PSAM 14

PROBABILISTIC SAFETY ASSESSMENT AND MANAGEMENT CONFERENCE
September 16-21, 2018

OIL AND GAS INDUSTRY I SESSION

Probabilistic Risk Analysis (PRA) of a Mobile Offshore Drilling Unit (MODU) Dynamic Positioning System (DPS)

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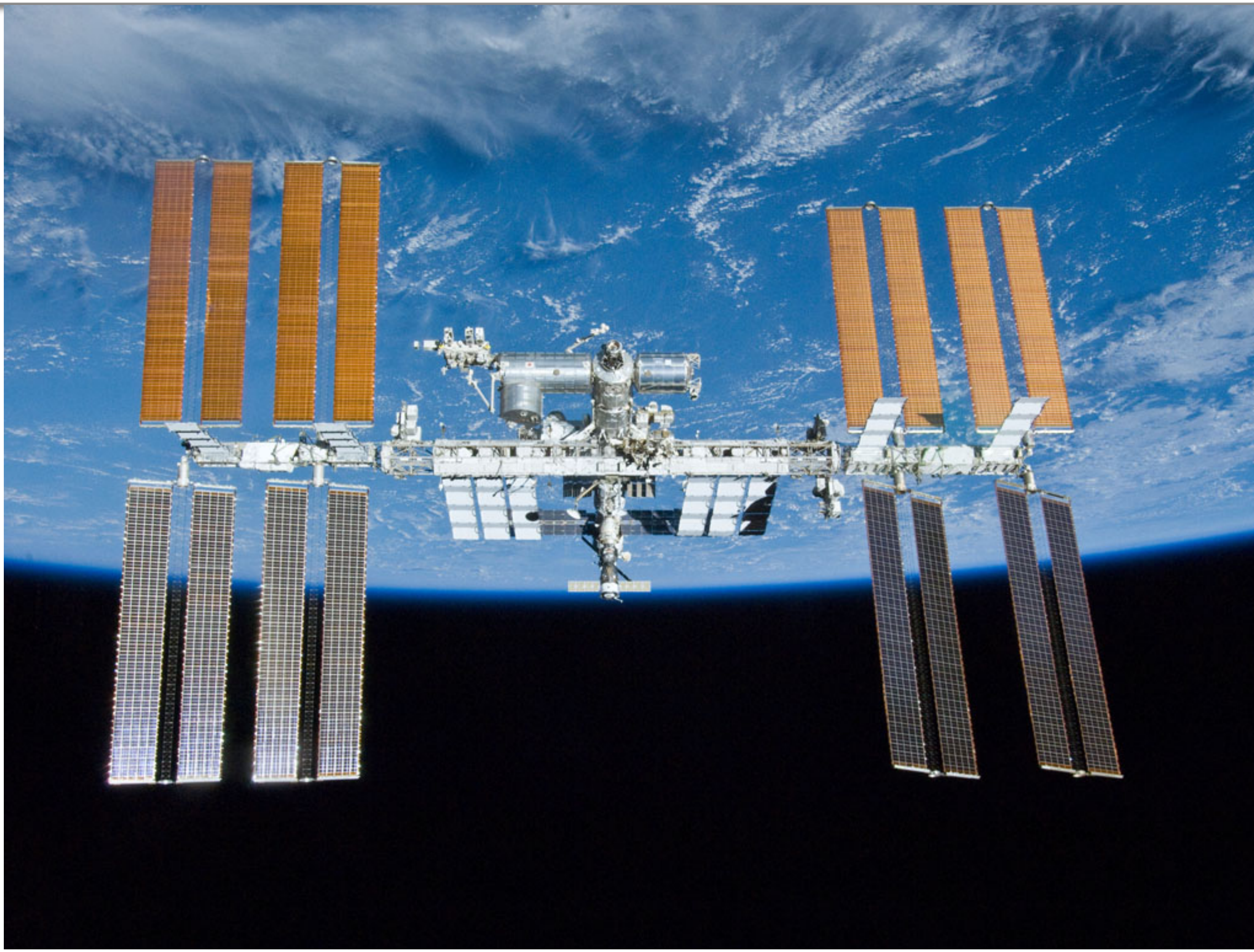
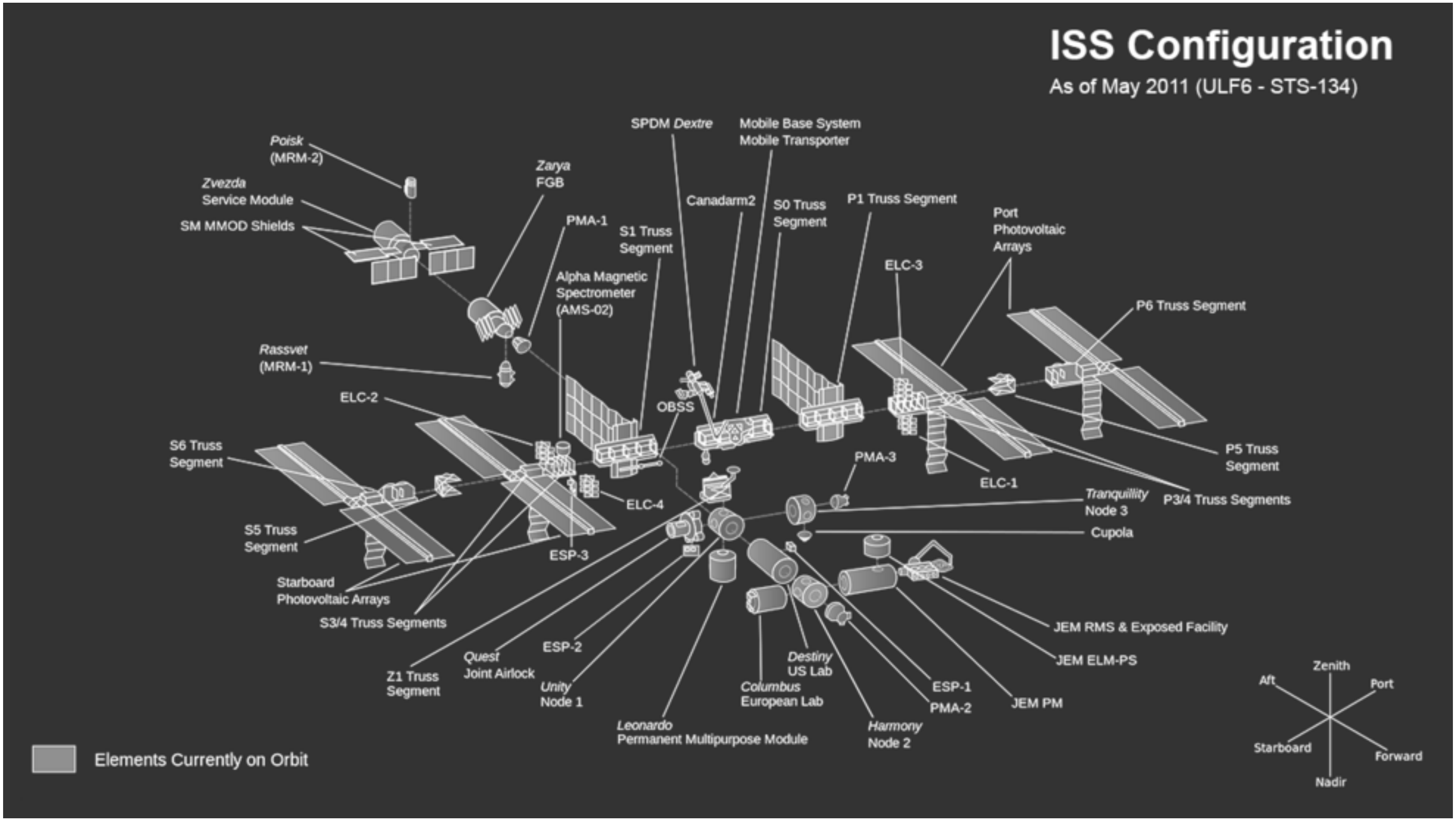
1. Why NASA's experience is relevant to the oil and gas industry.
2. Dynamic Positioning System (DPS) overview.
3. Dynamic Positioning System (DPS) Probabilistic Risk Assessment (PRA) modeling.

