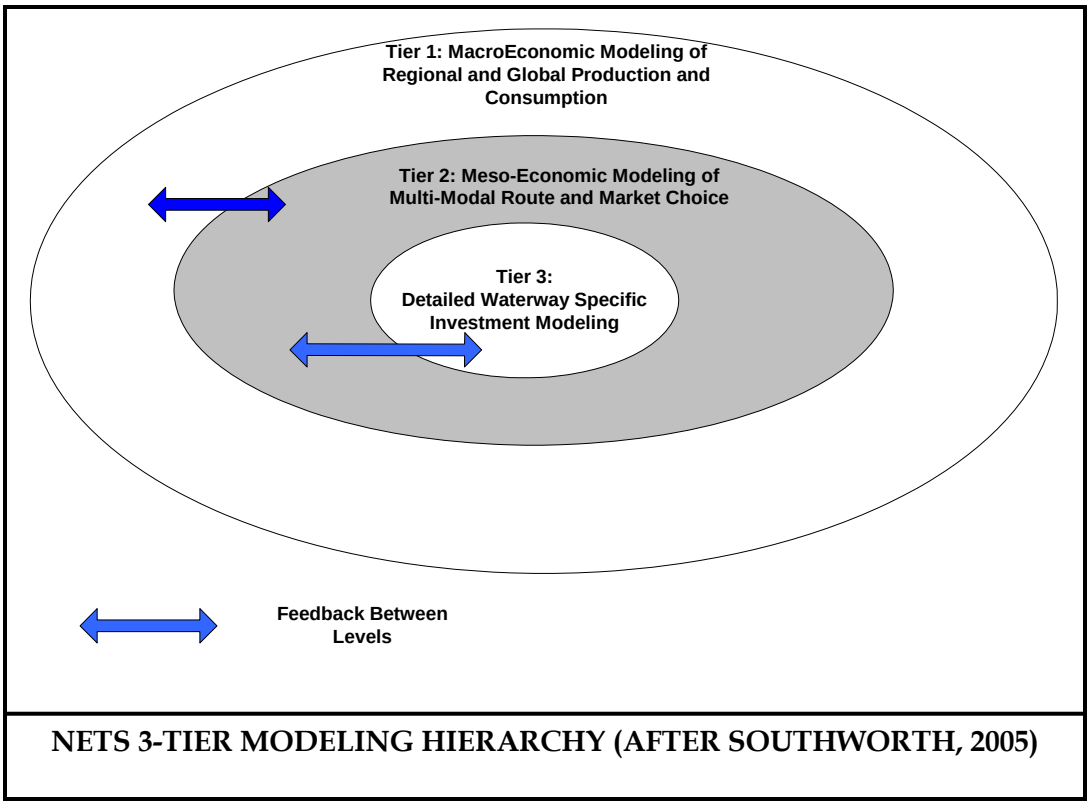
NaSS Status Summary Report
September 2007

The purpose of this report is to provide a review of the status of major work items associated with the Navigation System Simulation Model (NaSS) which is the Tier 3 model shown below.



NETS 3-TIER MODELING HIERARCHY (AFTER SOUTHWORTH, 2005)

Schedule and Costs

Model development began in April 2006 and is expected to continue through September 2008. The amount of funding received was significantly constrained in FY 07. In addition, FY07 funding was delayed due to lack of a timely appropriations bill. The funding shortfall and delay has resulted in a project which will not meet its originally scheduled completion date of September 2008. FY08 scopes are currently being negotiated, but it is apparent some major aspects of the model, as originally envisioned in the Design Document, will not be completed by the end of FY08. The NETS program has been extended into FY09 which should provide adequate capability to complete this effort.

Design Document Vision

The July 2006 NaSS Design Document envisioned the following major NaSS components and capabilities.

1. System Network Model
2. Investment Optimization Model
3. Data Analyzer-Preprocessor
4. Agent Based Prototype

The status of each of these components follows.

System Network Model

The Design Document envisioned a model with the following capabilities.

