Designing The Next Flagship

THE VALUE OF PERFORMANCE.

NORTHROP GRUMMAN

AAS 234

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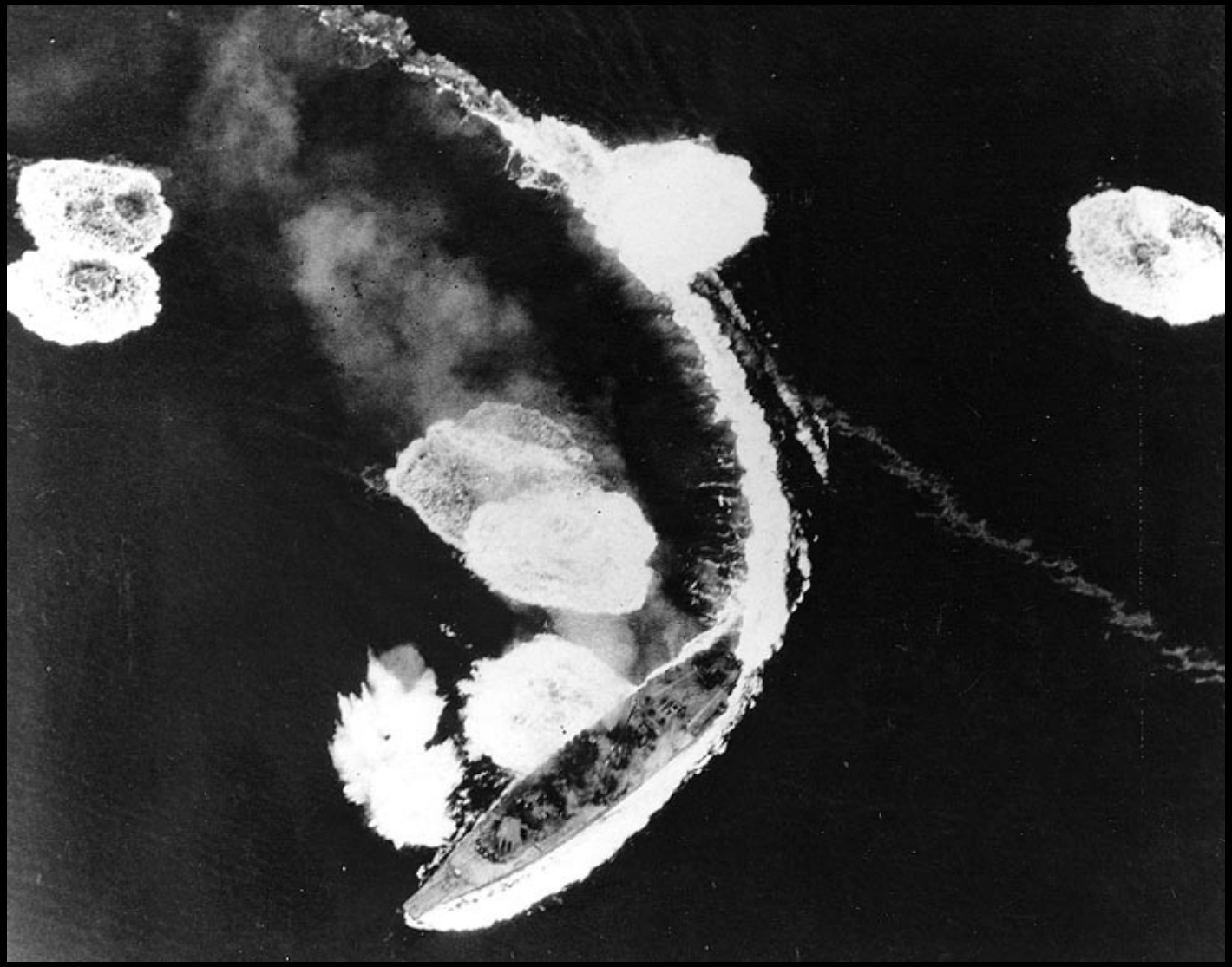
Large Mission Milieu