International Space Station

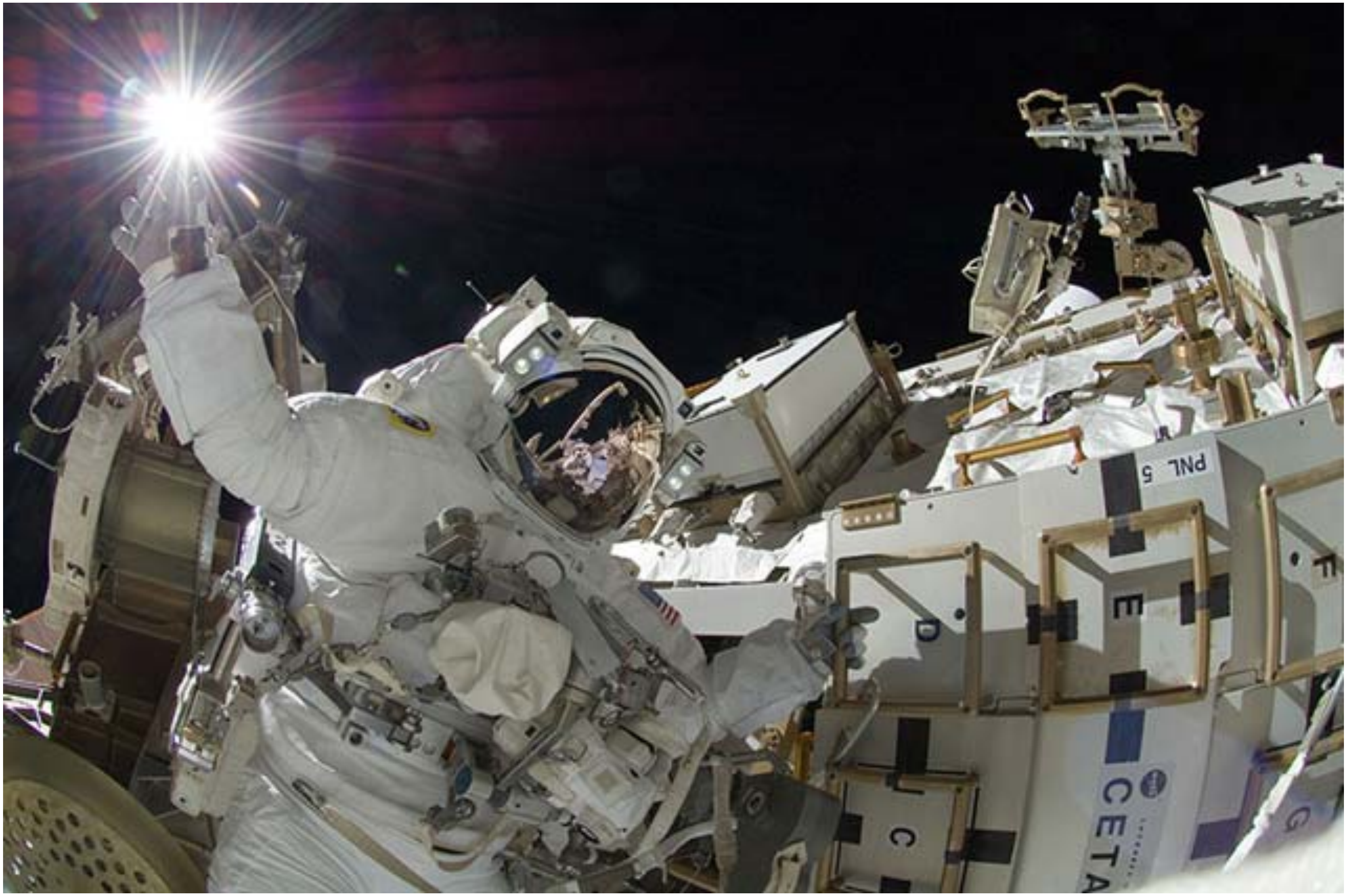


International Space Station

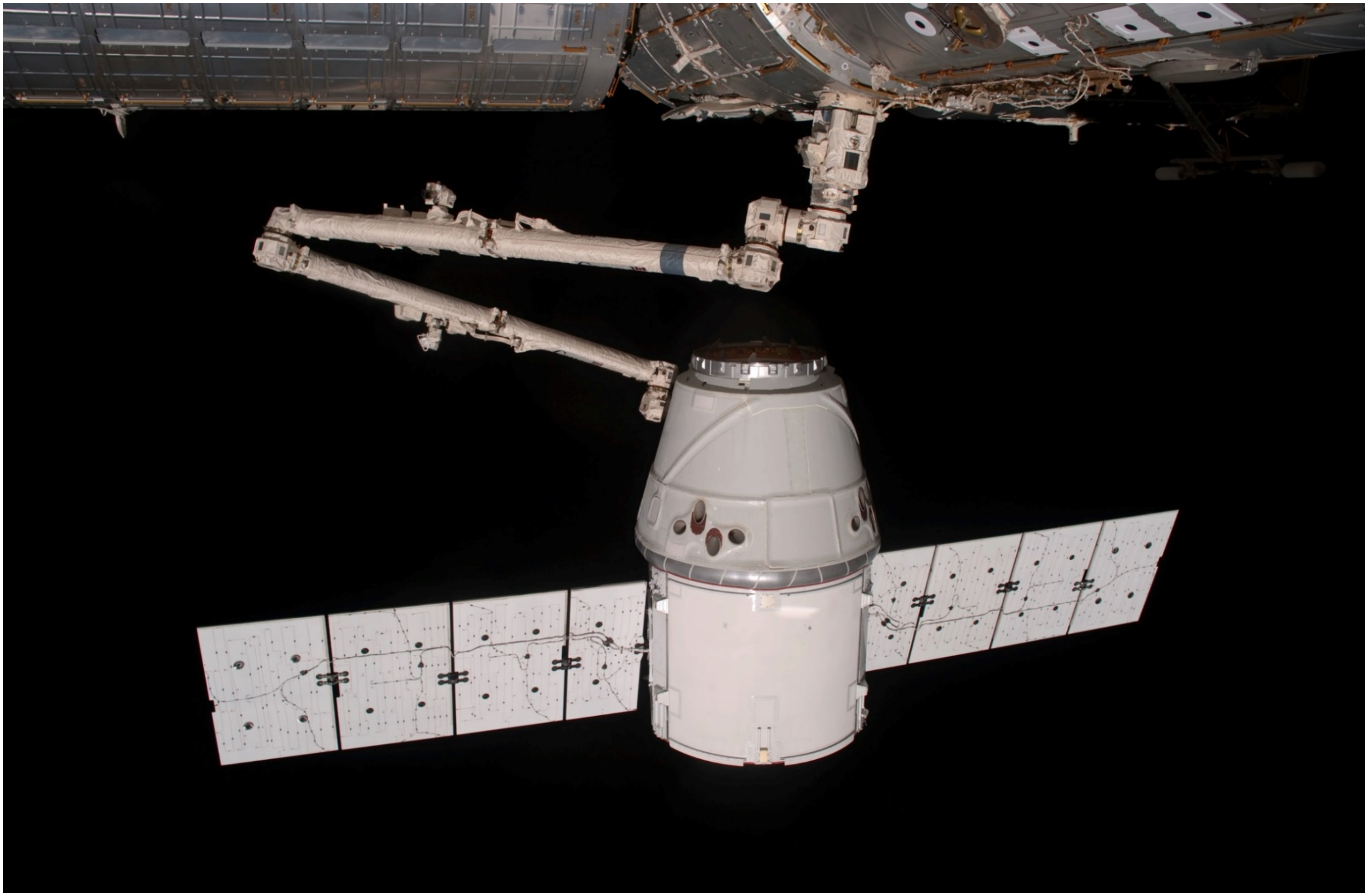


