SEAS

Neptune

NAVAIR Supply-chain Modeling

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Business wargaming is the management counterpart of combat simulation (as shown in Figure 1), where battles are fought in marketplaces rather than battlefields, and where the main players are people and programs (manufacturers, distributors, resellers, and business customers) and jobs or organizations rather than aircrafts, tanks, and ships. Business wargaming allows experimentation of alternative management (versus battlefield) decision-making policies under pre-specified scenarios, e.g. what effects going direct have on market share, and subsequently on company's revenue and profit?

Another major difference between business wargaming and combat simulation is the technology used to build each. As opposed to the top down, discrete event approach favored by combat simulations, business wargaming uses bottom up, agent-based simulation wherein software agents programmed with rules of engagement represent individuals or organizations. In this world, human players represent organizations, and the collective behavior of the individual software agents model markets and market forces.

Business wargames can take the form of a standalone game such as the popular commercial product, SimCity, or of a multi-player game. NEPTUNE is an example of a synchronous, multi-player game, that is, all players must be on site. The environment that facilitates the simulation game is called the Synthetic Environment for Analysis and Simulation (SEAS), which has been developed over the past five years at Purdue University.

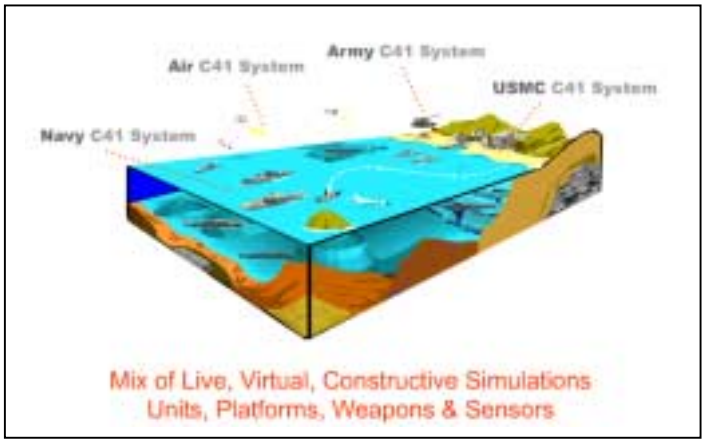

Figure 1. The Department of Defense wargaming environment. It consists of a synthetic terrain on which three classes of entities interact. These entities are live (e.g. a live army exercise somewhere in the Mojave Desert), Constructive (e.g. a person in a flight simulator or a tank simulator) and virtual (software agents). This environment enables DOD to simulate a theatre level of war with a small number to people.

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SEAS is a result of six years of research and development at Purdue University's Krannert Graduate School of Management. The United States Department of Defense and many other business and government organizations collaborated in the development of SEAS. SEAS seamlessly incorporates all aspects of managerial decision-making to provide a complete and integrated view of economies, industries, and organizations.

The following are some of the essential features of *SEAS*:

Technical features

- It is a **web-based** distributed computing environment that is robust and fault tolerant
- It employs a state-of-the-art networking, collaboration, data-warehousing and knowledge management technologies
- It employs genetic algorithms that allow for re-configurable systems. One can customize its framework and the rules of engagement (such as organizational behavior rules, trading rules, regulatory constraints, and foreign policy) to the users exact needs using a high-level interface, and **dynamically alter them during a LiveCase exercise.**

Economic features

- It can model the **global economy** as a collection of inter-linked national economies, and each national economy can be **governed independently**
- It can model an arbitrarily large number of **configurable and inter-linked** goods and services, labor, asset and foreign exchange markets
- Its production and demand processes can be **arbitrarily complex and can be plugged in seamlessly**
- It can incorporate all the essential features of the government, including the legislative, executive and judicial branches.
- It can incorporate external and environmental variables pertaining to technical change, growth or societal shifts

Management features

- It supports a full complement of management functionalities such as strategy, production, marketing, finance, and human resources. In addition, one **can configure SEAS to model any firm, in any industry, in any economy at any level of detail**
- It can incorporate quantitative relationships as well as qualitative relationships which are calibrated using actual data and can be updated in real time as new data emerges either in the real world or in the simulation

Organizational features

- **It records participants' every action and communication**
- It can accommodate **large numbers of human and artificial agents** playing in the same setting.
- It provides high level decision making and analytical tools to every participant
- It allows teams to collaborate internally by sharing the various decision making functions across several different entities

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- It has a highly evolved **visualization and decision support system** that allows the human players to rapidly assimilate and use the large quantity of real time information generated during the LiveCase.

PROJECT NEPTUNE

Navy has no such counterpart yet in its business arena, especially for major process re-engineering that comes with enterprise resource planning (ERP) implementations. However, there is plausible justification for viewing the spectrum of investment and re-engineering issues from a battlefield perspective, particularly in light of current dynamic geo-strategic environments and those envisioned well into the future. For example, rapid technological innovations are giving rise to new business models such as business-to- business exchanges, e-hubs, etc. Typically, policy issues are addressed on an isolated, model-by-model basis. For example, the question, "where should depot be located?", may elicit development of a depot location model. This problem may be analyzed in minute detail but the means for assessing the larger issue of the impact of depot location decisions on overall readiness, for example, is never engaged because the models can't be linked easily, if at all.

