OFFICE OF THE PARLIAMENTARY BUDGET OFFICER

CANADA

BUREAU DU DIRECTEUR PARLEMENTAIRE DU BUDGET

PRICE®

Confusing Precision with Accuracy

How data availability informs budget sufficiency

ICEAA Canada

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Today's Presenters

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Agenda

- The short history of PBO Budget Sufficiency Analysis
- How data drives methodology and outcomes
  - Estimating for Budget Sufficiency
  - Precision vs. Accuracy
  - Modeling the PBS for Budget Sufficiency
- Case Vignettes
  - JSS - How Much to Set Aside for Program Success?
  - AOPS - Is a Given Budget Sufficient for a 6-8 Ship Program?
- Advances in Best Practices
  - Template / Test Case Approach
- Lessons Learned

Short History

- PBO, created in 2008, to provide independent analysis to Parliament and serve as a second data point to government "estimates"
- Economic and fiscal analysis:
  - PBO= 2007-08 recession would cause significant deficits
  - Gov't=2007-08 recession would pass Canada by and leave a small surplus
- Cost estimate of government programs:
  - PBO =JSF would cost $30 billion acquisition and operating
  - Gov't (public) =JSF would cost $75 million per plane
  - Gov't (private) = JSF would cost $30 billion acquisition and operating

Cost Estimating Best Practices

- ICEAA **(GAO)** steps

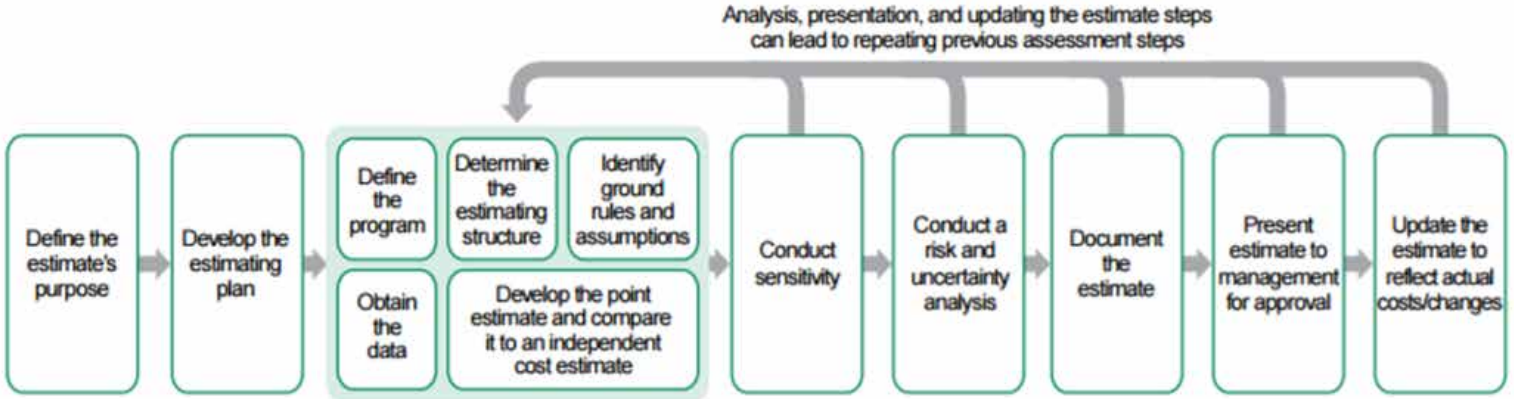
Figure 1: The Cost Estimating Process

Initiation and research
Your audience, what you are estimating, and why you are estimating it are of the utmost importance

Assessment
Cost assessment steps are iterative and can be accomplished in varying order or concurrently

Analysis
The confidence in the point or range of the estimate is crucial to the decision maker

Presentation
Documentation and presentation make or break a cost estimating decision outcome



Source: GAO.

