

**COMPREHENSIVE OPERATIONAL MODELING AND SIMULATION POLICY
DEVELOPMENT: PRIVATE SECTOR HEALTHCARE SYSTEMS AND THE US MILITARY
HEALTHCARE SYSTEM**

David L. Morgareidge

Page
1800 Main Street
Suite 123
Dallas, Texas, USA

ABSTRACT

The author performed four pilot simulation projects for the US Military Health System (MHS) before being awarded a contract to develop guidelines on the use of simulation throughout the MHS. The process was difficult because the MHS' existing methodologies are based on static rules-of-thumb and do not account for simulation's dynamic, performance-based processes. Initial project results were so positive, however, that the MHS decided it needed to begin to change its approach and fund the subject study. The policy guidelines have nine components: 1) Reasons for Implementing Simulation; 2) Current Industry Practice Overview; 3) Expected Benefits; 4) Typical Data Requirements; 5) Typical Time Requirements; 6) Typical Schedule Requirements; 7) Typical Cost Requirements; 8) Facility Life Cycle Management Integration and Impact; and 9) Implementation Scope and Schedule Decision Framework.

1 INTRODUCTION

Based on the current healthcare facility design guidance employed by the DOD (NIBD 2014), spatial, technological, staffing and financial resources cannot be holistically and interdependently optimized within the current facility design paradigm, which leaves the patients, staff, and taxpayer with less than optimal healthcare delivered through a less than optimal cost model. This guidance is outdated and not responsive to contemporary project requirements. Based on the author's experience, the same situation exists in private sector healthcare provider organizations, and the results of the study apply equally to them as they do to the US Department of Defense's (DoD) Military Health System (MHS).

Operational modeling and simulation (simulation) is an integrated component of, and indeed the driving force behind, a new, highly effective design methodology that allows the project team to evaluate very early designs with precisely the same objective, quantitative clinical and financial metrics with which the built facility will be evaluated, post go-live. Simulation adds system level performance analysis to today's component level focus. Simulation implementation is simple and has already been tested and validated in the private sector, at the level of a single in-patient department or of a single out-patient clinic.

Task Order 27, a set of policy guidelines previously developed by the author and submitted to the DOD (DHA/NIBS 2014), shows how simulation is the preeminent healthcare facility design methodology recommended for the MHS, and is not simply a bolt-on solution to a traditional approach. The guidelines were developed with respect to eight key elements, and resulted in a recommended scope of implementation for simulation throughout the MHS.

2 LITERATURE AND SIMULATION STUDY REVIEW

2.1 Review of Current MHS Standards

The MHS currently has a prescriptive, component-level approach to providing its architecture and engineering (A/E) design teams guidance regarding both new military construction (MILCON) and sustainment, restoration and modernization (SRM) projects. Examples of this approach include the Unified Facility Criteria (UFC) 4-510-01 - Design: Military Medical Facilities (DOD 2014), the Department of Defense (DoD) Space Planning Criteria for Health Facilities (NIBD 2014a), and the Military Health System Templates (NIBD 2014b).

These documents, the static design processes which support their use, and the lack of integrated system-level performance benchmarks prevent the MHS from knowing with certainty how each new or renovated space will perform under various usage scenarios and they prevent the MHS from achieving resource optimization.

2.2 Review of MHS Pilot Simulation Projects and Past Private Sector Simulation Projects

Additional research undertaken to support policy guideline development relied on the author's first-hand experience conducting simulation studies within healthcare environments. One source of information came from the execution of four pilot simulations for the MHS. The simulation study results were very positive, but the integration with existing project processes was difficult, and motivated the development of a new set of policy guidelines that would allow simulation to be integrated into, and to become the foundation of, a new set of protocols. Furthermore, the author reviewed the execution of 36 projects performed first-hand in the private sector to develop an understanding of the all of the elements that impact an organization trying to implement simulation.

Throughout the Task Order and this paper, the scope, timeline, cost, and schedule of simulation projects are discussed, as they provided the basis upon which the MHS policy guidelines were developed.