Succinctly, there is as yet no re-engineering/ERP/B2G game equivalent to combat simulation where Navy policymakers can ask overarching "what if" questions:

- What is the ERP/B2G business model for NAVAIR and NAVSUP?
- What impact changes in business models has on readiness and costs?

The benefits of such a system are self-evident. As in combat simulation, the NAVAIR/NAVSUP simulation can provide an environment where critical policy decisions can be modeled, assessed, refined, and more fully understood prior to implementation. The ultimate outcome is an integrated, high-level perspective on the dynamics of ERP/B2G implementation and its impact on inventory levels, costs, and service level guarantees.

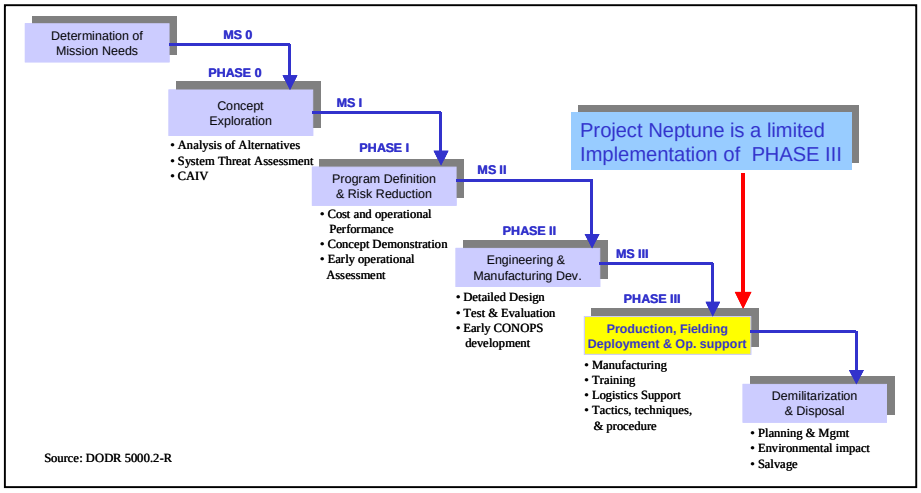

Figure 2. Project Neptune is a limited implementation of PHASE III of DoD's Acquisition Guidelines

The purpose of the Neptune Project is to maximize the results obtained from the SAP implementation by moving beyond ERP inventory management to supplier relationship management. A second goal is to better understand the relationships within the NAVAIR value chain, what decisions members of the value chain make and the potential impacts of these decisions upon the balance

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between fleet readiness and cost. Neptune partially simulates Phase III of the DoD acquisition management as shown in Figure 2.

This simulation is designed to replicate the procurement decisions made by NAVSUP and how these decisions impact upon the balance between fleet readiness and cost. The initial simulation will address two scenarios. The first scenario models the impacts of inventory level decisions upon the cost of managing inventory and the risk of decreased fleet readiness. The second scenario will model the creation and use of a simulated E-marketplace upon the cost of managing inventory and the risk of decreased fleet readiness.

Differences between the two scenarios highlighted include:

- Access to multiple vendors
- Decreased product costs
- Decreased transaction costs

NEPTUNE BUSINESS MODELS

We create a synthetic economy to evaluate different business models. The design of the Synthetic Economy was as follows:

In the SEAS environment, we create a partial economy representing the defense aerospace industry and populated it with three classes of agents played by human players – NAVAIR, NAVSUP, and Manufacturers. The interaction between these players is shown in Figure 3.

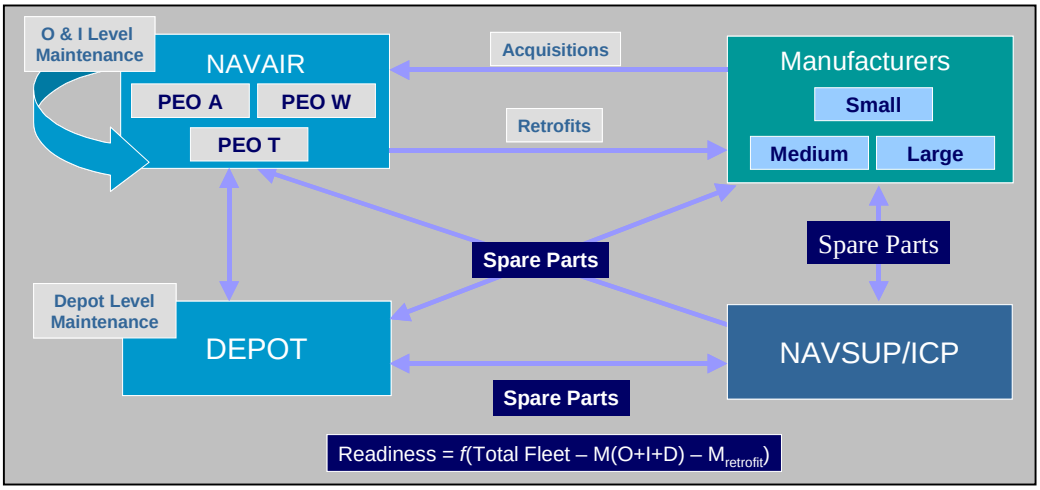

Figure 3. Neptune Game Board. We use available data to create calibrate the synthetic economy.

