Efficiencies in Distribution—Improving Fleet Manning and Reducing Nonproductive Time

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Efficiencies in Distribution:

Improving Fleet Manning and Reducing Nonproductive Time

Dr. Warren Sutton
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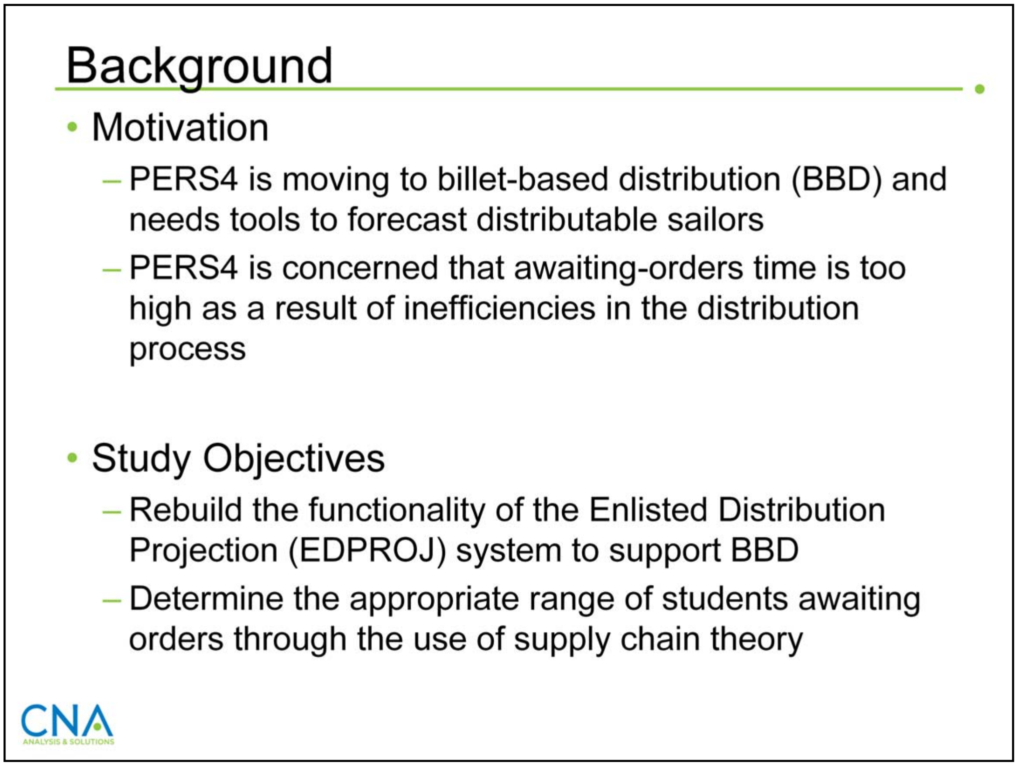
The Navy Personnel Command for Career Management (PERS4) asked CNA to identify potential sources of efficiency gains in the distribution process to improve fleet manning and decrease nonproductive time. This annotated briefing is the report of our findings.

Executive Summary

This annotated briefing describes our investigation of nonproductive time in the Navy's Manpower, Personnel, Training, and Education (MPT&E) supply chain. Our objectives were (1) to develop a tool to assist PERS4 in the transition to billet-based distribution (BBD) of personnel and (2) to analyze ways to optimize efficiency in the MPT&E supply chain with respect to the amount of time sailors spend awaiting instruction and/or orders.

To fulfill the first objective, we developed a tool, the EDPROJ Redux, that projects the number of sailors available for distribution each month across an 18-month time horizon, thus supporting the transition to BBD.

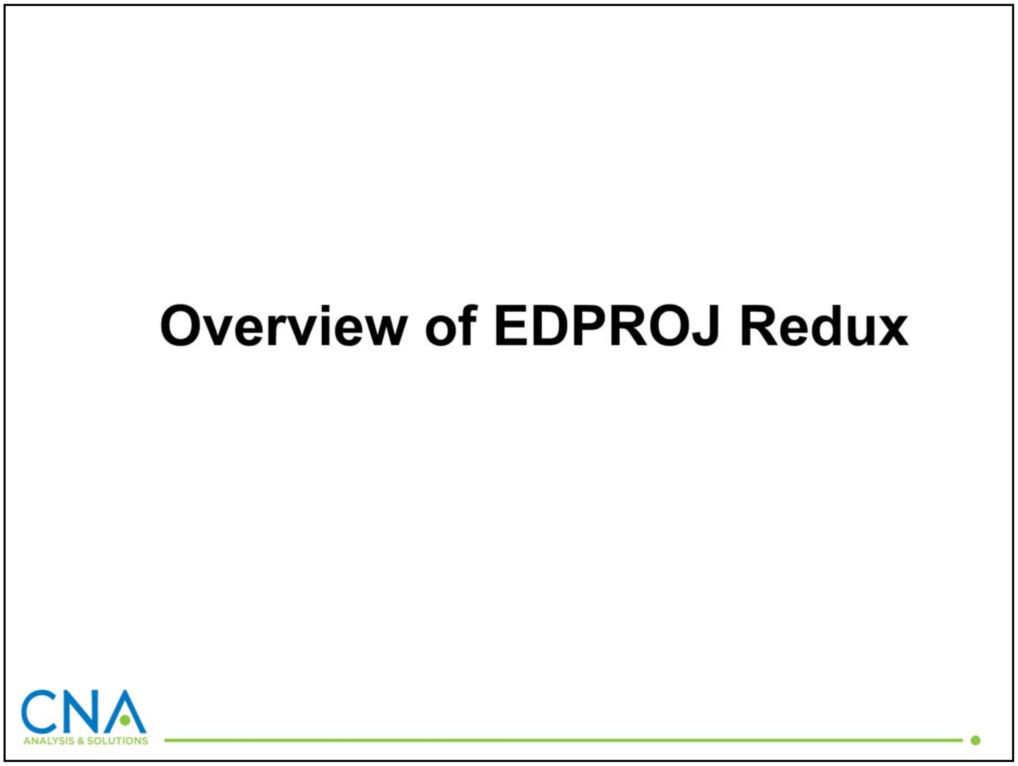
To fulfill the second objective, we used a simulation model to analyze the non-productive time between A-school and C-school. We find that the presence of some number of nonproductive sailors between these stages of training is necessary for supply efficiency and flexibility; however, there are many more students awaiting instruction (in C-school) than there are students awaiting orders (from the fleet). This finding suggests that the order writing process is efficient and that the biggest gains in efficiency could be made by decreasing the number of sailors awaiting instruction at C-school. This could be accomplished by devoting additional resources, such as additional school seats, to the C-schools or by making other changes in Navy policy that would allow for a quicker transition to C-school.



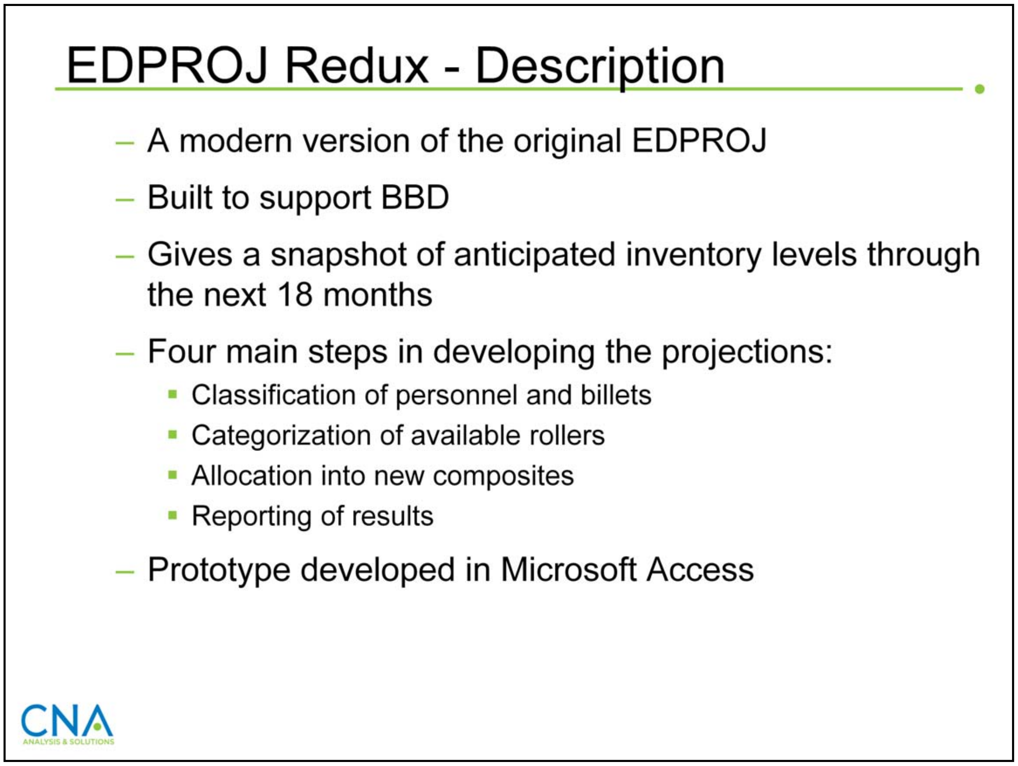
PERS4 is transitioning from aggregate manning to billet-based distribution. BBD is a method of assigning sailors to discrete billets, rather than aggregate needs of the unit, as was used under aggregate manning. In support of this effort, CNA developed a prototype decision-support tool for BBD. This tool (EDPROJ Redux) is an updated version of the Enlisted Distribution Projection (EDPROJ) system. EDPROJ Redux projects the number of sailors available for distribution each month across an 18-month time horizon. This functionality is critical for the new requisition priority algorithms used to determine the relative importance of manning needs in BBD.

In addition to the development of EDPROJ Redux, PERS4 asked CNA to investigate awaiting-orders time in the MPT&E supply chain, particularly between A-school and C-school. Although some evidence suggests that awaiting-orders time is too high, there is little practical evidence to support the proposition that having zero awaiting-orders time would be desirable for a "healthy" MPT&E system. A healthy MPT&E system needs some amount of awaiting-orders time to effectively satisfy the fleet's demand. Unfortunately, the range of optimal awaiting-orders time is not well defined. To address this knowledge gap, our study uses supply chain theory to establish reasonable bounds for awaiting-orders time.

An analysis of the causes of awaiting-orders time is beyond the scope of this study but can be found in a 1999 CNA research memorandum by Belcher et al., *Analysis of Student Not-Under-Instruction Time in Initial Skills Training: Trends, Causes, and Proposed Fixes* [1].



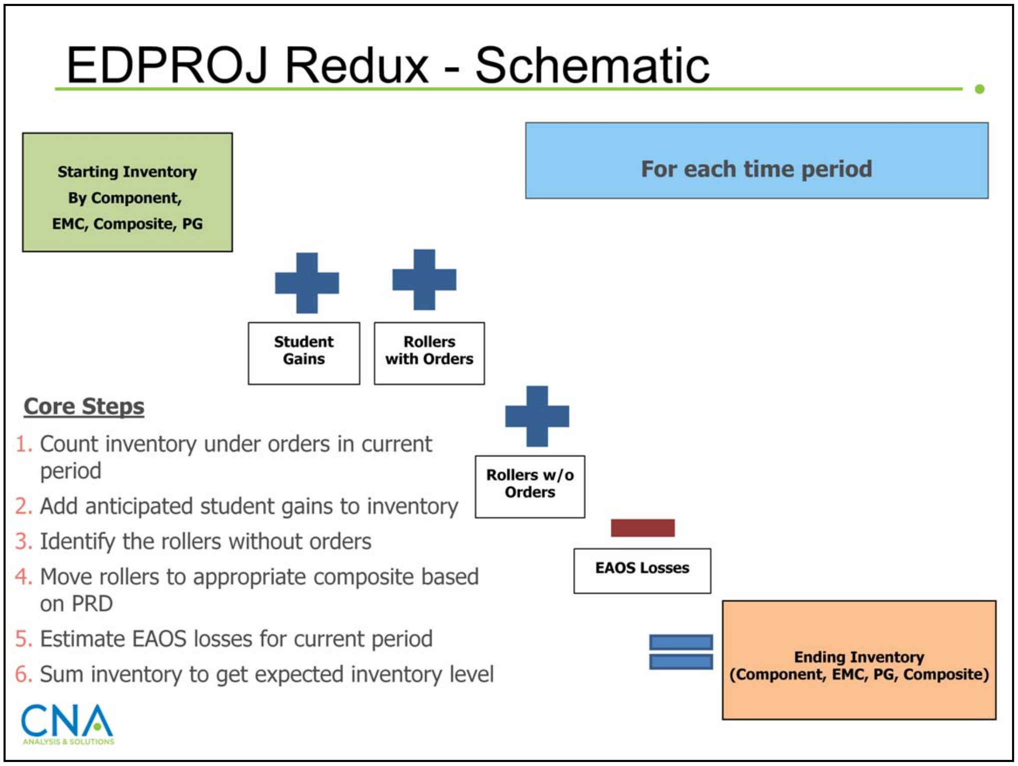
This section of the annotated briefing gives an overview of the prototype EDPROJ Redux tool that we built in support of BBD.