3 METHODS

The DOD-MHS Task Order was completed after performing a qualitative and quantitative assessment of the merits of a simulation-focused methodology for designing future MHS healthcare facilities. The policy guidelines were developed with respect to the following eight key elements which are discussed in further detail throughout this section:

1. Reasons for Implementing Simulation
2. Current Industry Practice
3. Expected Benefits (Qualitative and Quantitative)
4. Typical Data Requirements
5. Typical Time Requirements
6. Typical Schedule Requirements
7. Typical Cost Requirements
8. Facility Life Cycle Management (FLCM) Integration and Impact

3.1 Reasons for Implementing Simulation

Operational modeling and simulation (simulation) is a new, highly effective design methodology that allows the project team to evaluate very early designs with precisely the same objective, quantitative clinical and financial metrics with which the built facility will be evaluated, post go-live. Simulation adds system level performance analysis to today's component level focus.

3.2 Current Industry Practice Overview

At the request of the DoD, the Task Order sought to demonstrate and confirm that there was an adequate infrastructure to support the architecture/engineering (A/E) community trying to provide this service. AnyLogic, FlexSim Healthcare, MedModel, and Simul8 were evaluated using 43 criteria and all were found to be adequate, with entry-level costs below \$6,000. Other programs are also available, but the budget constrained the analysis to four. There are opportunities to lease software on a project basis, and there are firms that provide the service, so an A/E firm could easily build the subcontracted work into their fee if they chose not to bring the service in-house. The labor force is also adequately supplied with staff who can perform this work. Fourteen universities in the US have undergraduate and graduate degrees specifically in the simulation field and countless others provide simulation modeling and analysis courses.

3.3 Expected Benefits of Simulation

The benefits of simulation observed through a number of completed simulation projects, separated into quantitative and qualitative categories, are listed below.

3.3.1 Quantitative Benefits

The return on investment (ROI) of a simulation project is the most global measure of its quantitative benefits, and they have ranged from 10:1 to 20:1 in the author's work. In addition, other quantitative measures characterizing patient health outcomes support a simulation-based design methodology. Eight examples included in the Task Order are provided below.

1. Construction Cost Eliminated: The construction cost of an OR expansion, which was initially assumed to be necessary and to cost between \$3M and \$5M, was eliminated by focusing on improving processes and scheduling.
2. Equipment Cost Reduced: The medical equipment cost for opening a new hospital's 35 OR surgical suite was reduced by over \$8M.
3. FTE Costs Reduced: An Emergency Department's FTE labor expense was reduced by \$100,000 per year. A Central Pharmacy's FTE labor expense was reduced by 26%.
4. Over-building Prevented: The number of exam rooms needed to support a clinic's patient volume was shown to be 27, when the physicians had argued for 36.
5. Under-building Prevented: Under-building by 50% of the echo-cardiogram portion of a clinic was prevented and under-building by 67% of the in-patient holding bays was also avoided.
6. Revenue Increased: A clinic's revenue per exam room was increased by 50%. Non-value-added nurse walking time was reduced by 21,900 hours per year.
7. Visit Cycle Time and Length of Stay Reduced: Visit Cycle Time was reduced by 30% in a clinic. The median Length of Stay was lowered by 40% in an Emergency Department.
8. Turn-Around-Time (TAT) Reduced: The TAT of a lab's blood analyses was reduced by 40%.

3.3.2 Qualitative Benefits

Highlighted within the Task Order were four major qualitative benefits of simulation, based on the experience of the author.

First, simulation sets performance benchmarks and eliminates unmet expectations at go-live. Unlike any other design methodology, simulation uses the same clinical and financial performance benchmarks that will be used to assess the success of the facility after go-live, to guide the design choices from the concept design phase forward. Simulation performs the work of the future facility during design; there is no doubt about whether or not the desired objectives will be achieved.

Second, simulation provides for hundreds of scenarios to be analyzed. In this way, simulation supports the rapid, inexpensive and no-risk analysis of scores to literally thousands of scenarios. Optimization engines allow the design team to “exhaust the solution space” and to identify what is truly the optimal solution within the specific spatial, financial and temporal constraints of each unique client and each unique project.

