FPSO’s

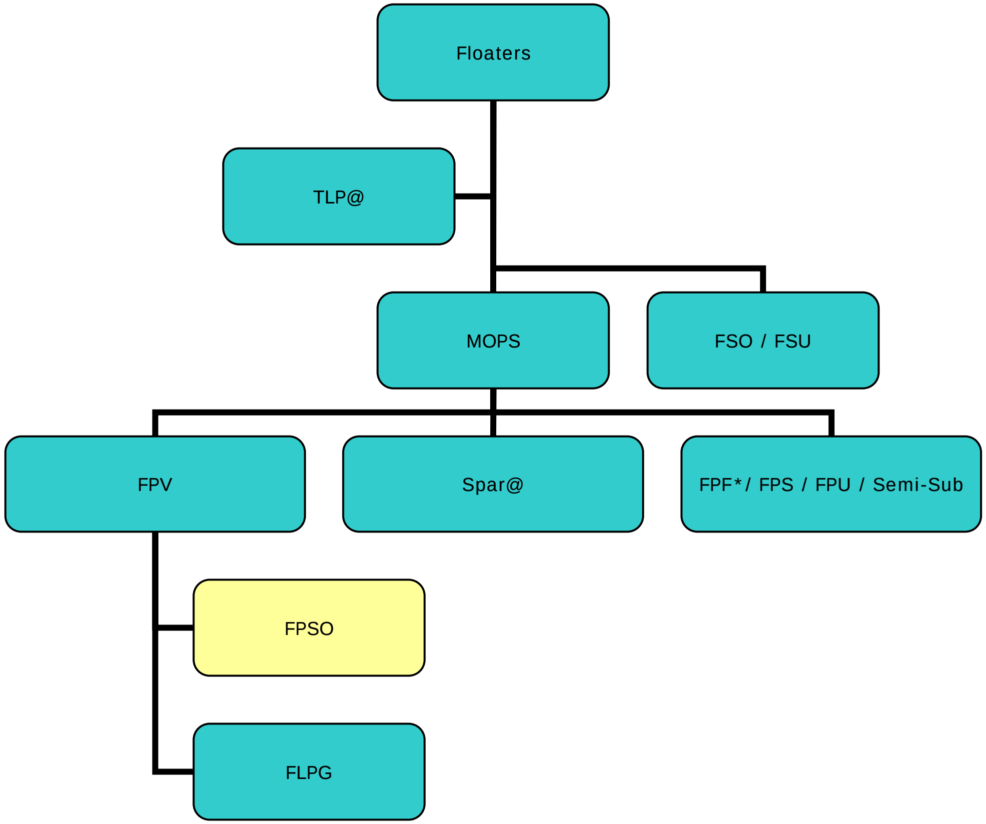
Floating Production Storage & Offloading

Francis Lobo – Zurich Global Energy

Outline

- Introduction
- Drivers
- Risk Concepts
- Risk & Design
- Risk & Operation
- Typical Hotspots
- Closing Comments

Introduction



F = Floating
F* = Facility
LPG = Liquefied Petroleum Gas (Propane, Butane)
MOPS = Mobile Offshore Production System
O = Offloading
P = Production
S = Storage
S* = System
TLP = Tension Leg Platform
U = Unit
V = Vessel

