# Concept Exploration of the Amphibious Combat Vehicle

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# Introduction

- Assault Amphibious Vehicle (AAV)
  - Still in service after 40 years
- Expeditionary Fighting Vehicle (EFV)
  - Cancelled in 2011
- Amphibious Combat Vehicle (ACV)
  - Initial Capabilities Document
    - 25 Oct 2011
  - Acquisition Decision Memorandum
    - 1 Dec 2011
    - Authorized entry to Materiel Solution Analysis phase
    - Authorized Analysis of Alternatives (AoA) initiation
  - Analysis of Alternatives
    - Completed in June 2012
    - Validated Marine Corps requirement for an over-the-horizon, self-deployable, survivable, amphibious vehicle
    - Did not specifically address High Water Speed

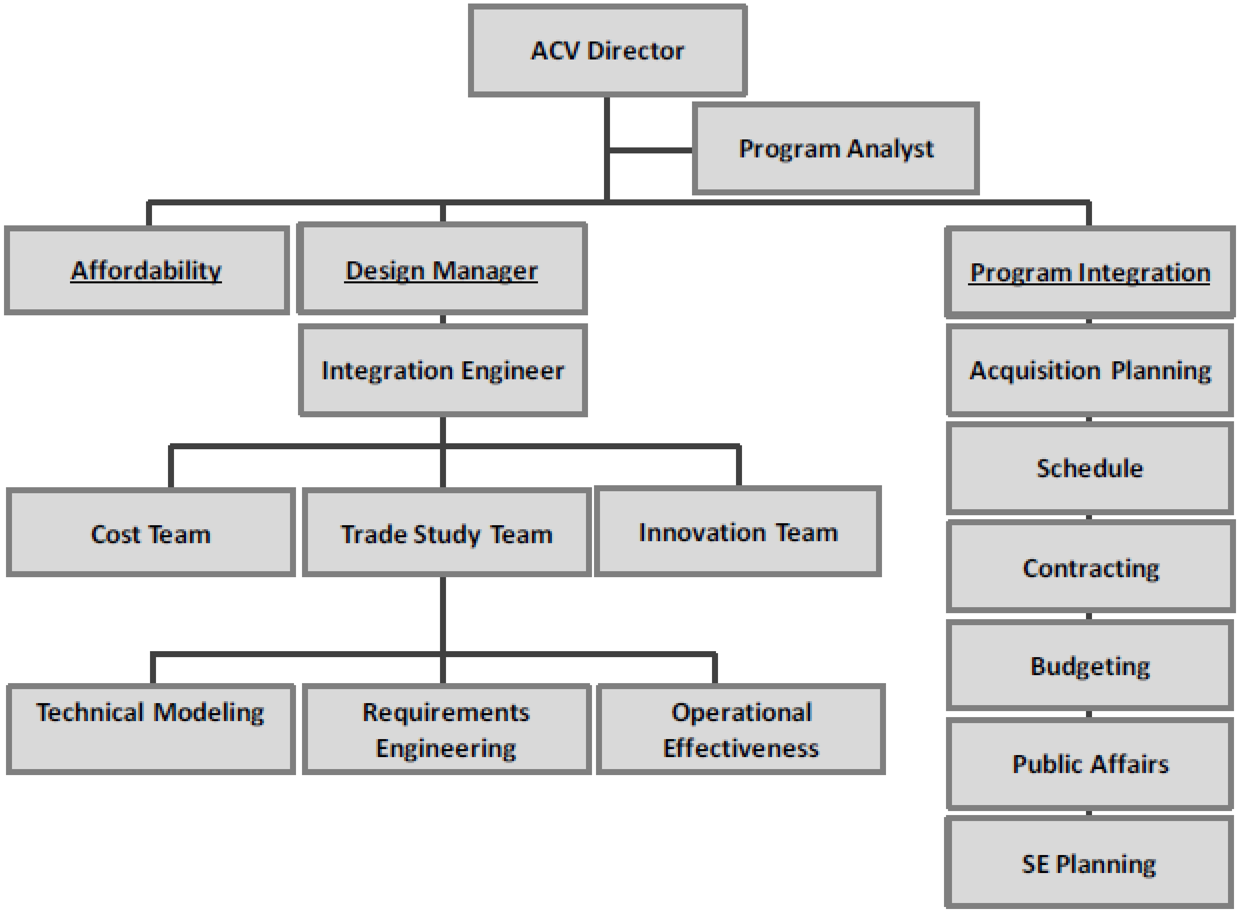
**AAV** (Photo By: Mass Communication Specialist 3rd Class Amanda Kitchner)

**EFV Prototype** (Photo By: Lance Cpl. Brandon R. Holgersen)

***"Is an affordable, survivable, high water speed ACV feasible?"***
***"What is the relative value of high water speed compared to low water speed?"***

