Improving system sustainment through an integrated modeling schema coupled with effective execution of the lifecycle sustainment plan

Joseph M. Bradley

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Agenda

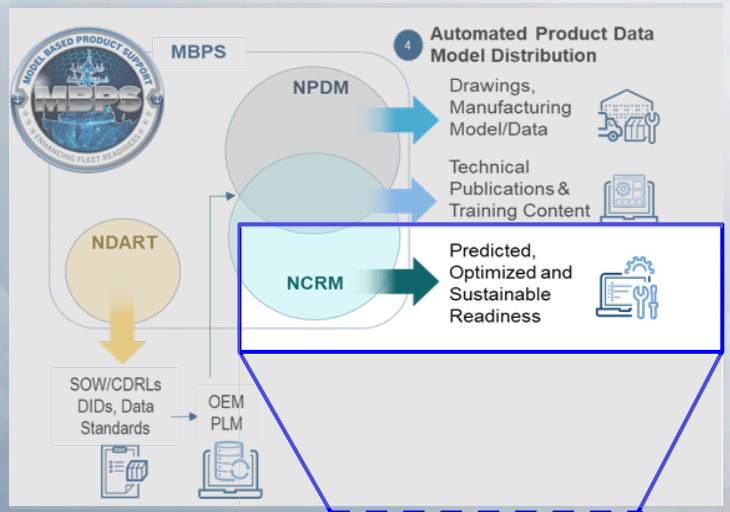
- Introduction
- Problem Statement
- Opportunity
- Approach
- Outcomes
- Future Work
- Questions

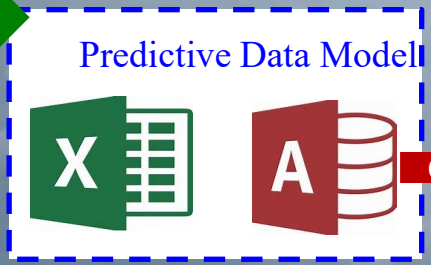
Problem Statement and Opportunity

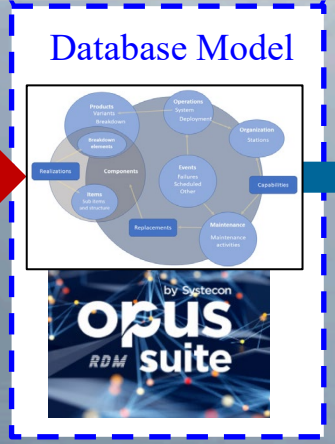
- Title 10 §4324 tasks the Product Support Manager (PSM) to "(B) ensure the life cycle sustainment plan is informed by appropriate predictive analysis and modeling tools that can improve material availability and reliability, increase operational availability rates, and reduce operation and sustainment costs;".
- Which leads to three questions:
  - How can a Product Support Manager (PSM) take advantage of the rapid advances in modeling and simulation to develop an integrated, through life cycle ecosystem of models and simulations to develop otherwise hard to find improvements that lead to cost sensible improvements in Fleet Availability and Operational Availability?
  - What considerations might a PSM evaluate as the ecosystem is developed from a collection of siloed simulation instances?
  - Can the learnings from this effort be applied to other current or future acquisition programs?

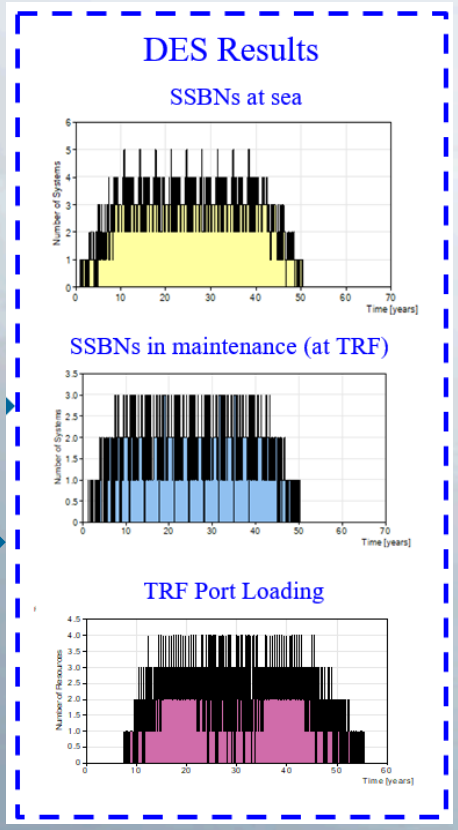
- Opportunity arises to use a Complex System Governance lens to develop an ecosystem if models to meet the statutory and regulatory requirements