NAVAIR is represented as two classes entities – the program executive office (PEOs) and Depots. Individual roles of these players are listed below:

NAVAIR's PEO Roles:

- Perform repeat and program buys from Manufacturers
- Purchase spot parts from NAVSUP
- Purchase services from Depot
    - DEPOT maintenance
    - Retrofits
    - Remanufactures

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NAVSUP's Roles:

- Purchase parts from manufacturers for PEOs and DEPOT
- Spot purchases
- Also provide
    - Inventory pooling
    - Rapid availability times
    - Improved unit readiness
    - Volume purchase discounts

Manufacturers' Roles:

- Sell program and repeat buy items to PEOs, ICP
- Perform Retrofit maintenance on PEO fleets
- Sell spot parts to NAVSUP

We implemented three different business models to accurately depict the business processes employed by NAVAIR and its relationship with NAVSUP and manufacturing firms. The models include procurement model, acquisition model, and business-to-business model. These processes are shown in Figure 5Figure 4, Figure 5, and Figure 6.

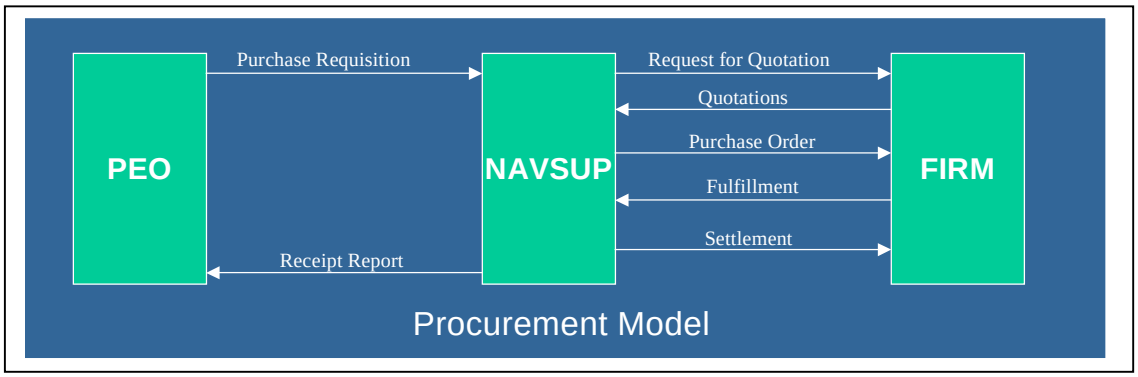

Figure 4. Workflow between NAVAIR'S program office, the firm and NAVSUP in the procurement model. This business model is used after fielding of the weapon system and used for purchasing spare parts. In this model, most of the interaction is between NAVSUP and the firm.

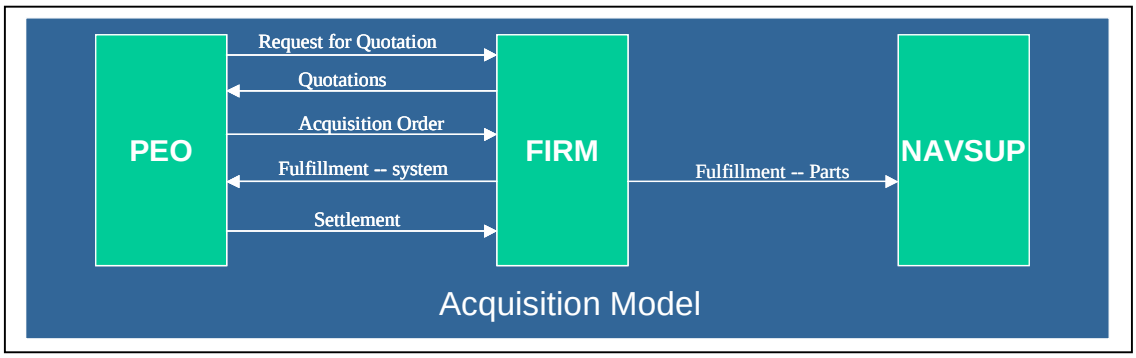

Figure 5. Workflow between NAVAIR'S program office, the firm and NAVSUP in the acquisition model. This business model is used for new programs. Here most of the interaction is between the PEOs and the Firms.

