HYPERBARIC INTERVENTION IN SUBMARINE RESCUE

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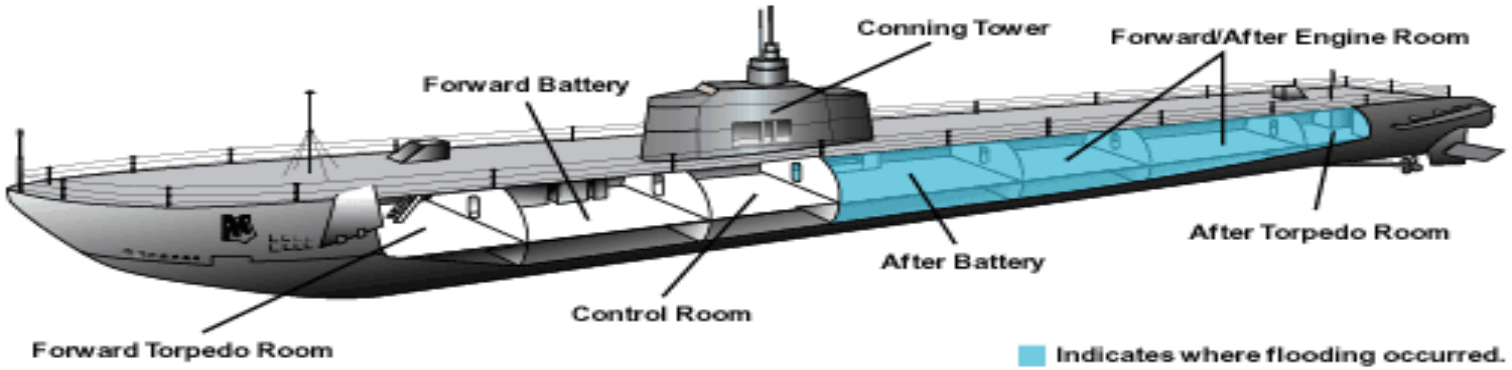
INTRODUCTION

Technologies and techniques developed for human survival in the ocean depths required to support the oil and gas industry have been adapted to provide a faster, highly mobile and comprehensive rescue capability for the world's submariners in the event of a survivable submarine accident. Submariners trapped in a stricken submarine may require the intervention of both external saturation divers, pressurised rescue submarines and surface recompression facilities to deal with the physiological effects of deep submergence during their rescue. This presentation seeks to explain the challenges and techniques deployed to enhance the odds of successful rescue.

WHAT IS A DISABLED SUBMARINE – DISSUB ?

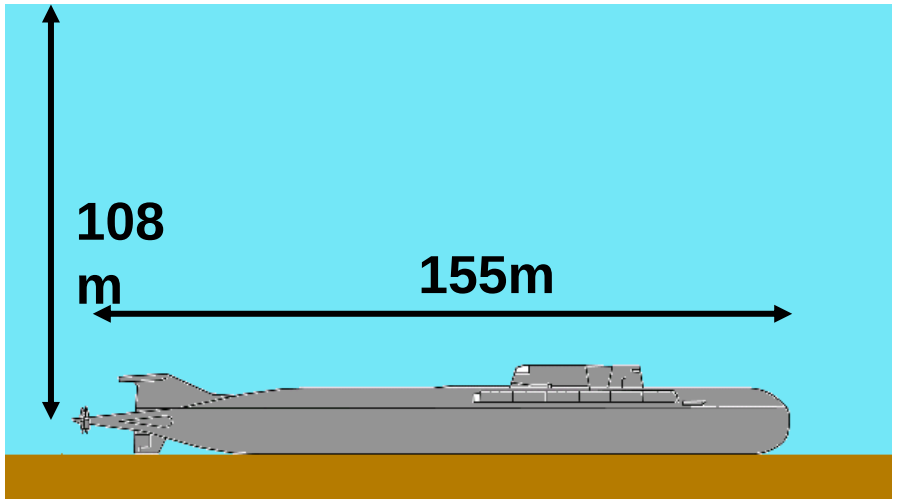
A DISSUB is a submarine which is unable to return to the surface, and has surviving crew trapped inside the hull.

The hull may or may not be compromised and thereby partially flooded. The survivable dry section may therefore become pressurised.



KURSK

A recent example of a DISSUB was the Kursk tragedy in Aug 2000, which sank in 108m of water off the Russian Coast
Unfortunately no rescue was possible.



