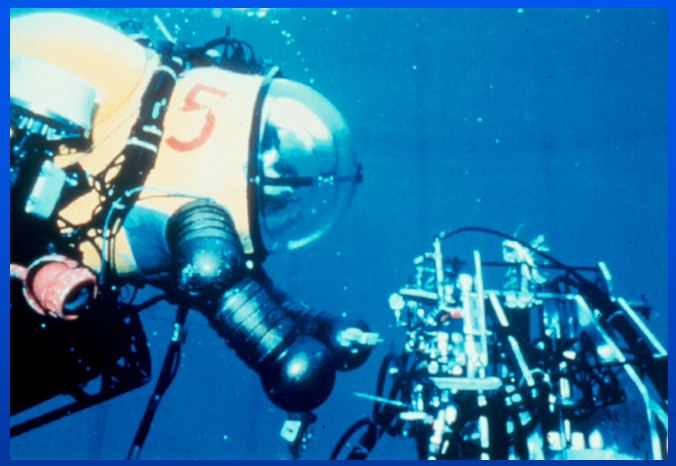
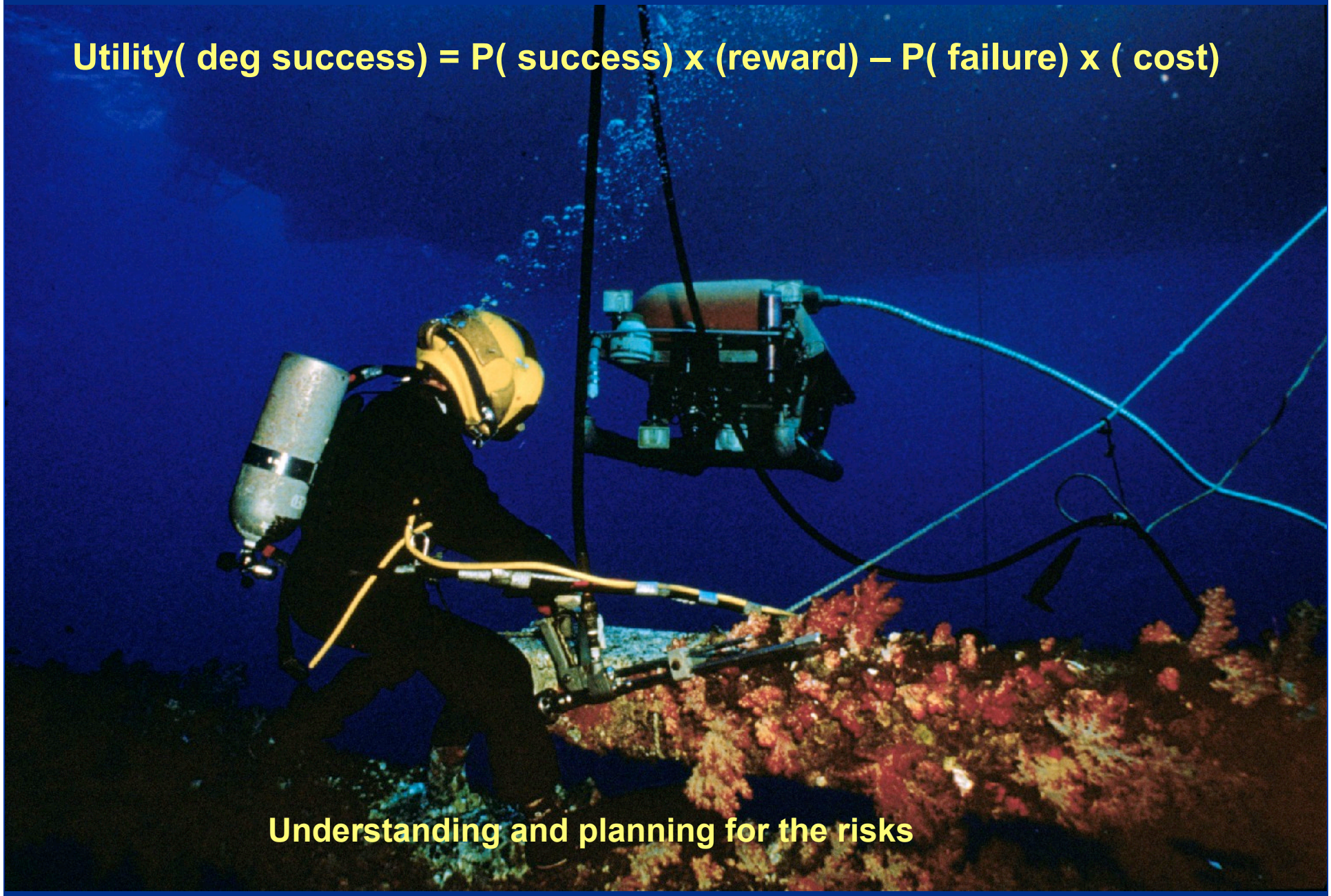
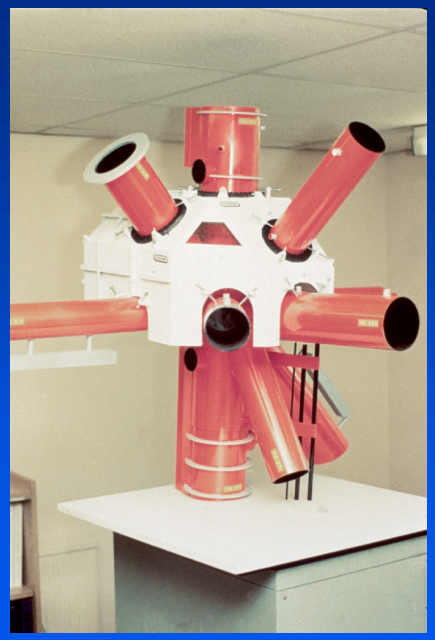
Acceptable Risks in Subsea and Space Exploration- Keeping the Edge

