



# Submersible Aircraft

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October 17, 2008

Proposers Day Overview Presentation



## Caveats / Security

- I have no authority to bind the government
- In the event of any discrepancies between material here and material on FedBizOps, the FedBizOps material takes precedence
- This is an unclassified meeting none of the questions or comments should imply or in any way relate to classified information if you have a question of a sensitive nature it can be addressed in another forum.

**Do not talk about classified information, and the BAA is always correct**



# Question Process

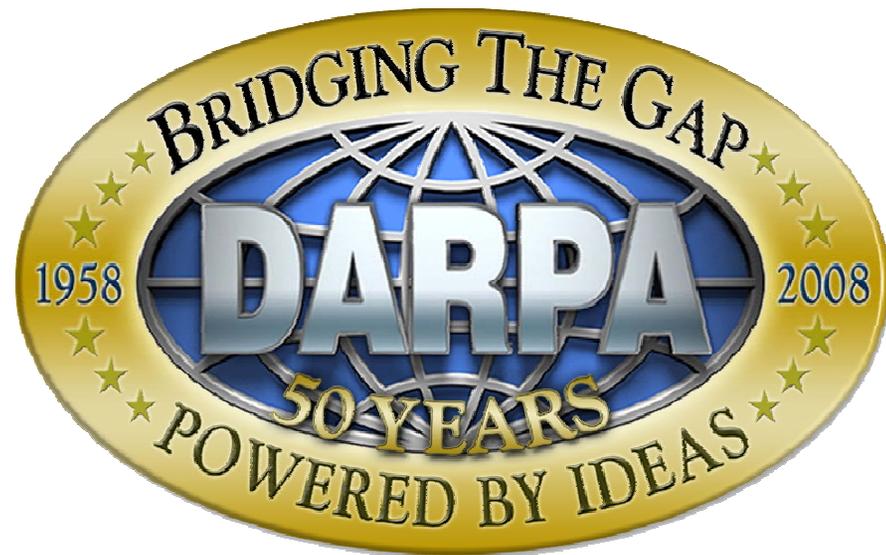
- **Please write your questions down on 3" x 5" cards**
- **Questions will be collected and answered after the morning break**
- **We will attempt to answer as many questions at this conference as time will allow**
- **Additional questions to DARPA-BAA-09-06@darpa.mil**
  - Last day for question submissions: November 7, 2008.
  - DARPA consolidated Questions and Answers will post after November 14, 2008
- **Answers to all questions will be posted subsequent to this meeting on the BAA 09-06 page:**

<http://www.darpa.mil/sto/solicitations/BAA09-06/index.html>



# Outline

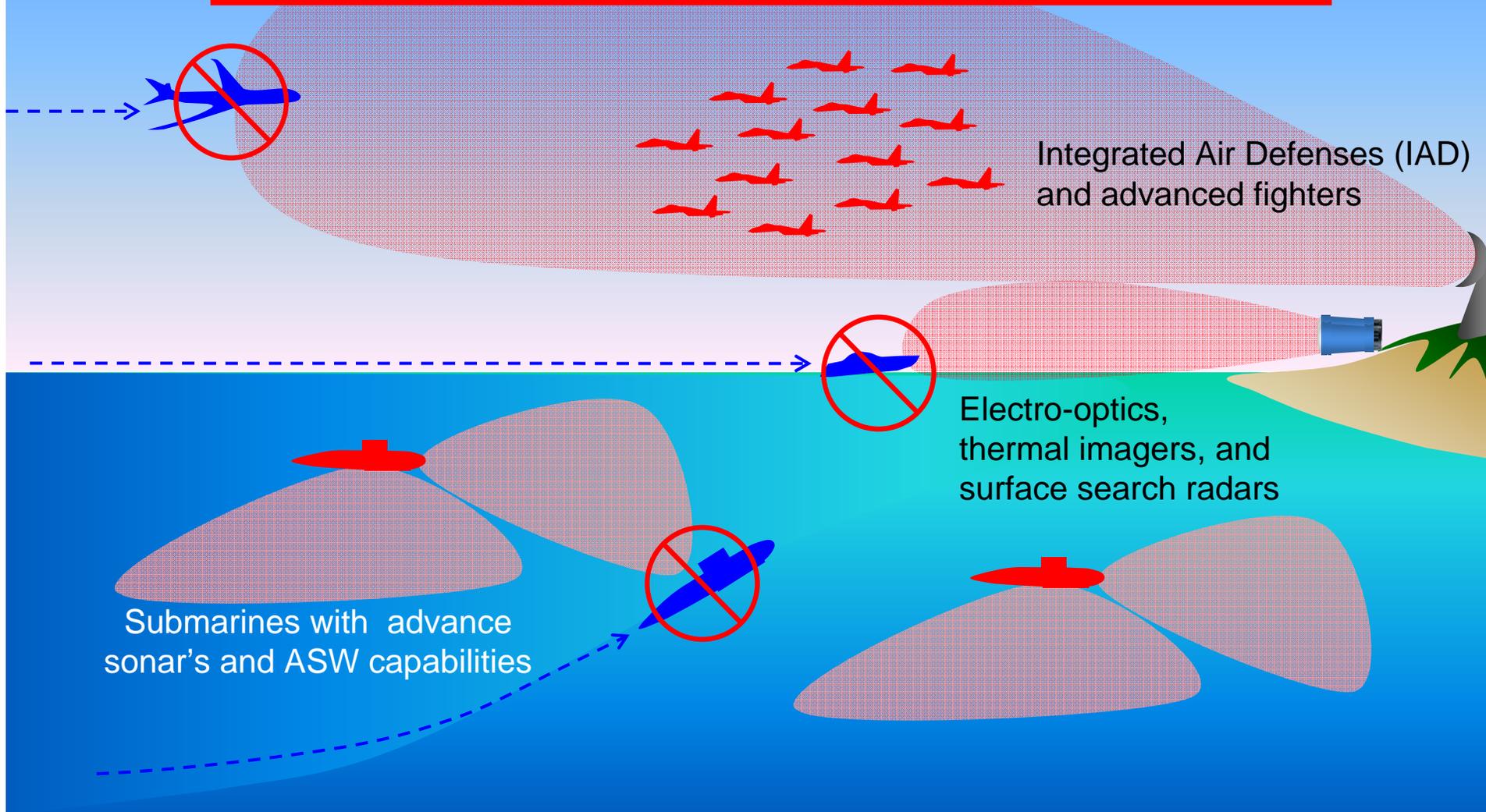
- DARPA's Charter & Commitment
- Submersible Aircraft Overview
  - Motivation / Vision
  - Objective System
- Technology Challenges
- Program Plan (all phases)
- Program Solicitation Overview
- Summary
- Question and Answers





