase 3 have focused on four key areas:

- Selection and Integration of a new RBIE
- Developing functionality to interoperate within the objective ONR Architecture including support to the August 2009 Data Analysis Demo (DAD) integration and test effort.
- Support to the September 2009 ISR-C2 demonstration
- Initial development of an Anthropological Ontology

3.5.1 Selection and Integration of a new RBIE

Phase 3 presented the need to revaluate the inferencing engine. The Jess engine that was used in Phase 2 did not provide the ability to access nested data types in a manner that was easy to the developer. Seeing as most of the structures generated from the ONR ontology are hierarchal in nature it was determined that a new direction was needed for the RBIE. Additionally Jess provided zero debugging capabilities. Numerous RBIEs were evaluated in the process. Table 4 lists these RBIEs:

Platform	Comments
Manadrax Inferencing Engine	No Protégé plug-in No debugging capability Last update 2008
Algernon	Protégé plug-in No debugging capability Last update 2005
JTP	No Protégé plug-in Last update 2004
JBOSS Rules (Drools)	JAVA based Protégé plug-in Good debugging capabilities Widely supported Last update May 2009
JENA	Protégé plug-in No debugging capabilities Last update 2009
Zilonis	Not Widely supported

Table 3-2 RBIE Tradespace

The decision was ultimately made to go with Drools due to its eclipse plug-in, support for all Java types, good debugging capabilities Java based rules, large community base, support of Rete chaining algorithm, and its suite of visualization tools. Drools is currently integrated into and tested in the Textron environment.

3.5.2 Objective ONR architecture and the DAD demonstration

Figure 3.7 illustrates the Objective architecture picturing the Textron team's services participating.

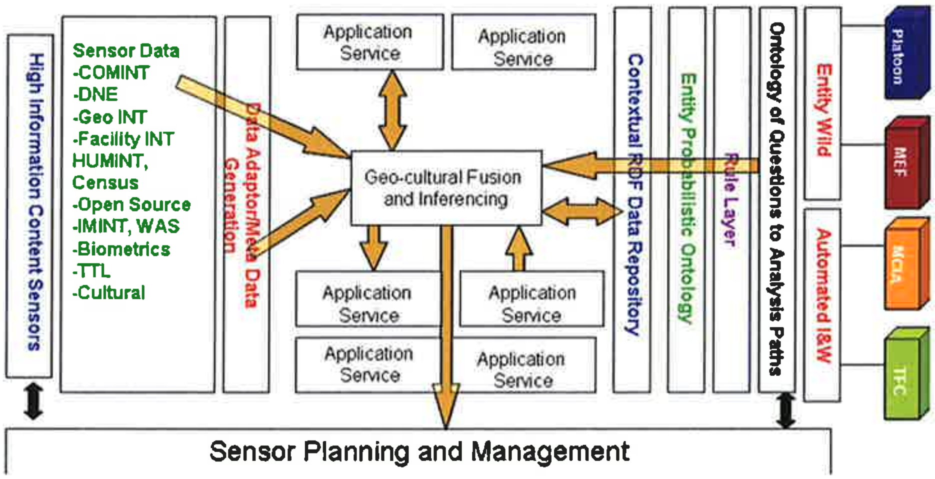


Figure 3-7 ONR Objective Architecture

The Geo-cultural Fusion and Inferencing Service interacts within the architecture as follows:

- Outputting RDF to the RDF repository
- Inputting user queries
- Receiving data from other services
- Outputting data to other services
- Interacting with other services
- Receiving sensor metadata
- Receiving raw sensor data
- Outputting Sensor Planning RDF

Efforts with regards to the DAD demo are a first step towards realization of this architecture. Figure 3.8 shows the Phase 3 usage and illustrates the implementation of the functionality to support interaction with the RDF repository.

