Investigation of a Graphical CONOPS Development Environment for Agile Systems Engineering – Phase II

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EXECUTIVE SUMMARY

Concept engineering, as addressed in this report, is the act of translating stakeholder needs into a operational concept (or CONOPS) for a product or system capable of satisfying the goals set forth by the stakeholder. This report summarizes the work performed in the second phase of research on development of an approach to use graphical and collaborative approaches to generating an operational concept for a new system.

The goal of this research phase was to develop an initial set of primitives (or core terms) organized into a hierarchy (taxonomy) that is reusable when creating a collection of future scenarios for different domain. The initial approach taken was to decompose a well tested scenario, the Noncombatant Evacuation Operation Intelligence Gathering Scenario (NEO). The first step was to perform a cognitive task analysis of what was necessary to plan the scenario, and then to perform a decomposition of terms and concepts used in the scenario. This effort resulted in a number of insights being discovered, which advance the research to the next step. However, the NEO scenario was found wanting in complexity and information. In discussions with the sponsor of this research, it was recommended the team investigate a news agency as a more representative analog for this research.

When a number of new agencies were investigated, and decomposed, a rich taxonomy emerged that can be the basis for new domains. While each new domain will require an expansion of the taxonomy with new terms and concepts, many are common. The notion of transporting objects between locations, information gathering, and communications are core to many actions that might be modeled. For instance, when looking at a military mission of close air support, objects are moving from one location to another, at specific times, and there is a high degree of communication and collaboration necessary. The same can be said for emergency response for an oil spill. While the objects may be domain specific, the movement, communications, collaborations and actions are common at some level of abstraction. If those actions can be collected and represented graphically, then the definition of new scenarios can be accomplished quicker, and can be easier to understand.

This research report also examines an easy to understand graphical modeling approach of snap together pieces associated with the developed taxonomy to aid the creation of scenarios, or operational concepts.

Finally, this report provides recommendations for follow-on research in this area, and proposes the development of a system that will aid the concept engineering process to produce graphical operations concept building on the reusable taxonomy developed in the research conducted in this phase.

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1 PURPOSE

1.1 PROBLEM STATEMENT

The weakest link in systems engineering is often the link between what the war-fighters or analysts needs, and what the development team "thinks" they need, together with a shared understanding of the operational environment and associated constraints and dependencies [ASSE 2009]. The concept of operations can be a means to bridge this gap significantly [ANSI/AIAA 1992]. There is a need to quickly and graphically articulate a concept of operations (CONOPS) for new missions, business processes, and feature sets to realize a shared mental model and understanding of the mission, and potential solutions across a set of diverse stakeholders. This graphical environment has the potential to become a mechanism for agile stakeholder expectation elicitation. It is likely that this environment will have to be tailored for selected application domains for operational, mission, and semantic consistency.

A systematic and disciplined approach should be undertaken to understand, assess, and catalogue the current and emerging state of research (elements that constitute a concept of operations; cognitive sciences and mental models; and modeling tools and environments) to allow a "domain oriented" environment for visualizing a mission concept of operations.

1.2 OBJECTIVES

This phase of research will leverage knowledge gained in Phase 1 of this RT. Specifically, these 7 tasks will provide an early look to help scope and further define the broader tasks in Section 5.1 (Defining the Building Blocks for a Graphical CONOP) of Phase 1 Final Technical Report. The Phase 2 tasks are:

1) Research, identify and document in an appropriate manner, an initial ontology for use in constructing a graphical CONOPS toolbox based on the findings from Phase 1. Investigate an appropriate tool for managing and defining this ontology to allow information interchange with other tools.
2) Ascertain the mental model content most appropriate for each phase of the agile CONOPS process.
3) Create an initial list of primitives (and the necessary information for each primitive) to ensure reuse based on the identified ontology
4) Identify the necessary semantics for information exchange between the identified primitives

5) Investigate programming languages/tools appropriate for creating a graphical CONOPS
6) Modify the Non-Combatant Evacuation Operation task to be an intelligence gathering task and pilot test the modifications. This will include a small sample of participants working through the revised task to ensure the modifications are effective.
7) Identify at least one additional intelligence task relevant to the sponsor for use in future phases

The deliverable from Phase 2 will be a final report documenting the results of the phase, and a presentation on the developed ontology.

1.3 RESEARCH APPROACH

The research was approached from a number of methods. The first was problem solving experimentation to investigate collaboration methods and tools to better improve collaboration on concept of operations tasks. That work is documented in section 3 of this report.

Mining of primitives was conducted through decomposition and modeling. The first decomposition was performed on a structured scenario – the Non-Combatant Evacuation Operation, as modified for an intelligence gathering task. This was then modeled in an ontological tool (Protégé) to create a taxonomy of terms. This research revealed that the tool selected was not optimal for reporting results, and a change of tools was made, and the NEO taxonomy was modeled once again.

The second primitive model leveraged what was learned from the NEO scenario, but was broader in scope. Instead of modeling a specific scenario, an organization was modeled based on the scenarios performed by the organization. This model was tested against five randomly selected scenarios that organization would perform.

Results of the research documented in this report, and recommendations for future work is provided.

2 INTRODUCTION TO CONCEPT ENGINEERING

Within the DoD, a Concept of Operations (CONOPS) is a broadly known document. Phase 1 of this research discovered that there are several standards for the development of a CONOPS, however when one looks at published CONOPS, there is little correlation between the standards and the final artifact. Further, in Phase 1, it was discovered that the term CONOPS had no meaning in the private sector. Yet, when the notion of a CONOPS was described to the private sector, they understood what was meant.

Based on this, the researchers have begun to refer to the practice of developing and describing how a new or modified system, or collection of systems, would be used when deployed, ***concept engineering***.

2.1 DEFINITIONS

CONOPS – Concept of Operations. A detailed description of how a new system will be deployed when in operational use

Model – an abstraction of reality, meant to increase understanding from a specific perspective

Ontology - a formal representation of the set of concepts, definitions, and relationships within a domain of knowledge

Primitive - a function or object which is core to a graphical programming language to improve performance and consistency of execution (i.e., the basic building blocks)

Taxonomy – in the context of this research, the practice of organizing and classifying of information and data and their relationships

3 COGNITIVE TASK ANALYSIS AND THE NEO SCENARIO

3.1 LITERATURE REVIEW

Cognitive Task Analysis

When team members work together on complex tasks, they are purposeful in coordinating their efforts toward task completion. In particular, the way team members' cognitive processes unfold during the coordination of effort may contribute to the success of the team (Salas and Fiore, 2004). As such, it is important for researchers and practitioners to understand what is going on in the minds of team members and how to facilitate it. For example, understanding how aircraft crew members integrate information in the cockpit may explain why a crew fails to make a corrective maneuver when an emergency situation arises. Cognitive activities, such as information integration, are team-level phenomena that have been termed team cognition (Cooke, Gorman, and Winner, 2007). The measurement and analysis of team cognition may be used to improve team interactions. For example, by understanding what was going on cognitively that created the errors by the aircraft crew in the emergency situation, more directed training efforts that facilitate crew communication in similar situations may be designed so that all necessary actions are taken in the future. Herein, we discuss cognitive task analysis and the way it has been applied in the team-domain to examine the underlying team cognition of taskwork and contribute to better team functioning.

The understanding of team cognition has been advanced by various theoretical frameworks that explain cognitive processes at the group- and team-level such as information processing (Hinsz, Tindale, and Volrath, 1997), mental model convergence (McComb, 2007), and transactive memory (Yoo and Kanawattanachai, 2001). Based on the theoretical underpinnings of cognitive processes such as those aforementioned, specific types of methodologies have been developed to capture and understand what is going on in the minds of members as they interact together. Cognitive task analysis (CTA) is a methodology purposeful in discovering the way cognitive processes unfold during taskwork to produce behaviors and actions (Crandall, Kelin, and Hoffman, 2006). Using CTA to capture an individual's cognition, such as the formulation of the task in the worker's mind, the way a worker makes sense of information, and how s/he is making decisions about the task, may explain what the worker does during taskwork (Chipman, Schraagen, and Shalin, 2000). CTA has also been applied at the team-level to study cognition. Past studies have applied the individual-level CTA methods to teams (e.g., Morgan, Glickman, Woodard, Blaiwes, and Salas, 1986; Prince and Salas, 1993; Stout, Salas, and Carson, 1992). Research suggests, however, that team cognition may be considered different than just the aggregate of the individual team members' cognition (Cooke et al., 2007). As such, applying methods from the individual-level may overlook team member behaviors and actions due to the aspects of interdependence,

cooperation, and coordination (Bowers, Baker, and Salas, 1994). To attend to these issues, recent research has focused on eliciting the cognitive process of all team members to facilitate the understanding of how the team members' cognition effectively leads to cooperative efforts that produce outputs (e.g., Klein, 2000).

The way in which researchers apply CTA to capture team cognition has been the subject of numerous reviews (e.g., Bisantz and Roth, 2007; Blickensderfer, Cannon-Bowers, Salas, and Baker, 2000; 2008; Wei and Salvendy, 2004) and a dedicated website with resources maintained by Aptima (2010). The review of CTA methods provided by Blickensderfer and colleagues (2000) and elaborated upon in other subsequent reviews suggest that team knowledge should be identified before, during and after taskwork. The analysis of knowledge outputs across time may demonstrate how cognition dynamically evolves to direct the behaviors and actions of team members toward the task. Further, the methods take three different approaches to data collection. Table 1 summarizes the different data collection techniques as they vary across the researcher's involvement. The issues regarding the different levels of involvement by the researcher are discussed in Wei and Salvendy (2004). While, all approaches have advantages and disadvantages, research suggests that multiple techniques should be applied in order to obtain multiple outputs. By analyzing multiple types of CTA data, the research may be able to better triangulate the underlying cognition of the team (Klein, 2000).

Table 1: CTA Data Collection with Different Levels of Researcher Involvement

Data Collection Responsibility:	Team/team member(s) alone	Researcher-Team/Team member	Researcher alone
Approaches Used	• Questionnaire • Skills analysis • Concept Map • Problem-solving/Critical decision method • Running Commentary • Rating data • Ranking data • Sorted concepts • Protocol analysis	• Interviews (structured to semi-structured) • Simulation interview • Process tracing	• Ethnography • Observation • Process diagram • Process tracing • Textual coding

The use of CTA to research team cognition in different contexts has contributed to both research and practice. Research has used CTA methods to obtain data about what is going on in the mind of team members to establish team cognition. This knowledge has lead to the improvement of training programs (e.g., Salas and Cannon-Bowers, 2001; Salas, Fowlkes, Stout, Milanovich and Prince, 1999), interface design (e.g. Naikar, 2006), and software design (Shrayne, Westerman, Crawshaw, Hockey, and Sauer, 1998) for practitioners. Thus, CTA extends research by providing a toolbox of methods for understanding teams at a cognitive level and benefits the way practitioners go about improving team collaboration.

3.2 PROCEDURES

3.2.1 COGNITIVE TASK ANALYSIS

Conducting a Cognitive Task Analysis (CTA) is anticipated for every scenario identified for inclusion in the Graphical CONOPS Agile System. As previously mentioned, the purpose of conducting a CTA is to identify the cognitive tasks required of the team to complete the task. More specifically, the results will help us understand the cognitive processes the team uses as they work on the task, ascertain the mental models necessary to be successful, inform the creation of primitives, and facilitate the development of the concept engineering system that will reduce the cognitive load associated with the task.

Data about team cognition will be collected for two different purposes: (1) as new scenarios are identified, we will conduct CTA with a small number of teams (one to three depending upon the difficulty of the task for the population available for study) to aid in the creation of primitives and concept engineering system design and (2) as the concept engineering system is being developed, we will conduct CTA as we run experiments to test various designs and design features to identify the mental models in play and inform the concept engineering system development process.

New Scenario CTA Approach

During this phase of the Graphical CONOPS project, we conducted case studies using CTA to ascertain the approach that would be most effective to capture team cognition and inform the creation of primitives. Based on these results (reported below), three data collection techniques will be used: concept maps, debriefing interviews, and observation.

Concept maps are graphical representations of individuals' information environments with nodes representing the various pieces of information available and arcs representing the linkages between the nodes (Fiol & Huff, 1992). They have been used extensively to capture team cognition (e.g., Marks et al., 2000; Marks et al., 2002).

Concept maps can be completed by giving a set of possible nodes to the respondents or by allowing the respondents to develop their own nodes. If nodes are given, the relationships among the nodes are of primary interest to the researchers. We, however, are more interested in the content of team cognition as we investigate new scenarios. Therefore, respondents will be allowed to devise their own nodes, thereby revealing the cognitive elements the team used to complete the task.

The session with the respondents begin with some brief instructions. The researchers observe the teams as they complete the task. Upon completion of the task, the respondents receive instructions on how to create concept maps and be observed by the researchers as they create a concept map for the task just completed. At the end of the session, a debriefing interview is conducted to (1) tap any additional cognitive elements not uncovered by the concept map and (2) identify any suggestions for making it easier to complete this type of task.

3.2.1.1 Concept Engineering Experiments CTA Approach

As the concept engineering system is developed, experiments will be conducted to validate various components of the concept engineering system. These efforts also provide the opportunity to further evaluate the cognitive processes of the team and examine how the concept engineering system reduces the cognitive load experienced by the team members as they complete the task. Here, we focus on the approach we will use to further evaluate the cognitive processes of the team. Based on our case studies using CTA, conducted as part of this phase of the project, and our experience examining cognition in past research, four data collection techniques will be used: questionnaires, concept maps, process tracing, and textual coding.

Pre- and post-questionnaires are designed to tap the change in respondents' knowledge about the task. They are administered (1) after the respondents learn about the task and their individual responsibilities/expertise with respect to the task but before they interact as a team and (2) at task completion.

Concept maps are created by the team. Unlike in the previous approach, however, respondents are given the nodes because our purpose here is to better understand how they are working through the task using the concept engineering system (vs. the identification of cognitive content when new scenarios are investigated). We anticipated that the structure will change based on the nature of assistance provided by the concept engineering system components under investigation.

A combination of process tracing and textual coding will be used to tap the mental model content at work during collaboration. This technique has been used extensively by the research team in other projects (e.g., McComb et al., in press). Transcripts of team sessions were created and coded. The coded communication strings were then analyzed to ascertain how/when mental model convergence occurs using survival analysis, mental model content is discussed, etc. These results will inform future concept engineering system developments.

3.3 Case Studies and Results

3.3.1 NEO Intelligence Gathering Task

The Non-Combatant Evacuation Operation (NEO) Intelligence Gathering Task requires teams comprised of three members with unique expertise (intelligence, weapons, and environment) to identify the intelligence data required to extract aid workers off a remote island that has been overtaken by hostile guerilla forces. The complete task documentation is included as Appendix A.

The aforementioned procedure for new scenarios was used for the case studies conducted in this phase. Upon completing the task, team members (graduate students) worked together to create a concept map of the process they used to complete the task (see example in Figure 1). Next, the team members were debriefed to ensure that no cognitive steps were omitted from the concept map and to discuss how technology might have assisted them in completing the task. The specific recommendations based on this scenario and the next one are combined and presented in Section 3.4 of this report.

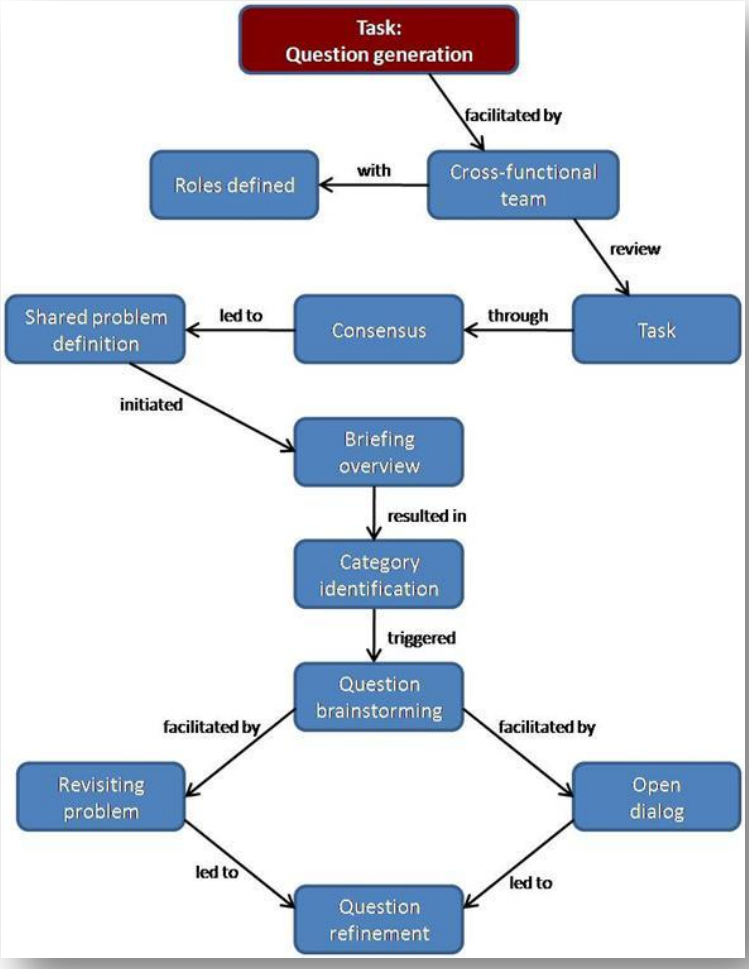


Figure 1: NEO Intelligence Gathering Task Concept Map

An additional element of this case study was a critique of the scenario. This scenario was modified to represent one step prior to the original NEO Mission Planning Task that will be described next. More specifically, we created a task to identify the intelligence data necessary to devise a mission plan. In the original task, the intelligence data was provided to the team members and they were required to create a mission plan. The purpose of the modification was to make the task more representative of the types of work undertaken by the sponsor of this study. From that perspective, the modification was successful. The revised task requires interdisciplinary knowledge, embeds subjects in a real-world scenario, and is relevant to the sponsor's domain. From a research perspective, the task has limitations. In particular, the task requires primarily brainstorming that is difficult for non-experts to complete (and access to experts for experimentation is virtually impossible). Our subjects found the uniformity of activity (i.e., only brainstorming) to be tedious and frustrating. It was tedious because they were brainstorming lists for every aspect of the task and frustrating because they did not have the background to be certain their ideas were valid. With non-motivated subjects (e.g., undergraduates earning extra credit for a class, which is the most often-used subject pool), they may not fully engage

in the activity to the degree of the graduate students who were used as subjects for the case studies and therefore the results would be suspect. A task that balances being representative with being engaging is recommended for future phases.

3.3.2 NEO Mission Planning Task

The Non-Combatant Evacuation Operation (NEO) Mission Planning Task was developed for the Office of Naval Research's Collaboration and Knowledge Interoperability program (Biron, Burkman, & Warner, 2008). While input from military personnel was used for the scenario development, both military and nonmilitary persons can execute the unclassified scenario. It requires teams comprised of three members with unique expertise (intelligence, weapons, and environment) to create a mission plan to extract aid workers off a remote island that has been overtaken by hostile guerilla forces. This task has been used extensively in studies examining team cognition. The complete task documentation is included as Appendix B.

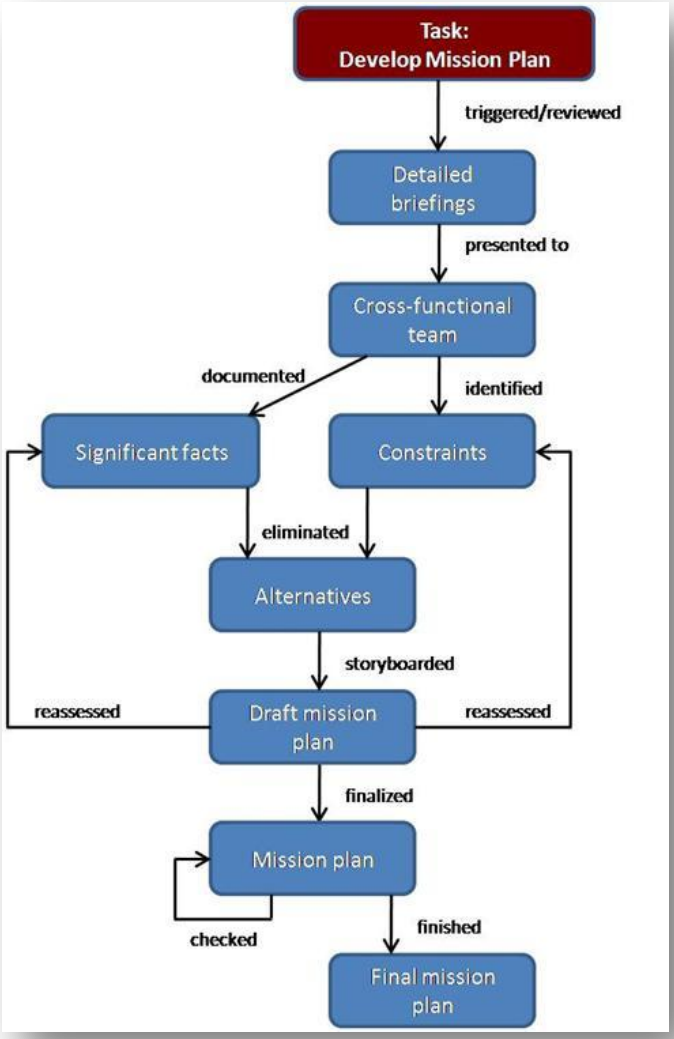


Figure 2: NEO Mission Planning Task Concept Map

As with the previous case study, team members were asked to complete a concept map after they completed the task (see Figure 2). They were then debriefed to ensure that no cognitive steps were omitted from the concept map and to discuss how technology might have assisted them in completing the task. The specific recommendations based on this scenario and the next one are combined and presented in Section 3.4 of this report.

3.4 RECOMMENDATIONS FROM THE STUDY

3.4.1 TOOL CREATION

3.4.1.1 System Structural Elements

Two suggestions for structural elements are offered: a "parking lot" and breakout rooms. During the brainstorming sessions, the team members would have good ideas that were relevant, but off the current topic. A visible location (i.e., a "parking lot") to store such ideas would be useful. Good ideas could be placed here while the discussion about the current topic is discussed. In this manner, neither the good idea nor the flow of the current conversation will be lost.

The team members also suggested during the debriefing that they would have benefited from side conversations periodically that may have been necessary, but disruptive to the flow of the team's conversation. They suggested creating breakout rooms for side conversations. When interacting in these rooms, only those participating in the conversation would have access to the activities in the room. From these rooms, the team members could still monitor the main team workspace and move quickly between the two spaces as the need arose.

3.4.1.2 Automated Assistance

Through the debriefing discussions following the creation of the concept maps, the team members and research team agreed that automated assistance in the form of autonomous agents and an entry portal that primes the system with baseline information. Autonomous agents could be embedded into the concept engineering system to augment team functioning and ease cognitive burden on the team members. The possible applications are numerous. We offer two suggestions as examples. First, agents could automatically update information as databases change (e.g., weather forecasts). Second, agents could be used to make connections among primitives. If the weather forecast is updated, an agent for the weather primitive could connect with an agent for the transport primitive because certain transports cannot function under some weather conditions.

A user-friendly, entry portal that primes the concept engineering system with baseline information available from databases would save a team significant start-up time as they initiate their collaboration. For instance, once the problem space and the team are identified, relevant information could be entered via the entry portal and the team's workspace within the system could be tailored to the current project, including team membership with photos, bios, notes, etc. and location geography, political climate, weather patterns, weather forecast, etc.

3.4.2 PRIMITIVE CREATION

During the debriefing interview, the team members and researchers brainstormed a list of primitives that would be useful, discussed various cataloging schemes that might be

practical, and suggested the need for both summary and detailed information to be available. Two of the individuals participating in the debriefing interview were also key individuals in the primitive creation activities. Therefore, these suggestions have been carried over to that part of the project and incorporated as appropriate.

3.4.2.1 Primitive Dimensionality

The group (i.e., team members and researchers) also discussed various approaches for reducing the cognitive load on team members through primitives. Specifically, we discussed the dimensions of primitives and a classification system. At a minimum, primitives should have meaning that is:

- Visual
- Intuitive
- Simple
- Robust

3.4.2.2 Primitive Classification

A classification system is also necessary. Through our discussion we determined that a subjective assessment was necessary for the primitives. This assessment would serve to alert team members to the usefulness of the information included in the primitive. At a minimum, the assessment should reflect the following meta data:

- Accuracy/Credibility
- Relevance/Importance
- Effect/Impact

An example of the type of classification system we envision is the Decision Making Constructs in the Distribute Environment (DCODE) program (Cowen & Fleming, 2005; Cowen & Fleming, 2006). DCODE provides a means of capturing implicit subjective assessment explicitly. A combination of multiple bars, colors, and categories in a simple, intuitive design allow the users to quickly classify the information they provide/review.

4 PRIMITIVES AND ONTOLOGY RESEARCH

4.1 APPROACH

One goal of this research was to develop a core set of primitives, or low level nouns and verbs that can be used to construct a collection of scenarios to demonstrate how a system would be used when deployed in the field. The initial problem investigated was the Noncombatant Evacuation Operation: Intelligence Gathering Scenario (NEO).

Once the research was initiated, the sponsor suggested the team focus on a news gathering agency instead. The team then constructed a taxonomy for that agency, based on five scenarios:

1. A news agency deploying a reporter and support assets (truck, video camera, sound equipment) to a new story (with time constraint option)
2. A news agency assigning a reporter to independently corroborate a news source
3. A reporter works to recruit a new contact for a story
4. A news agency deploying a new reporter and support assets (truck, video camera, sound equipment) to follow-up on an existing (with time constraint option)
5. A news agency to synthesize multiple stories to create a new edition for their customers (with time constraint option)

4.2 MODELING THE ONTOLOGY

4.2.1 TOOL USE

An ontology describes the concepts and relationships that are important in a particular domain, providing a vocabulary for that domain as well as a computerized specification of the meaning of terms used in the vocabulary. The initial plan was to use ***Protégé***, which is an open source software (OSS) product, written in Java, that is freely available. Its intended use is the collection and organization of knowledge models. It provides a collection of tools to create and manage knowledge structures. The NEO scenario was decomposed into Protégé, but it was found that Protégé provided limited reporting functionality.

While this may not be viewed as a deficiency of the tool creator since their belief is that the model is where the researcher should work, it did not allow the researchers to represent the findings in this report format. The researchers instead chose to represent both scenarios in SysML, a popular systems engineering model language, using the tool ***Sparx Enterprise Architect (SparxEA)***. Each scenario is investigated in detail

later in this report; however three high level diagrams of the NEO Scenario, one constructed using Protégé, and the others using SparxEA, are represented in Figure 3 - Figure 5 to demonstrate the differences in diagram creation and manipulation.