Third, simulation promotes consensus through a fact-based process. Simulation builds a mutual, fact-based perspective among all members of the project team. The process is entirely transparent and completely data-driven, so that all parties quickly gain a common understanding of the challenges, the opportunities and the most fruitful directions forward.

Lastly, simulation provides operational decision support post-go-live. The UFC requirement that the Concept of Operations (ConOps) be so detailed that it can become the basis for the facility’s Standard Operating Procedures after go-live will, for the first time, be achieved. The simulation software will be kept current with live feeds from the electronic health record (EHR) and other automated systems, and as immediate operational problems develop anywhere in the facility, the administration will be able to turn to the simulation to find the most effective plan to address the challenge.

3.4 Typical Data Requirements

Historical and current state data collection regarding clinical processes is often the most difficult phase of a simulation project for 3 reasons. First, the EHR sometimes lacks the ability to track all of the necessary data. Second, while it may be technically feasible to capture certain information, the staff sometimes do not use the features that would gather it. Third, the program’s interface may not be user-friendly, or there may be more than one system into which data must be entered, sometimes redundantly.

3.4.1 Current State Data Types Required

The Task Order cited 6 primary types of data required to support simulation, regardless of which in-patient or out-patient setting is being studied.

1. Architectural floor plans: In order to analyze and optimize spatial adjacencies, and to minimize travel distances and travel time, a scaled, current, accurate floor plan of the areas to be simulated must be obtained.
2. Medical equipment processing times: The through-put time of fixed equipment, such as MRI’s, mobile x-ray machines, and small point-of-care devices, such as the i-STAT System, are important elements of clinical process definitions.
3. IT and clinical communication technologies: These systems (wireless telephony, nurse call systems, real time location-based services, etc.) push information to or from the caregivers and prevent them from having to return to a central location.
4. Staffing models: It is important to know which staff types, with what levels of experience, at what pay rates, are performing what tasks with what degree of efficiency.
5. Patient scheduling protocols: Queuing is often the result of a temporary imbalance between space, equipment or personnel resources and the arrival of patients requiring those resources.
6. Clinical process definitions: This data should cover two years and should include the time stamp of every step of each patient’s journey through the clinic. Data should be sorted by service line, and by unique patient type.

3.4.2 Current State Data Collection Methodologies

The collection of the architectural floor plans, medical equipment processing times, IT and clinical communication technologies specifications, staffing models and patient scheduling protocols, is not

difficult. Clinical process definitions, however, are often challenging to obtain and may require from 1 to 14 weeks. Below are listed the 4 primary methods of capturing this information.

1. Anecdotal: The least desirable method for obtaining historical and current state process data. It is subjective and caregivers who perform the same work in the same facility will often define the processes differently and assign them different durations.
2. Electronic Health Record: More accurate than anecdotal methods and easy to analyze. EHR is the least expensive method for the client and for the simulation service provider firm. The data is already digital, resulting in efficiencies during the data collection and analysis phases.
3. Manual Patient Tracking Forms: If EHR data is not available, a cost-effective method for non-acute settings, such as clinics. At the end of each clinic day, the forms can be collected, scanned and emailed back to the office. Then the data is input into a database, analyzed and prepared for use as input into the simulation program.
4. Real Time Location-based Services (RTLS): The most accurate, the most thorough, and the most valuable sources of process definition and duration information. RTLS solutions are also the most expensive method for obtaining this data.

3.4.3 Future State Data Requirements

The future state scenarios require exactly the same type of information as does the current state model.

3.4.4 Future State Data Development

The first component to developing future state data is the “demand study”, which documents how demographics are changing, how the competitive market is changing with new challengers drawing away patients or existing challengers faltering and giving up patients, how the regulatory and reimbursement landscape will change and how that will affect which service lines should grow and which should be curtailed. The second component relates to the future state performance targets to which the institution will aspire. For example, if the organization is now in the 60th percentile, but their mission statement says they are supposed to be in the 90th percentile, how will they make adjustments to rectify this substandard performance? If an institution has not been working on both of these issues, and simulation brings them to the surface, it can spawn a debate that will place the simulation work on hold until a consensus is reached.