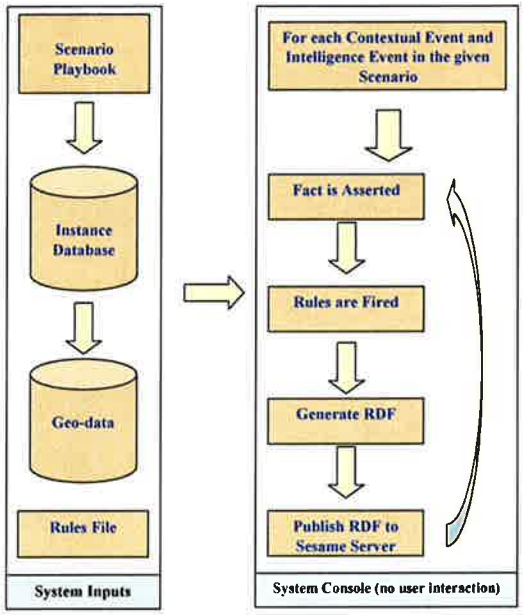


Figure 3-8 Phase 3 Usage

System Input Descriptions

The input components of the Phase 3 System provide scenario sequencing, geographic and geo-cultural data and the inferencing rules. Each is described below:

Scenario Playbook

While Phase 3 testing has been done with the same playbook as Phase 2, development of a new playbook has begun to support the DAD demonstration. Based on the classified NRL data provided by NRL, it will provide a relevant Afghanistan scenario for current demonstration and future development efforts.

Instance Database

As scenario data was delayed in delivery, an instance database has been under development for the DAD demonstration using unclassified sources.

Geo-database

While NRL provided the beginnings of a geo-database for the DAD demonstration, additional data is needed for complete support of the demonstration. Some of this will have to be manually generated based on the requirements provided by the actual content of the data.

Rules File

The functionality of the rules file has not changed between Phase 2 and Phase 3. Additional rules are continuously being developed. However, the Phase 3 system utilizes Drools rather than Jess as its inferencing engine.

System Console Display Events

Fact is Asserted

The Phase 3 System does not make use of the Jess GUI, and as a result, there is no interface that the user may utilize. Thus, the assertion of facts occurs once the scenarios have been loaded into the system. The user may watch what facts are asserted by watching the system console as they occur, but has no control over when they assert (as with Phase 2 System).

Rule is Fired

As with the assertion of facts, rules fire independent of any user input (this makes sense due to the correlation between fact-assertion and rule-firing). However, functionality of rules firing has not changed between Phase 2 and Phase 3.

Generate RDF

When the system has determined that an event should be marked 'Abnormal' (for the purposes of Phase 3 System, all events are considered 'Abnormal'), the event is mapped into the RDF resource 'ActualEvent'. This format allows other performers to subscribe to consistent information statements. The following figure represents an 'ActualEvent' RDF statement when output to a local file:

```
<?xml version="1.0"?>
<rdf:RDF
    xmlns:protege="http://protege.stanford.edu/plugins/owl/protege#"
    xmlns:xsp="http://www.owl-ontologies.com/2005/08/07/xsp.owl#"
    xmlns="http://www.owl-ontologies.com/Ontology1249996752.owl#"
    xmlns:Perception="http://ltsn.onr.navy.mil/Perception#"
    xmlns:owl2xml="http://www.w3.org/2006/12/owl2-xml#"
    xmlns:Ontology2="http://ltsn.onr.navy.mil/Ontology/"
    xmlns:swrlb="http://www.w3.org/2003/11/swrlb#"
    xmlns:rdf="http://www.w3.org/1999/02/22-rdf-syntax-ns#"
    xmlns:Ontology="http://ltsn.onr.navy.mil/Ontology.owl#"
    xmlns:owl="http://www.w3.org/2002/07/owl#"
    xmlns:xsd="http://www.w3.org/2001/XMLSchema#"
    xmlns:swrl="http://www.w3.org/2003/11/swrl#"
    xmlns:rdfs="http://www.w3.org/2000/01/rdf-schema#"
  xml:base="http://www.owl-ontologies.com/Ontology1249996752.owl">
```

```
  <owl:Ontology rdf:about="">
    <owl:imports rdf:resource="http://ltsn.onr.navy.mil/Ontology.owl"/>
  </owl:Ontology>
  <Ontology:ActualEvent rdf:ID="Metallic_Anomaly">
    <Ontology2:latitude rdf:datatype="http://www.w3.org/2001/XMLSchema#float"
    >45.1</Ontology2:latitude>
    <Perception:probability
rdf:datatype="http://www.w3.org/2001/XMLSchema#float"
    >0.75</Perception:probability>
    <Ontology2:longitude
rdf:datatype="http://www.w3.org/2001/XMLSchema#float"
    >45.2</Ontology2:longitude>
    <Ontology:dateCreated
rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >2009/08/11 09:19:14</Ontology:dateCreated>
    <Ontology:creator rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >TEXTRON1</Ontology:creator>
    <Ontology:hasThreatLevel
rdf:datatype="http://www.w3.org/2001/XMLSchema#int"
    >1</Ontology:hasThreatLevel>
    <Perception:generationTime
rdf:datatype="http://www.w3.org/2001/XMLSchema#string"
    >2009/08/11 09:19:14</Perception:generationTime>
  </Ontology:ActualEvent>
</rdf:RDF>
```