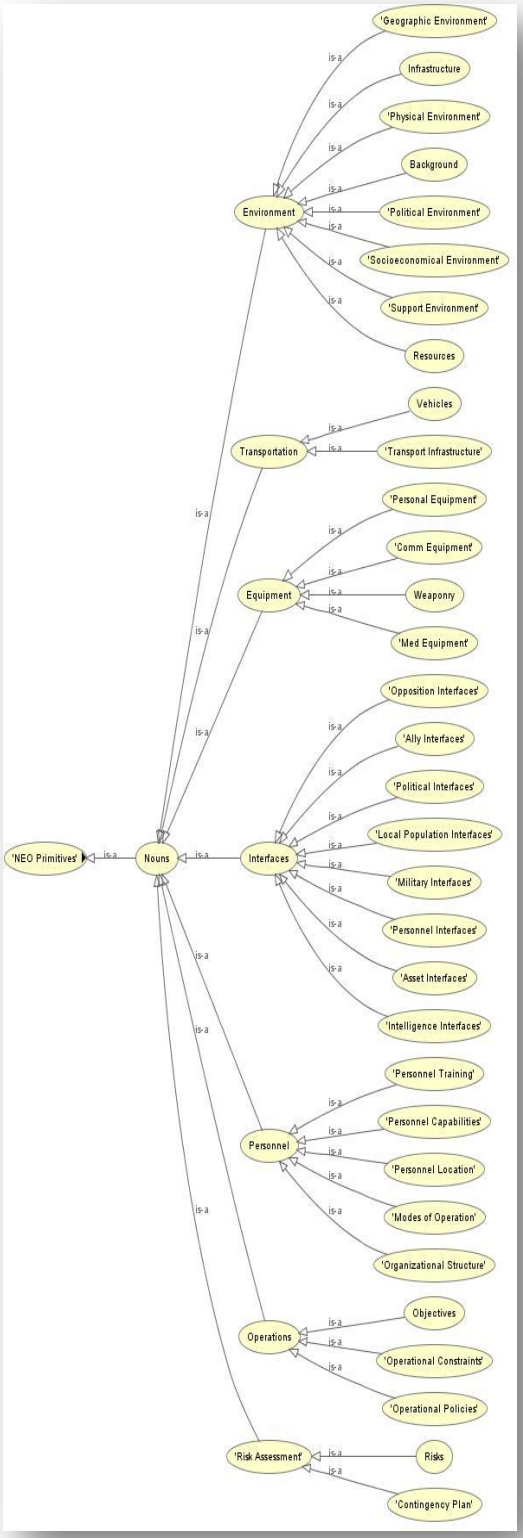


Figure 3: NEO Scenario Protégé Diagram

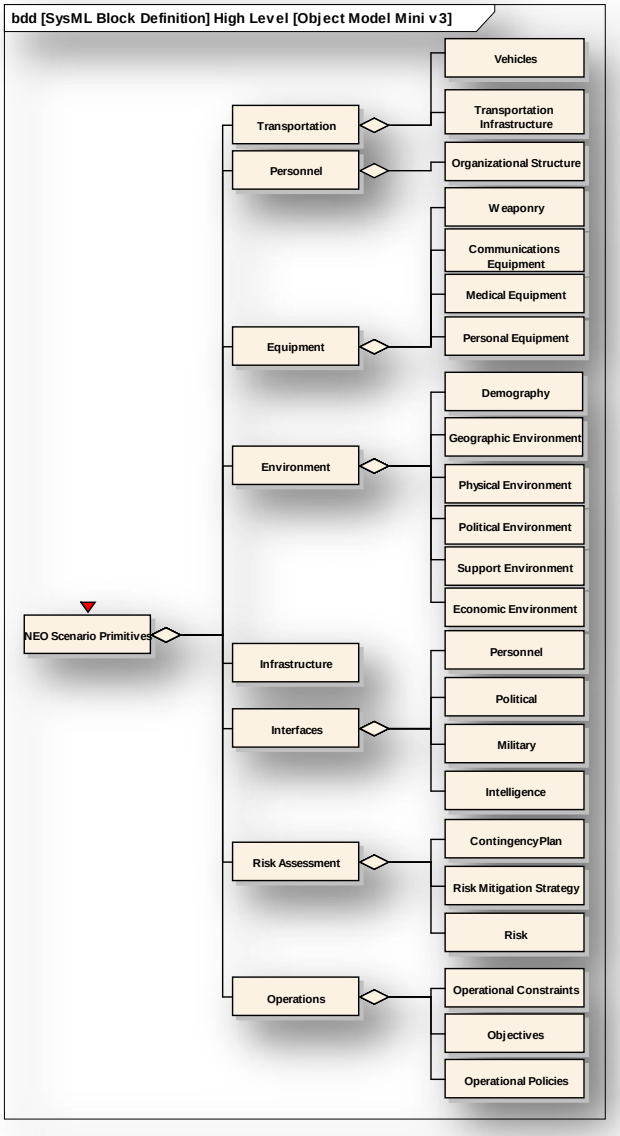


Figure 4: NEO Scenario SysML Diagram

The Protégé model was built to represent the nouns, properties and verbs associated with the successful planning and execution of the NEO Scenario. Each noun was created as a Protégé entity and added to the model in a hierarchy to represent the relationships between entities. Additionally, properties and verbs can be added to the tool and associated with nouns in a matrix style interface. Protégé is a tool that is used to build, maintain and share ontological data. There is a plug-in for Protégé that takes all of the entities and displays them in a hierarchy tree. However, this tree hierarchy will only display entities, and will not display associated properties and verbs. There is currently no method in Protégé to display or output relationships between entities and the properties and verbs that are associated to them. Therefore, the only way to display properties and verbs is to create them as entities and place them in a hierarchy tree. In terms of the NEO Scenario, the result is a tree that has NEO Primitives as its top level, which decomposes into Nouns, Adjectives and Verbs. Figure 3 only displays the nouns of the NEO Scenario; the properties and verbs alone number well over 200 elements, making the full model far too large to display in this report. Additionally, while Protégé allows modelers to output these hierarchy trees to the depth of their choice, it does not allow for any modification to the diagrams.

The SparxEA model was built using an object-oriented approach in SysML. Each object (noun from Protégé) was created as a block in SparxEA, and these blocks were placed in a Block Definition Diagram, connected to each other using an aggregation relationship (higher level objects are aggregates made up of lower level objects.) One of the many benefits of using SparxEA is the variety of diagrams the tool can create and the modifiability of each diagram to meet the modeler's needs. For example, Figure 4 represents all of the objects in the top levels of the NEO Primitive hierarchy. Each object block was modified in terms of its shape and its contents to create a clean, concise representation of the scenario. Figure 5 represents the SysML model as a Package Diagram, in which the top level objects of the NEO scenario are represented as packages, and their next level objects are simply inserted as objects within the packages. SparxEA provides the modeler flexibility in displaying diagrams, and the value of this is evident from comparing Figure 3 to Figure 4 and Figure 5.

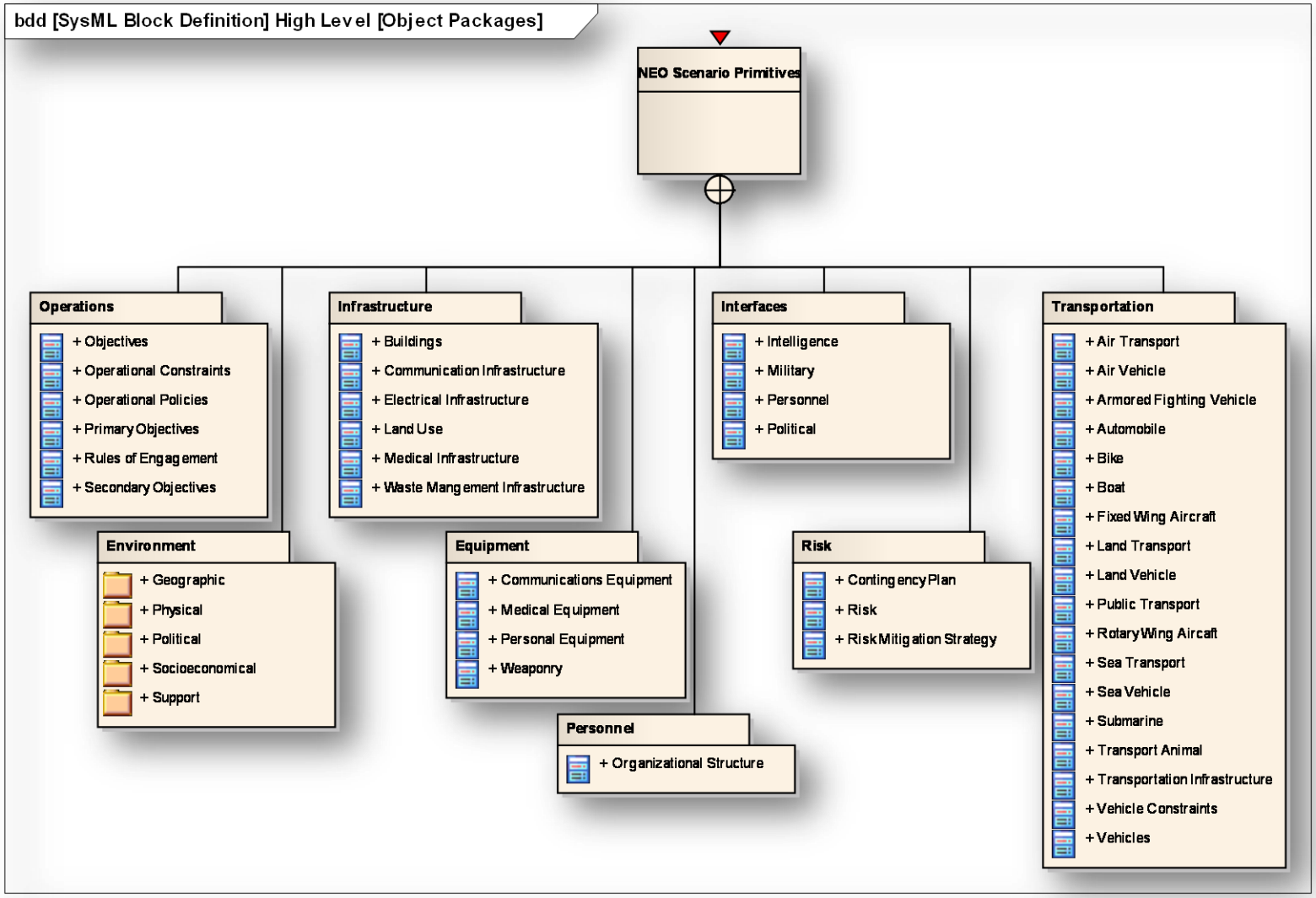


Figure 5: NEO Scenario SysML Package Diagram

Additionally, SparxEA allows for representation of the relationship between objects (nouns) and their associated attributes (adjectives) and operations (verbs) in a concise manner. Below we can see two sets of diagrams that fully express a vehicle in the NEO Scenario. Figure 6 was built in Protégé and consists of four different hierarchy trees, one containing the vehicle nouns, one containing the vehicle properties, one containing movement verbs, and one containing movement properties. The use of these four trees is necessary to fully display the properties and verbs of the vehicles in this report; however they do not represent any relationship between the elements.

In contrast, Figure 7 was built using SparxEA and uses the object note field to represent both the attributes and operations associated with the object, as well as providing the reader with the definition of the object. In this diagram, SparxEA is able to concisely represent the relationship between the vehicle objects and their attributes and verbs using only five blocks, instead of the 30+ elements required by Protégé. Another feature of SparxEA is its use of inheritance. The Vehicle block in Figure 7 contains many attributes that can be associated with any type of vehicle. Because Land, Air and Sea Vehicles are defined as parts of the Vehicle aggregate, they automatically inherit the Vehicle's attributes and operations. This allows for a full expression of each Vehicle Type's attributes and operations without excessive repetition.

A final benefit to be noted in using SparxEA is its data exchange capability. Whereas Protégé does not support exporting ontology data, SparxEA allows the modeler to export their model's metadata in a customizable XML format. This feature will prove to be useful by allowing the structure and properties of an ontology to be transferred to other software tools.

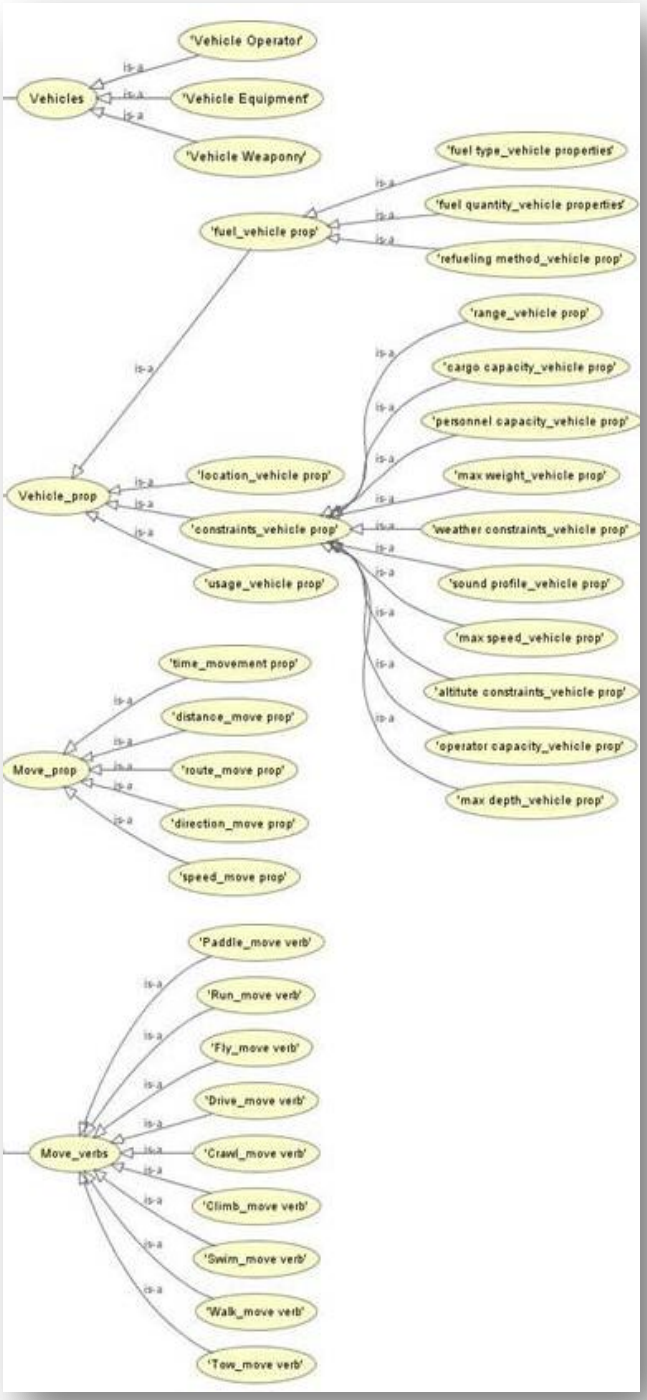


Figure 6: Vehicle Primitive using Protégé

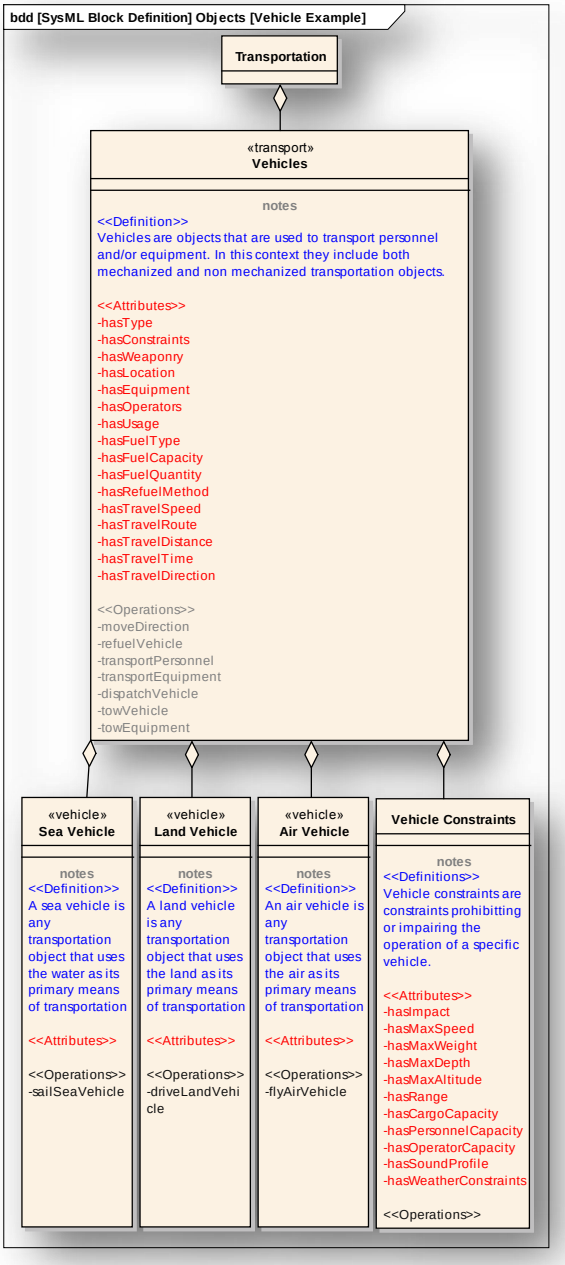


Figure 7: Vehicle Primitive using SparxEA

4.2.2 Modeling Methodology

For the purpose of developing the ontology using SparxEA, an object model was created which contained all of the primitives and their associated definitions, attributes and operations in the form of a block definition diagram. This object model was then split into smaller more manageable sections while SparxEA ensured all relationships, notes, operations, and attributes were mimicked across the diagrams. The primitives were defined, labeled as objects (nouns) and the associated attributes (properties) and operations (actions or verbs) were identified where applicable. The relationships between the primitives were then identified ensuring that the operations and attributes are inherited from higher level primitives to the lowest level primitive. This method was used to represent the ontologies of the NEO and the News Agency Scenarios, as described below.

4.3 NEO Scenario / Taxonomy

4.3.1 Methodology

The NEO Scenario was modeled for the purpose of identifying the relevant primitives associated with gathering intelligence for the successful planning and execution of the NEO Scenario. The NEO Scenario, as represented in Appendix D, was mined for its basic noun, adjective and verb building blocks, which were added to the ontology. Relationships were formed between these different elements, and the ontology was further expanded to capture missing elements. Finally, definitions were applied to each object and diagrams were assembled and exported to this report.

Protégé was initially used to build the NEO Scenario Ontology. However, for the reasons mentioned above, Protégé proved to be an ineffective tool for this task, and therefore all primitive modeling was transferred over to SparxEA. In the interest of space, this section will represent only the top level SparxEA diagram. The remainder of the diagrams, and all ofthe original Protégé diagrams, are available in APPENDIX D. The procedure for using SparxEA established above in Section 4.2.2 Modeling was applied to the News Agency Scenario and the resulting diagram can be seen below.

4.3.2 NEO Scenario Ontology Diagrams

Figure 8 represents the top level decomposition of the NEO Scenario Primitives. It breaks down the primitives into eight categories, *Equipment, Interfaces, Operations, Personnel, Risk Assessment, Infrastructure, Transportation and Environment*.

- *Equipment* represents the tools and hardware to be used in the scenario. It provides attributes specifying *Equipment Type, Location* and *Status*, as well as the necessary operations to *identify* these attributes.
- *Interfaces* are defined as instances where two systems or persons interact. *Interface* attributes include the entities involved in the interface and the *Point of Contact* for these entities. Operations include the actions taken at these interfaces.

- *Operations* is a generic category to represent the operational parameters defining how the scenario should be carried out, and can be further decomposed to *Objectives, Constraints* and *Policies*.
- *Personnel* refers to the human objects involved in this scenario, and has a wide variety of attributes describing the people and their associated attributes and operations.
- *Risk Assessment* involves the identification and mitigation of risks associated with the scenario.
- *Infrastructure* refers to the physical and organizational structures that are to be used during the scenario, and contains relevant attributes such as *Size, Age, Status, Location, Usage* and *Reliability*.
- *Transportation* contains all elements that facilitate the movement of persons or goods. This category was partially expanded to display vehicle types and constraints in Figure 18, but is further decomposed to include *Transportation Infrastructure*, which is omitted from the *Infrastructure* category described above.
- *Environment* refers to the location of the action taken in the scenario. It can be decomposed to include information about the *Physical, Economic, Demographic, Support, Political* and *Geographic Environments*.

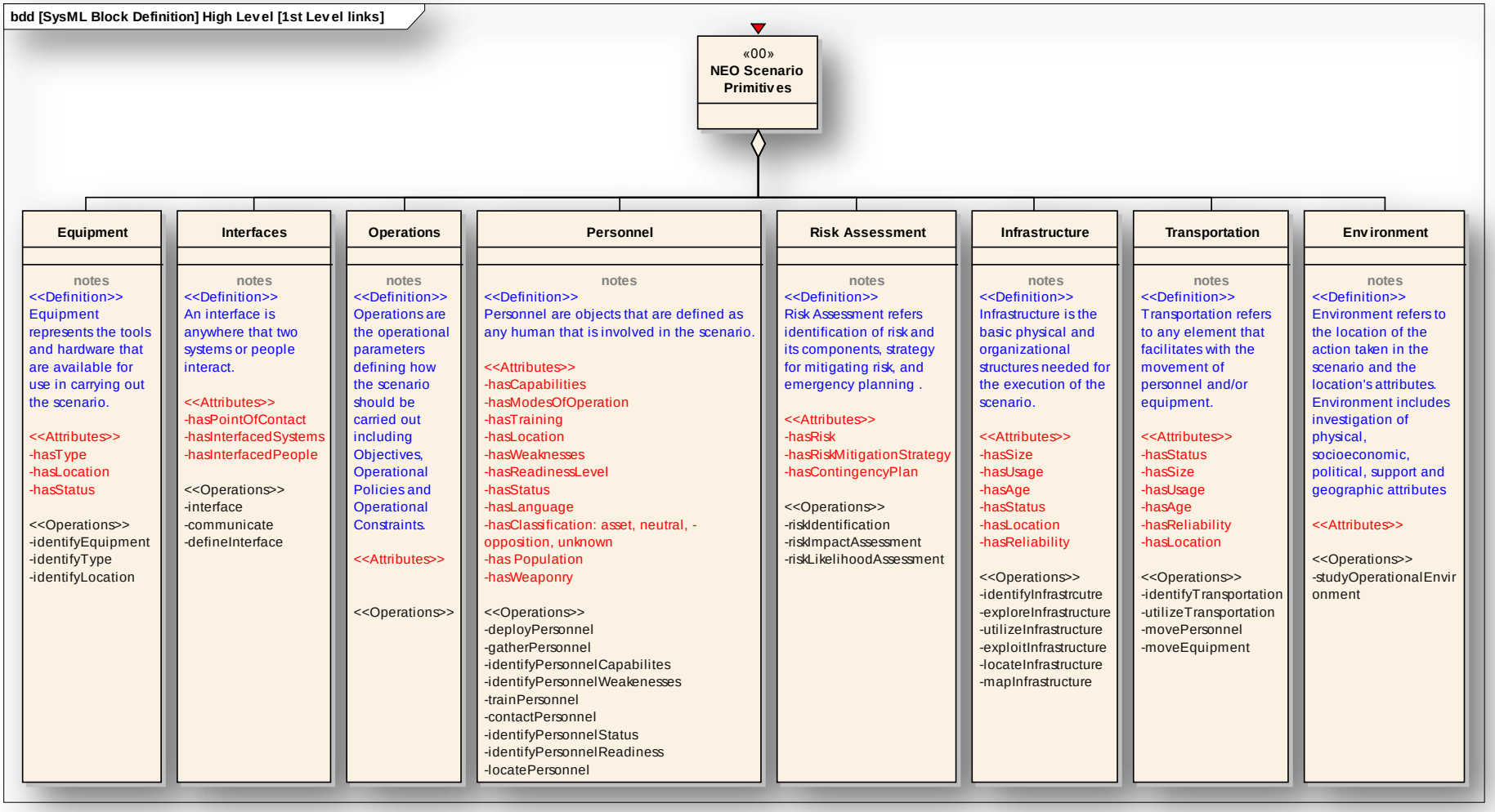


Figure 8: NEO Scenario Top Level Primitives Diagram

4.4 NEWS AGENCY SCENARIO / TAXONOMY

4.4.1 METHODOLOGY

A News Agency Scenario was developed for the purpose of identifying the relevant primitives associated with gathering intelligence for the research, development, and publication of news stories. The gathering of intelligence for a news agency is an activity that, although not specific to the sponsor's domain of interest, demonstrates a number of similar activities that are not unfamiliar to the sponsor, and as a result many parallels and similarities between the two domains can be identified.

The development of the News Agency Scenario required an in depth search of online sources covering a broad range of search topics including: journalism techniques and approaches, news agency organization structures, news reporting techniques and approaches, and information gathering methodologies, techniques and approaches. Sources such as www.poynter.org, www.pbs.org, www.cyberjournalist.net, and www.concernedjournalists.org provided starting points for the generation of primitives for this task. The information found was consolidated and reviewed in detail. Following the review, the information was mined for key words, terminology, and phrases relating to the gathering of intelligence for a News Agency Scenario.

Following the initial mining of the information for the appropriate key words, terminology, and phrases, the development of an ontology diagram for intelligence gathering in a News Agency Scenario could commence. An ontology diagram was created in order to:

- Ensure a common understanding of the structure of the intelligence gathering process within a News Agency Scenario
- Facilitate the reuse of domain knowledge
- Ensure all assumptions are explicit

The procedure for using SparxEA established above was applied to the News Agency Scenario and the resulting diagrams can be seen below.

4.4.2 NEWS AGENCY SCENARIO ONTOLOGY DIAGRAMS

The News Agency Scenario Object Model, which includes all of the News Agency Scenario primitives with their definitions, attributes and operations, is too large to be displayed here. However, as with the NEO Scenario ontology, the object model diagram was simplified to include only elements names, and is displayed in Figure 9.

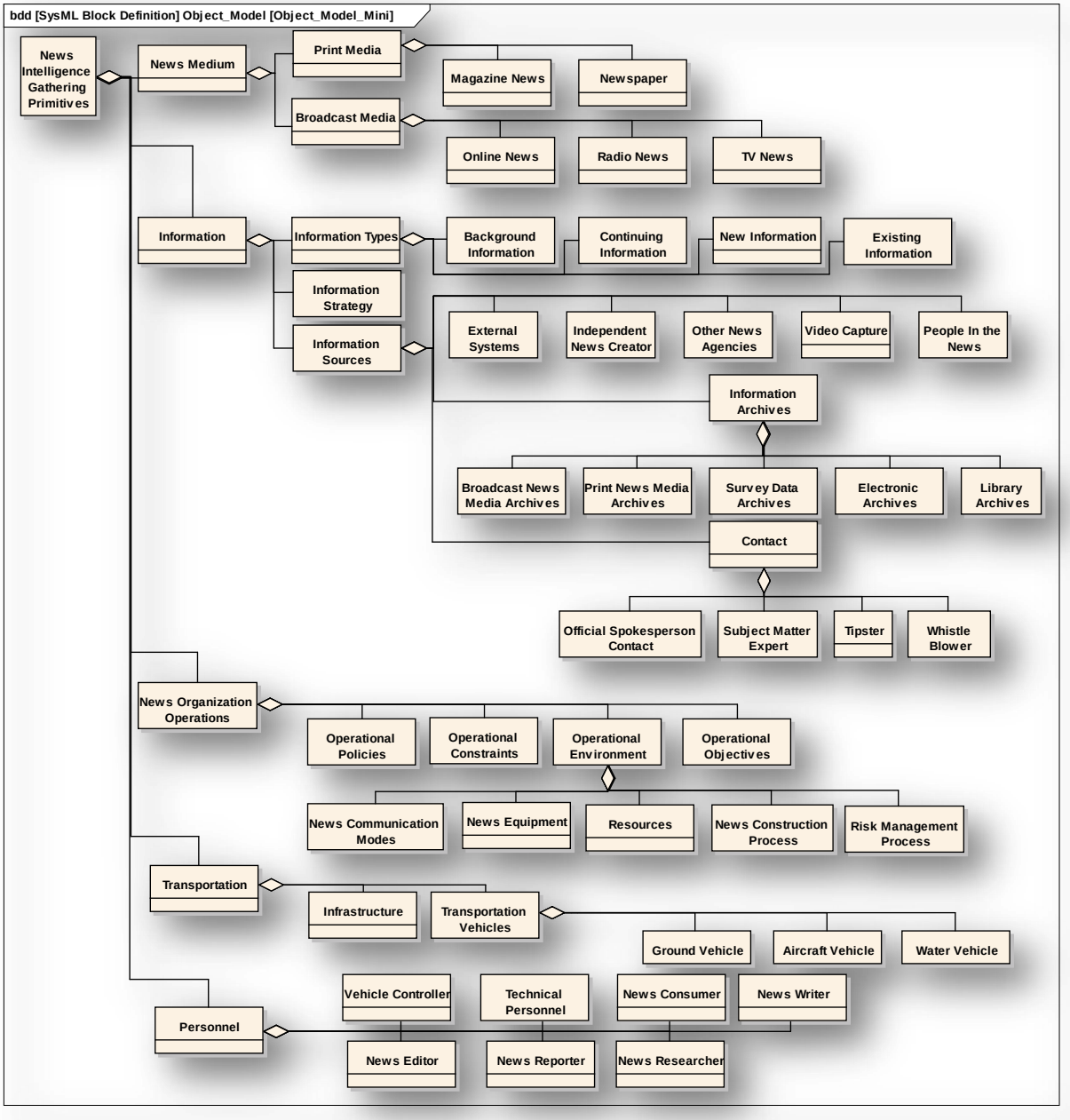


Figure 9: News Agency Scenario Ontology Simplified Object Model

As can be seen, this object model covers a set of *News Intelligence Gathering Primitives* (Figure 10) which can be broken down into five high level categories, *News Medium*, *Information, News Organization Operations, Transportation* and *Personnel*. These second level categories can be seen in more detail in Figure 10 and are further examined in the sections that follow.

