

2.3 Web-Based Predictive Analytics to Improve Patient Flow in the Emergency Department

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The Emergency Department (ED) simulation project was established to demonstrate how requirements-driven analysis and process simulation can help improve the quality of patient care for the Veterans Health Administration's (VHA) Veterans Affairs Medical Centers (VAMC). This project developed a web-based simulation prototype of patient flow in EDs, validated the performance of the simulation against operational data, and documented IT requirements for the ED simulation.

In addition to enabling VHA to provide higher quality, more convenient and comfortable care for veterans and their families, the application will provide the VHA with the following benefits:

- Web-based user interface to manage key input parameters
- Improved analytical approach to managing ED processes
- Better understanding of the operational variances within EDs
- Improved resource management
- Proactive versus reactive decision making
- Well-defined management reporting requirements
- Adherence to Federal patient care regulation guidelines
- Integration of simulation with Emergency Department Information System (EDIS) v1.5 rollout

The simulation application, built using CACI's SIMPROCESS™ software, is scalable so it can be deployed across the entire VHA. The initial focus was on VAMC Emergency Departments, but eventually the simulation will be expanded to include all inpatient flow processes, including bed management and surgical scheduling.

Goals of the Project

VHA EDs received both short term and long term benefits from this project. In

the short term the project helped EDs standardize their real-time data collection. In the long term simulation will help EDs develop better processes, improved efficiency, and optimal patient flow. ED personnel can use the web-based interface to examine their own "what-if" scenarios such as reducing the total number of patients waiting more than 6 hours for admission, reduce the total time EDs spend on diversion, reducing missed patient opportunities, and increasing the percentage of discharges before noon.

Overview of Concept

VAMC personnel need accurate and timely data to make smart decisions regarding patient care and resource planning. Simulation is an effective way to look at a system's current and future state performance, however most VA personnel don't have the technical training to build and execute a simulation model of their business processes. The concept of this project is to put these analytical capabilities into the hands of a VA decision maker rather than a trained simulation analyst. The simulation tool enables decision makers to access standard desktop simulation models through a stand-alone, web-based interface allowing them to change key parameters, e.g., mix of patient acuity and analyze the impact of these changes.

The diagram below shows the integration of data analysis into ED patient care. As patients are treated in the ED, data is collected by EDIS and other computer systems. Most of the patient data is entered by ED personnel, including patient arrival time, patient acuity, physical symptoms, medical diagnosis, and patient discharge time.

All of this data can be analyzed to determine the effectiveness of an ED's business processes. This tool can import all patient data and generate real-time and future-state reports which allows for immediate and long-term planning. As shown below, this is a continuous cycle of improvement.