Complex Operations Dependent on Human Involvement

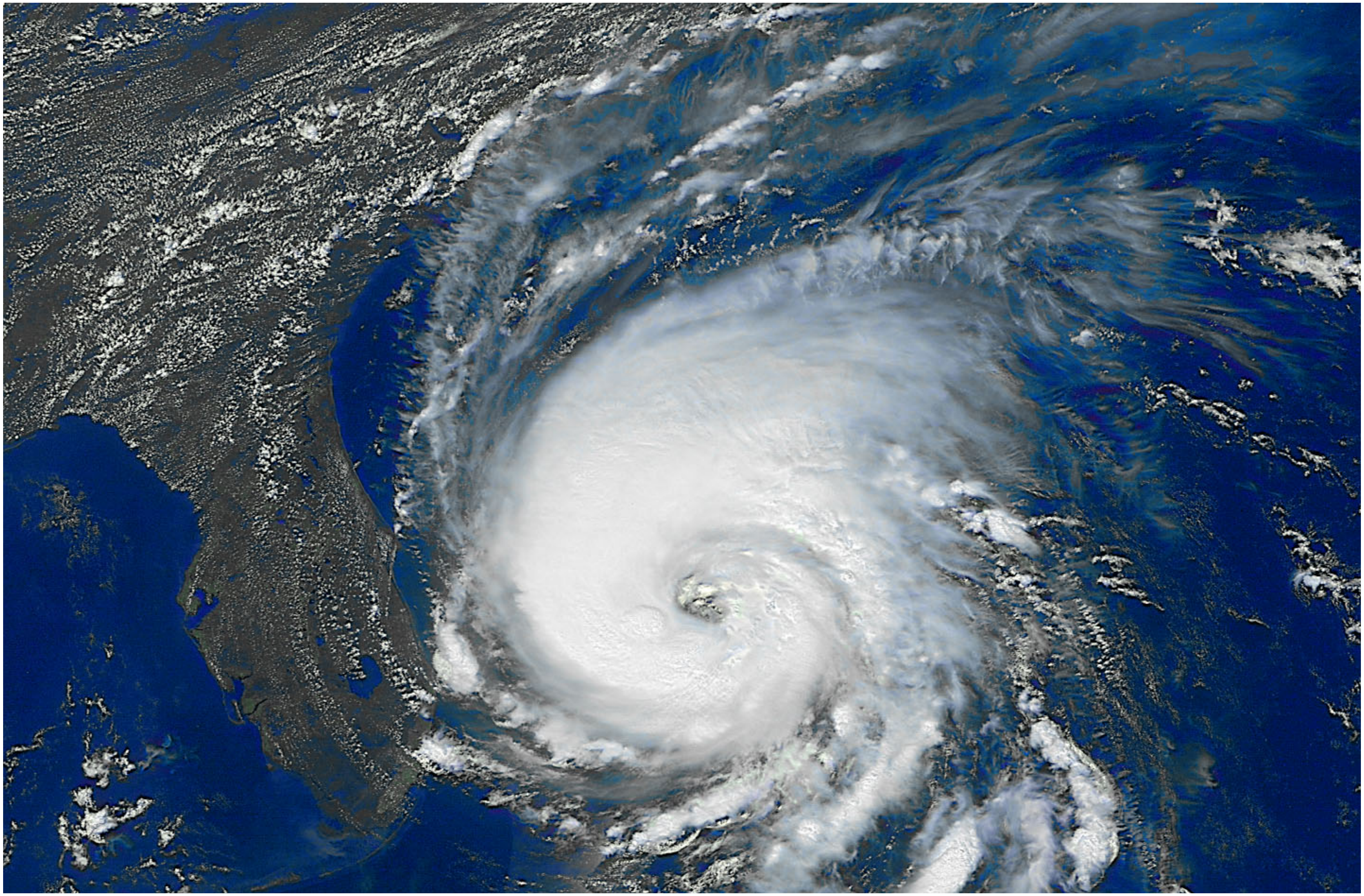
Repair and Maintenance Operations in a Hostile Environment