Modeling for Budget Sufficiency

- What is Budget Sufficiency?
  - Sufficient funding to enable a program to deliver on its intended outcomes, and to avoid program failure
- Example: Joint Support Ship
  - $2.1MM in 2008, for 3 ships
  - Cancelled in 2009 => bids came back over budget
  - 2008 figures reveal only a point estimate
  - JSS 2: Budget of $2.6MM in 2010, for 2 ships
  - Currently (2017) without any re-supply capability

Developing estimates that are more "precise" does not necessarily make them more "accurate". We don't know if the $2.1 billion for JSS1 was precise but we do know it was wildly inaccurate.

Precision vs. Accuracy – According to the Dictionary

- Precision according to Merriam Webster:
  - the degree of refinement with which an operation is performed or a measurement stated
- Accuracy according to Merriam Webster
  - freedom from mistake or error

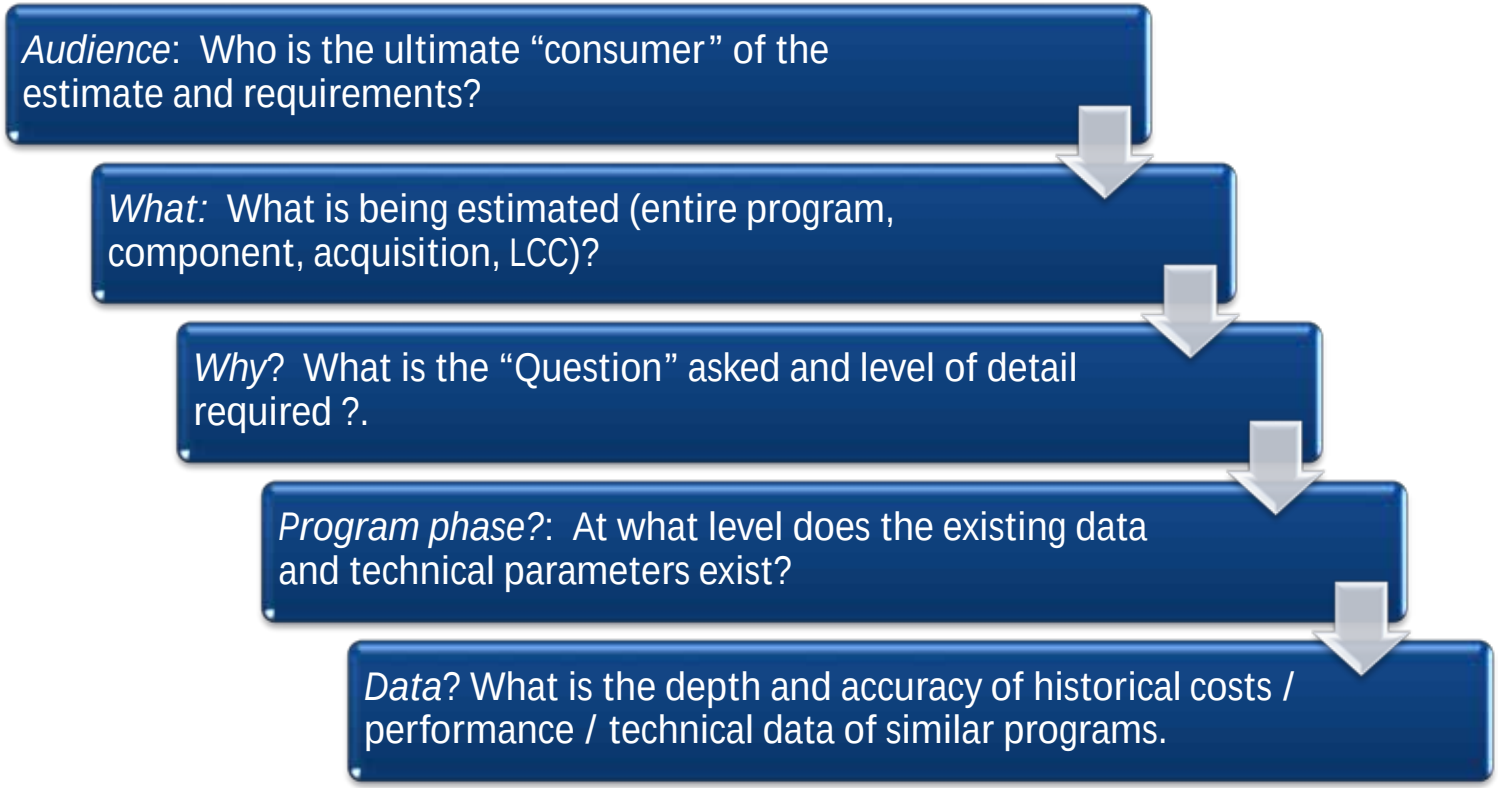
=> ”what if” JSS 1 budget had been increased by 500MM in 2008 dollars (Accuracy)
=> “what if” decision makers had been aware of the distribution of the estimate (Precision)
=> “what if” Canada had adopted the GAO 80% rule in 2008? (Degree of Accuracy)