As seen above, the RDF properties correspond to information related to the event.

Publish RDF to Sesame Server

Rather than updating local files, the most logical approach is to directly publish an 'ActualEvent' statement to a Sesame server that other performers can consume. RDF statements are only generated and published when an 'Abnormal' event occurs in the Phase 3 System, and as a result of this, the user has no transparency beyond the System Console of when RDF is being generated and published (same as the assertion of facts and firing of rules).

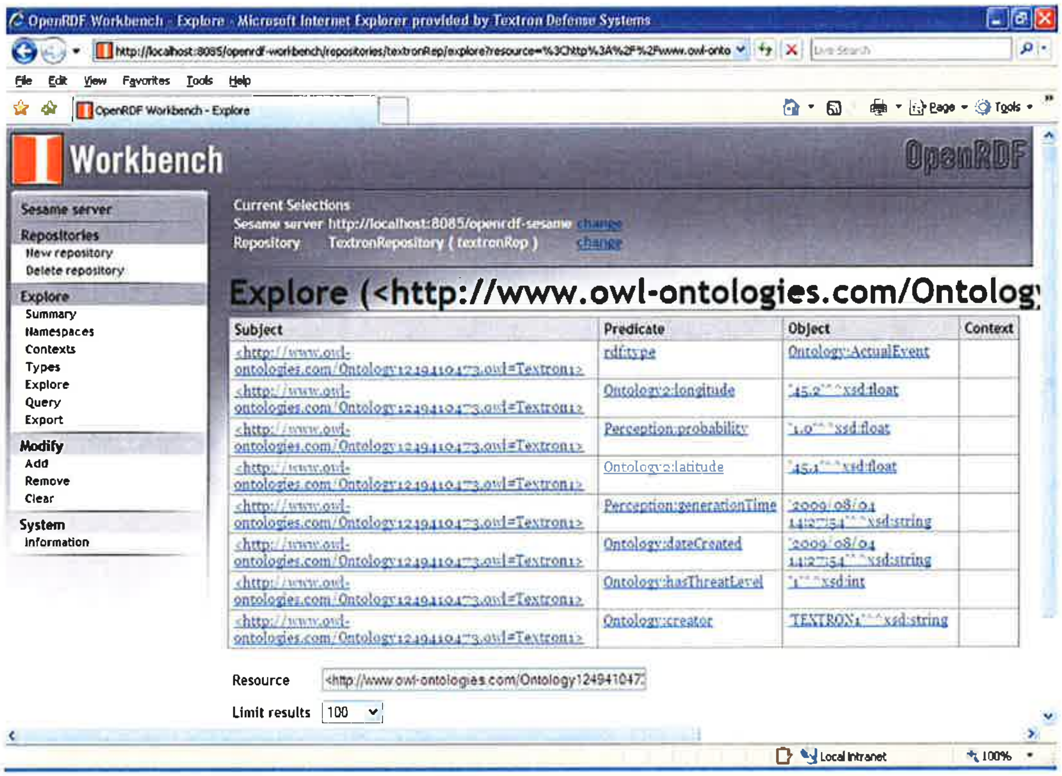


Figure 3-9 Published RDF Resource listed through Sesame API

Significant effort has gone into the development of ontologies to support this architecture under the direction of NRL. Additionally ONR has established a collection of potential data available, as identified in the Generic Intelligence Requirement Handbook (GIRH) and is mapping it to the various performer's services. While The Textron team's services are not directly outputting any GIRH data directly for the DAD demonstration, there is a significant amount of GIRH data that is present in the Geo-cultural Instance Data that could be leveraged in the future.

3.5.3 ISR-to-C2 Demonstration

Baseline development efforts have focused on the objective ONR architecture and participation in the DAD demo. Textron has also been asked to participate in the ISR-to-C2 demonstration at Ft Smith in Oahu Hawaii in September 2009. The paradigm for interoperability is different than in the DAD demonstration and requires using the publish subscribe architecture of the Raytheon Distributed Knowledge and Knowledge Needs (DKKN) system. As