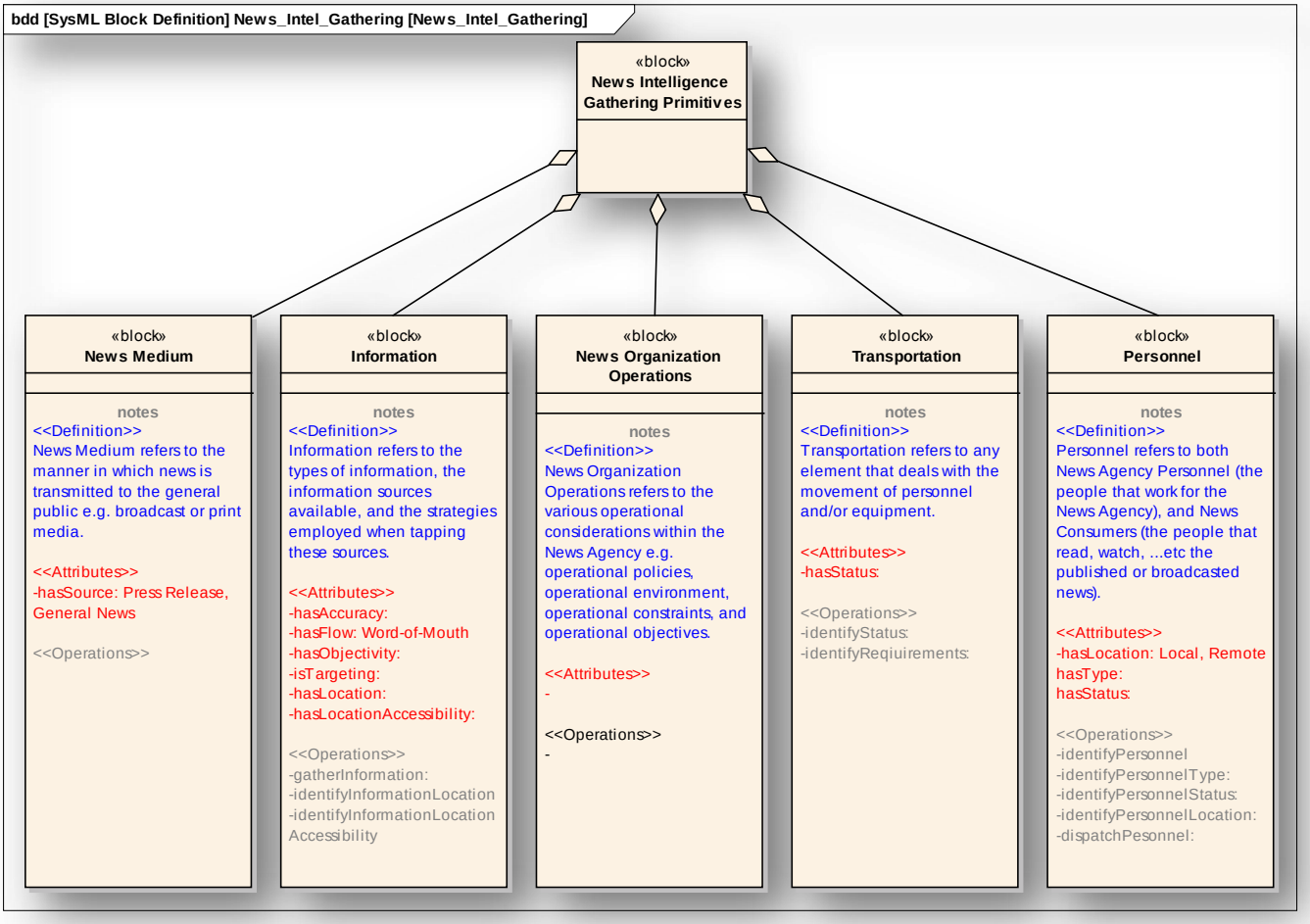


Figure 10: News Intelligence Gathering Primitives Second Level Categories

4.4.2.1 News Medium

In this scenario, *News Medium* (Figure 11) is the manner in which news is transmitted to the general public. Examples of *News Medium* would include television broadcasts, internet websites and newspapers.

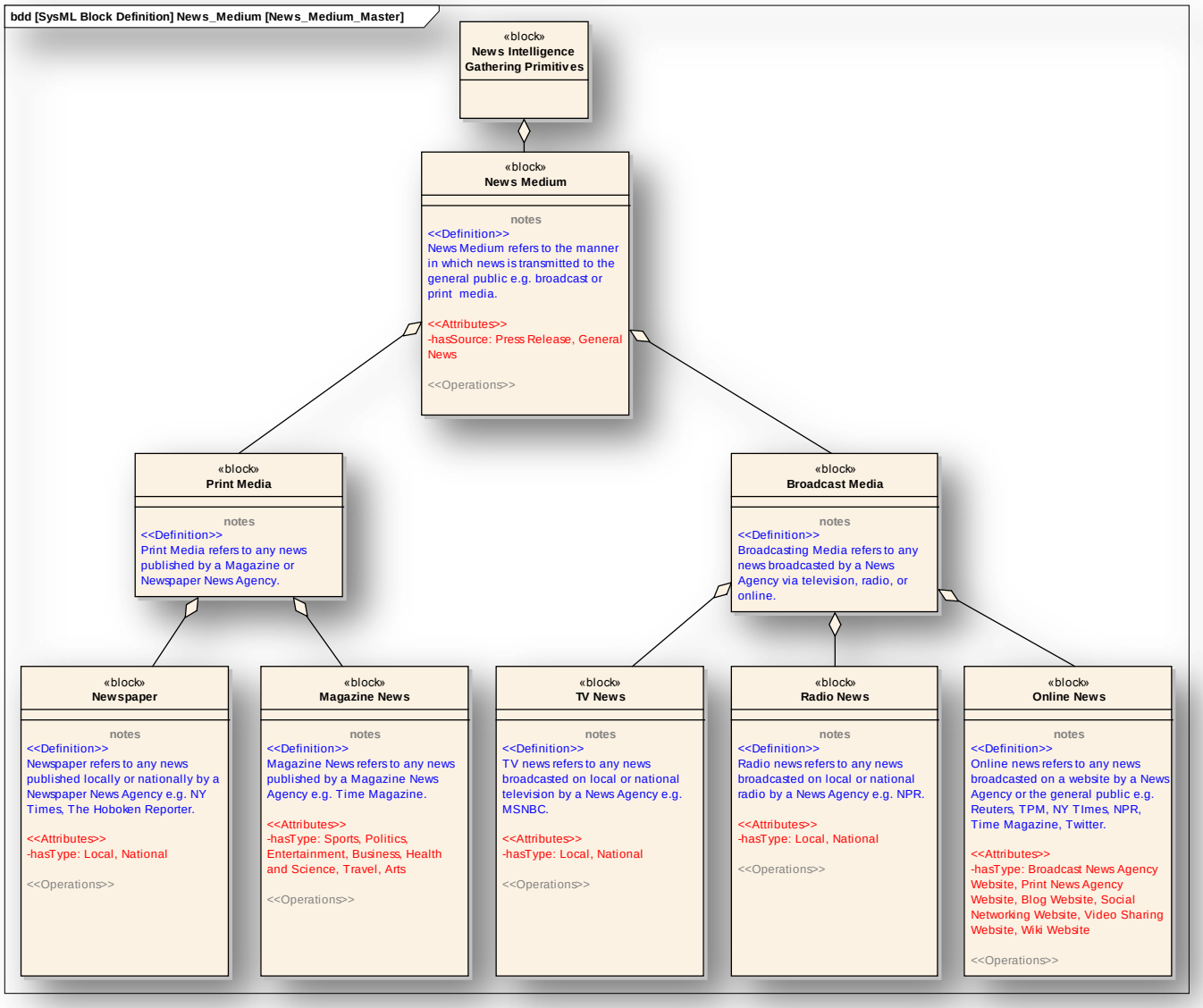


Figure 11: News Medium Primitive Diagram

News Medium is further decomposed to *Print Media*, which includes *Newspapers* and *Magazines*, and *Broadcast Media*, which includes *Television, Radio* and *Online* news. Each of these examples contains the attribute *Type*, specifying the scope of the media, both in terms of news types (sports, politics, entertainment, etc.) and the community that those types cater to (local or national). The higher level *News Medium* block also contains a *Source* attribute, which is inherited by all of its children, and documents the source of the *News Medium*. *News*

Media represents where the *Information* collected by the News Agency is presented to a customer.

4.4.2.2Information

Information is by far the largest category within the *News Intelligence Gathering Primitive*, which is appropriate given that information is the focus of any intelligence collection task. In addition to having the most number of decomposed elements, *Information* also contains some of the most extensive listings of attributes and operations. From the definition in Figure 12 it can be seen that *Information* is expanded to include both the types of information being conveyed, as well as the sources of this information and the strategies used to solicit these sources. Included in the high level *Information* block are attributes assessing the information's validity (*Accuracy* and *Objectivity*) as well as the relevant *Target* of the information, and its *Flow*. Again, these attributes are inherited by lower level blocks, which is discussed below.

Information is decomposed to include its *Strategy*, *Types* and *Sources*. Each lower level *Information* category has attributes and operations associated with it specifically, and will be expanded below.

Information Strategy is defined as the plan or method with which information is collected, analyzed and managed before it can be reported to the customer. Because *Information Strategy* is actively controlled by a News Agency, it has a number of attributes and operations associated with it, as can be seen in Figure 12. One of the most important attributes is the *Constraint*. These *Constraints* are crucial to an organization because they establish the playing field within which the organization will operate. Without fully understanding *Information Strategy Constraints*, a News Organization will struggle to complete its objectives. Additional critical aspects of the News Agency Scenario are the *Investigation, Validation* and *Fact Checking* operations. The effects of an immature story verification strategy can severely embarrass an organization and can make it vulnerable to attack by both its competitors and customer base. This was the case with Jayson Blair of the New York Times, whose extensive plagiarism and fabrication of sources and story content went completely undetected because of a lack of proper fact checking procedures, and brought embarrassment to one of the world's premier news outlets. Development of *Information Strategy* is crucial to an organization as it will impact nearly every other aspect of *News Intelligence Gathering*.

Information Types (Figure 13) are defined as the variety of information that can be used to assemble news stories for distribution to a customer. The types investigated in this News Agency Scenario include *New, Background, Continuing and Existing Information*, which can be seen below.

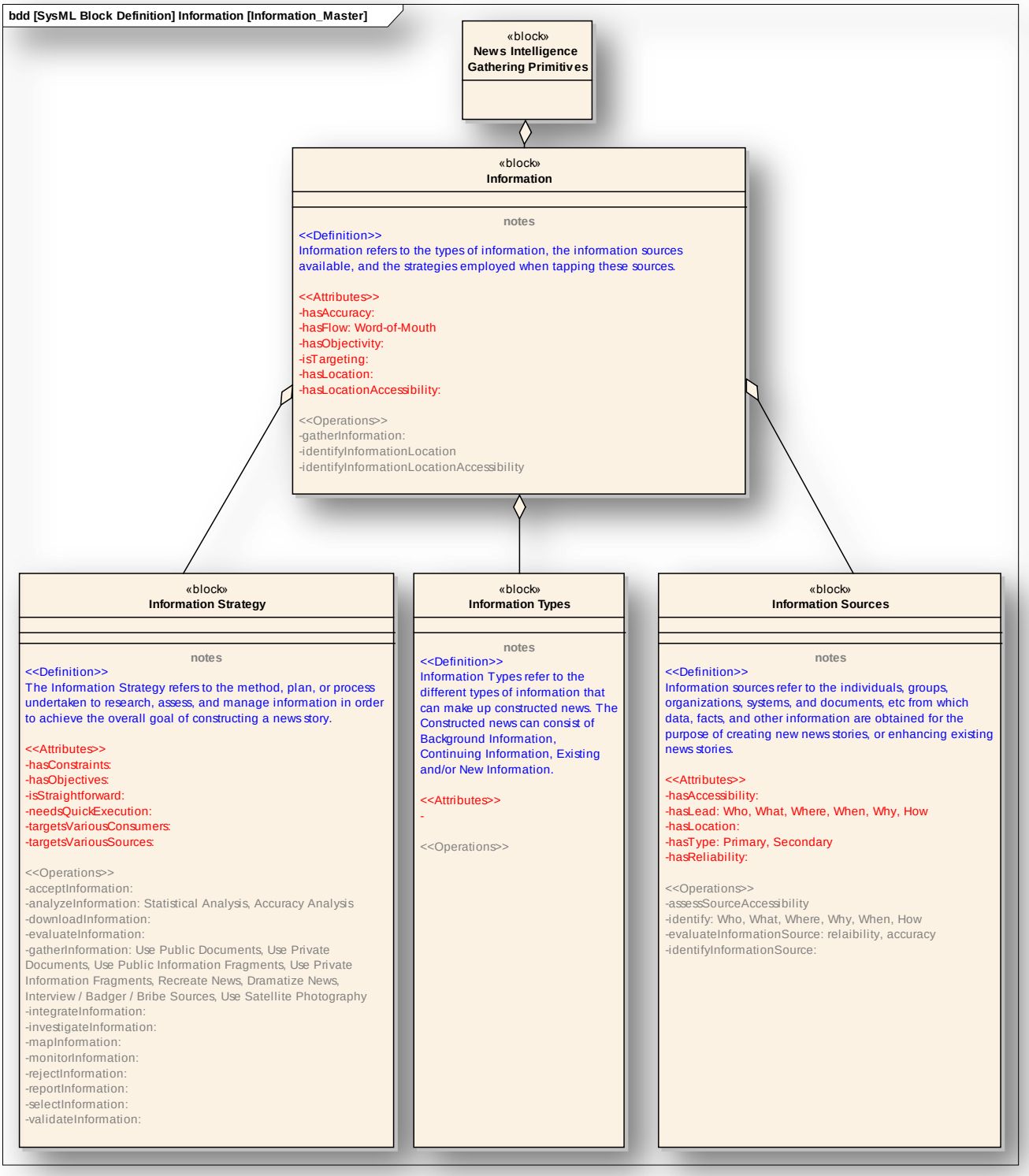


Figure 12: Information Primitive Diagram

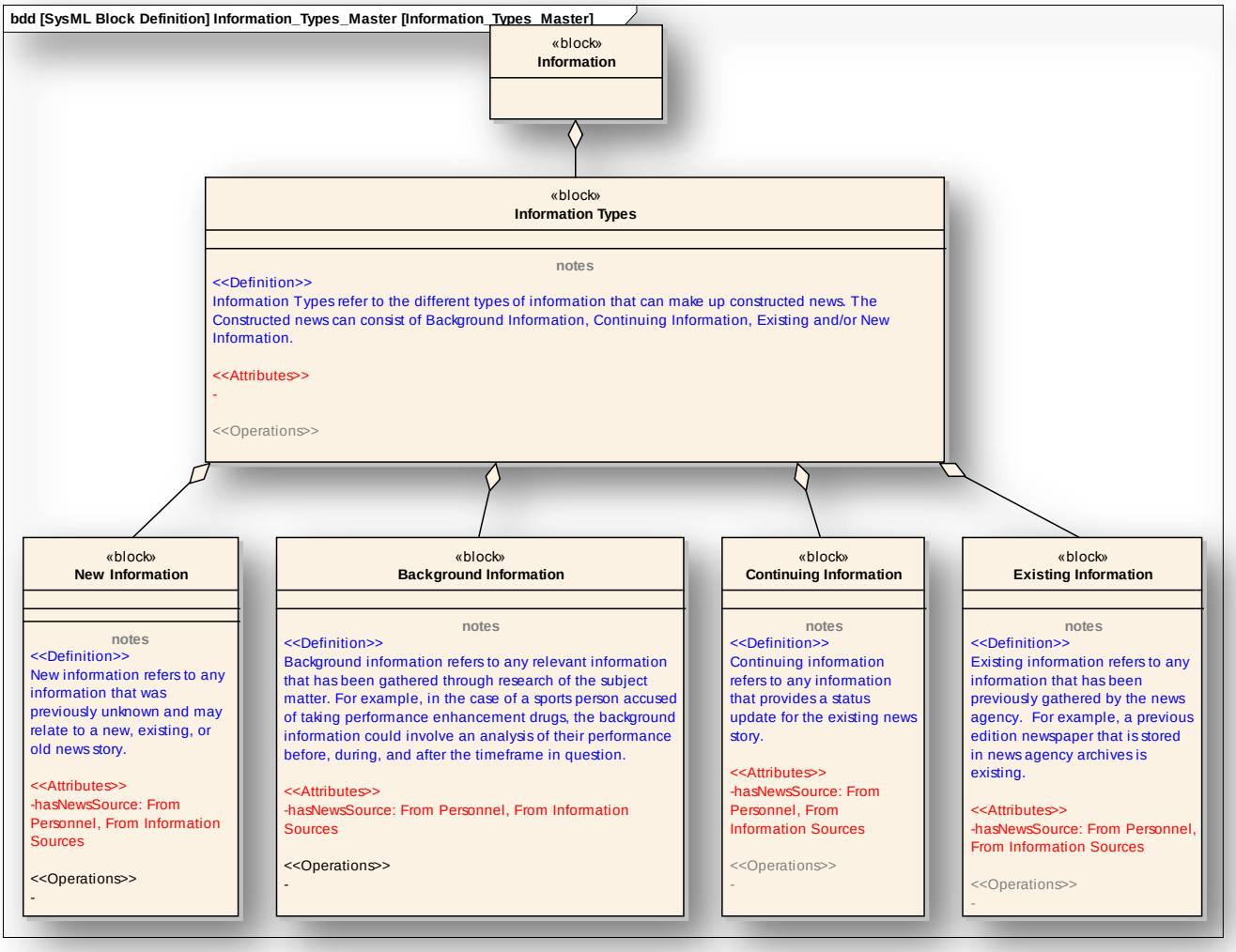


Figure 13: Information: Information Types Primitive Diagram

New Information relates to information that was previously unknown, whereas *Background Information* is information that is exposed through research of relevant subject matter, *Continuing Information* is information that updates a news story and *Existing Information* is information that could have been reported on in the past by the News Agency. Each type has a *NewsSource* attribute referencing where the specific information came from. This attribute leads directly to the next *Information* subclass from Figure 12, *Information Sources*.

Information Sources are the people, organizations, artifacts and systems from which a News Agency collects information. *Information Sources* has many key attributes including *Location* of the source, the source *Type* as either primary or secondary, the *Accessibility* of the source, both in terms of first and continuing communication, and source *Reliability*. Each of these is investigated through a complimentary operation that represents the action needed to collect these attributes. As seen in Figure 14, *Information Sources* can be decomposed into seven major categories: *Video Capture, People in the News, Independent News Creator, External Systems, Other News Agencies, Information Archives* and *Contact*.

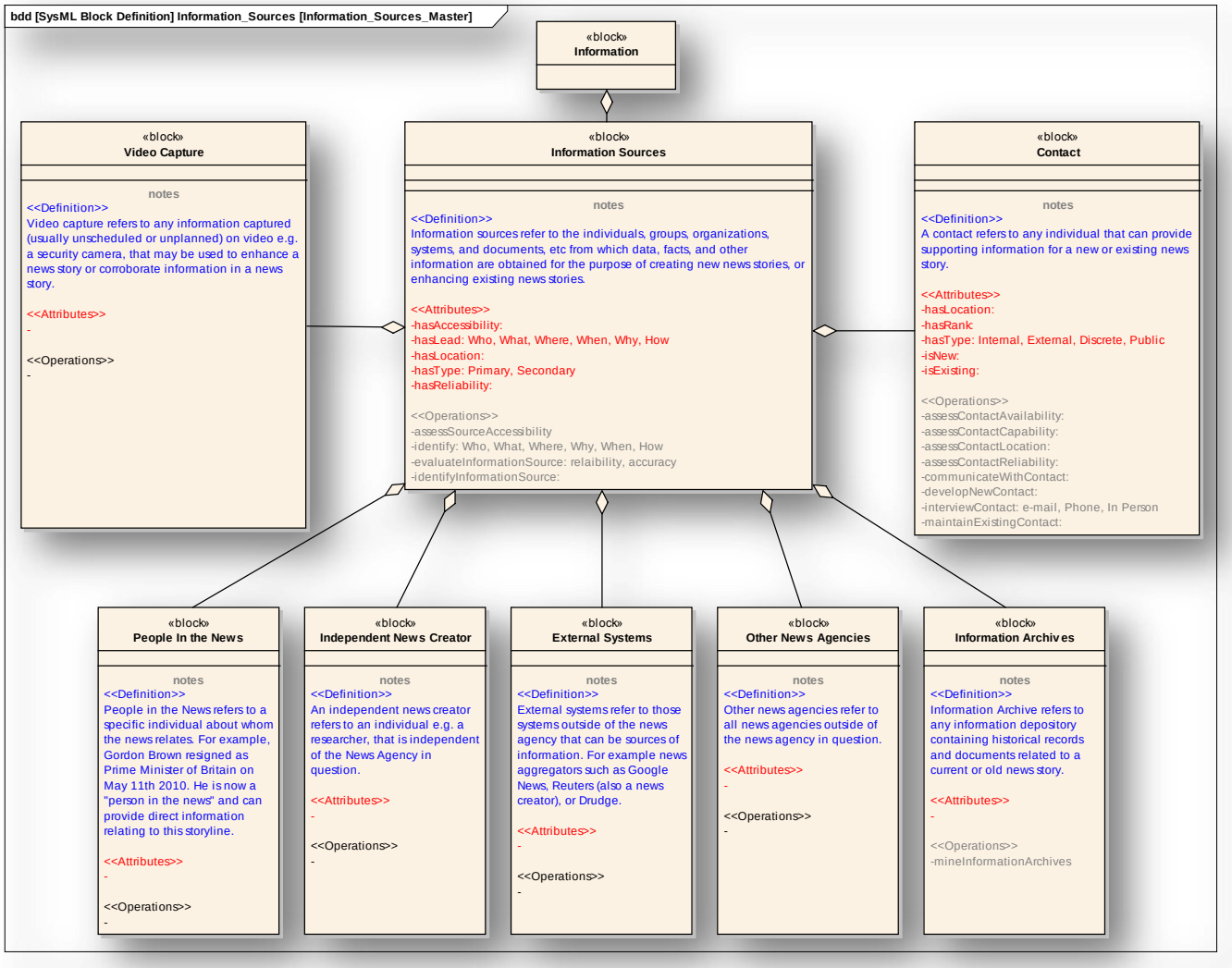


Figure 14: Information: Information Sources Primitive Diagram

Elements of *Information Sources* that are becoming a larger part of the way News Agencies operate are the *Video Capture* and *External Systems*. With increases in video device technology, more businesses are installing security cameras, more individuals own personal camcorders, and more law enforcement agencies are employing city wide surveillance networks, all of which can be potentially rich sources of news information. Additionally, in recent years, a growing segment of the news delivery market has been the so called news aggregators which, in this ontology, are considered to be *External Systems*. These entities are able to collect news reports from smaller local news agencies and deliver then rapidly via the internet to a national market of news readers. Services like Google News can be used as News Agencies as a "one-stop shop" of headlines from around the world, allowing the Agency to target specific stories and dispatch resources to collect *Continuing Information*. These two

elements are a growing part of the News Agency's possible *Information Sources*. The central element of the *Information Sources*, however, is represented by the *Contact* block, which is expanded in Figure 15.

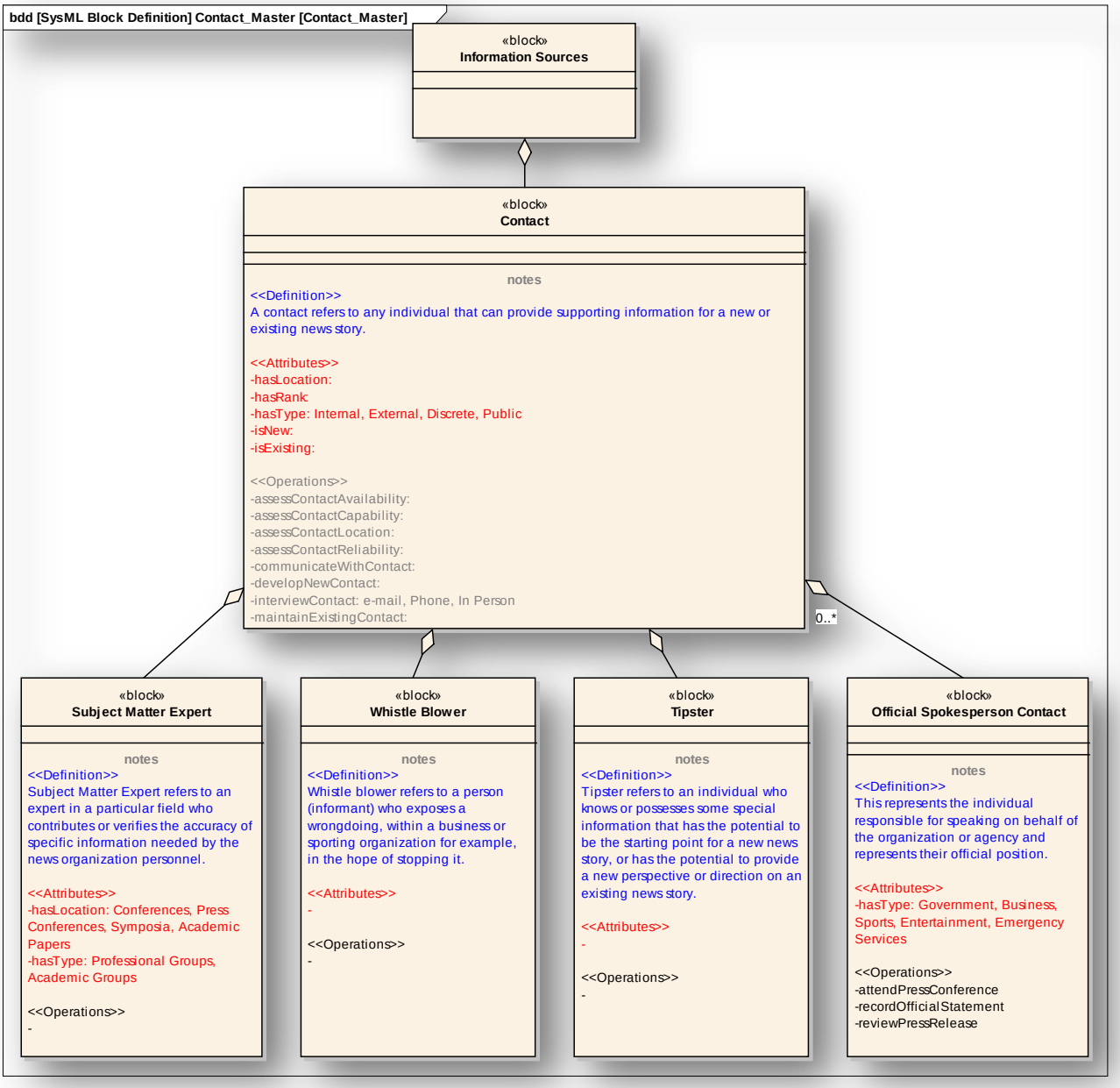


Figure 15: Information: Information Sources: Contact Primitive Diagram

The top level *Contact* block defines a contact as a person who is able to provide *Information* relating to a news story. *Contacts* have attributes that inform the news agency to their

Location, Rank, Type and their classification as a *New* or *Existing* Contact. These are accompanied by attributes of *Accessibility* and *Reliability* which are inherited from *Information Sources* and are used to assess the quality of *Information* that a *Contact* provides. *Contact* is broken down into four broad types of contacts, *Subject Matter Expert, Whistle Blower, Tipster* and *Official Spokesperson*. Each of these can be further broken down based on the *Type* attribute.

4.4.2.3 News Organization Operations

Stepping back to the News Intelligence Gathering Primitives Second Level Categories, the next decomposed element is titled *News Organization Operations*, and can be seen in Figure 16.