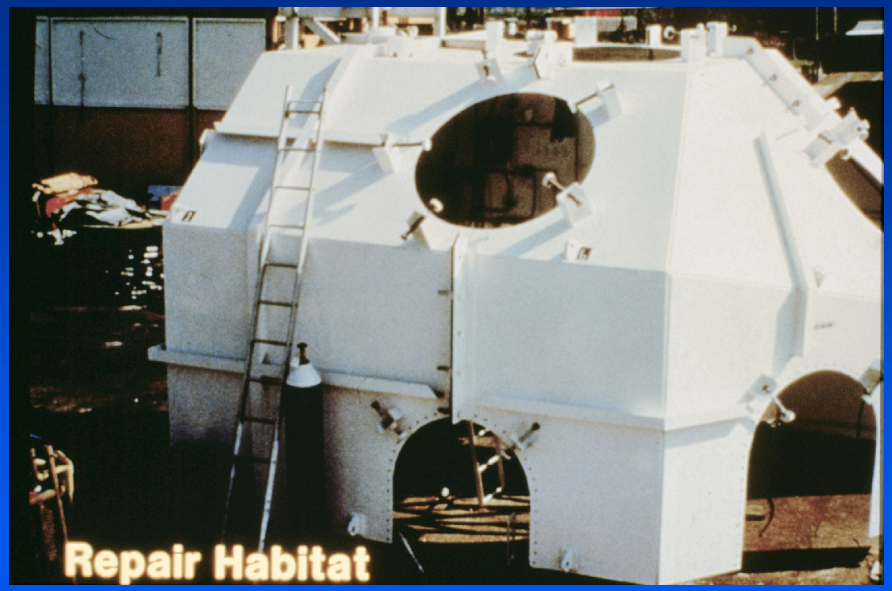


Mike Gernhardt

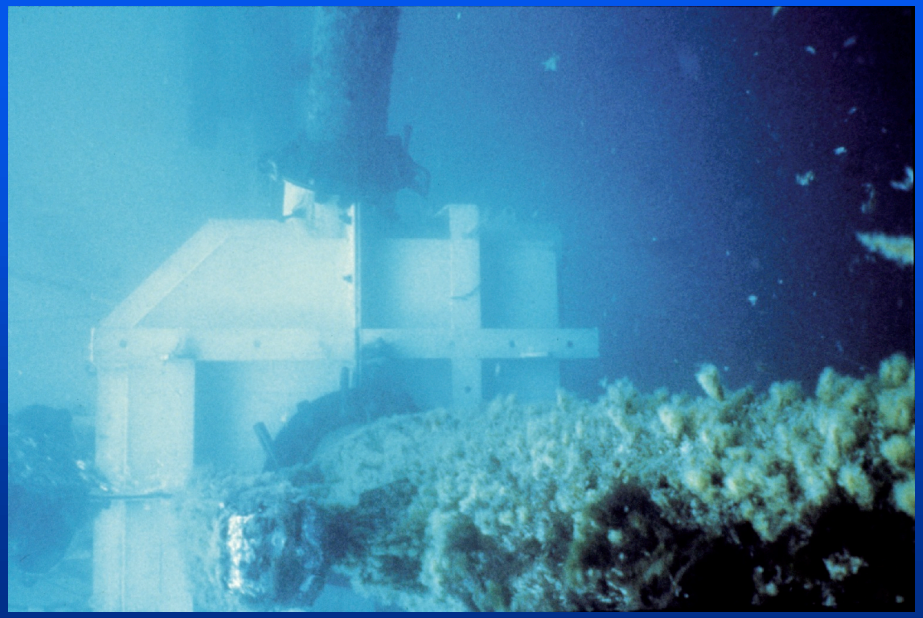
Sept. 28 2004

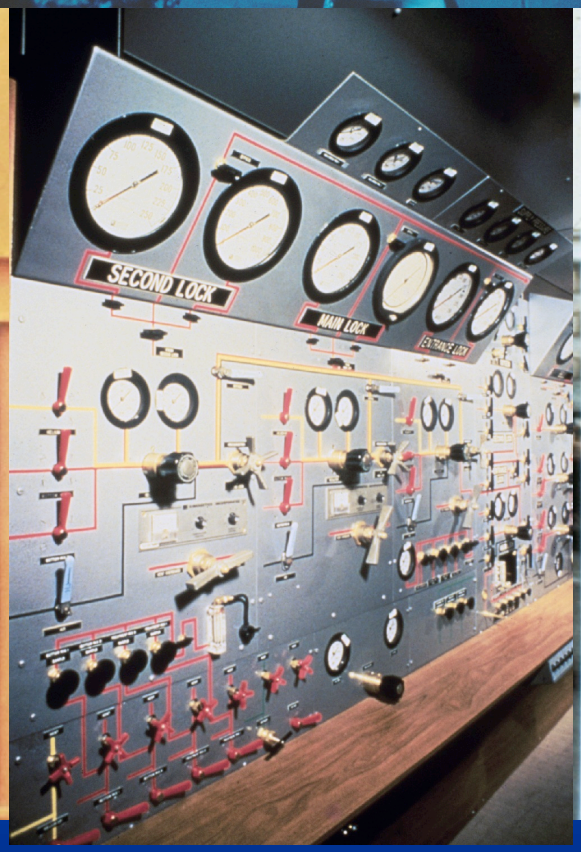

Utility(deg success) = P(success) x (reward) – P(failure) x (cost)
Understanding and planning for the risks





