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Resource Management and Decision Support System for Border Patrol

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Abstract: In order to achieve the two goals in the 2012-2016 border patrol national strategy, which are secure America's borders and strengthen the border patrol, many types of information and data from different resources should be integrated and considered. The data includes historical data, real time data from sensors, and data from supporting system, such as GIS. However, there is few research on an integrated decision making support system can provide the complete information to the users and assist users to make a systematically thinking decision. This paper focuses on providing a structured approach in developing an interactive decision making support system for both border security resource allocation and patrol routing plan. It will result in the development of new system and a new analysis tool for the border security resource management.

Keywords: Resource Management, Decision Making, System Development

1. Introduction

The U. S. Department of Homeland Security (USDHS) was created to response the September 11 attacks. The primary responsibility of USDHS is to protect US from terrorism, man-made accidents, and natural disasters. U. S. Border Patrol is the uniformed law enforcement component of the USDHS, which responsible for 6000 miles of land border between US and Canada and US and Mexico [1]. US shares 2000 miles of border with Mexico and 4000 miles of border with Canada. U. S. border patrol manages border security between designated ports of entry. In the past few years, multi-layered enforcement strategy has built upon the effective and efficient use of resources and capabilities [2]. The border patrol budget in 2011 is 3.5 times as much the budget in 2001. However, there is few system can systematically assist the decision makers to effectively and efficiently use the available resources including equipment, sensors, man power, and data.

Some researchers take the approach that the computer should be used to make the decision for the user. This method is called an expert system [3]. There are many expert systems, but none seem to consider that the decision maker may simply want support, not automated decision making. Expert systems can be used as stand-alone systems that make decisions in all situations (particular to some specific aspect of an environment) or they can be used as a subsystem for making decisions in particular situations.

Another form of decision support system is the On-Line Analytical Processing (OLAO) system, such as decision support system (DSS) Agent. These systems are being developed primarily to provide access to large databases. Generally, OLAP systems are used for non-real-time decision making, and are particularly designed for the manipulation of data in large databases.

In contemporary organizations, support for decision making in high dynamic situation is required to meet daily challenges [4-6]. This support is potentially possible through the use of the increased capabilities offered by modern information technology in the form of a DSS. DSSs have utility if they provide effective and efficient support that improves the results expected from a decision process [7].

Decision support tools, real time data communication, users' interaction, and situation awareness information are important and critical to an effective border patrol resource management system [8-9]. The focus of this paper is to use system analysis and design methodology to develop an implementable border security resource management and decision support system, which include two sub-systems: Resource Allocation Subsystem and Patrol Route Planning Subsystem. The major function of the resource allocation subsystem is to assist the chef officers and decision makers who in charge of several border patrol zones to optimize the resource allocation based on the historical data and the forecasting of the threats during certain time period. The patrol route planning subsystem is to assist the zone officers to plan daily patrol route for each shift. It can also help to make quickly response when any emergency happens.

2. Methodology

Model driven development will be used in the development of the border security resource management system. The key of the model driven development is to use the drawing of the system models to visualize and analyze the problems. It will also help to communicate and define the business requirement. Model-driven development includes process modeling, data modeling, and object modeling.

Structured system design tools are used in this research. In the process to develop a user satisfied system, the developers first need understand the system requirements from the customers correctly and express them in an understandable manner, so that the system can be verified and validated. User-centered development is a process of systems development based on understanding the needs of the stakeholders and the reasons why the system should be developed. Besides the system requirement analysis, there are many more benefits of the use case modeling. It will help define the test plan and test cases, and tracking the system development process.

There are many multi-objective decisions making support methodologies and tools are available [6-7]. In this system, the major tools to be integrated are the algorithms and tools have been researched by other research teammates, which include Arena simulation models, genetic algorithm and modified genetic algorithm programed in MATLAB, and game theory. For the different problem type and decision making (DM) objectives, a default method and tool will be suggested by the system. However, the experienced users can also pick up the algorithm and tool by themselves to solve a particular problem. Users who are familiar with MATLAB can also write the code of a new algorithm and connect it to the system.

3. System Development and Results

Model-driven development is a very effective development methodology for a complex system such as the Border Security Resource Management and Decision Support system [10-11]. It works well when fulfillment of user expectations when quality is more important than cost and deadline. There are several different model-driven techniques, and the most important three are: process modeling, data modeling, and object modeling.