- Vessels would move through a series of user defined reaches and locks.
- Vessels would be driven by commodity demand.
- Equipment inventory could modeled as a constraint.
- The modeled system could have a number of refleeting nodes where barges could be exchanged between towboats.
- Shipper response, based on the Wilson-Train method, would be incorporated into the system model.
- The user could select among several alternative lockage process levels of detail, from very simple to highly complex.
- The lock chambers could be made unavailable due to scheduled or unscheduled reliability based closures.
- The user could select among several available lockage policies. The model would select the "best" of these policies as the simulation progressed.
- The system network model and optimization model would be integrated.
- A prototype level Agent Based model which would be created.

System Network Model Status

Reaches and Locks

A test bed waterway consisting of the entire Ohio River Basin including tributaries has been defined for development purposes. Reach transit rules such as no passing and no overtaking have been implemented. Since the waterway contains loops, a shortest distance routing algorithm selects the shortest route. Alternative measures for selecting the best route can be easily implemented.

Locks are implemented as a special reach type. They are modeled as single or dual chamber facilities, as appropriate, and use a FIFO lockage policy to process vessels. Work has begun on a Detailed Lock model representation of locks. Two other less simplified lockage representations should be complete by the end of CY 2007.

Vessel Movement

The team has taken a spiral approach to vessel movement specification. We envision four different vessel movement schemes which will become more complex as development progresses. A prototype level Direct Shipment List has been implemented and a less simplified DSL should be complete by the end of CY07. The statistically generated shipment list and commodity demand driven shipments are CY08 activities.

Prototype Direct Shipment List

The team devoted a great deal of thought into development of a shipment list which would be valid over a large river system. The Corps Center of Expertise for Inland Navigation had never been able to "crack this nut" within a simulation context. Finally, after much thought and discussion, a serendipitous solution was discovered while discussing vessel animation. The team had a meeting with Tennessee Valley Authority personnel where it was pointed out that towboats are usually dedicated to operating on only a small portion of the inland river system, and that a barge may be picked up and moved along its way by several different towboats before the barge actually reaches its destination. During a discussion of how best to animate towboat and barge movements we discovered the method could also be used to generate movements which would drive the simulation. In this way the team moved from a paradigm where a towboat moves a set of homogeneous barges from origin to destination, to a paradigm where towboats make trips which may be independent of the barge's ultimate origin and destination.

Once we made this paradigm shift, we generated a prototype level direct shipment list that mirrored the movement of all towboats and barges in the Ohio River Basin for the year 2004. At the end of FY07, the system network model is drive by this prototype level direct shipment list which consists of approximately 51,000 towboat trips and 130,000 barge movement legs. Test runs were made where the entire 2004 shipment list was simulated. This simulation took about 81 minutes of clock time.

More Advanced Shipment Lists

The prototype DSL was a simplified proof of concept version which made certain simplifications regarding barge types. The DSL2 will eliminate these simplifications so barges will be fully defined by type, length and width. This information will be needed when we add more detailed lock processing representations to the model. After we have created DSL2, we will use that shipment list to gather statistics which will be used to

create the statistically generated shipment list and ultimately the commodity demand driven shipments.

Equipment Reservoirs

The concept of equipment reservoirs has been implemented. When a towboat or barge movement begins, the towboat or barge is removed from the pool of available equipment. When the movement ends, it is put back into the pool of available equipment. At the present time, equipment pools are maintained at the node level. However, the model is designed to allow combining of individual node pools into larger "area" equipment pools. At the current time we do not let equipment unavailability hinder initiation of a movement, we simply make a note that a piece of equipment was not available and one was created. True equipment constraints will be implemented in FY08.

Refleeting

The concept of some nodes being refleeting nodes and others being topological nodes has been overtaken by events. In essence, every node is a potential refleeting node where barges can be picked up or dropped off.

Shipper Response

Shipper response cannot be addressed until we have implemented the commodity driven shipment specification.

Lock Processing

The most simplified form of lock processing has been implemented. Lock processing time is represented by two cumulative distribution functions for each vessel type, one for upbound movements and one for downbound. The lock has a queue which can be used to store vessels until they are removed from queue based on a first in - first out policy.