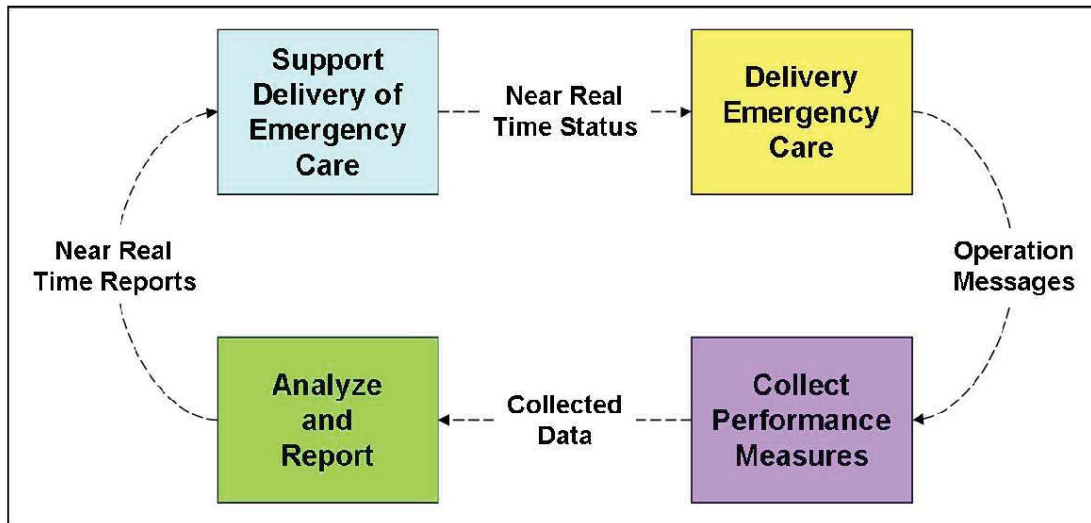


Figure 1 – Continuous Cycle of Improvement

The approach used in this project is intended to transform 'level 1' simulations to 'level 2' simulations and establish a framework for a real-time predictive analytics tool. The approach is as follows:

- **Step 1** – Build individual simulation models of several VAMC EDs. Personal interviews, site visits, and system data are used to build these models, which must be validated before moving to the next step. Apply stochastic variation to patient arrival and task completion to replicate the variability that exists in real-world settings.
- **Step 2** – Combine the individual models into one business process model.
- **Step 3** – Build a web-based interface and data repository that

connects to the combined business process model.

- **Step 4** – Run various “what-if” analyses on the models to examine the impacts of adding additional resources, inpatient beds, etc.
- **Step 5** – Build a template library that will contain the key tasks, resources, and activities associated with ED business processes. These templates can be accessed by any VAMC to build their own respective simulation.

Building the decision support application in SIMPROCESS creates a migration path to a 'level 3' solution, the most powerful application of simulation because it provides real-time predictive analytics and Business Activity Monitoring (BAM). By integrating the

simulation tool with current ED applications, administrators can monitor the status and performance of ED operations and make proactive, versus reactive, decisions.

The diagram below shows the planned interactions between the various inpatient flow management information systems. The EDIS, Bed Management,

and Surgical Scheduling applications share patient data with each other to minimize the required data entry and maximize the efficiency of patient flow. The data from these applications can also be sent to the SIMPROCESS ED model, and through the web-based user interface ED employees and managers can use this real-time data for current-state and future-state process analysis.

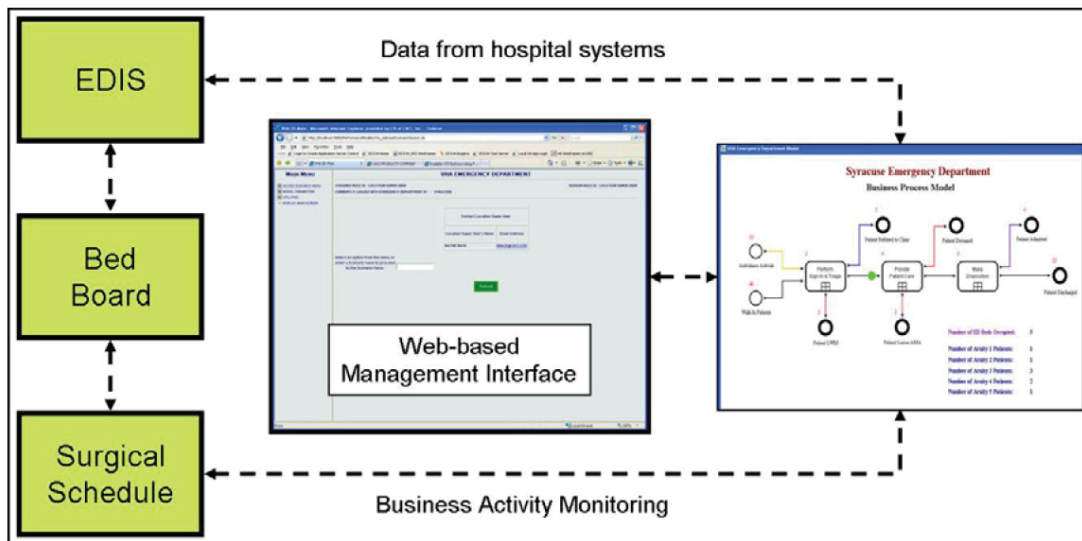


Figure 2 – Visualization of System Communications

Project Activities

The project began with a business process study of the Syracuse VAMC ED. This study included personal interviews with ED staff members, personal observations of the ED, and analysis of ED Tracker data, which provided the foundation for the Syracuse ED simulation model. This model included the patient profile, resource utilization, and business rules of the Syracuse ED. An initial draft of the model was reviewed by Syracuse administrators and the appropriate changes were made to validate the model. The model was considered valid when the simulation results for patient

arrivals, patient cycle times, and resource utilizations were statistically similar to real-life data.