Ongoing Resupply Operations



Isolated and Not Easily Accessible



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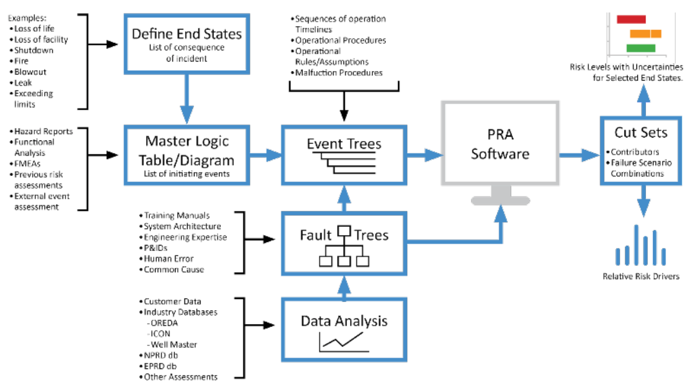
Dynamic Positioning System Project Background

- A recent Space Act Agreement signed with members of the oil and gas industry has made NASA's PRA expertise available.
- As a result, NASA was commissioned to conduct a PRA to estimate the risk of a Mobile Offshore Drilling Unit (MODU) equipped with a genericallyconfigured Dynamic Positioning System (DPS) losing location.
- The DPS modeled in this PRA is generic such that the vessel meets the general requirements of an International Maritime Organization (IMO) Maritime Safety Committee (MSC)/Circ. 645 Class 3 dynamically positioned vessel.



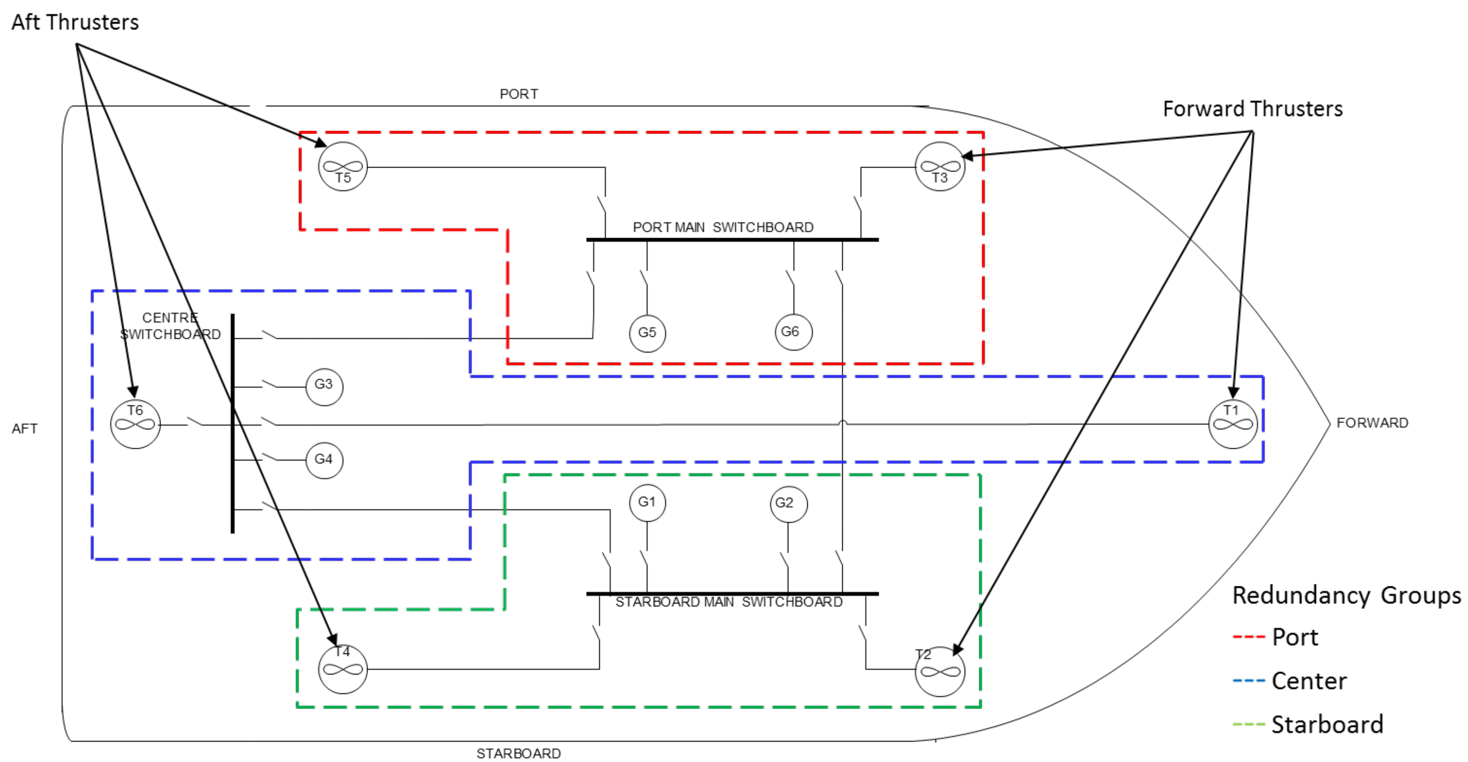
DPS Vessel Classification

The DP Class definitions were developed by the International Maritime Organization (IMO) in its Maritime Safety Committee (MSC)/Circ. 645. A vessel normally obtains a DP class notation which is issued by Marine Classification Societies as an additional notation to main vessel class.