Complex Sub Sea Construction

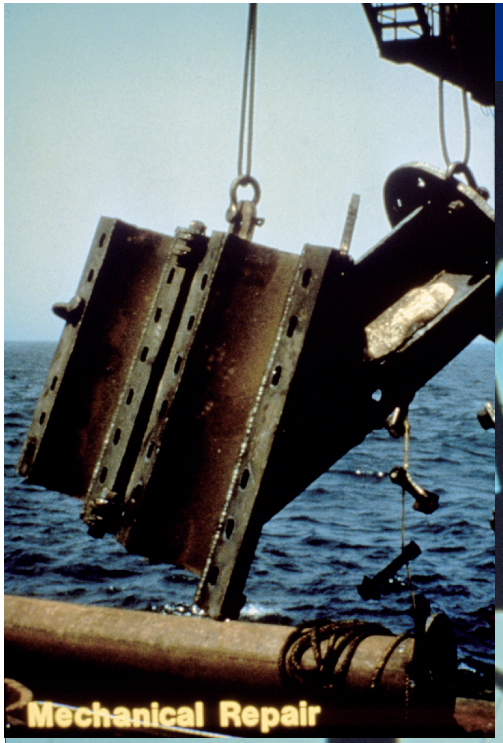




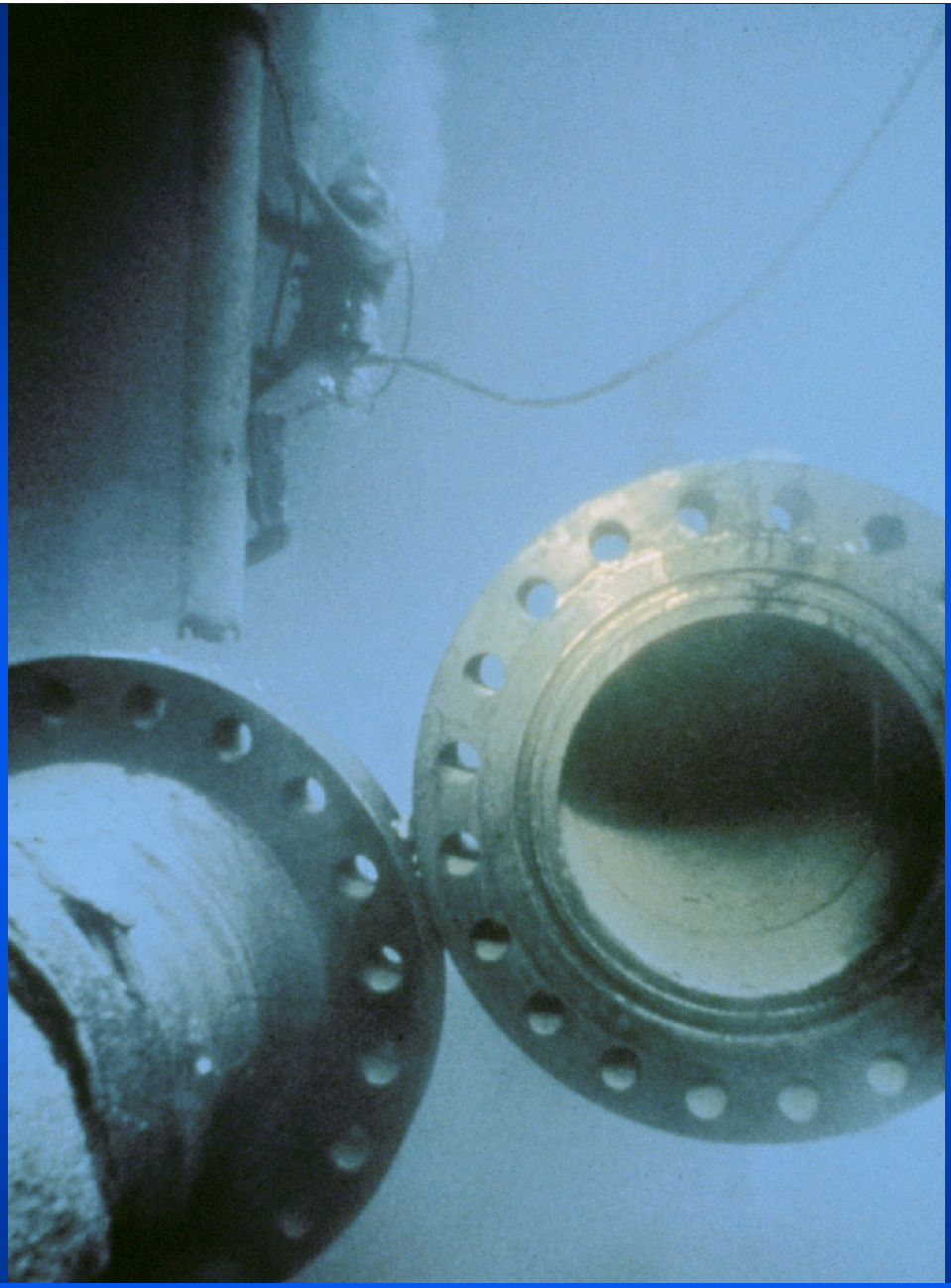
Helium Oxygen Saturation Diving

Equipment – corporate/programmatically controlled risks

What do we have to do? Now how do we do it safely ?