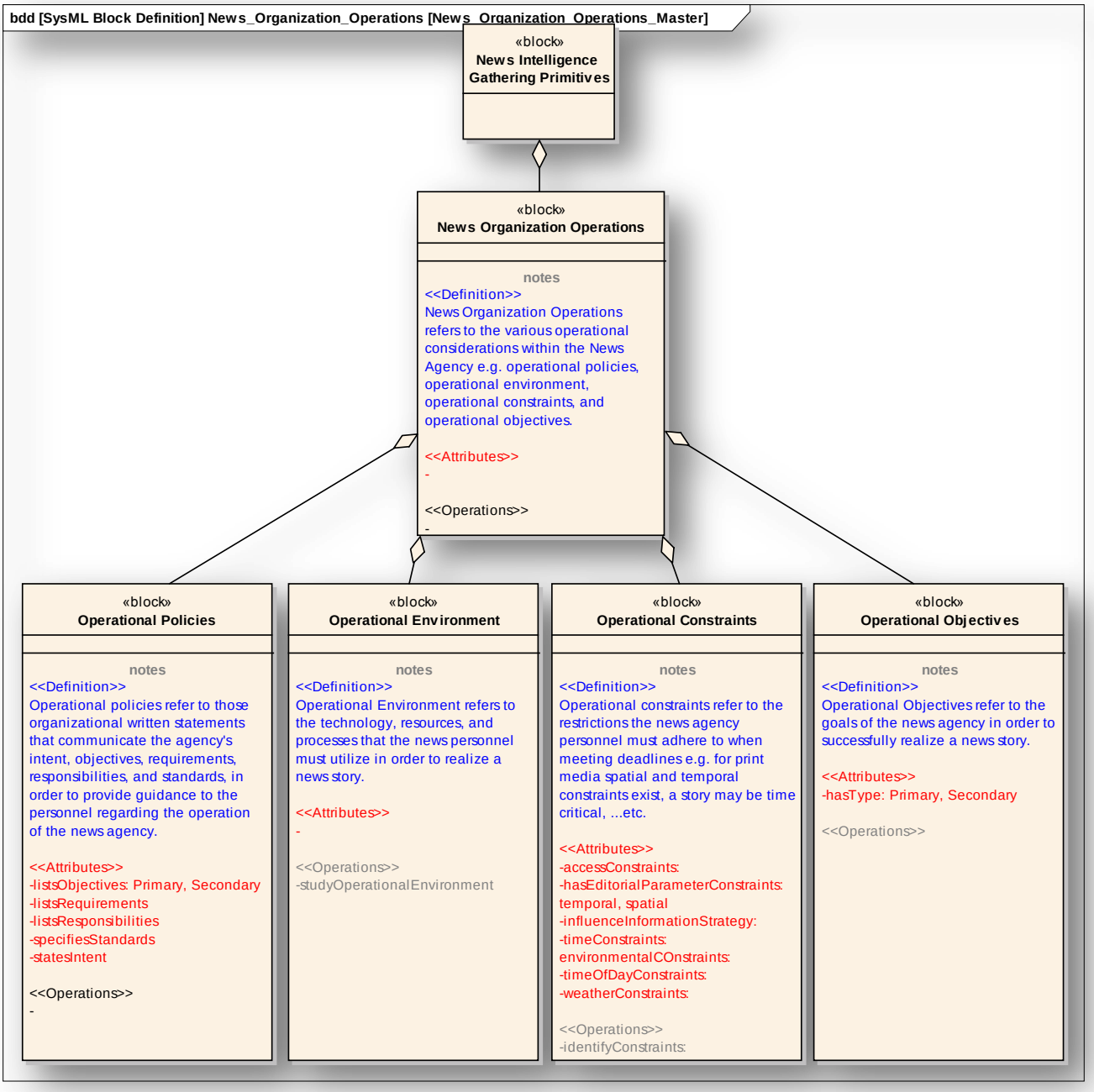


Figure 16: News Organization Operations Primitive Diagram

News Organization Operations is a broad category that includes many aspects related to how the News Agency operates. This ontology breaks down *News Organization Operations* into *Operation Policies, Environment, Constraints* and *Objectives*. *Operation Policies* are the guidelines that News Agency *Personnel* should follow so that the News Agency can successfully accomplish its objectives. *Operation Environment* is further decomposed and will be discussed below. *Operation Constraints* lists the restrictions that News Agency Personnel must adhere to

when creating news stories, such as *Time* deadlines. Attributes of *Operational Constraints* include the different types of constraints, such as *Editorial Parameter Constraints, Environmental Constraints, Time Constraints* and *Time of Day Constraints*. In order for the News Agency to be able to understand these *Constraints*, an *Identify* operation is included. Finally, the *Operational Objectives* refer to the primary and secondary objectives of the News Agency, which will usually include the presentation of an accurate news report to a customer.

The *Operational Environment* object is further decomposed to include:

- *News Communication Modes* – Methods of communicating within and outside of the News Agency
- *Resources* – Include technology, personnel and equipment that the News Agency needs to employ to successfully report on a news story.
- *News Equipment* – Deals specifically with the equipment needed to collect and report news stories, such as lights, cameras, microphones, etc.
- *News Construction Process* – A predetermined set of steps to be followed in the assembling of a news story.
- *Risk Management Process* – The News Agency's strategy for reducing the risk associated with assembling and reporting on news stories. *Risk Management Process* is of special interest as it will affect the News Agency in all aspects of its operation.

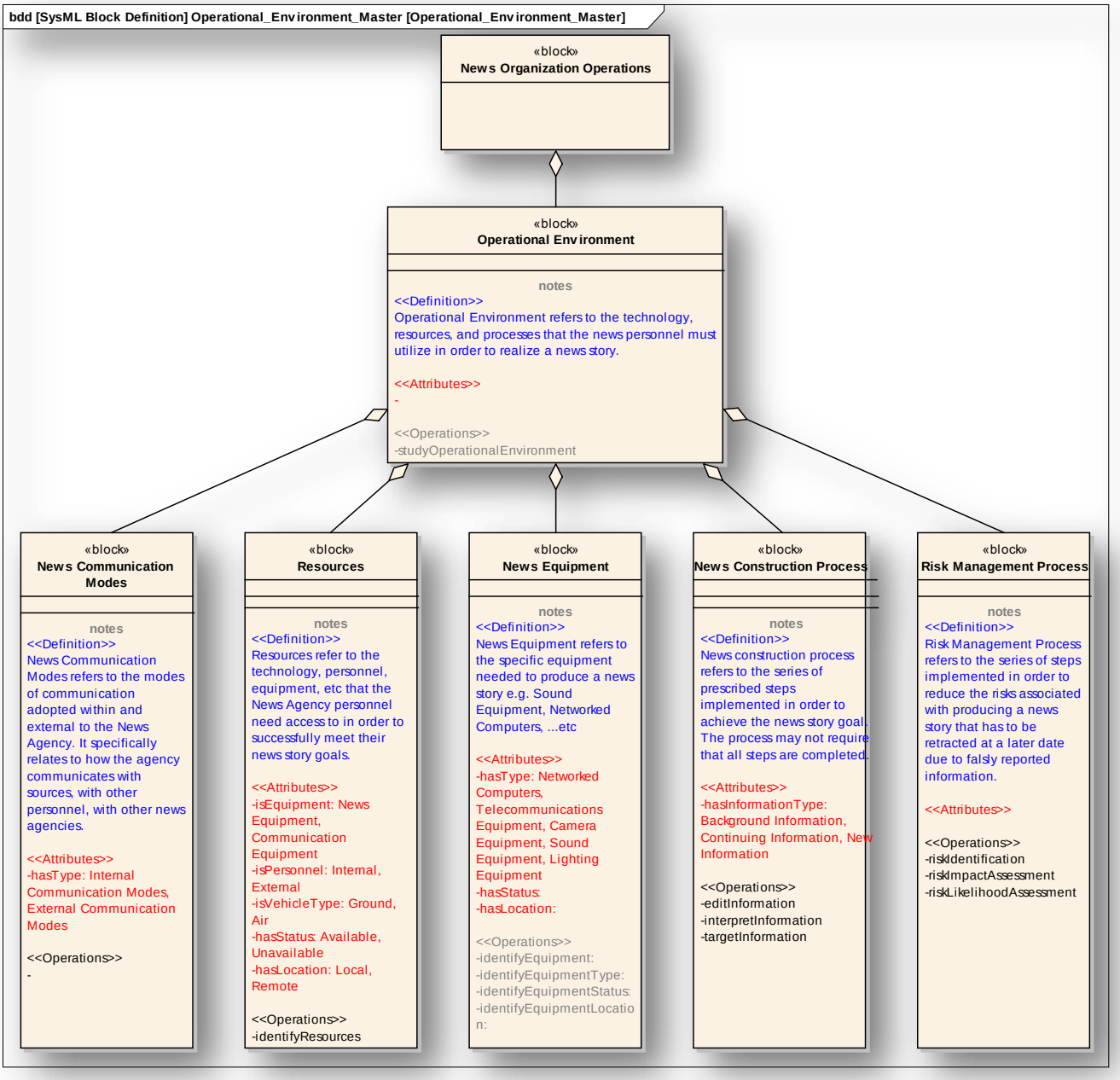


Figure 17: News Organization Operations: Operational Environment Primitive Diagram

Each sub class of *Operational Environment* (Figure 17) contains several relevant attributes such as *Type, Location,* and *Status*, and associated operations. The *Operational Environment* represents an important segment of the News Agency Intelligence Gathering Scenario in that is contains many of the "rules and regulations" and the standard operating procedures involved in news reporting.

4.4.2.4Transportation and Personnel

The final two objects from the News Intelligence Gathering Primitives Second Level Categories are *Transportation* and *Personnel*. These two elements will be discussed together since they strictly represent tangible physical items and are fairly straight forward. *Transportation* is represented in Figure 18 and is decomposed into *Transportation Vehicles* and *Infrastructure*. *Infrastructure* refers to installations allowing *Transportation Vehicles* to operate such as roads, highways, railroad tracks, etc. The *Transportation Vehicle* object is broken down into *Aircraft* and *Ground Vehicles*, which contain vehicle attributes such as *Max Speed, Max Elevation, Vehicle Equipment, and Operator Personnel*, and operations representing vehicle motion, as well as *Dispatch* and *Identify* vehicles.

The *Personnel* (Figure 19) object includes both News Agency *Personnel* and News *Consumers*. News Agency *Personnel* include *Reporter, Editor, Researcher, Writer, Technical Personnel* and *Vehicle Controller*. Each has attributes describing their *Status, Location, Capabilities, Skills and Training Level*. Additionally, each contains operations that allow for the identification of these attributes. At the head of each arrow linking specific personnel to the *Personnel* object are a set of numbers that indicate multiplicity. These numbers reflect the fact that each News Story must have a *Reporter, Vehicle Controller, Editor, Researcher* and *Writer* associated with it, however there need not be a *Consumer* or *Technical Personnel*.

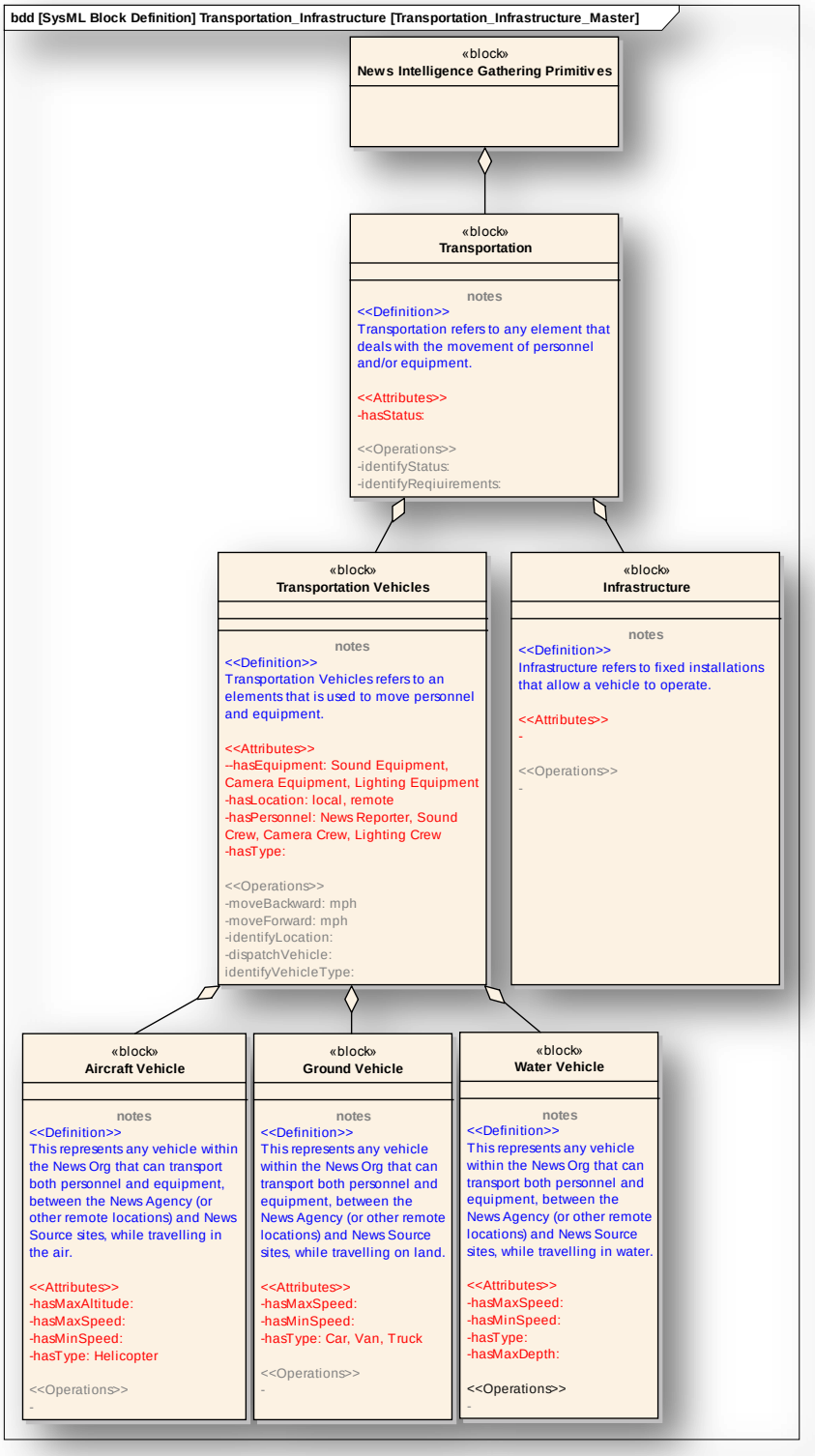


Figure 18: Transportation Primitive Diagram

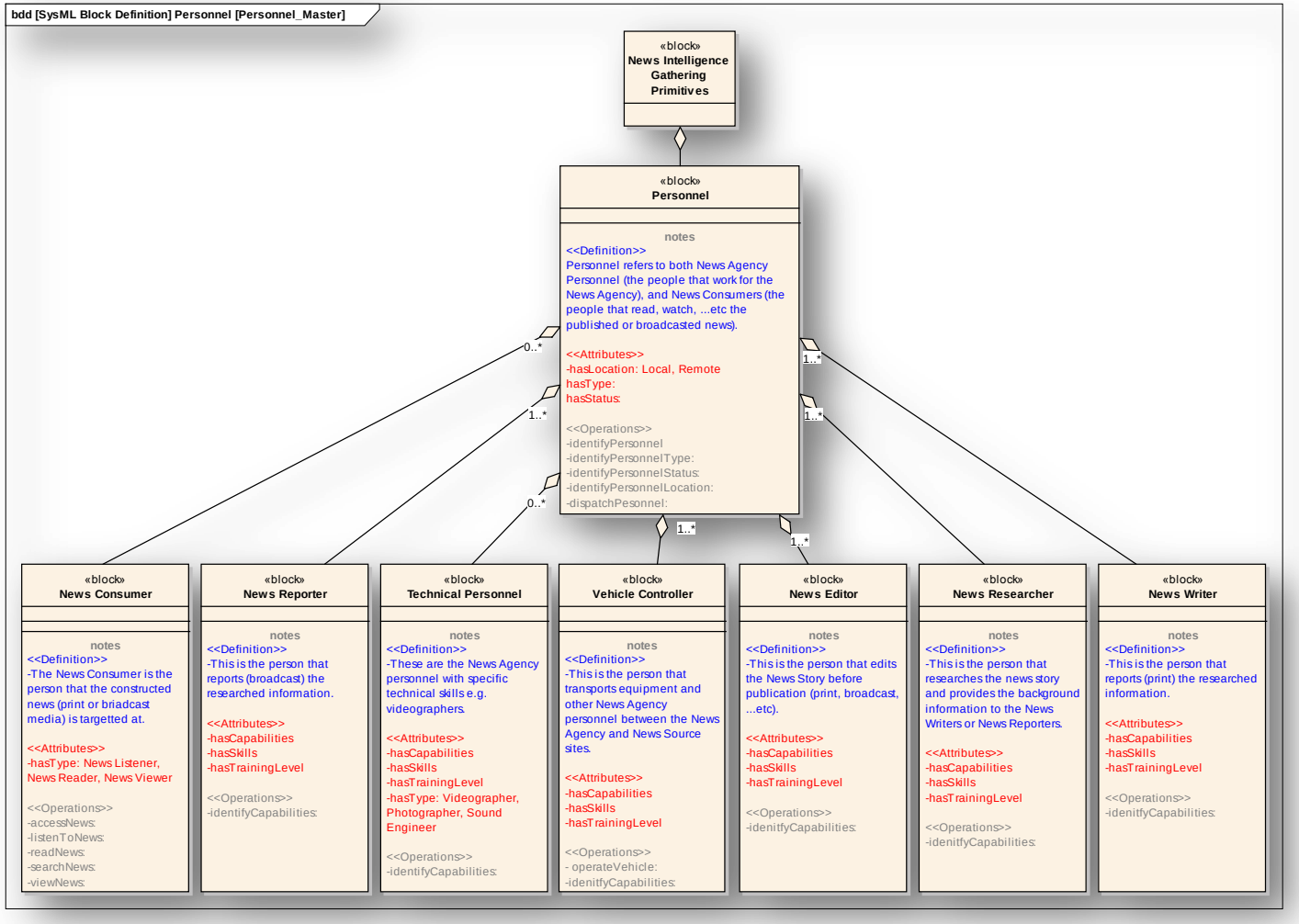


Figure 19: Personnel Primitive Diagram

5 THE SCENARIO GENERATOR INTERFACE

One example of a concept engineering interface that was introduced in Phase 1 was the interface found on StarLogo NXT. The concept is to have snap together "lego" like building blocks to graphically generate a scenario or story. A post processor will create an executable model from the graphically constructed scenario. As part of this effort, we have constructed a similar web-based prototype to demonstrate this concept which is discussed next.

5.1 SCENARIO INTRODUCTION

To further investigate an approach to scenario generation, and to test the robustness of the created news agency taxonomy, the team came up with five representative scenarios.

1. New Story: A news agency deploying a reporter and support assets (truck, video camera, sound equipment) to a new story (with time constraint option)
2. Corroborate Source: A news agency assigning a reporter to independently corroborate a news source
3. New Contact: A reporter works to recruit a new contact for a story
4. Follow-up: A news agency deploying a new reporter and support assets (truck, video camera, sound equipment) to follow-up on an existing (with time constraint option)
5. Information Synthesis: New agency to synthesize multiple stories to create a new edition for their customers (with time constraint option)

5.1.1 NEW STORY

In this scenario, a news agency has a lead on a new story, and deploys a reporter and the supporting equipment and personnel to support the reporter while covering the story.

5.1.2 CORROBORATE SOURCE

Considers the scenario in which a reporter is assigned to independently corroborate a news source.

5.1.3 NEW CONTACT

In the news business, many a story is developed via sources. In this scenario, a reporter works to recruit a new source/contact for a story.

5.1.4 FOLLOW-UP

Once a story has been covered, it is not unusual to do a follow-up story. This scenario depicts a news agency deploying a different reporter and support assets to follow-up on an existing story.

5.1.5 Information Synthesis

One form of news delivery is via the printed medium. This form of report requires the news agency to synthesize multiple stories to create a new edition for their customers.

Appendix C contains a list of each primitive used in creating these scenarios.

5.2 Scenario Generator Interface

5.2.1 Scenario Generator

The Scenario Generator was designed as a demonstration of what a possible user interface would look like in a concept engineering environment. It was assembled as a Java applet to make it platform independent and accessible via the web.

The Scenario Generator is shown in Figure 20.

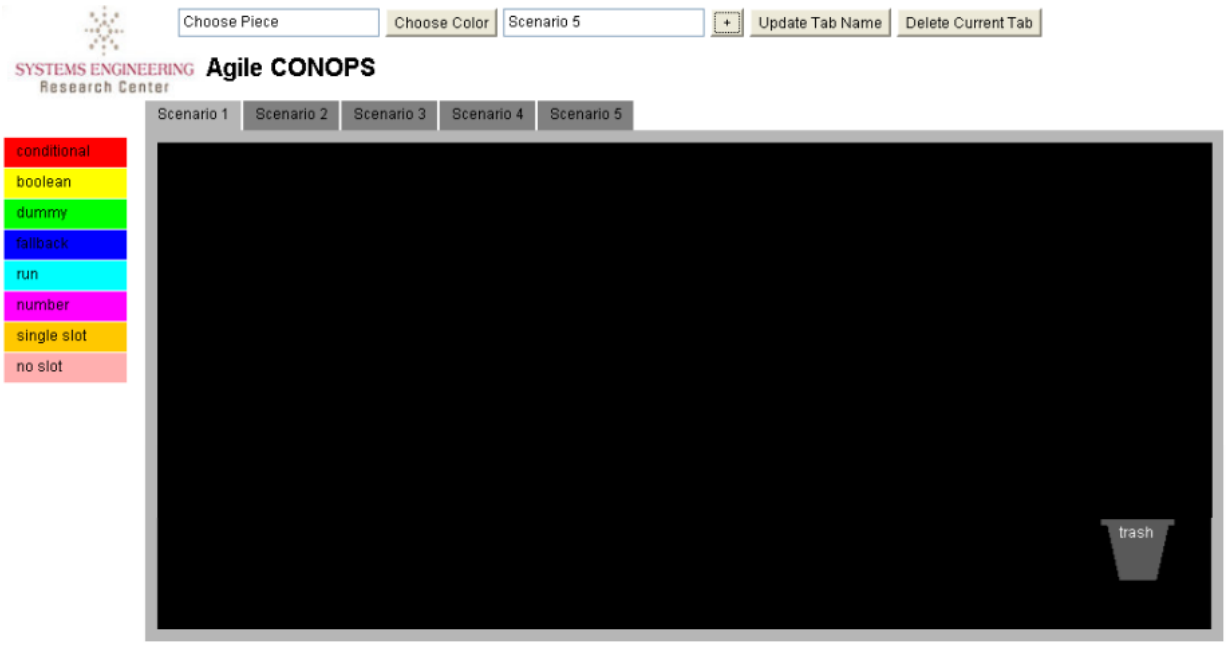


Figure 20: Scenario Generator Interface

Like today's Internet browsers the tool was designed to support multiple work spaces through the use of different tabs. The tabs are listed above the black workspace and can be created, deleted or renamed to allow the modeler a full range of flexibility.

Six basic building blocks were created, Run, Conditional, Boolean, Number, Single Slot and No Slot, as seen in Figure 21.

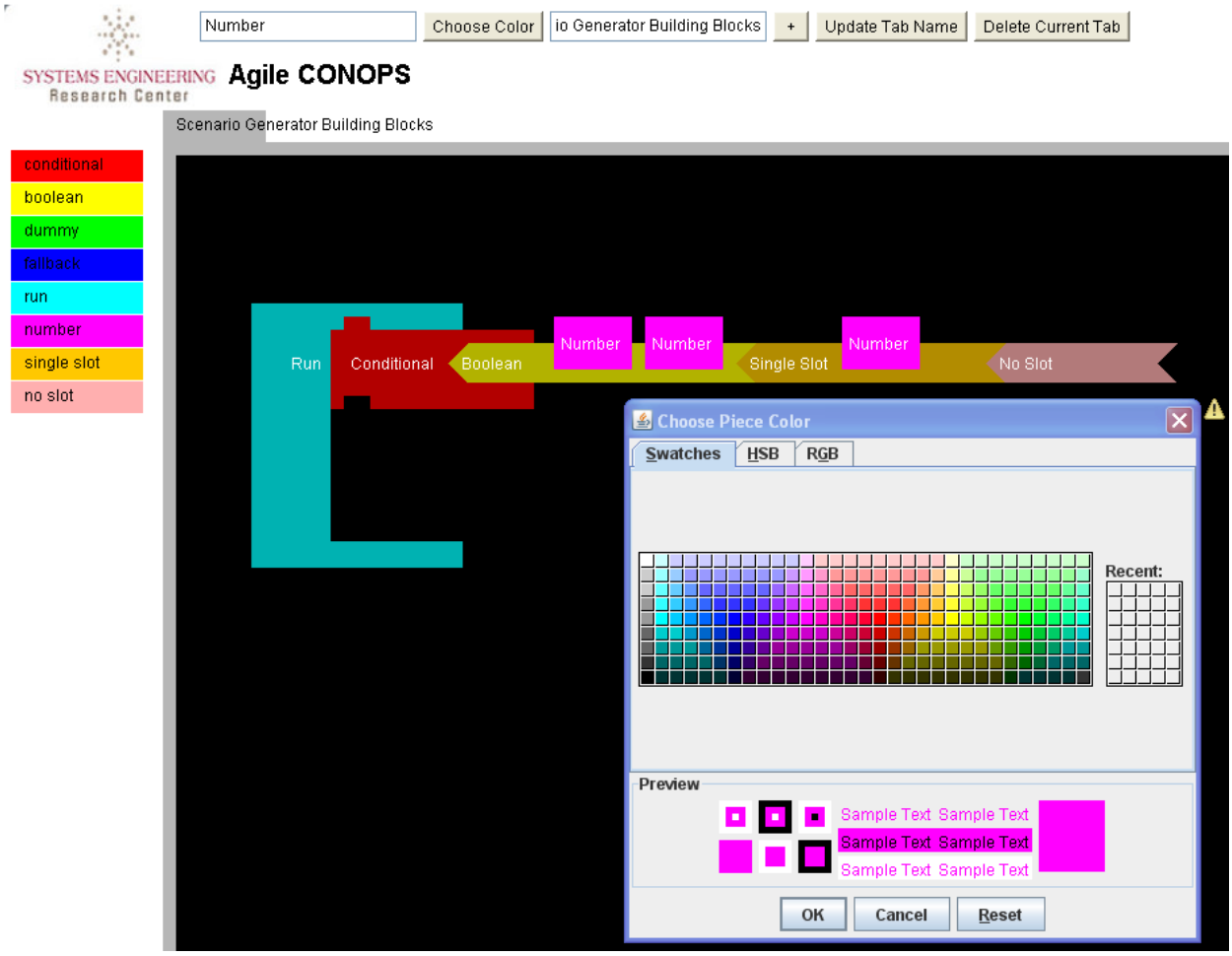


Figure 21: Scenario Generator Building Blocks

The blocks were designed to be flexible in what they represent, allowing for changes to be made to their name and color in the area above the workspace. Colors can be chosen from a color palette, or specified using RGB or HSB values using the color pop-up seen in Figure 21. Blocks can also be removed from the work space using the trash can, seen at the bottom of the workspace in Figure 20.

Like the Starlogo tool, the edges of some blocks are specific shapes that fit into other blocks, allowing them to be snapped together and moved as a single unit. This way the modeler is able to create chains out of related concepts. Some of the blocks in this version of the tool (Dummy and Fallback) are not able to be snapped together, and were created to simply represent the possibility of future block shapes.

The modeling process for the News Agency scenarios was relatively easy in terms of renaming and snapping together blocks, but slightly more complicated when it came to color coding blocks. The Scenario Generator modeling process will be discussed below, using Scenario 1 as an example

Scenario 1: A news agency deploying a reporter and support assets to a new story

The first action taken in the modeling process was to create Scenario Generator tabs for Scenarios 1-5, thus creating five independent work spaces (Figure 22). Next, colors were chosen that were to represent certain primitives. The Scenario Generator only supported white text therefore there were a limited number of colors that would be readable on the screen. As a result, colors were chosen for groups of related primitives. All attributes, which were to be represented by the number block, were set as a light grey color. The short name of each scenario is a run block and colored black to appear as if it is part of the background, and reduce clutter in the work space. From there, the primitives listed in Appendix C that represented similar concepts were assigned a color. For example, all primitives dealing with Operational aspects were assigned the golden color and all Personnel related primitives were colored orange. Some primitive color groupings were less obvious, such as dark blue which represents information gathering primitives, or light green, which represents information assessment primitives. Finally, some of the primitives did not fit neatly into a color category, and were assigned the turquoise color, such as dispatch and report.