Description	IMO Equip. Class	LR Equip. Class	DNV GL Equip. Class	ABS Equip. Class	NK Equip. Class	BV Equip. Class
Manual position control and automatic heading control under specified maximum environmental conditions	-	DP(CM)	-	DPS-0	-	
Automatic and manual position and heading control under specified maximum environmental conditions	Class 1	DP(AM)	DP 1	DPS-1	DPS A	DYNAPOS AM/AT
Automatic and manual position and heading control under specified maximum environmental conditions, during and following any single fault excluding loss of a compartment. (Two independent computer systems).	Class 2	DP(AA)	DP 2	DPS-2	DPS B	DYNAPOS AM/AT R
Automatic and manual position and heading control under specified maximum environmental conditions, during and following any single fault including loss of a compartment due to fire or flood. (At least two independent computer systems with a separate backup system separated by A60 class division).	Class 3	DP(AAA)	DP 3	DPS-3	DPS C	DYNAPOS AM/AT RS

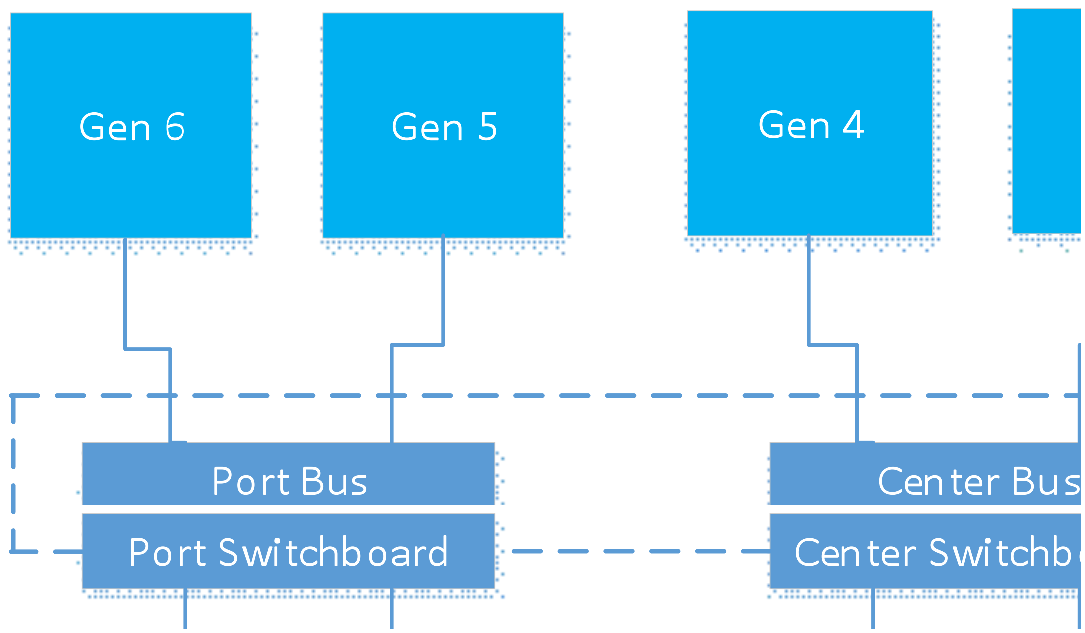
DPS System

- The DPS approximated in this analysis was considered generic. System architecture was established by consulting with a subject matter expert.
- The DPS is comprised of three basic subsystems: the power generation system, the thrusters, and the control system.
- With respect to vessel propulsion, it was assumed that the vessel would utilize six thrusters: three forward and three aft. The thrusters would be arranged in three redundancy groups: port, center, and starboard.



Power Generation Subsystem

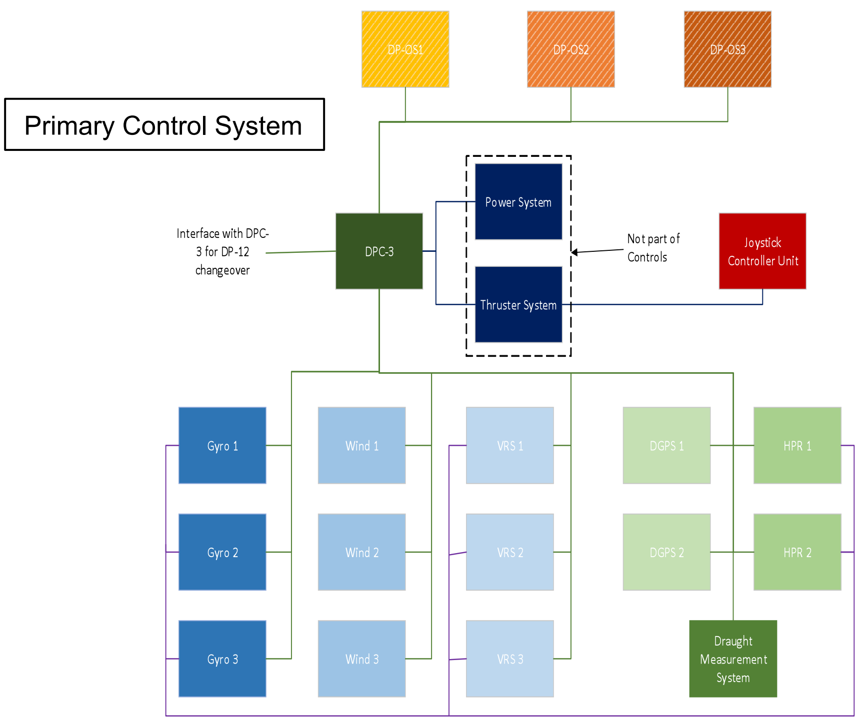
- The thrusters are powered by six diesel generators: two per redundancy group. Both generators in a redundancy group are connected through a switchboard that will allow them to be isolated, either individually or as a group, in the event of a failure.