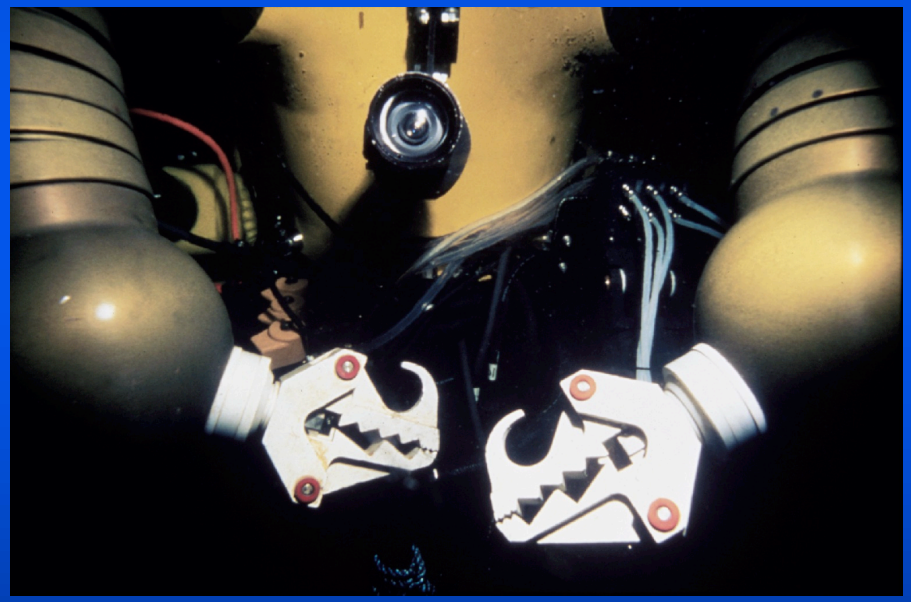


Individual/team controlled operational risks



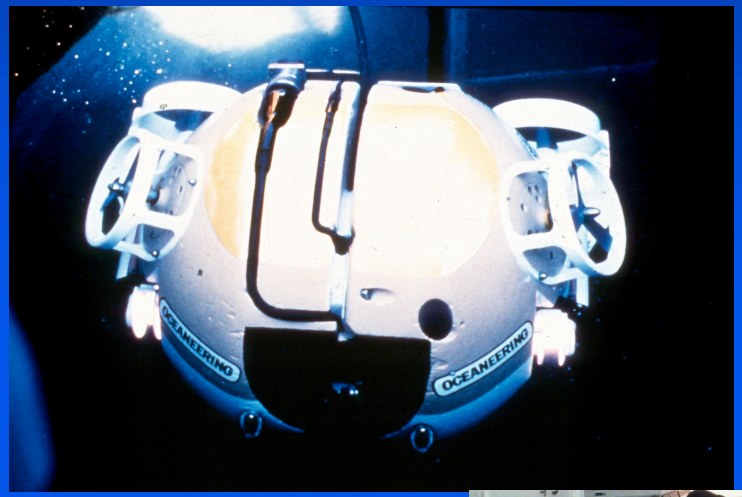
“It’s a fine line between bleep and bleep hot” – Dave Walker

Taking the human a step back from the hands on environment- risk reduction/cost reduction, capability reduction?

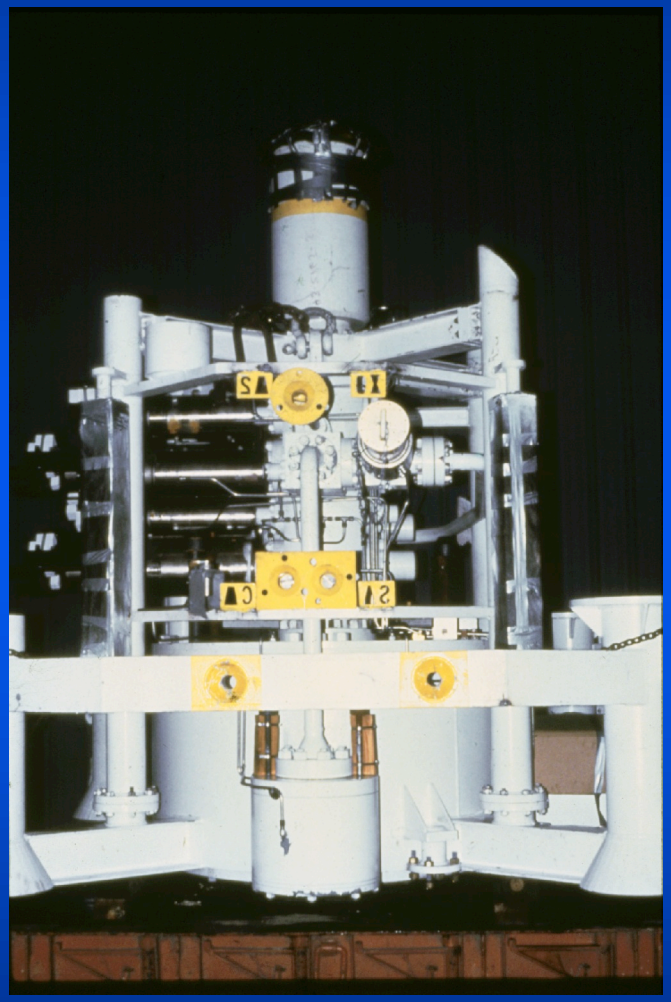


Worksite Accessibility interfaces and tooling

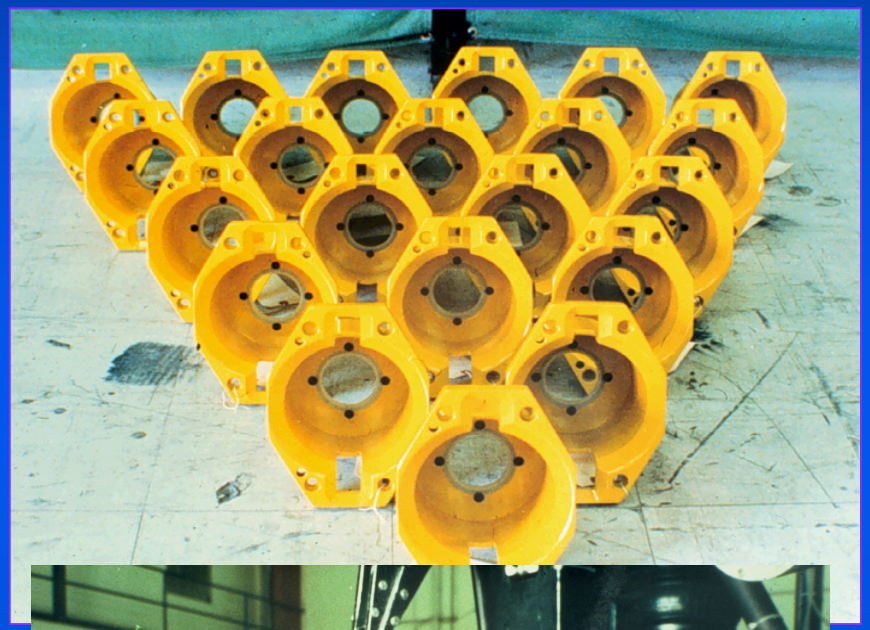
Introduction of ROVs
Another step back from the worksite