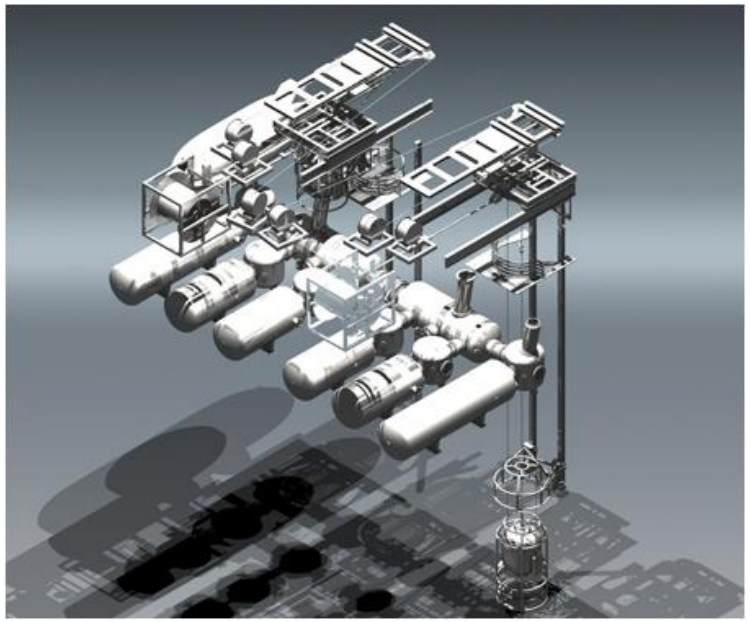
Air Saturation

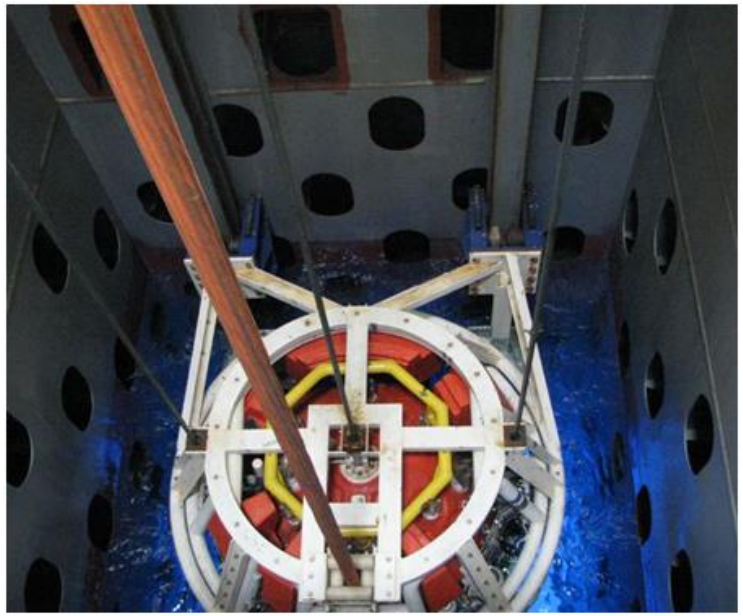
In a situation where a DISSUB is partially flooded, survivors in the remaining sections of the submarine are likely to be subject to increased pressure in their environment. This increased pressure exposes the submariners to the same issue as divers. Breathing air at increased pressure allows the inert nitrogen in air to “saturate” into the bloodstream in the form of microscopic bubbles. Over time, the submariners become “saturated” with this excess nitrogen. This creates a requirement to ensure any rescue of the crew prevents rapid “decompression” to atmosphere where the rapid expansion of these bubbles in the bloodstream could cause the harmful condition of decompression illness, known as the bends.

Rescues are therefore carried out using the same “transfer under pressure” and decompression technologies learned and deployed in oilfield saturation diving.