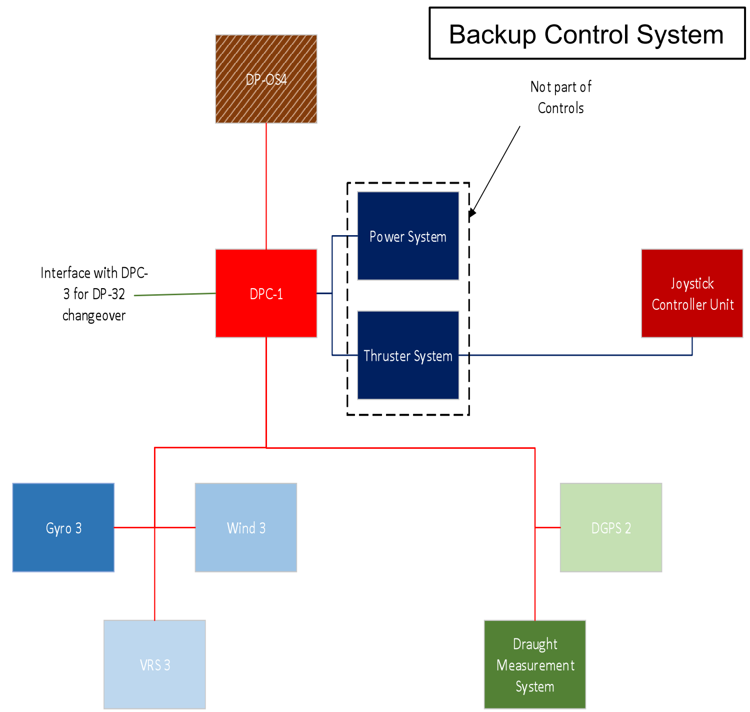


- Each of the diesel generator redundancy groups is supplied by an independent fuel system.
- Each diesel generator redundancy group is also equipped with a cooling system. The cooling system is comprised of both a fresh water and sea water cooling system.

Control Subsystem

- The DP control system controls the diesel generators and thrusters to maintain position and heading.
- It also includes operator stations that provide information to the DPO about system condition, vessel performance, the operating environment, and provides for entry of operator commands.
- The control system has a primary system and a back-up system that provides station keeping capability in the event of a primary failure.





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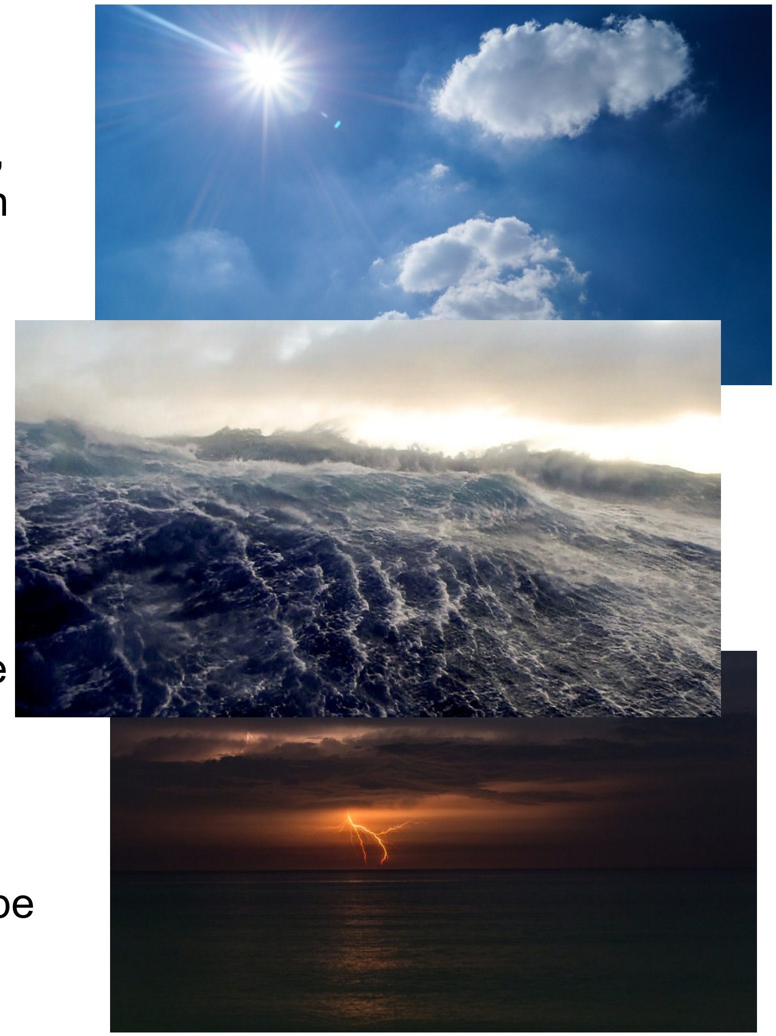
Modeling Approach