Precision vs. Accuracy - In Practice

- No estimate is “free from mistake or error”
  - Probability of achieving a given estimate is exactly zero! In other words, our cost estimates will always be exactly wrong!
- In cost estimating, accuracy is best thought of as achieving a given level of confidence based on the degree of inherent uncertainty in underlying parameters.
- A key decision early in an estimate is “appropriate” level of modeling of the Product Breakdown Structure.
  - Sets the stage for everything else including the “fidelity” of the estimate
  - Need to consider the ultimate outcome of the estimate.

The estimate only needs to provide necessary and sufficient decision-support information- nothing more and nothing less.

Asking the "right" questions to drive level of modeling for budget sufficiency



For "Budget Sufficiency" we only want to know if the resulting estimate will fit within a given "budget envelope". Is budget envelope being properly informed? What is basis of budget envelope?

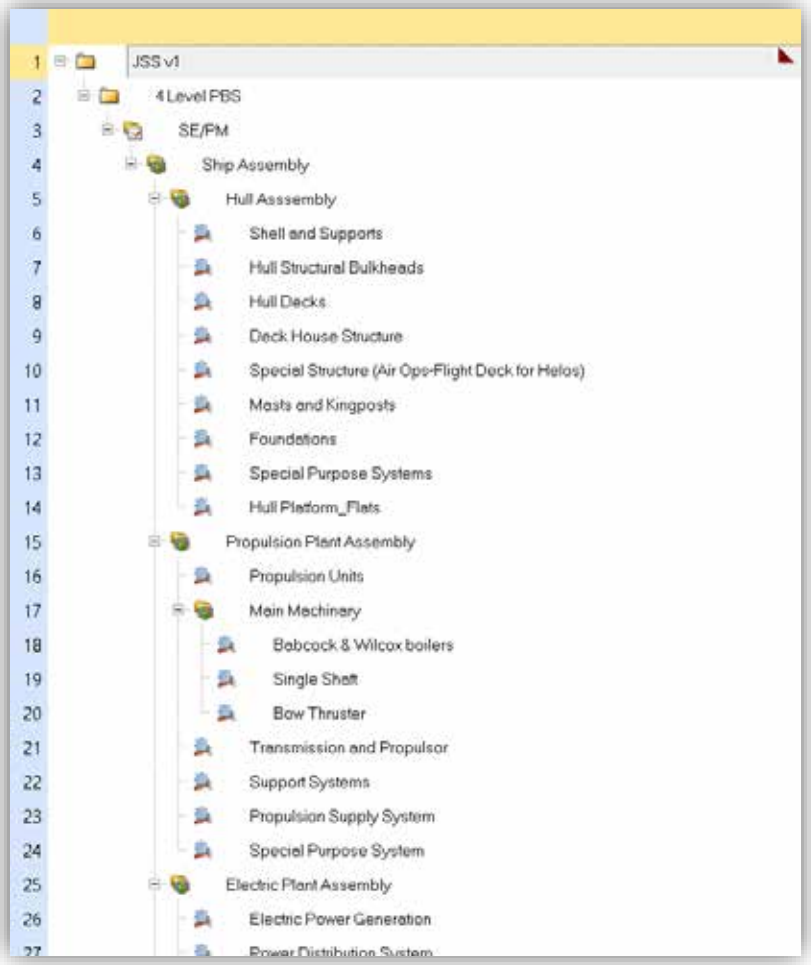
Case Study Vignettes: Canadian Joint Support Ship