# ACV Concept Exploration Team

## (February 2013-February 2014)



# ACV Team

CD&I

PP&O

P&R

DASN ELM

MCSC

PEO LS

NAVSEA

ONR

TARDEC

NSWC Dahlgren

NSWC Carderock

NSWC Philadelphia

NSWC Dam Neck

ERDC

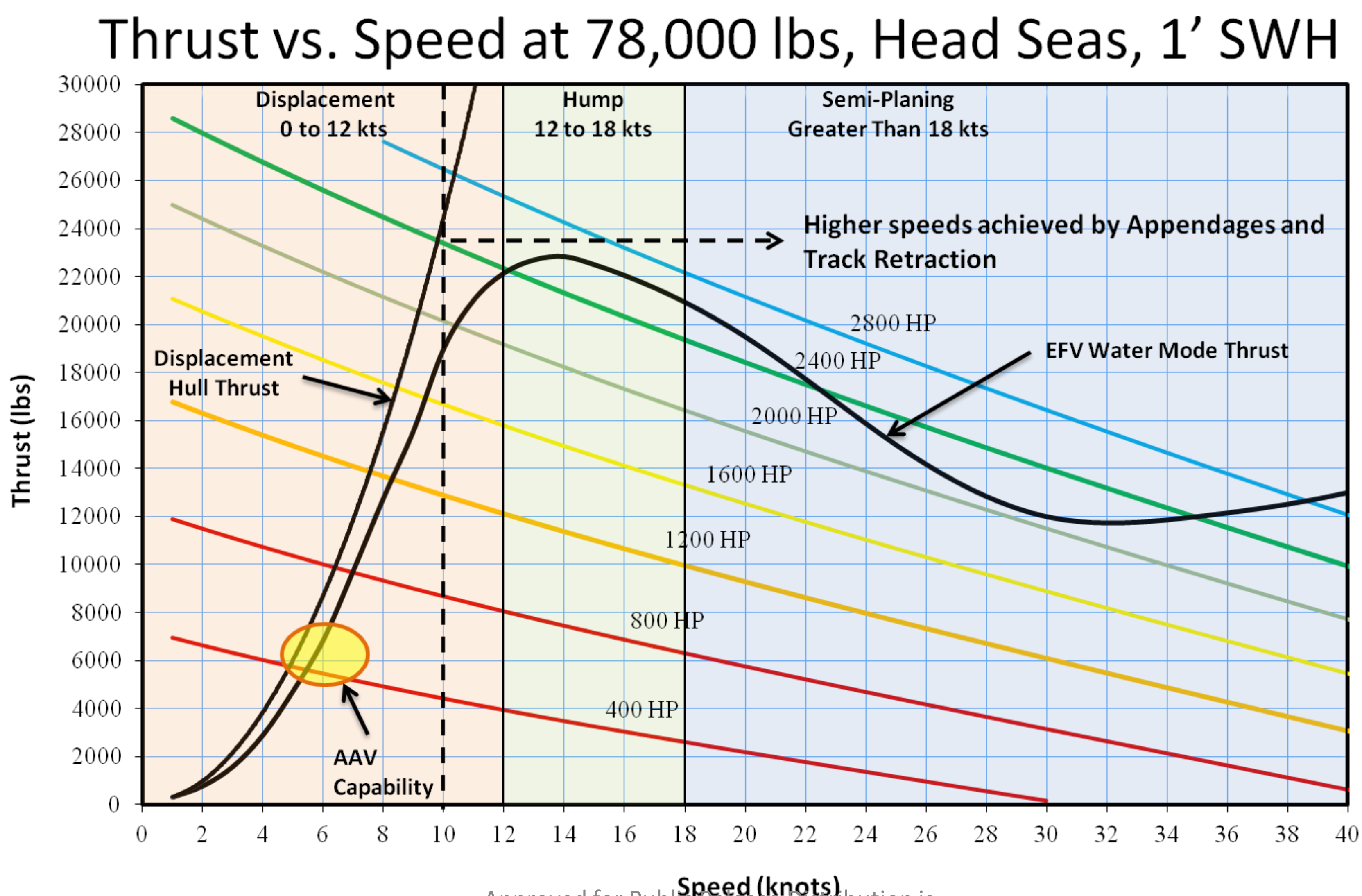
Industry

GTRI

Stevens University

University of Michigan

# High Water Speed Physics



# High Water Speed Defined

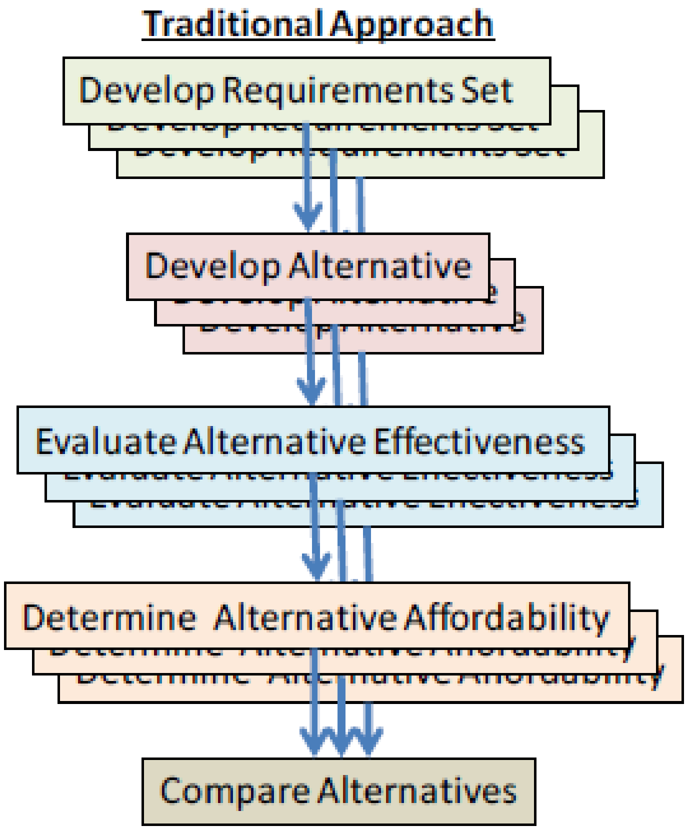
## Technically

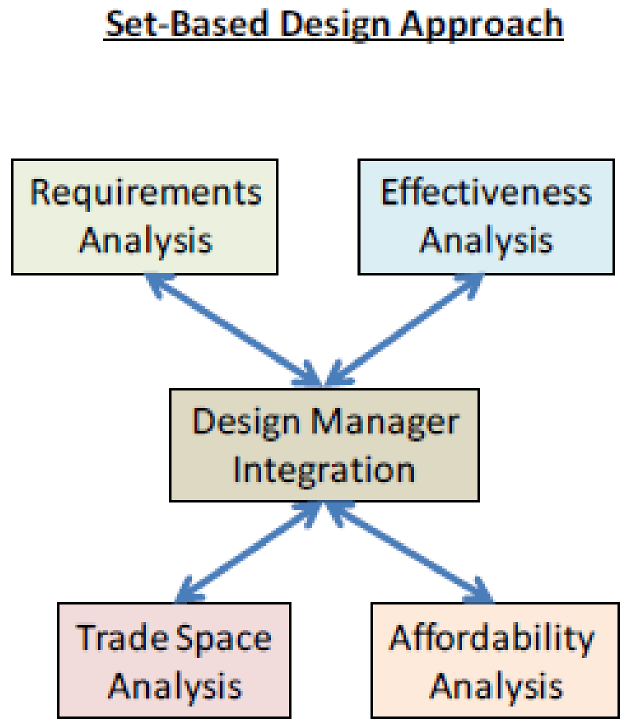
- Semi-planing craft that transitions to HWS between 12-18 knots (varies based on sea state)
- Once on plane the vehicle can accelerate to a higher speed in the 20-28 knot range