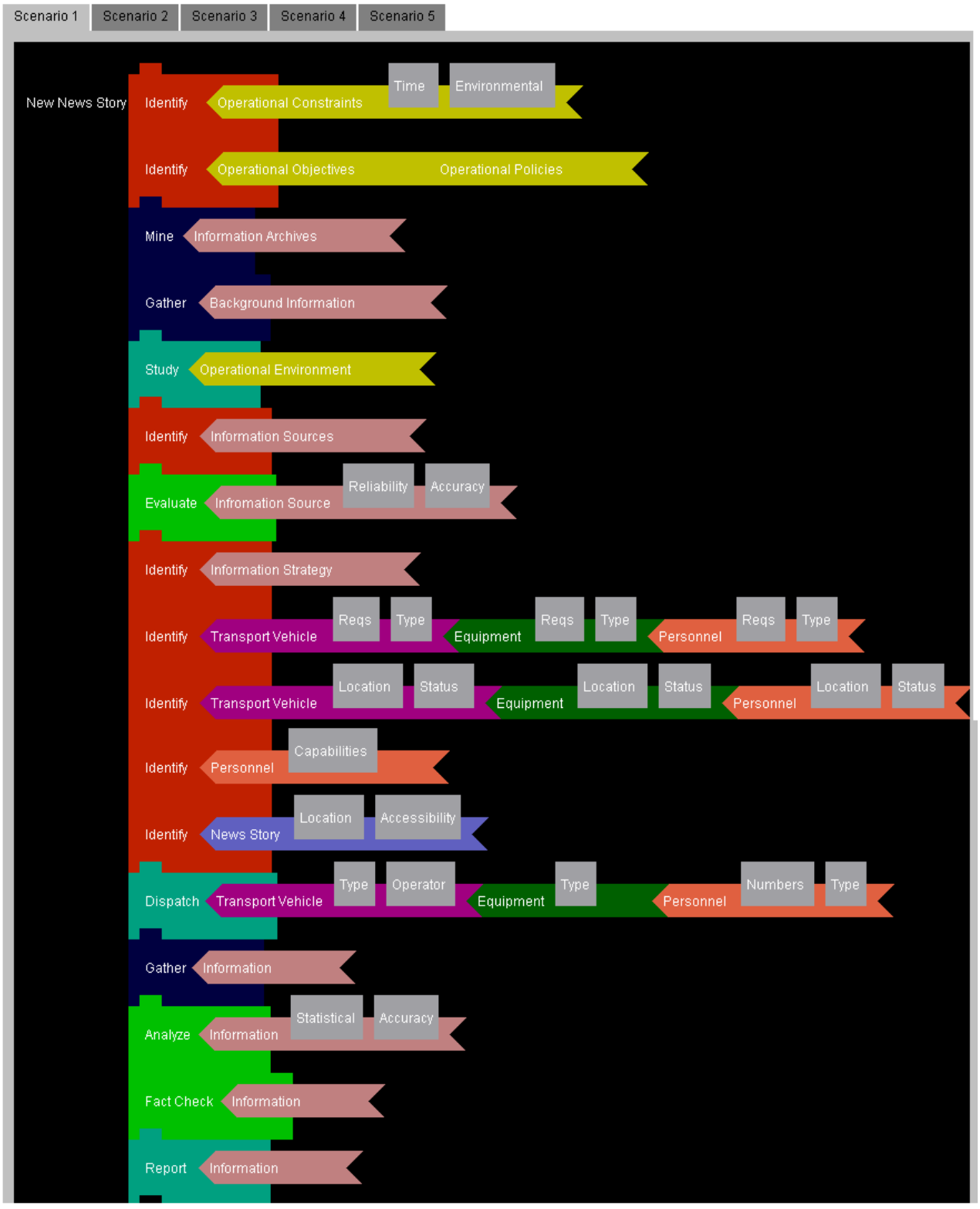


Figure 22: Scenario 1 - New News Story

Once each primitive in the scenario list was assigned a color, the modeling began. As mentioned above, the run block was used to label the scenario using its short name, and was placed in the far left to allow the remainder of the blocks to be snapped to it. The first primitives in each scenario listing, operations, were assigned to a conditional block, labeled and colored appropriately, and snapped to the run block in the order in which they appeared in the scenario listing. From here, objects, the second primitive in each scenario listing, were assigned either the boolean, single slot or no slot blocks based on the number of attributes associated with them. These blocks were labeled, colored, and snapped to their appropriate location, either into a conditional block or after another object block. Finally, where needed, the number block was labeled as the appropriate attribute and inserted into the object block slots. This process was repeated until each scenario listing was complete, and the scenario model was finished.

This process taught the modeler two valuable lessons:

- First, while the changing of block names was fairly straightforward, the coloring of each block was a more difficult matter. This was due to the fact that, in order to maintain consistency, the exact same color had to be used for each similar block. Since the color palette is not an exact way to select a color, the modeler was left with the choice of picking a color from the palette and seeing if it matched the color of the related blocks, or entering the specific RGB values for the desired color; either process is time intensive.
- The second lesson learned attests to the value of modeling. The same modeler built the Scenario Generator model and the News Agency Ontology model; therefore, based on the modeler's familiarity with both works, the same language should have been used for the scenario models as was used in the ontology model. This is the case in all scenario listings except for one, the object of the twelfth scenario listing in Scenario 1, *News Story*. *News Story* was not a term used in the News Agency Ontology, but was the best term to describe the concept that the modeler was trying to convey, that personnel need to be dispatched to a specific location to gather information. This omission from the News Agency Ontology was realized when the Scenario Generator outputs were being examined by the project team. This discovery, and ensuing discussion, solidifies the value of using a model to reason about a problem and to communicate with others. Had this communication of the model never occurred, this omission of critical terminology would probably not have been realized. The project team's consensus was that the News Story is a generalized term for New, Existing, Continuing and Background Information, but the correction of the News Agency Ontology was withheld to allow discussion of this situation in the report.

The same process used for Scenario 1 was employed in the construction of Scenarios 2-5. Due to space concerns, the diagrams of Scenarios 2 and 3 can be seen below (Figures 23 and 24 respectively).

Scenario 2: A news agency assigning a reporter to independently corroborate a news source

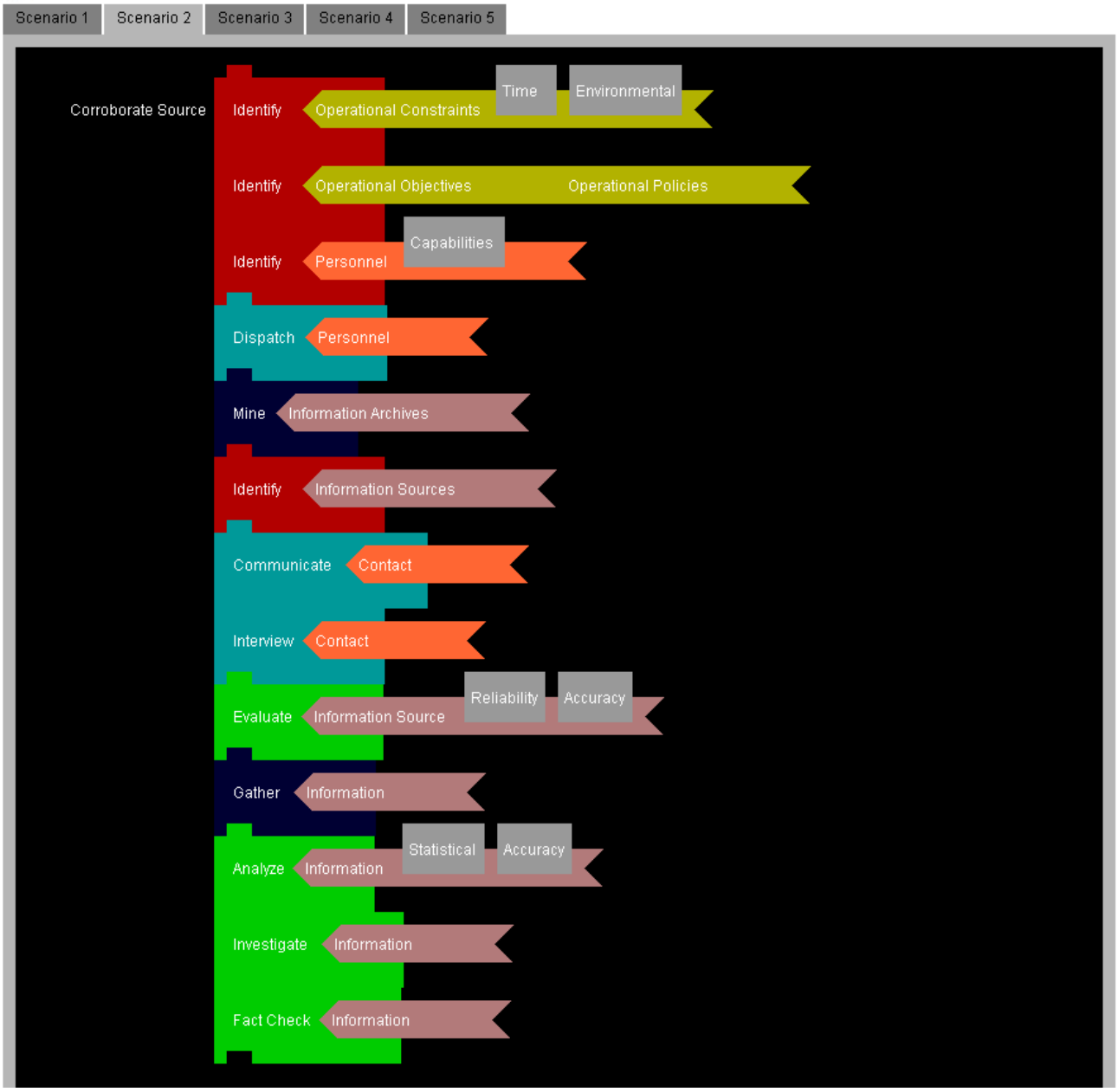


Figure 23: Scenario 2 - Corroborate Source

Scenario 3: A reporter works to recruit a new contact for a story.

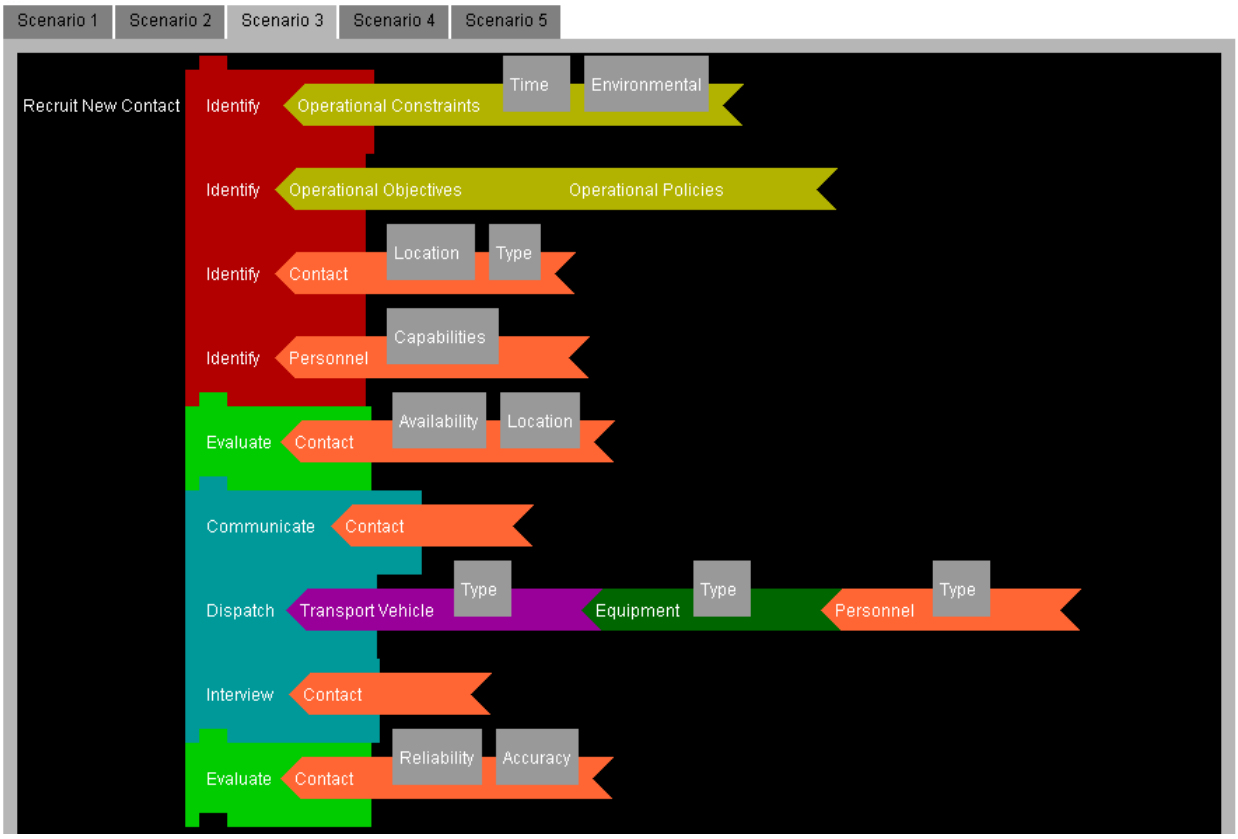


Figure 24: Recruit New Contact

Because the Scenario Generator was built as a simple prototype, some desired features and capabilities have been withheld to allow for ease of development and flexibility of use. Based on analysis of the current implementation, additional functionality that could be added to enhance effectiveness includes:

- Instead of the blocks being blank, some would be pre-named and pre-colored to match some of the discovered scenario primitives. There would be a block palette on the left side that would display high level categories of building blocks. Clicking on such a high level label would expand the category to show pre-named, pre-colored blocks that were to be most commonly used primitives. There would also be a set of blank blocks that would allow the modeler to name and color blocks to their specification
- The Choose Piece Color window would hold past color selections for future reference. Although the Choose Piece Color window in Figure 21 contains an area for recent colors, the set of recent colors resets when a new block is selected. By allowing the Scenario Generator to store colors selected across many blocks, the time and effort needed to exactly match each block's color would be greatly reduced.
- A specific workspace would be saved for future work. As it exists now, when the tool is closed, all work is lost. Clearly this is not appropriate for a concept engineering effort, where modeling is an iterative process that will frequently be spread across a long

period of time. To be useful to a modeler, a further developed Scenario Generator would need to allow for saving and reopening of model files.

5.3 APPLICABILITY TO OTHER CONOPS/DOMAINS

The notion of transporting objects between locations, information gathering, and communications are core to many actions that might be modeled. For instance, when looking at a military mission of close air support, objects are moving from one location to another, at specific times, and there is a high degree of communication and collaboration necessary.

Joint Publication 3-09.3, dated 8 July 2009, provides joint doctrine for executing close air support. Chapter V Execution contains scenarios for each types of close air support. The appendices contain glossaries, check lists, etc. One approach to adapting to other domains would be to extend the libraries of primitives to include domain specific primitives. A second approach would be to create a table of equivalencies for domain specific language. In this way, if an equivalent term is available depending on the domain, it is used. Otherwise, the scenario generator would use the core primitives. Yet another approach is to create a unique set of libraries for each domain. Further research and design are necessary to determine the best approach, but it is sufficient at this point to know there are a number of alternatives to enable this concept for multiple domains.

6 SYSTEM ARCHITECTURE

When one considers what is needed for a concept engineering system (CES), the high level architecture is not overly complicated. There must be a highly collaborative user interface, the capability to create scenarios and the complete CONOPS, a repository for reusable elements for use in new scenarios, the ability to add to, or extend the primitives, and an execution engine to put the scenarios in motion. Another capability that needs to be included is the ability to interface with other systems/tools to exchange data. This must be bidirectional in that the CES must be able to accept data from another tool as well as export data to a downstream tool.

6.1 HIGH LEVEL SYSTEM ARCHITECTURE

Figure 25 represents this logical architecture. In this diagram, The CES is comprised of the following major components:

1. External system interface
2. User collaboration interface
3. Scenario generator
4. Execution engine

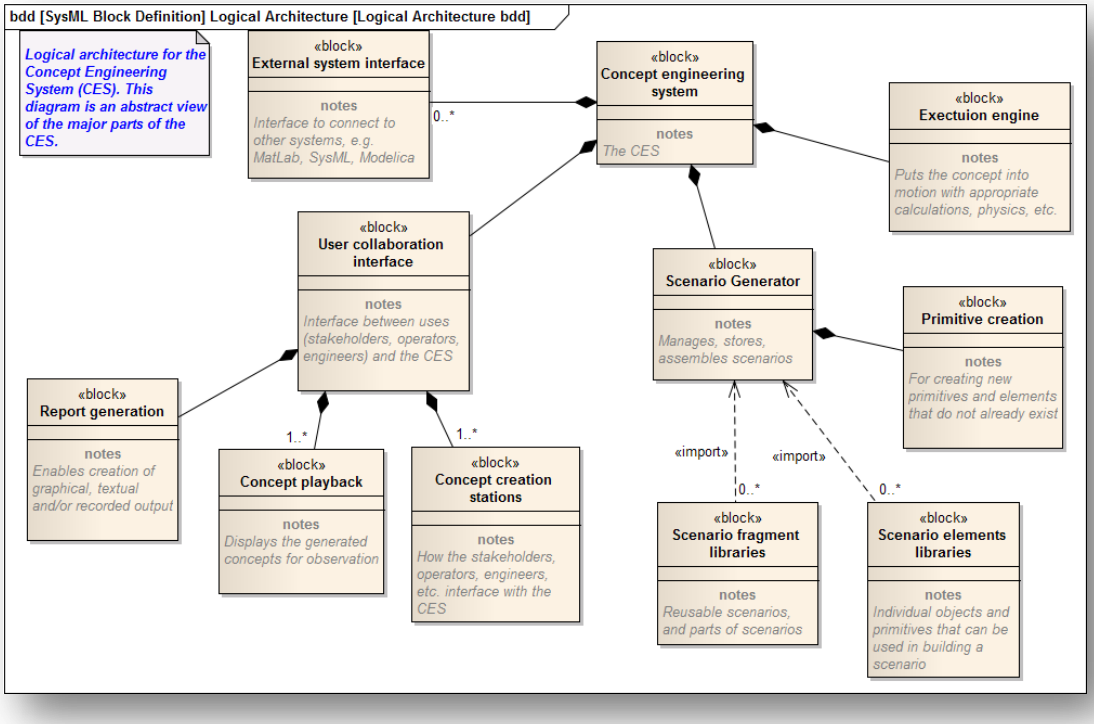


Figure 25: Concept Engineering System (CES) Logical Architecture

The user collaboration interface has several major components. The first is the concept creation station. This may be a single workstation such as a horizontally mounted computing table, or may be a collection of multiple workstations. The second component is the concept playback component. This is probably a large screen or projection unit where operational concepts that have been completed can be viewed by a larger group. Finally, the user collaboration interface must have a report generation capability. These reports may be textual, but they may also be a recording in some video format that can be burned on a DVD for sharing.

The Scenario generator component must have access to libraries of elements and fragments (collections of elements that have already been assembled) that can be imported into a new scenario. It must also have the ability to add new domain specific primitives to the system for future use.

Potential connectivity for the major components of the CES high-level architecture is represented in Figure 26.

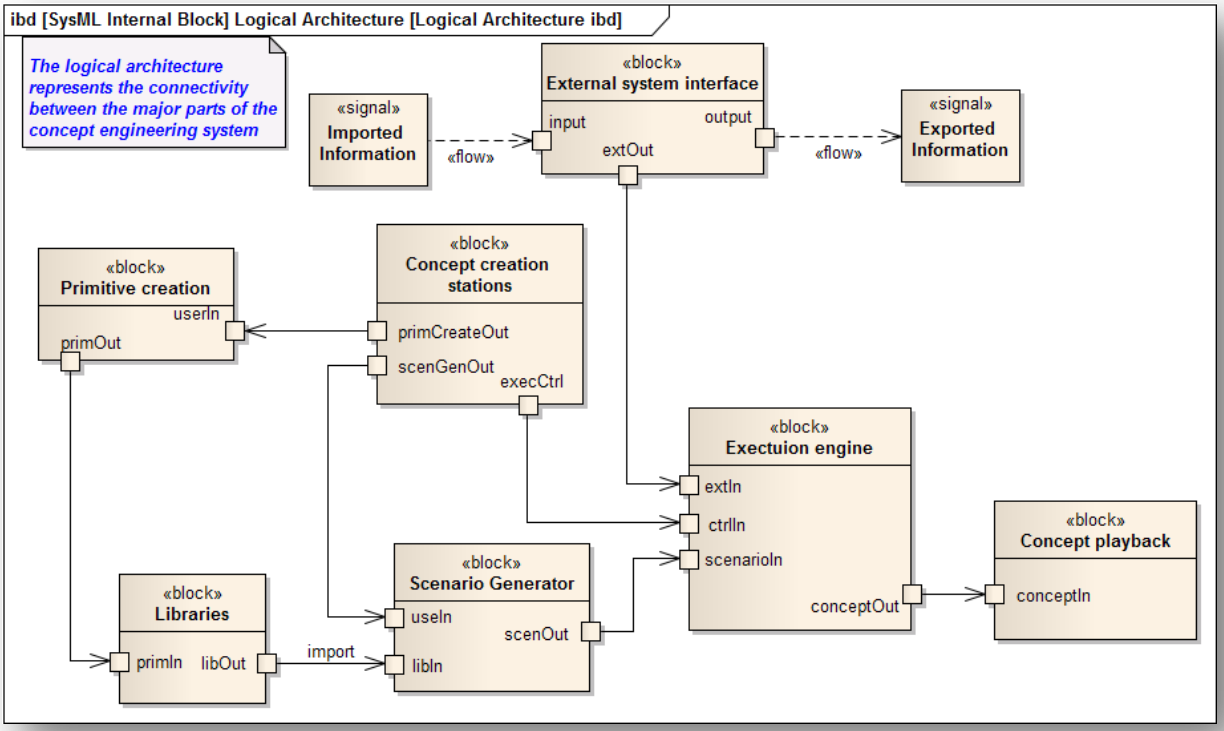


Figure 26: CES Logical Architecture Connectivity

6.2 Potential CES Components

Phase 1 of this research identified several potential software tools that might be part of the solution space. Upon further research carried out in this phase, some of those options still are promising. And, others have also emerged as the requirements are better understood. The CES physical architecture is comprised of the end-user interaction devices, scenario playback

environments and the integration infrastructure needed to enable the CES logical architecture, shown in Figures 25 and 26.

The primary criteria in selecting an appropriate component for a specific concept engineering application are the necessary *cognitive exchange bandwidth,* which is a function of how much information/knowledge needs to exchanged between the end-users; available *time and budget*, which restrict the complexity of options used; and the *reusability* of the infrastructure, which determines optimal initial setup investment limits. While most concept engineering frameworks address the graphical or visual aspects of end-user interaction, the next-generation infrastructures need to focus on maximizing the cognitive exchange bandwidth between concept developers at an appropriate time/cost investment level.

6.2.1 PROGRAMMING LANGUAGES

While there are a large number of programming languages available today, they fall into 3 categories shown in Table 2. This section is not intended to be a computer science tutorial, and it does not even begin to scratch the surface of the topic.

Table 2: Example Categories of Programming Languages

Procedural	Object Oriented	Specialty
Fortran	Java	Lisp
C	C++	Prolog
Cobol	Python	Aspect oriented languages

Each of the above languages offer advantages and disadvantages. When high performance is necessary, C/C++ is used, though that brings a set of challenges such as managing pointers and preventing memory leaks.

As was discussed earlier in this report, the taxonomy resulted in a collection of primitives, the vast majority of which were objects. Therefore, while Blender (which is discussed in Section 6.2) is written in C/C++ for performance, it makes sense that Blender also allows users to use Python (an Object Oriented scripting language) to manipulate the environment.

The Scenario Generator Demo was written in Java. Most computers today have either the Java Runtime Engine (JRE) or the Java Development Kit (JDK) installed due to the pervasiveness of Java use on the Web.

Execution engines such as Open Simulator (which will also be discussed in Section 6.2) are written in C#, which is a Microsoft language that was influenced predominately by Java.

There is no clear recommendation for a single programming language for the CES. Each open source programming initiative has its language of choice. Therefore, it will be dependent on the amount of open source software that is incorporated as to which programming language is best for the new portions of CES. What may become more important will be the application programming interfaces (API) options provided by each software program considered for incorporation into the CES.

6.2.2 CONCEPT CREATION STATIONS

Concept Creation Station is the element of the CES physical infrastructure that allows the end-users to interact with the system and each other. Concepts of operation are created by dragging and dropping CONOPS primitives onto a screen and connecting via operations from a mouse. Several distributed Concept Creation Stations could be linked to enable distributed teams to collaborate. Following are descriptions of some of the potential technologies that can be used for Concept Creation Stations.

Sift Table Smart Blocks

SiftTable Smart Blocks are physical blocks that have functionality associated with them. Additionally, these smart blocks can also be placed with others to form groups that have the composite functionality. Smart blocks may be used as primitives to create concepts of operations by placing them in a specific logical arrangement. The smart blocks concept is attractive from the dynamic composability perspective. However, the physical blocks themselves are not very convenient to create large systems or for virtual teams. Implementing the Smart Block concept within the Surface Computing hardware environment (and extending that to a networked setting) offers a scalable solution.

Surface Computing

Surface Computing allows a number of people to simultaneously interact with graphical building blocks to engineer a concept. In addition, this concept could be extended to multiple sites and distributed collaboration with the networking of a number of tables. Templates, or patterns, could be used to quickly create new combinations or variants of existing scenarios. Tapping the blocks could be used to dive deeper into the hierarchy, squeezing could allow you to pop up in the hierarchy. The two scenarios below give an idea of the use of surface computing in future CES (note: both the cases use the Microsoft Surface table. The first is related to the NEO rescue problem, and the second demos the control of a real-time dynamic system):

1. http://mrrichie.spaces.live.com/blog/cns!DD16C3F34F4D913E!3112.entry
2. http://kiwigis.blogspot.com/2009/06/police-dispatcher-on-microsoft-surface.html

HubNet

HubNet is a network of handheld devices and up- front computer, developed for classroom participation application (http://ccl.northwestern.edu/netlogo/hubnet.html). HubNet is designed specifically with the goal of creating a fully participatory, networked, classroom learning space. The core features of this space include:

1. A collection of hand-held computing devices with significant resident functionality (e.g., a programmable graphing calculator);
2. A network layer of flexible communication protocols including the ability to upload and download data sets, upload and download program (e.g., applets), monitor key-presses at the hand-held level, support real-time interaction as in

network computer games, and form collaborative groups of various sizes (e.g., peer to peer, small groups, and whole class modes);

3. Development tools for programming individual devices and the network;
4. Public display capability (e.g., a projection system);
5. An up-front computer (the "hub") capable of addressing the network of handhelds and running systems modeling programs (e.g., NetLogo, STELLA) as well as core analytic tools (spread sheets, function graphs, etc.);
6. An ability to be addressed using open standards and protocols;
7. A cross-platform implementation (using HTML, Java, etc.);
8. An ability to connect and interact with other layers of network 'up' from the classroom, including various school- based LANs, district WANs, and the Internet.

HubNet devices can be used by concept developers to choose primitives, create logical arrangements and interact with other developers.

Multipoint

Multipoint technology allows the use of 2-250 active mice on a single computer. Using mice as a primary interaction interface is certainly a cost effective, easy and intuitive option for most users. An SDK can be downloaded to assist in the development process. Collaborators can sit around a table, each with their own wireless mouse, participating in a concept engineering exercise on a shared large screen. Multipoint can be deployed in any modern conference room with the addition of wireless mice.

6.2.3 Primitive Creation

Primitive creation was explored as part of this phase. It is recommended that the lego-like interface continue to be expanded so it generates XML that can be utilized by the scenario generator in conjunction with libraries and other scenario fragments.

6.2.4 Scenario Generator and Concept Playback

Scenario generator allows the end-users to create a complex concept using primitives, represent all the interactions, capture the rationale and allow the session to be played back for analysis and reuse.

Typically, 3D presentations of information can be very informative and impressive. The scenario generator and concept playback can provide a number of different views, both 2D and 3D. The 2D views can be of an entire system or of a particular layer in a system hierarchy. Moving to a 3D view, various layers in the hierarchy can be presented. What is represented in a particular layer can be selected by each user which enables them to view the system from a number of different vantage points. With multiple screens, a number of participants can each interact with, build and modify the system simultaneously, each from their own perspective. A global view could be presented to all on the large screen on the wall, while each participant interacts on their own workstation. Finally, each user can have personalized information

relevant for the stakeholders that he/she represents on his/her view. This information can be customized to provide each user with what they need to see, while the information pertaining to the global good can be viewed on a global screen. It should be noted that both the CONOPS structure and the simulation outcomes can be personalized for each of the viewers. With a package of scenarios, the end-users quickly build up the complexity of the CONOPS to address ever increasingly challenging requirements. Following are some descriptions of the potential technologies that can be used for Scenario Generator and Concept Playback modules.

E-Wall

EWall introduces a computational framework for the formation of ideas in a collective brainstorming process. EWall is a web-based environment that allows users to collect, organize and view graphical and contextual information. It introduces new methodologies for brainstorming, supports the negotiation process among multiple users and provides mechanisms to arrange data in various ways. The objective is to reduce the necessary amount of verbal communication during a brainstorming process in order to improve efficiency, allow more people to collaborate and encourage asynchronous and remote participation.

Blender

Blender is an open source 3D content creation suite, available for all major operating systems under the GNU General Public License. It provides the ability to create professional quality graphics that would make a CONOPS come to life. Examples of artwork created with Blender are shown below. There is a 3D Open Movie Project: SINTEL which will be a short movie. The graphics are all created using Blender. The trailer can be found at: http://www.youtube.com/watch?v=HOfdboHvshg.

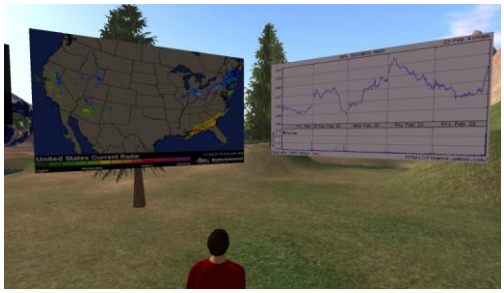
The quality of the tool has been compared to that of Maya, which is a commercial tool. The graphics below were generated using Blender and can be found on the Blender website.

OpenSimulator

OpenSimulator is a 3D grid-based application server. It can be used to create a virtual environment (or world) which can be accessed through a variety of clients, on multiple

protocols. There are versions for Windows, Linux and Apple. The software is built as loadable modules for custom configurations, and is released under a BSD License.

Out of the box, OpenSimulator can be used to simulate a virtual environment similar to Second Life™ (including client compatibility). Other environments, protocols and features are supported via add on modules. OpenSimulator is still considered alpha software, but seems to have a large and growing following. The following graphics can be found in OpenSimulator grids that are openly available.