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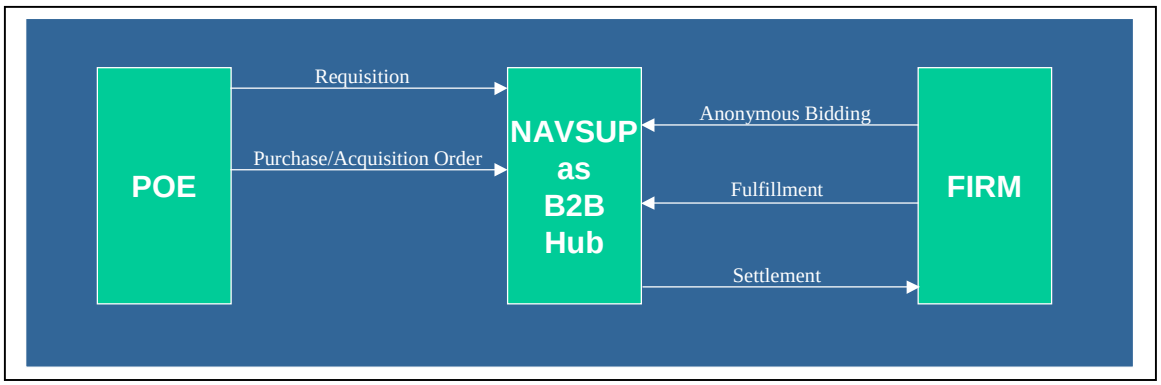

Figure 6. Workflow between NAVAIR'S program office, the firm and NAVSUP in the B2B model. This is "to- be" model. In this proposed model, NAVSUP is being used as business-to-business hub.

ARTIFICIAL AGENT MODELING

We create artificial agents to represent four different types of aircrafts in the synthetic partial economy of the defense aerospace industry. An individual artificial agent represents each aircraft. Each aircraft consist of four components -- avionics, life support, missiles, and targeting systems. Each component has a unique mean time between failures (MTBS) and the minimum MTBS represent MTBS of the composite agent.

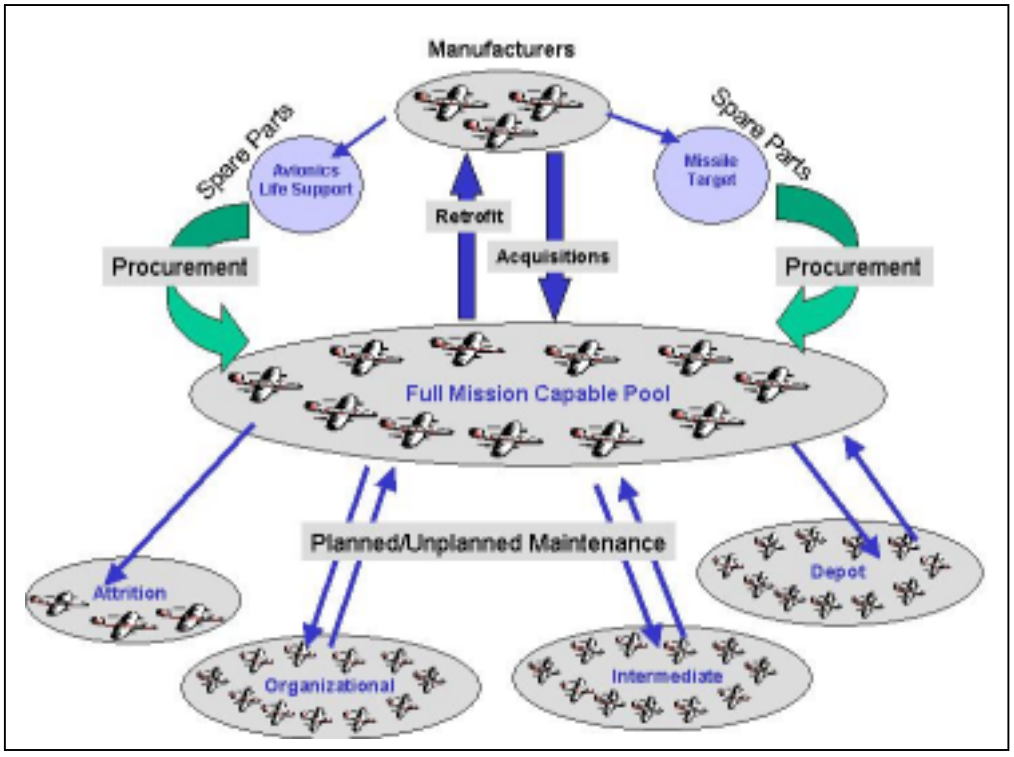

Figure 7: Aircraft Artificial Agents flow model

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The flow of agents in the synthetic economy is shown in Figure 7. When new aircrafts are acquired, they move from manufacturers' pools to NAVAIR's full mission capable pool. These aircrafts stay in that pool and perform missions. The usage and the failure rates are calibrated based on real data. Based on the type of failure, an agent can move to one of the three pools – organizational, intermediate, or depot for repair. The meantime to repair (MTR) depends upon availability of spares and other resources such as technicians and facilities. Based on certain probability, an aircraft may also end up in the attrition pool and get out of the system. The attrition probability depends upon the operation tempo or OPTEMPO as well as the scenario – peacetime or combat.