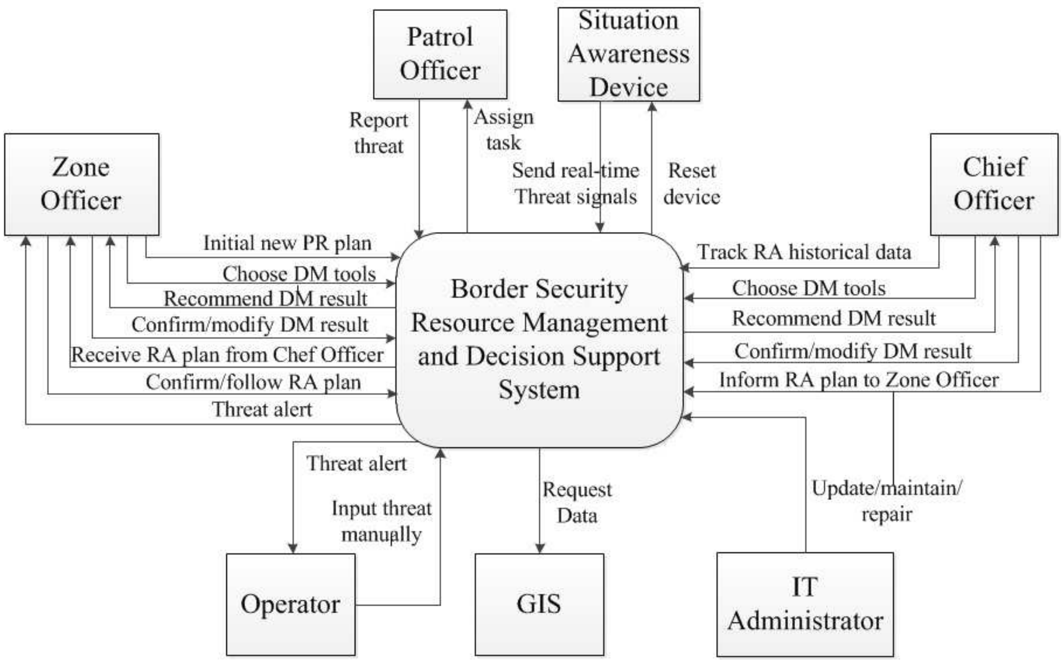

Figure 1. *System Context Diagram.*

In figure 1, it shows the system context diagram, which is an analysis for the system interactions with the world around it to specify the system inputs and outputs in general. It is the first step and helps potential users to understand the problem domain. In the center of the diagram, the box is the Border Security Resource Management and Decision Support System. There are seven actors, Chief Officer, Zone Officers, Patrol Officers, Situation Awareness Device, Operator, and System administrator, who have interactions with the system. They are represented by stick figures. Lines with arrows indicate inputs provided by actors to the system and the outputs responding to actors' actions.

The use case diagram, as shown below in figure 2, has its roots in object-oriented modeling [12]. It is a tool for capturing functional requirements, serving as a starting point for the identification of data objects, and providing a baseline for test plans. Use cases, represented as a horizontal ellipse in the figure 2, are initiated by external users called actors, which can be human, organizations, information systems, or external devices.