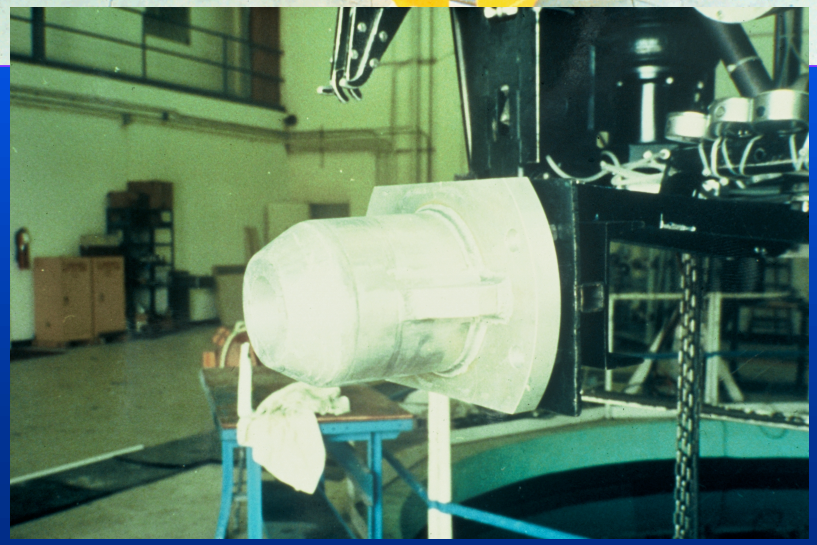


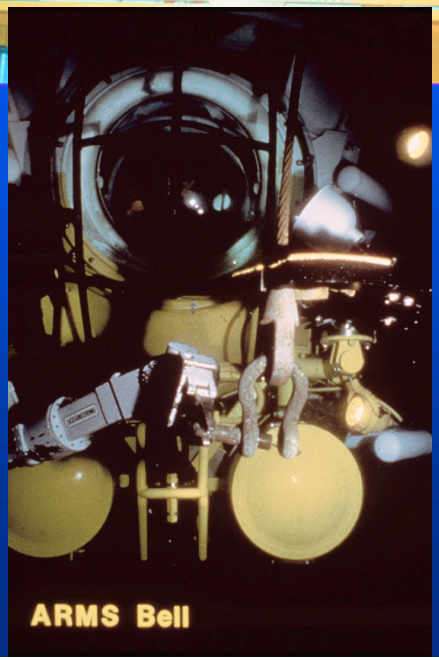
Re-engineering the sub sea equipment for ROV intervention



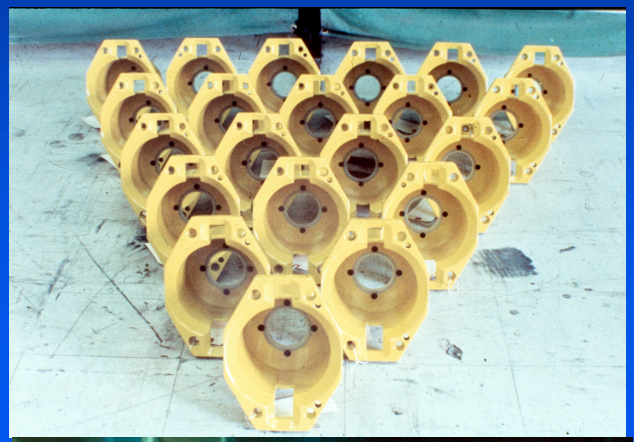
Simple Standardized Interfaces vs. Complicated Manipulators