Approach – Discrete Event Simulation (DES)





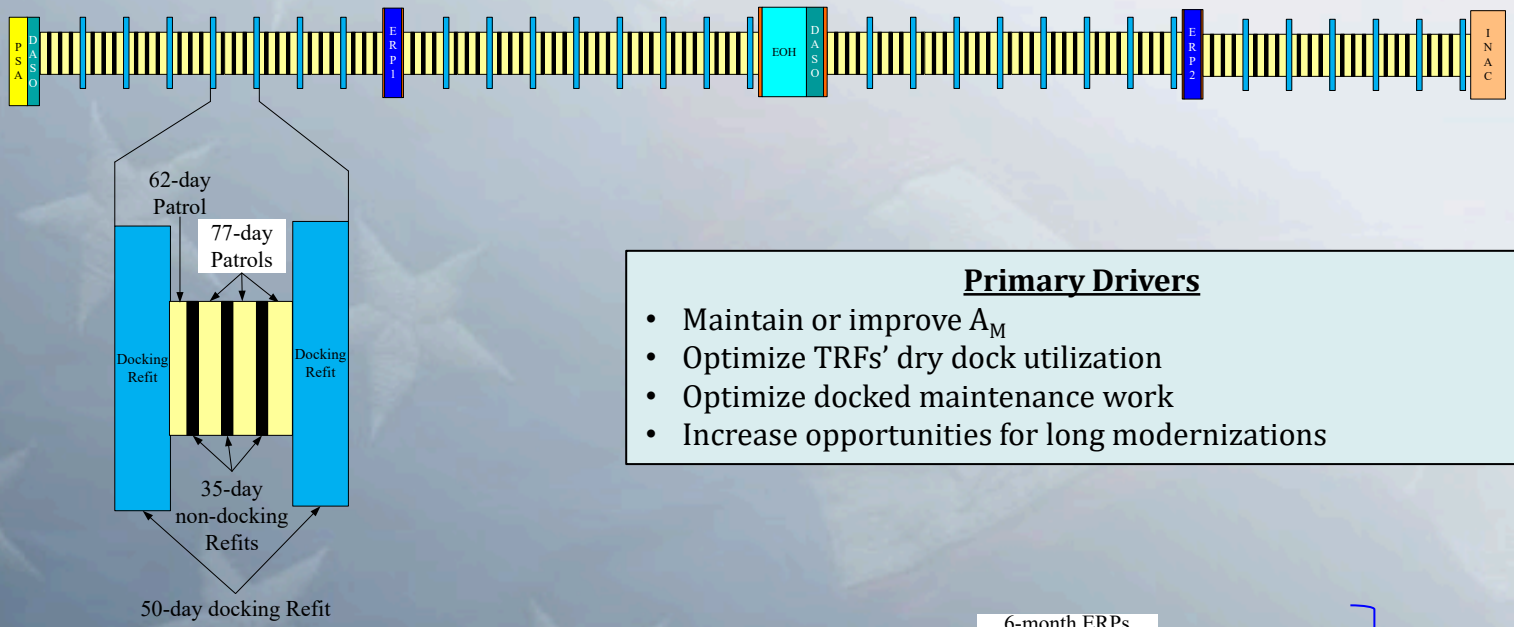




The discrete event simulation turns operational, maintenance and modernization requirements and constraints into a hull by hull schedule for the life cycle