The agents are structured as to take into account the following:

- Locate and deliver newly arrived acquisitions (new agents)
- Deliver components that have been ordered in previous rounds
- Check for any Maintenance pools that might be awaiting the arrival of components into inventory
- Return any agents that were in a Maintenance pool to the FMC pool upon the completion of needed repairs
- Determine how many agents of each type need to be sent to the attrition pool.
- Determine how many agents of each type need to be sent to each of the Maintenance pools (Organizational, Intermediate, & Depot) for planned/scheduled maintenance.
- As agents are moved to maintenance pools, determine which component has failed.
- Once it has been determined that a particular part has failed, determine whether or not the component is in inventory.
- If so, the agent is given a return date and the inventory for that component is decremented accordingly.
- If not, an emergency order is issued for the declared non-quarterly number of components and the agent is put on hold until those parts are delivered. The player is penalized through a higher fee for delivery.
- At the end of the quarter, the average overage or shortage cost is determined for the player. This is then used to determine the cost of capital for the quarter in order to judge the player's performance.

METRICS

Two critical measures of effectiveness were developed for the simulation. They are readiness and cost.

Readiness.
The overall readiness of the fleet is calculated as follows:

R = (Full Mission Capable)/Total Number of Aircrafts
F = T-(O+I+D+A)
Where,
F = Number of full mission capable aircrafts
T= Total number of aircrafts in the fleet
O = Number of aircrafts grounded for Organizational maintenance
I = Number of aircrafts grounded for Intermediate level maintenance
D = Number of aircrafts grounded for Depot level maintenance
A = Number of aircrafts lost

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Costs.
Several costs components are incorporated on the simulation.. They include

- Unit cost – this is a static cost for each component or agent
- Shipping cost – This cost is adjusted based on the priority of the shipment. Example, emergency orders incur a higher shipping cost than regular orders.
- Transaction cost – at the present, this is a cost that can be supported but has not currently been implemented.
- Overage cost – this cost is computed by figuring out the average overage (daily units of inventory in excess of 0) for the quarter. This amount is then multiplied by the unit cost of the component and then by 5%. This cost is used to represent the cost of capital for the organization. It dissuades the player from merely carrying a large amount of inventory to avoid stock outs.
- Shortage cost – this cost has not yet been fully developed

BUSINESS PROCESSES

Business processes implemented in Neptune are: Planning, Status, Markets, Finance, and Measure of Effectiveness (MOE). Core processes and their respective sub-processes are shown in Figure 8. Their screen shot is available in Appendix A.

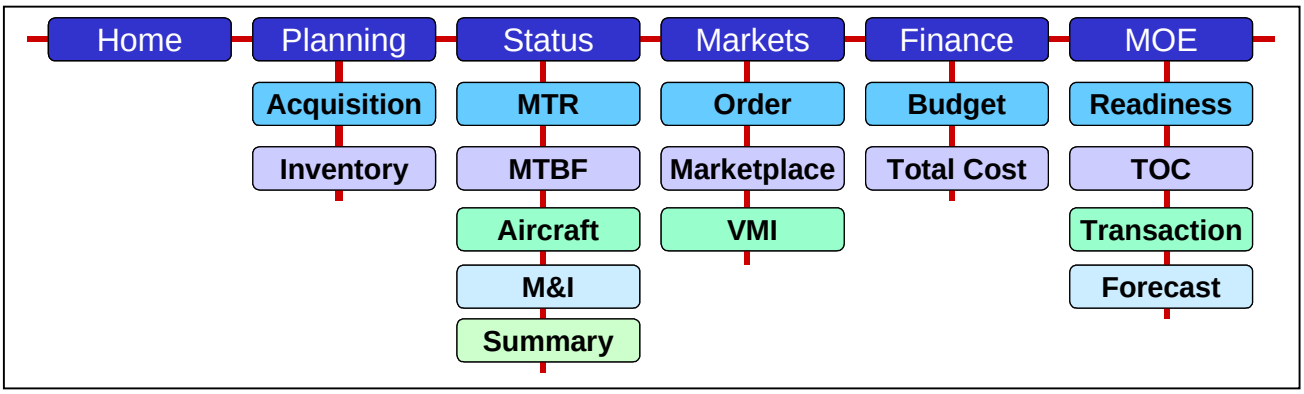

Figure 8. Neptune's Business Processes

NEPTUNE LIVE CASE

Neptune live case was conducted at NAVAIR's Enterprise Solution Program Office (ESPO) at Pax River base, MD.