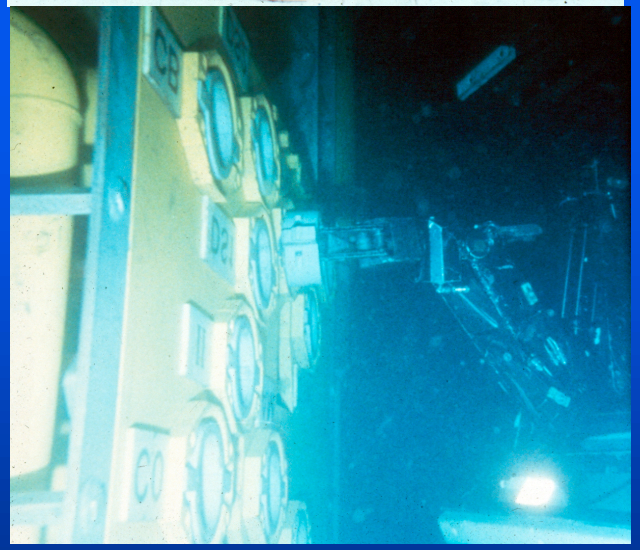


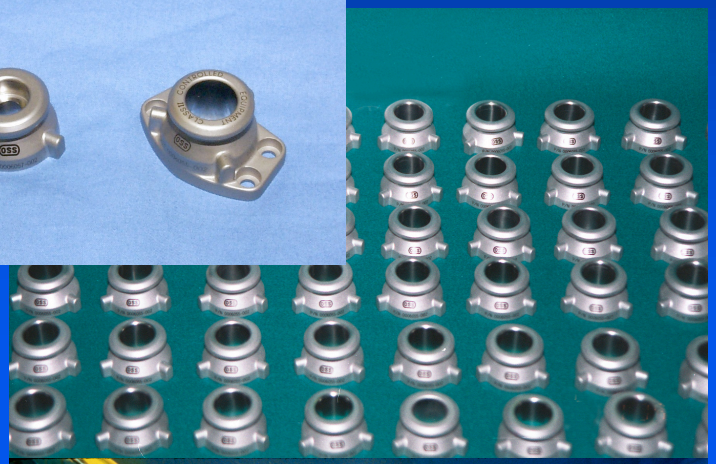


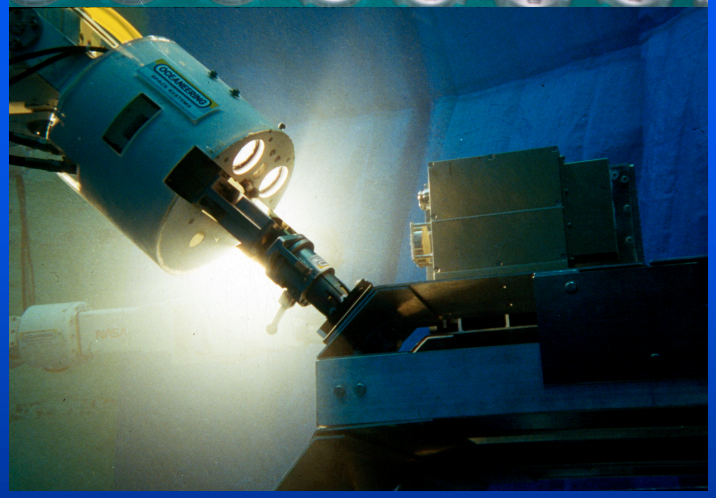


Evolution of Subsea to Space Interfaces

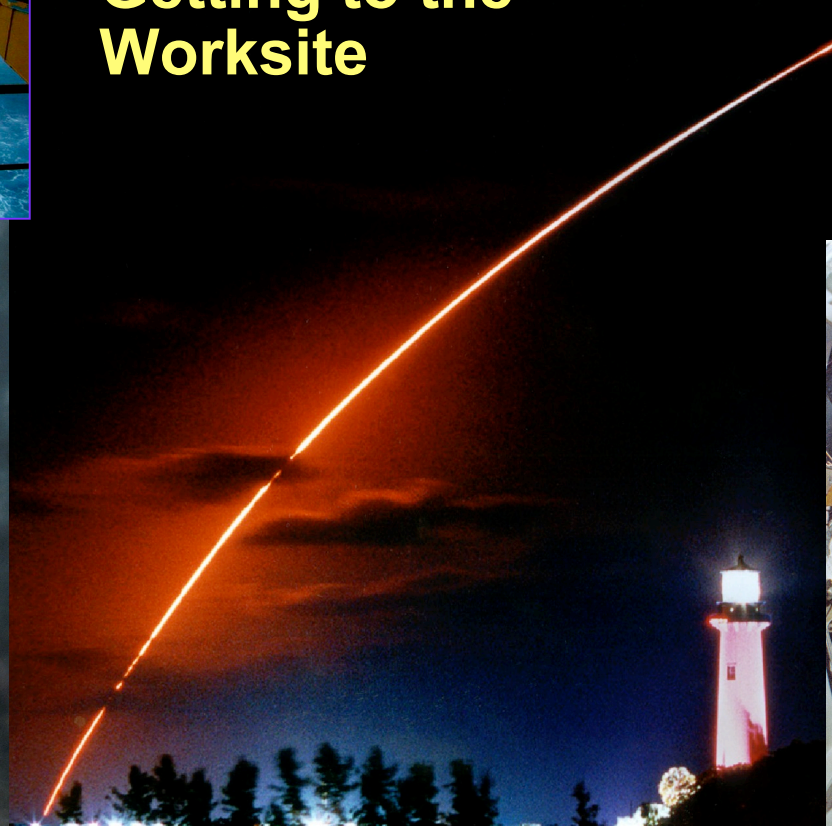






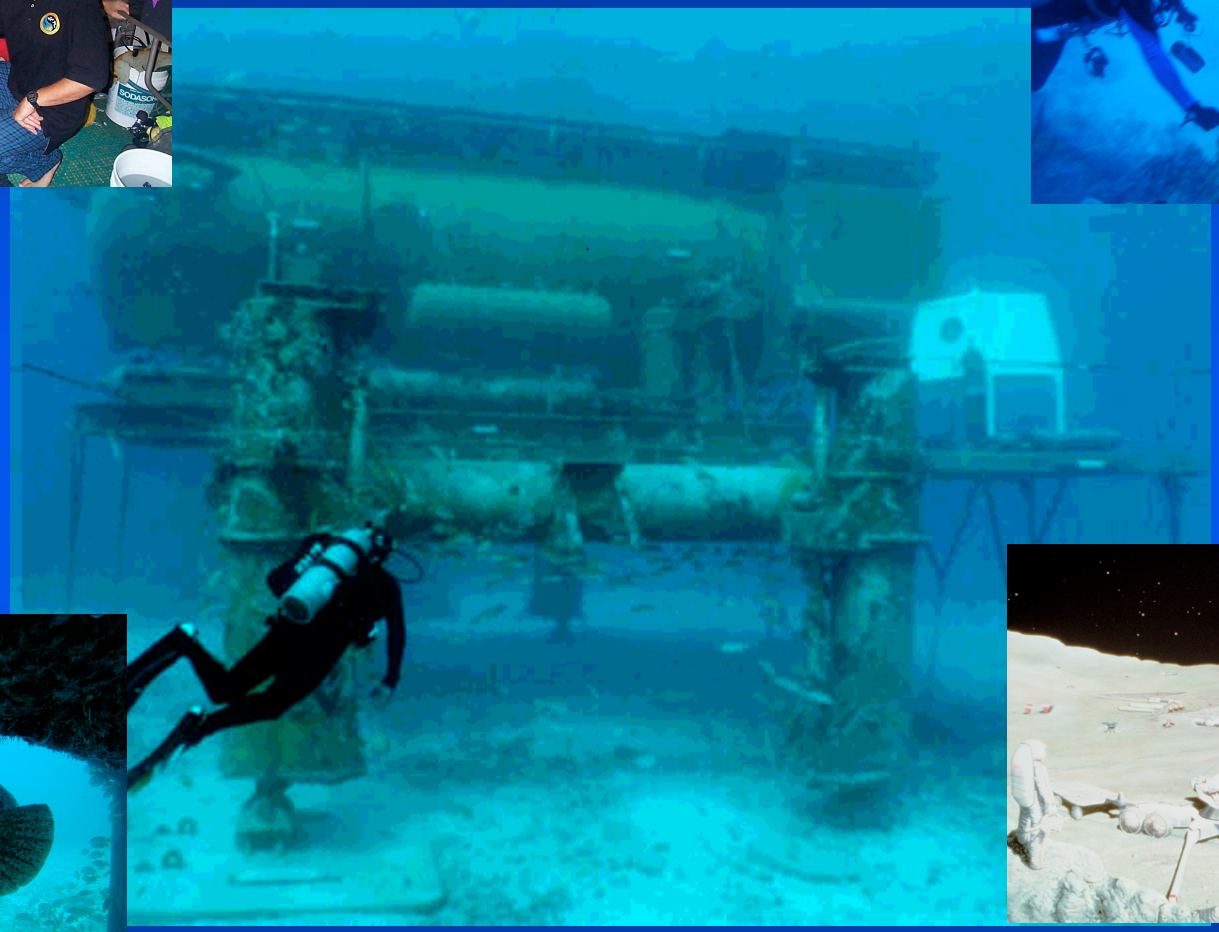


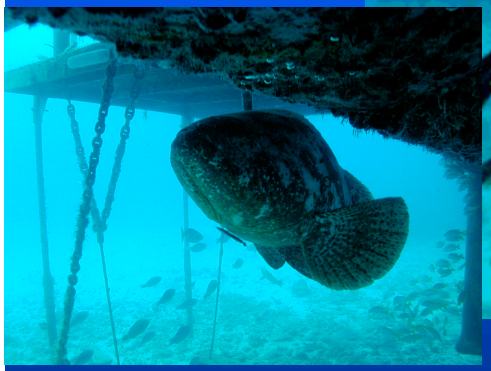
Getting to the Worksite

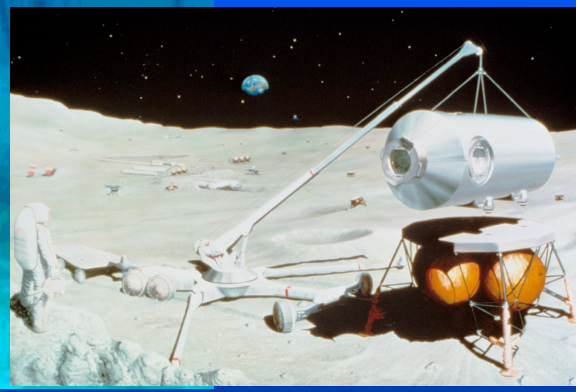