@ Surface Wellheads

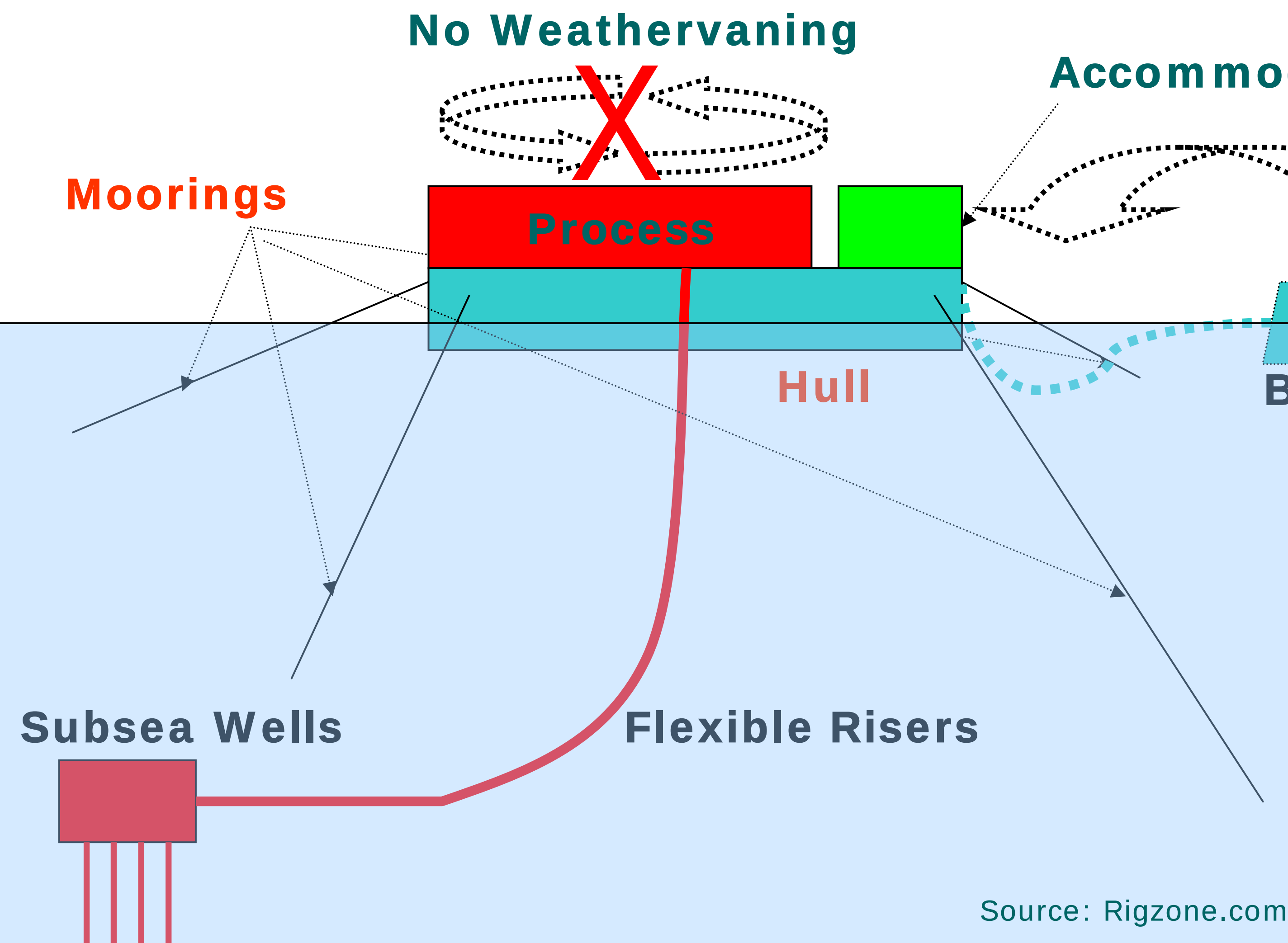
Main Categories

Types
- New Build
- Conversions

Environments
- Benign
- Hostile

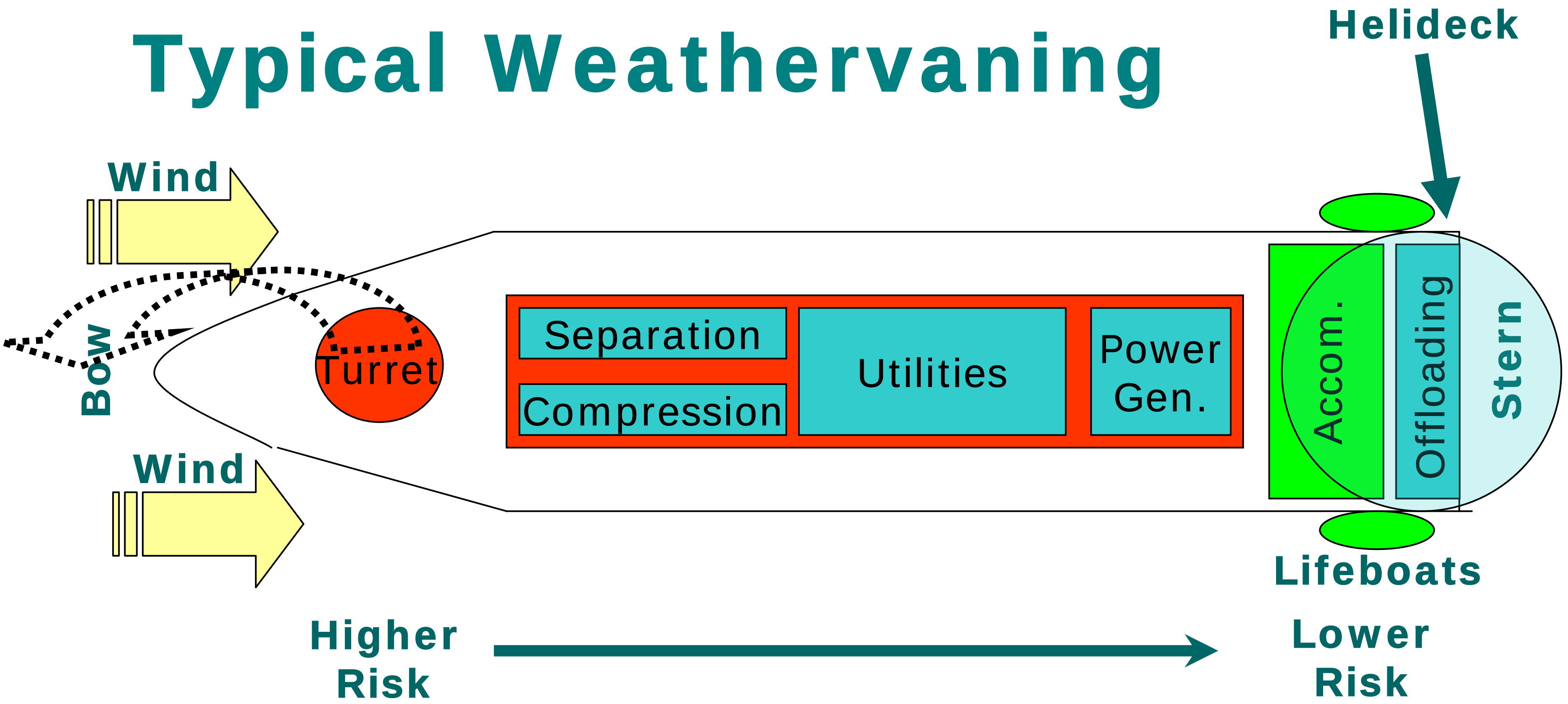
Operated
- Contractor
- Oil Company

Typical – Spread Moored



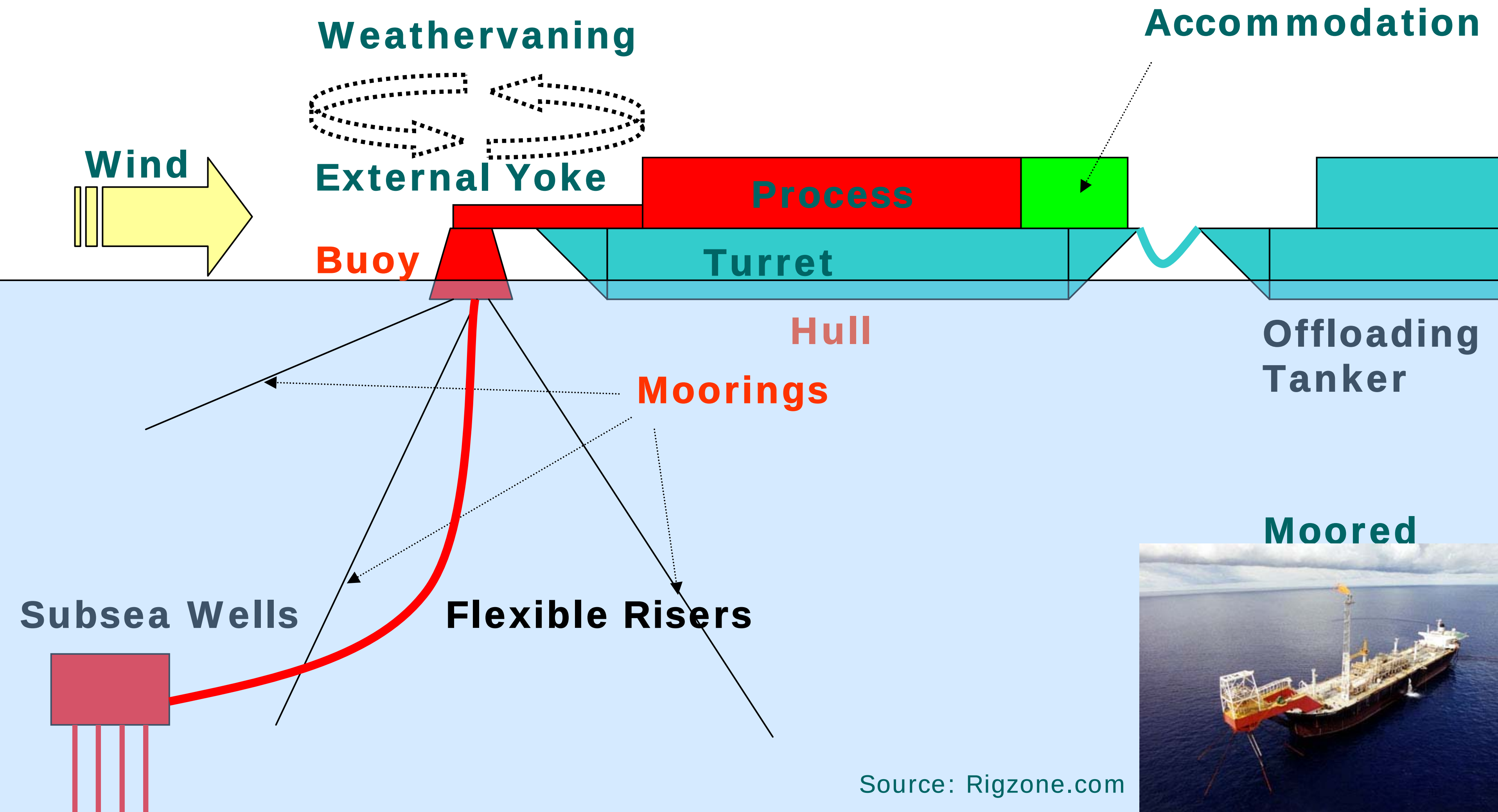
Source: Rigzone.com