EDPROJ Redux is a modernized version of the original EDPROJ tool. The functionality of the two tools is very similar, but EDPROJ Redux focuses on supporting BBD. To accomplish this goal, EDPROJ Redux is primarily designed to forecast distributable inventory across over an 18-month period (P18).

The four steps in producing inventory projections in EDPROJ Redux are classification, categorization, allocation, and reporting. First, classification involves the separation of personnel and billets into groups based on distribution community, paygrade, composite, and manpower type. Second, categorization groups the inventory based on sailors with orders, sailors designated as rollers without orders, and anticipated losses. Third, the allocation process moves sailors from one composite to another, based on their projected rotation date (PRD). Finally, a report is generated that captures the projections of distributable inventory for the 18-month period.

Because the prototype EDPROJ Redux tool was built in Microsoft Access, it is more modern than the original EDPROJ tool, which was developed in COBAL and ran on a mainframe computer. This modernization allows for the integration of EDPROJ Redux into the production system tools currently used by the Navy.

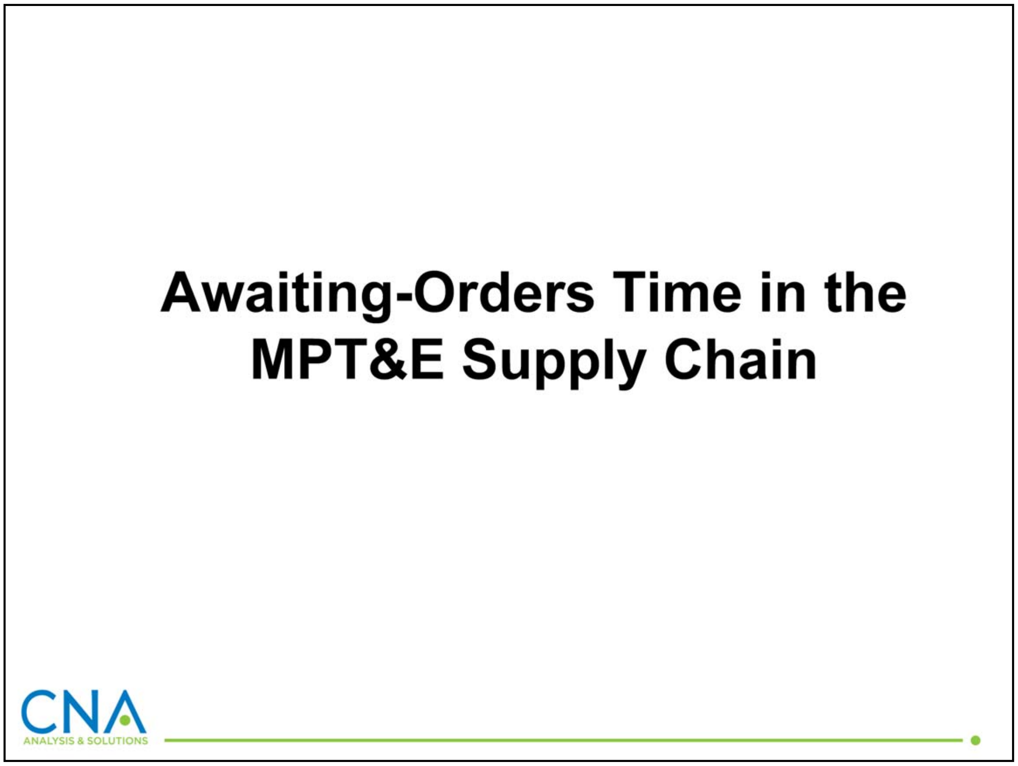


At its core, EDPROJ Redux is a database used to project inventory that compares inventory to billets authorized across an 18-month time horizon. As the model iterates, over the course of 18 months, the sailor total counts change as sailors come up on their PRDs and newly trained sailors enter the fleet. Thus, when sailors are accurately added to or subtracted from the various categories, the EDPROJ Redux tool can identify anticipated shortages of distributable sailors.

Beginning with a starting inventory grouped into the appropriate categories (described in the categorization phase), student gains and rollers with orders are added to the inventory. Then rollers without orders are added to the inventory. Finally, end-of-active-obligated-service (EAOS) losses are subtracted from the inventory to produce the ending inventory for the period. The ending inventory from the previous month is then used as the starting inventory for the next month, until 18 months of projections are completed.

Some of the details of aging an inventory of sailors are not captured in EDPROJ Redux. For example, advancement of sailors from one paygrade to the next is not included. We recognize that this is a limitation on the accuracy of the results, but EDPROJ Redux nevertheless still captures the key details of sea-shore rotation, a foundational element in understanding distributable inventories.

Complete details on EPROJ Redux are found in the CNA information memorandum by Stoloff and Sutton, *Enlisted Distribution Projection System (EDPROJ) Redux-User's Guide* [2].

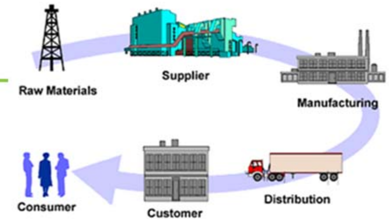


We now turn to the issue of understanding how many sailors are awaiting orders in the MPT&E supply chain. In particular, PERS4 plays a critical role in the awaiting-orders time between A-school and C-school. This is the point in the supply chain where a sailor does not move on in his or her training unless he or she has a set of orders to satisfy a requisition in the fleet.

The objective of this section is to demonstrate that the use of a supply chain theory approach provides insight into the amount of awaiting-orders time that should be expected in a healthy MPT&E supply chain. We first show how the Navy's MPT&E parallels a hybrid push-pull supply chain. Then, we use queuing theory to analyze how the variables involved in determining the number of students awaiting orders are related to one another. Finally, we present a simulation model that captures many of the details of the MPT&E supply chain.

We use the term "awaiting orders" to mean the sum of the time a sailor is awaiting orders, awaiting transfer, and awaiting instruction. This represents all the time that a sailor is in the training pipeline and not under instruction (NUI). Other types of holds (legal, medical, etc.) are not included in our definition of awaiting orders.

Supply Chain Strategies



Most supply chains work in one of two ways:

– Push System
- Production and ordering decisions are based on long-term forecasts and inventory
- Allows for long lead time in production
- Has difficulty meeting changes in demand patterns
- Can create products that are obsolete

– Pull System
- Production is based on demand for a product
- Allows for true coordination with customers' true demand
- Results in decreased inventory levels and better response to demand variability
- Does not leverage economies of scale
- Does not work when lead times are long

Push-Pull System: A new hybrid strategy that takes advantage of both systems

- Initial portion of supply chain is a push system, based on long-term forecasts
- Latter part of supply chain is a pull system, based on actual customer demand

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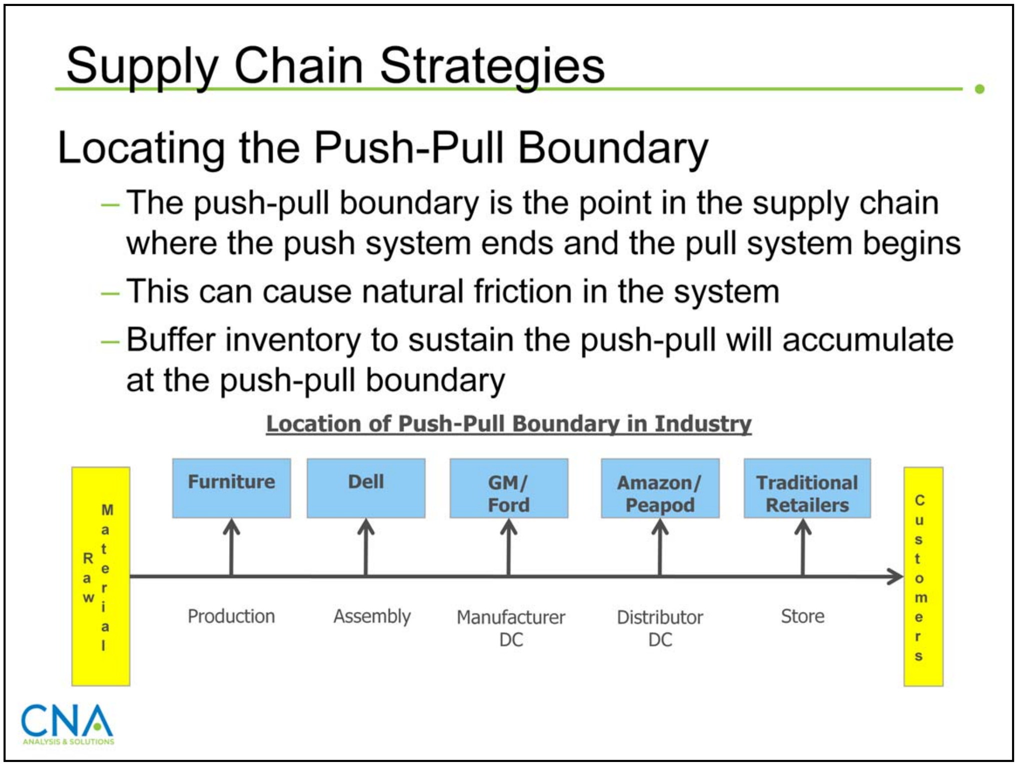
Most supply chains follow one of two major supply chain paradigms: push systems or pull systems. The push system moves items to subsequent stages of the supply chain whenever the items finish the prior stage. As such, product is constantly moving forward, and large amounts of inventory may accumulate at various stages in the supply chain. This can cause problems when there are changes in the demand pattern for products, leading to obsolescence of certain production. However, the push system can be effective when long lead times are needed to produce a product and the product demand is accurately forecasted.

In the pull system, items only begin production when there is an upstream demand for them. By waiting for a demand signal to begin production, the pull system can better respond to variability in demand and ensure that the item produced will be immediately consumed at the end of the supply chain. This generally results in lower inventory levels throughout the supply chain. The major shortcoming of the pull system is that it does not take advantage of economies of scale and, as such, can lead to underutilization of resources. In addition, the pull system assumes that products are made rapidly. If this is not the case, however, demand may outpace supply because production will not begin until there is a demand signal.

A new hybrid strategy called the push-pull system was developed to leverage the benefits of both the push and pull systems. The push-pull system starts the initial portion of the supply chain with a push system and the final stages end with a pull system. This allows for the benefits of both systems to be realized.