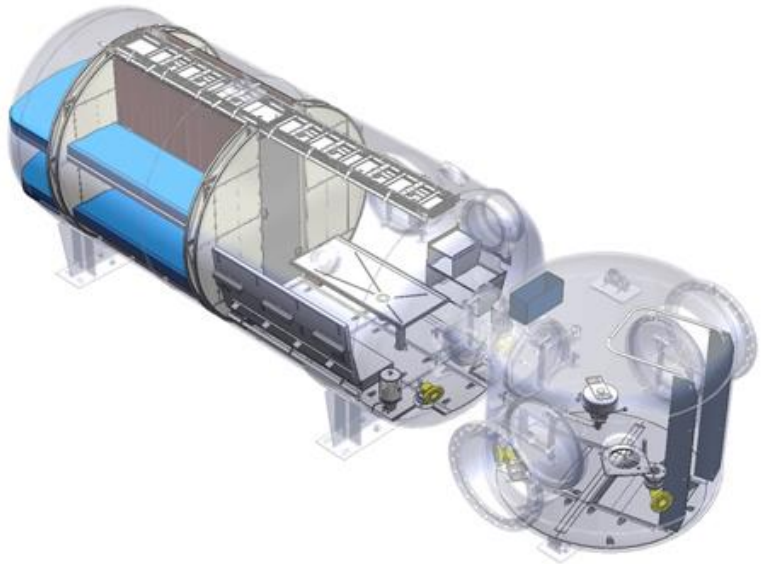
Saturation Diving

Pioneered as early as 1942, saturation diving is a technique employed to compress deep divers to the equivalent pressure of the water at the depth they intend to dive, permitting the divers to live in decompression chambers at these depths and deploy to their working depth in a pressurised diving bell.





For a typical oilfield diving operation, the “storage depth “ of the diving team may range from 50 metres to 200 metres equivalent water depth. At a water pressure increase of one atmosphere per 10m of depth, at 200m the divers are therefore living at an ambient pressure of 20bar or 290 psi. Typically 12 -18 divers are “stored”in a diving system.



The working depth, and time spent at that depth, determine the decompression requirement for the divers and the time required to return them to surface ambient pressure. For a typical oilfield work programme, this may be 7-10 days.

Submarine Rescue, Transfer Under Pressure and Decompression

The challenge to rescue submariners, who have been subjected to air saturation therefore is to provide a means to evacuate them from the DISSUB under the same ambient pressure as their stricken submarine, and transfer them on the surface to a decompression facility.

As submarine complements can range from 30 to over a hundred crew, who could have been exposed to pressures as high as 4 atmospheres (4 bar) for as long as 5 -7 days the logistics of a rescue are demanding. The decompression requirement can be as long as 24 hours and therefore the requirement to rescue and decompress large numbers of crew is a significant challenge.

There is also a submarine escape scenario to consider where multiple submariners may “free ascend” through the water to leave the DISSUB. This scenario requires rapid recompression of the escapee to prevent or treat the effects of decompression.

Submarine Escape & Rescue – Sequence of Events

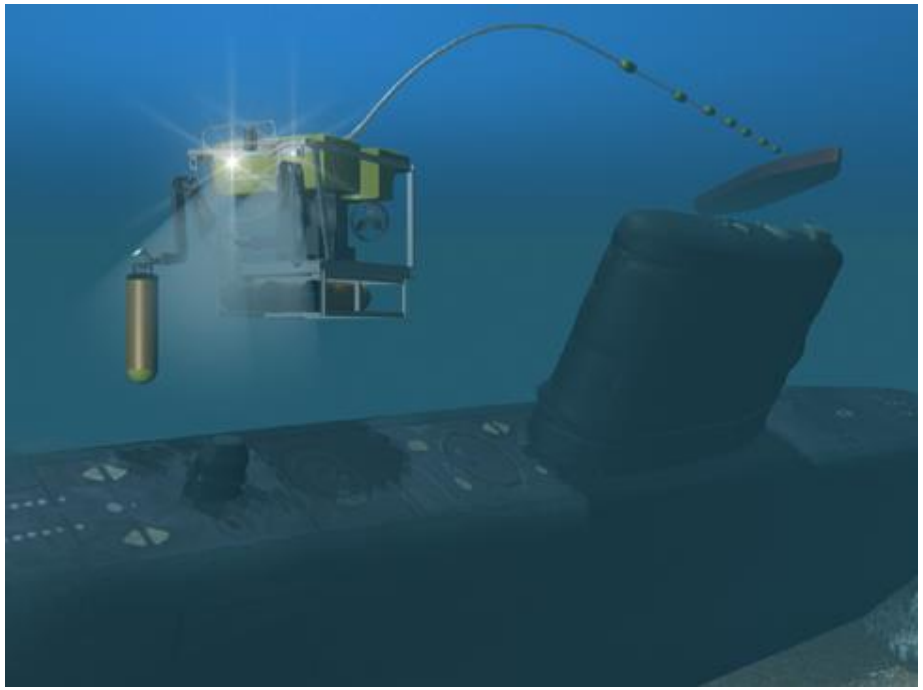
INTERVENTION SPREAD

Functions:

DISSUB Localisation/ underwater tracking
Survey/debris clearance
Resupply Emergency Life Support Stores

Response:

Mobilised within 8 hours of call-out



Intervention by Saturation Divers

Some nations submarine rescue capabilities extend to saturation diving systems, which are capable of deploying divers to the DISSUB where intervention tasks such as debris clearance, emergency air connection or simply observation can be undertaken.