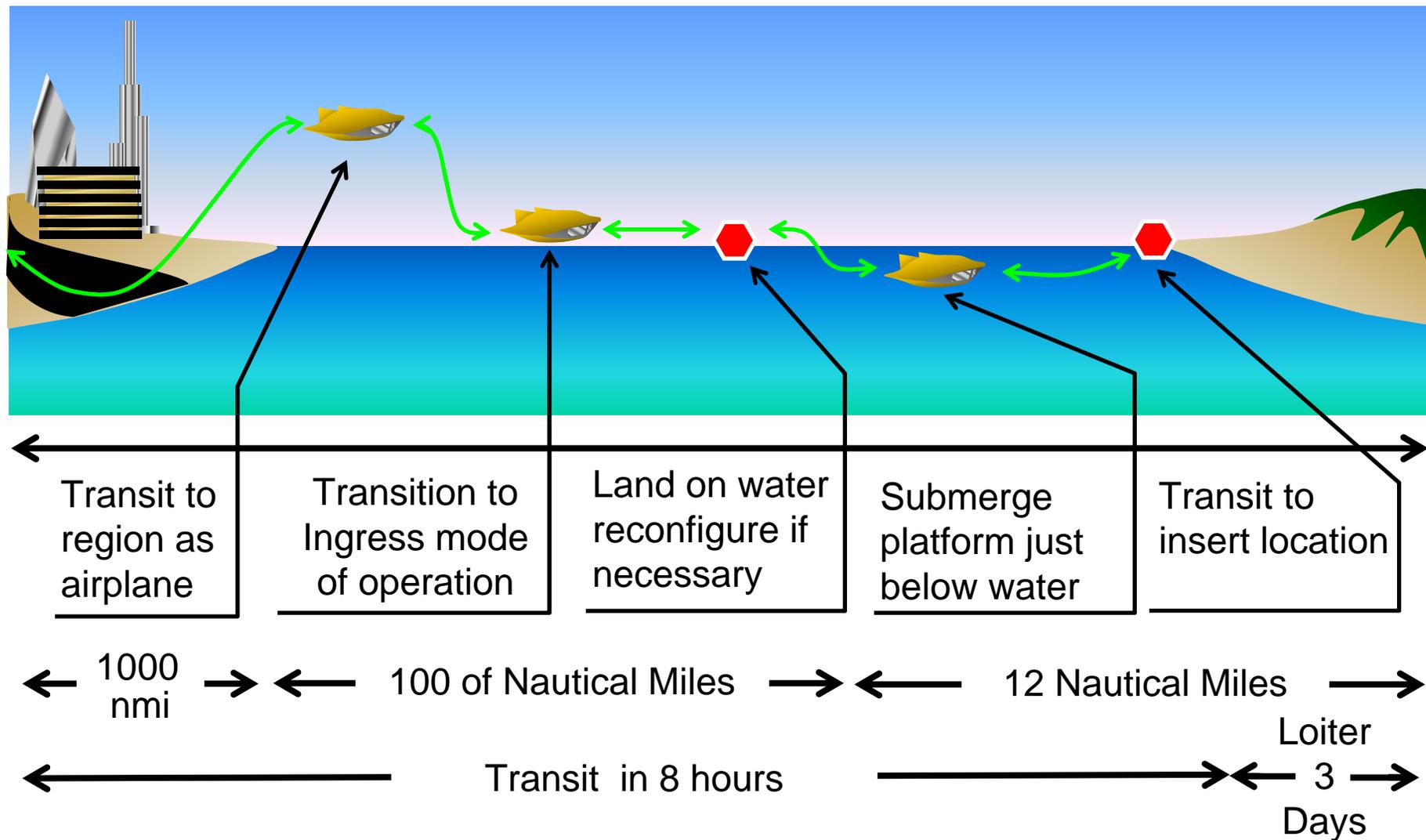
# Motivation/Vision

**How will we be able to insert and extract personnel in the face of these challenges?**





# Objective System



**Perform in reverse for extraction**



# Technical Challenges

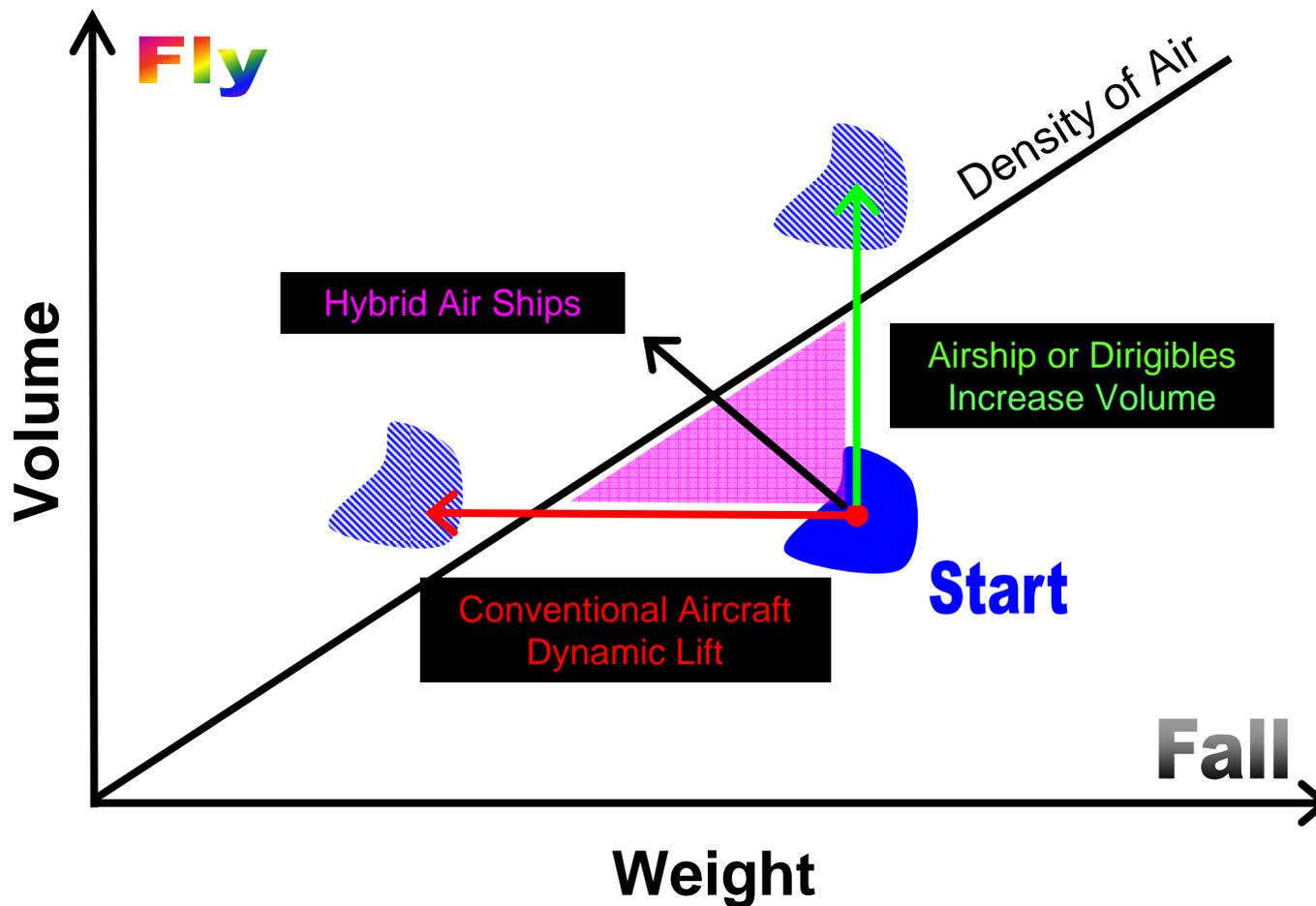
- 1) **Weight:** Can the need to reduce mass in order to fly and increase density in order to submerge be simultaneously addressed ?
- 2) **Geometry:** Can a wing or body that is designed to operate in air still be effective in a different fluid at a radically different speed ?
- 3) **Structures:** Can a structure designed to operate in one fluid work in another at a radically different pressure?
- 4) **Wing Location:** Can one design a wing to operate at two different locations ?
- 5) **Powering:** Can a power plant operate in both air and air independent environments ?



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## Technical Challenge 1

# Weight & Volume Required For Flight



To fly, one needs to increase the aircraft's volume or counteract its weight using dynamic lift