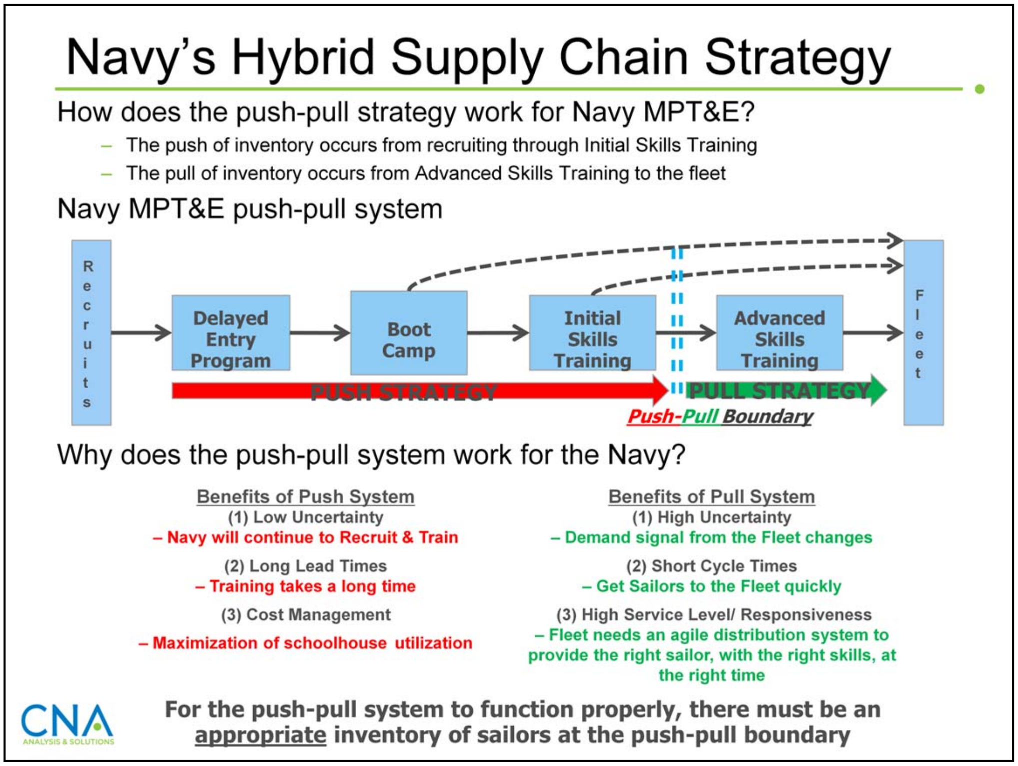


A critical factor in the push-pull system is the location of the push-pull boundary, or the point in the supply chain at which the push system ends and the pull system begins. The location of this decoupling point varies across industries and is application specific. For example, in Dell's supply chain, the push-pull boundary occurs at the assembly phase. This means that all the subcomponents of the computer are made in a push system, stored in inventory until a customer orders a computer, and then the computer is assembled and sent through the remainder of the supply chain.

Although the push-pull boundary varies across industries, common to all applications is the fact that the push-pull boundary is a natural point of friction (i.e., a point at which inventory builds in the supply chain). The inventory here is necessary for the handoff from the push system to the pull system; there must be existing inventory on hand when the demand signal is given and the pull system is initiated. Thus, any "healthy" supply chain using the push-pull system has significant inventory at the push-pull boundary.

Two references offer additional information on the push-pull boundary:

- "Selection of decoupling points in supply chains using a knowledge-based approach," by S. Kundu, A. McKay, and A. de Pennington [3]
- Jiunn-Chenn Lu, et.al. "Analysing optimum push/pull junction point location using multiple criteria decision-making for multistage stochastic production system," by Jiunn-Chenn Lu et al. [4]



For the Navy, the MPT&E supply chain is operated using the push-pull strategy. The initial portions of the supply chain—recruiting, delayed entry program, boot camp, and initial skill training (A-school)—are operated using the push strategy, meaning that students are moved along to the next step of the supply chain as soon as they finish the prior step. The final portions of the supply chain—advanced skill training (C-school) and deployment to the fleet—are operated using the pull strategy. This means that students are not given orders to attend C-school until there is a need for them in the fleet. In the Navy's push-pull MPT&E supply chain strategy, the push-pull boundary is located between A-school and C-school. Thus, there is a natural and necessary buildup of sailors awaiting orders at this junction.

Why does the Navy use a push-pull strategy for the MPT&E supply chain? The precise answer is beyond the scope of this study, but operating with a push-pull strategy has several benefits. A push system is advantageous for the MPT&E supply chain because of the length of time it takes to train new sailors, the certainty that the Navy will continue to recruit and train sailors, and the desire to maximize the use of training resources. Likewise, there are advantages to using a pull system, such as the uncertainty in the fleet's demand signal that cannot be satisfied through long-range planning and the ability to rapidly respond to the fleet's demand. In summary, neither the pure push system nor the pure pull system could accommodate the Navy's expectations of the MPT&E supply chain. So, the Navy properly leverages many of the benefits of using a push-pull strategy for its MPT&E supply chain strategy to make it an excellent fit.

The Navy's Key Push-Pull Questions

Inventory = students awaiting orders

1. Are students awaiting orders necessary in the push-pull system?
   - YES
2. Does a healthy MPT&E system have zero students awaiting orders?
   - NO
3. How many students awaiting orders is too many?
   - UNKNOWN
   - The following portion of the study seeks to answer this question with (1) theoretical results from queuing theory and (2) the use of simulation modeling

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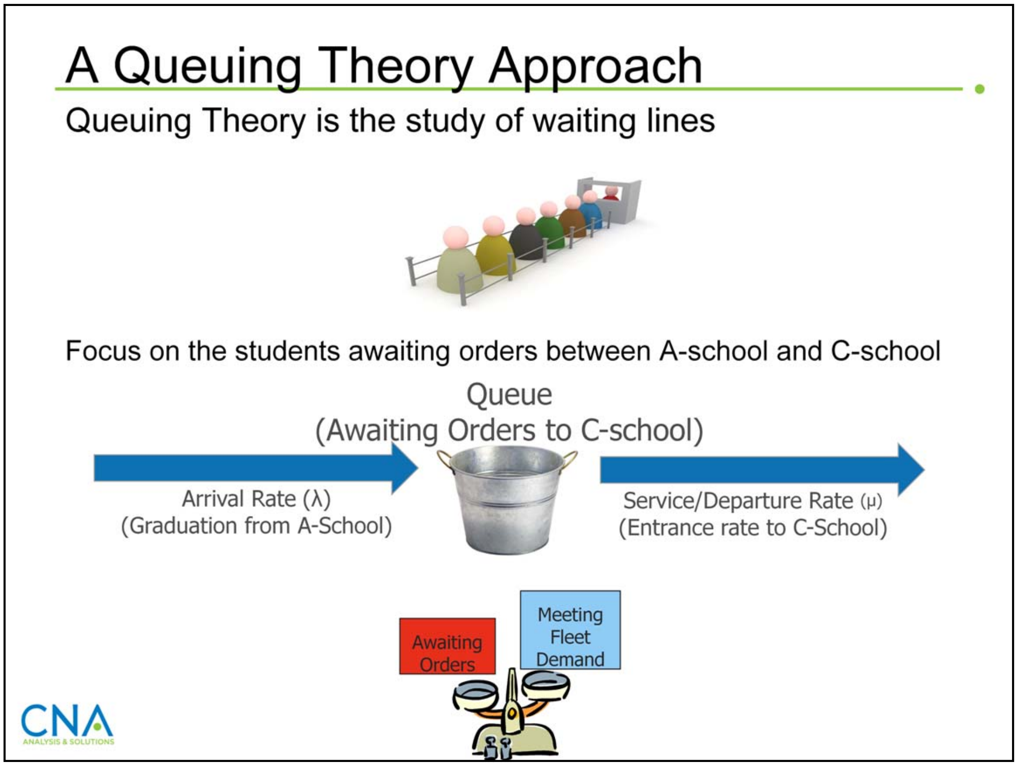
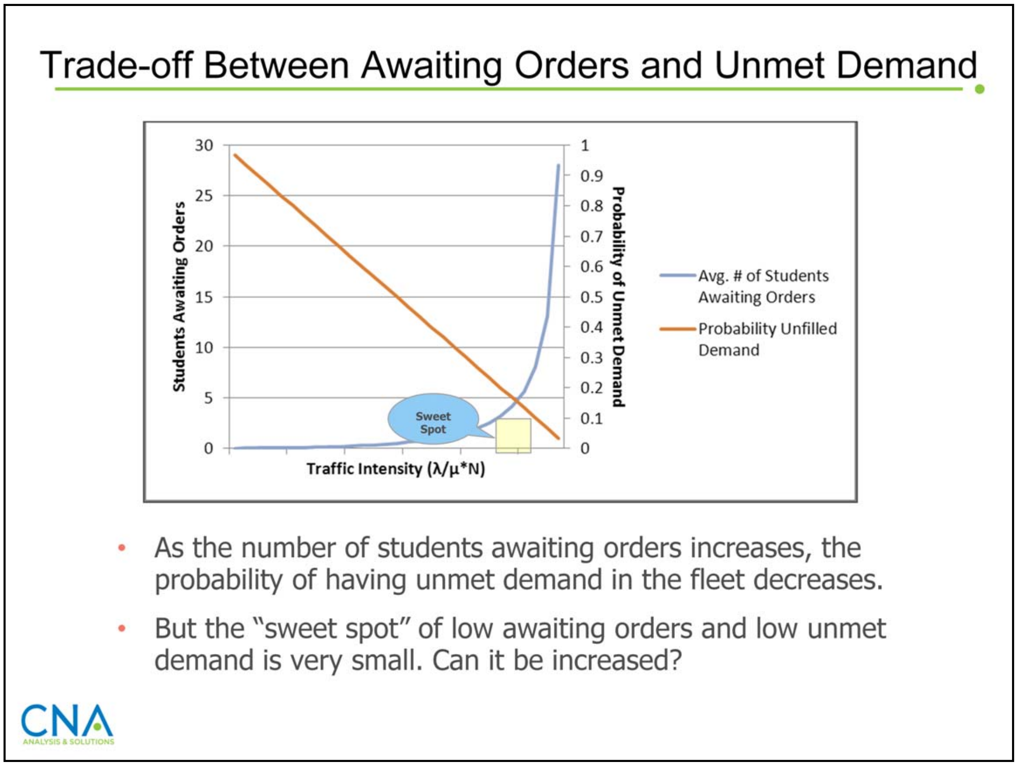
Now that we have established that the use of the push-pull supply chain strategy is beneficial to the Navy, and that having inventory (particularly at the push-pull boundary) is necessary for a healthy push-pull supply chain, we address the question of how much inventory is needed. More precisely, if the inventory in this case is students awaiting orders, how many students awaiting orders should exist in a healthy MPT&E supply chain? The remainder of this briefing seeks to answer this question. To do so, we will use both queuing theory and simulation modeling.



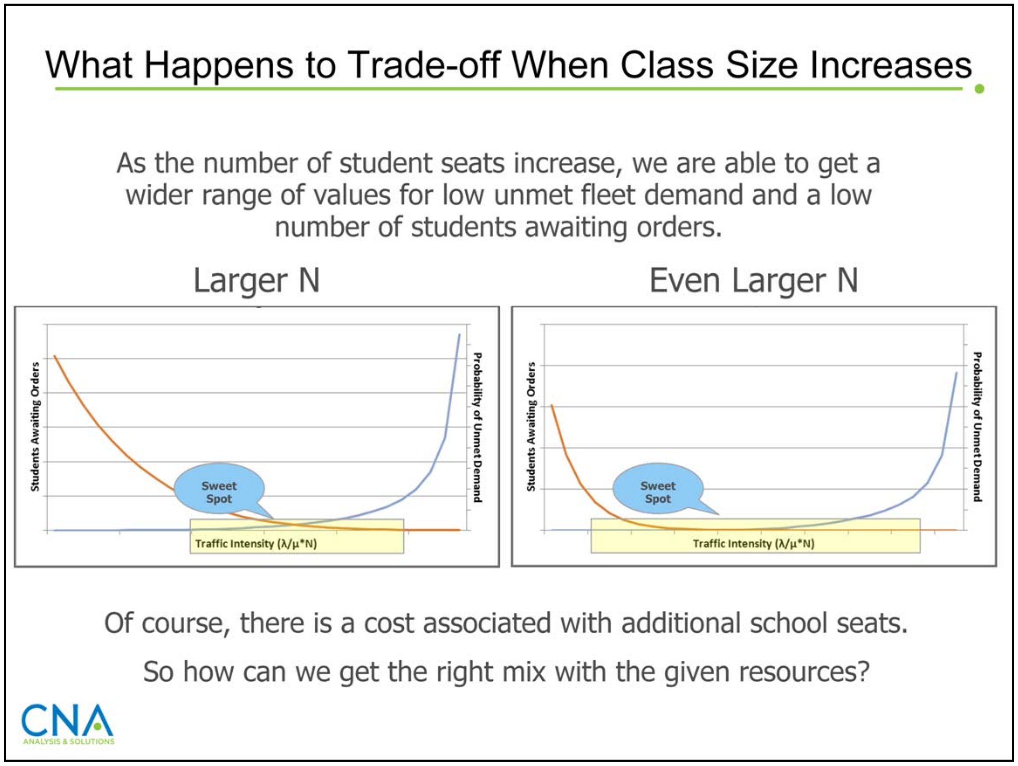
Queuing theory is the mathematical method of analyzing the delays and congestion of waiting in line. This discipline allows us to draw conclusions about the state of a "stable" queue, where all customers in the queue are served. Particular to our Navy application, we are interested in the queuing of students between A-school and C-school. Here, the arrival rate to the queue is determined by the graduation rate from A-school. The departure rate is determined by the entrance rate to C-school, which is dependent on the availability of school seats (N) and a valid fleet requisition to generate the pull demand signal from the queue. In the simplified queueing context that we consider here, however, the fleet demand signal is assumed to always be present. We understand that this is not exactly how the queue between A-school and C-school operates, but making this assumption allows us to gain some insights about the dynamic complex nature of the queue. Later, we add the pull demand signal back into our analysis when we use the simulation approach.