SUBMARINE ESCAPE

If circumstances onboard the DISSUB deteriorate, or the crew are able to determine a surface presence a mass submarine escape may be determined to offer the highest chance of survival.
Submariners free-ascend through the water after donning specialised escape suits, and rely on surface vessels to recover them quickly from the water and provide decompression facilities to treat barotrauma and decompression sickness.

RESPONSE

48 hours – possibly more if submarine is not pressurised.

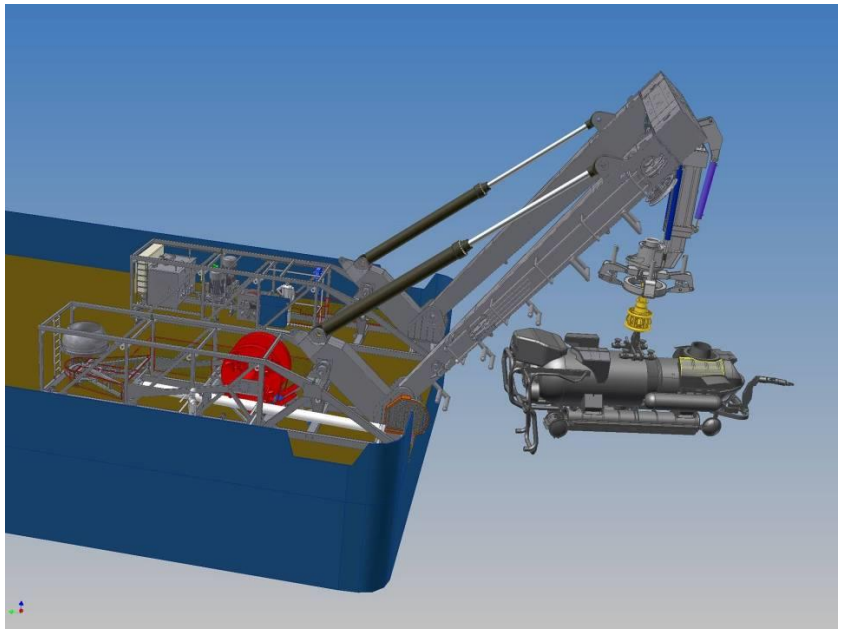
RESCUE SPREAD

Deployment of Rescue Submersible
from mother ship to commence
submarine
rescue operations.

RESPONSE

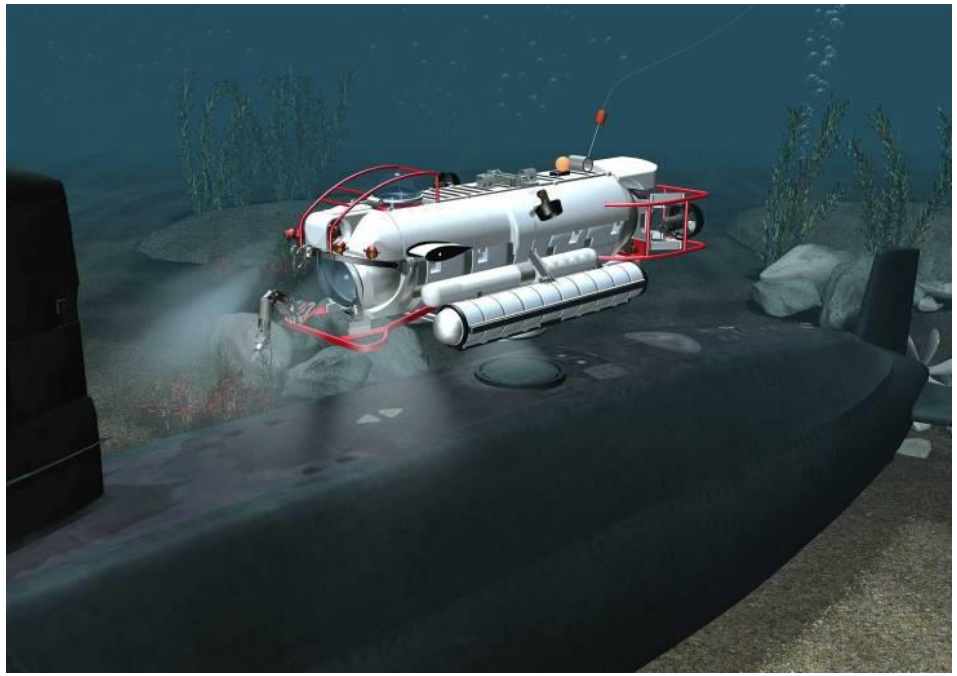
To be mobilised from JFD facility in 12 hours