## Operationally

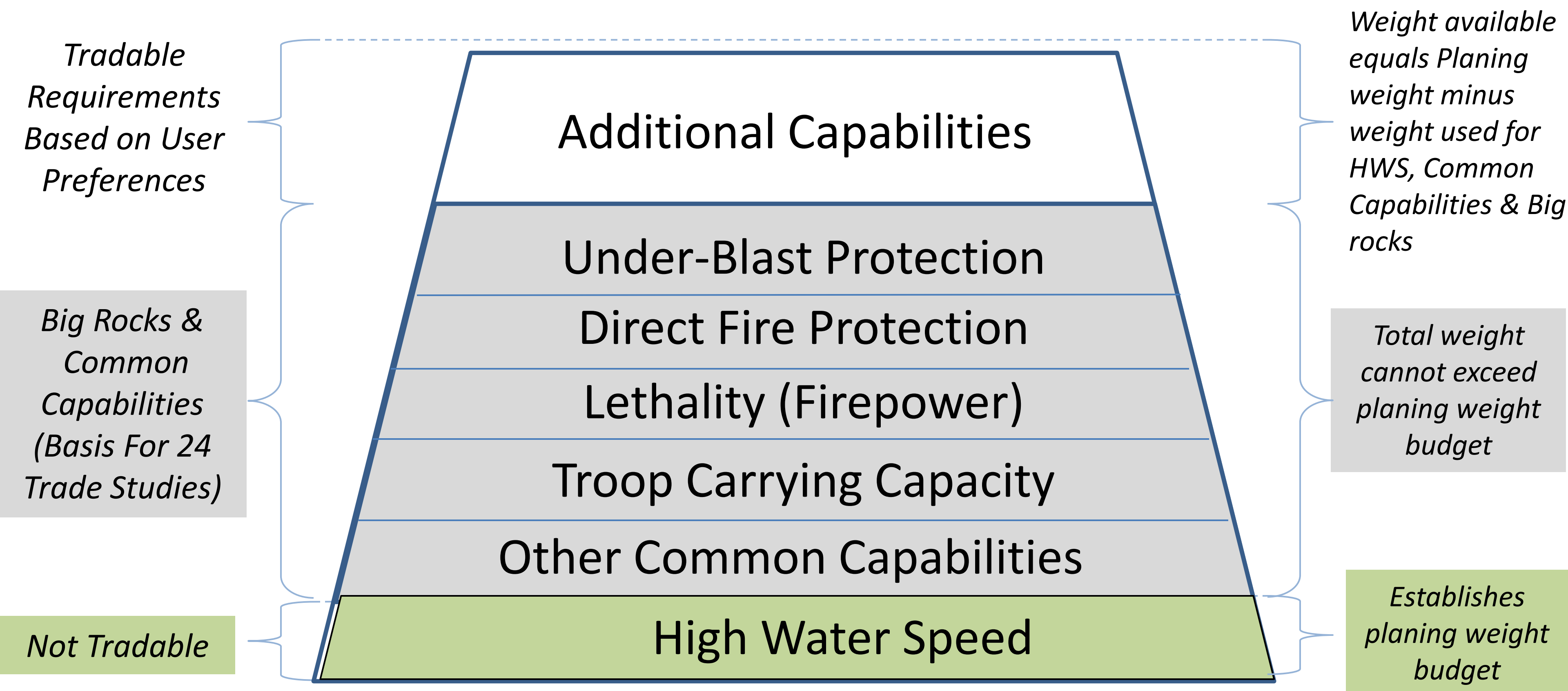
- Deploy off an amphibious warfare ship: LHA/LHD/LPD/LSD.
- Accelerate to semi-planing mode and drive to the shore at high speed.
- For deployment distances 25 NM and greater, reach shore at least 1.5 hours faster than a displacement craft.
- As approach shore, transition to displacement mode and close the shore at eight knots.