Challenging Transportation and logistics- everything has to go well

~80% of training spent on ascent and entry

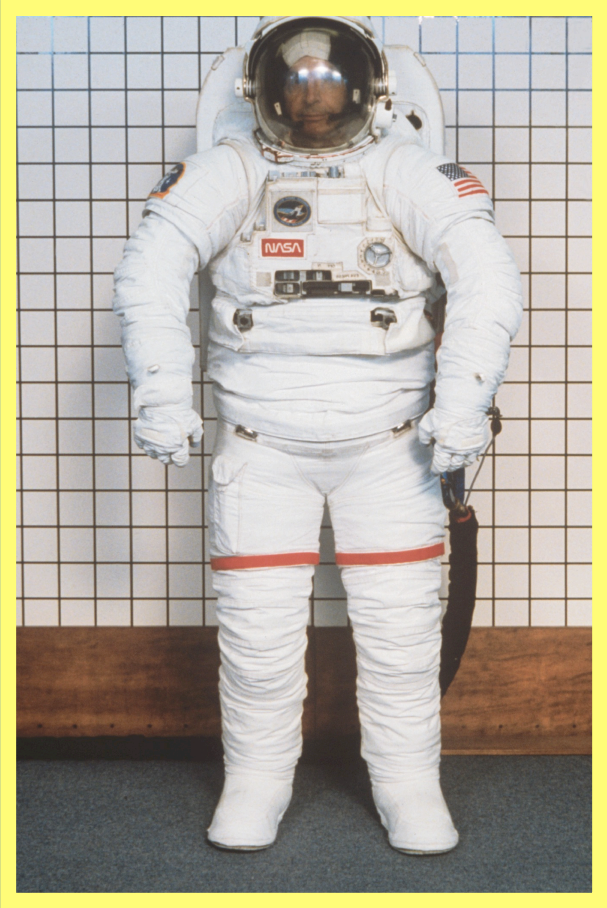






Aquarius Underwater Habitat- Exploration Analogue (prospective vs. retrospective risk control)

Space Decompression



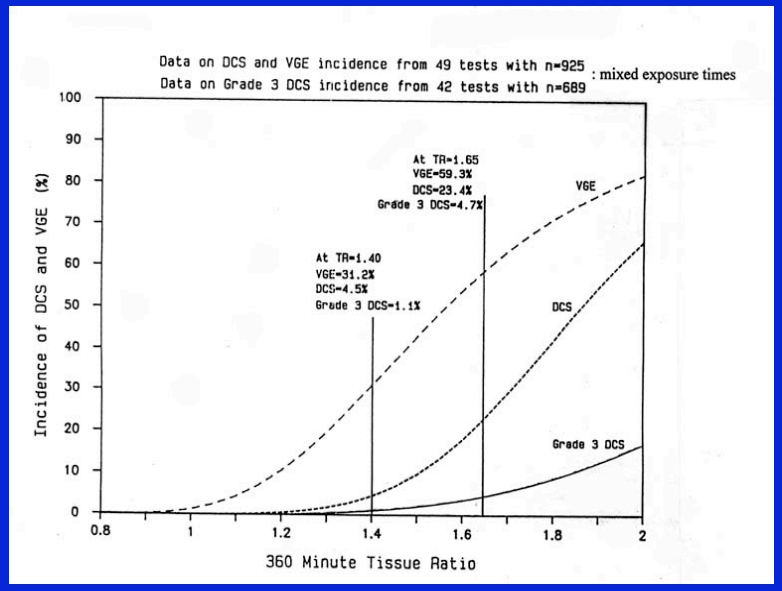
-Low pressure suit (4.3 psi) to reduce the forces and torques necessary to work in vacuum