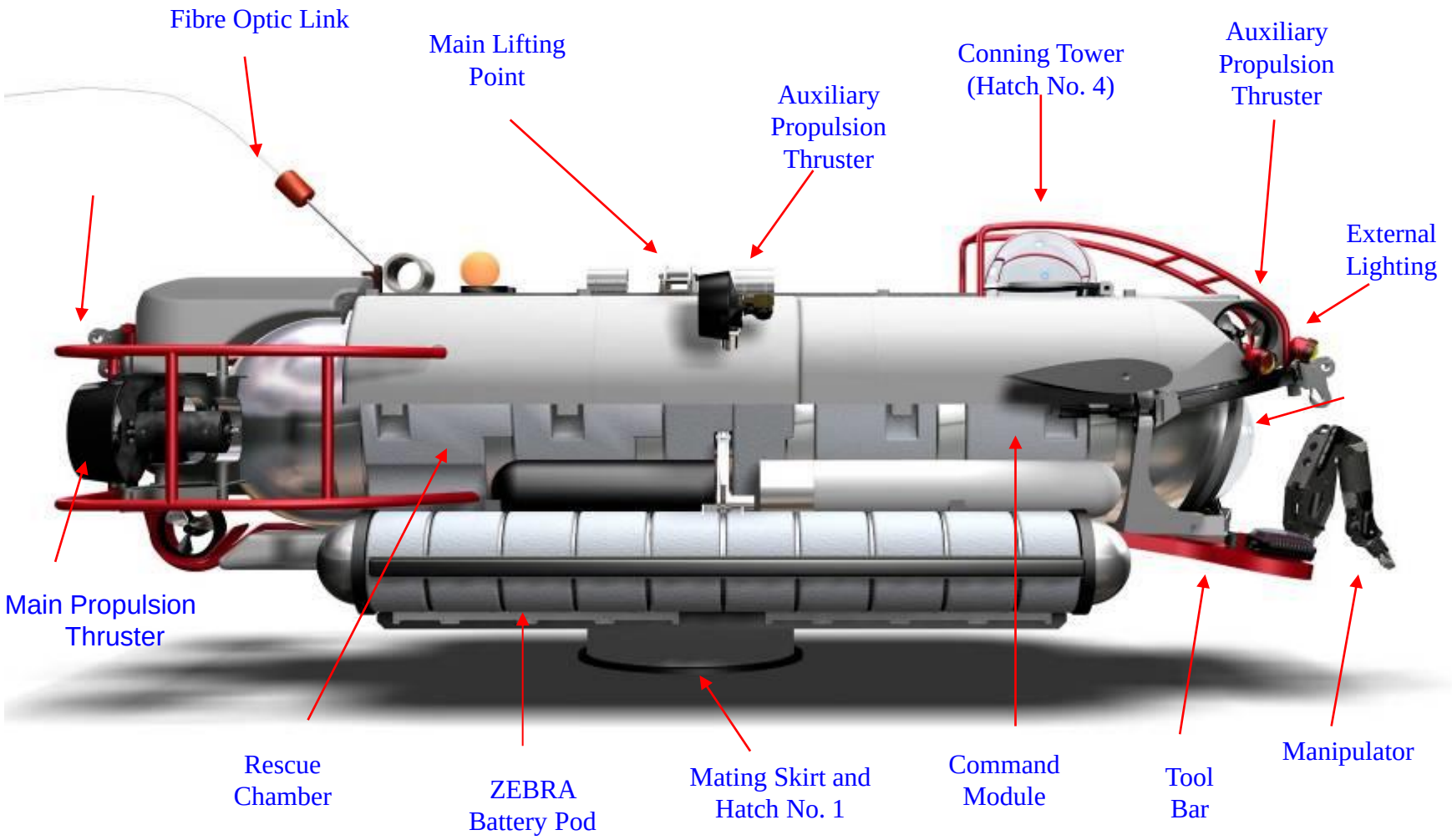
Ideally first rescue 72 hours from call out