Typical Weathervaning



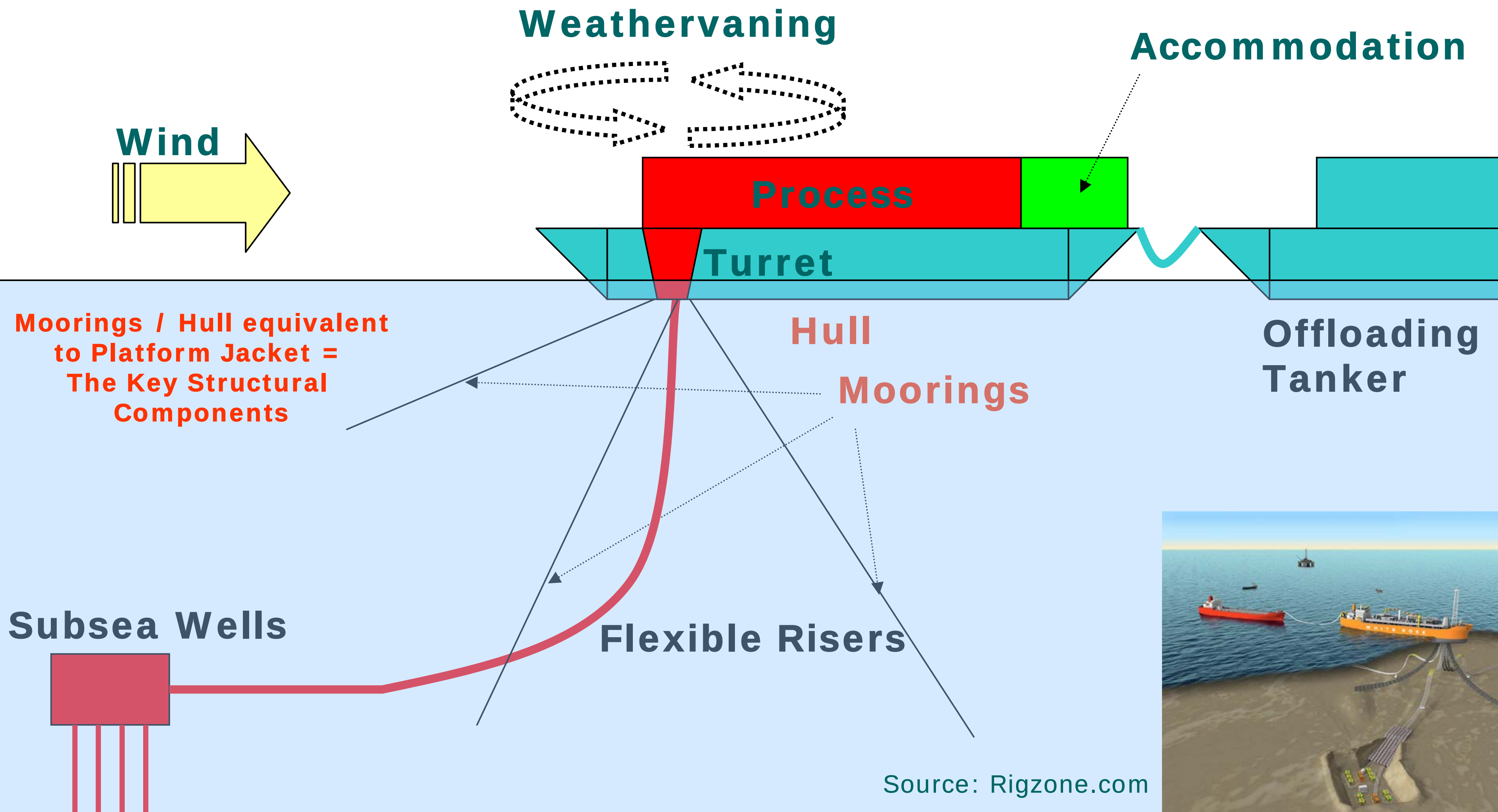
Weathervaning on a typical FPSO means that in case of loss of containment (or fire) the hazard is directed by wind and vessel trim to the safe area compromising personnel, control stations and escape means.

Typical – External Turret



Source: Rigzone.com

