# A DECISION SUPPORT SYSTEM FOR EVALUATING TRAINING SYSTEM IMPROVEMENTS AND ENSURING RETURN ON INVESTMENT

**Sarah Aust**
**ProcessModel, Inc.**
**Provo, Utah**

**Scott Dunlap**
**Chief of Naval Education and Training**
**Orlando, Florida**

**Steve Broussard**
**Dynamics Research Corporation**
**Orlando, Florida**

## ABSTRACT

The Chief of Naval Education and Training (CNET) is improving training decision support processes and systems through the innovative application of current business modeling and simulation practices. This effort is being conducted under CNET's Training Business Modeling and Simulation (TBMS) program. Through the development and implementation of a standardized architecture and methodology, CNET is incrementally developing a training decision support capability anchored by a foundation of computer simulation models that provide "ground-truth" information.

This maturing decision support capability will allow decision-makers to "Fly Before They Buy" new training technology or process improvements. The end-state of the TBMS program is envisioned to be a web-based Training Business Area Resource Repository (TBARR). Decision-makers will be able to use this repository to quickly test simplistic or complex improvements to underlying business processes or information technology systems in support of the training continuum, and also evaluate the consequences of such actions in simulation before implementation. The tested and validated scenarios will provide critical metrics to the training community, such as cost, resource requirements, and student time-to-train (to include Under Instruction (UI), Awaiting Instruction, (AI), Interrupted Instruction (II), and Awaiting Transfer (AT)). The simulated consequences can then be compared to the cost of implementation to compute Return on Investment to the Navy.

This paper will describe the TBMS architecture and standardized methodology for executing TBMS efforts. Leveraging High-Level Architecture (HLA) concepts, this architecture is developed for the use and re-use of business process models created using commercial-off-the-shelf (COTS) applications. The architecture purposefully sacrifices complete interoperability in an open system with open standards to gain the benefits of rapid model development in a structured architecture with standard methodologies for development, modification, and analysis.

This paper will also present a real-world application of this methodology for Navy Training. A short demonstration of the simulation model will be presented with a summary of how the model was used to provide cost benefit analysis of information technology and support process modifications.

The sharing of information that is fostered by the TBMS architecture will increase capability and cost-effectiveness by increased interoperability and reuse of business process models and business simulations. Participants in the CNET TBMS project will have the benefit of using a one-stop shopping location for all modeling and simulation related materials. Common standards, methodology, ROI requirements, and validation and verification policies and procedures will also mark the architecture and will provide substantial payback. A system level view of business processes will be documented, validated, and available for future reference and training applications. Ultimately, the Navy will spend fewer resources on training process simulation development and analysis, and will benefit by more informed decisions through a robust training decision support system.

## AUTHOR BIOGRAPHIES

Sarah Aust is a Senior Consultant with Process Model, Inc. in Provo, Utah. She has ten years experience leading cross-functional teams in organizational development, computer simulation modeling, and business process reengineering. She has developed and taught multiple courses on Simulation and Quality Management implementation. She possesses a Bachelor of Science in Mathematics from Bowling Green State University, and is currently working towards a Master's Degree in Simulation Modeling and Analysis from University of Central Florida.

Mr. Scott Dunlap is the head of the CNET Assessment Project Office in Orlando, Florida. His office is part of the CNET Assessment Division in Pensacola that is responsible for CNET's Revolution in Training and Education and resultant reengineering initiatives. He holds a Master's Degree in Economics from the University of Central Florida. He has over 15 years of experience in the analysis and development of training systems for the Navy. He worked in the private sector and in the government as an Economist, and has served as an operations research analyst for the last five years. He was part of the team that established the Navy's Office of Training Technology, and served as the project manager for development of the Navy's OTT SPIDER web site. His team received Vice President Gore's Hammer Award for their work on the OTT SPIDER. Mr. Dunlap is currently a Council for Excellence in Government "Millennium" Fellow.

Steve Broussard is a Senior Staff Systems Analyst with Dynamics Research Corporation in Orlando, Florida. He is a 1972 graduate of the United States Military Academy and retired from the Army in 1995. He has 26 years of military leadership and management experience at all levels of the military hierarchy. His background includes four years of strategic planning and change management with OSD (Office of the Secretary of Defense) and the White House. While assigned to the Joint Staff, he participated in the redesign of the military's strategic command and control system. He has five years of experience teaching both undergraduate and graduate level courses in strategic planning and business process improvement, and an additional seven years of instructional design and training development.