RESCUE

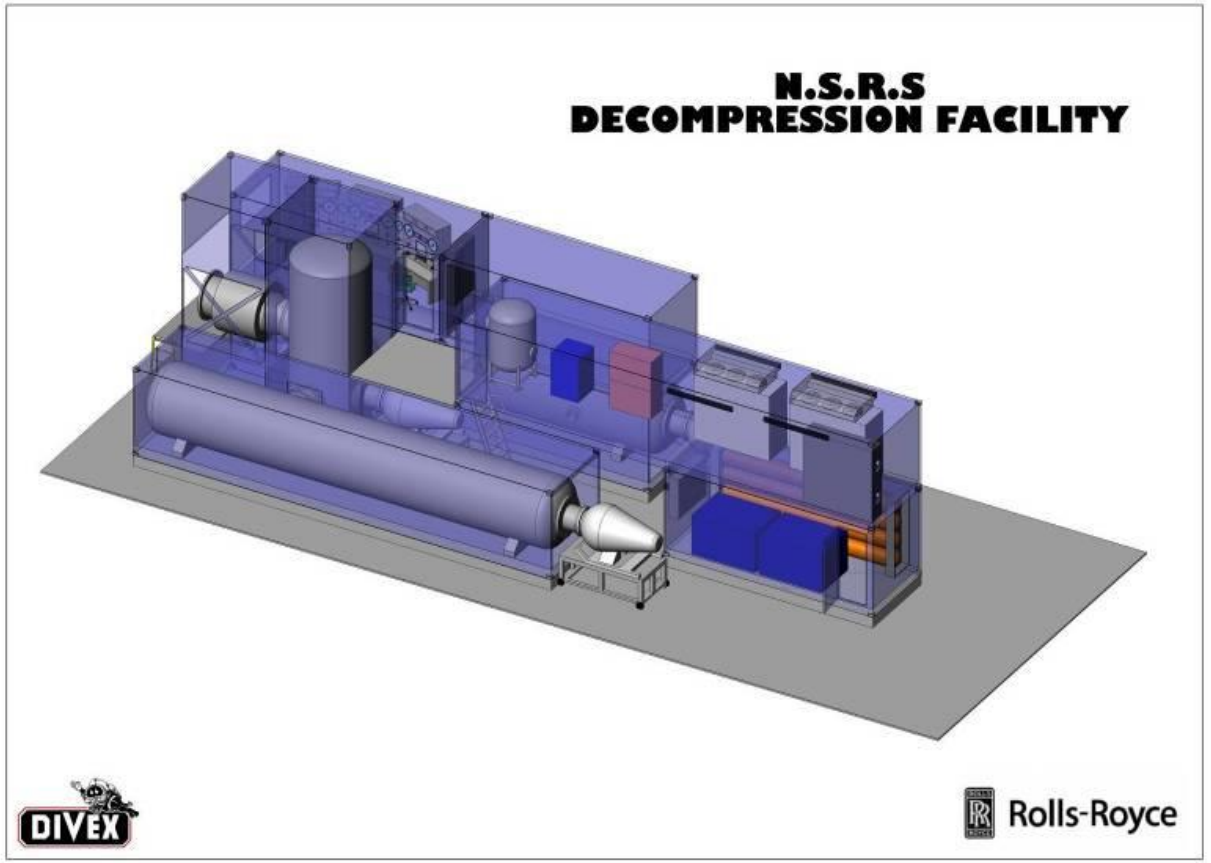
The rescue submersible “mates” with the DISSUB on a dedicated escape hatch, and the pressure inside the rescue compartment is equalised with the submarine