The second step of the project was to conduct a similar business process study of the Lexington VAMC ED. Like Syracuse, this study consisted of personal interviews with ED staff members, personal observations of the ED, and analysis of their ED Tracker data. Based on this analysis, a second simulation model was built. This model not only included the patient profile, resource utilization, and business rules of the Lexington ED but showed the variations in patient care between the two ED sites. An initial draft of the model was reviewed by Lexington

administrators and it was validated in much the same manner as the Syracuse model.

Once both of these models were complete, a front end application was developed that provided access to each model via an Internet Explorer web browser. The process models themselves were transferred to a database and hosted on a server, which connects to the web-based user interface. This transition allows VA users to build scenarios, change a few key parameters, run simulations, and conduct future-state "what if" analysis.

St. Louis was the third VAMC ED chosen for the prototype. After a site visit to St. Louis, a St. Louis business process model was built, validated, and integrated into the existing web-based simulation prototype. This completed the activities associated with the first phase of the project.

The second phase of the project will focus on making the simulation prototype both scalable and flexible so it has utility for every VAMC ED. The

initial prototype will serve as the foundation of a template library of process, activities, and resources. This library will allow any ED to build its own business process model and execute simulations. The user will be able to change any model parameter and the tool will feature a more robust visualization and reporting capability.

Simulation Model

Figure 3 shows the top level of the Syracuse ED simulation model. The model follows patients from the time they enter the ED until the time of their disposition, highlighting the 3 main processes associated with patient care: "Perform Sign-In and Triage", "Provide Patient Care", and "Make Disposition". Patients can arrive via ambulance or through the main door. The model captures all of the different ways a patient leaves the ED: discharged by the physician, admitted to the inpatient facility, against medical advice, referred to a clinic, deceased, or without being seen.

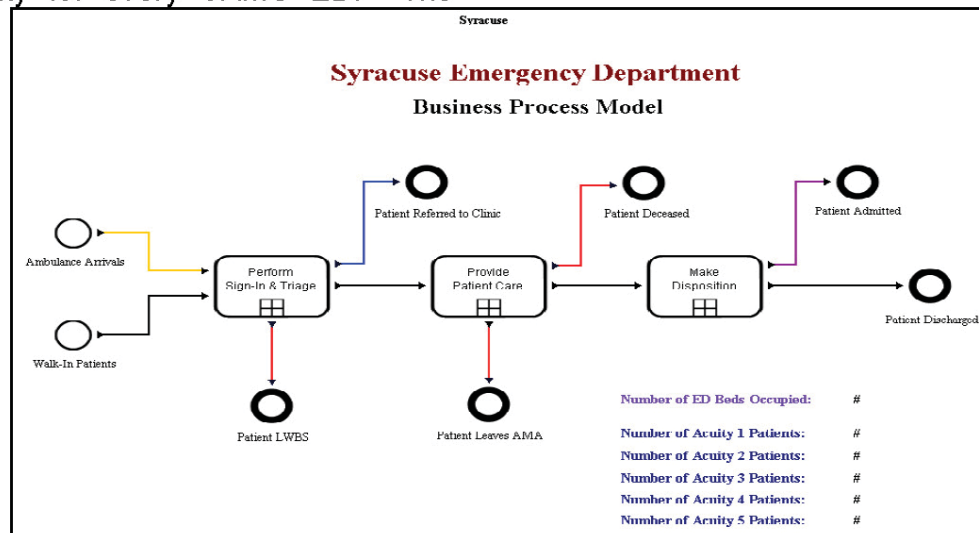


Figure 3 – Syracuse VAMC ED Business Process Model

The Lexington and St. Louis ED business process models are broken out into the same general structure, however, each site contains variations in patient population, resource utilization, and business practices. Combining

these models into a template library allows other ED sites to build their own unique simulation model from a group of prebuilt constructs which reduces the time to generate results.