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## THE NEED FOR A NAVY TRAINING DECISION SUPPORT SYSTEM

### Current Navy Constraints and Changing Environment

Sustaining Navy readiness through training is a complex and challenging enterprise. A typical day in the CNET claimancy sees 41,550 students at approximately 170 activities worldwide. CNET is responsible for the delivery and maintenance of over 3,400 courses. Every man and woman serving in the Navy today (and there are over 320,000 presently) is a CNET graduate. This training transforms civilians to Sailors, changes knowledge levels, skill sets, behaviors, and culture. CNET produces the intellectual capital that forms the core of Navy readiness.

CNET is actively pursuing new training strategies, methods, and technologies to include classroom automation, distributed learning, micro-simulator systems, advanced PC-based visualization tools, and homeport training. Although these training methods may provide sufficient training quality, dwindling budgets and pressure to train even more sailors better, quicker, and cheaper requires CNET to carefully consider the Return on Investment for the substantial cost of implementing any new training technology or method. CNET is aggressively searching for innovative approaches to better train individual sailors, and improve management of training, including the analysis of alternative strategies and technologies, and changing management of the supply chain (to include recruiting, selection, classification, distribution, assignment, and requirements determination) as well as day-to-day management operations.

New systems or processes put into motion must show short-term value as well as long-term usability and supportability. Just within the Navy Manpower, Personnel, and Training communities, there are many different tools and techniques used to conduct analysis, provide forecasts, and evaluate management decisions. These efforts generally follow a one-time use pattern (see Figure 1). Consequently, reusability for new efforts and interoperability with other on-going efforts are more difficult to maintain.

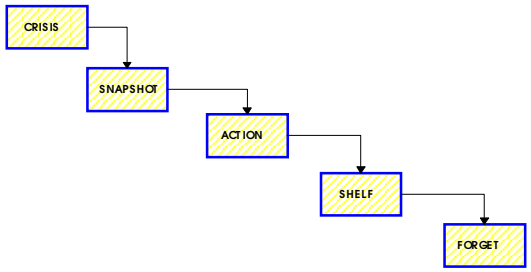


Figure 1: One Time Use Pattern

### A Systems Approach is Essential to Navy Training Improvement

Scott (1961) argued “the only meaningful way to study an organization is to study it as a system”. To better accomplish CNET’s vision of providing more knowledge to more sailors at a faster pace at less cost, one might suggest that if you optimize each training course, in terms of time to train, instructors required, cost efficiency, and quality curriculum, then

you would satisfy that vision. A course that is optimized and produces trained graduates faster is definitely an improvement. However, sailors usually attend multiple courses in a variety of sequences depending on the training objective. Without a systems approach, the sequencing of multiple "optimized" courses may not decrease the total time to train if the sailors do not efficiently move between the courses.

There are several key training metrics CNET is most concerned about: 1) the quality of training, 2) the time a sailor is away from the Fleet for training, and 3) the cost to train a sailor. The research and findings presented in this paper only address the cost to train a sailor and the time a sailor is away from the fleet. This analysis is conducted after CNET training experts have determined specific training options that provide quality training for the Navy.

The time a sailor is away from the Fleet for training purposes is tracked in several smaller subcategories:

1. Under Instruction (UI). The time a sailor is under formal instruction (i.e. actively participating in a course of instruction).
2. Awaiting Instruction (AI). The time a sailor must wait for the course of instruction to begin after arriving at the training location. This may happen because more sailors arrive for a course of instruction than available seats, and some must wait for the next course to begin.
3. Awaiting Transfer (AT). The time a sailor must wait to travel back to the Fleet after the instruction is complete.
4. Interrupted Instruction (II). This may occur because of something like a physical injury, holidays, natural disasters, or legal hold.
5. Individual's Account (IA) for training. The total time a sailor is away from the fleet for training. It includes all the above described training categories (AI +UI + II + AT).

The before suggested approach of optimizing each training course will optimize UI, but can drastically increase both AI and AT. To accurately address all critical metrics, we must take a systems approach for analysis.