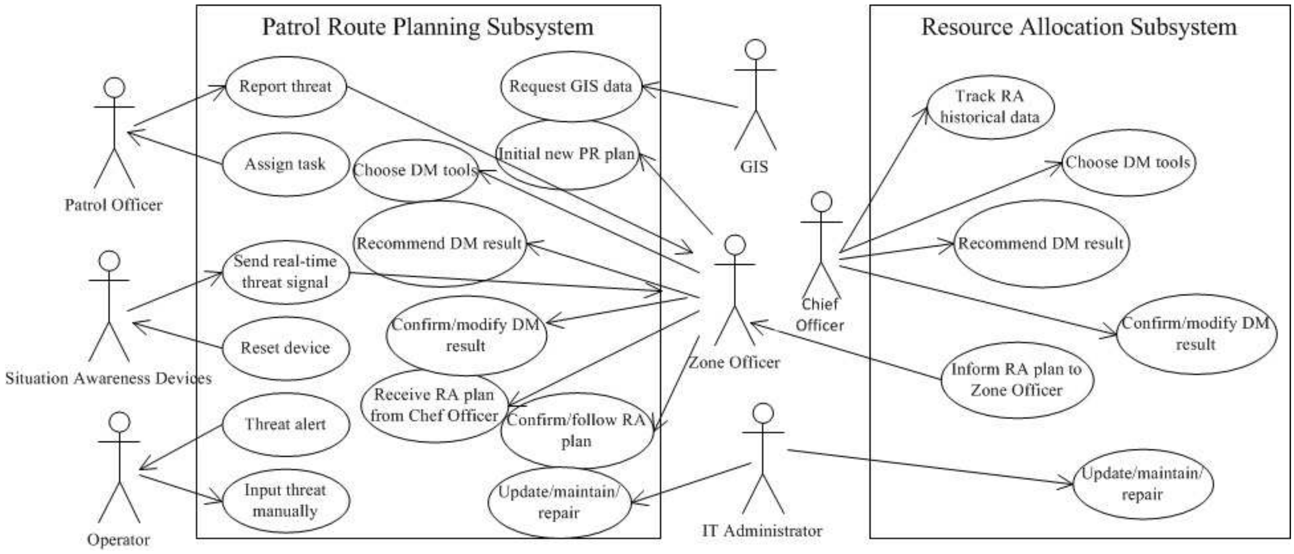

Figure 2. *Use Case Diagram.*

An actor is represented as a stick figure labeled with name of the role the actor play. A relationship between an actor and a use case describes an interaction between them. A line with an arrow is used to represent that interaction. For the system context diagram developed and discussed previously, system can have totally seven actors and twenty use cases. This diagram also shows that Border Security Resource Management and Decision Support System can be divided into two subsystems: Patrol Route Planning (PRP) subsystem and Resource Allocation (RA) subsystem. Table 1 is the glossary of use cases. The detail documentation for business requirements use case narratives can be fully developed after meeting and discussing with business clients.

Table 1. *Use Case Glossary.*

Use-Case Name	Use-Case Description	Participating Actors & Roles
Track RA historic data	Event of tracking resources allocation historic data	Chief and Zone Officers
Choose DM tool	Event of a chef officer selecting one of DM tool	Chief and Zone Officers
Recommend DM result	Event of the system recommending the DM result	Chief and Zone Officers
Confirm/modify DM result	Event of a chef officer or zone office confirming/accepting the system DM result or modifying as necessary	Chief and Zone Officers
Inform RA plan to Zone Officer	Event of informing resources allocation plan to corresponding zone officers	Chief Officer
Initial new PR plan	Event of a zone office start a new patrol route plan	Zone Officer
Request GIS data	Event of the system requesting maps and real-time traffic from external GIS system	GIS
Receive RA plan from Chief Officer	Event of a zone office receiving a resources allocation plan from the chef officer	Zone Officer
Confirm/follow RA plan	Event of a zone office confirming and following the resource relocation plan from the chef office	Zone Officer
Report threat	Event of a patrol office reporting a threat	Patrol and Zone Officers
Assign task	System assigning a task or a patrol route to a patrol office	Patrol Officer
Send real-time threat signal	Event of situation awareness devices sending incidents' signals to the system	Situation Awareness Devices and Zone Officer
Device Reset	Event of the system resetting situation awareness devices	Situation Awareness Devices
Threat alert	Event of an operator receive an alert from the system	Operator
Input threat manually	Event of an operator input a threat manually	Operator
Update/maintain/repair	Event of an IT administrator maintaining, updating and repairing the system	IT Administrator

Data modeling is a technique to define business requirements for a database. An entity relationship diagram (ERD) is a modern and common data modeling tool. An entity is something about which the business needs to store data to abstractly represent all instances of a group of similar things. There are twelve entities in Border Security Resource Management and Decision Support System, which are described in Table 2. The key-based ERD diagram is shown as figure 3, with their primary keys and foreign keys, as well as relationships among entities.