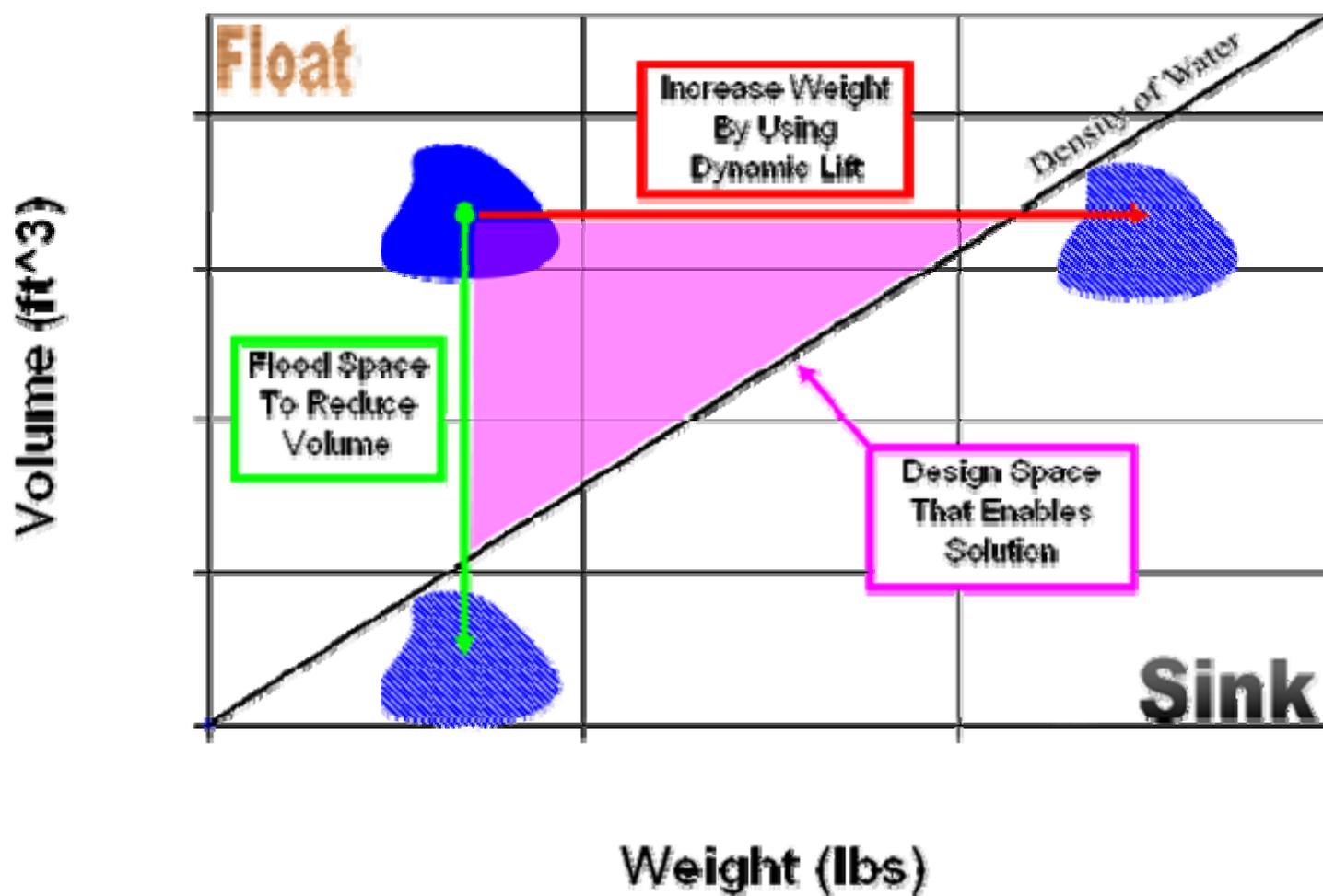


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# Technical Challenge 1

## Weight & Volume Required to Submerge



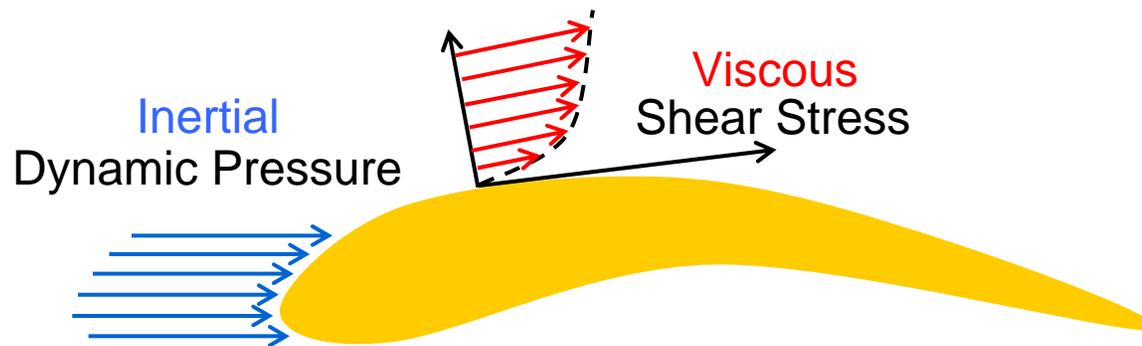
Need to increase density approaches can include using dynamic lift and increasing effective mass