Comparative Analysis with Life Cycle Models

SSBN Life Cycle Schedule



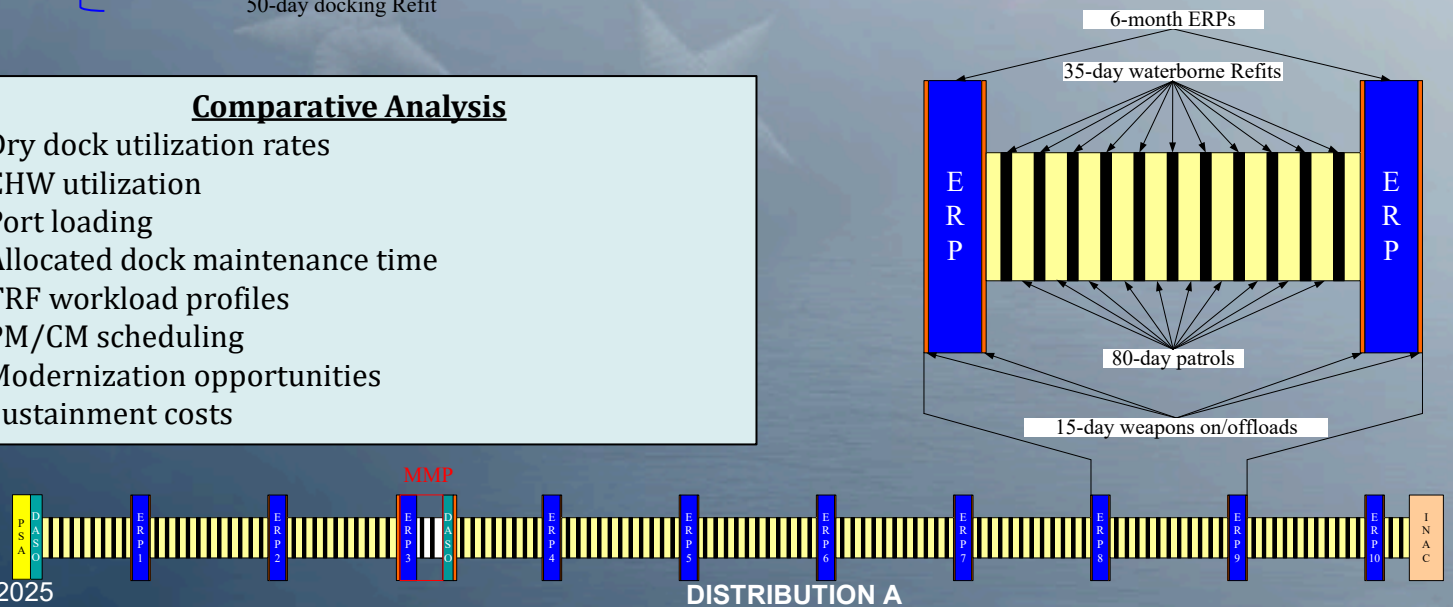
Primary Drivers

- Maintain or improve A_M
- Optimize TRFs' dry dock utilization
- Optimize docked maintenance work
- Increase opportunities for long modernizations

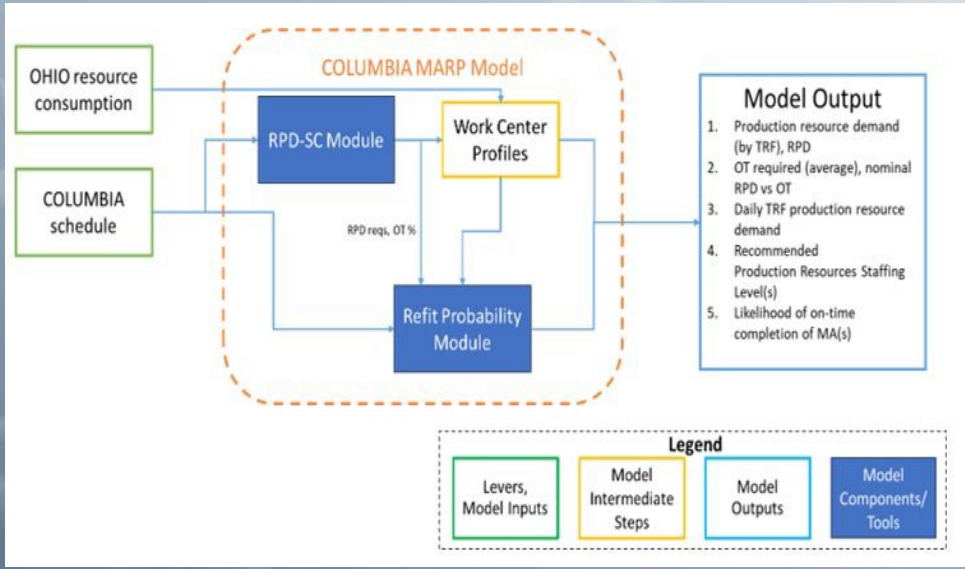
Comparative Analysis

- Dry dock utilization rates
- EHW utilization
- Port loading
- Allocated dock maintenance time
- TRF workload profiles
- PM/CM scheduling
- Modernization opportunities
- Sustainment costs