of the date of this report DKKN integration is progressing. The intent in this demonstration is for geo-cultural queries to be executed based on soldier I2W voice-to-text data or direct queries or event statements from the Company Level Operations Center (CLOC) Figure 3.10 illustrates the functionality of this system

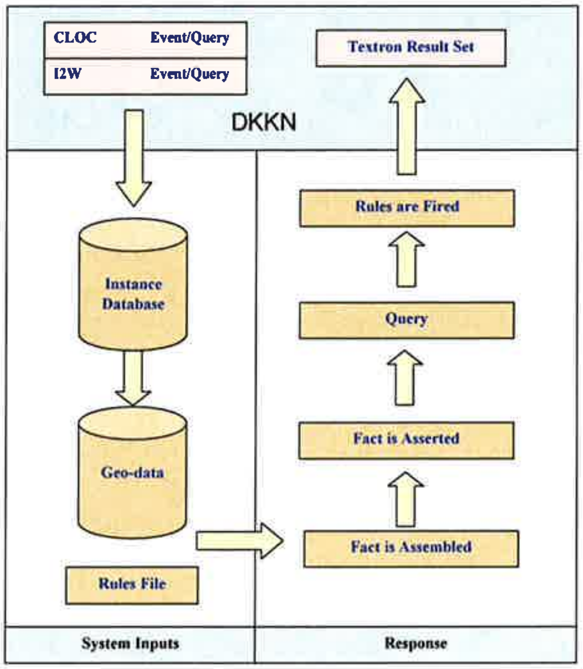


Figure 3-10 Phase 3 Usage

System Inputs

The input components, shown in figure 3-10, of the ISR-C2 System are responsible for driving the dynamic element of the system. The interest events serve to simulate real-time events as they occur. The instance and geo-databases serve to provide context for the location and associated activities with the given location. The rules file serves to provide inference capabilities for given events. The combination of these input events, whether static or dynamic, allows for a responsive real-time system that will provide inferencing on a given event and return an appropriate output.

DKKN: CLOC Interest Event and Queries
This event will occur when the CLOC publishes an event of interest or generates a query.

DKKN: I2W Interest Event and Queries
This event will occur using the I2W voice-to-text interface Lockheed Martin has developed. There are a number of common phrases that a user may speak, such as “Market is not busy,” that will be digitized, recorded, and published to the DKKN server as an interest event. Other queries from the I2W device will be supported as needed.

Instance Database
Considerable unclassified instance data has been collected for the Garmsir area in Afghanistan. This data will be enhanced and/or modified to support the efforts of this demonstration.