In this simplified scenario, we understand that, when the arrival rate is much higher than the departure rate, a large number of students are awaiting orders, and the fleet's demand will always be satisfied. When the converse is true, a very small number of students are awaiting orders and the probability is greater that the fleet's demand will not be satisfied. Queuing theory will tell us how to balance these two rates to obtain a stable queue, or a queue that does not grow out of control.

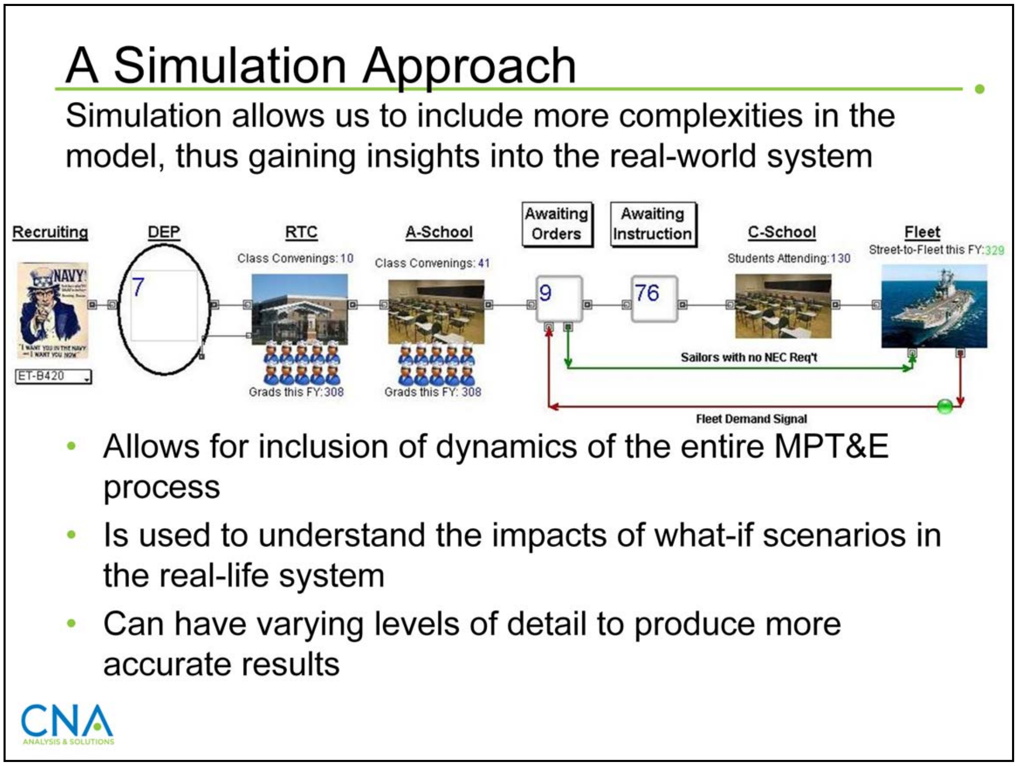


After making some assumptions about the distribution parameters of the graduation rate from A-school and the entrance rate into C-school, we are able to generate a set of curves that relate the average number of students awaiting orders to the probability of not fulfilling the fleet's demand. These curves are plotted as a function of the traffic intensity, or the number of sailors awaiting orders in the queue. All points on these curves are not assumed to be feasible alternatives for the Navy, but rather demonstrate the functional relationship between the variables.

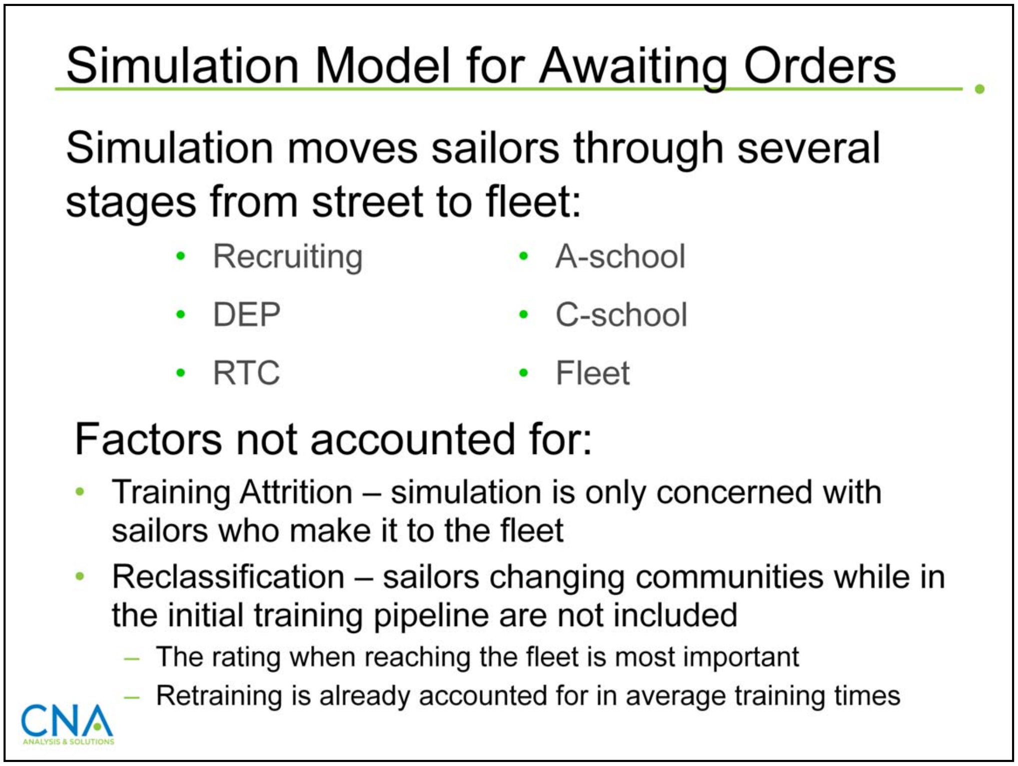
As we would expect, as the average number of students awaiting orders increases, the probability of unfulfilled demand decreases. The intersection of these two curves represents a desirable level of traffic in the queue. From this selection of parameters, we notice that the "sweet spot," or the point on the graph representing the lowest possible number of students awaiting orders and the lowest probability of unfilled demand, is very small and suggests a high traffic intensity in the queue. We next investigate how to maximize the range of the sweet spot while minimizing the traffic intensity of the queue.



By increasing the number of school seats, we are able to increase the range of the sweet spot and shift it toward a lower traffic intensity. In this configuration, there is a larger range of graduation rates from A-school and entrance rates into C-school that produce a stable queue, or a queue that does not grow out of control. This buys additional flexibility and allows for more robust performance of the entire supply chain. Of course, such an outcome comes at the cost of adding additional school seats, which would require more training resources. The exact quantity of additional resources required would depend on the specifics of the community being modeled. To incorporate community-specific training data and precise graduation rates, we next move to a discrete-event simulation approach. This approach allows us to include more data from the MPT&E supply chain.



Our insights from queuing theory are useful but are limited to the set of assumptions that we have to make about the fleet demand signal and various distribution rate parameters. By moving our analysis to simulation, we are able to include additional details about the dynamics of the MPT&E supply chain. The remainder of this briefing focuses on a discrete-event simulation model of the Navy MPT&E supply chain that incorporates the previously discussed concepts of the push-pull supply chain with the real-world data for a select set of enlisted Navy surface ratings.

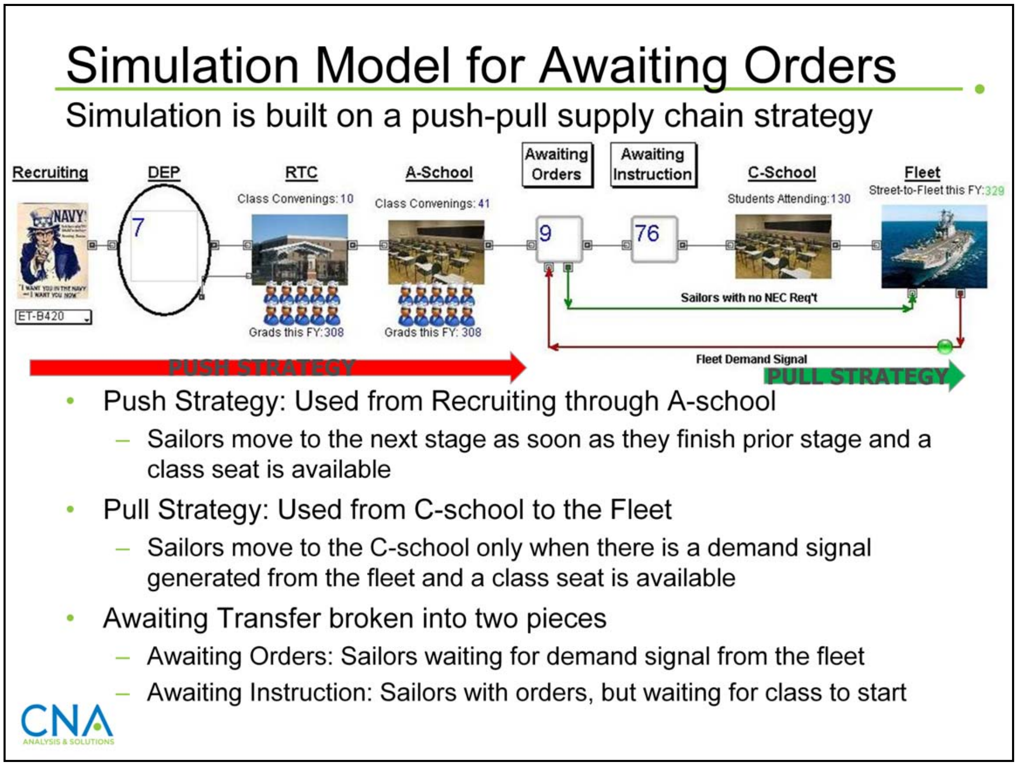


The following basic steps of the MPT&E supply chain are captured with varying levels of detail in the simulation model:

- Recruiting: the process that brings in new sailors to the Navy
- Delayed Entry Program (DEP): a buffer stock of sailors that allows the Navy to evenly flow sailors into the training pipeline
- Recruit Training Command (RTC): the basic military skill training provided to all Navy enlisted personnel, also known as boot camp
- A-school: the initial skill training for the specific occupation of an enlisted sailor
- C-school: the advanced skill training for the specific job or Navy Enlisted Classification (NEC) of an enlisted sailor
- Fleet: the ultimate destination of the vast majority of Navy enlisted sailors that come through the MPT&E supply chain