# Technical Challenge 2 Multi-Fluid Dynamics



**The performance of a section is determined by the balance of the inertial and viscous forces**



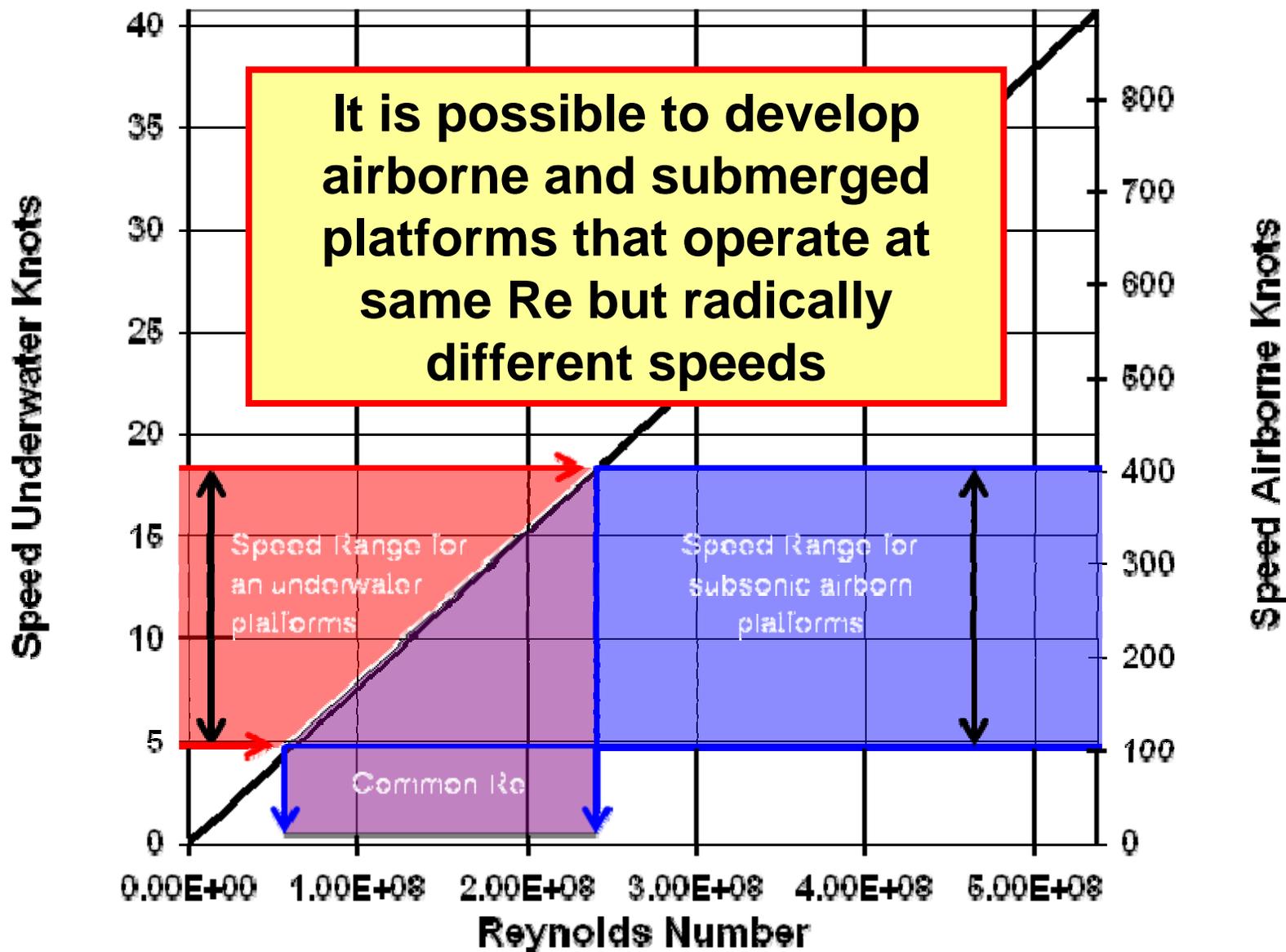
When comparing different geometries and flows one uses the non-dimensional coefficient Reynolds Number because it represents the ratio of these forces

$$\text{Re} = \frac{\text{Dynamic Pressure}}{\text{Shear Stress}} = \frac{\frac{\rho v^2}{l}}{\frac{\mu v}{l^2}} = \frac{\rho v l}{\mu}$$