Geo-database
The specific content of the geo-database for this demonstration is still being discussed. This will change based on the final content of the demonstration.

Rules File
The Rules file contains 'rules' that contain a subject and a predicate. The subject is the input to the system, such as a market observed as being 'not busy', and via the associations drawn from the Instance Database and Geo-database, the predicate, or output of the event, is that the Target Level for the given location is increased. For the purposes of the ISR-C2 demonstration, the rules file will contain only a subset of the developed rules with the intent of demonstrating input/output functionality in conjunction with other performers, rather than advanced inference-making.

Query Response

The ISR-C2 System Response details how the system will respond to any input. The process involves assembling and asserting the pertinent information pertaining to the 'fact', leveraging the limited rules set to fire a small number of rules, and providing the updated result set back to DKKN for other performers to subscribe to.

Fact is Assembled
When an event of interest occurs and is published to the DKKN server, the system must respond to it in the same manner, no matter what the source of the event is. Thus, assembling the fact into a meaningful data format is necessary to allow proper inferencing.

Fact is Asserted
Once the 'fact' has been assembled in a manner that will allow the inference engine to interpret the information contained within, the 'fact' is asserted. The assertion process is simply adding the 'fact' to the initialized local Knowledge Store (which also contains stateful intelligence regarding the Rules File).

Rules are Fired
For a given fact, a subset of the total number of rules will fire, where that subset is between 0 and the total number of rules. Thus, though unlikely, an asserted fact could cause every single rule to fire, or could cause none. When a fact is asserted that meets the criteria of the subject of a rule, then the predicate of the rule is executed. For instance, if an 'Arrest' event occurs (subject), then the Threat Level of that person's organization, based on their Socio-Economic Status and previous attack history will be elevated (predicate). The output of a subset of rules firing is an increasing and decreasing of appropriate Target and Threat Levels, which will be cataloged in the 'Textron Result Set' and published back to the DKKN server. A direct query into the system should in theory fire 0 rules.

DKKN: Textron Result Set

The Result Set is simply the observed changes in the system given the most recent rule firing. This Result Set exists to show the cause-effect relationship between an event occurring (cause), and the appropriate Target and Threat Levels changing (effect).

3.5.4 Anthropology

Development has been ongoing in Phase 3 of an expanded Ontology that covers queriable Anthropological constructs and data types. A team of subject matter experts have been used to define the new Ontology elements. They include:

- TUS team members including a geographer
- An anthropologist
- Former Army Infantry Officer
- Former Army Intelligence Officer
- Former Marine Corp Intelligence Officer
- Former Navy Seal
- The Ontology has currently been instantiated in Protégé and development of linkages between elements is ongoing, to be further defined in the next phase of the program. Figures 3.11 -3.13 illustrate the combined ontology:

Figure 3-11 Geo-Cultural Elements

Dynamics (How)

Expression
Individual symbolism
Group symbolism
Group symbolism
Laminate Behavior
(Has Symbols)
Exterior Symbolism
Interior Symbolism:
- **Home**
- **Workplace**
- **Mosque, etc.**

Detection/Symbols (Top Level)
Images
Smell
Sounds
Gestures/Proxemics
Alcohol/Drug/Smoking behaviors
Food/Dining
Animals
Vehicles
Buildings and Spaces
- homes
- marketplaces
- streets
- parks
- workplaces
- public buildings (government)
- public buildings (private)
- public buildings (leisure)

Sanitary practices
Weapon Ownership and use
Media assertion
(Has scope)
(Has Cultural Practice)
(Has Routine Activities/Events)
(Has Non/routine Activities/Events

Characteristics (Why)

Scope of a Symbol
International
National
Regional
Economic Class
Political Group
Religious Group
Military
Anti-Military
Government
Educational/Literacy
Gang
Cult
Clan
Other organizational group
City
Neighborhood
Other geographically defined location
Age Group
Gender
Family
- domestic/homestead
- extended

Sports Team
Sport
(Has attributes)