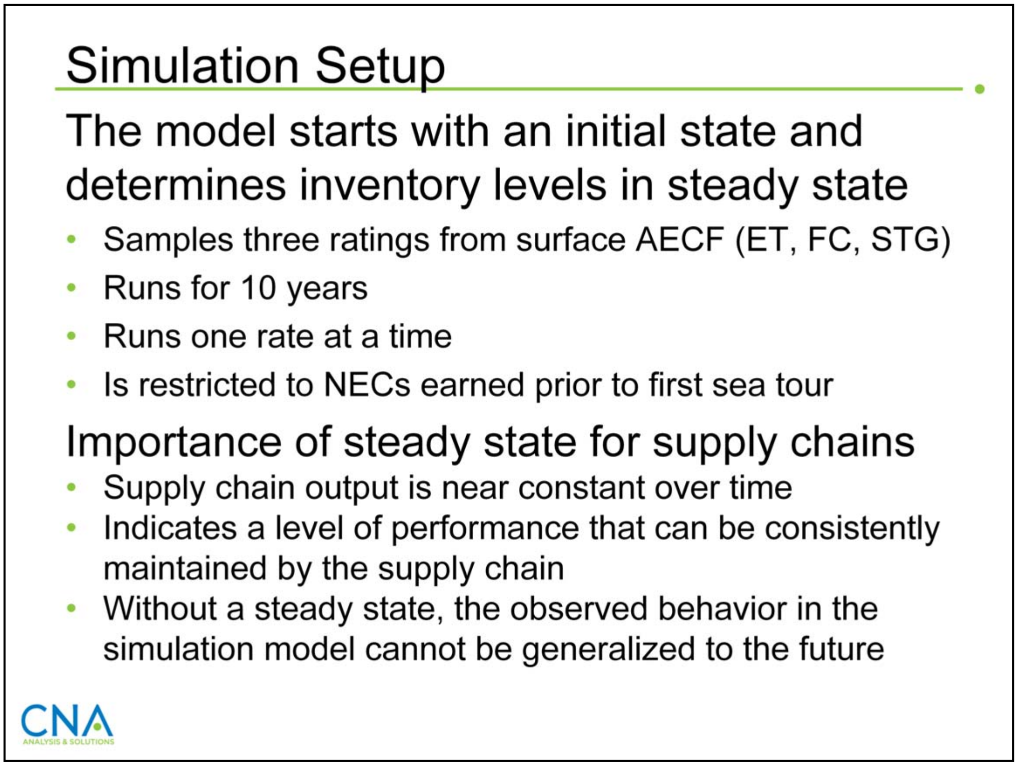
Most recruits in the Navy follow the sequence of training steps outlined above; however, occasionally a particular career field does not require advanced skill training, allowing a sailor to go straight to the fleet without attending C-school. This variation is accounted for in the simulation model.

Training attrition and sailor reclassification are currently not included in the simulation model, although these variations can be included if deemed necessary. Both of these factors are more important when all Navy ratings are considered simultaneously; however, as the current model runs only a select set of ratings individually, we did not deem it necessary to incorporate these factors.



Earlier, we described how the Navy MPT&E supply chain uses a push-pull supply chain strategy. We mirror this in the simulation model, using the push strategy from recruiting through A-school and the pull strategy from C-school to the fleet. This creates the push-pull boundary, a natural friction point, between A-school and C-school. This area of the model is of particular interest to PERS4 because sailors wait at this point for the pull signal, or demand from the fleet to move on to C-school and, ultimately, to the fleet. We have divided this point in the supply chain, generally referred to as "awaiting transfer," into two stages. The first stage we refer to as "awaiting orders." At this stage, sailors are waiting for PERS4 to cut a set of orders and send them to C-school. The use of awaiting orders in this context is different from our previous use of the term, but it is more in line with its common usage by the Navy. The second stage is referred to as "awaiting instruction." This is the time in which a sailor has orders but is waiting for his or her particular class to start. The sum of awaiting orders and awaiting instruction is the total NUI time considered in the simulation model.

In talking with subject matter experts (SMEs), we understand that a sailor usually has a significant amount of waiting time between physical transfer from A-school to C-school. Because of data availability, we decided not to account for this time explicitly in our model. Rather, we implicitly built this time into the awaiting transfer metrics discussed above. Although this decision prevents us from drawing specific conclusions about time awaiting physical transfer, we still present a robust model that captures many of the elements of NUI time.



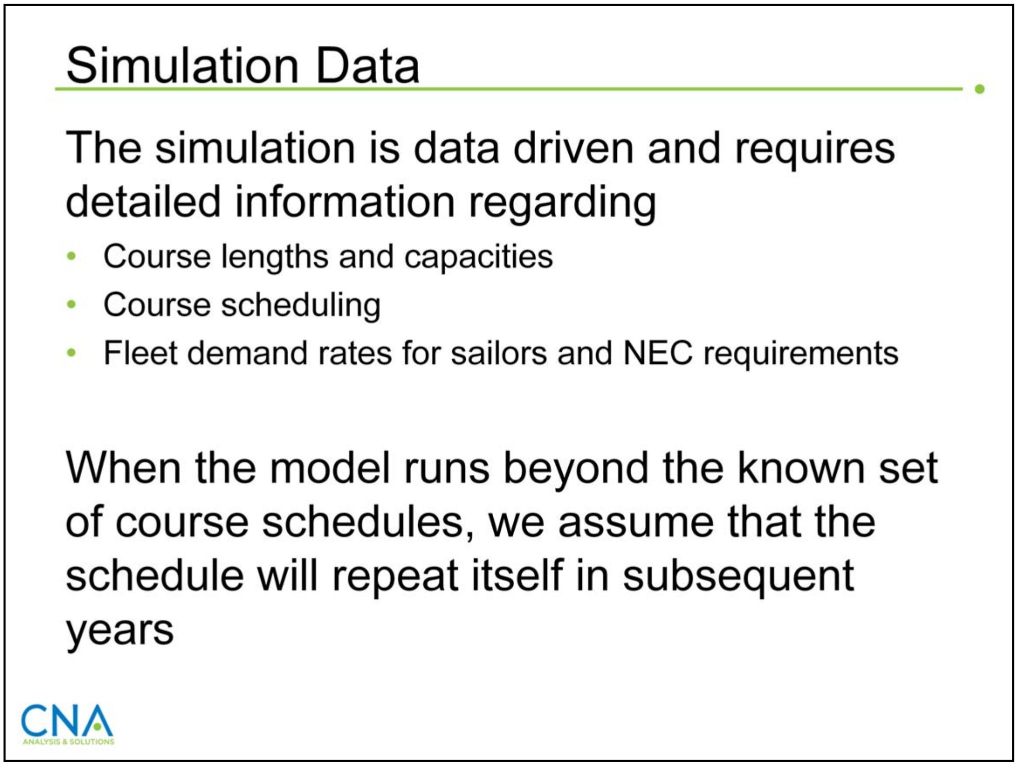
The simulation model is set up to run one rate community at a time. We have selected a sample of three occupational ratings to investigate: two from the surface advanced electronics computer field (AECF) and one from the surface advanced electronics field (ACF). The selected ratings are:

- Electronics Technician (ET) from the AECF
- Fire controlman (FC) from the AECF. This rating does not include sailors trained in the Aegis combat system serving in the FC Aegis rating.
- Sonar Technician (STG) from the ACF

This simulation model is restricted to sailors coming through the training pipeline for the first time, and it excludes sailors returning from the fleet for additional training. As a result, we model only the skills (NECs) acquired by apprentice sailors. These particular skills are identified by NECs attached to E3 and E4 billets, which are the most junior jobs in a unit.

We run the simulation model for 10 years for each rating, with the goal of achieving a “steady state,” or a state in which the model output is nearly constant over time. A steady state is an indication that the supply chain is operating in such a way that its performance can be maintained consistently. Once a steady state is reached, its results may be generalized to any time period in the future with similar input parameters.

When the simulation model starts, some estimate of initial inventory is loaded in various parts of the model to help it converge more quickly to the steady state.



Simulation is a very data-intensive analysis technique. The data drive the quality of the model and, ultimately, the quality of the results. As such, it is important to get accurate data when available. The key data elements for this model fall into two categories: course data and demand/supply data.

The elements of the course data are course lengths, capacities, and schedules. All of this information is acquired through Corporate Enterprise Training Activity Resource Systems (CeTARS). In our simulation model, we supplement the CeTARS data with empirical data from SMEs for the length of A-school. Since we run the model for 10 years and course schedules are not produced 10 years in advance, we assume that the existing course data will repeat itself over the next 10 years.

The demand and supply data are less concrete and contain some approximations from SMEs in PERS4. The supply data for new recruits coming into the model through recruiting could be substituted with the actual accession mission. For purposes of the accuracy of results sought in this model, we did not require this level of detailed data. The demand signal from the fleet is approximated using the snapshots of unfilled requisitions in the PERS4 demand planning tool. We supplement these data with information on the total annual demand for NECs in the fleet. Since the demand/supply data are static rates of sailors per unit time, the model can use the same information for the entire 10-year model run.

Simulation Data

Rate	Days in A-school	Minimum Weeks in C-school	Maximum Weeks in C-school
FC-B320	203	8	26
ET-B420	283	2	29
STG-B340	152	4	28

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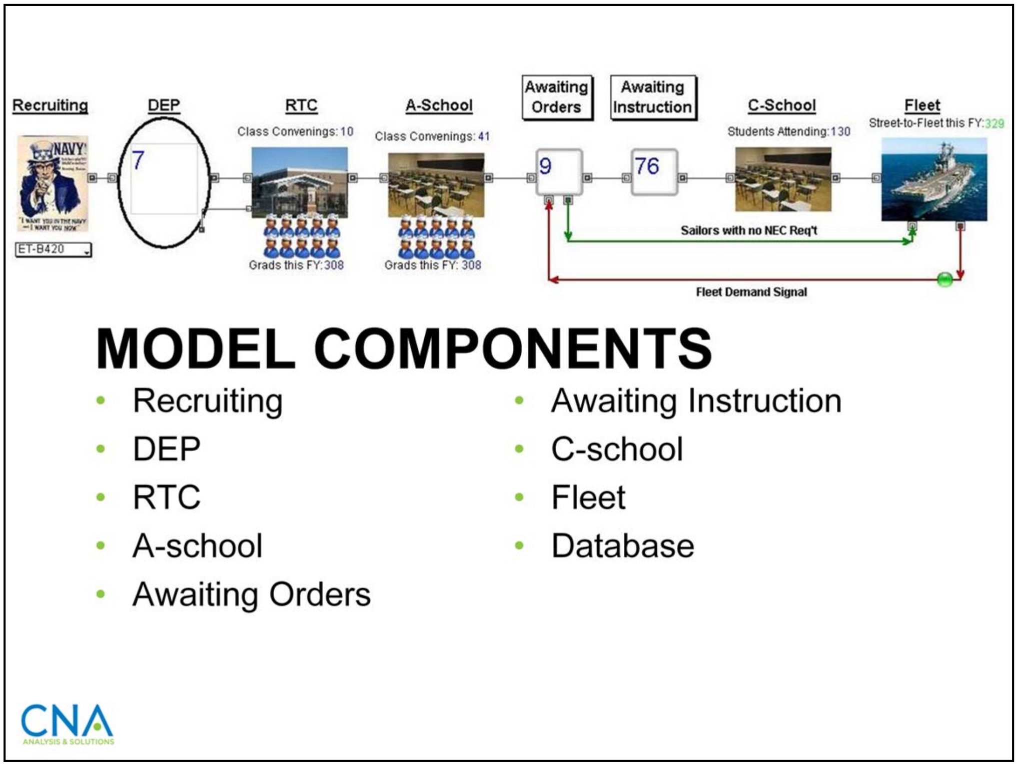
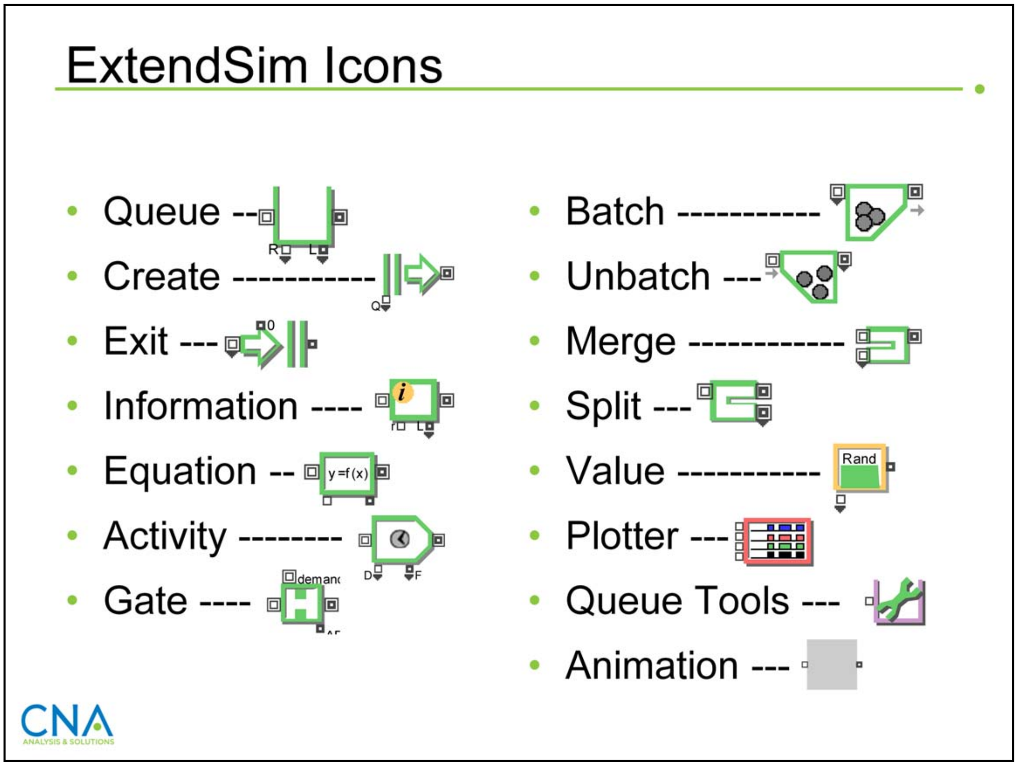
These data are a representation of the duration of training for each of the three ratings used in the model. In general, everyone in the same rating attends the same A-school. So we use a small amount of variation around the mean days in A-school presented in the table. For the C-schools, each course has a different length depending on the NEC granted. As such, we use the exact durations from CeTARS for the C-school courses. The values in the table for C-school duration represent the minimum and maximum duration of the possible courses offered for each rating.