**Even if the properties of the two fluids are different the flows are similar if the Reynolds Numbers (Re) match**



# Technical Challenge 2 Multi-Fluid Dynamics

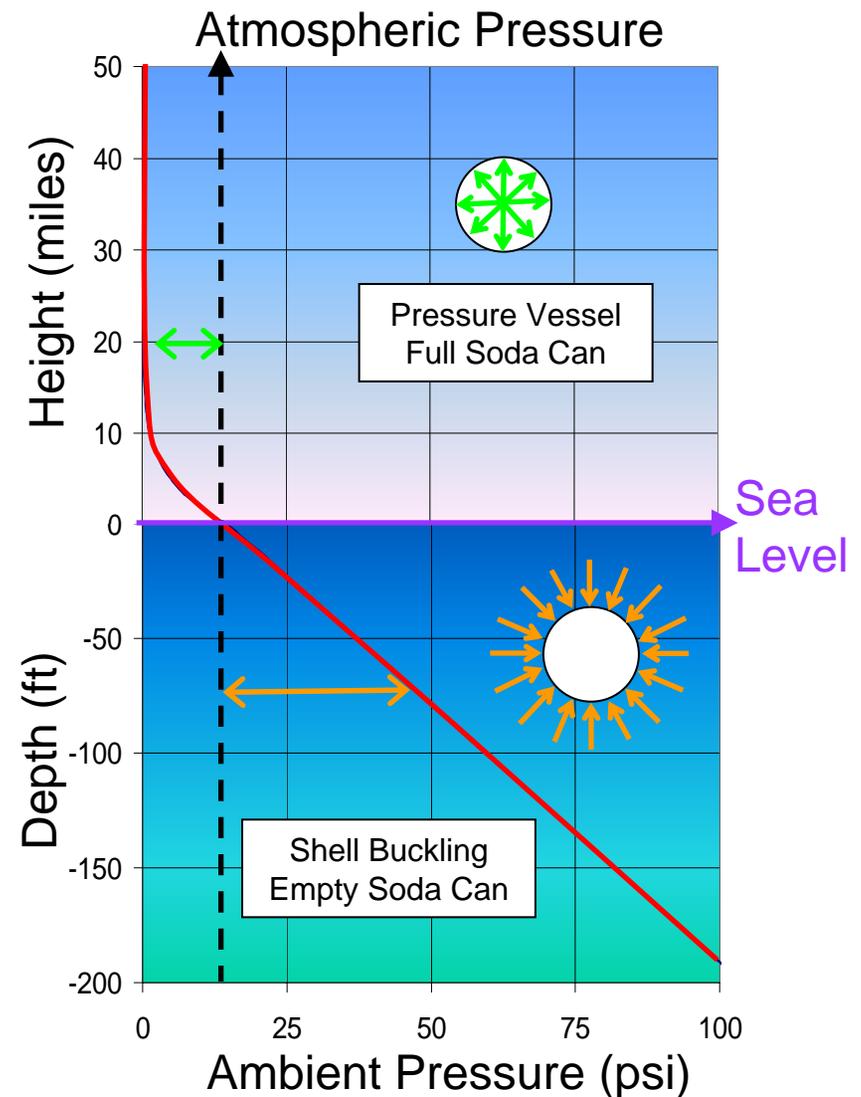




# Technical Challenge 3 Structures

- The direction of loads applied to an airplane and a submarine are in the opposite directions
- The magnitude of the crushing load applied to hull is a function of pressure drop across the hull.
- The pressure outside the hull is a function of water depth, internal pressure can be defined by users
- The required operating depth for this platform is minimal

**By limiting operating depth one dramatically reduces structural requirements**

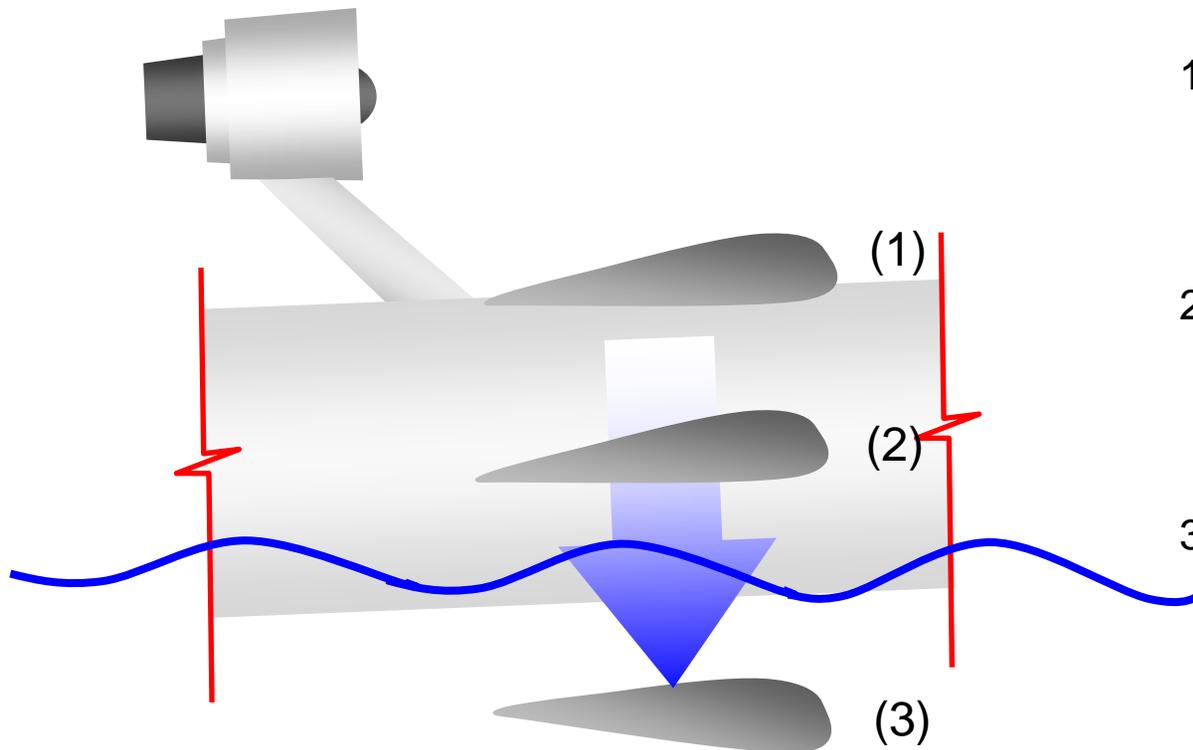




# Technical Challenge 4 Wing Location



**Wing has two diametrically opposed requirements: lifting surfaces need to be placed high and low in order to transition between modes**



1. Wings are placed high on sea plane to reduce interaction with waves and to shield engines
2. Lowering the wing closer to the water better leverages the ground effect
3. The wing will need to be below the water in order to generate the down-force required to submerge