3.5 Typical Time Requirements

3.5.1 Lead Time Required to “Set Up” Simulation

“Setting up” refers to the organizational effort required to move a simulation project from an idea to a funded reality. “Setting up” simulations that are part of MILCON and SRM projects requires no additional calendar time. Once simulation policy guidelines become adopted, it will be a simple matter to incorporate the simulation requirements at the same time that all other aspects of a project are being defined along each step of the Facility Life Cycle Management process.

3.5.2 MHS Staff Time Required for Standard Simulation Project Support Activities

An outline of the major project steps in a simulation project is provided below in Table 1. The majority of these steps (Idx. Nos. 1-8 and 13-23) represent the same type of work, and the same work durations, as those that would be required on a standard MILCON or SRM project without simulation.

Table 1: The amount of time, by phase, that MHS staff will need to spend on a simulation project with today’s historical and current state data collection technologies.

Idx. No.	Work Activity Definition (1)		Staff Involved (number)		Time Spent (hours)		Varies from Concept or SD
			Low	High	Low	High	
1	Project conceptualization		1	4	6	20	No
2	RFP	Preparation	1	4	10	20	No
3		Review responses, interview firms	2	8	24	48	No
4		Award	1	1	1	3	No
5	Kick-off		3	8	3	8	No
6	Current state assessment	Provide floor plans in AutoCAD format	1	2	1	2	No
7		Provide a staffing model.	1	2	1	2	No
8		Provide a concept of operations.	1	3	2	12	No
9	Data collection (1 of 4 options):	Anecdotal	2	8	20	44	No
10		Manual Tracking Form	6	30	69	159	246% - 256%
11		Electronic Health Record	2	4	36	80	No
12		Real Time Location-based Service	6	30	110	222	358% - 393%
13	Future state objectives (process, metrics)				80	150	No
14	Simulation Specification		2	6	4	18	No
15	Simulation Set 1	Output review	2	6	2	12	No
16		Simulation specification update	2	6	2	6	No
17	Simulation Set 2	Output review	2	6	2	12	No
18		Simulation specification update	2	6	2	6	No
19	Final results review	Draft	2	8	2	12	No
20		Final	2	8	2	12	No
21		Board presentation	6	10	3	5	No
22	Periodic team web-based meetings		2	4	32	48	No
23	Administrative (contracting, etc.)		1	2	4	8	No
24	TOTAL (varies based on Current state assessment method used)	Anecdotal			203	448	0%
25		Manual Tracking Form			252	563	16 - 17%
26		Electronic Health Record			219	484	0%
27		Real Time Location-based Service			293	626	26 - 28%

If the manual tracking form option is selected, the increase in MHS labor is about 251% and about 376% if the real time location-based service option is selected. Note that the type of work performed to support either the manual form or the real time location-based service methodologies will not require different skill sets than those of the current MHS staff once they have been provided a brief orientation.

At each phase of simulation project review, the MHS will need to evaluate the work of the firm providing simulation services regarding input, output, model verification and validation. The amount of time required to perform this work will not be much different than what is now required to confirm compliance with current prescriptive design guidance. However, individuals performing this work will be industrial engineers and will represent a new staff profile for the MHS. Furthermore, just as an automated checking routine was developed for the Space & Equipment Planning System (SEPS), similar routines will be developed for simulation work, thereby reducing the amount of time and expense required.

3.6 Typical Schedule Requirements

To fully inform the estimation of schedule requirements, the author first presented a standard for conducting simulation projects and then discussed the factors that may affect all phases of project execution.

3.6.1 The Seven Phases of a Simulation Project

The Task Order defined the schedule requirements of a simulation project based a seven phase approach to conducting simulation projects.

1. Kick-off (1 week): This series of meetings can usually be conducted in 1 or 2 days, with a broad cross section of the organization’s staff, from the CEO to the technicians. This is also a good time to conduct the on-site observations, which can last from one to several days.