Alternative Schedule

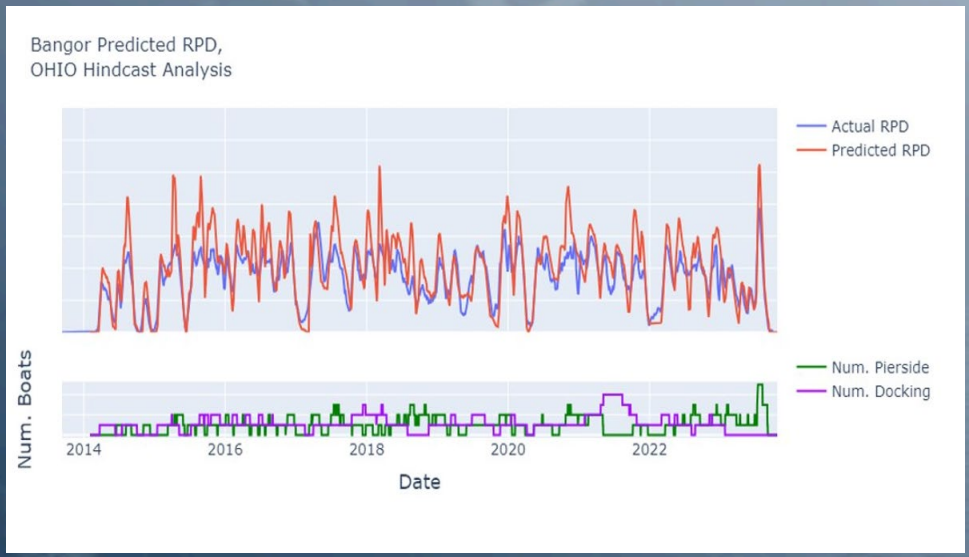


AI/ML applied to the repair facilities



Model Highlights

- Trained on historical OHIO maintenance data;
- Predicts on Resources Needed (in Resource Days(RDs)) and Refit Completion probabilities
- RPD-SC module simulates required work, overtime at various nominal staffing levels
- Refit Probability Module (RPC) estimates on-time completion percentages
- Work can be analyzed at TRF or work center/shop level
- Hindcast analysis (bottom left) on OHIO shows promise for predicting workload for future COLUMBIA refits
- Model outputs can be applied to a notional COLUMBIA schedule to show predicted work for future refits (bottom right)