Attributes
Appropriate or Normal Values
Inappropriate Values
Honorable Values
Stability
Attitudes (Scope vs Scope)

Figure 3-12 Anthropological Elements

Detection/Symbols (Top Level)
Images
- Colors
- Flags and Banners
- Body Art (tattoos, piercings, hair)
- Clothing (Norms, Styles and materials)
  - Hats and scarves
  - Armbands
  - Eyewear
  - Footwear
  - Status indicators
  - Uniforms
  - Jewelry
  - Other
- Murals and Pictures
- Graffiti
- Statues
- Structures (non-building)
- Signage or Markers (rocks denote minefield)
- Transient or Homeless Populations
- Missing Populations
- Public human motion
- Physical Violence

Smell
Gestures/proxemics
- Food/dinning
- Gender interaction
- Displays of affection
- Group interactions

Sounds
- Verbal Taboos
- Songs
- Chants
- Chimes
- Religious sounds
- Explosions
- Gunfire
- Machinery
- Vehicles
- Animals
- Human background
- Verbal Violence

Vegetation
Alcohol/Drug/Smoking behaviors
Food/Dining
Animals
Vehicles
Buildings and Spaces
Sanitary practices
Weapon Ownership and use
Media assertion
Weather/Seasonality:
- rain
- sun
- storms
- phases of moon

Figure 3-13 Expanded Symbols

3.6 Performer Interaction

The Textron team has worked hard to interact with other performers to support information sharing, architecture interoperability and development and execution of ONR demonstrations. These performers included:

- Aptima: Interoperability, service interaction (event modeling) and DAD demo
- SAIC: Sensors
- Toyon: Sensors
- Eureka: Sensors
- Chi: Geo-cultural
- Raytheon: DKKN and ISR-C2 demo
- LM-ATL: I2W
- BBN: Loan of UGS platforms and ISR-C2 demo
- SPADAC: Sensor placement and Cultural
- CCRI: Joint visit to NRL for DAD and interoperability
- Metron: Joint visit to NRL for DAD and interoperability

Additional Textron's team has been actively participating in the TWiki on a daily basis for the last 8 months. They have participated in the following WebTopics

- PerceptionOntologyTutorial
  - Actively participated in the perception ontology web topic which was the first ontology that members collaborated on
- InformationVoidOntology (later SensorTaskingOntology)
  - Developed and submitted a sensor tasking ontology which is included in the latest version of the ontology
- EventUseCase
  - Developed an event use case for others to leverage when generating RDF.
  - Researched generating RDF from the Protégé API's programmatically instead of using string builders to produce XML. This gives us scalability when generating RDF in the future
- DiscussionOfRequiredEventProperties
  - Actively discussed and collaborated with Aptima and Metron regarding the generation of events. Ultimately a simplistic approach was taken to the eventing as the data is still a mystery to most.

Textron has been very active in the TWiki process and has been vocal on many topics related and unrelated to Textron's RDF output.

3.7 Testing

Testing activities are documented in the Experimentation Test Plan, an update of which is being delivered prior to this document (see section 2.3).

3.8 Demonstrations

Demonstrations were provided for TIM1 and TIM2 and are documented in the meeting minutes for each TIM (see section 2.3). Ongoing efforts to support the Data Analysis Demo DAD and the ISR-to-C2 Demo will be concluded in the next phase of the program and are discussed in section 3.5. 2 and 3.5.3

4 Results, Conclusions and Next Steps

The base year of the Textron Transparent Urban Structures effort was an evolutionary path of developing increasing functionality in support of a very dynamic, very interactive architecture and surrounding community. After this year the overall goals of the combined performers have become much clearer. Additionally the individual interactions between specific performers are becoming apparent. Jointly developed and defined ontologies are allowing common views of large amounts of contextual data. Finally the standards required to implement the architecture are beginning integration into each performers environment, enabling what is about to become the DAD demonstration and the C2-ISR demonstration.