The live case focused on how various entities in the Navy's value-chain functioned and interoperated under differing external conditions. The goal of the exercise was to provide an increased participants' insight and awareness into the following issues:

- Adoption of different e-biz models in response to the changes in environment.
- Interaction among the various entities in the value chain (e.g., NAVAIR, NAVSUP, Manufacturers);

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- Nature of conflicts and their implications;
- Effect of B2B exchanges on Navy's and manufacturers' measures of effectiveness.
- How sustainable are these business models?

As such, the focus was on the *process* rather than the *outcome*. Thus, the outcome of any particular engagement which may arise in the simulation was of less concern than the tradeoffs and decisions which the various players made in the process of responding to other participants' moves, and the effects those tradeoffs and decisions had upon the other players in the game.

Data from several sources were used to populate and configure the Neptune's synthetic economy for Live Case. Data used to calibrate the behavior of artificial agents came from the data provided by the Navy. Company and product specific data came Annual Reports, SEC filings, Company Websites, and published materials. Critical agent behavior data were verified from different sources. Missing data was obtained by interviewing industry experts and Navy personnel.

Once the economy was populated, agents' behaviors were calibrated and verified against a few known scenarios to create the SEAS virtual execution environment.

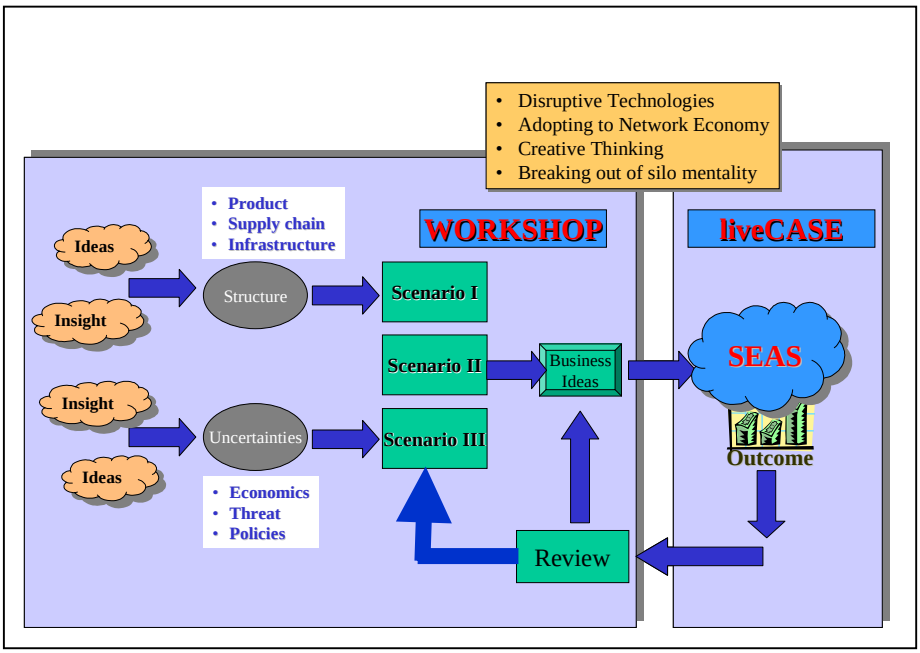

Figure 9: The live CASE methodology uses a combination of workshop and computer-based simulation for maximum impact.

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Figure 9 describes the methodology adopted for the exercise. The exercise comprises of several steps; some involve facilitated workshops and the others involve computer-based simulation. The first step involves ideas and insights generation. In this step, participants bring forth their own ideas, insights and understanding of the issues facing NAVAIR, NAVSUP, and the Manufacturing firms as a whole. The second step involves testing these ideas and insights under different structures in a facilitated workshop. In addition to the structure, the ideas and insights are also tested for robustness against peacetime and combat scenarios representing different levels of uncertainties. The fourth step involves the development of different options and business ideas. The fifth step involved testing the business ideas in SEAS' synthetic economy. The sixth and final step involved after action review, in which participants discuss their moves, counter-moves, outcomes and refine and develop new ideas.

OUTCOMES AND LESSSONS LEARNED

It was clear from the live case that a single business model for all types of acquisition and procurement processes would not work. Different items on inventory have different risk and cost profiles. Based on these profiles, four classes of strategies emerged as shown in

Figure 10.