### Navy Manpower and Personnel Communities Affect Training Operations

Because of the way the Navy is organized, this systems approach crosses several Navy organizations (see Figure 2). Within the Manpower, Personnel, and Training communities are six functional areas managed by five different organizations that all converge on the individual sailor. It is very difficult to get a shared mental model of the tooth to tail training production process. The significant business decisions made by one organization in any of these functional areas will impact the operations of another.

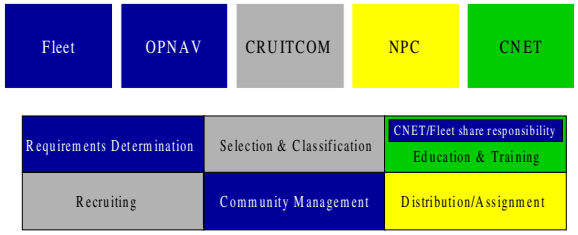


Figure 2: Functional Areas in Manpower, Personnel, and Training Communities

The training requirements are set by the Fleet and Chief of Naval Operations (OPNAV). These requirements change frequently due to changing missions around the world, and from rapid advances in military technology. The Fleet and Recruiting Command (CRUITCOM) provide the student input into CNET's training process. Training requirements are forecast far in advance, and generally CNET has little control over who shows up at the door for training. The current challenges in Navy recruiting have provided much greater diversity in the student population, meanwhile the dynamic Fleet demand for training varies unpredictably with operating tempo. The total training production process runs from raw material input (recruiting), to product planning (selection, classification), to development of the human capital (training and education), through product distribution (assignment and distribution). The result is a training production process wherein the input, demand, movement and distribution of "raw material" are beyond control of the producer.

## TBMS ARCHITECTURE AND METHODOLOGY DEVELOPMENT

### Rapid Business Model Development

Considering the size of Navy training operations, coupled with the complexities of both internal and external factors, CNET staff quickly realized an architecture and methodology were crucial to

effectively analyzing and improving training business operations. In a funding constrained environment, with ever-increasing pressure to implement solutions quickly, CNET staff saw the need to integrate rapid and low-cost business process model development.

Rapid and low-cost business process model development advocates quick turn-around prototype models very early in the process to "test" concepts and better define requirements. Traditional methods of system development often require many months of requirements analysis. This stage of development is designed to thoroughly understand the exact requirements of the new system. Once requirements analysis is complete, the developers would typically design a working prototype of the system to show the customer, which may take many more months. Too often, the customer is not happy with the results. Not because the designers did anything wrong, but because the customer did not really understand the requirement in the context of a complete system until it was seen as a prototype. This often results in frustration for both the designers and the customer, and requires a lot of rework. (Schrage, 2000).

Using the concept of Rapid Prototype development, the designers instead create prototypes as part of the requirements analysis phase. These down and dirty prototypes are rough in nature, but allow the customer to "play" with the design early in the development cycle and better understand true requirements. CNET staff found this approach to be very appropriate in a complex and quickly changing environment. This approach provided short-term value, but was not enough by itself to provide the long-term solutions required. In order to ensure the most effective use of analytical resources and reusability CNET looked to the concepts of HLA development.

**Leveraging High Level Architecture Concepts**

CNET was encountering many of the same issues HLA was created to address: "No longer was it affordable to develop a new simulation to address each new problem…It was no longer acceptable for multiple organizations to create simulations of similar systems…Often the largest cost of developing simulations was the hidden costs: understanding the system characteristics and validating the simulation." (Kuhl, 1999). Although CNET could not afford the time or dollars to create "truly" interoperable federates, they could benefit from leveraging the structured concepts of building an architecture, using standard methods of development and validation, and using an integrated product team approach.

**Training Business Modeling and Simulation (TBMS)**

CNET created the Training Business Modeling and Simulation (TBMS) program to provide an architecture or framework in which to fit all Training Business Modeling and Simulation efforts. It is an effort to standardize the methodology and tools involved with initiating, conducting, and reengineering business processes, and upgrading or purchasing new decisions support systems. The methodology will be infused into all business process reengineering and analysis efforts to "fly before buying" management changes.