Typical - Internal Turret



Source: Rigzone.com

Key Variations

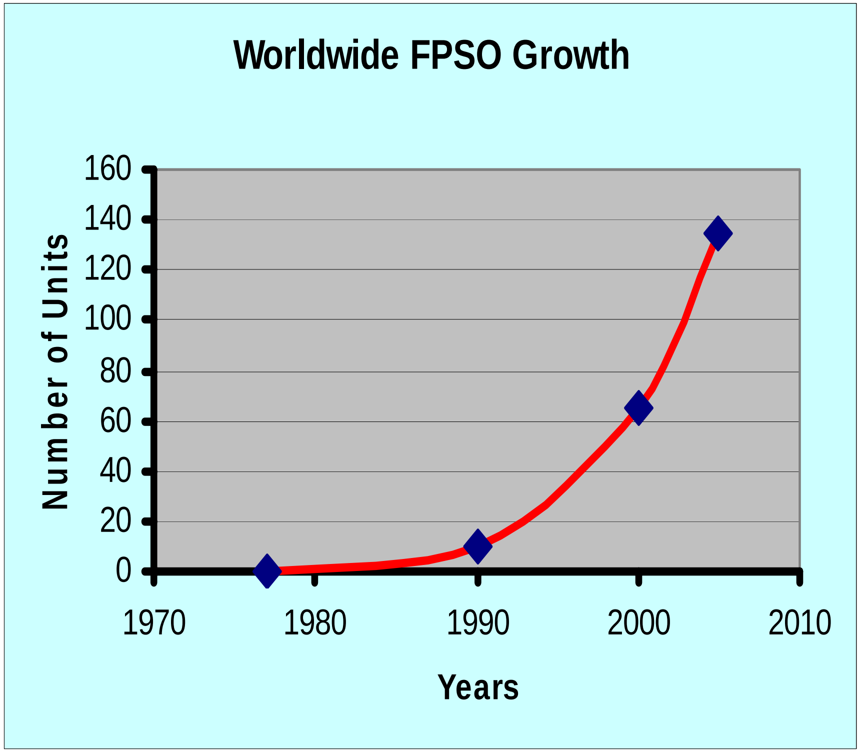
- Hull – Double side* / Single side / Double or Single bottom
- Station Keeping – DP
- Turrets – Forward* / Amidship - Permanent / Disconnectable*
- Accommodation – Forward / Aft*[1]
- Loading – Tandem / Using Buoy*