2. Data collection and current state assessment (1 – 14 weeks): This process is the most variable of all of the phases and can require from 1 to 14 weeks, depending on the methodology employed to gather the data.
3. Lean process analysis (2 – 3 weeks): This process can take many forms, depending on the institutions experience with Lean, and depending on how much they want Lean to be a part of the project.
4. Prepare a simulation specification (1 – 2 weeks): This is one of the most important parts of a simulation project because in the process of developing this matrix of scenarios, the entire project team must come together in agreement about what is working in the current environment, what needs to be improved, how it should be improved, and to what extent it should be improved.
5. Build the baseline model (1 – 3 weeks): The initial simulation model is prepared, using current state data.
6. Perform the base case simulation (1 week): The fully developed model is run, using the base case, or, current state, performance levels. When this model's output results match those of the existing facilities actual performance levels, then the model is considered to be "validated", and it ready for testing the future state scenarios.
7. Perform the future state scenario simulation (2 – 9 weeks): A logically grouped and sequenced batch of simulations is performed, the results are analyzed and reviewed with the project team, and decisions are then made about how to structure the next batch of simulations. This cyclical process is repeated until the optimal solution is identified.

3.6.2 Thirteen Factors that Influence the Scope, and Therefore, Schedule of a Simulation Project

Many factors may impact the scope, and therefore, schedule of a simulation project. Unlike most architectural efforts, the physical size of the project, as measured in square feet, does not significantly contribute to the scope, schedule and cost. Below is a list of 13 factors that do.

1. Number of service lines or departments
2. Number of unique patient types: The number of patient types is arguably the most important contributor to project scope. A "unique patient" is one that travels through different spaces, uses different medical equipment resources, uses different staffing resources, or uses the same spatial, equipment or staffing resources but for different lengths of time. Each unique patient type requires specific effort for data collection, data analysis, lean discussion, simulation logic development, and reporting.
3. Number of simulation scenarios
4. Degree of architectural plan development
5. Current state data collection methodology
6. Extent of process improvement: Some clients are committed to process analysis and reengineering, and they wish to fully exploit simulation to aid them. This can result in a large number of scenarios and lengthen the time it takes to complete them.
7. Chassis throughput capacity analysis: These are simple analyses without significant floor plan or process changes, where the client wants to examine only a few variables (most related to patient volumes) to determine when a space will reach its maximum capacity and trigger the next phase of a master plan expansion.
8. Inclusion of upstream and downstream departments: If the simulation project is a hospital department, such as the surgical suite, that has process dependencies with several other departments, then the model logic will be more complex and take more time to develop, debug, alter and evaluate.
9. Number and length of planning horizons

10. Number of market growth alternatives
11. Simulation skill of the simulation specialist
12. Healthcare knowledge of the simulation specialist: If the simulation specialist is new to healthcare, it will be harder for them to develop the processing logic, harder to interact with the client and the A/E team, the model will be more likely to require debugging, and the time required to build a sophisticated healthcare model could increase by 20%.
13. Number of simulation specialists

3.6.3 Overall Durations of Typical Simulation Projects

The Task Order provided the estimated timelines and project schedules for a range of potential projects and clients. Below are a sample of four Emergency Department (ED) project schedules, which range from 10 to 35 weeks. The standardization achievable in the MHS would yield a target duration of 10 to 15 weeks.

1. Schedule 1 (35 weeks): Data collection assumes that a **new RTLS installation** will be required, that there is no existing relationship with a vendor so that time will be required to have the equipment specified, shipped to the vendor, and then time will need to be set aside to find an opening on the vendor's installation calendar. **Lean process analysis** will be performed. A **medium number of simulation** studies will be performed. Only **one simulation specialist with moderate experience** will work on the project.
2. Schedule 2 (28 weeks): Data collection assumes that a **new RTLS installation** will be required, that there is an existing relationship with a vendor, that the required equipment is on the shelf, and the vendor makes an immediate opening on their installation calendar. **Lean process analysis** will be performed. A **medium number of simulation** studies will be performed. Only **one simulation specialist with extensive experience** will work on the project.
3. Schedule 3 (19 weeks): Data collection assumes that existing data is useful from either **anecdotal or EHR** sources. **Lean process analysis** will be performed. A **medium number of simulation** studies will be performed. **Two simulation specialists with extensive experience** will work on the project and some work will be performed in parallel.
4. Schedule 4 (10 weeks): Data collection assumes that existing data is useful from a **perfect EHR** source. **Lean process analysis** will be performed. A **light number of simulation** studies will be performed. **Two simulation specialists with extensive experience** will work on the project and some work will be performed in parallel.