There are many Commercial-Off-The-Shelf (COTS), as well as proprietary, simulation modeling tools. These tools provide continuous, discrete, and object-oriented modeling capability. Multiple organizations within the Navy are called upon to analyze and improve training and business operations. And like any statistical tool, two simulation models of the same process can show very different results depending on the level of fidelity, viewpoint, time period, modeling approach, and tool utilized. CNET staff decided to apply business process simulation in a structured environment using common tools and data collection processes to avoid the aforementioned problems.

The goal for TBMS is to standardize data produced from multiple efforts and provide "ground truth" to base "What-if" scenarios and make decisions based upon conceptually and operationally valid data, models, and simulations. The TBMS architecture and methodology is intended to provide a common framework for all analytical, modeling and simulation efforts of business processes and create

future interoperability of business process models, data, business rules, and simulation programs.

**The Training Business Area Resource Repository (TBARR)**

A major part of the TBMS architecture is creating a web-enabled, knowledge management tool. "Knowledge management essentially embodies organizational processes that seek synergistic combination of data and information processing capacity of information technologies, and the creative and innovative capacity of human beings" (Malhortra, 1998). Erik Brynjolfssn, a professor of information systems at MIT Sloan School, notes in *Information Week* (Sept. 9, 1996): "The same dollar spent on the same system may give a competitive advantage to one company but only expensive paperweights to another." Hence a key factor for the higher return on the IT dollar is the effective utilization of information as it relates to organizational performance. (Malhortra, 1998).

Any major change to Navy training business processes typically requires modification to the information systems that support those processes. Information Technology (IT) has had significant difficulty meeting the challenge due to the inherent complexities in "retooling" complex legacy environments. Navy training has over a dozen complex, legacy systems currently in place. It is critical to ensure a relationship between IT and business operations are formed early to determine system retooling strategies. A reciprocal cycle needs to be established where current systems analysis helps articulate the as-is business model while the redesigned business model dictates the impact on existing information architectures. (Ulrich, 1999).

The Training Business Area Resource Repository (TBARR) will provide the knowledge management medium for bringing together the business model of Navy training and the IT architecture. The first layer of the repository will contain an organic blueprint of Navy training to provide a common understanding of organizational functions. Process maps pictorially demonstrate process flows, which are linked to legacy functions, business rules, organizations, and resources. As processes are eliminated, added, and re-sequenced, links to legacy system functions are maintained in the repository.

The second layer of the repository will contain process-based simulation models of training operations. These simulation models will allow "What-If" analysis, to test potential solutions through simulation before costly implementation. Simulation helps avoid counter-productive and non-productive changes, both in strategy and implementation. In other words, managers will be able to "fly before they buy" their management decisions.

**Standard Methods to Ensure Success**

Historically, companies could separate business operations and underlying technology. This distinction is no longer possible. Both areas must be analyzed in an integrated fashion to understand current business processes. This involves analyzing the system, as well as human interaction with the system. It means involving the knowledgeable IT personnel as part of the business analysis team from the very beginning. However, involving such diverse knowledge sources also quickly leads to communication barriers and confusion.
A standard methodology needed to be developed to ensure effective communication and data integrity. This standard methodology was borrowed from the many years and lessons learned by the community developing simulation systems. If the Navy can build highly complex, physics-based simulators that operate together in a networked environment, then the same underlying process should also be useful in building business simulations. The TBMS standard methodology employs four major phases: Knowledge Acquisition, Knowledge Engineering, Conceptual and Operational Validation, and Redesign.

*Knowledge Acquisition* is gathering the right data, from the right data sources for the objectives at hand. Once a business area of Navy training is identified for analysis, a cross-functional team is formed. This team includes subject matter experts, IT professionals who understand employed systems, process modelers, and the process owner. Process diagrams are developed depicting the process flow, and a standardized data collection tool is populated with specifics of process flow, organizations performing the work, IT system involvement, and business rules.

*Knowledge Engineering* transforms the data from Knowledge Acquisition into computer simulation models for analysis. Once these models are validated and verified, they provide a baseline for comparison analysis. What-if scenarios can be executed to provide metrics on performance, cost, throughput, resource utilization, and cycle time.