* Preferable Characteristics

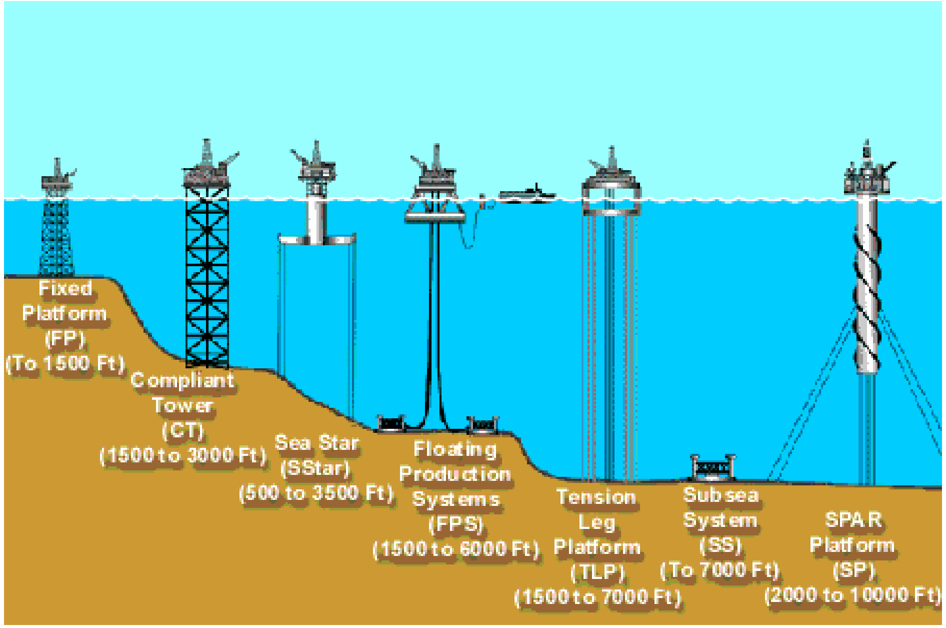
[1] With Side Thrusters

Brief History

- 1^{St} Ship Shape Production Vessel – Ardjuna field (Arco) in Indonesia in 1974
- 1^{st} FPSO – Castellon (Shell) in Mediterranean in 1977



Technology vs Depth



Source: MMS website

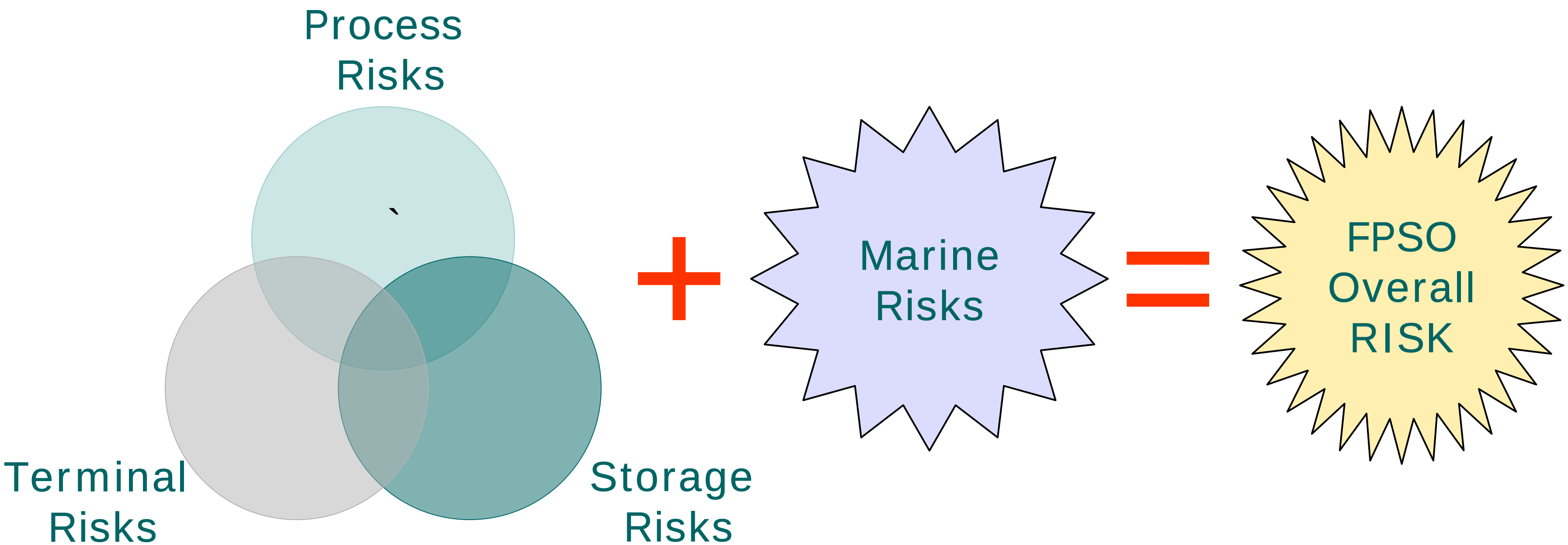
FPSO's can be used from shallow water to ultra deep water (using DP systems) – only limited by other technologies