3.7 Typical Cost Requirements

3.7.1 Factors that Influence the Scope, and Therefore Cost, of a Simulation Project

As described in Section 3.6.2 above, the factors that influence cost are the same factors that influence the schedule. Tables 2, 3 and 4 define the impact, in ranges, qualitative and quantitative factors have on simulation project costs.

Table 2: A list of the primary qualitative aspects of a simulation that affect cost with a range of typical impact in thousands of dollars.

Idx. No.	Variable		Cost Impact - Multiplier	
	Definition	Qualifier	Low	High
			(\$ 000)	(\$ 000)
1	Experience of the simulation modeler	With simulation	1	1.10
2		With healthcare	1	1.06
3	New construction vs. renovation	This often effects the number of floor plans that must be considered	1	1.50

Table 3: A list of the primary quantitative aspects of a simulation that affect cost with a range of typical impact in thousands of dollars.

Idx. No.	Variable		Cost Impact - Dollars	
	Definition	Qualifier	Low	High
			(\$ 000)	(\$ 000)
1	Number of service lines or departments		8	96
2	Number of unique patient types		5	45
3	Number of simulations	As defined in the Simulation Specification (the effect of the number of growth scenarios, the number of planning horizons, etc.)	25	90
4	Type of simulations	As defined in the Simulation Specification (whether the simulation is full scope or only a chassis capacity throughput test, etc.)	10	40
5	Degree of architectural plan development	Concept Design, 50% Schematic Design, 100% schematic Design, 50% Design Development	15	55
6		Anecdotal	10	30
7	Current state	Manual Tracking Form	17	35
8	data collection methodology	Real Time Location Based Service	35	60
9		Electronic Health Record	10	35
10	Extent of process improvement (re-engineering, lean, six sigma)		20	60
11	Up- and down-stream departments	For example, if simulating an ED, the OR Suite, Lab, Imaging and the In-patient Beds should also be examined.	20	100
12		Are they simulated, or are simpler capacity analyses performed using Excel?	5	20
13	Simulation specification development		2	5
14	Staffing model		3	5
15	Current state analysis without simulation		15	80

Table 4: The summary cost ranges for a single service line or a single department simulation project.

Idx. No.	Variable		Cost Impact - Multiplier	
	Definition	Qualifier	Low	High
1	Maximum - High-Low - Single department or service line		100	320
2	Average - High-Low - Single department or service line		130	150

3.7.2 Reduction of Construction and Operating Costs

One category of positive financial contribution includes reduced construction and operating costs. From the author’s experience, gathered during the course of performing 40 projects in both in-patient and out-patient settings, the ROI for these efforts is typically between 10:1 and 20:1.

3.7.3 Reduction of Architectural Fee

A second category of positive financial contribution includes the “transfer” of some traditionally architectural MILCON and SRM project effort to the simulation team. The “total” project cost may not diminish, but the individuals performing the work, and the discipline carrying the costs, will change. The three design process elements in which this occurs include current state assessments, development of alternative design solutions, and client decision support documentation.

3.8 Facility Life Cycle Management (FLCM) Integration and Impact

Simulation’s highest value can only be realized when it is pervasive across all FLCM phases and all MHS facilities. Simulation has the ability to affect six FLCM phases: **Planning, Design, Transitioning, Operations, Post-Occupancy Evaluation (POE), and Knowledge Management Portal (KMP).**

For planning, simulation is the most effective methodology available to help the client to obtain an accurate assessment of current state performance, to determine future state performance goals and to determine how best to achieve those goals within the unique financial, spatial and temporal constraints of each project. Simulation can be used at the department, facility, campus, and regional level to analyze both master planning and facility options.