*Conceptual Validation* is first performed on the process diagrams and populated data tool. This step validates the pictures are depicted correctly, relationships are understood, and data feeding the

simulation model is accurate. The second step is *Operational Validation*. This checks the resulting statistics from the simulation model against historic data to ensure the simulation model is truly approximating the behavior and results of the modeled operation. Once this validation is complete, the baseline simulation model is ready to be used for what-if analysis.

Using tools like simulation modeling provides accurate solutions to complex problems during the last phase of *Redesign*. Since IT professionals have been part of the team from the beginning, the proposed solutions are also realistic for implementation. The resulting information, process diagrams, data collected, and simulation models are placed in the TBARR for knowledge sharing and become key documents in defining requirements for future IT solutions.

## EXECUTING TBMS: NAVY TRAINING CONTINUUM AT HIGH-LEVEL

### Knowledge Acquisition

CNET choose to analyze the Navy Training Continuum at its highest level for the first TBMS effort. Using a cross-functional team composed of subject matter experts from multiple Navy organizations, IT professionals, and process modelers, a high-level model was developed for the Navy Training Continuum (see Figure 3). The color-coding represents functional control by different organizations in the Navy Training Continuum management process. A standard data collection tool was used to collect data elements relating to the training operations, to include IT data sources and systems, human interaction, resource constraints, cost, and business rules.

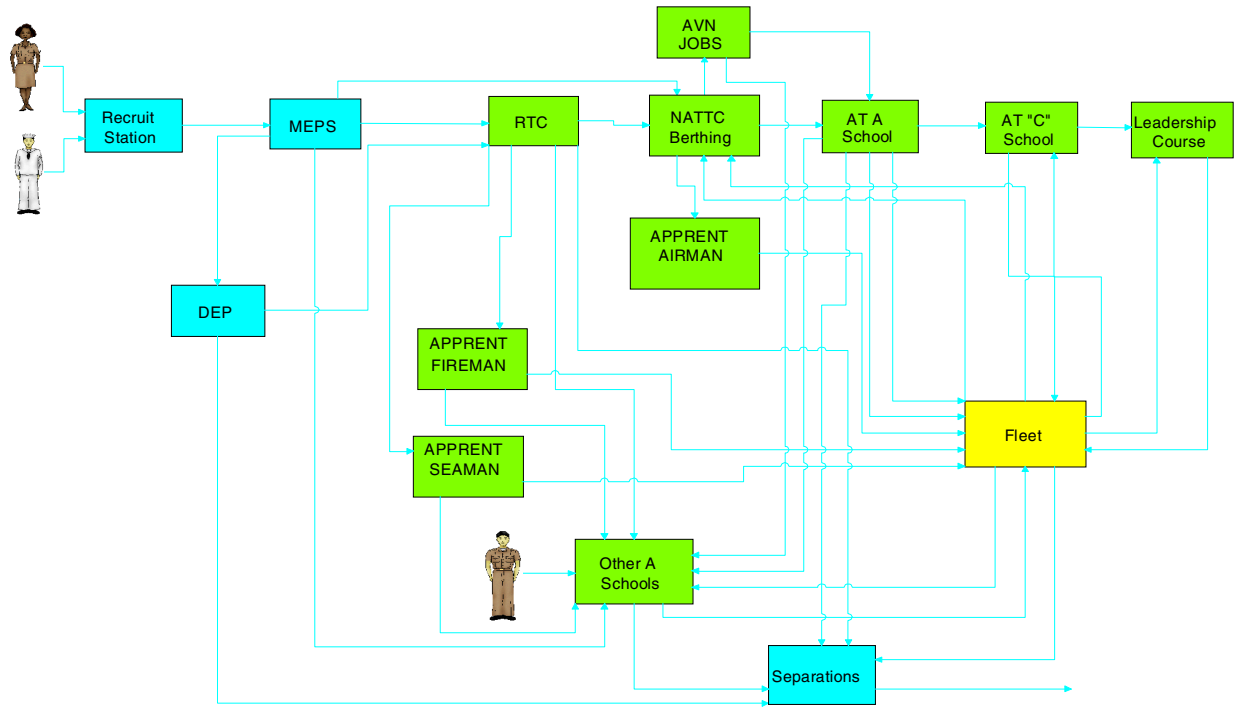


Figure 3: Process Diagram of Navy Training Continuum

### Knowledge Engineering

A process-based simulation model portraying the Initial and Sustainment Training Production Flow for one Navy rating was developed using off-the-shelf process simulation technology.