# Study Approach
## (Traditional vs. Set-Based Design)

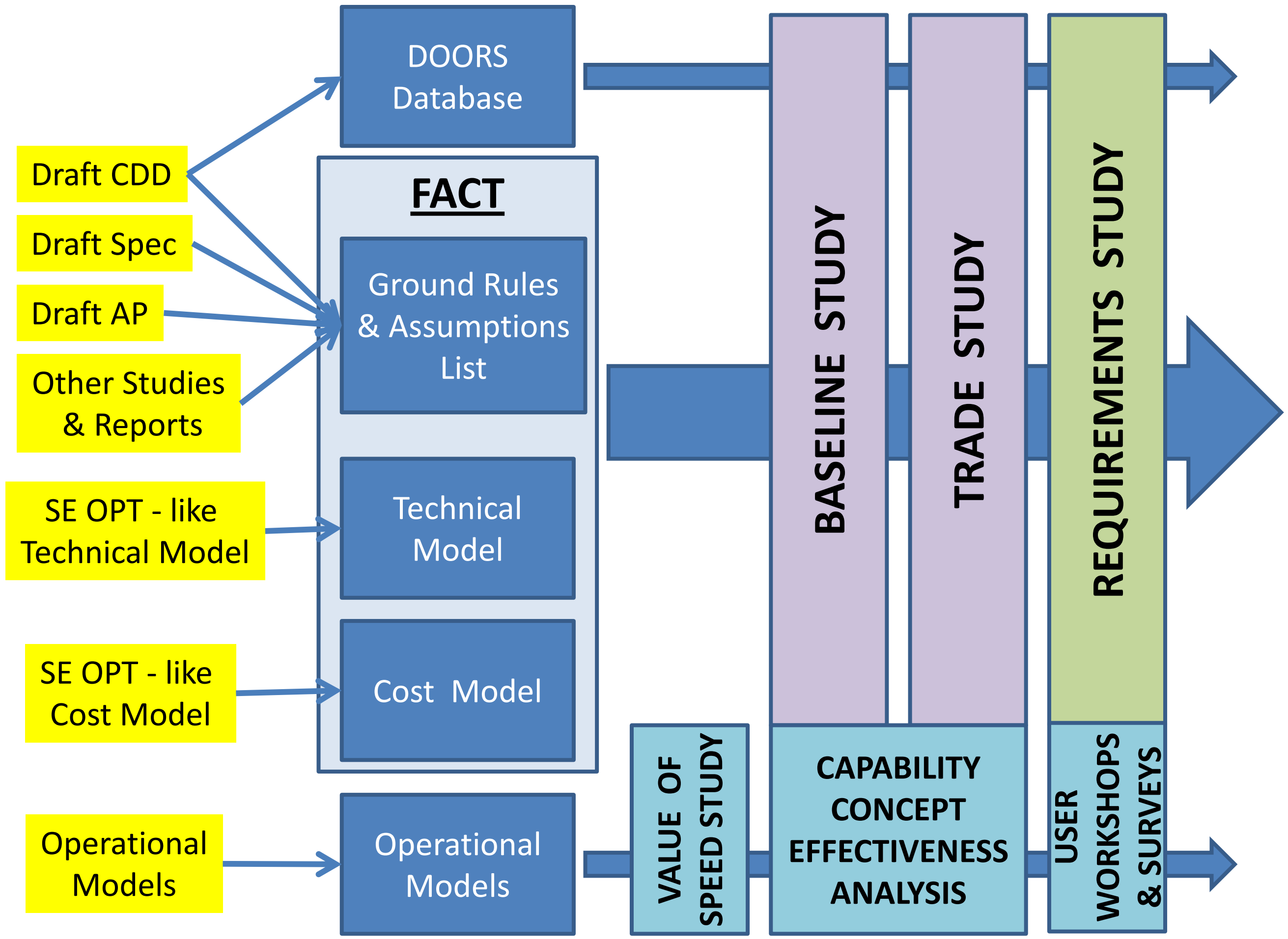


# ACV Capability Partitioning



# Analysis Plan



# ACV Studies

| STUDY | PURPOSE | PRODUCTS |
|---|---|---|
| Requirements Study | To analyze the Draft ACV Capability Development Document (CDD) to determine the number of requirements specified, the relationship between requirements from both a mission and technical perspective and user preferences for tradable requirements. To develop Draft CDDs for all viable capability concepts. | - Requirements database<br>- Requirements traceability (e.g., inter and intra requirements relationships)<br>- User preferences and values placed on requirements<br>- Draft Capability Concept CDDs<br>- Design strategies(e.g., modularity, future growth, etc) |
| Baseline Study | To understand and evaluate the design and cost implications of less than acceptable capability concepts, as well as to test and validate the analytical methodologies and tools used to assess Trade Study capability concepts. | - Baseline Capability Concepts assessment (feasibility and costs)<br>- Processes, models and tools validation |
| Trade Study | To evaluate the technical viability and costs of capability concepts derived from all possible permutations of lethality, troop capacity, under-blast protection and direct fire protection alternatives. | - Trade Capability Concepts assessments (feasibility and costs)<br>- Trade Capability Concepts performance and effectiveness |
| HWS Study | To determine the performance, effectiveness, operational flexibility and tactical advantages provided by a HWS ACV when compared to a low water speed (LWS) ACV. | - Measures of Performance<br>- Measures of Effectiveness<br>- Operational Contributions |