Table 2. *Entity/Definition Matrix.*

ENTITY	BUSINESS DEFINITION
Officer	An officer who works for border control agent.
Chief_Officer	An officer who in charge of several border patrol zones.
Zone_Officer	An officer who in charge of one border patrol zone.
Patrol_Officer	An officer who does the border patrol duty.
Resource_Allocation	Working place for each resource.
RA_Zone	Physical range of each border patrol area.
Patrol_Route	Travel route of each patrol vehicle.
DM_Tool	Decision making support algorithm or tool which integrated to the system.
Threat	Any incident or suspected information reported by patrol officers or collected by situation awareness device.
Situation_Awareness_Device	A device to monitor certain areas of U. S. boarder for both fixed stations and dynamic locations, such as motion detection camera, thermal imaging camera, unmanned aerial vehicle (UAV), etc.
Operator	A person who operates and monitors the system. System will alert to operator if there is any type of threat received. An operator also input threats manually if he/she receives them by phone calls, short wave radios or walk-ins.

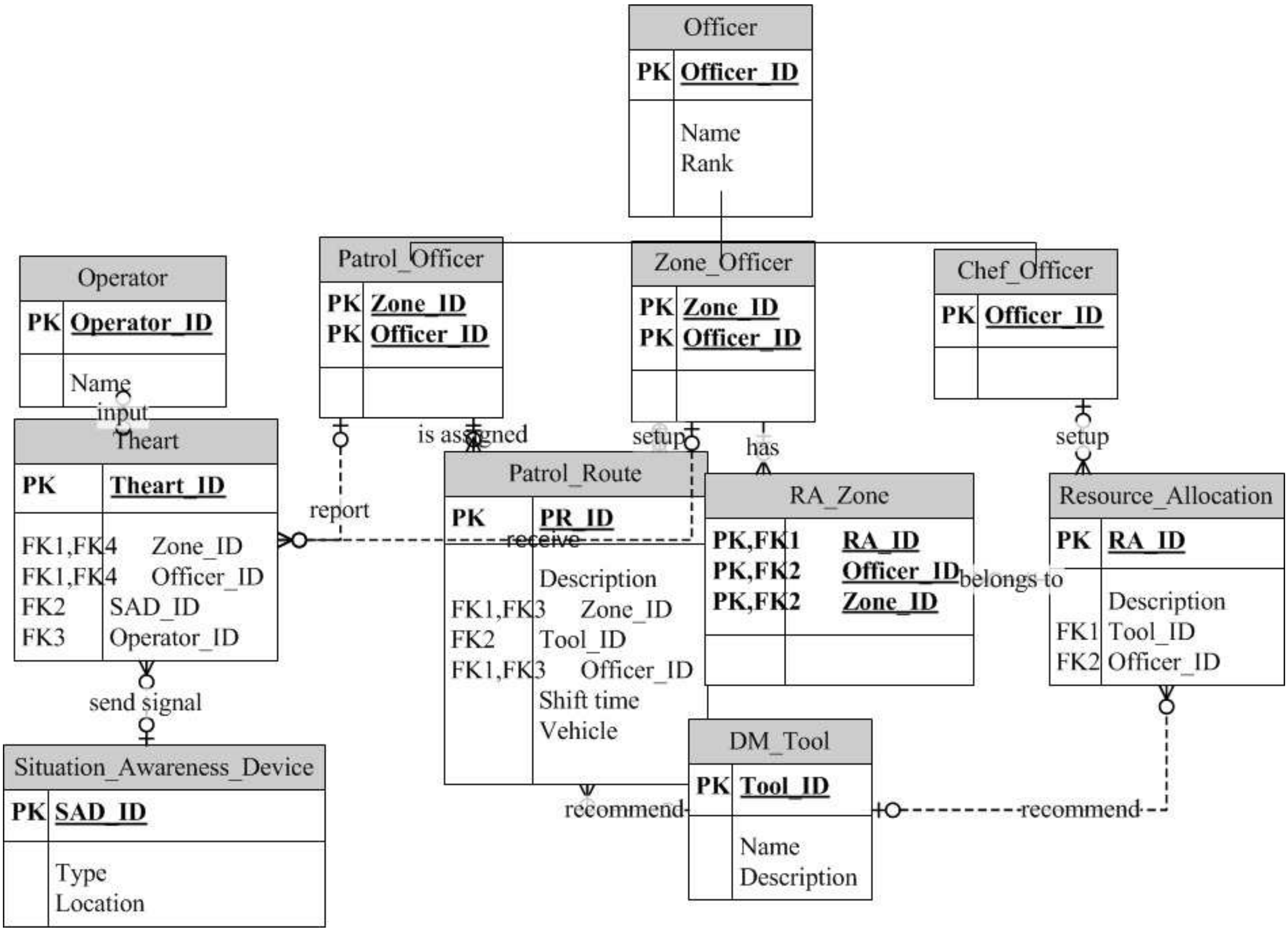

Figure 3. *Key Based Entity-Relationship Diagram (ERD).*

A system sequence diagram depicts how objects interact with each other via messages in the execution of a use case or operation. Figure 4 and figure 5 show system sequence diagrams for the Patrol Route Planning (PRP) subsystem and the Resource Allocation (RA) subsystem respectively. The stick figures and rectangle boxes represent actors and subsystems. The vertical bars are called the activation bars, which are used to indicate the period of time when the participant is active in the interaction. The horizontal arrows from actors to the system, indicate the message inputs, are represented by solid line. The dot lines are output message from the system to actors.

For the Resource Allocation (RA) subsystem, the chef officer can initialize a new RA plan by tracking RA historical data and the system will response the request by provide and list previous resource allocation data. The chef office can select one or more Decision Making (DM) tools from a list of available tools, such as Arena simulation models, genetic algorithm and modified genetic algorithm programed in MATLAB, goal programming, analytic hierarchy process

(AHP), and game theory according to users' preference. After the decision making process, the chosen tools will provide recommended results to the chef officer for his/her confirmation or modification. In the next step, the confirmed RA plan will be forward from then RA subsystem to the Patrol Route Planning (PRP) Subsystem. The zone officers in each zone will be informed. The zone officers can confirm and follow the RA plan to their zones.