Using Simulation modeling is not a new technique to the military, and especially not for the training community. Many organizations have used forms of live, virtual and constructive simulation to train for years. With the recent technological breakthroughs, we are beginning to see a much greater use of

process-based simulation to provide organizational analysis and improve operations. In this particular case, simulation technology was necessary to perform adequate analysis because of the complexity and dynamics of the Navy Training Continuum process.

The model depicts the Navy Training Continuum at a high-level. It is one of ten simulation models that act in concert to dynamically simulate sailors moving through the Navy Training Production flow. Figure 3 is the overarching framework for the Navy Training Continuum, with hierarchical submodels depicting the details of operation (submodels not shown). When all models are considered together, a sailor has over 160 paths he could go through depending on his career field, aptitude, motivation and circumstances.

When a new recruit enters the Navy, he or she must first attend Recruit Training (RTC). Over 52,000 new recruits are sent to Recruit Training every year. From there, the sailor goes on to his/her initial training. There are multiple schools and locations a particular sailor might attend depending on career field and/or the equipment the sailor is to specialize on. Once initial training is complete, the sailor may continue on to other training, or go directly to the fleet. Again it depends on his career field. The scenario up to this point has multiple paths, but is fairly straightforward, and can be predicted and planned for.

The Navy's Training Continuum also supports Navy sustainment training. Many of the courses and schools utilized for initial training are also used for sustainment training. The changing needs of the Fleet are much more dynamic than the flow of new recruits, so predicting the training demand for specific courses becomes much more complex. As this process is happening, CNET also has an on-going flow of sailors from the Fleet requiring additional training. The Fleet's requirements are much more fluid and unpredictable, depending on current force structure, changing military environment, new ships, geo-political requirements, and many other variables. And lastly, CNET also trains Non-US Navy personnel, to include other United States government as well as foreign US military.

The complexity captured by this simulation model include:

- New recruits arriving during the summer months, creating a skewed arrival curve with much of the student flow bulging into RTC over the summer periods, then into follow-on schools during the first half of each year.
- Sailors returning to training from the Fleet, driven primarily by permanent moves to another permanent location, in which training is in route along the way.
- Additional training provided to non-U.S. Navy personnel (like the Marines), which also arrive on a similar distribution.
- CNET training functions generally manned on a level-loaded algorithm. In other words, they are manned assuming the sailors arrive evenly distributed throughout the year, which does not match true arrival distributions.

**Conceptual and Operational Validation**

Conceptual Validation was accomplished through a central website hosting all process model diagrams and related data. Using Internet technology, the team was able to open the process of conceptual validation to many other subject matter experts located at various installations.

Operational Validation was conducted using data from a historical period. The estimated simulation model metrics were compared to actual data from existing Navy management information systems.

**Redesign**

Once the simulation models were validated, several scenarios were modeled and compared for analysis against the historical period (Jun 97 – Dec 98).

The first scenario kept the CNET schoolhouses open to train over the Christmas holiday period. Normally, CNET shuts down training for two weeks over the Christmas holiday. While this boosts morale, the ripple effect of this temporary interruption of instruction induces a "bubble" of awaiting instruction that takes until March or April to work off in follow-on schools. The Navy was most concerned with the impact this would have on Awaiting Instruction (time away from Fleet, waiting to start a course of instruction). Figure 4 shows a cumulative ten man-year reduction of AI when training is offered throughout the year.

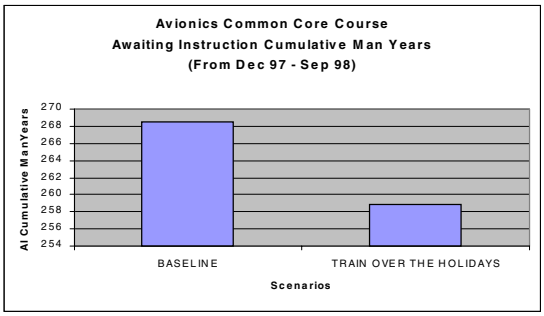


Figure 4: AI Comparison for Holiday Training

The second scenario added 5000 new recruits to the aviation electronics technician-training course during the summer months. Figure 5 shows a cumulative increase of over 300 man-years on AI when these additional recruits are added during the busiest training time of the year. Recall that Recruit Command often finds they can make up for a lean winter by recruiting numbers in the summer when most high school graduates are available and willing to join the Navy. This is a scenario is a very realistic and cyclical event that CNET experiences almost every summer.