Operating Environment:



- Based on discussions with subject matter experts, the environment, specifically the weather, in which the vessel is operating is fundamental to maintaining location in the event of a DPS failure.
- To simplify the analysis, two environments were established to represent the full range of operational conditions that the vessel will experience in the GoM; normal operating environment and extreme weather.
- The normal operating environment exists any time the vessel is within the green operation area and well operations are occurring.
- The extreme weather environment is meant to capture the rare occasions when the vessel may be forced to remain on location during extreme weather.

Scope and Objectives

Scope

- The DPS PRA is intended to address only failures of the DPS that can result in a loss of location (i. e. probability of loss of location).
- Failures associated with other shipboard equipment or drilling hardware are beyond the scope of this analysis, although human error as it pertains to operation of the DPS is included.

Objectives

- The fundamental objective of this analysis is to determine the probability of the DP vessel losing location during well operations.
- Of equal importance in this analysis is to determine which elements of the DPS are the principal contributors to the overall risk and their relative risk ranking.

Initiating Events and Success Criteria

Initiating Event(s)

The initiating condition or event for these models is a fully functioning DPS. In other words, there is no initiating failure at the outset of the failure sequence that ultimately results in a loss of location by the vessel.

Success Criteria

The analysis does take into consideration the possibility that certain weather conditions will affect the level of DPS failure that the vessel can withstand and still maintain position.

- In a normal weather environment with calm seas, low winds, and mild currents, the vessel requires less power or thruster control. A vessel with a Class 3 certification must be able to withstand and remain operational during Worst Case Failure (WCF) which is defined as the loss of a single redundancy group or one pair of generators or thrusters. Since the DPS must be able to maintain location with the loss of a redundancy group, it was assumed that any system failure occurring after the loss of a redundancy group would be considered failure.
- In an elevated or high weather environment, such as sudden hurricanes, the MODU requires more power and thruster capability to keep station; therefore, loss of a single thruster or generator was assumed to result in a loss of location.

End States

The end states for this analysis were established by identifying the general failure modes by which the MODU could lose location. The three separate end states were identified: drift-off, drive-off, and push-off.

1. Drift-off occurs when one or more failures inhibit the DPS from maintaining vessel location and it drifts beyond the designated radius of operation.

2. Drive-off occurs when the DPS experiences operational degradation to an extent where human intervention is required. During this intervention, human error causes the thrusters to begin moving the MODU off location. As the vessel gains momentum, the risk of potential damage to subsea equipment before re-establishing position becomes unacceptably high resulting in the initiation of an emergency disconnect.

3. Push-off occurs when the weather environment exceeds the position keeping capabilities of a fully operational DPS resulting in the vessel losing location and an emergency disconnect must be initiated.

Data Development

Generic Data

- Oil and gas industry specific generic data was used when available, and non-industry specific generic data was used otherwise.
- Most published data was also somewhat dated and may not have represented the most recent conditions or uses for the equipment.

Weather Data

- For this analysis extreme weather frequency was determined from weather data in the Gulf of Mexico.
- The weather frequency estimates along with vessel DP capability plots provided by the system expert were used to establish the extreme weather environment based on wind speed.

Human Reliability Analysis (HRA)

- HRA were performed by identifying areas were human interaction with the drilling vessel were required and then surveying oil and gas industry experts to gain insight into possible outcomes.
- In general, the Cognitive Reliability and Error Analysis Method was (CREAM) was applied to calculate HRA probabilities.

Conclusions

- Aggregating the results of the DPS PRA model indicates that the MODU losing location and initiating an emergency disconnect during DP operations would be less than 5% of the time. This assumes no shutdown or refurbishment between wells; however, routine maintenance was taken into consideration in the models.
- Looking into the risk of initiating an emergency disconnect as a function of the operating environment reveals that failures occurring in the normal weather environment are the largest contributors to the overall risk at over 90%, because as approximated by the analysis for the Gulf of Mexico, the vessel spends most of its operation time in the nominal environment.
- Human error is the dominant risk contributor to the overall risk. For this reason, it may be prudent to focus risk reduction efforts on improving human factors, vessel specific training, ergonomics, automation, or decision support tools or technology rather than improve hardware reliability.
- The importance of the generators and thrusters to the DPS cannot be overstated; however, from a risk perspective they are relatively low contributors at less than 10% of the overall risk. The reason for this low occurrence rate is due primarily to the ability of the vessel to operate in a degraded state during nominal operations, the respective levels of redundancy within the generator and thruster subsystems, the independence of the redundancy groups, and the fact that repairs are possible during nominal operations.

Thank you for your attention!