FPSO's are used widely in offshore regions around the world

Drivers

- Low reservoir confidence – short term production – data gathering (EWT)- Marginal Fields
- Fewer appraisal wells – Early project commitment
- Reduces exposure to Political / War risks
- Project Economics – Early revenue (Fast track developments (converted FPSO)– low Capex / high Opex = high ROR)
- Deepwater Provinces
- Optimisation of PSC contract
- Lower abandonment costs
- Reusable asset - can be redeployed

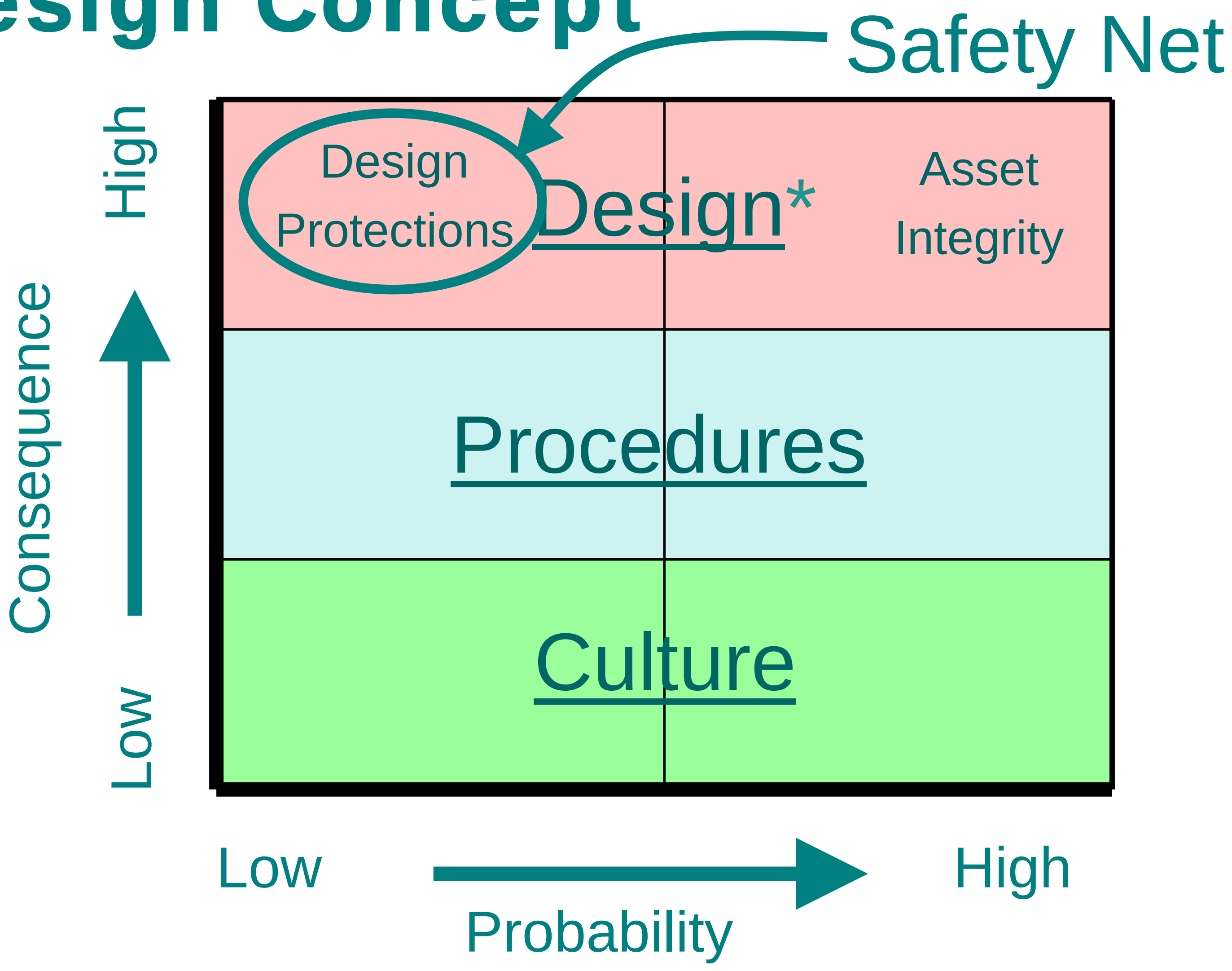
Risk Concepts



Major positive of FPSO's is that typically there is no significant well (subsurface) risk at the facility, the wells being remote (typically subsea).

Imperative that QRA (Quantified Risk Assessment) is performed and measures implemented to reduce overall risks to acceptable levels. Particular attention must be given to mooring integrity and flooding of machinery spaces.

Design Concept



* Includes Manufacture

Intrinsic Safety in Design

- Mooring / Station Keeping
- Pressure / Non pressure containing systems
- No gas / volatile liquids in any spaces below waterline
- Failsafe power/ ballast systems
- Prevailing Weather and FPSO orientation*
- Oil field systems / Marine systems
- Machinery Spaces - Flooding Risk (failure of large bore sea water pipework, valves and associated control systems)
- Using gravity flow for safe design is more difficult
- Include operational marine expertise in design stage

*Incorporating side thrusters provides significant benefits. It reduces risk of event escalation, improves the chance of safe evacuation and can be used to minimise risk of collision (with third party rogue vessels or with shuttle tanker due to better heading control)

