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MULTI-PLATFORM INSPECTION MAINTENANCE & REPAIR IN EXTREME ENVIRONMENTS

Webinar – 15th of July 2021

Innovate UK

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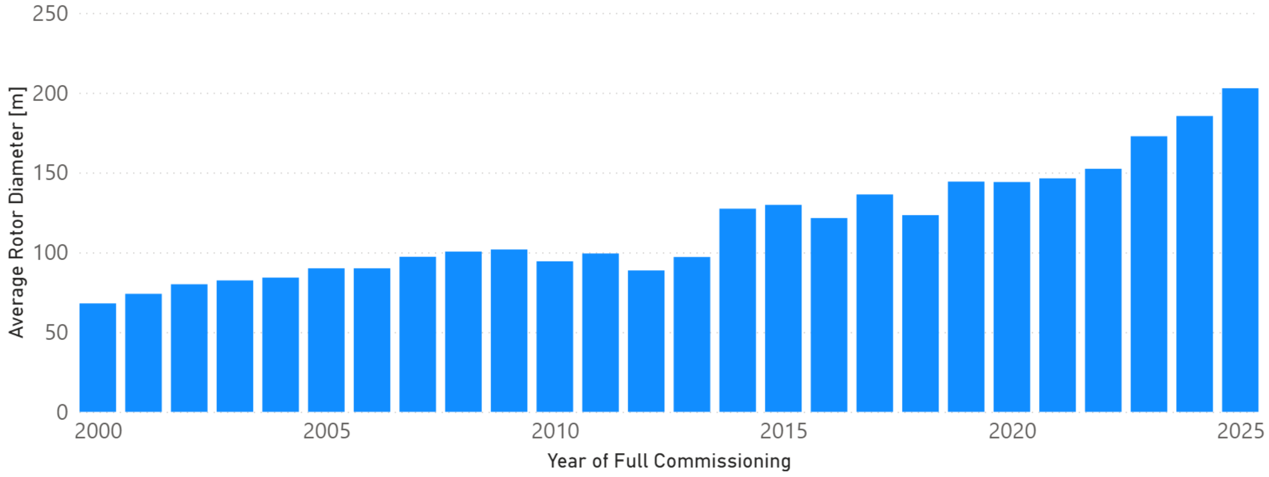
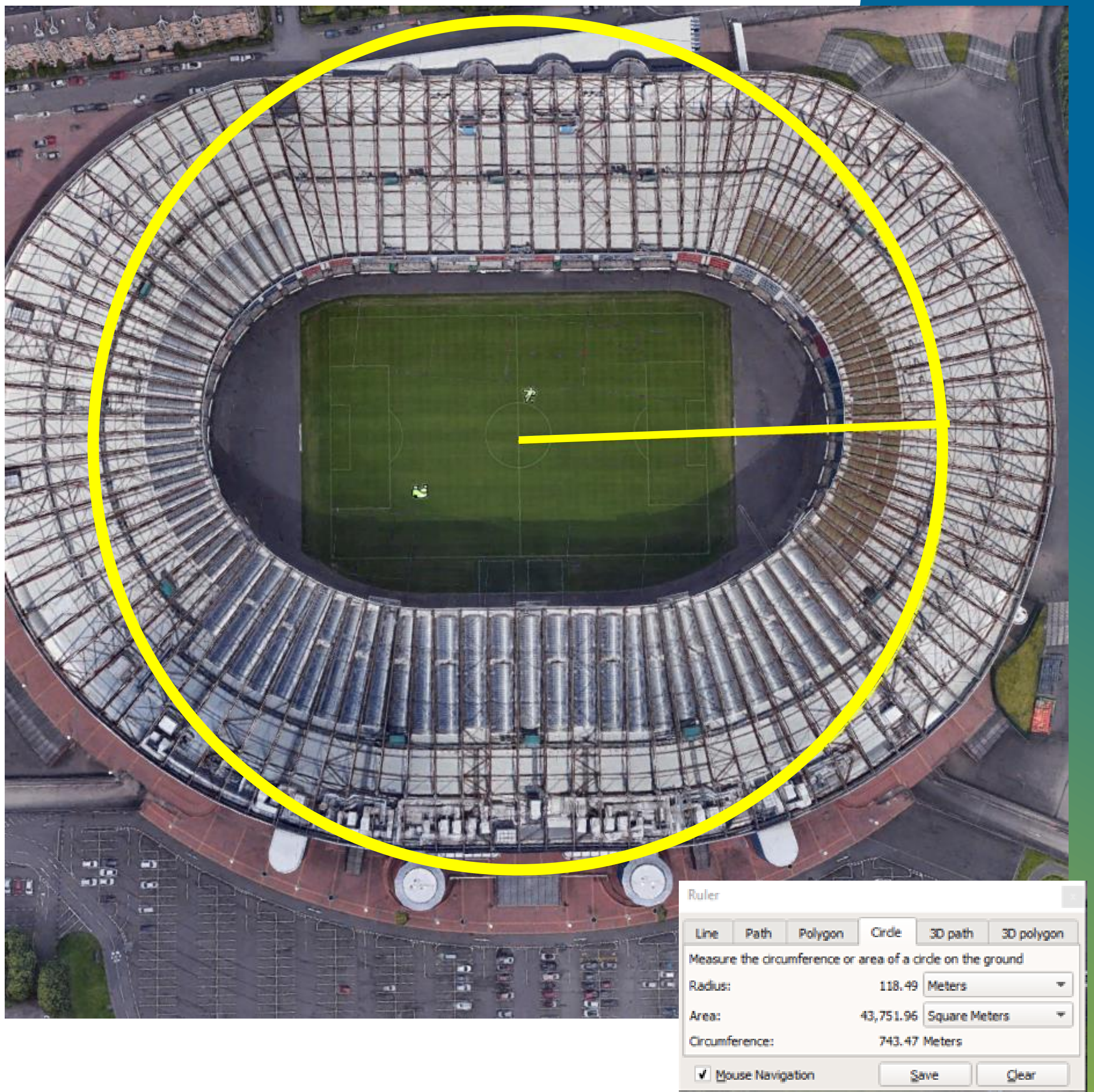
Scale of Offshore Wind – Turbines