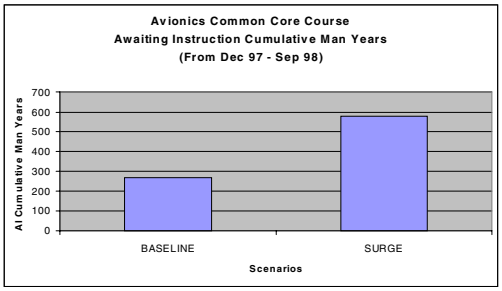


Figure 5: AI Comparison for Training Surge

The third scenario shows the impact of Temporary Duty Under Instruction funding constraints. This funding provides for the travel of sailors back to the Fleet after completion of training. When this funding is not available, sailors must wait at the training location after graduation until funding becomes available again. This scenario shows an impact of 10 additional days added to each sailor's Individual's Account (the total time spent away from the Fleet at the training location), because funding was not available from July through September.

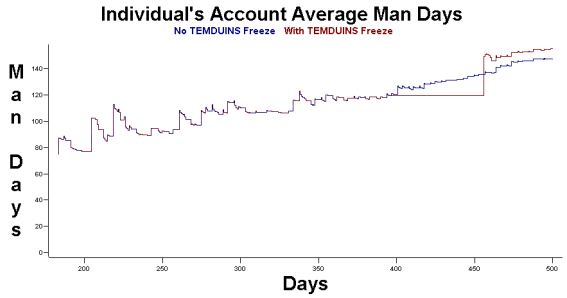


Figure 6: TEMDUINS Impact on Individual's Account

The long-term goal is to complete the system level production model of all Navy ratings and officer designators. These models are intended to become part of a larger Navy Manpower, Personnel, and Training Decision Support framework, and will incorporate data from key Manpower, Personnel, and Training (MPT) information systems.

## CONCLUSION

The first TBMS effort of analyzing the Navy Training Continuum at its highest level proved very successful. The TBMS methodology has now been applied in numerous CNET reengineering efforts from recruit berthing to IT system requirements determination. CNET has begun to standardize data, algorithms, process models, and business rules produced from multiple business process reengineering efforts. The underlying architecture in which the data is collected, categorized, stored and accessed defines the long-term value of this new and innovative way to solve complex problems in systems that are far too difficult to represent in spreadsheets.

TBMS has evolved into a hybrid combination of HLA concepts, leveraging a structured approach of model development methods and architecture, and rapid business model development. While the rapid business model development provides the short-term value of immediate solutions, the structured methodology and architecture provides long-term gain in reusability and training. Implementing the TBARR will provide the knowledge management tool necessary for bringing together the business and IT architectures. The TBMS architecture and methodology will pay huge dividends in improving all participants' understanding of the training production process and ensuring that future IT and BPR efforts take the system view of the production process into consideration.

**REFERENCES**


Hansen, G. (1996). What are Modeling and Simulation? (online) Enterprise Reengineering. <http://www.reengineering.com>

Kuhl, F., & Weatherly R., & Dahmann J. (1999). Creating Computer Simulation Systems. Upper Saddle River, NJ: Prentice Hall PTR.

Malhotra, Y. (1998). Knowledge Management for the New World of Business. Asian Strategy Leadership Institute Review, vol. 6.

Profozich, D. (1998). Managing Change with Business Process Simulation. Upper Saddle River, NJ: Prentice Hall PTR.

Schrage, M. (2000). Serious Play. Boston, MA: Harvard Business School Press

Scott, W. (1961). Organization Theory: An Overview and an Appraisal. Academy of Management Journal, 4, 7-26.

Ulrich, W. (1999). System Transformation. (online). Tactical Strategy Group, Inc. <http: www.systemtransformation.com>

Sagan, D., & Kersey, D. (2000). Conceptual Modeling Lessons Learned from WARSIM 2000. (Paper 00S-SIW-052). Orlando, FL: Proceedings of the Simulation Interoperability Workshop.