FPSO Process Functions

- Oil / Gas / Water Separation
- Export product Stabilisation
- Gas Compression (Gas Lift / Gas Reinjection)
- Water processing and treatment
- Water Injection
- Oil / Gas Export

Fatigue

- Loading - Unidirectional, repetitive and consistent (due to stationary position / weathervaning) and frequent cargo loading / unloading cycles
- New Build typically better than Converted FPSO hulls
- Converted hulls usually require extensive upgrading to achieve strength and fatigue performance
- In-situ detection of developing problems is difficult and offshore repair is very inconvenient and costly
- FPSO's are often designed to remain on station for field life without dry-docking – However it is advisable to design for mooring and riser controlled disconnection as this could be required (due to collision or other events)

Risk & Design

New Builds

- Can optimise deck space / layouts
- Hull tailored for weather, production & offloading frequency - especially fatigue life
- Better for harsh environments
- Small or novel hull forms can give problems – crew fatigue and motion sensitive equipment Separators, gas turbines etc.

Converted Tankers

- 1970's mild steel hulls preferred (better fatigue performance than High Tensile Steels (HTS) – HTS is more flexible so topsides/piping design needs to accommodate movement - also welding requirements stricter than mild steel)
- Good motion performance due to conventional hull shape

Risk & Design

Harsh Environments

- Weathervane to minimise environmental load on mooring system
- Converted vessels can be problematic – Onerous wave climate imposes high hull loads which require extensive upgrading of existing hulls
- Vessels tend to be 90,000 – 105,000 DWT
- Green water / Bow wave impact
- Sloshing in Cargo and Ballast Tanks

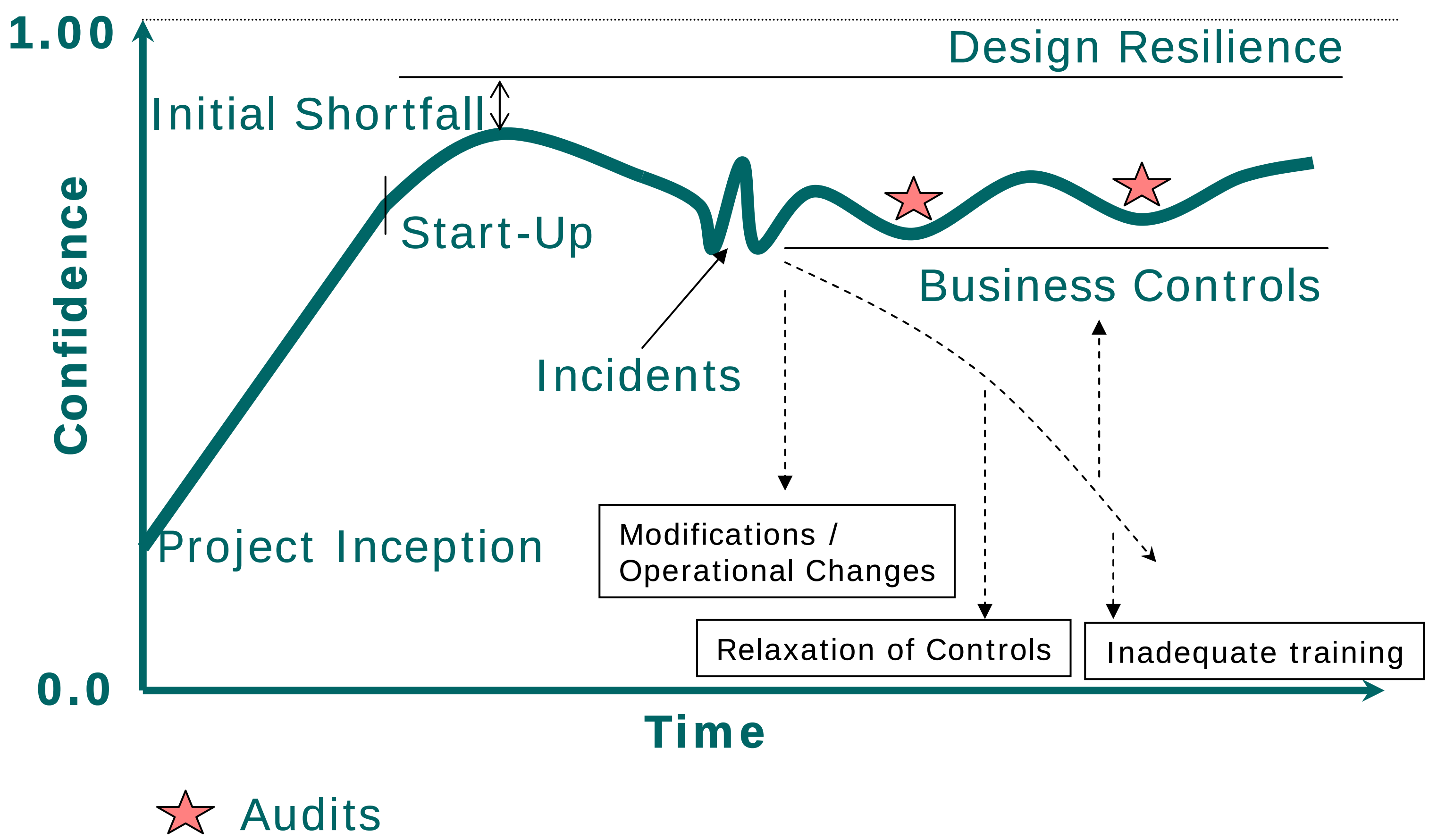
Risk & Operation

- Integrity Management plan should be developed when hull structure / systems and mooring systems are being designed