For Textron each phase had a different set of goals. Phase 1 provided refinement of the architecture and implement of the framework and infrastructure need to support the next phases. Phase 2 provided the integration of the geo-cultural service, the first attempt at an RBIE, the development of rules and the development of an experimentation environment and scenario. Phase 3 involved developing interfaces to enable integration with other performers and the ONR architecture, development of performer wide ontologies, development of an initial anthropological ontology and collaboration in support of the DAD and ISR-to-C2 demonstrations.

As the option year begins, a series of goals are in front of this team in order to develop a better more interoperable system. They include:

- Successful demonstration with DAD and ISR-to-C2 efforts
- Advanced anthropology ontology and query capabilities
- Further development in interfaces and standards
- Broader inferencing capabilities for multiple environments
- Larger testbed capabilities using existing Iraq and Afghanistan data sets
- Sensor planning capabilities
- Data confidence assessment
- Stronger ties to and collaboration with other performers

5 Directory

5.1 Glossary

Table 5-1: Glossary

Term	Definition
ActiveMQ	The most popular COTS middleware software which enables communication of loosely coupled systems via the JMS standard.
Drools	Rules based inferencing and event processing engine
Jess	JAVA based inferencing engine
MAK	Is a suite of products which include visualization, simulation and link analysis tools. We will be using the simulation tools provided by back to integrate real hardware into the system.
Ontology	A formal representation of a set of concepts within a domain and the relationships between those concepts
Protégé	A suite of tools to construct domain models and knowledge-based applications with ontologies, developed by Stanford University
Rete	Speed optimizing forward chaining rule algorithm
Sesame	Open source Java framework for storing, querying and reasoning with RDF and RDF Schema
Service Oriented Architecture	A service-oriented architecture is a collection of software services. These services communicate with each other either by simple passing data or it could involve two or more services coordinating some activity. Some means of connecting services to each other is needed.
TWiki	A structured wiki, typically used to run a collaboration platform, knowledge or document management system, a knowledge base, or team portal
Warfighter	The Warfighter is a term used to identify coalition forces in this urban environment.
Web Services	A software system designed to support interoperable machine-to-machine interaction over a network. It has an interface described in a machine-processable format.

5.2 Acronym List

Table 5-2: Acronym List

API	Application Programming Interface; Application Program Interface; Application Programmer Interface
C2	Command and Control
CAF	Common Application Framework
CLOC	Company Level Operations Center
DAD	Data Analysis Demo
DKKN	Distributed Knowledge and Knowledge Needs
EDA	Event Driven Architecture
ERDC	Engineering Research and Development Center – US Army Corp of Eng.
ETP	Experimentation and Test Plan
GCAT	Geo Cultural Analysis Tool
GIRH	Generic Intelligence Requirement Handbook
GUI	Graphical User Interface
HITL	Hardware-in-the-Loop
HLA	High Level Architecture
ISR	Intelligence Surveillance and Reconnaissance
JMS	Java Messaging Service
M&S	Modeling and Simulation
OWL	Web Ontology Language
RBIE	Rules Based Inferencing Engine
RDF	Resource Description Framework
SIC	Sensor Information Collection Service
SITL	Software-in-the-Loop
SME	Subject Matter Experts
SOA	Service Oriented Architecture
SOAP	*Simple Object Access Protocol*
SWRL	Semantic Web Rule Language
TIM	Technical Interchange Meeting
TUS	Transparent Urban Structures
UGS	Unattended Ground Sensor
XML	Extensible Markup Language

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14. ABSTRACT

Textron Defense Systems and its subcontractors have been developing a Geocultural service, a software framework and inferencing engine for the Transparent Urban Structures program. The scope of the effort has evolved as the program has matured and is including multiple data sources, as well as interfaces out to the ONR architectural framework. Tasks also include additional development in the areas of Geocultural and Anthropological ontologies.

15. SUBJECT TERMS

API Application Programming Interface; Application Program Interface; Application Programmer Interface
CAF Common Application Framework
EDA Event Driven Architecture

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