# Technical Challenge 4 Design Space for Wing Variability



Higher  
Maturity



Lower  
Maturity

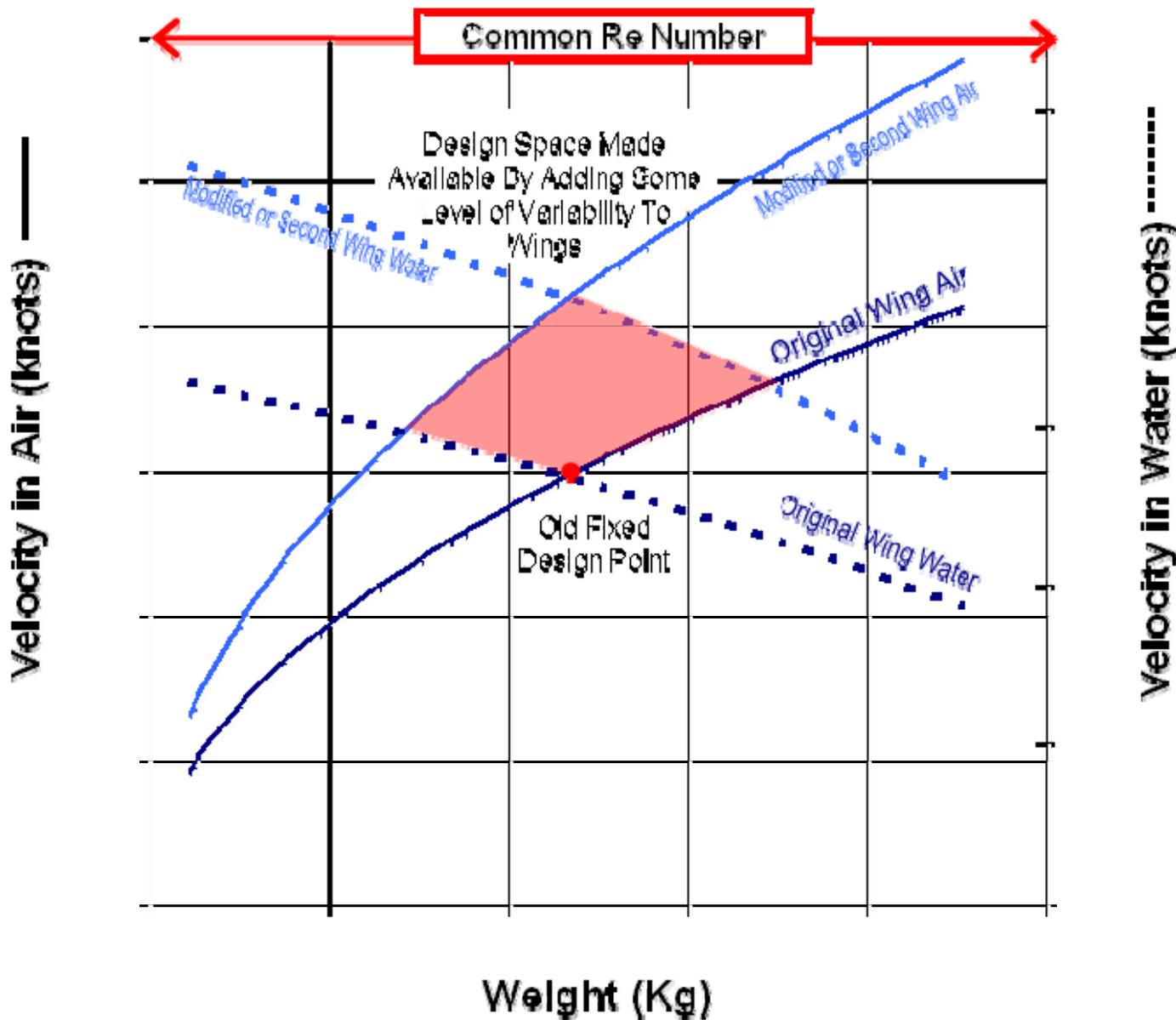
Approach	Advantages
Two separate fixed wings	Simple, Two wing sections
Two separate wings, airborne wings retract underwater	Dramatically reduced drag, Two wing sections
Two separate wings that both retract	Further reduced drag, Two wing sections
Folding Wings	Leverages a single wing, Height and Area are variable
Morphing Wing	Leverages a single wing, Height, Area and Wing Section are variable,

**Range of approaches to address required wing variability, but need to balance the complexity and technical risk against potential performance**