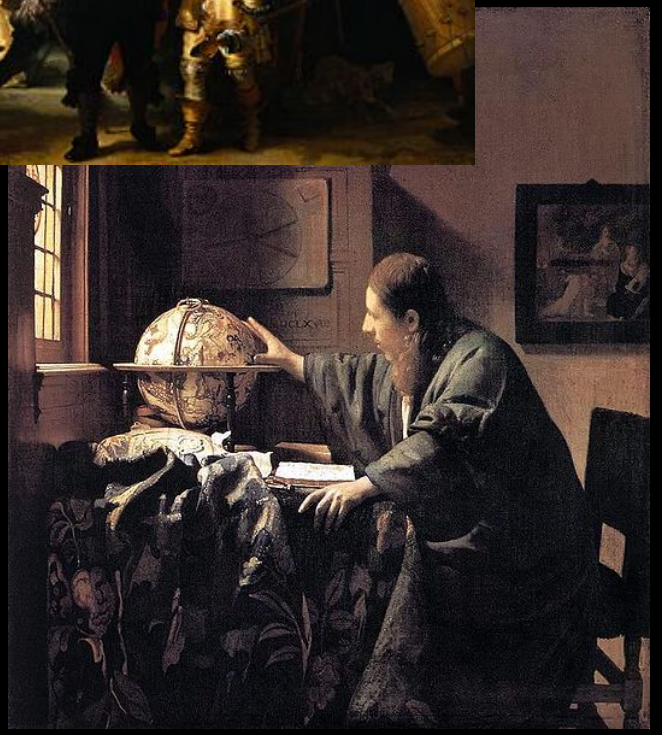
Central Problem of System Design For Science

- To design and execute a system capable of producing worthy (new) science, with constraints
  - **Under-defined or improperly defined problem**
  - **New designs or technology --**
  - **Complexity**
  - **Imperfect parts**
  - **Finite funds**
  - **Finite time**
    - Celestial schedule
    - Graduation (or Retirement)
- Why is the SE job for Flagship systems special?
  - **Generally scientific instruments are aimed at doing something new or better than previously achieved**
    - "there is no book for this"

Uncertainty is expensive

Big Picture View of SE For Science

- Systems Engineering should be thought of as guidelines
  - **Not a hard one size fits all recipe**
- This is especially true for large space astronomical systems
  - **For new systems there is no book**



Systems Engineering is both Science and Art

The Design "Process"

- Know and understand the customer's objective
- Ask the design question in a way it can be answered
- Determine ALL possible solutions
- Select the best option
- Understand how the design works
- Execute the design (fill in all the details)
- Build, test, deliver
- Dispose

Design is more than technology

Know and understand the customer's objective

- What is the objective?
  - **Concentrate on what NOT how**
- Who is (are) the customer(s)?

Ask the design question in a way it can be answered

- Asking the correct question is fundamental to getting the right answer
- Learn how to speak customer and system
  - **Corollary- Scientists need to learn to speak engineer and manager**

Determine ALL possible conceptual solutions

- Think through the problem and determine as many ways to solve as possible
  - **Imagination lives here**
- Don't reduce the field (yet)
  - **Flexibility is key**
- Study the various options in preparation of selection
  - **Evaluate along the customer and solution provider needs**
  - **How do technology, design and operations interact?**

Avoiding a failure of imagination is key to successful design

Select the "best" option

- What is best for this customer(s)
  - **Do they all want the same thing?**
    - What if they don't?
- Use a rational process for evaluation
  - **Have an objective function**
    - Cost, schedule, performance, risk
      - Understand them quantitatively
- Recognize the Big Fundamental Problem, aka the *sine qua non* of the solution
  - **One BFP is ok, more than one is not good**
- Do not believe in miracles, but you can bet on on ONE
  - **Technology development to address BFP**

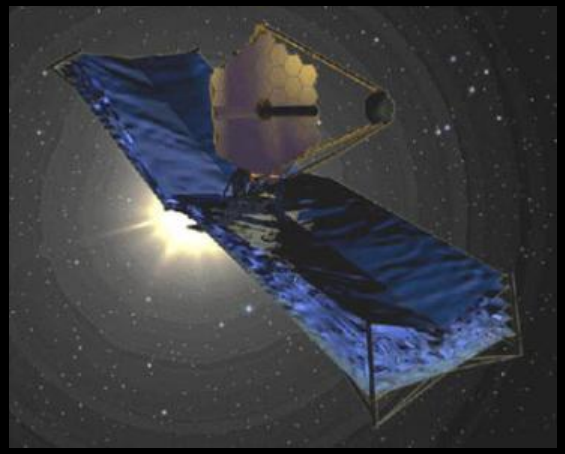
Understand how the design works

- ***Knowing how the selected design work, enables you to know how it fails***
- Make a model of the system and keep it current
  - **Model is used to predict performance**
  - **Train intuition**
- Have a performance (error) budget(s)
  - **Understand and be able to explain allocations of tolerance**
    - Requirements flow down
    - Reserves
- Understand the interfaces
  - **This is usually where problems occur**
- How will the design be verified?