During design, the detailed ConOps that will become the basis of the facility’s post-go-live SOPs, is defined and codified into the simulation model. Tens, hundreds, or thousands of scenarios are evaluated to exhaust the solution space and find the optimal design. Simulation work for MILCON and SRM projects should be completed early in the design process as significant changes in adjacencies and spatial locations could be adopted that would have expensive ramifications for engineering disciplines.

During transitioning, all of the operational logic embedded in the simulation model, that was the foundation for selecting the final design, can be used to help train the new staff. The visualization capabilities of simulation programs can be helpful and instructive in this regard.

The simulation model is also a very powerful decision support tool for operations. When kept current with real-time feeds from the EHR and other automated systems, the simulation model can be used to examine scores of possible scenarios to correct a problem with process.

The POE has two initial objectives. The first is to determine whether or not the documented performance of the new facility is as it was forecast to be by the simulation model. The second is to determine whether or not the processes, staffing model, scheduling protocols, and other components are being followed as defined in the simulation model, consistent with the ConOps. The “simulation POE” is focused on clinical and financial operational issues and is performed three months after go-live.

Without a comprehensive repository of past experience, analyses may be needlessly repeated because a project team does not know that a particular concept has already been evaluated, and important linkages between design intent and post-go-live performance may go unnoticed because the data either was not captured or cannot be easily analyzed.

4 RESULTS

Based on the eight key factors researched, documented, and evaluated in the Task Order, the author recommended to the MHS scope of simulation implementation that included the following three components:

1. All existing and future hospitals should have simulation performed on 20 primary departments.
2. All existing and future clinic facilities should have simulations performed for each service line.
3. A new “Performance Improvement” project type will be instituted to apply the benefits of simulation to the existing stock of facilities, and not just to new or renovated buildings.

To provide an estimate of the length of time over which it would be reasonable to complete the full implementation of simulation throughout the DOD, a financial cost model was built. Ten variables were identified and we chose to hold 7 of them constant and to vary 3 of them for the initial analysis. The set of decision variables included in the model are listed in Table 5.

Table 5: Financial model decision variables used to determine the total implementation timeline.

Decision Variable	Description/ Baseline Assumption
MHS Improved	The MHS current state operational effectiveness will improve over time, until

Efficiency	the 13 th year of implementation, when it becomes 20% more efficient than today.
Simulation Improved Efficiency	The simulation efforts will become less expensive by 45% by the fourth year of implementation due to efficiencies gained through repetition and standardization.
Elimination of Architectural Effort	All simulation project costs are reduced by 20% because of the overlap with currently budgeted architectural work on MILCON and SRM projects.

The seven key constant parameters within the financial model define the simulation study requirements for new construction, renovation, and process improvement efforts throughout the MHS.

1. ConOps: Each new facility will have a complete, digital ConOps, embedded in a simulation model.
2. MILCON: One new hospital project will be added to the MHS every 2 years and that 3 new clinics projects will be added to the MHS every 2 years.
3. SRM: Each existing facility will have a complete, digital ConOps, embedded in a simulation model.
4. New Hospital Simulations: Each new hospital is assumed to require twelve departmental simulations.
5. New Clinic Simulations: Each new clinic is assumed to require seven service line simulations.
6. Existing Hospital Simulations: Each existing hospital is assumed to achieve a complete simulation model through the execution of four SRM and eight Process Improvement simulation projects.
7. Existing Clinic Simulations: Each existing clinic is assumed to achieve a complete simulation model through the execution of three SRM and five Process Improvement simulation projects.

In total, sixty alternatives were evaluated to determine the best one for the MHS. One such scenario, “Scenario 35”, was selected as one that could likely be implemented by the MHS. Its cost impact across a twelve year implementation timeline is shown in Figure 1. The cost model for Scenario 35, which assumed a 12 year implementation period, an estimated ROI of 1.5, and efficiencies in both the MHS and simulationist efforts gained over time, showed that clinical performance will improve and operational costs are projected to drop by \$983M over the 12 year implementation time period.