Development of a Detailed Lock Model began in May 2007. The Detailed Lock Model is the most complex lock processing system envisioned in the Design Document. It will have all the capabilities of the Corps Waterway Analysis Model but will not be constrained by WAM's shortcomings. The Detailed Lock Model and System Network Model are being developed by two different teams. As a result, integration of the Detailed Lock Model with the System Network Model is of paramount importance. By the end of FY07 we expect to fully integrate a "simple" Detailed Lock Model with the System Network Model. From that point on, the Detailed Lock Model team can proceed

secure in the knowledge that their model can be integrated with the overall System Network Model.

Scheduled and Unscheduled Lock Closures

Scheduled lock closures are currently implemented at the chamber level. Unscheduled closures based on component reliability are being implemented as this document is being written, and should be functional by the end of FY07.

Lock Service Policies

At this time, First In – First Out is the only functional lock service policy. Additional service polices will be developed as part of the Detailed Lock Model work effort. By the middle of FY08, we expect all service policies specified in the Design Document to be implemented.

System Network – Optimization Model Integration

This is one of the items impacted by FY07 funding shortfalls and delays. Although FY08 Scopes of Work are not finalized, it appears this item will not make the FY08 activities list.

Optimization Model

Development of the Genetic Algorithm Optimization model and its associated simulation model occurred in three phases of development over approximately 2 years. During this time standard genetic algorithm optimization techniques were modified to address the specific problems faced by Corps of Engineers Planners. Corps specific modifications include:

- Treatment of multi-year construction schedules. Standard optimization techniques assumed a project could be built in one year. Such is not the case with large scale inland navigation improvement projects which may take decades to complete.
- Compensating for service reductions and interruptions during the construction period. Prior techniques assumed service levels would not be impacted by construction.
- Multiple project analysis. Corps Planners are responsible for identifying the best among several alternative plans at a particular site and the best mix of plans over a system of sites. Some of these Plans are mutually exclusive while others may be complementary if implemented in a certain sequence.

- Time efficiency. As the optimization evolves towards a solution, a test solution may be produced that duplicates a previous solution. The process was modified to recognize these duplicates and use the results of the previous simulation instead of calling for another simulation.
- Precedence Relationships. Based on technical, political or geographical considerations, some precedence relations among projects or locations may be imposed on the scheduling process. That is, some projects may not begin until another project has finished or begun. Since precedence constraints define an order of succession among projects, it is important to note that some solutions (i.e., project sequences) are infeasible and should be prescreened and discarded before being simulated.
- Regional Budget constraints. Given the current state of the inland navigation system, there are more "good" projects than there is money to build them. In this case, budget constraints must be taken into account.
- Improvements to the optimization process itself.

Documentation of the work performed to enhance the Genetic Algorithm process may be found at http://www.nets.iwr.usace.army.mil/inlandnav.cfm under the Navigation System Simulation section.

Data Analyzer – Preprocessor

The Design Document envisioned the DAPP as being a data repository, data analysis tool, data preprocessor, and model output processor. Activities to date have been focused on the data repository aspects of the DAPP with minor efforts dedicated to data analysis. Early in the process the team decided to use the NDC LPMS data warehouse as the data source. The warehouse resides on Corps Oracle servers and contains information collected by the LPMS web based collection system, the Rock Island OMNI system and the Huntington OMNI system. The warehouse schema is designed for efficient data collection and storage, which makes analysis rather difficult. Therefore, one of the teams first tasks was to design a storage schema which would facilitate quick and easy data analysis. After the NaSS was designed, the team converted the warehouse schema into the NaSS schema. The conversion was validated as each table was created. At the time of this writing the DAPP team has completed the process of creating a user friendly LPMS data repository.

In addition to creating and populating the NaSS schema, the DAPP team was also responsible for creating the prototype version of the Direct Shipment List and a commands file that drives the Inland Navigation Animation Model.

The DAPP team is currently working on a method to create the enhanced Direct Shipment List.

Agent Based Model

A discovery level Agent Based model was created as part of the FY06 work effort. However, development ceased due to the FY07 funding shortfall. There are no plans to restart development on the Agent Based model.