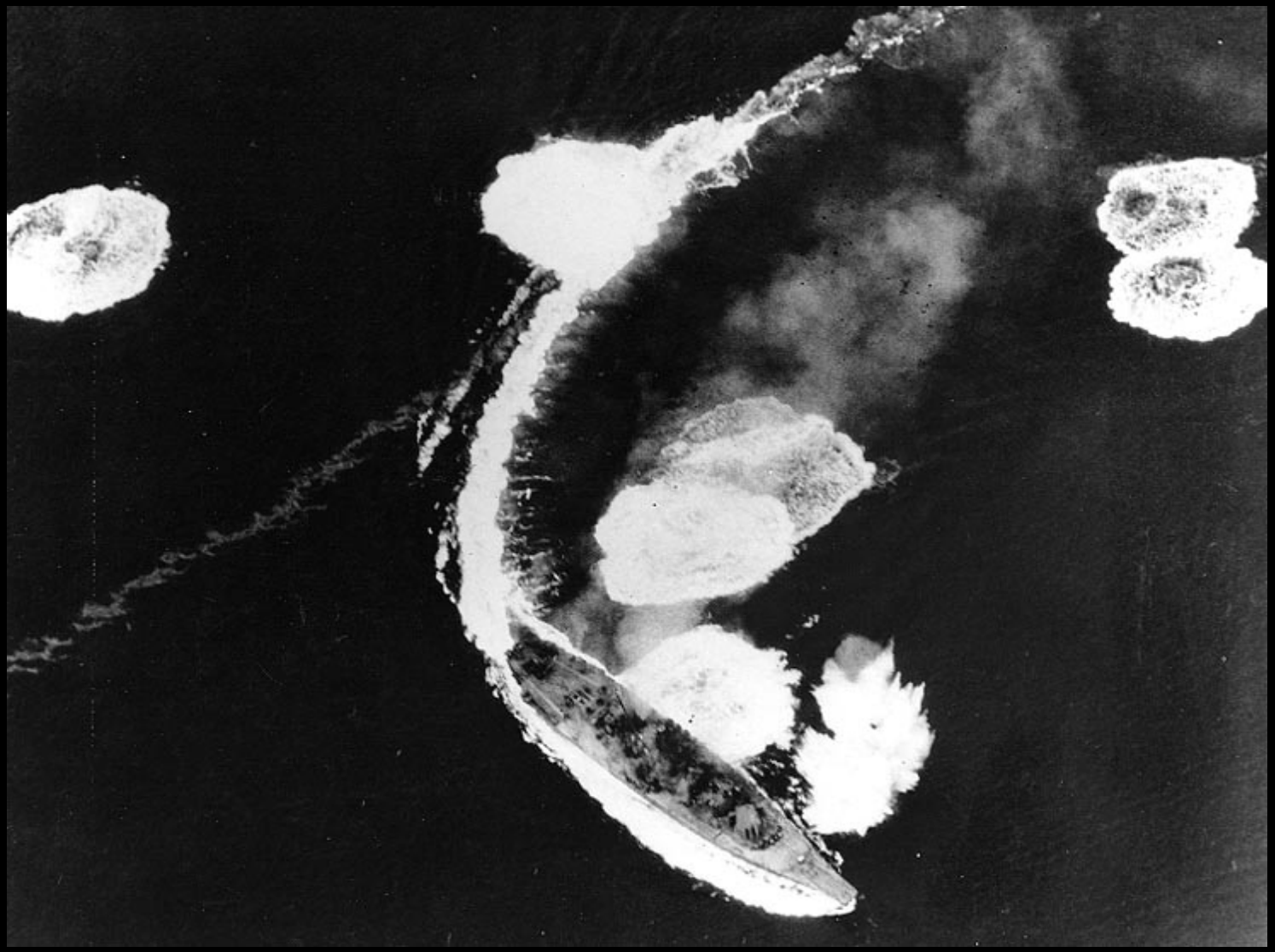
The purpose of design is the mitigation of failure

Execute the design (fill in all the details)

- Expect to learn and update performance models
- Have adequate reserves
  - **Performance, cost and schedule**
- *"If the design is wrong, change it."*
  - **Be able to explain why the change is necessary**
  - **The design WILL evolve (change)**



Let's Turn the Battleship to a Sustainable Future




Thank you.