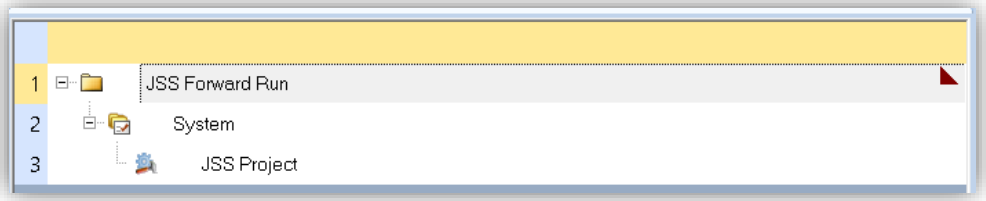
Question	Response
Who?	Parliament
What?	Joint Support Ship total acquisition cost
Question Asked?	How much to set aside to ensure program success?
Program Phase	• No ship design nor detailed specifications • No cost details • No recent analogous acquisitions
Depth/Accuracy of historical data	• High-level public domain
Product Breakdown Structure	• Modelled at total ship level, not WBS • No sub-system data available

Modeling The PBS for Budget Sufficiency

Which is more accurate? Which is more precise?

- 4 Level 68 "Cost Object" PBS Vs. 2 Level 2 "Cost Object" PBS





http://www.navy-marine.forces.gc.ca/en/fleet-units/jss-home.page

Joint Support Ship

...depends on reliability of the models and strength of the underlying CERs

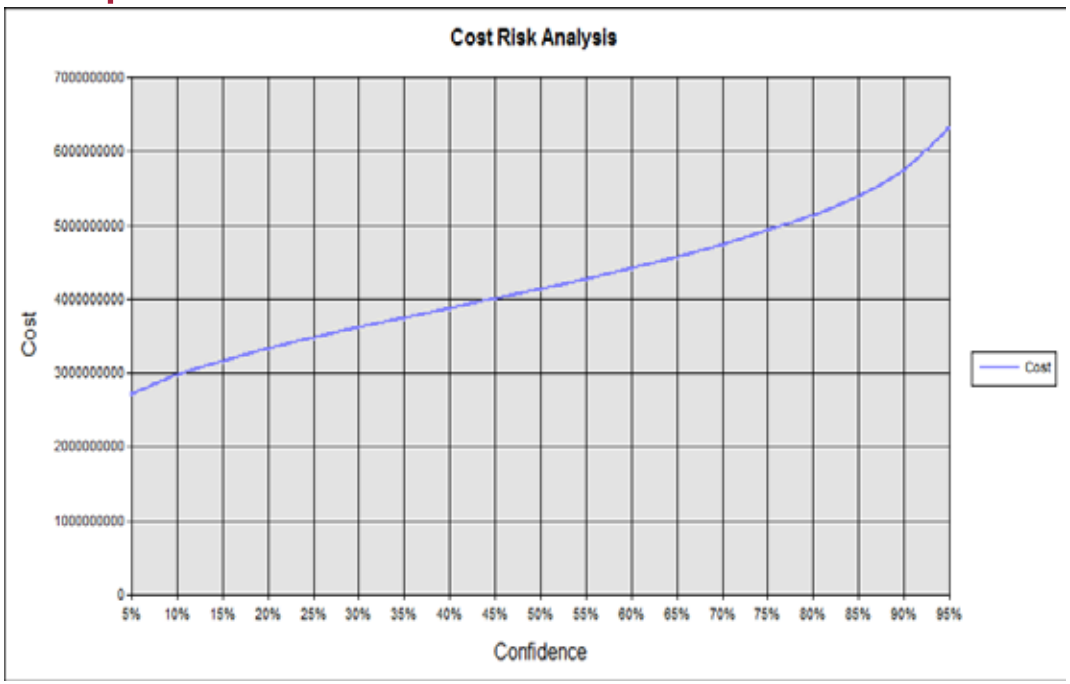
- Available level of historical data
- Calibrated to level of historical data