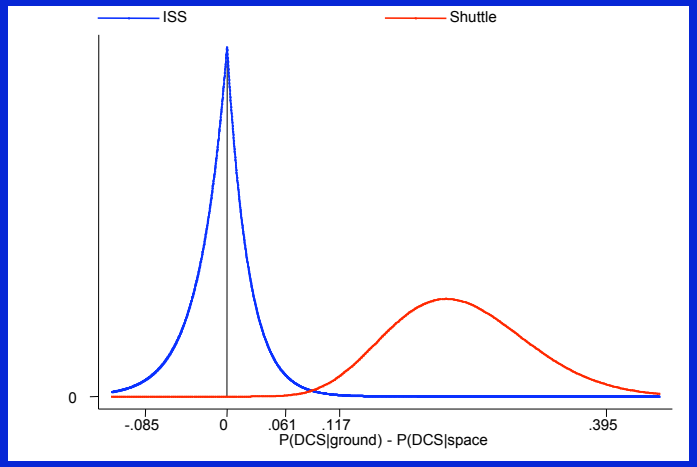
-Denitrogenation is necessary to prevent gas phase separation that can lead to DCS

-From Boyles Law the pressure/volume response of a bubble increases at progressively lower pressures

-Lower suit pressures require increasingly more nitrogen elimination.

Shuttle Prebreathe protocol Ground Trials

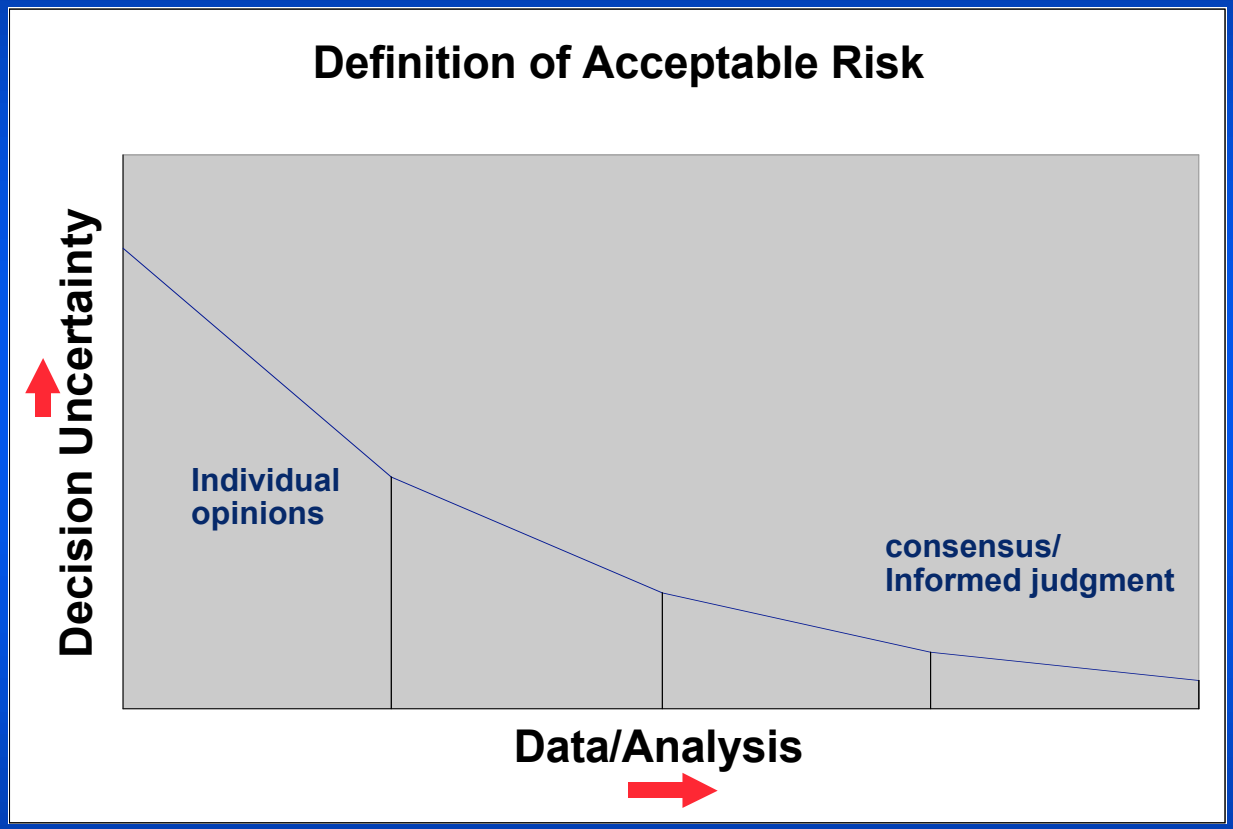




95% Bayesian Confidence limits for P{DCS|ground}-P{DCS|space}

Is ~ 25% decompression sickness (DCS) acceptable risk for EVA?

Definition of Acceptable Risk for Decompression Sickness



Data Driven Risk Decisions

Opinion vs. Informed Opinion

Definition of Acceptable Decompression Sickness Risk on ISS

- What is the highest risk we can stand and still be able to build and maintain the International Space Station?
  - Apply NASA DCS disposition policy (JPG 1800.3) to ISS assembly and maintenance model
    - One type 1 DCS return to EVA in 72 hours
    - Second type 1 – out of EVA rotation
    - First type 2 – out of EVA rotation
  - Monte Carlo simulation, applying policy to ISS assembly and maintenance model
    - Assume 3 EVA crewmembers
    - Protect for a two-person EVA capability throughout ISS life at 95% C.L.

Limit DCS and grade IV VGE to below the type II serious DCS threshold

Acceptable DCS criteria

- DCS incidence ≤ 15% @ 95% C.L
- Grade IV VGE ≤ 20% @ 95% C.L.
- No type II DCS
- Reject for risks > than the above at 70% C.L

Stay on the right side of that fine line