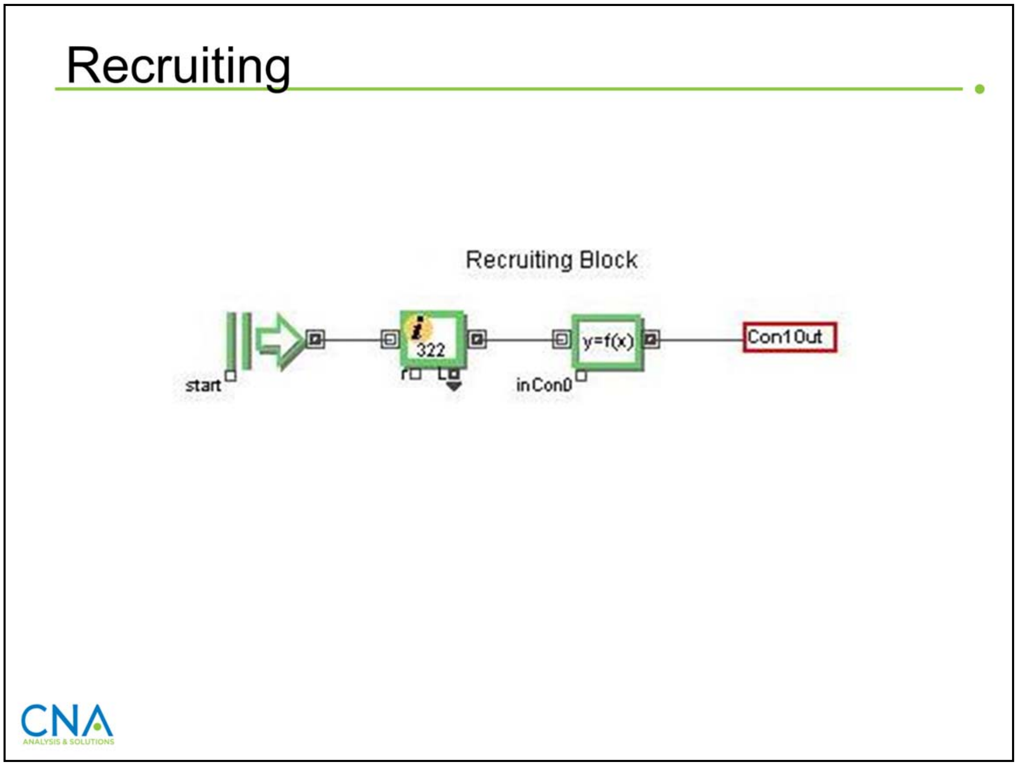


The next few slides detail how each model component is developed in ExtendSim8.0. The icons or blocks used in ExtendSim represent basic programming processes that are combined to make meaningful representations of a real-world system. The programming details of each block are omitted, but the slides give a general feel for the level of detail captured in each component. The slides each address the purpose of a particular model component and include several bullet points on its functionality.



ExtendSim uses a flowchart-like pattern of icons that represents various functions of a process and information that is gathered from the process. Below we describe some of the icons used in this simulation model and their purposes:

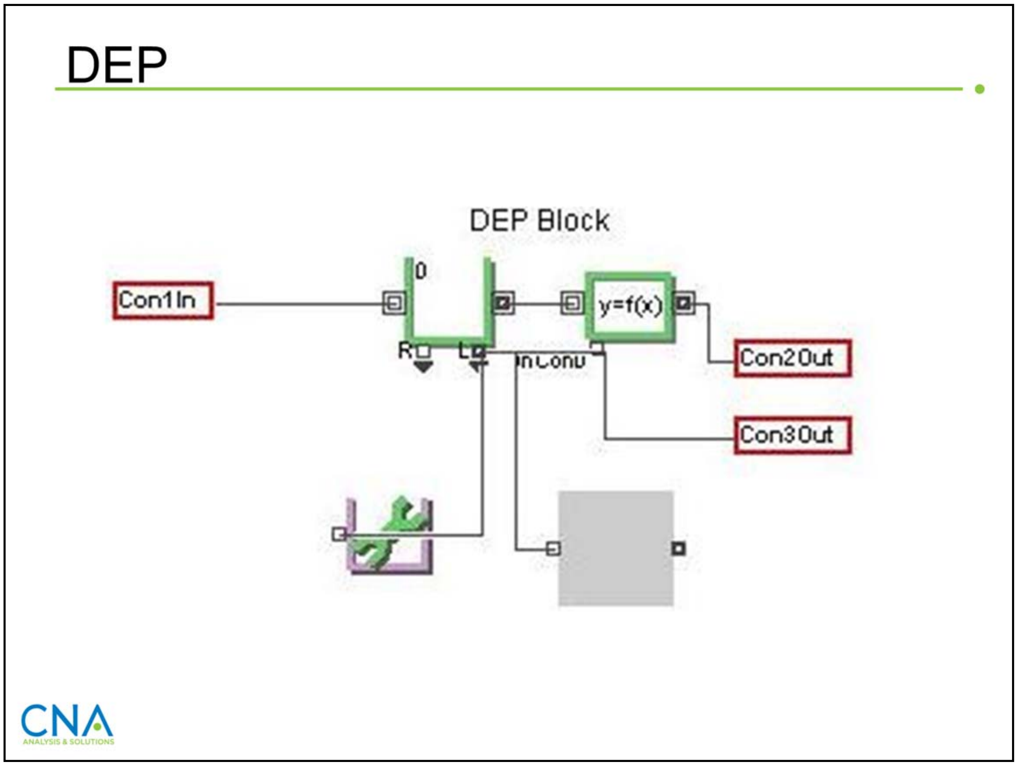
- Queue – an area used to hold sailors until they are needed in other areas
- Create – used to bring new sailors into the model
- Exit – used to remove sailors from the model
- Information – collects information on sailors that pass by
- Equation – a general block that allows for customization via coding
- Activity – a place where sailors wait for a set period of time
- Gate – blocks sailors from moving to later parts of the model until a condition is met
- Batch – groups the sailors into classes or with NEC requirements
- Unbatch – disaggregates groups that were previously batched
- Merge – brings two sailors together to flow along a common path
- Split – separates the flow of sailors into distinct paths
- Value – used in a variety of ways to provide numeric values to other icons
- Plotter Queue Tools – used to plot results of system behavior
- Animation – used to display real-time numeric values of system behavior



Purpose of Recruiting Component: To bring new recruits into MPT&E supply chain. Seven sailors are produced every three to seven days, with the exact timing determined by the particular occupational rating being modeled.

Attributes/Functionality of Recruiting Model Component:

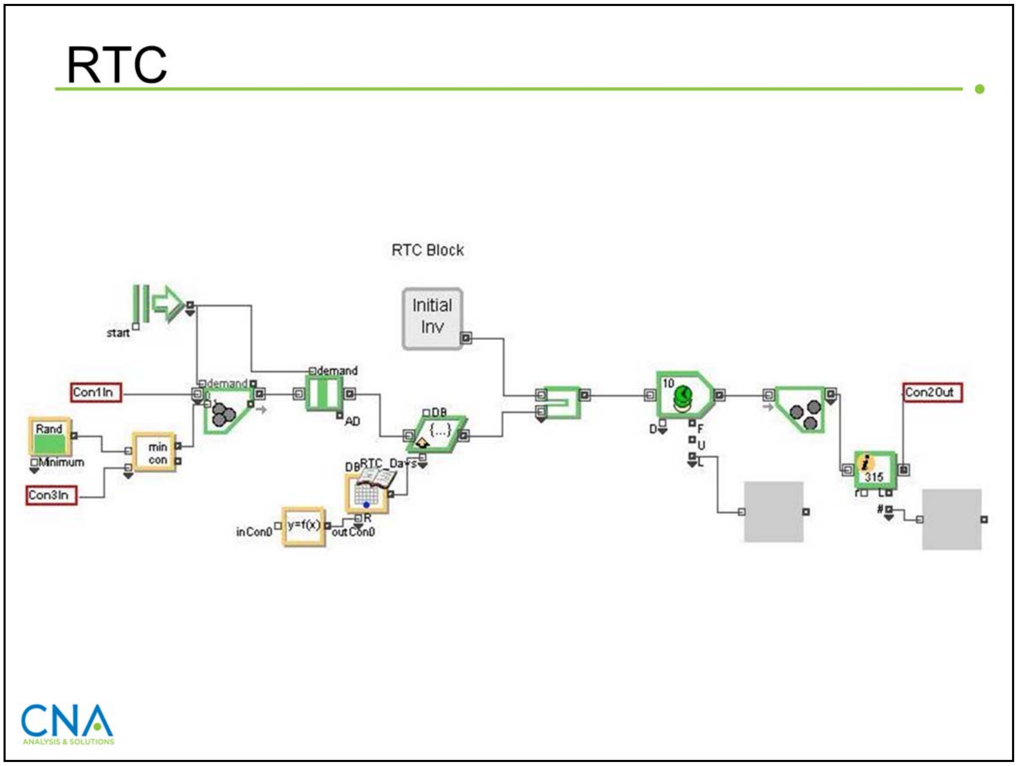
- Counts sailors produced by recruiting
- Assigns sailor attributes



Purpose of DEP Component: To hold sailors until they are needed by the MPT&E supply chain. Sailors enter DEP from recruiting and wait until a class is available in RTC.