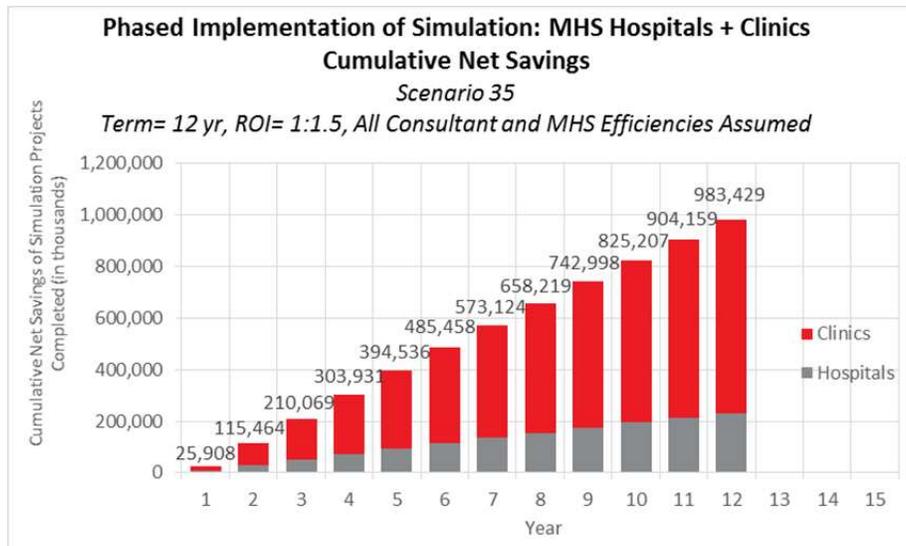


Figure 1: Scenario 35: MHS Hospitals + Clinics Cumulative Net Savings.

5 CONCLUSION

Based on the current healthcare facility design guidance employed by the DOD, the MHS cannot be holistically and interdependently optimized within the current facility design paradigm, which leaves the patients, staff, and taxpayer with less than optimal healthcare delivered through a less than optimal cost model. Therefore, a set of policy guidelines developed to show how simulation is the preeminent healthcare facility design methodology recommended for the MHS. The guidance was developed with respect to eight key elements, and resulted in a recommended scope of implementation for the use of simulation throughout the MHS.

While simulation implementation as a comprehensive design methodology will require significant change to the current structure of design guidance and design methodology, it is expected that its implementation would improve clinical performance and decrease operational costs over a 12 year implementation time period by nearly \$1B.

REFERENCES

- Defense Health Agency/National Institute for Building Sciences. 2014. "Task Order 27 – Simulation Policy Development for the MHS." December, 2014.
- National Institute of Building Design. 2014a. "Military Health System (MHS): DoD Space Planning Criteria for Health Facilities." http://www.wbdg.org/ccb/browse_cat.php?o=29&c=261, Accessed April 3, 2014.
- National Institute of Building Design. 2014b. "Military Health System Templates." http://www.wbdg.org/ccb/browse_cat.php?o=64&c=260#8264, Accessed March 12, 2014.
- The Department of Defense (DoD) Military Health System (MHS). 2014a. "Capital Investment Decision Model." <http://facilities.health.mil/Repository/getFile/37>, Accessed March 24, 2014.
- The Department of Defense (DoD) Military Health System (MHS). 2014b. "Space & Equipment Planning System." <http://facilities.health.mil/home/SEPS>, Accessed April 25, 2014.
- The Department of Defense (DoD). 2014. "Unified Facility Criteria Design: Military Medical Facilities." http://www.wbdg.org/ccb/DOD/UFC/ufc_4_510_01.pdf. Accessed June 10, 2014.

AUTHOR BIOGRAPHY

DAVID L. MORGAREIDGE is the Predictive Analytics Director at Page, a firm that is headquartered in Washington, DC, and that provides architectural, engineering, interiors, planning and consulting functions to clients around the world. His undergraduate degree is in architecture from the University of California at Berkeley and he has taken graduate work in computer and information sciences. David has practiced architecture in the US and Europe. The focus of his work has always been achieving objectively and quantitatively optimized design solutions through the use of digital, virtual design environments and parametric modeling tools. His email address is: dmorgareidge@pagethink.com