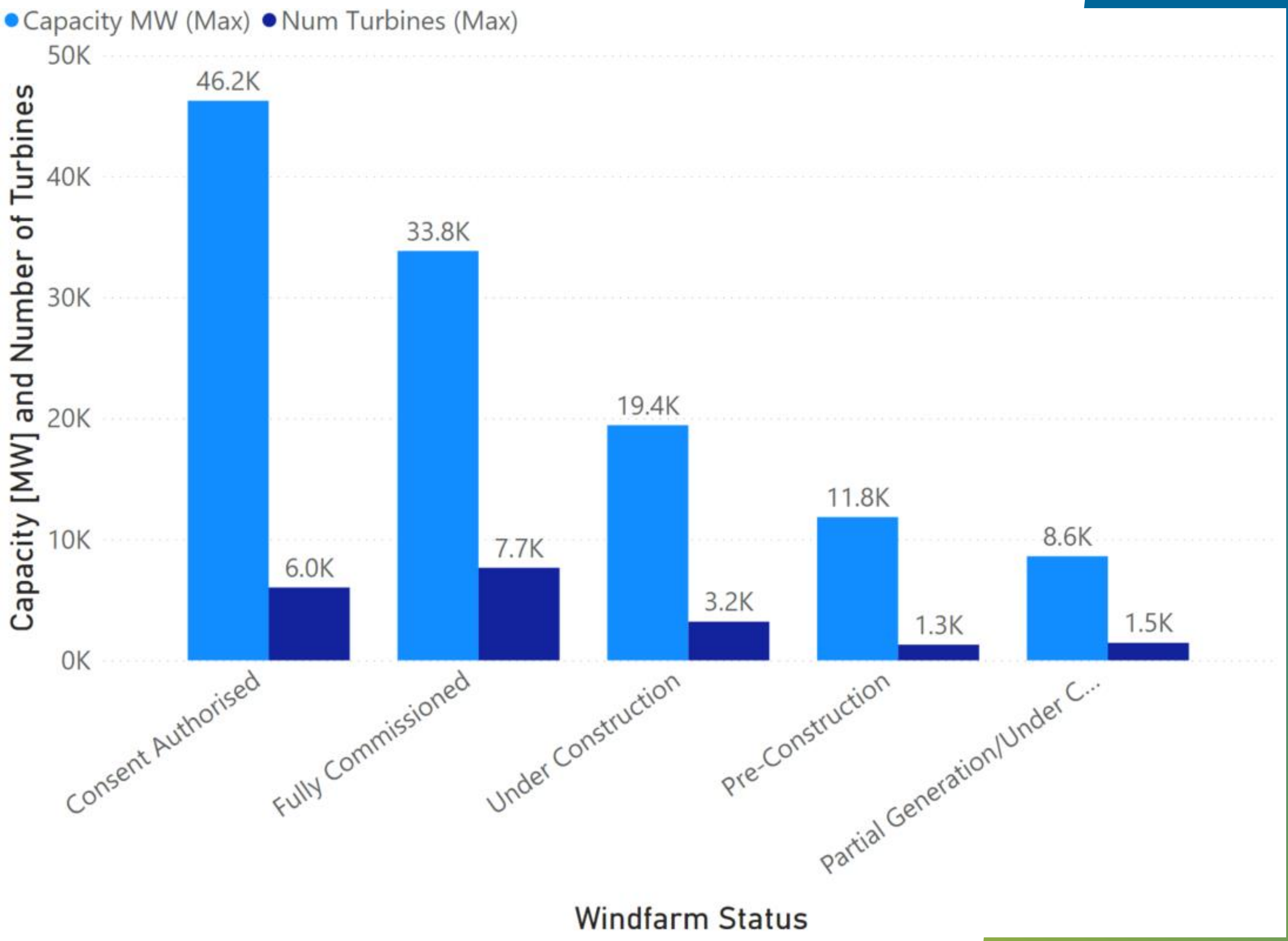


Turbine OEM	Vestas	Siemens Gamesa	GE
Rated Power [MW]	15 MW	14/15	12/13/14
Blade Length [m]	115	108	107
Swept Area [m²]	43,742	38,707	38,013



Scale of Offshore Wind – Windfarms

- Worldwide Installation Capacity
  - 20,000 offshore turbines
    - ~7700 'Fully Commissioned'
  - Compared to ~6000 offshore O&G platforms [2]
- ~60,000 blades
  - Collated Blade Surface Area
    - ~ 4200 football Pitches
- Locational trends
  - Further from shore
  - Harsher Environments
    - Weather windows