Second Life

Second Life (SL) is a virtual world developed by Linden Lab that is accessible on the Internet (http:// http://secondlife.com). A free client program called the Viewer enables its users, called Residents, to interact with each other through avatars. Residents can explore, meet other residents, socialize, participate in individual and group activities, and create and trade virtual property and services with one another, or travel throughout the world (which residents refer to as "the grid").

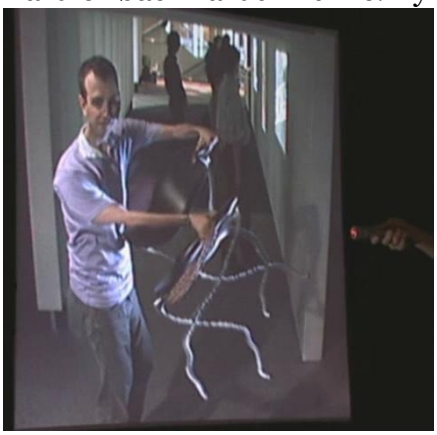
Built into the software is a three-dimensional modeling tool based around simple geometric shapes that allows a resident to build virtual objects. This can be used in combination with the Linden Scripting Language which can be used to add functionality to objects. More complex three-dimensional sculpted prims (colloquially known as sculpties), textures for clothing or

other objects, and animations and gestures can be created using external software. The Second Life Terms of Service ensure that users retain copyright for any content they create, and the server and client provide simple digital rights management functions.

This thoroughly modern Peugeot Island, featuring Design, will make it possible for "Second Lifers" to discover in 3D the concept car Flux, winner of the fourth Peugeot Design Contest, a full-scale model of which is presented on the Peugeot stand at the Frankfurt Motor Show.

Khronos Projector

The goal of the Khronos Projector is to go beyond these forms of exclusive temporal control, by giving the user an entirely new dimension to play with: by touching the projection screen, the user is able to send parts of the image forward or backwards in time. By actually touching a deformable projection screen, shaking it or curling it, separate "islands of time" as well as "temporal waves" are created within the visible frame. This is done by interactively reshaping a two-dimensional spatio-temporal surface that "cuts" the spatio-temporal volume of data generated by a movie. The Khronos projector unties time and space in a pre-recorded movie sequence, opening the door for an infinite number of interactive visualizations. Using the Khronos projector, event's causality become relative to the spatial path we decide to walk on the image, allowing for a multiple interpretation of the recorded facts. In this sense, the Khronos projector can be seen as an exploratory interface that transforms a movie sequence into a spatio-temporal sculpture for people to explore at their own pace and will. http://www.k2.t.u-tokyo.ac.jp/members/alvaro/Khronos/



7 RECOMMENDATIONS FOR FUTURE RESEARCH

In this section, we present our recommendations for future research. We begin by summarizing how the first two phases of this project have positioned us to undertake the requisite work.

In Phase 1, we developed the Agile Concept Engineering Phases (see Figure 27) and highlighted how the mental model content, primitive, and tool requirements would be a function of these various phases. Moreover, we identified cognitive task analysis and content decomposition as two analysis techniques that would help us to achieve our objectives and presented various potential software and hardware products that might be appropriate for the tool we were envisioning.

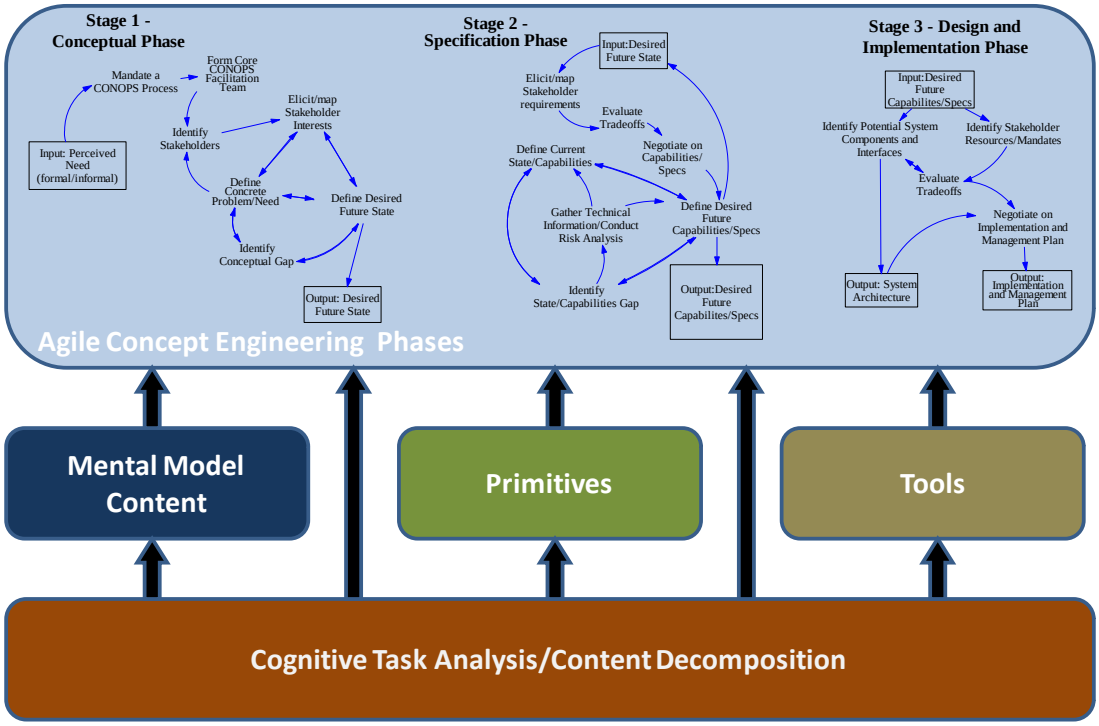


Figure 27: Activities in Phases 1 and 2

In the current phase, we have devised methodologies for identifying mental model content and primitives through cognitive task analysis and content decomposition, developed the framework and initial primitive taxonomy, as well as establishing a high-level architecture for the concept engineering system (i.e., the tool).

Based on the research conducted in the first two phases, we will now present our roadmap for developing a prototype concept engineering system that is applicable across a wide array of application domains.

7.1 CONCEPT ENGINEERING SYSTEM DEVELOPMENT

The research that has been performed up to this point served to lay the framework for understanding the requirements for a concept engineering system (CES). That framework is shown in Figure 28, in which the CES must support the agile concept engineering phases identified in phase 1, and support the creation and management of both the core and domain-driven mental model content and primitives.

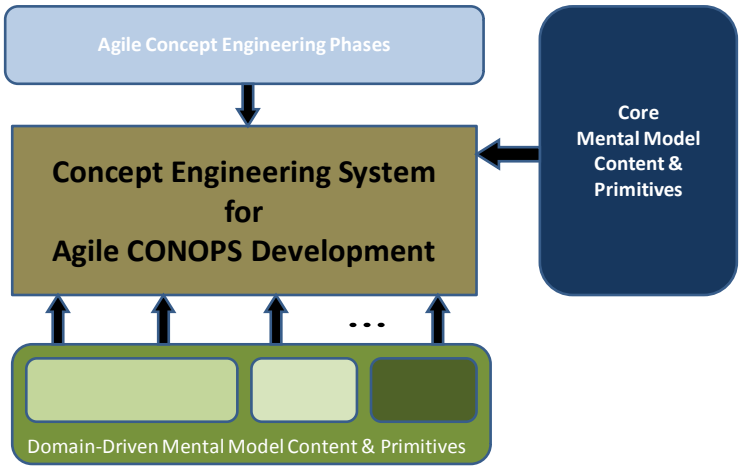


Figure 28: Inputs to Concept Engineering System

7.1.1 INTEGRATION

The first two phases of this research identified a number of robust products that are used in other domains to develop high quality models and simulations that are rich in capability and fidelity. Section 6.1 detailed a logical architecture for the CES. Much of the next phase will require working out the details of modifying and integrating existing software, and designing/ building the "glue" that will create a cohesive and easy to use collaborative concept engineering system.

7.1.2 CES DEVELOPMENT

Scrum, as it is applied to software development, is shown in Figure 29 can be modified to be applicable in a systems engineering environment (Crowe and Cloutier, 2009). The CES development will be performed using Scrum. It is recommended that the opportunity be taken to identify and capture relevant metrics relating to the use of Scrum in a research & development (R&D) environment.

One modification to the typical application of Scrum that may need to be adjusted is the timeframes. When Scrum is used in a software development organization, Sprints can be 1 week to 1 month in duration. In the university development environment, it may be necessary to use the longer period – one month, per sprint. The shorter meeting – the Scrum, may be better suited to a once weekly meeting of the collaborators.

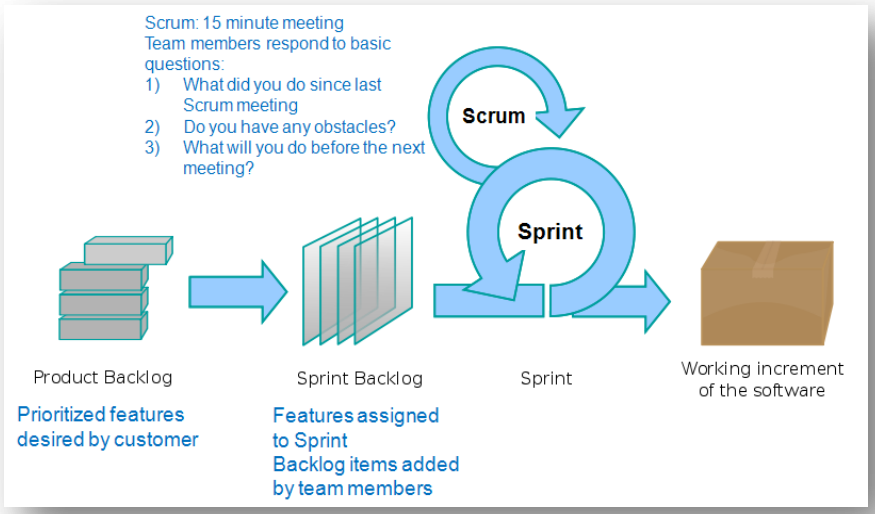


Figure 29: Software Scrum Approach

7.2 Further Scenario Development

This phase of the research looked at intelligence gathering tasks in both the military and news domains. We applied a set of techniques including cognitive task analysis and decomposition to identify the basic functions required to complete these tasks. Further, we mined the primitives into a taxonomy of reusable terms and objects. The result of these research activities is a set of procedures for identifying mental model content and taxonomies that can be applied to other domains.

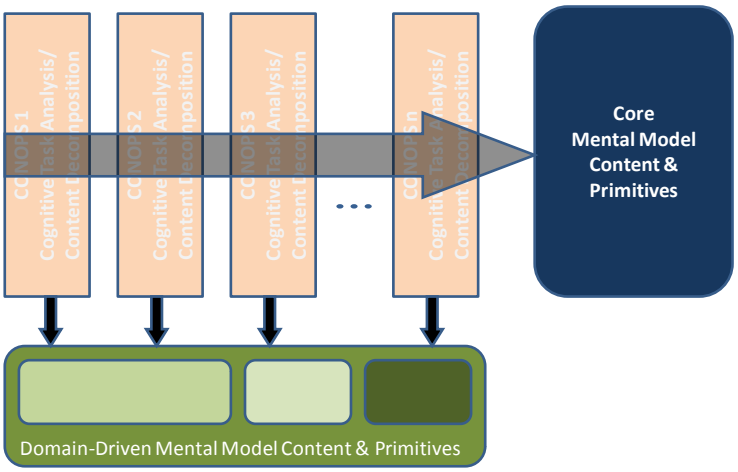


Figure 30: Process for Adding Libraries

We recommend that a wide range of additional domains be investigated during the next research phase of this project (see Figure 30). Once the target domains are identified, the team will identify additional operational scenarios for cognitive task analysis, decomposition and modeling. Additionally, we will apply the aforementioned methodologies to build the libraries of mental model content and primitives.

7.3 EXPERIMENTATION

Experimentation results will provide feedback to the concept engineering system development process throughout the next phase of this project (see Figure 31). Specifically, as components and versions of the prototype are developed, experiments will be conducted to test those elements. The experimental design will be driven by research questions focused on component functionality, human-computer interfaces, cognitive load, data import/exportability, etc. Results from the experiments will be used to inform the next generation prototype of the concept engineering system.

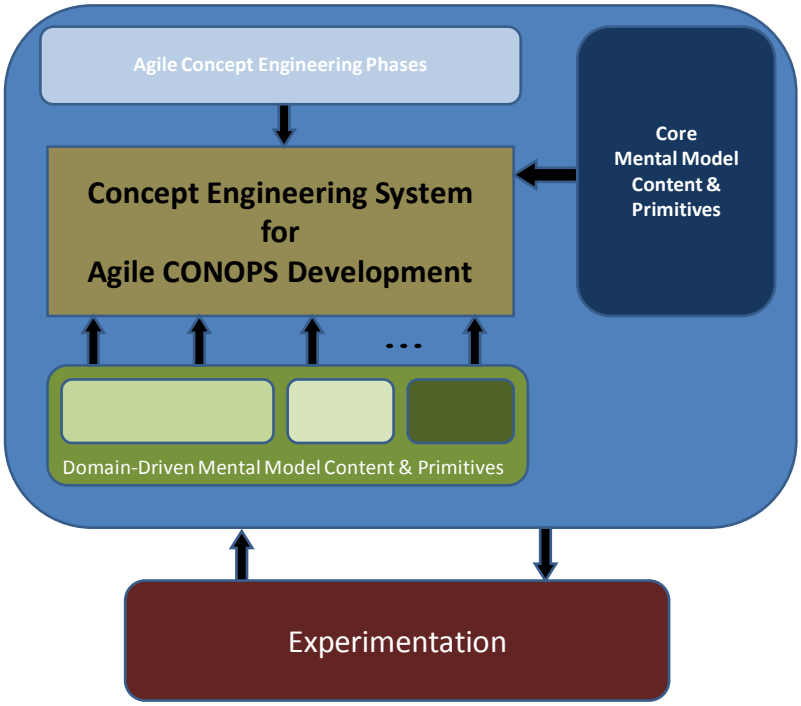


Figure 31: Iterative Approach

Scenario selection will be a critical aspect of experimentation. The scenario(s) that subjects will be asked to complete must balance realism/relevance for the project sponsors with experimental requirements. The intelligence gathering tasks that have been the focus of our efforts in the current phase may prove to be difficult for student subjects to complete due to their limited background knowledge of the scenario domain. Therefore, the research team will work with the sponsors to identify tasks that meet the criteria for an experimental testbed, while at the same time are relevant to the sponsors' domains of interest. One potential scenario for these purposes is the "Special Operations Reconnaissance (SOR) Scenario" developed at the Naval Air Warfare Center Aircraft Division (Warner, Burkman, and Biron, 2008).

7.4 PROPOSED PROJECT PLAN

The next phase of research will be entail significant amount of effort and it will be necessary to expand the size and expertise of the team and the work that must be performed. This will require establishing a collaborative development environment and testbed. An OpenSimulator grid will be established, managed, and maintained to support the agile development of the CES. The first year will deliver a prototype, and experiments to measure the effectiveness of the prototype in satisfying the agile CONOPS process. The results of those experiments will become the product backlog which becomes the sprint tasking for the second year (Figure 29).

Table 3 represents the team's recommendation for follow-on work on this task.

Table 3: Concept Engineering Research Plan

Year	Deliverables
Year 1	Concept Engineering System (CES) Architecture 1st CES Prototype Concept Engineering Process Prototype experiments using students (undergraduate and industry graduate) Requirements for 2nd iteration
Year 2	2nd CES prototype iteration 2nd experiments, with customer participants Requirements for 3rd iteration 3rd CES prototype
Year 3	Field test CES Requirements for 4th iteration 4th CES prototype

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APPENDIX A: NEO INTELLIGENCE GATHERING SCENARIO

Noncombatant Evacuation Operation: Intelligence Gathering Scenario

Intelligence Expert Briefing

You are an Intelligence Officer for an organization within the U.S. Department of Defense in the U.S. Pacific Command. As a military intelligence officer, your responsibilities may include collecting information about the operational environment; hostile, friendly and neutral forces; the civilian population in an area of combat operations; and other, broader areas of interest. This information may be gathered from personnel on the ground in the area of interest, the Internet, drone and satellite data, other agencies or personnel, etc.

It is currently 2:05 a.m. on January 15. You just finished reading an alert that came across your handheld device at 2:00 a.m. from the American Red Cross. Three of their aid workers are trapped on a remote island in the South Pacific and are caught in the middle of guerilla warfare.

You immediately contacted a weapons and an environmental expert to meet with you about this situation. Your first task will be to ascertain what information is necessary to create a mission plan for extracting the Red Cross personnel. Since contacting them, you have had a brief communication with your contact on the ground who is working with the local military to fight the guerillas. The aid workers escaped the village and are somewhat safe in one room of a church. They have no source of water except rainwater. At least one worker is in need of medical attention. You were cutoff before you could get any more information from him.

When you and the others have finished reading your briefings, your meeting will begin. Your deliverable will be a comprehensive set of questions about the information and intelligence needed to plan the extraction mission. The questions should be organized by specialty (e.g., intelligence) and subject matter (e.g., weather).

As you work together to complete the deliverable, be sure that you consider your expert perspective. You may need particular information that one of the other team members can collect for you or you may be in a position to gather information that will help one of them. Also, you must be as specific as possible. For example, asking “What is the weather forecast?” is too vague. You need to clarify exactly what information about the weather you may need by including questions such as, “What is the chance of rain? What is the timeframe?”

Noncombatant Evacuation Operation: Intelligence Gathering Scenario

Weapons Expert Briefing

You are a newly hired Weapons Expert for an organization within the U.S. Department of Defense in the U.S. Pacific Command. Your responsibilities include providing information about the military capabilities available for missions, including transport, personnel, and weapons. You have some basic knowledge, but are still learning. You have colleagues at other Commands that can provide you with the information you do not know.

It is currently 2:05 a.m. on January 15. An Intelligence Officer in your Command has just informed you that three American Red Cross workers are trapped on the remote South Pacific island of Drapo and are caught in the middle of guerilla warfare. You are to attend a meeting with the Intelligence Officer and others to ascertain what information is necessary to create a mission plan for extracting the Red Cross personnel.

Quickly, you ran reports to identify the military assets in the region. You prepared the attached reports about the Navy SEALS, Army Special Forces, and Marine assets available, and included the limited information you know about their capabilities. You are certain additional, more specific, information will be needed. But have decided to wait until the meeting to see what others deem necessary.

When you and the others have finished reading your briefings, your meeting will begin. Your deliverable will be a comprehensive set of questions about the information and intelligence needed to plan the extraction mission. The questions should be organized by specialty (e.g., weapons) and subject matter (e.g., weather).

As you work together to complete the deliverable, be sure that you consider your expert perspective. You may need particular information that one of the other team members can collect for you or you may be in a position to gather information that will help one of them. Also, you must be as specific as possible. For example, asking “What is the weather forecast?” is too vague. You need to clarify exactly what information about the weather you may need by including questions such as, “What is the chance of rain? What is the timeframe?”

Navy Seals Assets

Personnel:

- 7-man squad consisting of:
  - ~ 1 Corpsman
  - ~ 1 Radioman
  - ~ 1 Heavy Gunners
  - ~ 2 Riflemen with M-16 rifles
  - ~ 2 Riflemen with M-16 rifles and grenade launchers
- Night vision capability
- Need local translator if communicating with villagers.
- Ability to be virtually undetected
- All Navy SEALS are trained as medics.
- Navy SEALS usually initiate covert operations from the sea. (Covert operations are secret, undetected operations.)
- All weapons and personnel are located on the USS Enterprise.
- The USS Enterprise has full medical facilities.

Transportation & Weapons:

Navy Seahawk (SH-60): A twin-engine helicopter used for anti-submarine warfare, drug interdiction, cargo lifts and special operations in the day or night regardless of the weather conditions.	
Navy Hornet (F-18): A one or two seat super sonic jet used for air-to-air or air-to ground support.	
Zodiac: A 7-man inflatable boat which can travel at speeds up to 15 miles/hour.	

Army Special Forces Assets

Personnel:

- 6-man Special Forces Team consisting of:
  - ~ 1Team Lead
  - ~ 2 Snipers
  - ~ 2 Team Medics
  - ~ 1Translator(Speaks several languages, but NOT Draponese.)
- Highly trained in multiple languages.
- Night vision capabilities
- Weapons: M-16, M-60, Grenades
- Army Special Forces usually initiate covert operations from the land. (Covert operations are secret, undetected operations.)

Transportation & Weapons:

Abram Tanks: Used for enemy suppression.	
Blackhawk Helicopter (UH-60): A twin engine helicopter used for special ops in the day or night, regardless of the weather conditions.	
AH-64 Apache: A twin engine helicopter used for enemy suppression.	
C-130 Hercules: A large aircraft used for troop and cargo transport, paratrooper deployment and airborne refueling.	

Marine Assets

Personnel:

- 12 Man Team that includes:
  - ~ 2 Medical Corpsmen
  - ~ Use of M-16, M-60, Grenades
  - ~ Night vision capabilities
- Marine personnel are stationed on the USS Enterprise.

Transportation & Weapons:

AH-1: An attack force helicopter used to suppress enemy troops and provide air support.	
CH-53: A cargo/transport helicopter used in amphibious and shore operations.	

Noncombatant Evacuation Operation: Intelligence Gathering Scenario

Environmental Expert Briefing

You are an Environmental Expert for an organization within the U.S. Department of Defense in the U.S. Pacific Command. Your responsibilities include gathering information about the geography, climate, wildlife, etc. for the locations and surrounding areas where missions will be executed.

It is currently 2:05 a.m. on January 15. An Intelligence Officer in your Command has just informed you that three American Red Cross workers are trapped on the remote South Pacific island of Drapo and are caught in the middle of guerilla warfare. You are to attend a meeting with the Intelligence Officer and others to ascertain what information is necessary to create a mission plan for extracting the Red Cross personnel. You pulled the most recent aerial map of Drapo Island (attached) to take with you to the meeting.

When you and the others have finished reading your briefings, your meeting will begin. Your deliverable will be a comprehensive set of questions about the information and intelligence needed to plan the extraction mission. The questions should be organized by specialty (e.g., environment) and subject matter (e.g., weather).

As you work together to complete the deliverable, be sure that you consider your expert perspective. You may need particular information that one of the other team members can collect for you or you may be in a position to gather information that will help one of them. Also, you must be as specific as possible. For example, asking "What is the weather forecast?" is too vague. You need to clarify exactly what information about the weather you may need by including questions such as, "What is the chance of rain? What is the timeframe?"

The South Pacific Island of Drapo

APPENDIX B: NEO MISSION PLANNING SCENARIO

The Mission:

The time is 2:00 am, January 15th. Three American Red Cross workers are trapped in a church basement on a remote island in the South Pacific, caught in the middle of guerilla warfare. Your mission is to rescue them within 24 hours.

The situation is described in the next few pages along with the assets of U.S. forces available to rescue the workers. Work together to develop a course of action, using ANY assets available to you. The detailed plan can be made up of Army, Marine or Navy Seal assets (or a combination of the three), but must include the following:

a description of how the rescuers will get to the church
a description of how they will evacuate the Red Cross workers
and a description of how they will return to the Army base or aircraft carrier.

Choose the best and most efficient solution to rescue the workers safely. Minimize damage to the village and villagers, and avoid contact with the enemy if possible. Keep in mind, however, the rules of engagement state that any forces will defend themselves if needed.

Good Luck!

BACKGROUND INFORMATION:
Drapo Island

Date:

January 15th , 0200 (2:00 AM), Drapo Time Zone

Location:

Drapo Island, located 750 miles north of Australia, slightly northeast of the Solomon Islands. (See Map 1)

The church where the workers are trapped is located 3 miles from the northern-most shore of the island. Directly in front of the church is a dirt road, which leads to the ocean in one direction and into the main village on the island in the other direction. The village is 1.5 miles from the church. The road also passes homes and farms of the natives on the way into the town. The church has some vegetation around it, primarily coconut trees and some brush, but no heavy forest or swampland. The land around it is mostly cultivated for farming.

A small port is located on the opposite end of the island from the church, and is heavily guarded by the local military. To reach the church from the port, you must cross an uninhabited volcanic mountain pass, which is covered by dense rainforest.

Because of the coral reefs, it is impossible to bring large ships any closer than 1 mile from the coast. The shore is only accessible by small boats. Significant amounts of coral can be seen above the surface of the water at low tide.

There is one paved highway around the perimeter of the island. This road also leads to the dirt road where the church is located. (See Maps 2 and 3)

Size:

The island is 250 miles wide by 250 miles long

Topography:

Drapo Island is made up of volcanic mountains, atolls (ring-like coral island and reef), some swampy lowlands, and rugged mountainous terrain with some low dense rainforest. Because much of the island is made up of volcanic mountains, there is a constant threat of volcanic activity. The terrain consists of coastal plains, swampy lowlands, a large rainforest and mountain ranges.

Climate and Weather:

The climate on Drapo is tropical with rainy seasons from December through March and May through October. There are also periodic tropical monsoons. In January, there are periods of heavy fog in the morning, which burns off as the day progresses. Visibility is usually clear by noon. There are strong winds throughout the day.

Military:

The local military is made up of about 100 volunteers who support their government. It has recently been built up in response to increasing threats from rebel forces. The government has limited military intelligence and limited analysis capability. Drapo is in good and peaceful standing with the United States.

Village:

The village is home to the government center, school, church, markets, and communication center for the island. Any weapons and military intelligence possessed by the island will be centered in the village. The majority of the island's homes are located within 1 mile of the village. There are between 100 and 150 huts housing 5 to 10 natives each. The village is about 1.5 miles from the church and 4.5 miles from the northern-most point of the island.

The local language is Draponese. The locals do NOT speak English, so if any attempt is going to be made to communicate with the local military, a translator will be needed.

Transportation:

One main paved highway surrounds the perimeter of the island. (See Map 2) Dirt roads connect the airport, homes, village, and the church where Red Cross workers are trapped.

There is one main port, which is used for the export and import of goods. Directly off the shore of most of the island are atolls, which make it impossible for large ships to come within one mile of the shore (with the exception of the port).

There is one main airport with a paved runway, located 200 miles from the village. The airport is heavily guarded by the local military to keep rebel forces out. The airport flies into Australia, the nearest mainland (750 miles away), and from there can connect to other countries. (See Map 3)

Communication:

Communication on the island and off the island is possible, but is limited by the remoteness of the island. The Red Cross workers have working mobile phones, however the batteries died soon after they contacted the American Red Cross Headquarters. The church where the workers are trapped does not have a telephone. There is limited radio communication on the island (3AM, no FM stations). There are no television stations on the island. Internet access on the island is limited to government workers only.

Condition of Red Cross Workers:

The workers are somewhat safe in one room of the church. They have no source of water except rainwater. They are able to collect food easily from areas around them but that supply is limited and venturing too far to collect food is dangerous. Rescuers should be aware that workers will most likely be dehydrated and suffering from malnutrition.

One of the workers is a diabetic in need of insulin. He will most likely go into insulin shock if not treated within 24 hours. Another worker has a broken leg. The third worker appears to be

healthy at this time. There is a chance that workers could be injured from the outside warfare and that their location may not be safe for long. They must be rescued within 24 hours.

BACKGROUND INFORMATION:
Rebel Forces

- The Rebel Forces consists of 500 trained soldiers.

  - They guard the perimeters of their captured areas at ALL times.
  - They have no night vision capability.
  - The have Stinger missiles. (Stinger missiles are hand-held, infrared, heat-seeking rockets with a range of 1 – 5 miles.)
  - Their small arms fire consists of M-16 rifles (range: 500yards) and 9mm pistols (range: 25 yards).
  - They have land mines. (It is possible that local roads might be mined.)
  - Their weapons storage, communication centers and anti-aircraft locations are not known to the U.S or Drapo military.
  - They have RPG's (rocket propelled grenades).
  - Warfare is constant between rebels and local military.
  - They have easy access to trucks and jeeps.
  - They are aware the Red Cross workers are on the island, but unaware of their exact location. They are on-guard for possible rescue operations.

Navy Seals Assets

Personnel:

- 7-man squad consisting of:
  - ~ 1 Corpsman
  - ~ 1 Radioman
  - ~ 1 Heavy Gunners
  - ~ 2 Riflemen with M-16 rifles
  - ~ 2 Riflemen with M-16 rifles and grenade launchers
- Night vision capability
- Need local translator if communicating with villagers.
- Ability to be virtually undetected
- All Navy SEALS are trained as medics.
- Navy SEALS usually initiate covert operations from the sea. (Covert operations are secret, undetected operations.)
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- The USS Enterprise has full medical facilities.

Transportation & Weapons:

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Personnel:

- 6-man Special Forces Team consisting of:
  - ~ 1Team Lead
  - ~ 2 Snipers
  - ~ 2 Team Medics
  - ~ 1Translator(Speaks several languages, but NOT Draponese.)
- Highly trained in multiple languages.
- Night vision capabilities
- Weapons: M-16, M-60, Grenades
- Army Special Forces usually initiate covert operations from the land. (Covert operations are secret, undetected operations.)