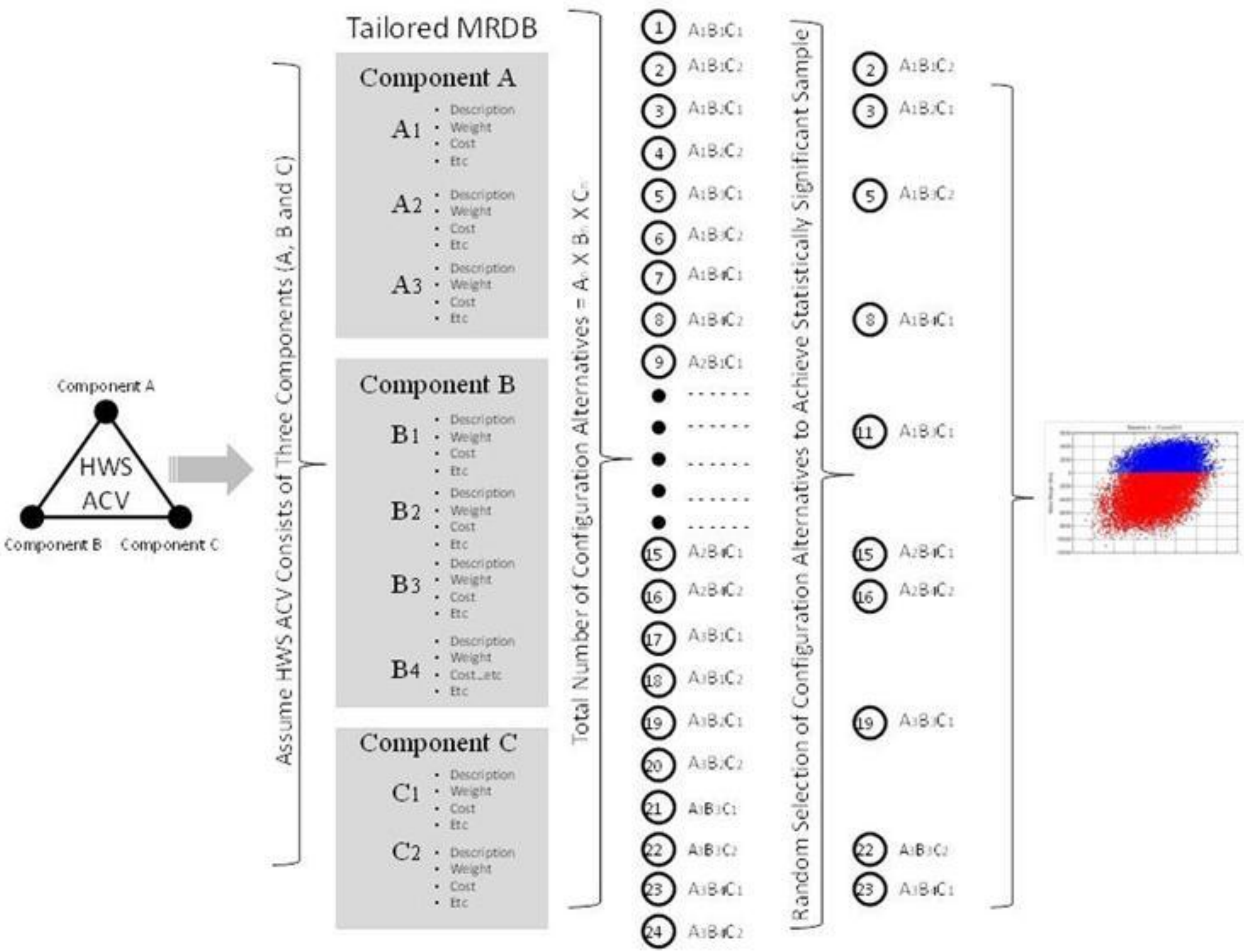
# Definitions

- Capability Concept
  - Requirements set
  - Specific levels for each of the "big rocks"
  - Ground Rules & Assumptions (GR&A) for everything else.
- Configuration
  - A specific set of components comprising a complete vehicle.
- Feasible Configuration
  - A configuration that our current analysis shows will work and meet the requirements of the associated capability concept.
  - For this study, analysis limited to weight and component compatibility.
- Viable Configuration
  - A configuration that actually works when produced and meets the requirements of the associated capability concept.
  - Concepts currently deemed Feasible may prove not to be Viable due to future analysis or testing.

# Configuration Modeling

- Market Research Database
  - Documents ACV component cost and technical data
  - Uses a modified EFV Work Breakdown Structure
  - Based on information provided by Industry
    - Data traceability retained
  - Translates study concept requirements to component selection
- Technical Parameters Tool
  - Calculates first unit Bill of Material cost
  - Other technical parameters needed by the Common Cost Model
  - Assumptions documented in GR&A
- Common Cost Model
  - Calculates Average Per-Unit Cost (APUC) and a lifecycle cost estimate.
  - Assumptions documented in GR&A

# Assembling a Configuration



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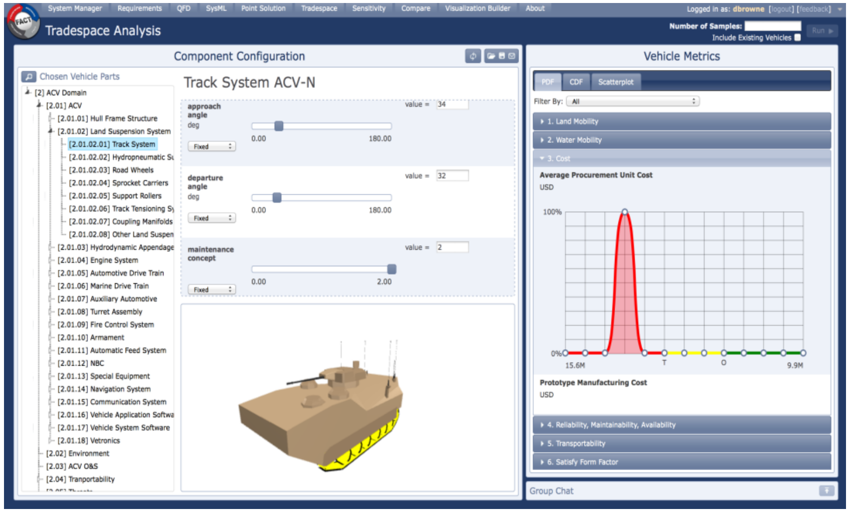
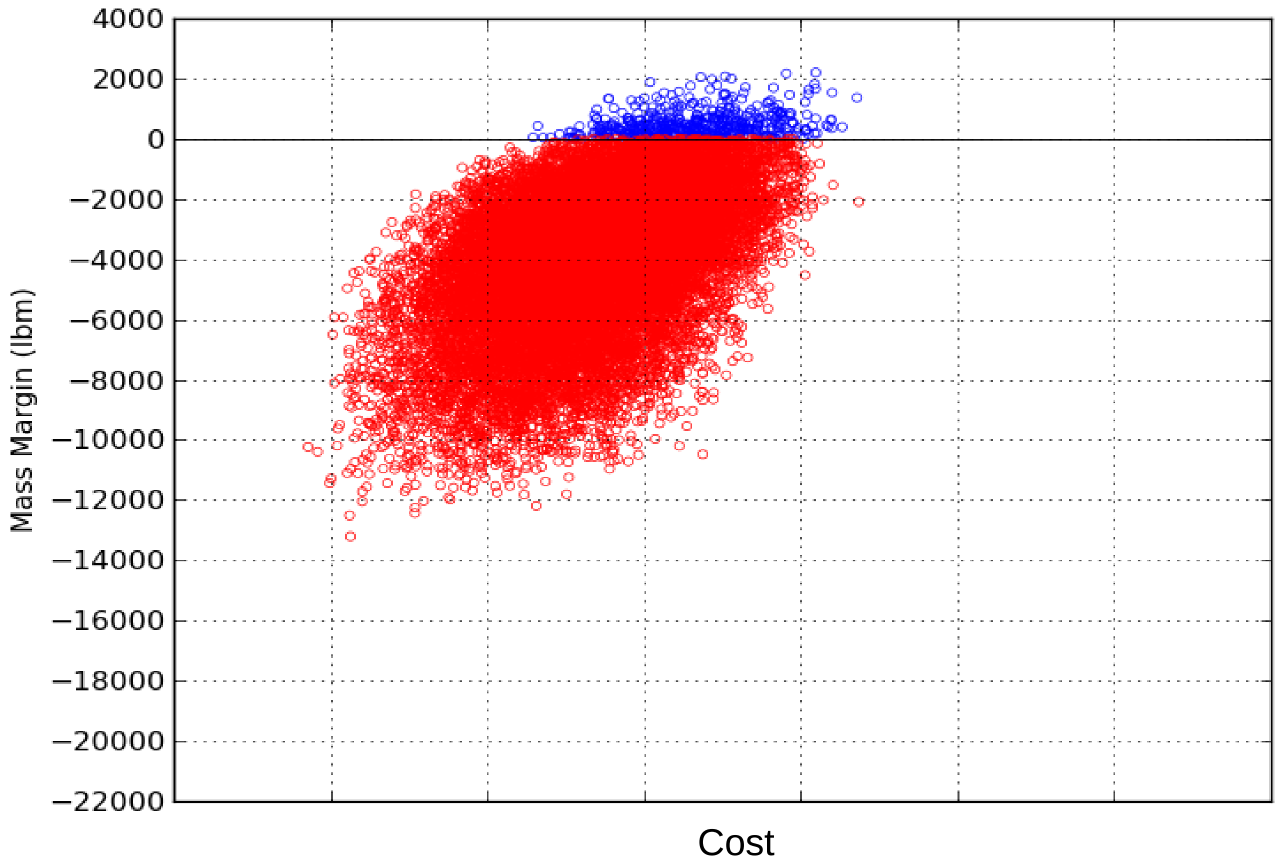
# Framework for Assessing Cost and Technology (FACT)