Case Study Vignettes: Canadian Joint Support Ship

Question	Response
System Cost Object	• Tasks associated with the overall planning, directing, and controlling of the definition, development, and production of a system • 1 Hardware Cost Object
Basis of Estimate	• SE/PM, design and manufacturing costs calibrated with analogous ship programs • Heavily reliant on the True Planning model, which holds industry average data and estimating relationships • Modified slightly with input data

Canadian Joint Support Ship - Outcome

- Cost of 2 ships: 2.73 to 6.31 $B



- Lack of data, even when relying on industry standard CERs, does not allow for either a precise nor an accurate estimate
- Does not provide meaningful decision-making support. Increases the risk to program failure as decision-makers get fixated on the point estimate and "contingency"

Case Study Vignettes: AOPS

Question	Response
Who?	Parliament
What?	AOPS acquisition cost
Question Asked?	Is $2.8B sufficient to purchase 6-8 ships?
Program Phase	• No comparable design: parabolic hull and broad beam for ice vs longer streamlined hull for open waters
Depth/Accuracy of historical data	• Statement of Operating Requirements "unavailable" • No recent analogous acquisitions • But: reliable cost and schedule data from coast guard ships
Product Breakdown Structure	• Modelled at total ship level, not WBS • No sub-system data available • But: "shocking" the model for construction delays and quantity changes requires 8 hardware cost objects

Modeling The AOPS PBS for Budget Sufficiency

- Highly Calibrated Historical Data

1	AOPS Final Calibration
2	Louis S. St-Laurent
3	Henry Larsen
4	Amundsen
5	Des Groseilliers
6	Pierre Radisson
7	Griffon
8	Edward Cornwallis
9	Sir William Alexander
10	Ann Harvey
11	George R. Pearkes
12	Sir Wilfred Laurier
13	Martha L. Black
14	Samuel Risley
15	Earl Grey

- Allows modeling of multiple production ships

1	AOPS Base Model for review
2	System Engineering and Proj...
3	Development Ship
4	2nd in class
5	3rd in class
6	4th in class
7	5th in class
8	6th in class
9	7th in class
10	8th in class

...depends on reliability of the models and strength of the underlying CERs

- Available level of historical data
- Calibrated to level of historical data

Arctic Offshore Patrol Ship

Case Study Vignettes: AOPS

Question	Response
System Cost Object	• Tasks associated with the overall planning, directing, and controlling of the definition, development, and production of a system
Hardware Cost Object	• Modeled at ship level, not WBS level, • 8 ships therefore 8 hardware cost objects
Basis of Estimate	• SE/PM, design and manufacturing costs • Calibrated against manufacturing complexity of analogous ships • Heavily reliant on the True Planning model, which holds industry average data and estimating relationships • Calibrated to reliable cost and schedule data