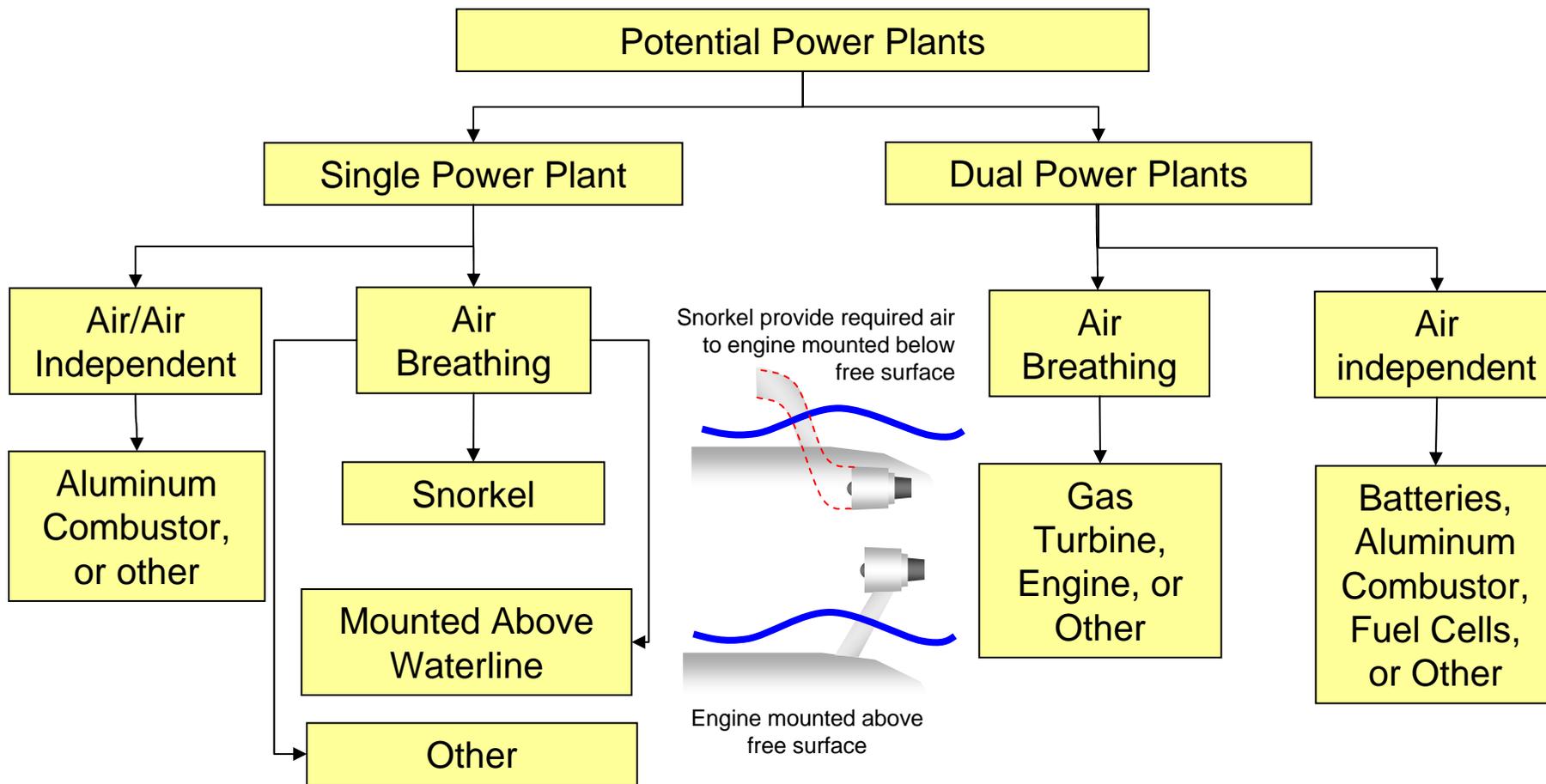
# Technical Challenge 4

## Performance Benefits of Separate Wings





# Technical Challenge 5 Power Plant Options



**There are a variety of possible power plants, but need to balance the complexity and technical risk against potential performance**



# Evaluation Criteria

- It is critical that the proposal be responsive to all BAA requirements, including page limits and formatting requirements.
- Read the BAA section on Evaluation Criteria, section 5.1, starting on pg. 22, very carefully. The evaluation criteria in descending order of importance are given below...
  - **5.1.1 Ability to Meet Program Metrics** -- The feasibility and likelihood of the proposed approach for satisfying the program metrics, as described in **Section 1.2.1**, are explicitly described and clearly substantiated. The proposal reflects a mature and quantitative understanding of the program feasibility demonstration metrics, the statistical confidence with which they may be measured, and their relationship to the concept of operations that will result from successful performance in the program.
  - **5.1.2 Overall Scientific and Technical Merit** -- The proposed technical approach is feasible, achievable, complete and supported by a proposed technical team that has the expertise and experience to accomplish the proposed tasks as referenced in **Section 4.3.2.1**, Sub-section III "Detailed Proposal Information" on page 18. Task descriptions and associated technical elements provided are complete, address the "Key Program Elements" described in **Section 1.2.2**, and in a logical sequence. All proposed deliverables are consistent with **Section 1.2.3** "Program Deliverables" and are clearly defined such that a final product that achieves the goal can be expected as a result of award. The proposal clearly identifies major technical risks and planned mitigation efforts and provides ample justification as to why the approach (es) is / are feasible.
  - **5.1.3 Potential Contribution and Relevance to the DARPA Mission** -- The potential contributions of the proposed effort with relevance to the national technology base will be evaluated. Specifically, DARPA's mission is to maintain the technological superiority of the U.S. military and prevent technological surprise from harming our national security by sponsoring revolutionary, high-payoff research that bridges the gap between fundamental discoveries and their military use.

***Criteria in order of importance***



## Evaluation Criteria (Cont.)

- **5.1.4 Proposer's Capabilities and/or Related Experience** -- The proposer's prior experience in similar efforts must clearly demonstrate an ability to deliver products that meet the proposed technical performance within the proposed budget and schedule. The proposed team's expertise to manage the cost and schedule will be evaluated. Similar efforts completed/ongoing by the proposer in this area are fully described including identification of other Government sponsors.
- **5.1.5 Plans and Capability to Accomplish Technology Transition** -- The capability to transition the technology to the research, industrial, and operational military communities in such a way as to enhance U.S. defense, and the extent to which intellectual property rights limitations creates a barrier to technology transition.
- **5.1.6 Cost Realism** -- The objective of this criterion is to establish that the proposed costs are realistic for the technical and management approach offered, as well as to determine the proposer's practical understanding of the effort. This will be principally measured by cost per labor-hour and number of labor-hours proposed. The evaluation criterion recognizes that undue emphasis on cost may motivate proposers to offer low-risk ideas with minimum uncertainty and to staff the effort with junior personnel in order to be in a more competitive posture. DARPA discourages such cost strategies. Cost reduction approaches that will be received favorably include innovative management concepts that maximize direct funding for technology and limit diversion of funds into overhead.

***Criteria in order of importance***



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# Important Dates

- BAA Posted: October 03, 2008
  
- Last day for question submissions: **November 7, 2008**
  
- Proposals Due Date: **December 01, 2008, 4:00 PM EDT**
  - The proposal (one electronic copy) must be submitted to one of the following:
    - TFIMS -- <http://www.tfims.darpa.mil/baa>
    - Grants.gov
  
- BAA Archive Date: October 04, 2009