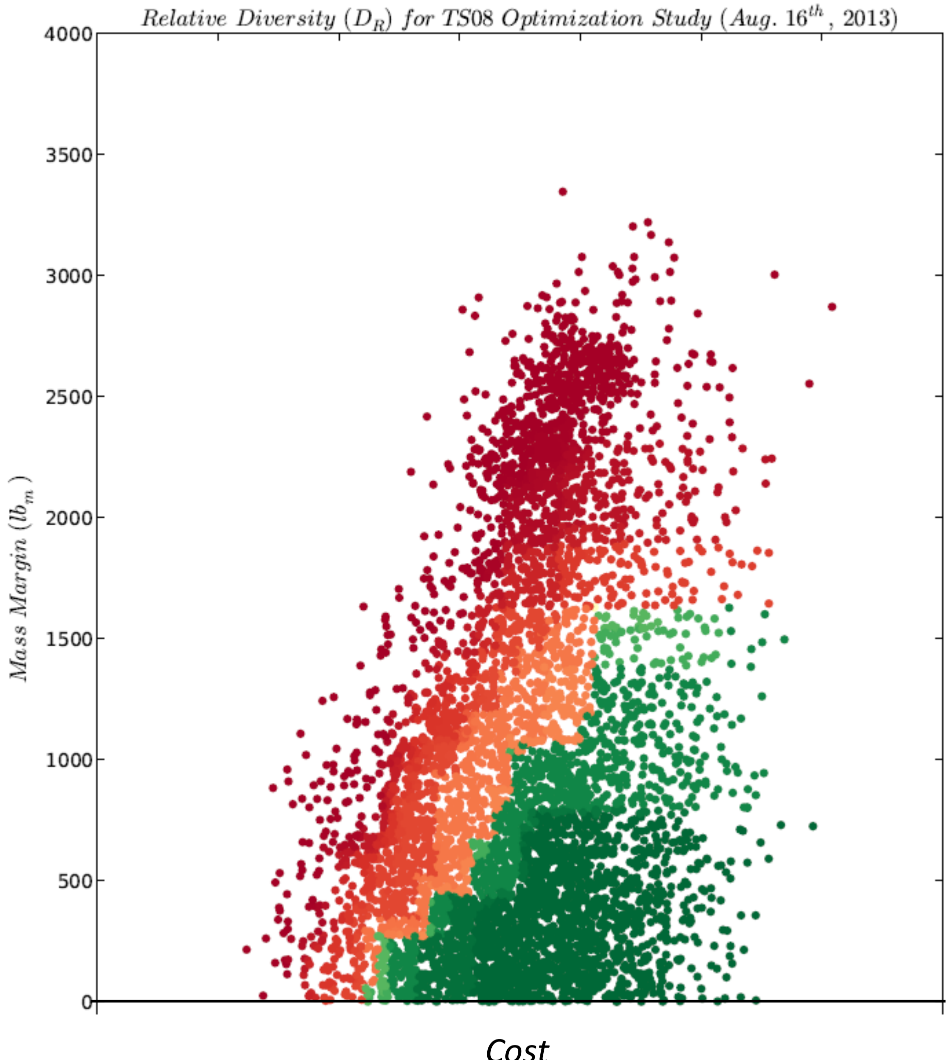
- Provides a framework for integrating models, synthesis tools, and analysis tools.
- Employs a Work Breakdown Structure.
- May use fixed parameters or parameters specified as probability density functions.
- Enables Monte Carlo simulation to create many configurations for a given concept.
- May employ optimization algorithms to increase probability of producing feasible configurations.
- May employ filters to remove configurations that are not feasible.
- Incorporates multiple options for visualizing results.
- Uses Model-Based Systems Engineering standards.
- Developed cooperatively between the Marine Corps Systems Command and Georgia Tech Research Institute.