Attributes/Functionality of DEP Model Component:

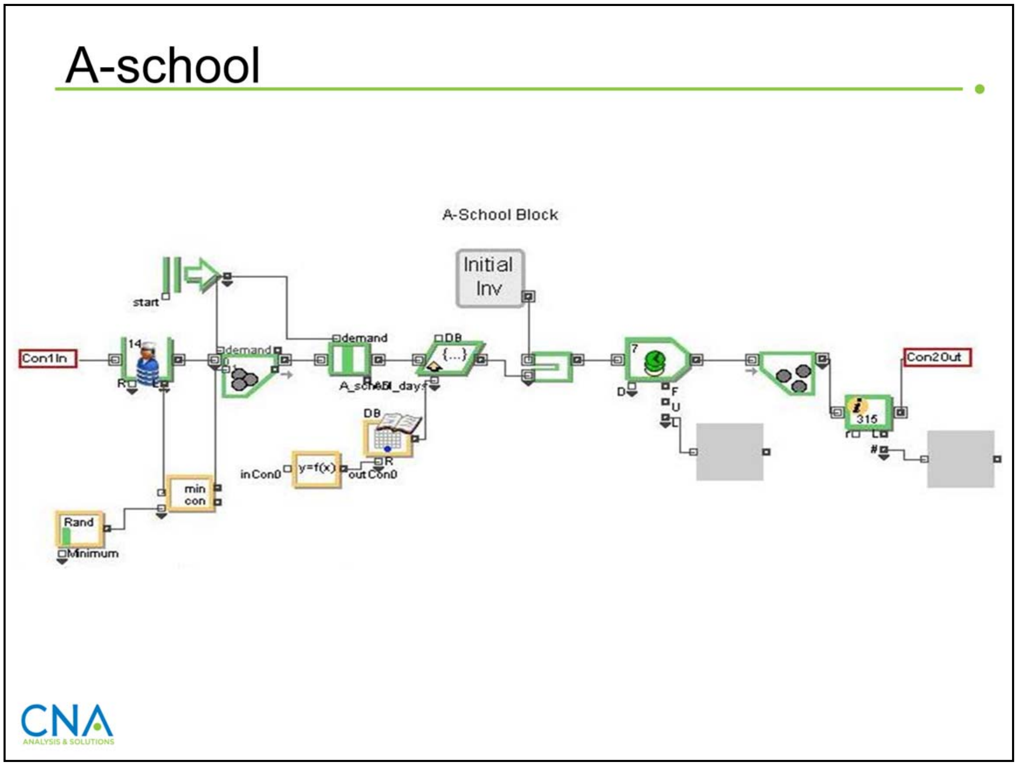
- A queue where sailors wait until they go to RTC
- The grey box displays the number of sailors in the queue to determine RTC class size
- The wrench initializes the DEP with sailors at beginning of the model run



Purpose of RTC Component: To group sailors into RTC classes and hold them until classes are complete

Attributes/Functionality of RTC Model Component:

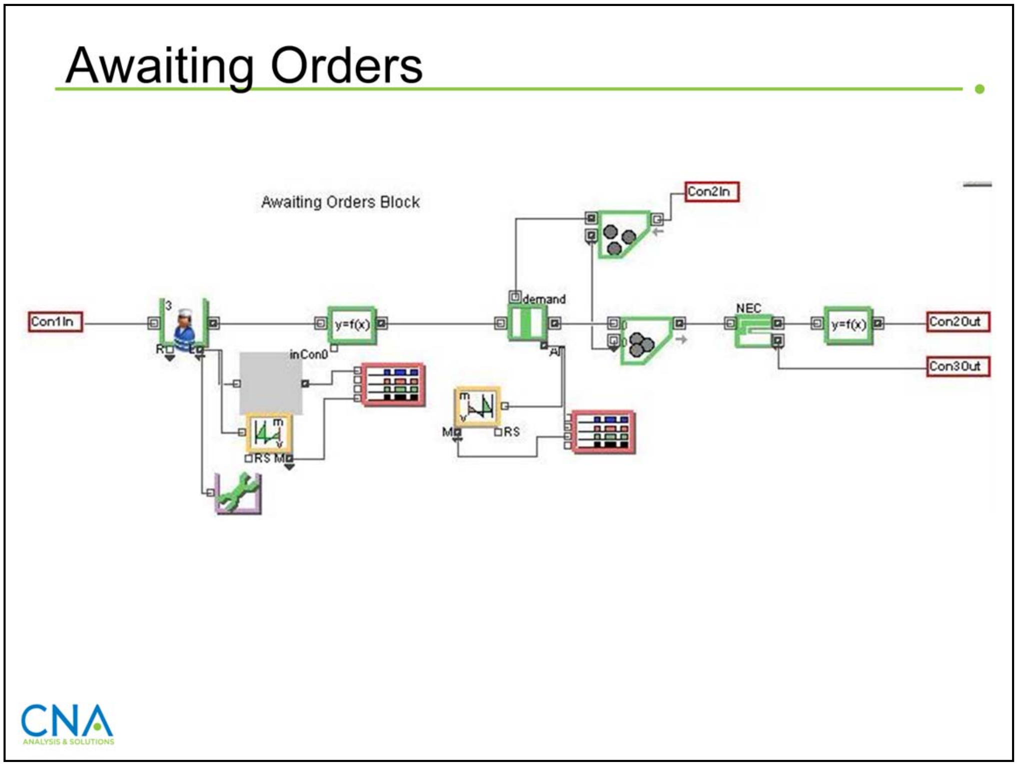
- Create a random batch of sailors for RTC
- Sailors are assigned to classes based on their particular rating
- Depending on a rating, RTC classes may run from 1 to 3.5 weeks
- Time in RTC is constant across ratings, but can be adjusted
- Sailors are unbatched when a class is completed
- RTC is initialized with a specific number of sailors at beginning of the model based on rating
- The grey boxes display the number of current RTC courses convening and the number of sailors who have completed RTC



Purpose of A-school Component: To group sailors into A-school classes and hold them until classes are complete

Attributes/Functionality of A-school Model Component:

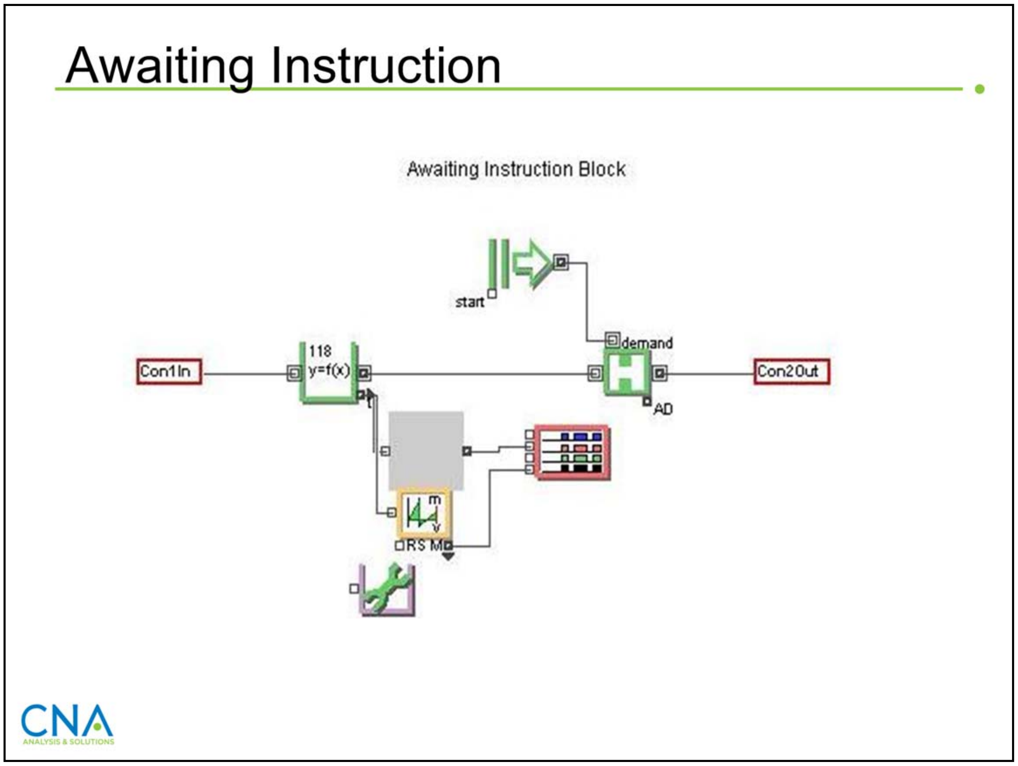
- Create a random batch of sailors for A-school
- Sailors are assigned to classes based on their particular rating
- Depending on a rating, A-school classes may run from every 7 to 21 days
- Time in A-school is rating specific
- Sailors are unbatched when a class is completed
- A-school is initialized with a specific number of sailors at beginning of the model based on rating
- The grey boxes display the number of current A-school courses convening and the number of sailors who have completed A-school



Purpose of Awaiting-Orders Component: To monitor sailors waiting for fleet demand to be assigned to C-school

Attributes/Functionality of Awaiting-Orders Model Component:

- Sailors wait until the fleet demand comes for a specific NEC requirement
- The next available C-school for a given NEC is assigned to a sailor and appropriate course length and duration are attached that sailor
- The sailor is joined with the NEC requirement and exits the awaiting orders section to wait for C-school to begin
- Sailors with no NEC requirement wait for a fleet demand with no NEC and are then shipped directly to the fleet
- The grey box displays the number of sailors currently awaiting orders

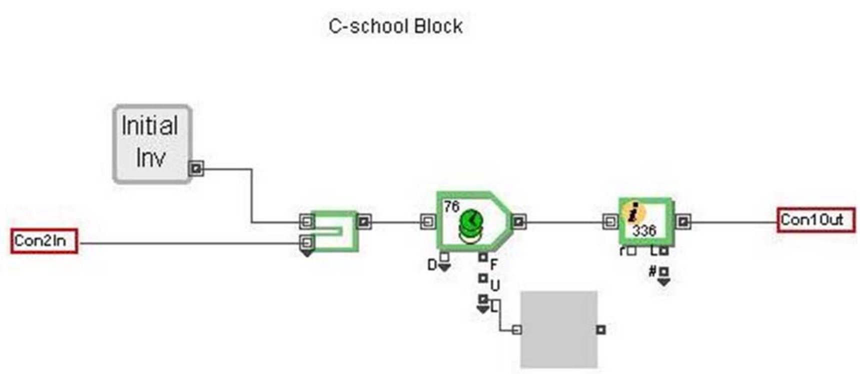


Purpose of Awaiting-Instruction Component: To monitor sailors waiting for C-school to start

Attributes/Functionality of Awaiting-Instruction Model Component:

- Sailors wait until their scheduled C-school begins
- This queue is a special block that monitors the current simulation time in the model; when C-school begins, sailors automatically exit the queue
- The grey box displays the number of sailors currently awaiting instruction

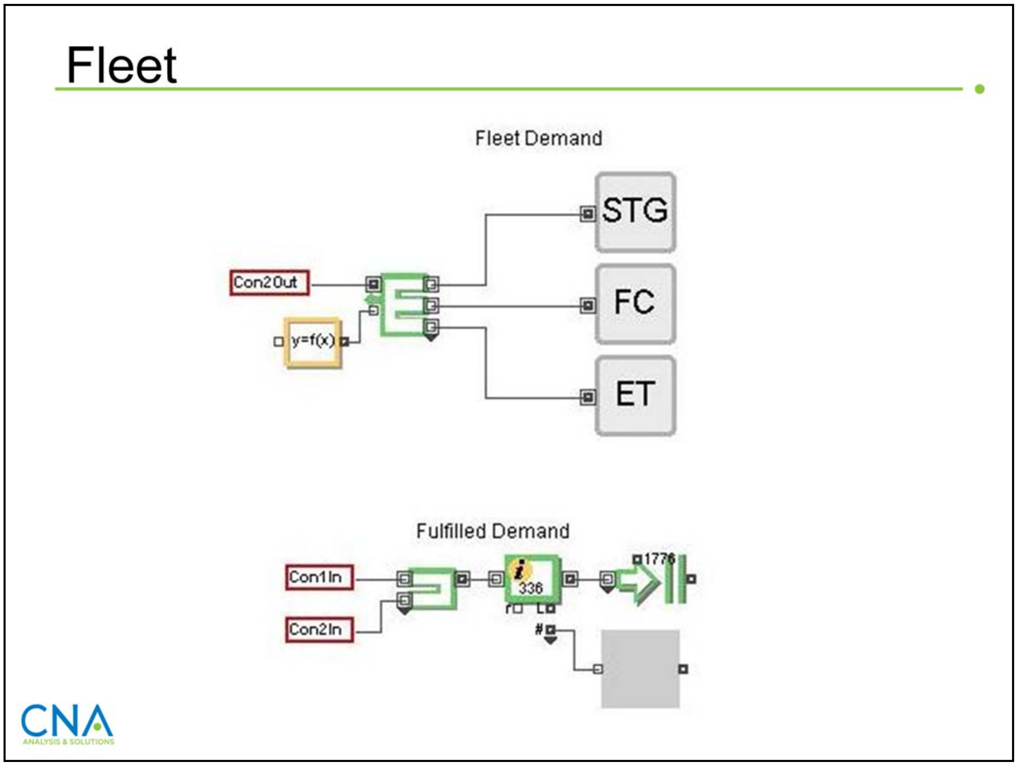
C-school



Purpose of C-school Component: To hold sailors until their C-school class is complete