Transportation & Weapons:

Abram Tanks: Used for enemy suppression.	
Blackhawk Helicopter (UH-60): A twin engine helicopter used for special ops in the day or night, regardless of the weather conditions.	
AH-64 Apache: A twin engine helicopter used for enemy suppression.	
C-130 Hercules: A large aircraft used for troop and cargo transport, paratrooper deployment and airborne refueling.	

Marine Assets

Personnel:

- 12 Man Team that includes:
  - ~ 2 Medical Corpsmen
  - ~ Use of M-16, M-60, Grenades
  - ~ Night vision capabilities
- Marine personnel are stationed on the USS Enterprise.

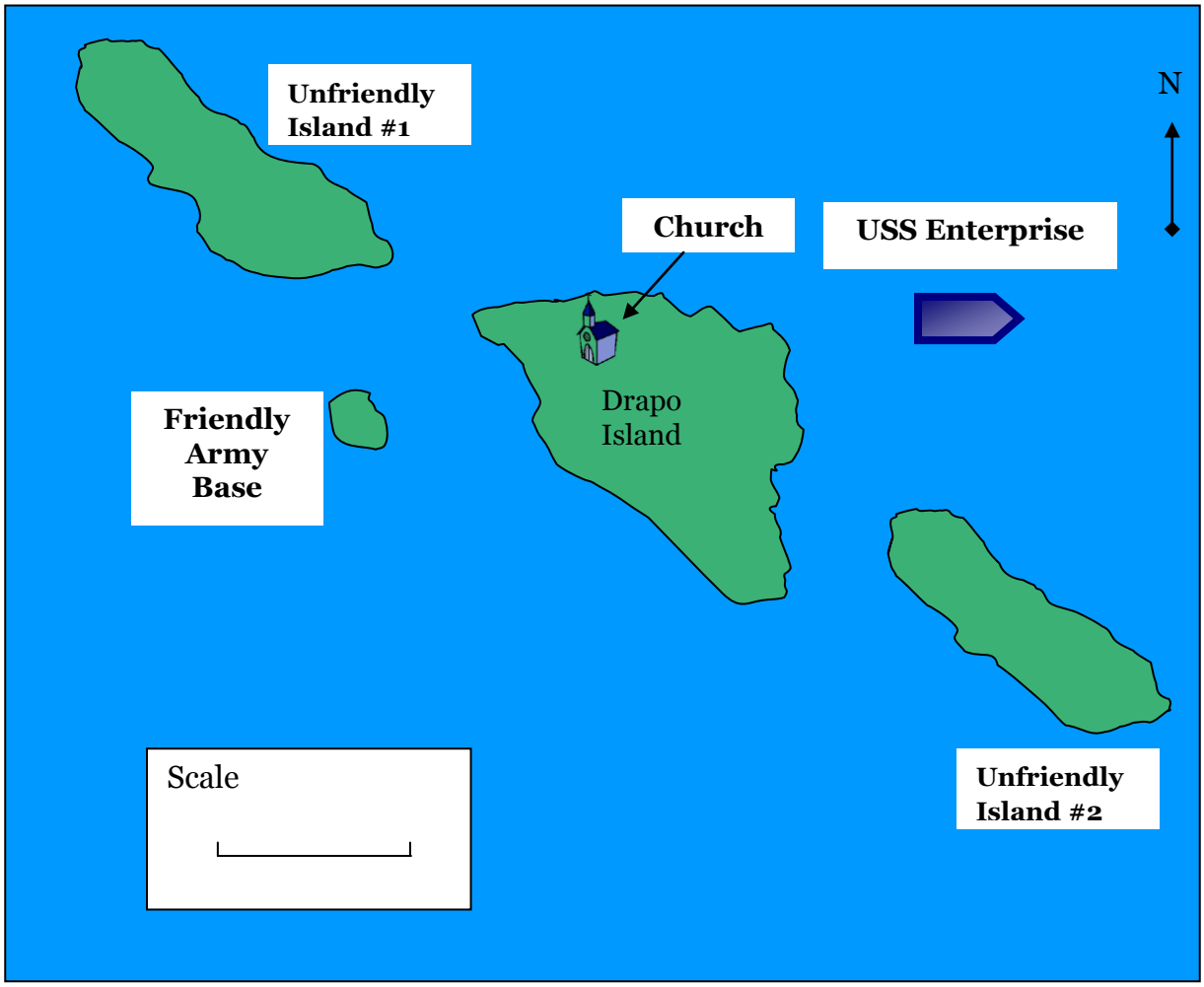
Transportation & Weapons:

AH-1: An attack force helicopter used to suppress enemy troops and provide air support.	
CH-53: A cargo/transport helicopter used in amphibious and shore operations.	

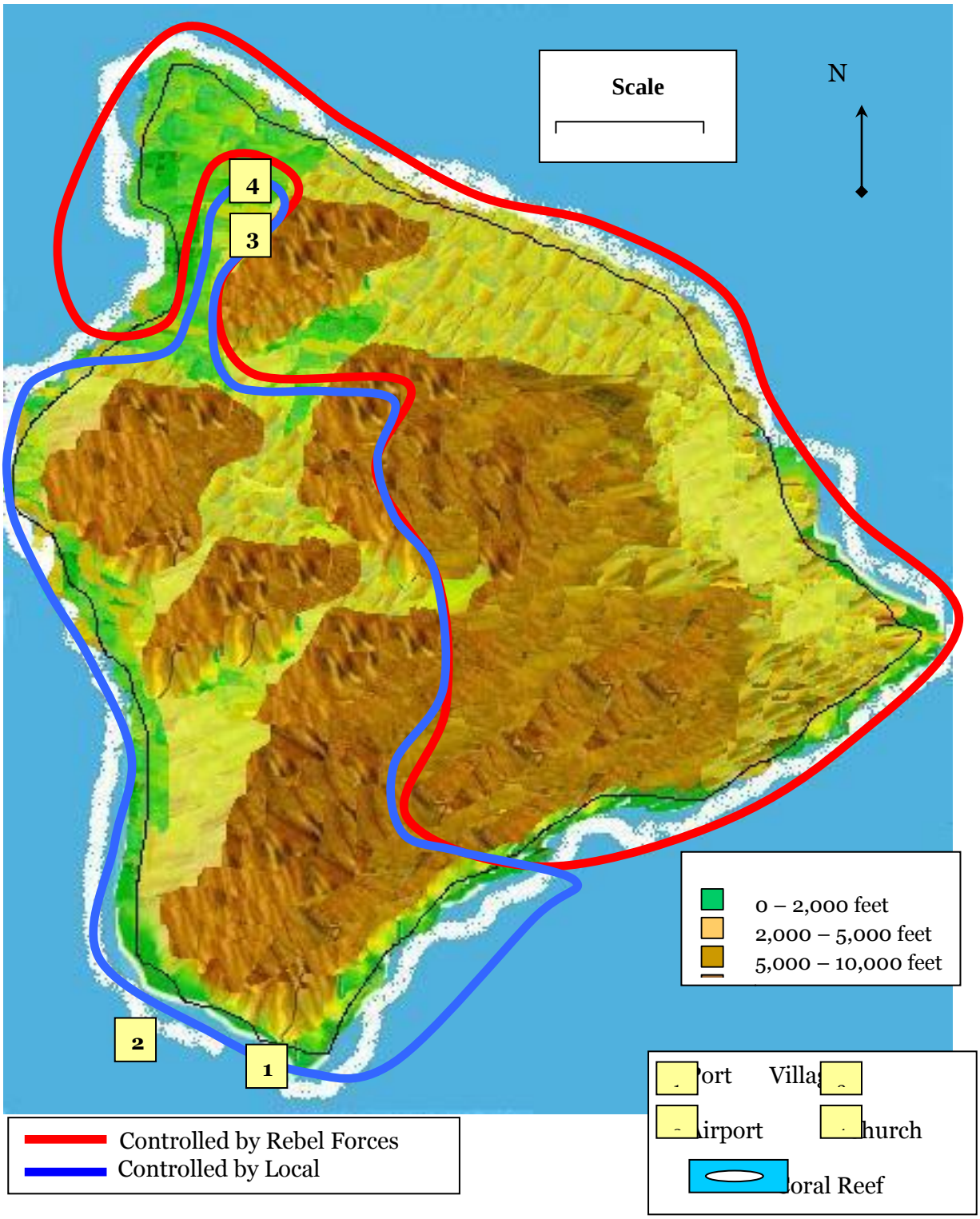
Maps

The South Pacific Island of Drapo

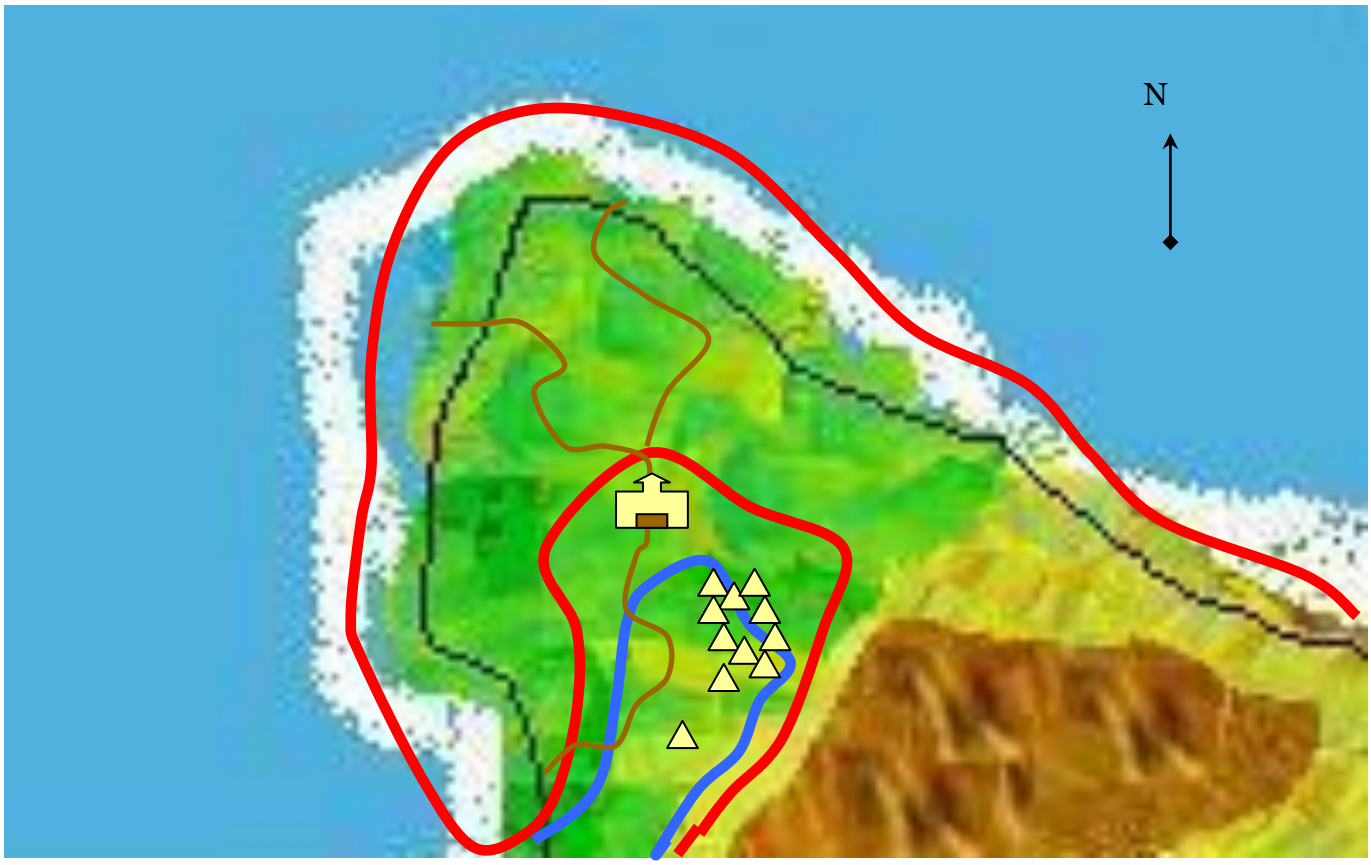
Map 1: Drapo Island



Map 2: Drapo Island



Map 3: North Shore of Drapo Island



APPENDIX C: NEWS AGENCY SCENARIO PRIMITIVES

Scenario 1. A news agency deploying a reporter and support assets to a new story

1) Identify - Operational Constraints – time – environmental
2) Identify – Operation Objectives – Operational Policies
3) Mine – Information Archives
4) Gather – Background Information
5) Study – Operational Environment
6) Identify – Information Sources
7) Evaluate – Information Source – reliability - accuracy
8) Identify – Information Strategy
9) Identify – Transportation Vehicle - requirements - type - Equipment – requirements - type - Personnel – requirements - type
10) Identify – Transportation Vehicle - location - status – Equipment – location - status – Personnel – location - status
11) Identify – Personnel - capabilities
12) Identify - News Story – location - accessibility
13) Dispatch – Transportation Vehicle - type – operator - Personnel – numbers – type – Equipment - type
14) Gather - Information
15) Analyze – Information – statistical – accuracy
16) Fact Check – Information
17) Report – Information

Scenario 2. A news agency assigning a reporter to independently corroborate a news source

1) Identify - Operational Constraints – time – environmental
2) Identify – Operation Objectives – Operational Policies
3) Identify – Personnel – capabilities
4) Dispatch – Personnel
5) Mine – Information Archives
6) Identify – Information Sources
7) Communicate – Contact
8) Interview - Contact
9) Evaluate – Information Source – reliability - accuracy
10) Gather - Information
11) Analyze – Information – statistical – accuracy
12) Investigate - Information
13) Fact Check – Information

Scenario 3. A reporter works to recruit a new contact for a story

1) Identify – Operational Constraints – time – environmental
2) Identify – Operational Objectives – Operational Policies
3) Identify – Contact - location - type
4) Identify – Personnel – capabilities
5) Evaluate – Contact – availability – location
6) Communicate - Contact
7) Dispatch – Transportation Vehicle – type - Personnel – type – Equipment - type

8) Interview – Contact
9) Evaluate – Contact – reliability – accuracy

Scenario 4. A news agency deploying a new reporter and support assets to follow-up on an existing story

1) Identify - Operational Constraints – time – environmental
2) Identify – Operation Objectives – Operational Policies
3) Mine – Information Archives
4) Gather – Background Information
5) Study – Operational Environment
6) Gather – Existing Information
7) Validate - Existing Information
8) Identify – Information Sources
9) Evaluate – Information Source – reliability – accuracy
10) Identify – Information Strategy
11) Identify – Transportation Vehicle - requirements - type - Equipment – requirements - type - Personnel – requirements - type -
12) Identify – Transportation Vehicle - location - status – Equipment – location - status – Personnel – location - status
13) Identify – Personnel - capabilities
14) Identify - News Story – location - accessibility
15) Dispatch – Transportation Vehicle - type – Personnel – numbers – type – Equipment - type
16) Gather – Continuing Information
17) Analyze – Information – statistical – accuracy
18) Fact Check – Information
19) Integrate – Information – existing - continuing
20) Report – Information

Scenario 5. New agency to synthesize multiple stories to create a new edition for their customers

1) Identify - Operational Constraints – time - spatial
2) Identify – Operational Objectives – Operational Policies
3) Identify – Personnel – requirements – Equipment – requirements
4) Dispatch – Personnel type – Equipment - type
5) Identify – Information Strategy
6) Gather – Information – new – background
7) Gather – Information – existing - continuing
8) Mine – Information Archives
9) Validate - Existing Information
10) Analyze – Information - statistical – accuracy
11) Fact Check – Information
12) Integrate - Information
13) Report - Information