This should include for example:

- A reliable means of monitoring the integrity of each mooring line and anchor
- Safe means of access to all tanks and void areas for inspection and maintenance at sea
- Access to pumps and valves to facilitate changeout
- A sufficient number of tanks to enable production operations to continue uninterrupted while selected tanks are cleaned for inspection and maintenance
- Remote Detection and closure of safety critical shipside valves from a safe location

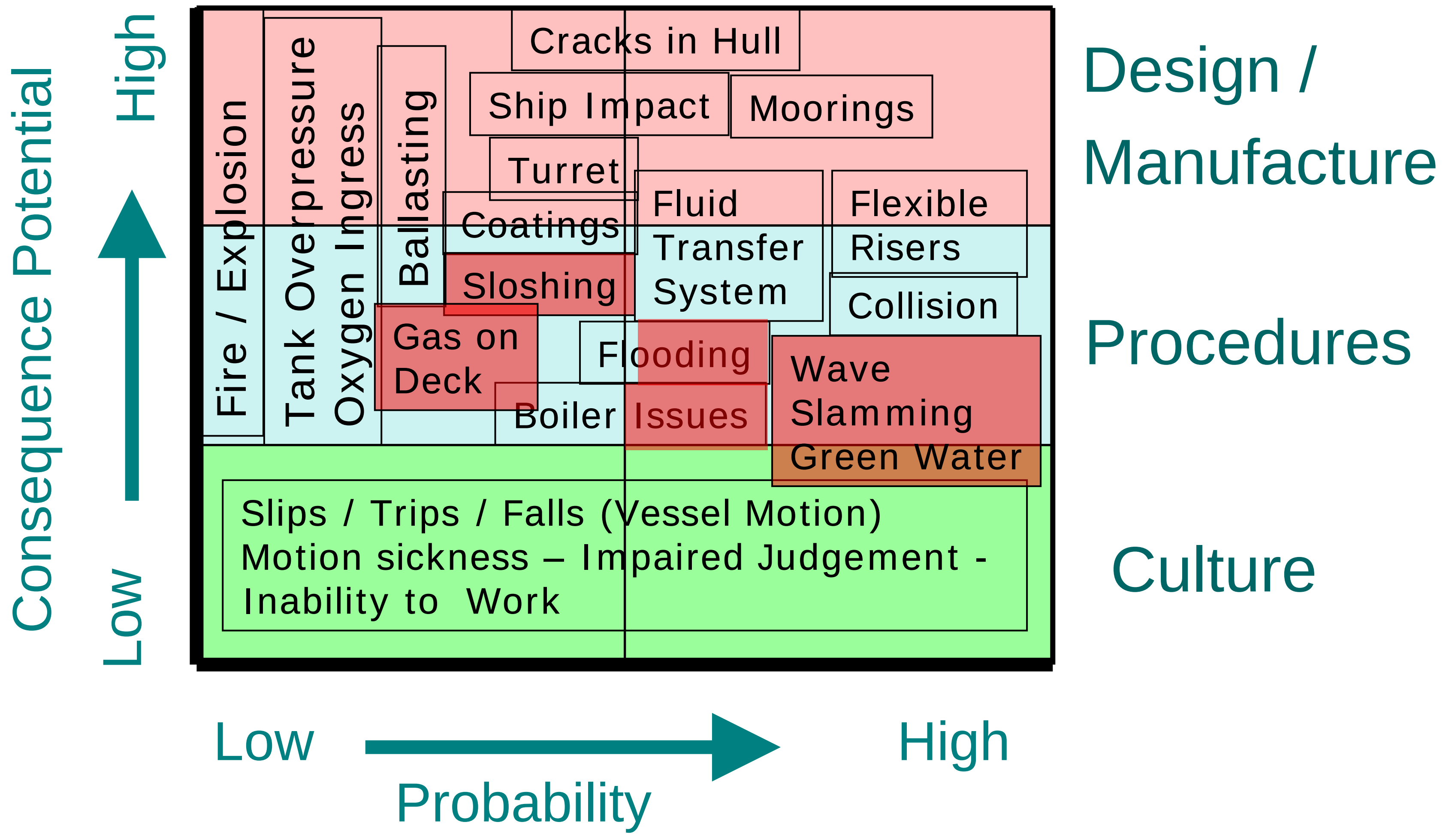
Lifecycle Profile



Risk & Operation

- Design basis – relaxation of assumptions / monitoring during operating phase
- Maritime competency: Process vs Marine. Marine often given lower profile with risk levels increasing insidiously – Crew training and experience is of paramount importance in FPSO ops.
- Over reliance on computer based systems
- Prescriptive marine approach vs rigorous risk assessed approach
- Use bilge alarms and CCTV to enable quick action if flooding detected
- HVAC systems

Typical Hotspots



Closing Comments

- FPSO's continue to grow as a class of business
- FPSO's typically designed appropriately for inherent hazards (meteorological and process)
- Good QRA during design is very important.
- Maintenance to design and design assumptions is very important (more focus on marine aspects required)
- Less room for error with Harsh Environment FPSO's – both in Design and Operation
- Floating Solutions continue to evolve –Concrete FPSO's (existing), FDPSO's, FLNG, FGSO's, etc.