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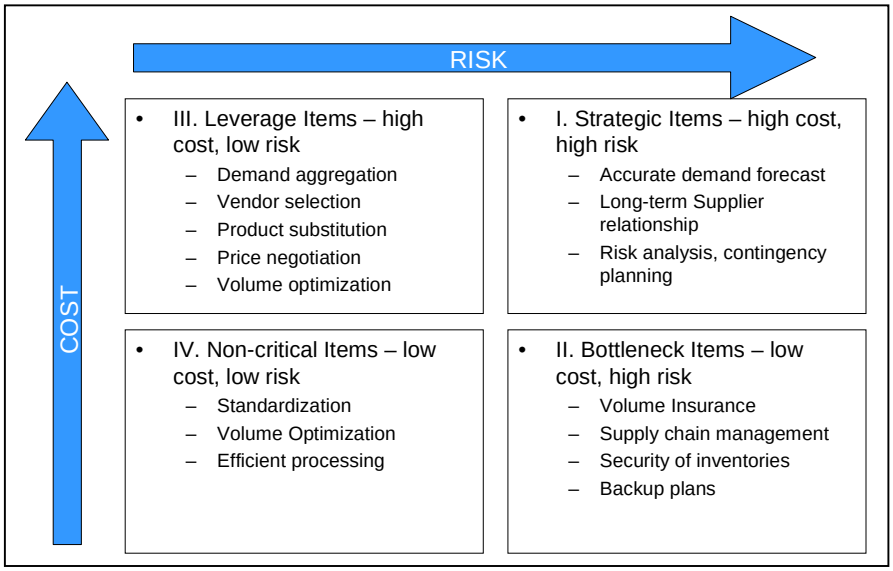

Figure 10. Supply management strategies.

Lessons from the live cases indicate that there could be substantial savings from using the above supply management strategies as shown in **Figure 11**.

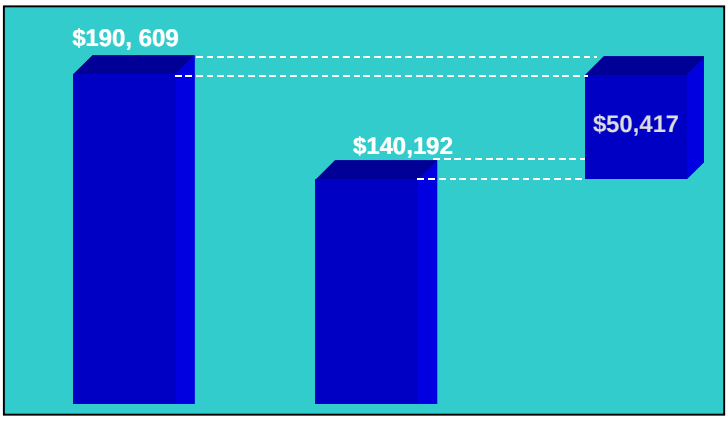

Figure 11: Potential savings from the implementation of supply management strategies

APPENDIX A: Neptune's User Interface

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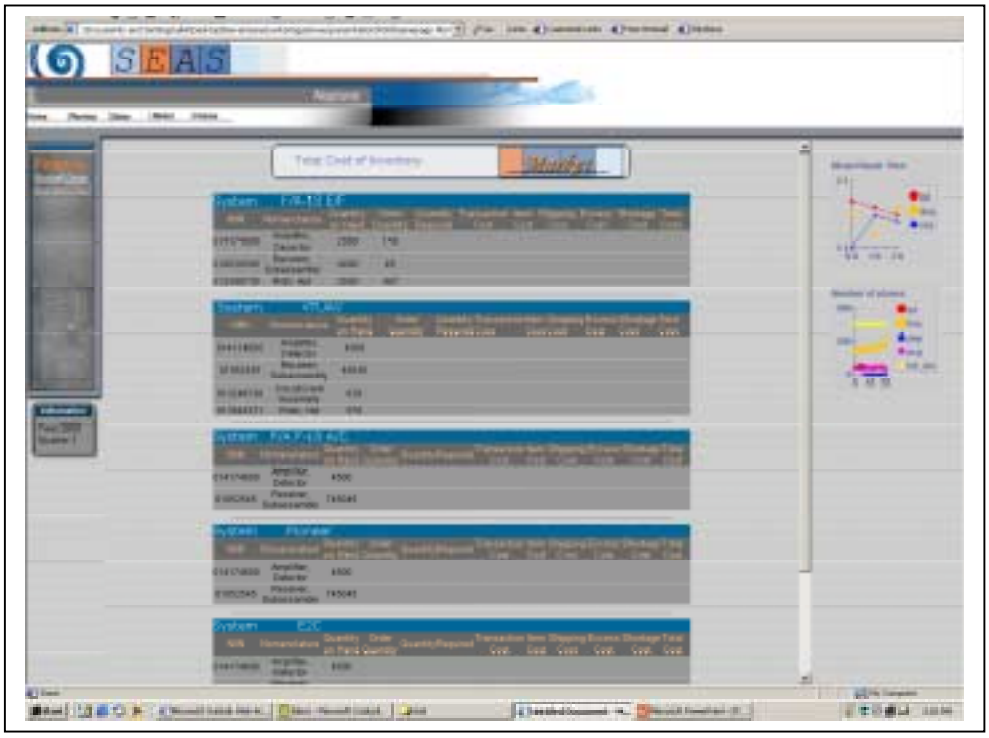