APPENDIX D: NEO SCENARIO ONTOLOGY DIAGRAMS

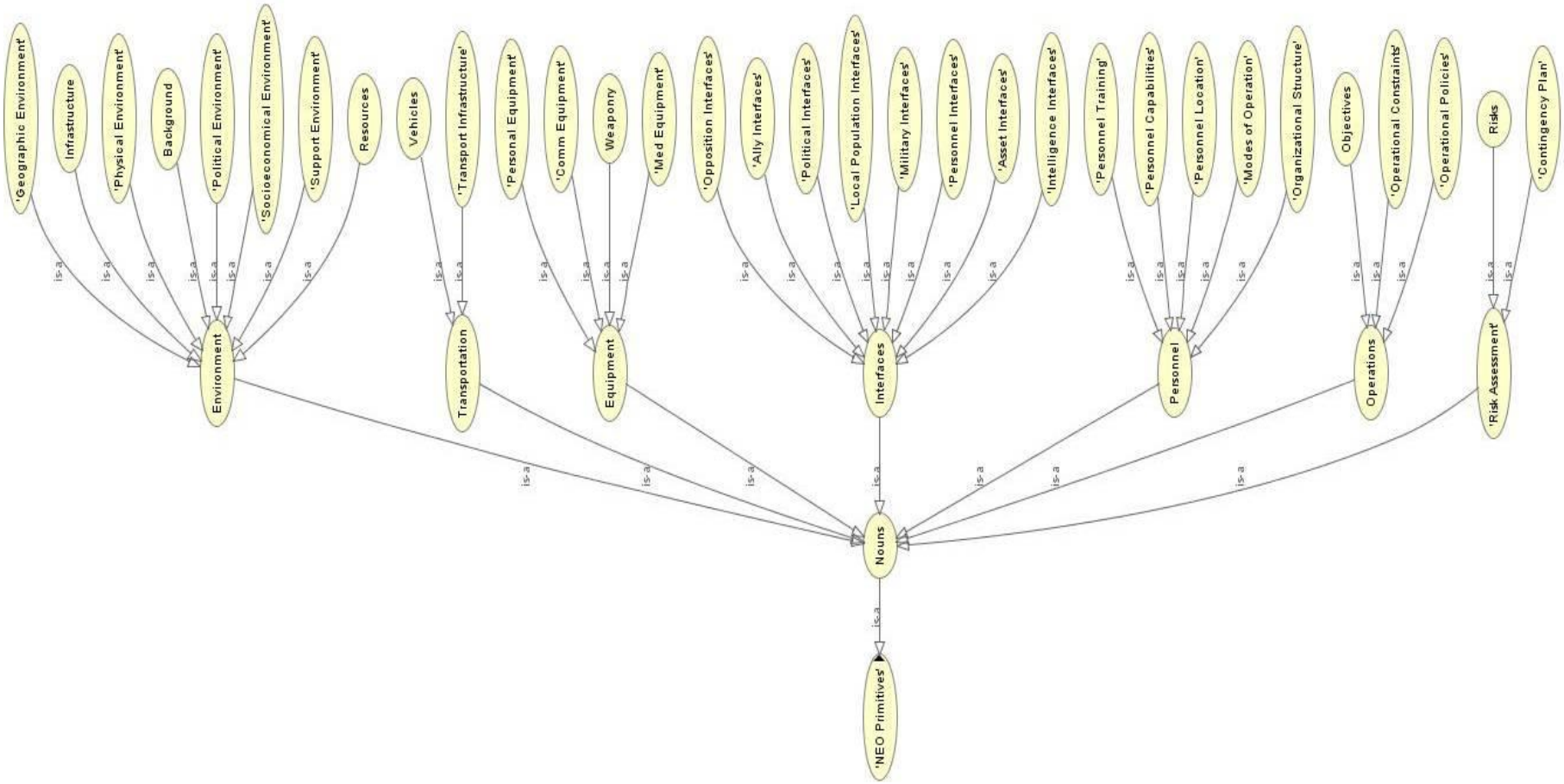


Figure 32: NEO Scenario Noun Primitives from Protégé

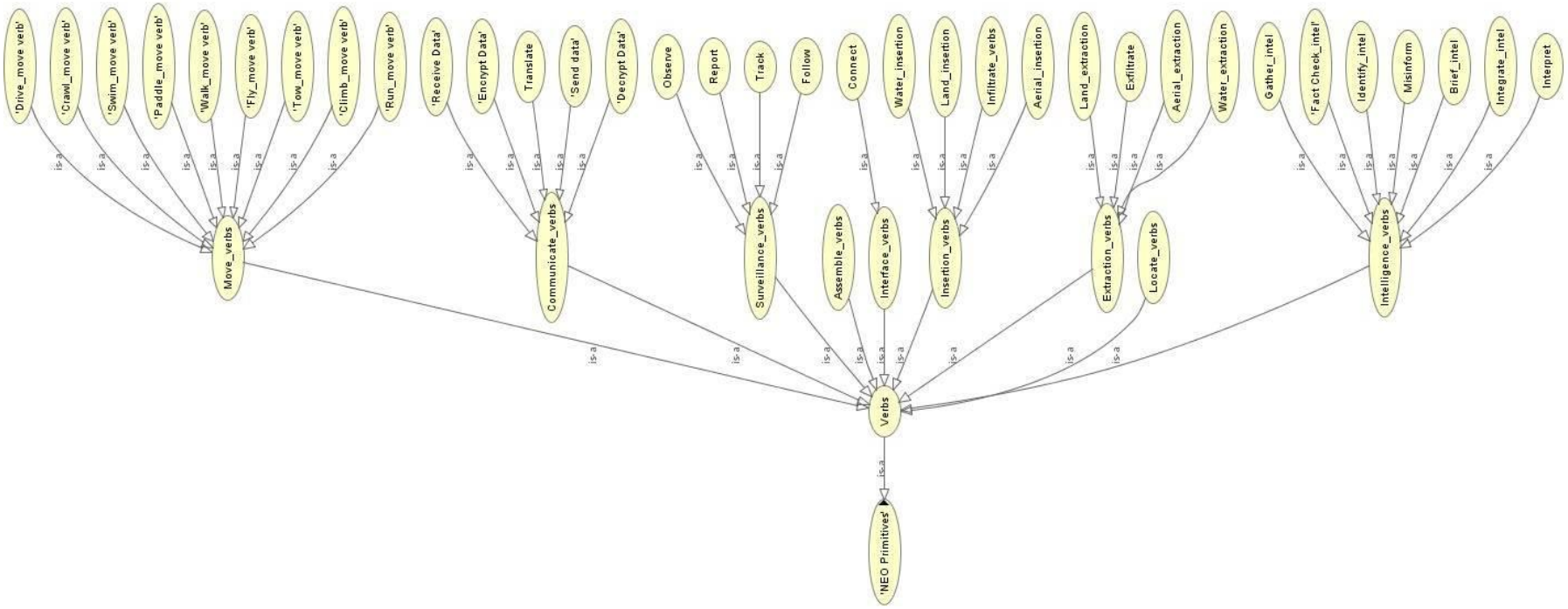


Figure 33: NEO Scenario Verb Primitives from Protégé

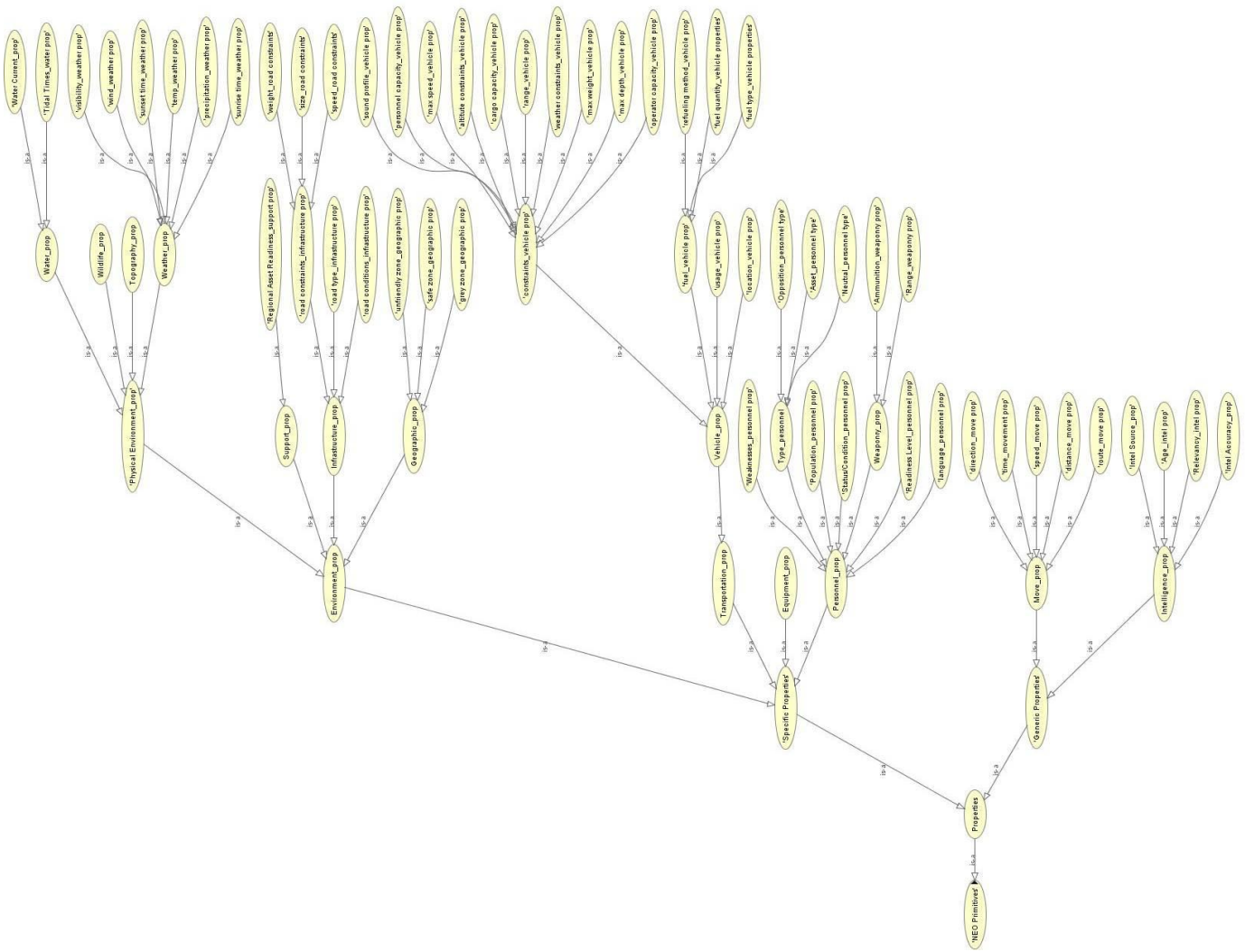


Figure 34: NEO Scenario Adjective Primitives from Protégé

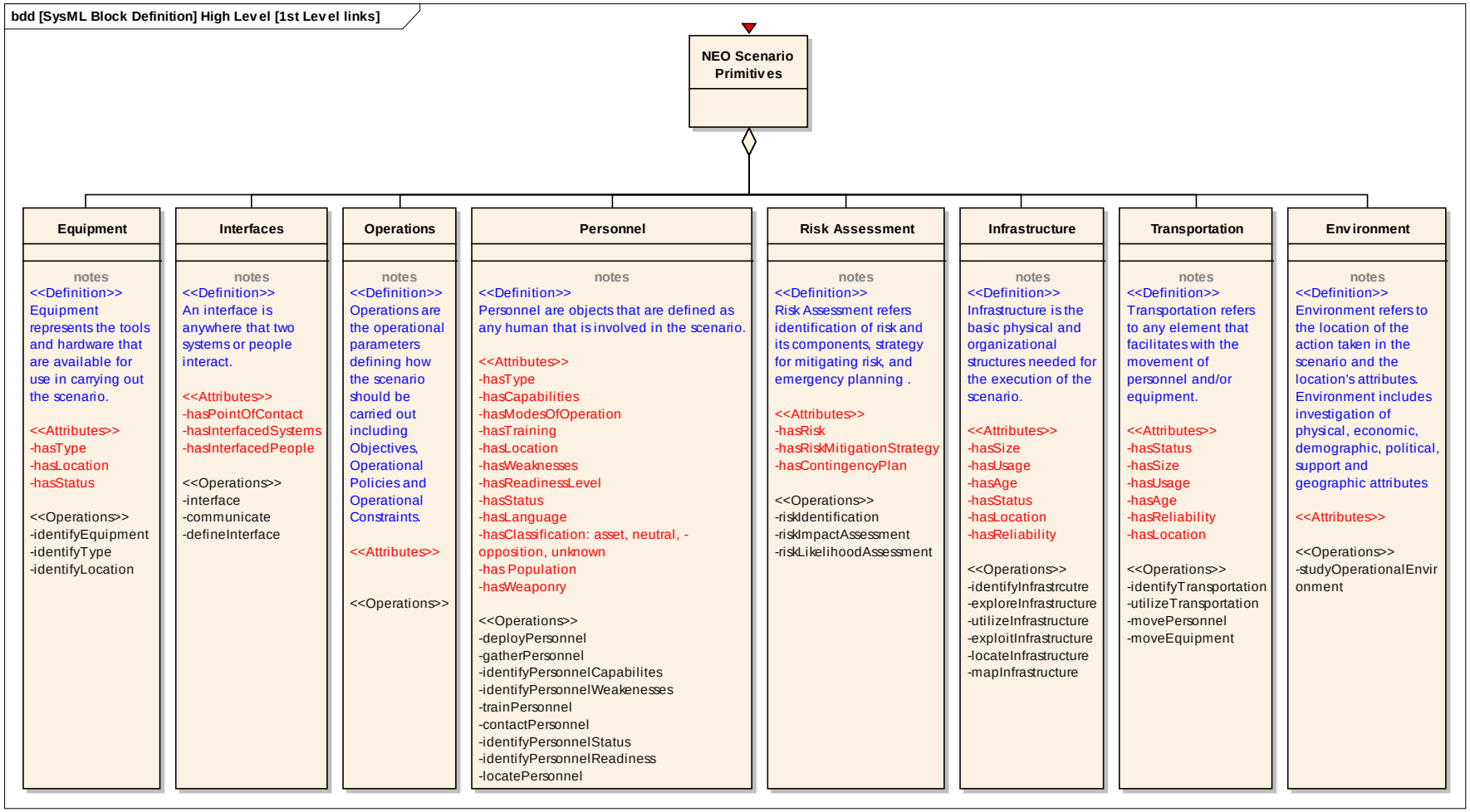


Figure 35: NEO Scenario Top Level Primitives from Sparx

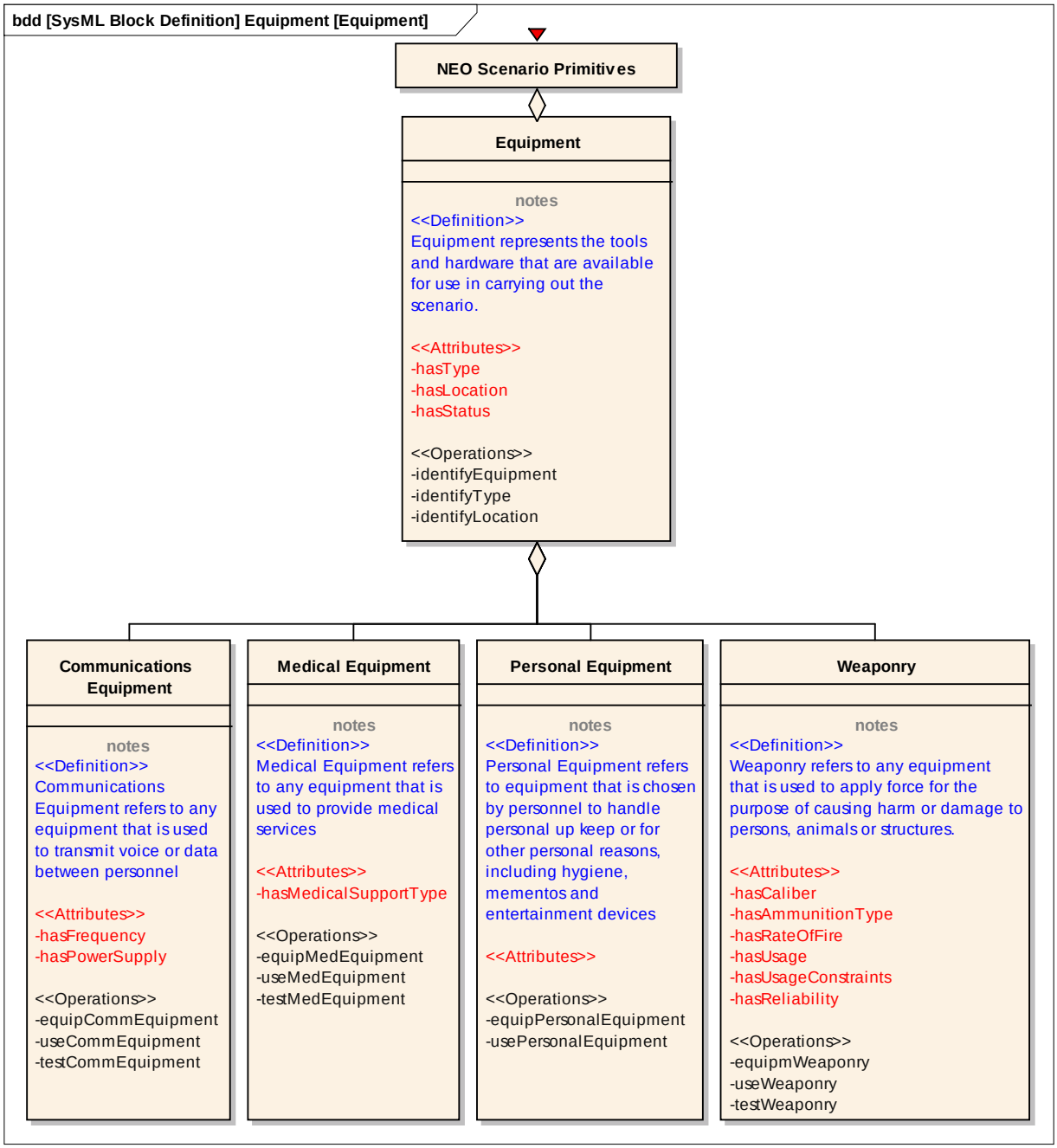


Figure 36: NEO Scenario Equipment Primitives from Sparx

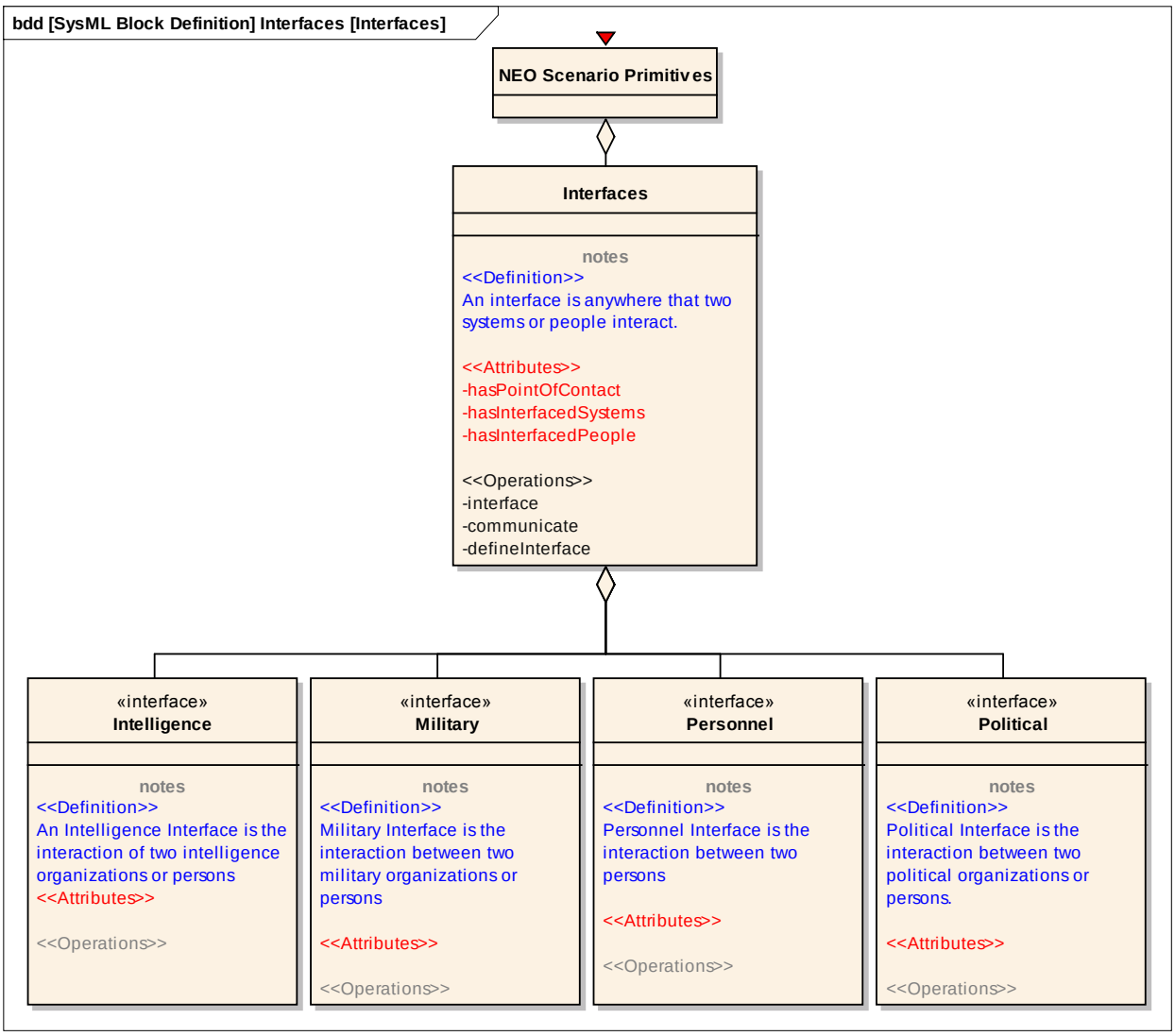


Figure 37: NEO Scenario Interface Primitives from Sparx

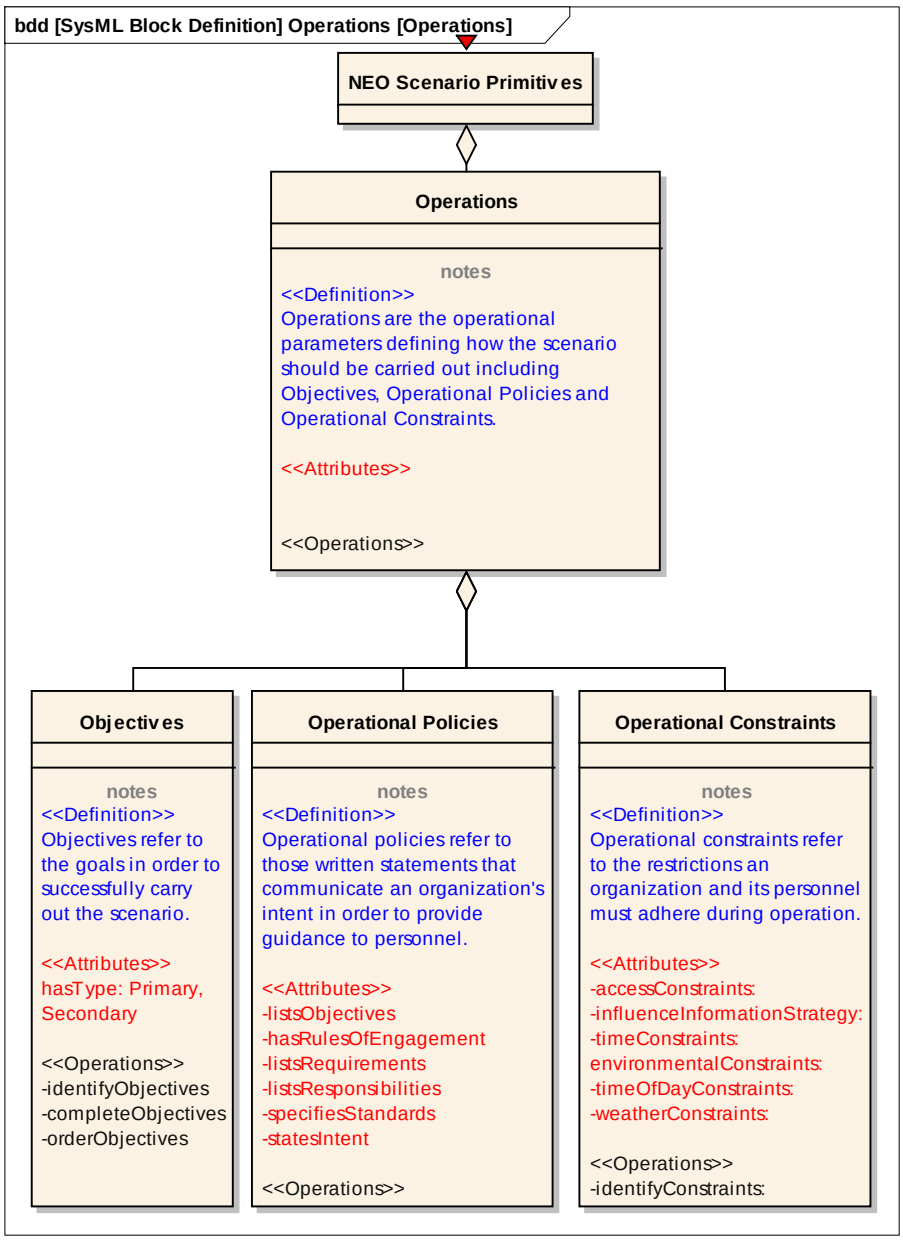


Figure 38: NEO Scenario Operations Primitives from Sparx

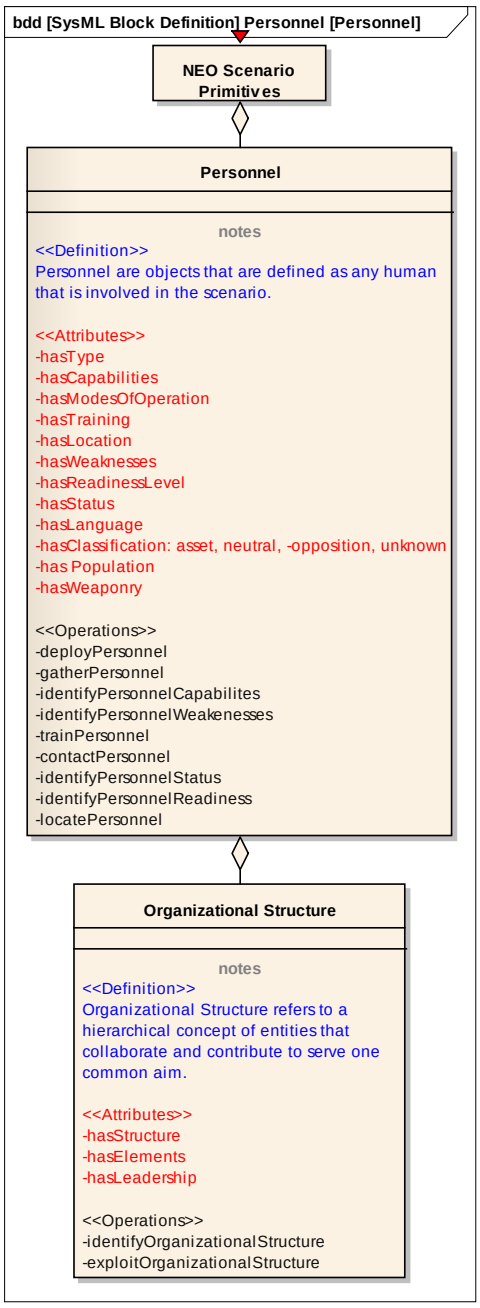


Figure 39: NEO Scenario Personnel Primitives from Sparx

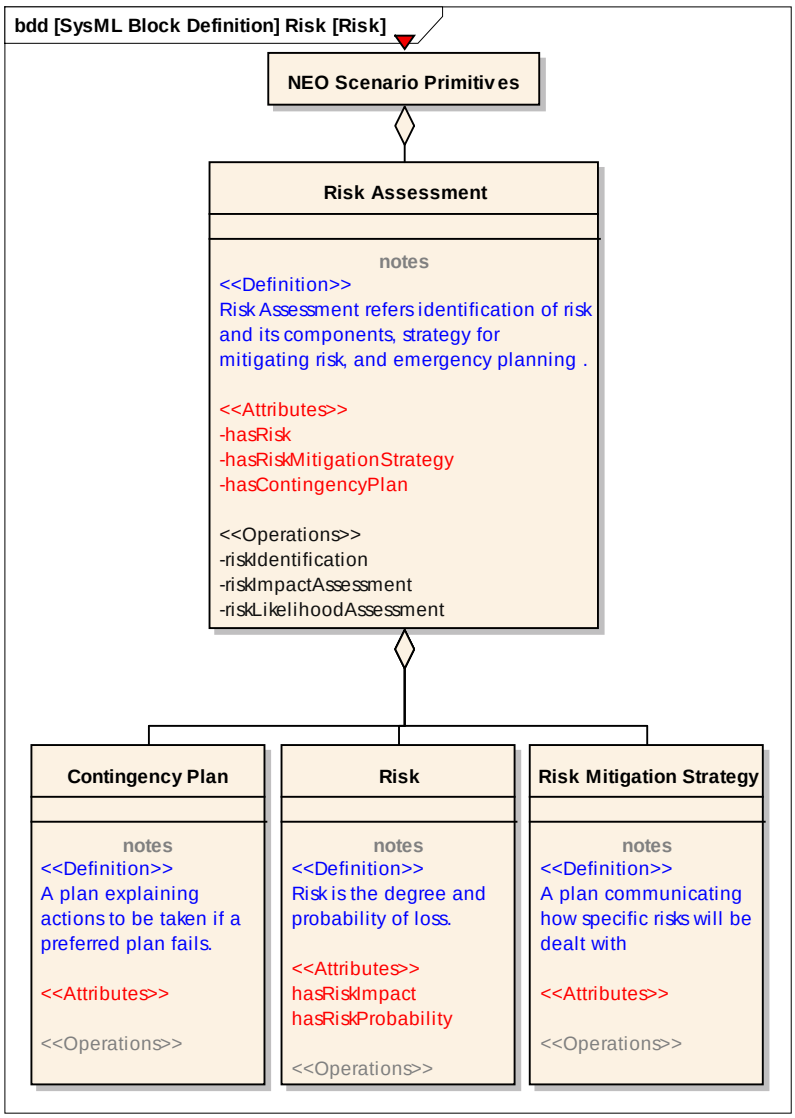


Figure 40: NEO Scenario Risk Assessment Primitives from Sparx

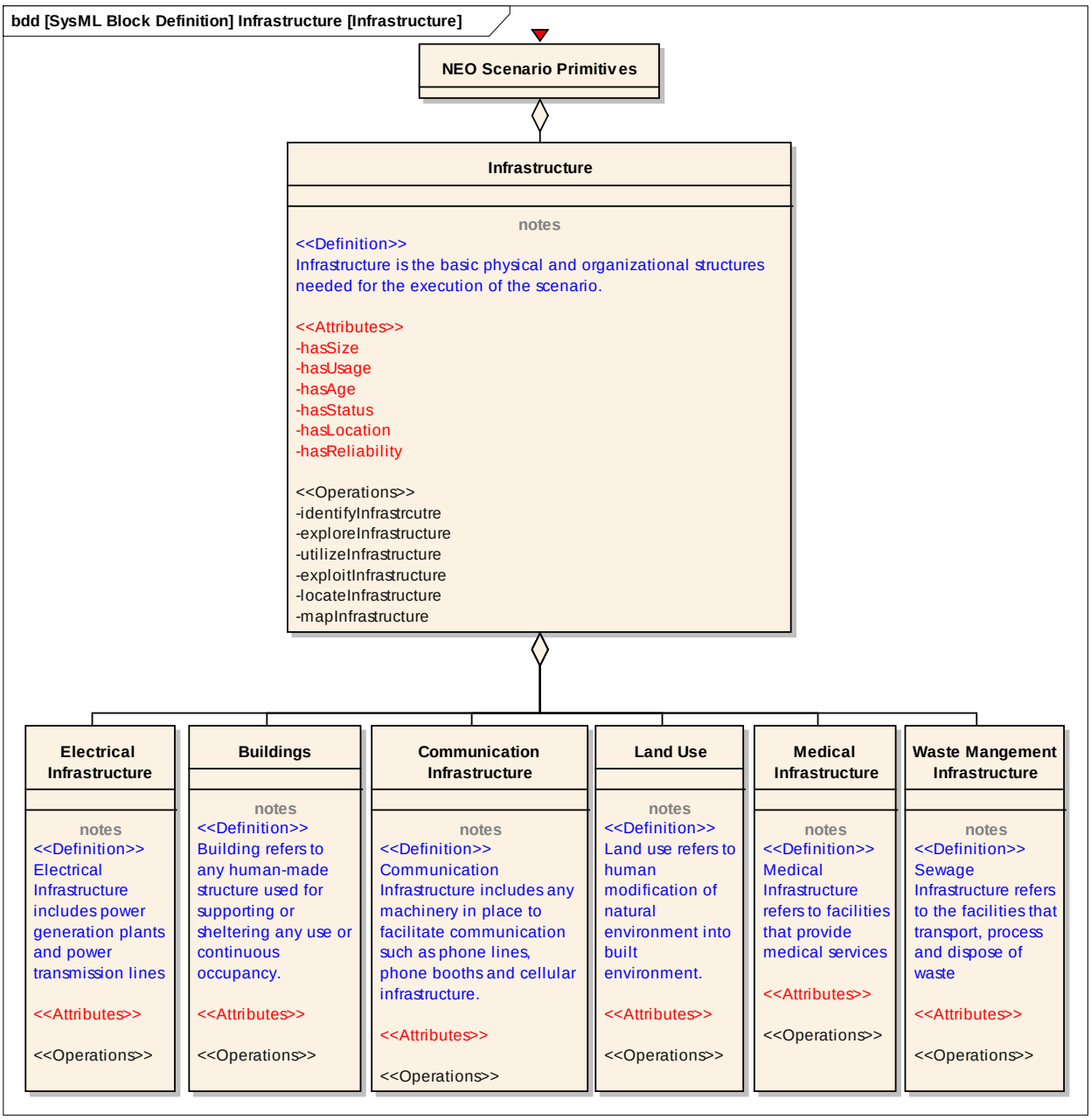


Figure 41: NEO Scenario Infrastructure Primitives from Sparx

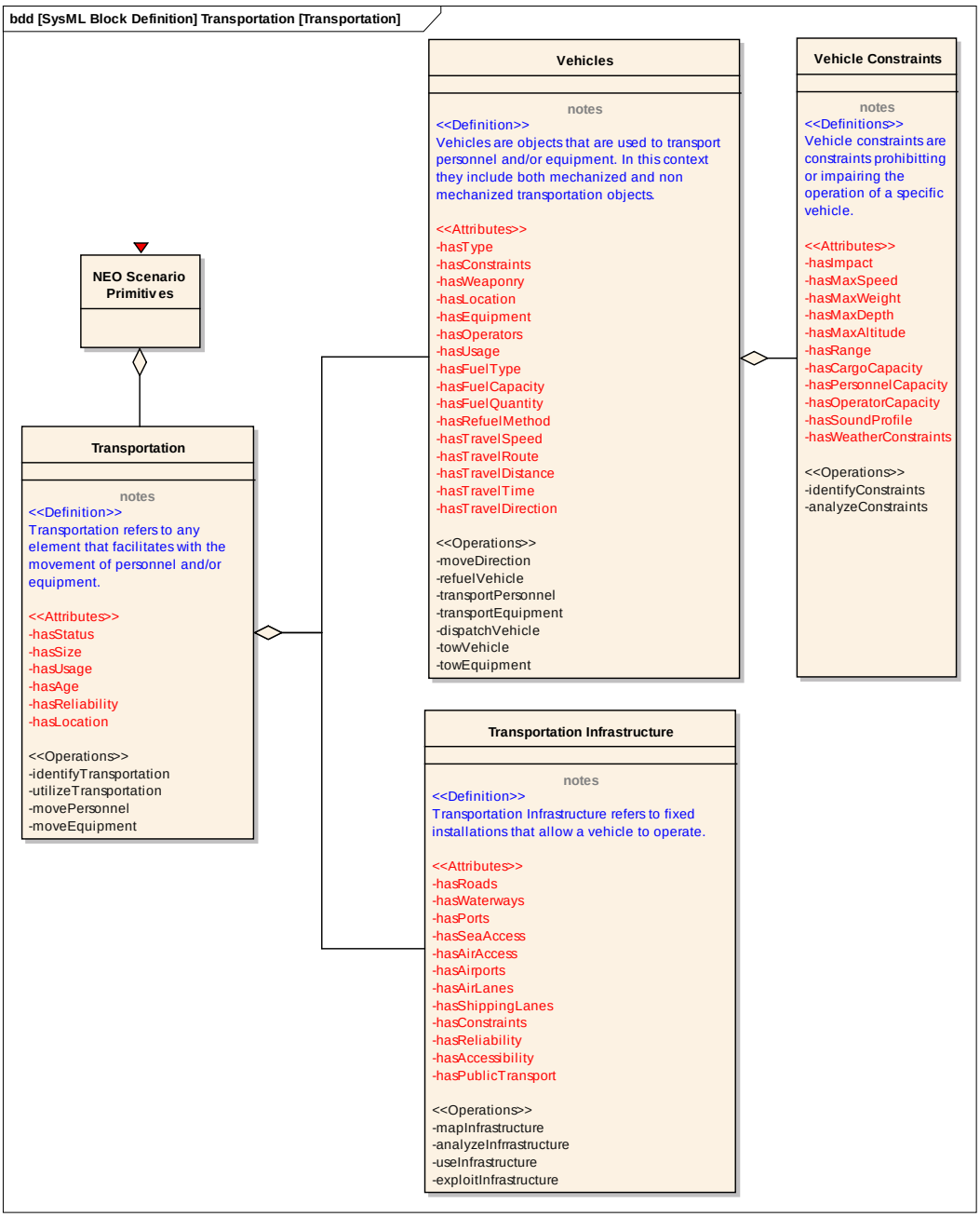


Figure 42: NEO Scenario Transportation Primitives from Sparx

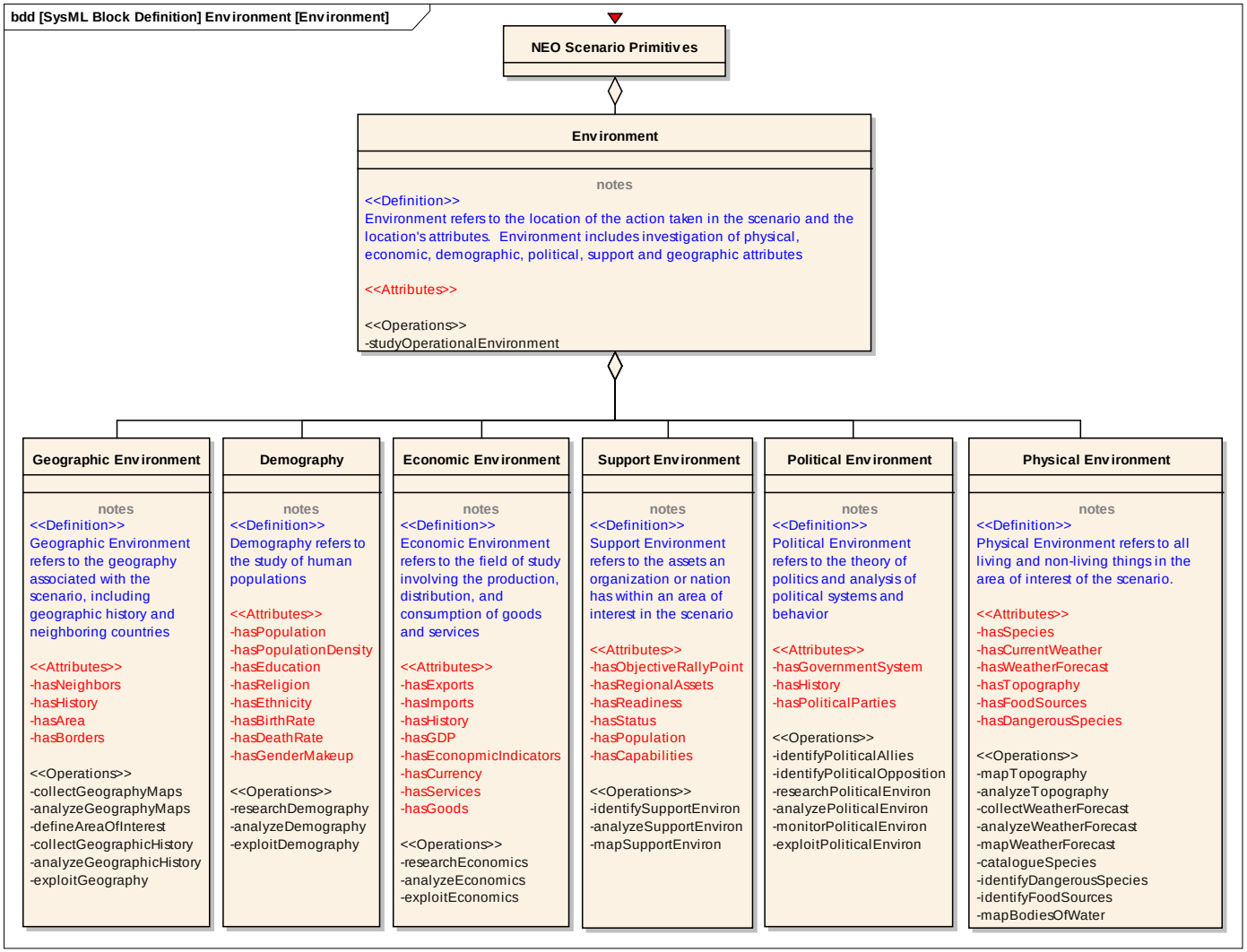


Figure 43: NEO Scenario Environment Primitives from Sparx