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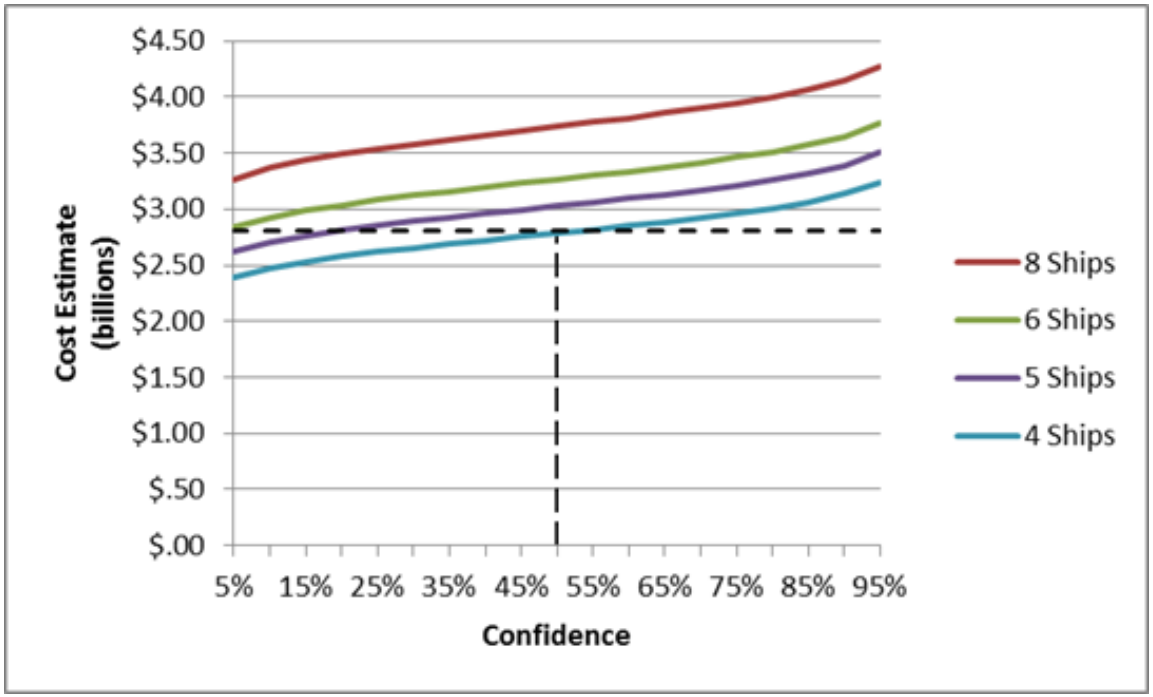
AOPS - Outcome

§ 6 ships cost $3.27B; Gov't budget was $2.6B



- Build 4 – 8 ships? - Can afford 4 ships at 50% CI no delay
- Build 3-4 ships with one-year delay - 3 ships at 80% CI with one-year delay
- Build 3-4 ships with two-year delay - 3 ships at 75% CI with two-year delay

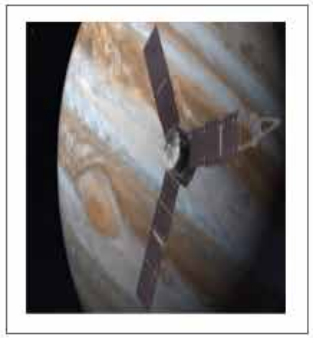
Bridging Precision and Accuracy – Templates/Test Cases

- Recognizing the need to bridge precision with accuracy, starting in 2016, PRICE Systems developed (and continues to develop) templates that serve as actionable starting points for future estimates.
  - A Template represents a specific product type that bypass the need for client creation of product structure from scratch and which can be adapted to represent a specific product of the type.
  - A Test Case is application of publicly available case (a known product) information to a template in order to gauge reasonableness of the template for it's intended purpose (to be a reasonable starting point for modeling a specific product of a product type).
  - A test case is a template scaled to size, time frame, and quantities of the case.

Surface Vehicle Test Case- Humvee

Aircraft Carrier Sea Systems Test Case-

Aircraft Test Case- F15 Eagle



Planetary Spacecraft Test Case-Juno

Submarine Sea Systems Test Case-SSN774

Reasonableness is the comparison of test case estimate against publicly available cost.