Attributes/Functionality of C-school Model Component:

- C-school class frequency depends on a sailor's rating and NEC
- Time in C-school is rating and NEC specific
- The grey box displays the number of sailors currently in C-school
- C-school is initialized with a specific number of sailors at beginning of the model based on rating

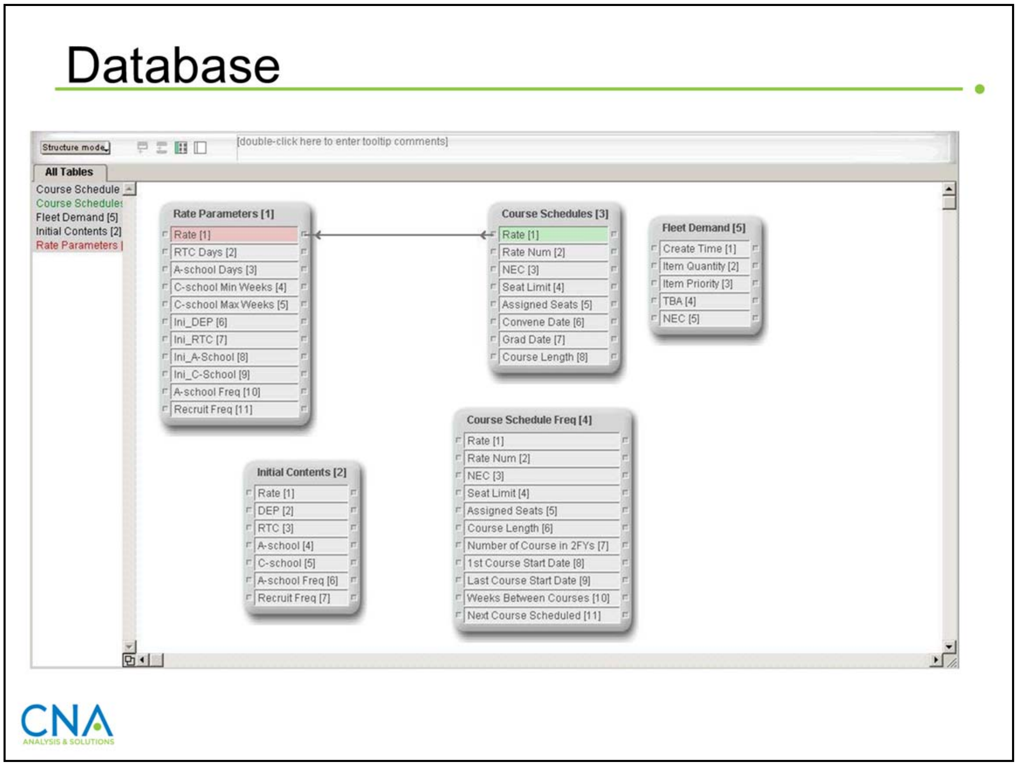


Purpose of Fleet Demand Component:

1. To create the fleet demand for sailor NECs
2. To count sailors that exit to the fleet

Attributes/Functionality of Fleet Demand Model Component:

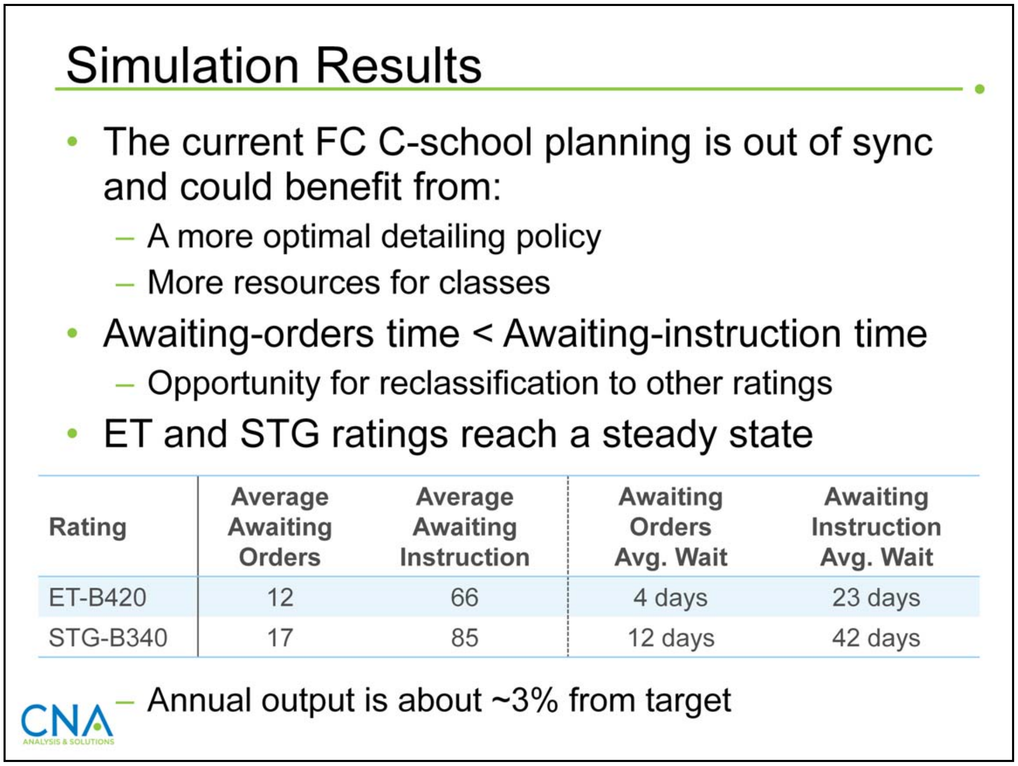
- Frequency of demand for NECs is determined based on historic demand
- The total sailors that reach the fleet is the measure for determining steady state. When a similar number of students reach the fleet in consecutive years, the model has reached a steady state.



Purpose of Database Component: To store all relevant data for the simulation model

Attributes/Functionality of Database Model Component:

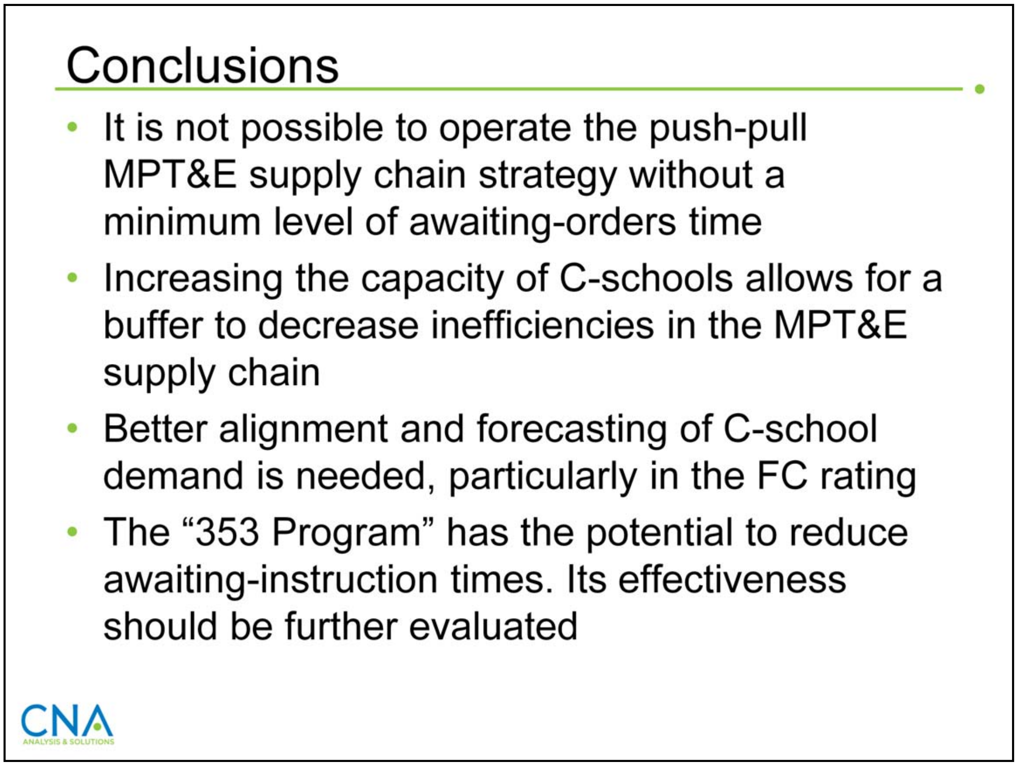
- Structure of database is similar to many common databases (Access, FileMaker Pro, etc.)
- Allows for complex data management inside simulation without connection to external programs



When the model reaches a steady state, the simulation provides us with the average number of students awaiting orders and awaiting instruction, and the average time they spend doing each. Note that we report results for only two of the three ratings tested in the model because the FC rating does not reach a steady state using the current resources in the MPT&E supply chain. The main reasons are (1) a lack of resources in C-school and (2) the Navy's current assignment (detailing) policies.

For the two ratings that achieved a steady state, we make the following observations:

- The awaiting-orders inventory and time are much less than for awaiting instruction. This indicates that 70 to 85 percent of the NUI time (as defined in this model) is spent waiting for classes to start. The awaiting-instruction time could be lowered by:
    1. Adding additional C-school resources
    2. Better aligning detailing practices with C-school scheduling
- Friction in the supply chain is approximately 3 percent; output is 3 percent less than input into the supply chain. This is mainly the result of inventory accumulation at various points in the supply chain.



The key finding in this study is that it is not possible to operate a healthy MPT&E supply chain with zero awaiting-orders time. This is especially true when using a push-pull strategy because such a strategy necessitates some minimum number of sailors awaiting orders at the push-pull boundary. The minimum awaiting-orders time/inventory is rating specific and depends on training resources and detailing policies. Additional resources (i.e., school seats, instructors, equipment, etc.) provide a buffer to handle variations in fleet demand and inefficiencies in the MPT&E process, while maintaining a steady-state supply chain. Without additional resources, some ratings may never achieve a steady-state supply chain.

In lieu of additional resources, changes in policies show the potential to reduce awaiting-instruction times. One such change in policy is the 353 Program, which allows sailors to skip advanced skill training and go straight to the fleet until their C-school convening date. This represents a departure from the push-pull strategy currently used, but it has potential to reduce awaiting-instruction time/inventory. Consequently, incorporating the 353 Program into this simulation model is an area of potential future research.

References

[1] Steven Belcher et al. *Analysis of Student Not-Under-Instruction Time in Initial Skills Training: Trends, Causes, and Proposed Fixes*. CNA Research Memorandum 98-138. Jan. 1999.

[2] Peter H. Stoloff and Warren T. Sutton. *Enlisted Distribution Projection System (EDPROJ) Redux - User's Guide*. CNA Information Memorandum Aug. 2012.

[3] S. Kundu, A. McKay, and A. de Pennington. "Selection of Decoupling Points in Supply Chains Using a Knowledge-Based Approach." In *Proceedings of the Institution of Mechanical Engineers, Part B. Journal of Engineering Manufacture* 222(11), Nov. 2008: 1529–1549.

[4] Jiunn-Chenn Lu et al. "Analysing Optimum Push/Pull Junction Point Location Using Multiple Criteria Decision-Making for Multistage Stochastic Production System." *International Journal of Production Research* Jan. 2012: 1–15.

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