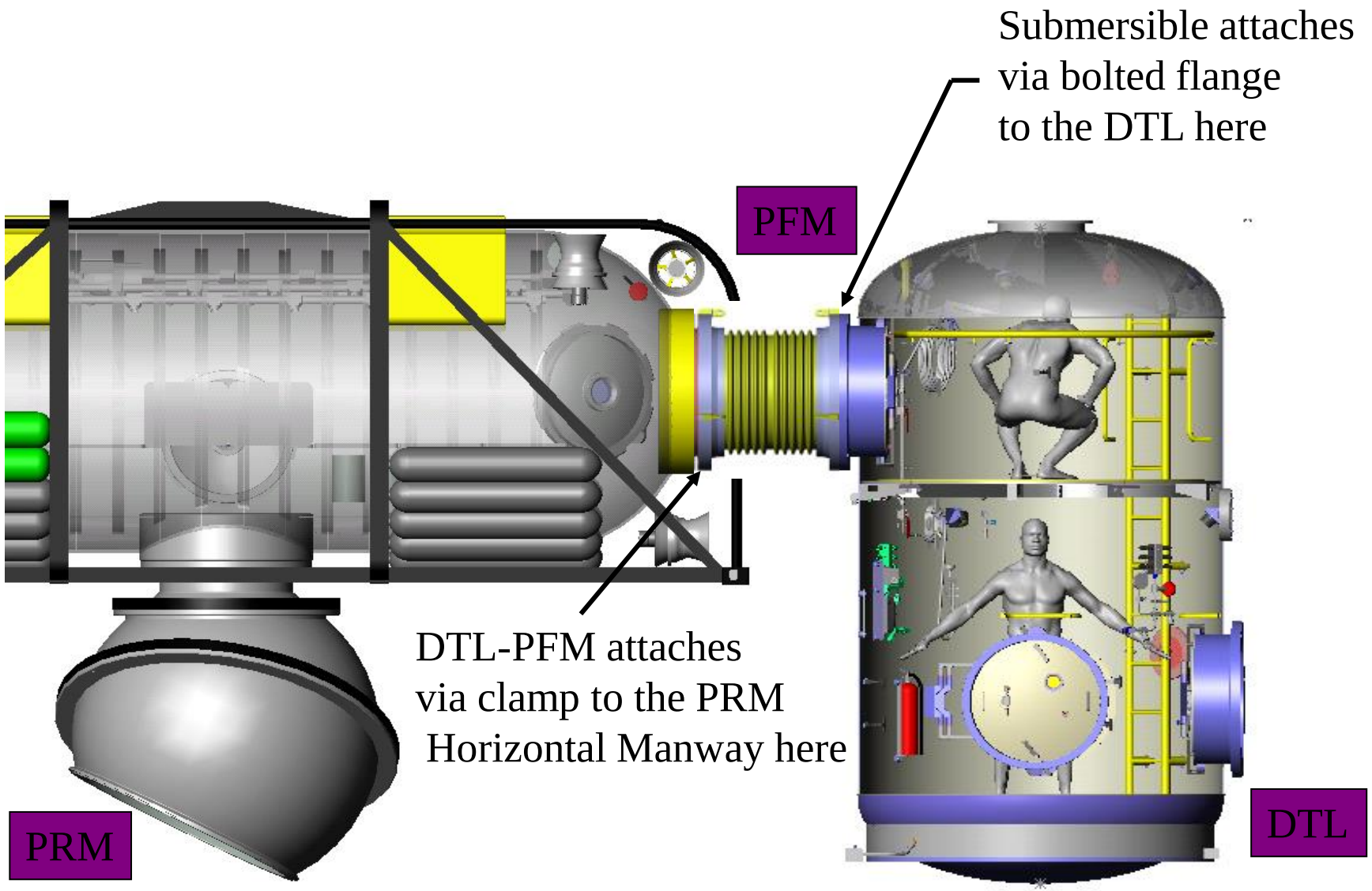



Fibre Optic Link
Main Lifting Point
Auxiliary Propulsion Thruster
Conning Tower (Hatch No. 4)
Auxiliary Propulsion Thruster
External Lighting
Main Propulsion Thruster
Rescue Chamber
ZEBRA Battery Pod
Mating Skirt and Hatch No. 1
Command Module
Tool Bar
Manipulator

DECOMPRESSION SPREAD

The submersible mates under pressure with a pressurised “holding” chamber allowing the submariners to transfer under the same ambient pressure as the submarine into the decompression facility. The facility has multiple pressure “locks” to allow staged decompression to be undertaken




Submersible attaches
via bolted flange
to the DTL here
PFM
DTL-PFM attaches
via clamp to the PRM
Horizontal Manway here
PRM
DTL

Decompression

Submariners are brought slowly back to ambient pressure, following decompression tables calculated to ensure the nitrogen bubbles pass through their tissues with no harmful effect.