# Scatter Plot



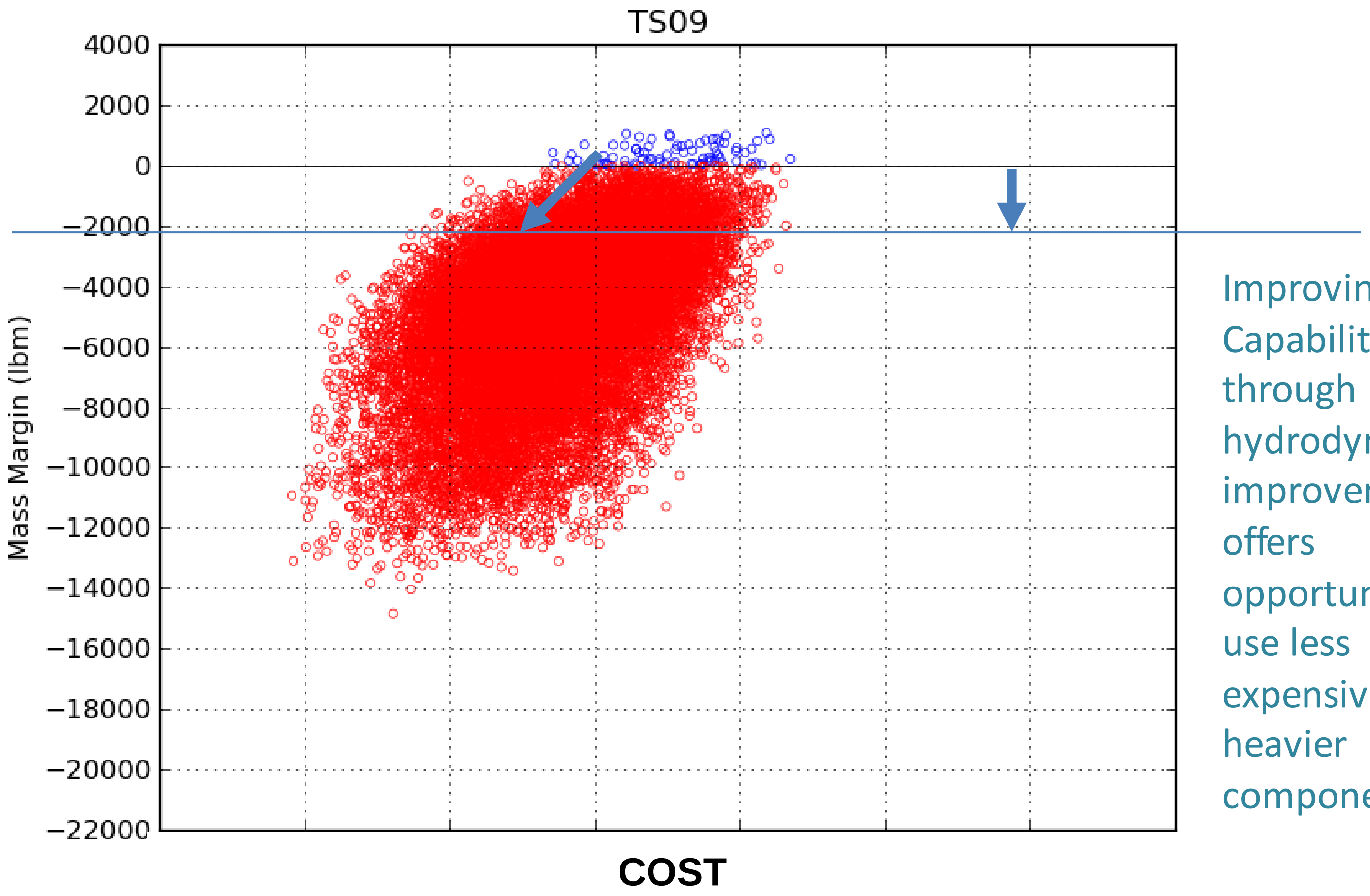
# Configuration Optimization & Diversity



# Trade Study Results

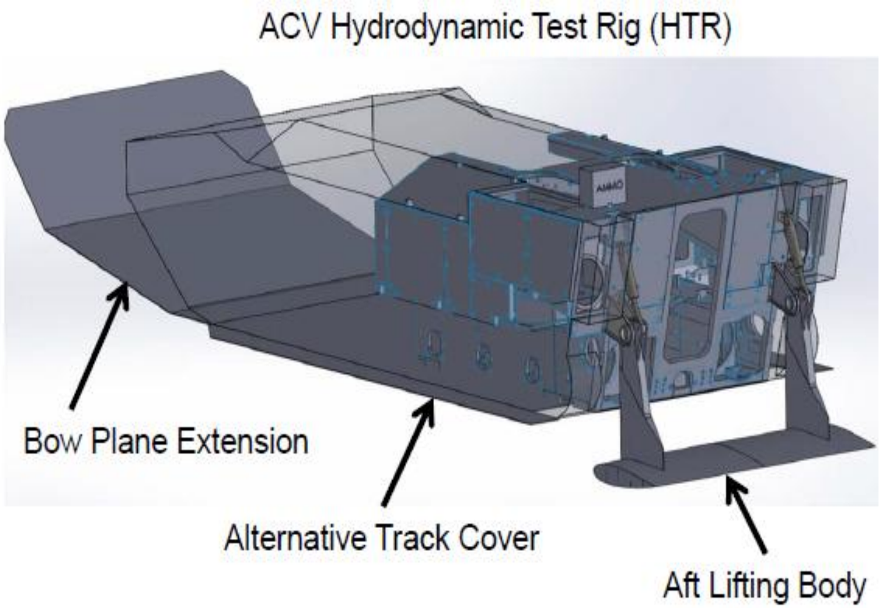
| Capabilities | 14 Troops; "A" Direct Fire Protection | 14 Troops; "B" Direct Fire Protection | 17 Troops; "A" Direct Fire Protection | 17 Troops; "B" Direct Fire Protection |
|---|---|---|---|---|
| "C" Under-Blast Protection; Weapon "X" | **Feasible** | **Feasible** | **Feasible** | **High Risk Feasibility** |
| "C" Under-Blast Protection; Weapon "Y" | **Feasible** | **Feasible** | **Feasible** | **High Risk Feasibility** |
| "C" Under-Blast Protection; Weapon "Z" | **High Risk Feasibility** | **Not Feasible** | **Not Feasible** | **Not Feasible** |
| "D" Under-Blast Protection; Weapon "X" | **High Risk Feasibility** | **Not Feasible** | **Not Feasible** | **Not Feasible** |
| "D" Under-Blast Protection; Weapon "Y" | **High Risk Feasibility** | **Not Feasible** | **Not Feasible** | **Not Feasible** |
| "D" Under-Blast Protection; Weapon "Z" | **Not Feasible** | **Not Feasible** | **Not Feasible** | **Not Feasible** |

# Insight

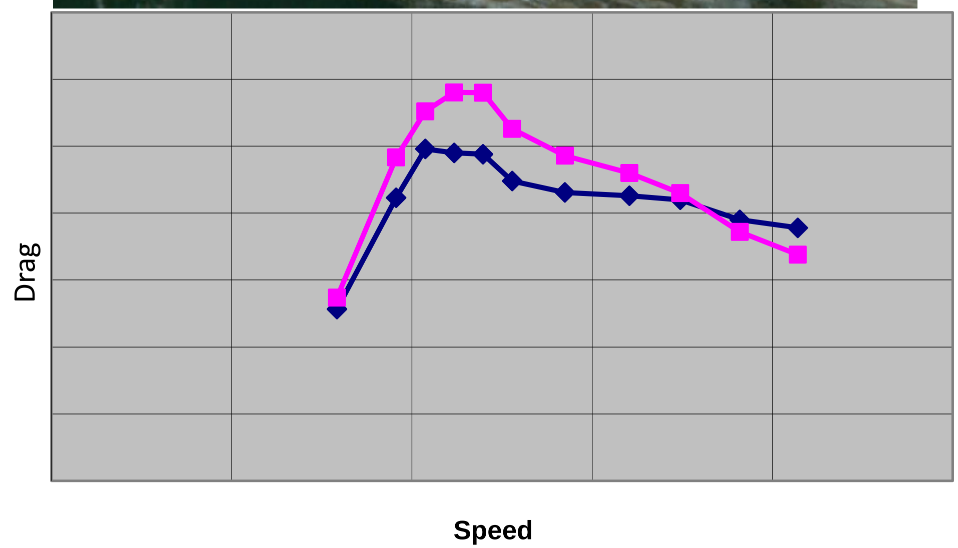



Improving Lift Capability through hydrodynamic improvements offers opportunity to use less expensive but heavier components.