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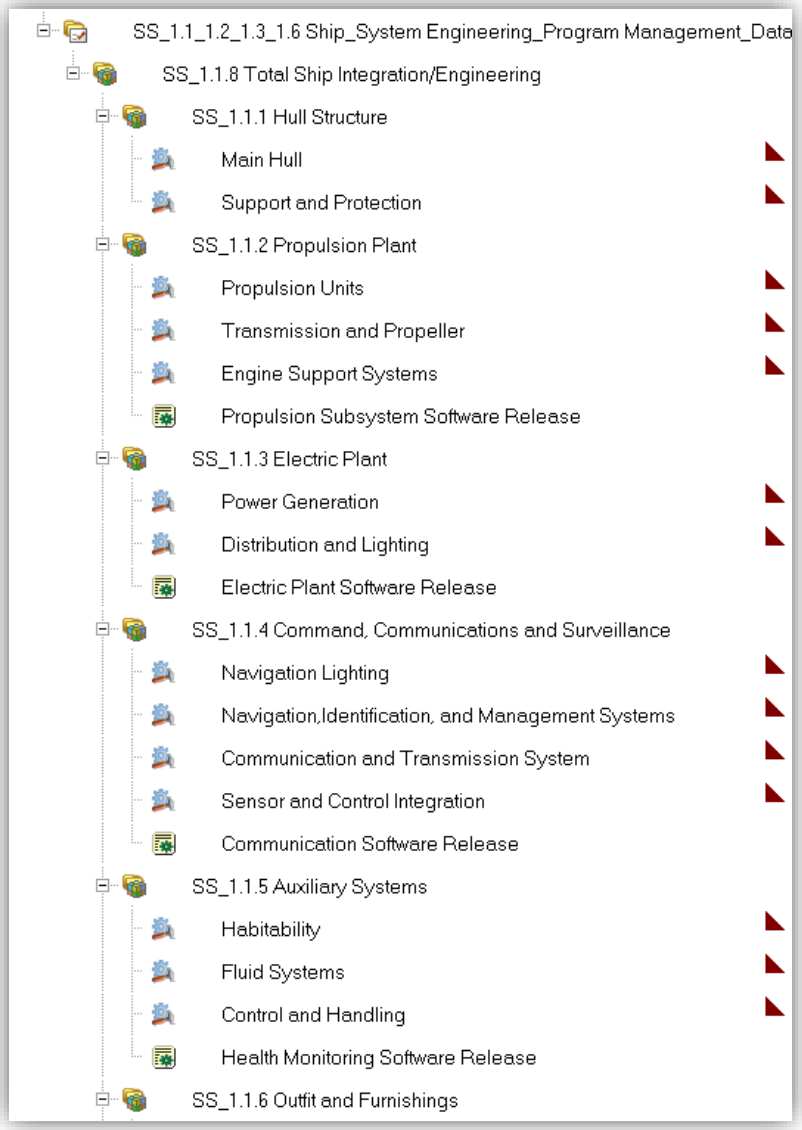
Bridging Precision and Accuracy

- Bridge between precision and accuracy accomplished by high level modeling of JSS and A/OPS based on lower levels validated PBS
  - The starting point would be building out Supply Ship and Artic Ship Class Templates
  - Development of a "Test Case" against the known historical data (unit cost, schedule, weight, quantity)
  - Ability to run the test case against known historical program to test reasonableness of the test case.
  - Once validated used as a start point for future ship estimates.
  - Can be used at both a high level and lower level PBS depending on known program information.



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Lessons Learned

1. **Precision**: Lack of precision can limit the usefulness of an estimate. In the case of the JSS, the confidence interval is so wide that the risk tolerance of decision-makers can become over-emphasized.

2. **Accuracy**: Reliable cost and scheduling data allow a much narrower range of estimates, even when no sub-system level data is available, as long as CERs are well developed and stable.

3. **Depth of Accuracy**: Focus on CI and range allows decision-makers to test meaningful options and identify risks to budget by shocking the model. Focusing on program outcomes (i.e. number of ships) rather than single-point budget estimate creates space for a discussion of program success.

4. **Bridging Precision and Accuracy:** Importance of matching level and quality of data to drive the appropriate level of modeling. Templates / Test Case methodology provides actionable starting points for future estimates.

Questions?