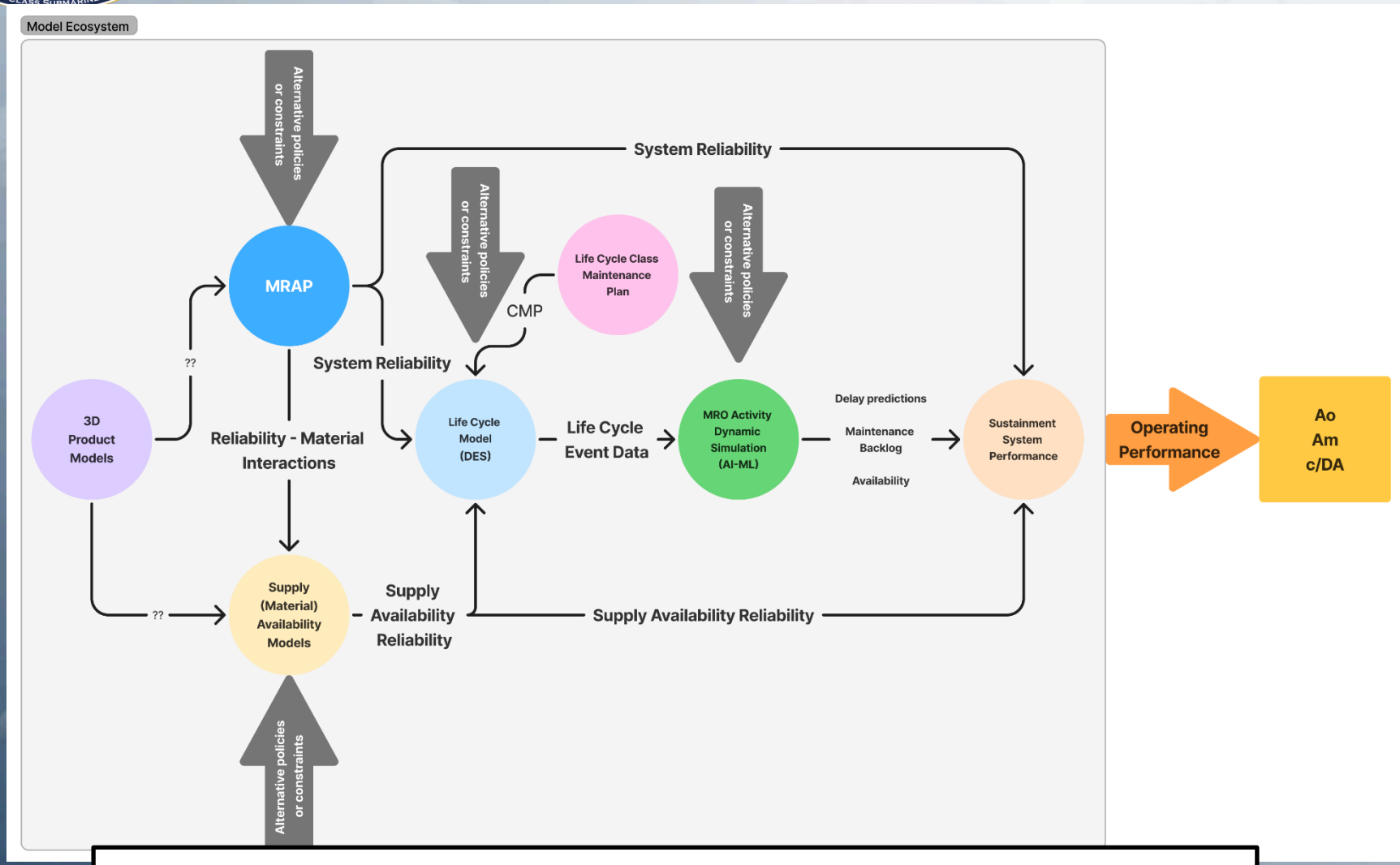
Outcomes

Capability	Model Name	Description	Integration with Other Models in Eco-system
Predict RPD per day given a future (notional) Refit Schedule	RPD-SC	Developed refit profiles and use RPD-SC refit predictions to predict RPD over the course of a refit schedule. Can adjust policy levers of overtime and workload flexibility (Bangor and Kings Bay)	RPD-SC integrated with DES model – takes a notional CLB schedule from DES and provides RD forecasts.
Predict the probability, a refit completes on time	RPC	Given refit characteristics and concurrent facility workload, predict the probability a refit will complete on time (Bangor and Kings Bay)	RPC integrated with DES model – takes notional CLB schedule and provides refit completion probabilities.
Predict expended RDs per refit at a TRF level	RPD-SC	Given total estimate of jobs to be completed, predict expended overall RDs and planned/unplanned RDs. Continuing to explore non-linear models (Bangor and Kings Bay).	Future Work
Predict expended RDs per refit at a Work Center/Shop Level	RPD-SC	Predict expended overall RDs and planned/unplanned RDs. Continuing to explore new models that take job level inputs. (Bangor)	Future Work
Job-level analysis and predictive analytic tools	Cluster Models	Develop capability to have job lists as input/output of models. Supports capability to predict unplanned work given planned job lists or generate synthetic job lists.	Future Work

Conclusions

- The work to date has demonstrated the viability of our intended path to develop an interconnected ecosystem of models, including 3D product models, reliability models, supply models, and class maintenance plans, to enhance decision-making and operational efficiency.
- The model ecosystem offers an improved ability to optimize workforce sizing and predict maintenance needs, with a variety of factors.
- Initial assumptions may need to be updated as illustrated by efforts to use reinforcement learning illustrated the limitations in a high noise data environment,
- Since the new class of submarine has not been completed, the use of synthetic data generation routines will allow for credible simulations of realistic staffing and planning, enabling better analysis and prediction of job compositions and staffing needs.
- Iterative model development led to the creation of non-linear and machine learning-based models, which improved long-term predictions and reduced prediction errors.

Future Work



Build an integrated model ecosystem spanning from the 3D product model to operational models to report, predict and improve $\mathbf{A_o}$, $\mathbf{A_m}$ and C/DA

Questions

- William G Baker – william.g.baker.civ@us.navy.mil
- Joseph M Bradley – joseph.m.bradley.ctr@us.navy.mil
- Arthur Salindong – arthur.r.salindong.ctr@us.navy.mil
- David Sathiaraj – david.sathiaraj.ctr@us.navy.mil
- Tobias Lemerande – tobias.j.lemerande.ctr@us.navy.mil