# Innovation Team: Aft Lifting body

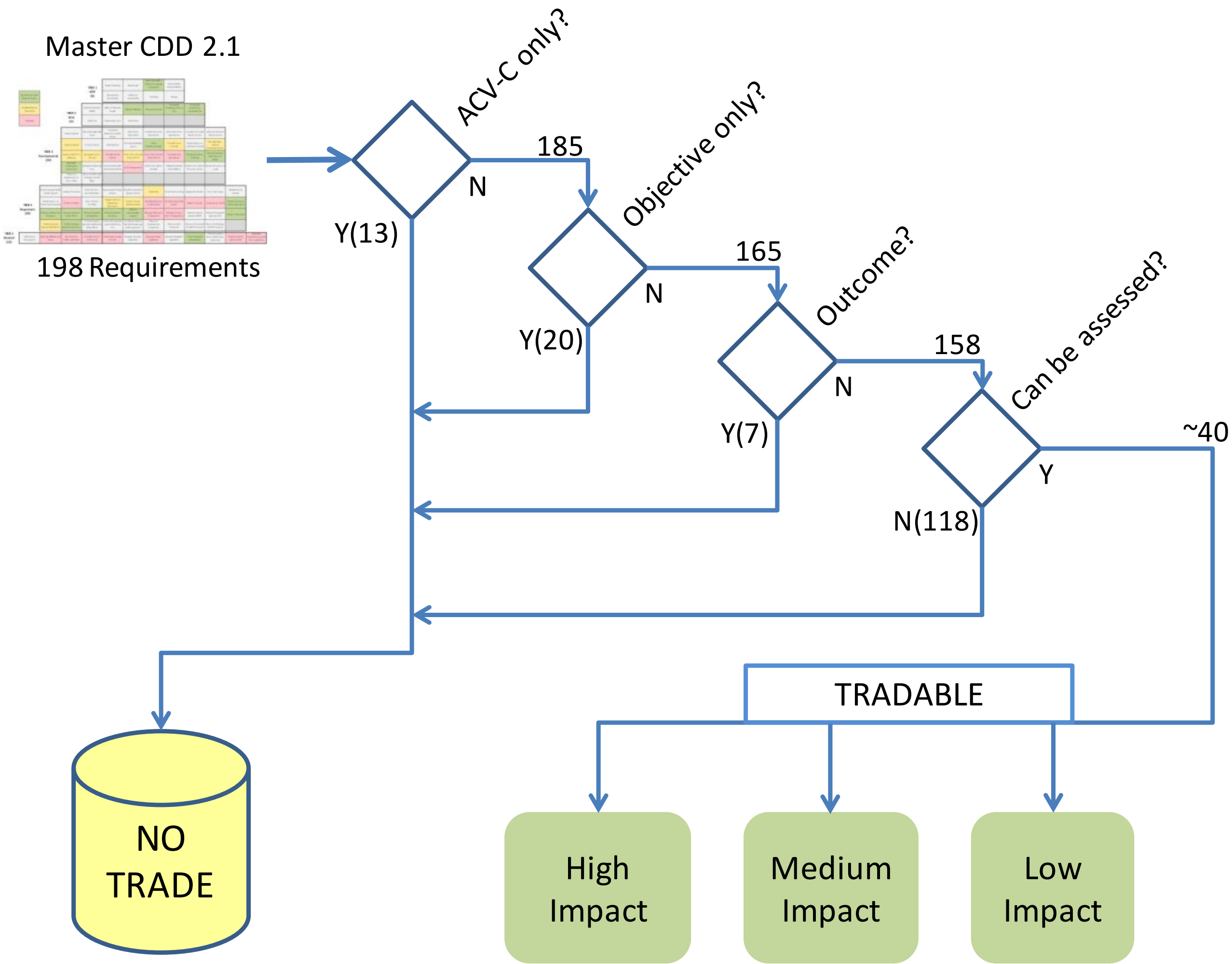



Need to test at full-scale to confirm




**Model Testing: Aft Lifting Body Reduced Drag**

# Tradable Requirements



# Flexibility and Modularity

*Flexibility*

- Exact value of a requirement not yet determined
  - A range for the value is established.
- Time when requirement will be determined specified
  - Short Term: Before MS A
  - Mid Term: Within 1 year after MS A
  - Far Term: Before MS B
- Design must affordably accommodate range of requirement until the value is established.
- Enables deferring decision until more is known about the impact of the requirement on cost and value.

HWS ACV is weight critical.
Providing all desired capabilities together not currently feasible.

*Modularity*

- Ability to inherently meet the current threshold and accept the modularity impacts in order to grow to the final desired capability
- Categories:
  - Field: modules selected and changed out in the field
  - Depot: modules changed out in a depot environment
  - Variant: design modularity; variant with high commonality ordered for production, but not designed to be modified later.
- Modularity requirements documented in pairs:
  - Threshold requirement at Initial Operational Capability (IOC)
  - Modularity features for future upgrades

# User Feedback

- Clearly emphasized the importance of offensive capability (lethality and troop capacity) over defensive capability (under-blast protection and direct fire protection).
- Assigned critical importance to protecting and enhancing offensive capability.
- Consistently expressed their top principal capabilities.
  - Some differences in rankings based on specialty or MEF affiliation

Workshop conducted at Ellis Hall on 9-11 July 2013

# Conclusions

- A survivable, capable, high water speed ACV is technically feasible
  - No new technology required
- Additional R&D could enable increased planing weight
  - More capability
  - Use heavier, but less expensive components