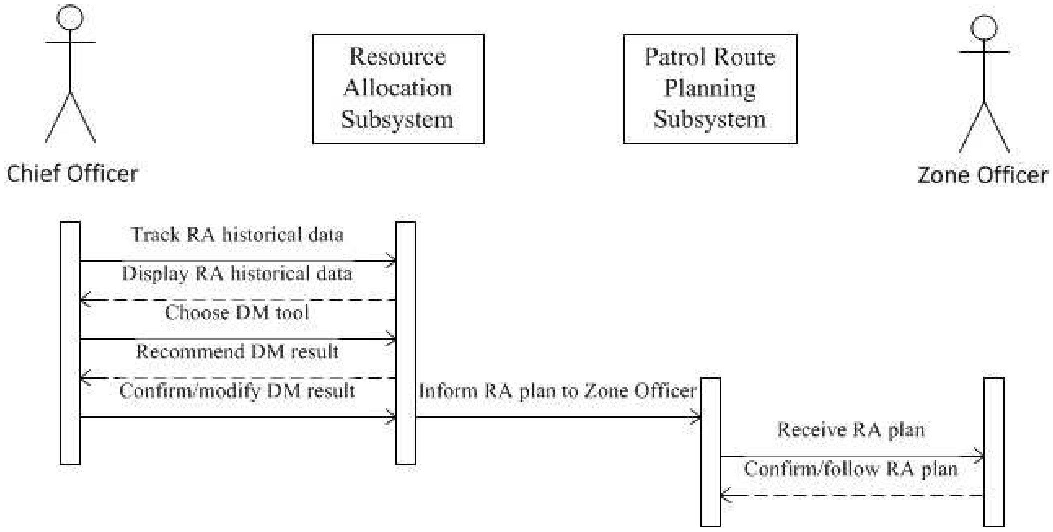

Figure 4. *Sequence Diagram for Resource Allocation (RA).*

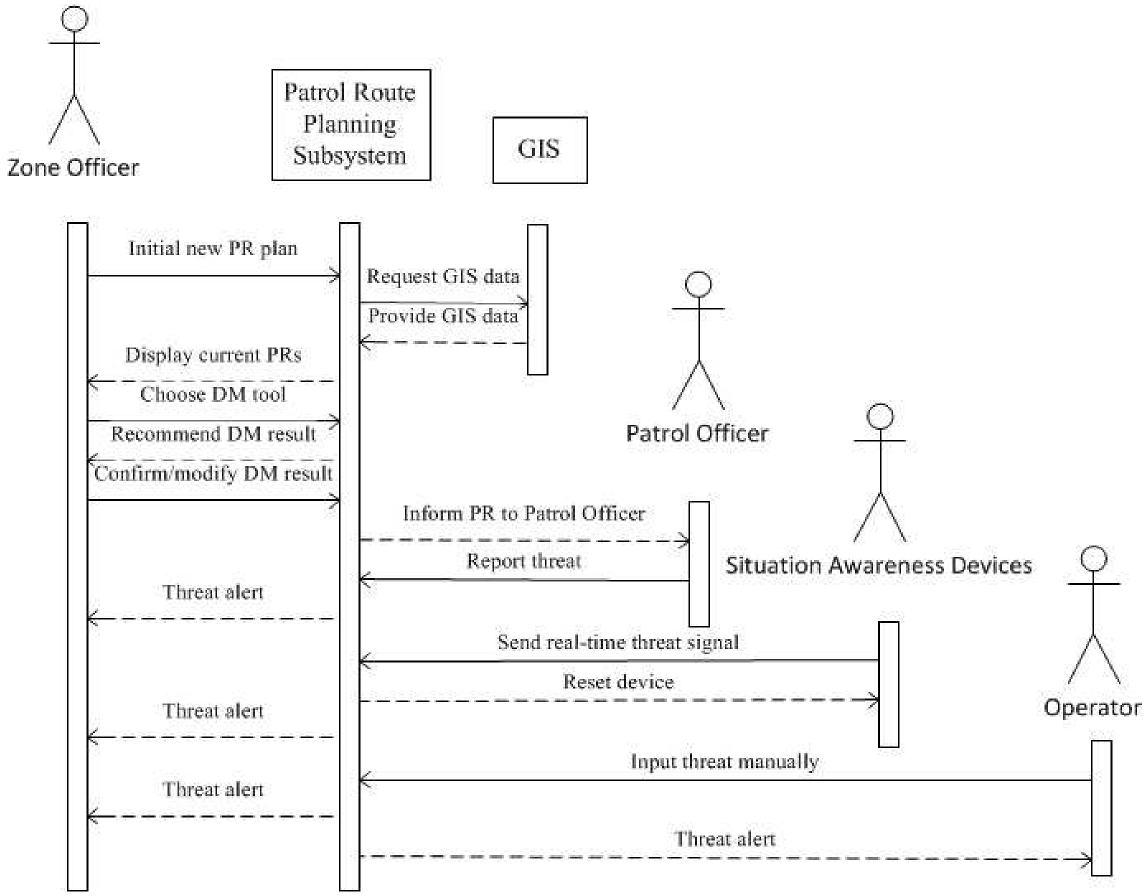

Figure 5. *Sequence Diagram for Patrol Route Planning (PRP).*

For the PRP subsystem, a zone officer for any zone can initialize a new PR plan. The external GIS system shall provide real-time GIS data to the PRP system. The decision making process is similar as the RA system described before. After a zone officer confirm the recommended result from the system, the PRP system will inform patrol officers who are doing daily patrolling and other tasks, so the patrol officers can follow the new plan and order from the zone office. The Situation Awareness Devices (SADs) in the diagram are devices to monitor certain areas of U. S. boarder for both fixed stations and dynamic locations, such as motion detection camera, thermal imaging camera, and unmanned aerial vehicles. Those devices can send real-time signals to the PRP subsystem if the devices detect any illegal activities in the covered detection ranges. Finally, an operator can operate and monitor the system. The PRP subsystem will alert to operators if there is any type of threat received, and operators also can input threats manually if the operators are alerted by phone calls, short wave radios or walk-ins.

4. Conclusion and Future Research

The system developed in this paper provides a structured framework to implement a complete system with data connection with historical records, GIS, sensors, and users' input. The model-driven development used in the research will allow the future system implementation completed easily by different developers. Previous research using simulation and genetic algorithm for the multi objective optimization and modeling can be integrated easily to the system.

The system is open to the connection to other software tools, such as Arena and other simulation software and MATLAB. This feature will allow the users to implement and test different decision making support modules and algorithms. System implementation can start from object design for a complex and changing system.

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