Web-based User Interface:

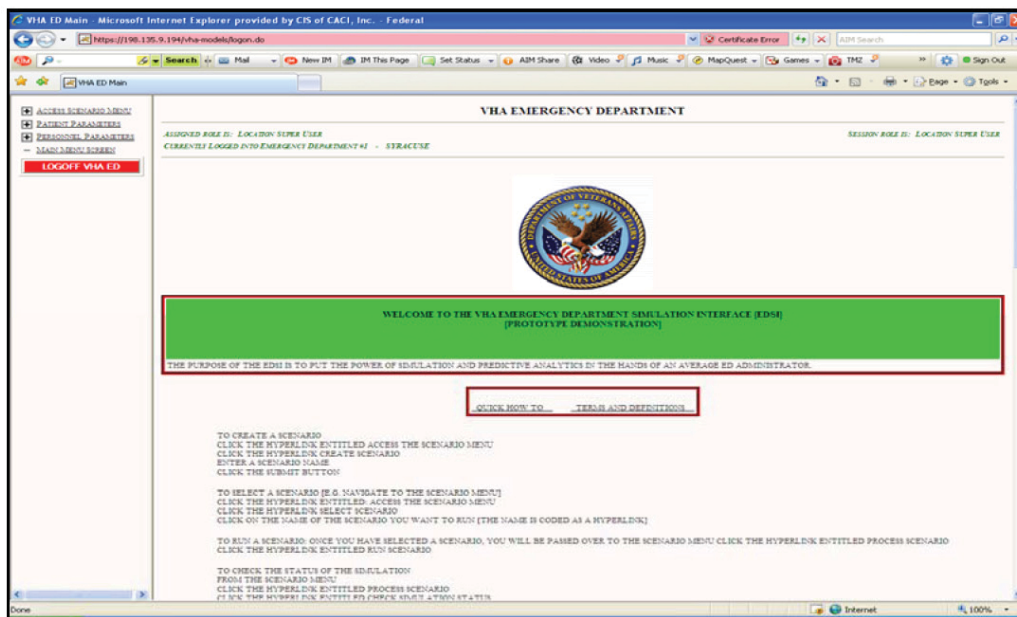


Figure 4 - Main user interface screen

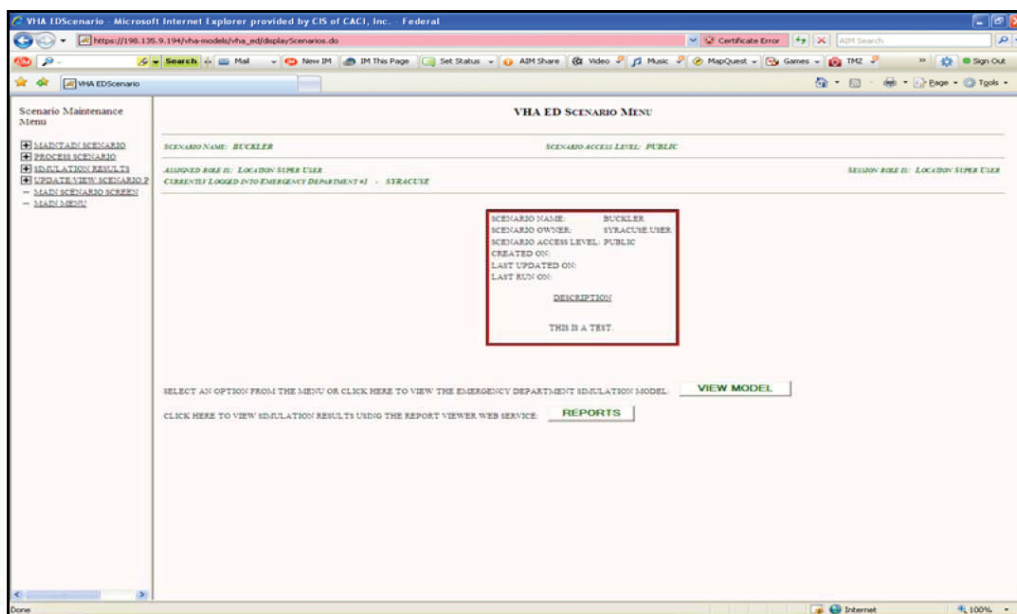


Figure 5 – Scenario creation screen

Lessons Learned

Building an ED simulation prototype produced a number of “Lessons Learned” that can be applied to future prototype efforts. The lessons learned encompass the technical aspects of the simulation, the challenges of working with VA patient data, and the variations of ED business processes.

Process Variations:

Three VAMC ED sites were included in the simulation prototype: Syracuse, Lexington, and St. Louis. Based on our site visits, we concluded that the foundation of ED patient care consisted of three treatment stages: Sign-in and Triage, Provide Patient Care, and Make Disposition. However these sites revealed that there are significant process differences between each site, and that reinforced the need for a flexible tool that can be adjusted to reflect the business processes at any ED facility. Some of these process differences include:

- The existence of an Urgent Care center
- Sign-in / Triage processes
- Resource shifts are scheduled differently at various sites.
- Location of lab and testing equipment greatly impacts a patient’s cycle time.
- When a patient is waiting for a bed in the inpatient facility, which should get charged that delay time, the ED or the hospital?

Data Issues:

The long-range goal is to connect the ED simulation prototype to other patient

flow prototype models, primarily a Bed Management and Surgical Scheduling application. Connecting to these other models may require data elements that are not currently collected or under consideration. However the ED prototype is flexible enough to add in new data and demonstrate the expected impacts. Other data observations include:

- When working with VA patient data it is imperative that personal identifiers be removed, such as social security numbers, etc.
- Each site can provide information concerning resources and resource scheduling within their respective ED. Users should be able to change all of these parameters because resource management is a significant concern to hospital administrators.
- EDs should collect more accurate data regarding patient tests and consults. Better data would allow the simulation models to more accurately calculate the average number of tests ordered (per acuity level), the average number of consults ordered (per acuity level), and the travel time to and from lab equipment. This could vary widely from one ED facility to another and cause unwanted patient delays.