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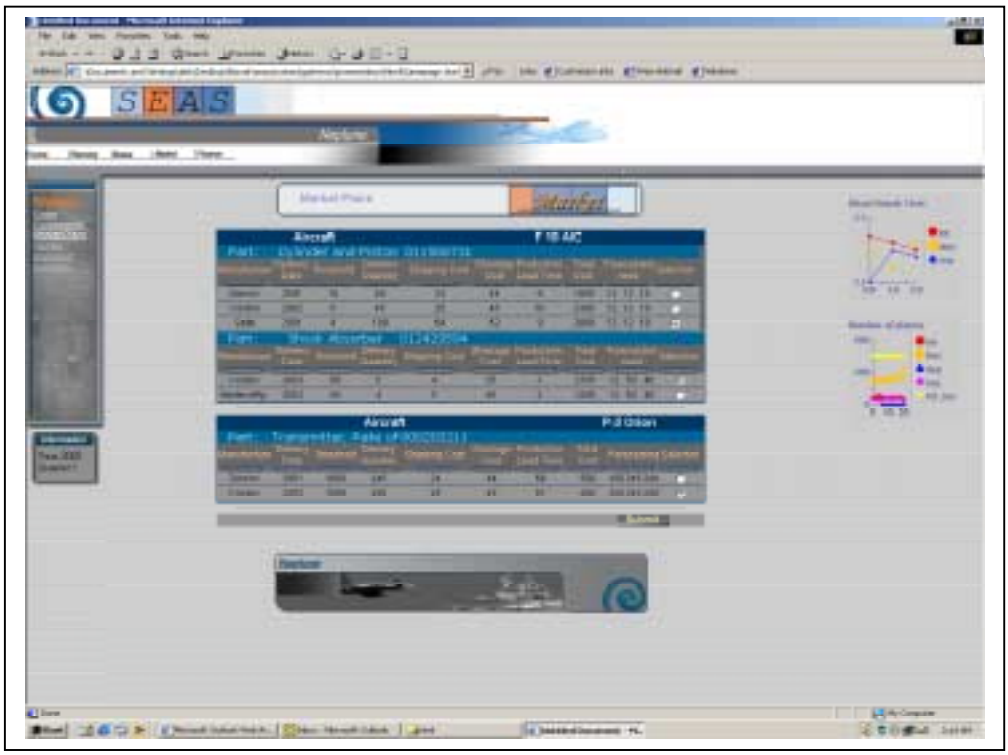

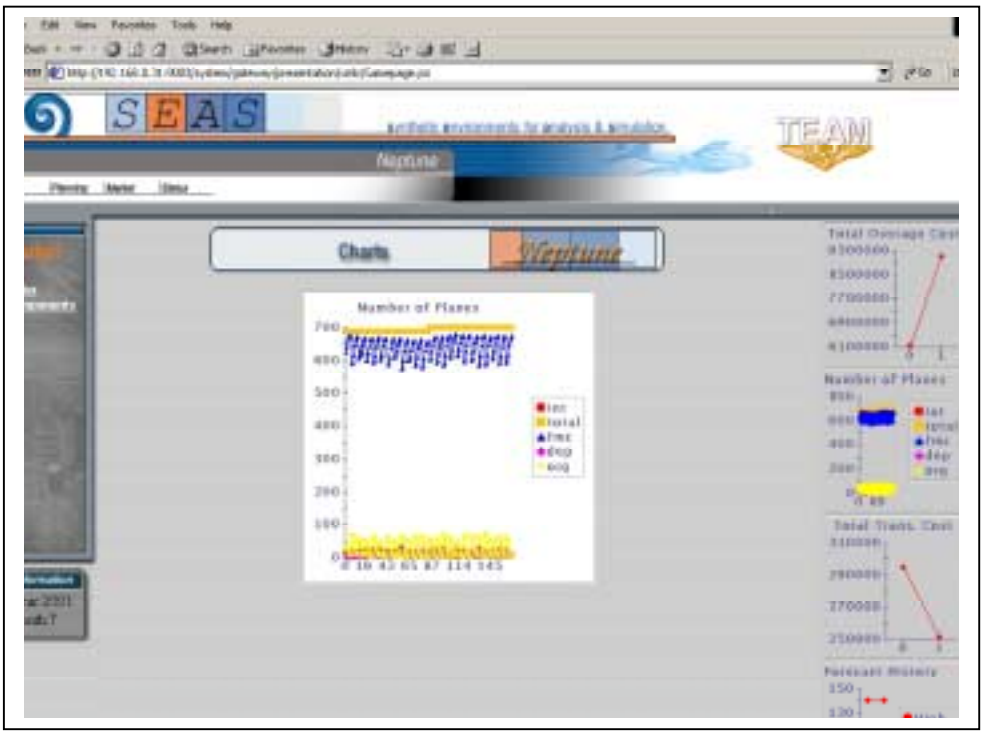

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