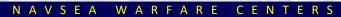# Modeling the Specification

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Motivation

"A Shipbuilding Specification is an engineered product typically not tested until placed in service."

- Defects in a shipbuilding specifications result in
  - Delivered ship not meeting expectations
  - Costly contract changes and possible schedule delays to fix the defects
- Current specification development process not highly effective in preventing, identifying, or correcting many defects

Would all ships that meet the specification requirements also meet the Government's expectations?

Purpose of a Shipbuilding Specification

- Elements of a legal contract
  - **Offer: The offer must clearly state what each party is providing to the other so that both parties have a common understanding.**
  - Acceptance: The party receiving the offer must voluntarily accept the offer.
  - Consideration: Each party must receive something of value from the other party.
  - Capacity / Competency: The parties must legally have the ability to enter into a contract.
  - Lawful Purpose / Legal Intent: The parties must intend for the agreement to be legally binding and the offer must adhere to all applicable laws.

The Shipbuilding Specification must clearly state what the shipbuilder is to provide to the Government to ensure agreement on the consideration provided by the shipbuilder to the Government

Developing a Shipbuilding Specification

- Decomposed into sections organized by Ship Work Breakdown Structure (SWBS)

- Often specification sections of recent similar ships are used as a starting point.

- Development of sections reflect the ongoing design and is coordinated with Technical Warrant Holders (TWHs) and developers of related sections.

- Requirements Management tools or System Engineering tools (such as SYSML) may be employed to manage the process.

  - Also used to demonstrate traceability to higher level requirements.

- Reading Sessions are primary means for finding errors

  1. Before placing specifications under configuration management

  2. Prior to Certification by TWHs.

"Shipbuilding specifications do not represent a particular ship design, but rather define a design space from which the shipyard must develop a detail design. The design space is intended to provide degrees of freedom that enable the shipyard to optimize the detail design for the shipyard production processes and lower material costs, thereby reducing overall cost."

Sources of Defects

- "Starting point" specification sections don't match the indicative design.

- Specification section language poorly translate the lessons learned from indicative designs.

- Specification section language does not define the remaining design space well.

- Reading sessions inefficient at finding defects – and often add new ones.

We are not effective at:
- Keeping Defects Out.
- Finding the Defects that are In.
What to Do?
- Set-Based Design
- Modeling the Specification

Model of a Specification

- Typically, we model the indicative design, then extrapolate results to the design space by the shipbuilding specification
- We propose to develop models that directly incorporate the degrees of freedom offered by the shipbuilding specification design space.
- Modeling often can be simpler, because while it must cover the range of what is allowed, it need not be validated against a particular set of hardware. Goal is to demonstrate the system design is robust to all solutions that meet the specification.

Models can include
- Geographical Models
- Relational Models
- Static Models
- Dynamic Models
- Logic Models
- Behavior Models
- Stochastic Models
- etc

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Testing a Specification

- A set of use-cases, perhaps auto-generated, that should be challenging, but consistent with the shipbuilding specifications.

- The ability to populate parameter values within the component models and system models within the range allowed by the component specifications and shipbuilding specifications.

- The ability to run a simulation that implements the use-case with the populated parameter values

- The ability to evaluate the simulation results to determine if the results are acceptable or not.

- A search algorithm to identify which combinations of parameter values result in unacceptable behavior.

The ultimate goal of Testing a Specification is to identify defects that can be corrected before the ship is placed under contract.

Implementation

- Incremental Approach
    - Model the shipbuilding specification in a few disciplines where dynamic models already exist. Use the experience gained in this effort to refine the process. The models may be federated.
    - Extend the modeling effort to additional disciplines where the risk of a defective specification has been evaluated higher than other disciplines.
    - Integrate the federated models.
    - Add additional disciplines until the entire shipbuilding specification is modeled.

Modeling the Specification requires refocusing modeling efforts from the indicative design to modeling the design space defined by the shipbuilding specification.   The need for an indicative design may disappear as it becomes a single point in the design space.

The Model as a Specification

- Terry Ericsen proposed using the models as a specification, thereby eliminating the need to create the traditional text-based documents.
- The capability to model the specification is an important enabler to a possible future of using the model as the specification.
  - Many issues remain, including how the model satisfies the fundamental purpose of the specification.

https://www.rijksmuseum.nl/nl/collectie/NG-MC-386

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Recommendations

- Establish an organization to create and maintain a modeling environment and models. Ensure this organization is adequately and stably funded.

- Have this organization create and implement an incremental plan for developing and employing the models and modeling environment in all future naval ship preliminary and contract designs.

- Use the model and modeling environment during source selection to ensure proposals are responsive to the solicitation.

- Use the model and modeling environment during detail design and construction to ensure Engineering Change Proposals only have intended results.

- Structure sea trials and special trials to validate the models.

- Transition the models to a digital twin to support in-service operations, maintenance, and modernization.

- Expand the organization's mission to implementing "Model as the Specification"

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