- The following data elements that should be collected by EDIS or clarified by the VHA:
 - EDIS should standardize disposition codes across all EDs.
 - The number of tests and consults ordered per patient should be entered into EDIS.

- The exact patient “check-in” time to the ED should be standardized. Is it when a patient walks through the door, when a patient signs in, or when a patient is seen by a health care provider first sees a patient?

Conclusions

Each site agreed that a simulation tool would be very useful in helping them manage their ED processes. The ED simulation prototype provides a test environment that can assist in evaluating patient flow improvements and it establishes a quantitative basis for decision-making that allows comparison among different types of business processes, resource staffing, and patient care options. In the near-term, the prototype provides a tool for continuous improvement, and in the long run it supports documentation and sharing of best practices among VAMC facilities.

The unique composition of the VA's patient population changes the way users should analyze their business processes. Since many ED patients return at some point, performance metrics should be understood to reflect the efficiency of an ED, not necessarily the quality of care provided. Trying to measure overall patient satisfaction and quality of patient care is very difficult and requires different analytical techniques such as conducting patient surveys.

The ED simulation prototype allows users from the Syracuse, Lexington, and St. Louis EDs to study their respective business processes. They can change

a few key parameters and conduct “what-if” future-state analysis. Although the ED simulation prototype produces accurate results when compared to real ED data, more testing and consult data is required to gain full confidence in the results. Bed requirements are needed when admitting patients to the inpatient facility. The current prototype does not model to this level of detail and it will need to be adjusted before it can connect to the overall flow management model.

This simulation project proved that despite several real-life data shortcomings an effective tool could be developed from personal observations, smart statistical assumptions, and available process data. If the VA starts collecting additional data, the simulation can be refined to provide even better predictive analytics.