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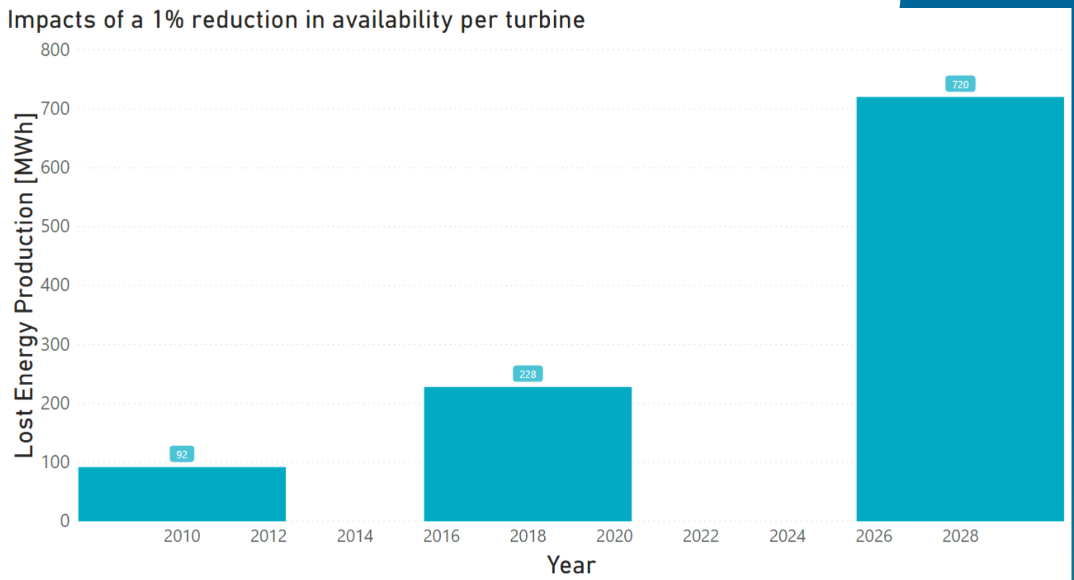
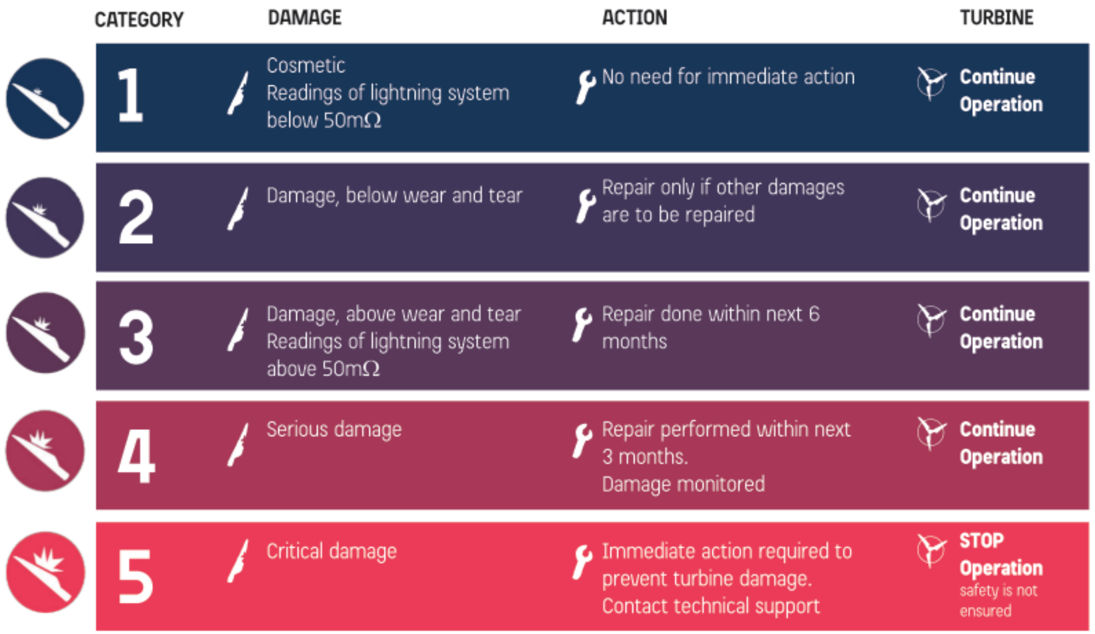
[1] 4C offshore, "Offshore Wind Farms Database," July 2021.
[2] Bull & Love, "Worldwide oil and gas platform decommissioning: A review of practices and reefing options", Ocean & Coastal Management, Volume 168, pp 274-306, 2019

Scale of O&M Challenge

- Initial Generation of Turbines
  - Increased age of assets.
  - “26 GW of projects to become older than 20 years over the next five years.” [Wind Europe 2021]
- Next Generation of Turbines
  - Downtime more significant
- O&M Implications
  - Status quo not sustainable for LCOE
    - Crucial role of condition monitoring / structural health monitoring
    - Appropriately timed intervention
      - Cost of doing repair vs. influence on performance





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Wind Turbine Blade Drone Inspection

- Increased uptake over the past 10 years
  - Transition from onshore windfarms
  - Initially manual (piloted) inspection
- Stated advantages
  - Operational wind speeds (up to 15 m/s)
    - Still restricted by transit vessel
  - Quicker inspections
    - Several turbines in a day vs. 1-2 turbines per day rope access
  - Reduced H&S risk
    - Inspection possible from vessel (CTV/SOV)
  - Inspection data format and metadata
- Implementation of autonomy
  - Blade pitch and rotor “inching” not required
    - Faster inspections

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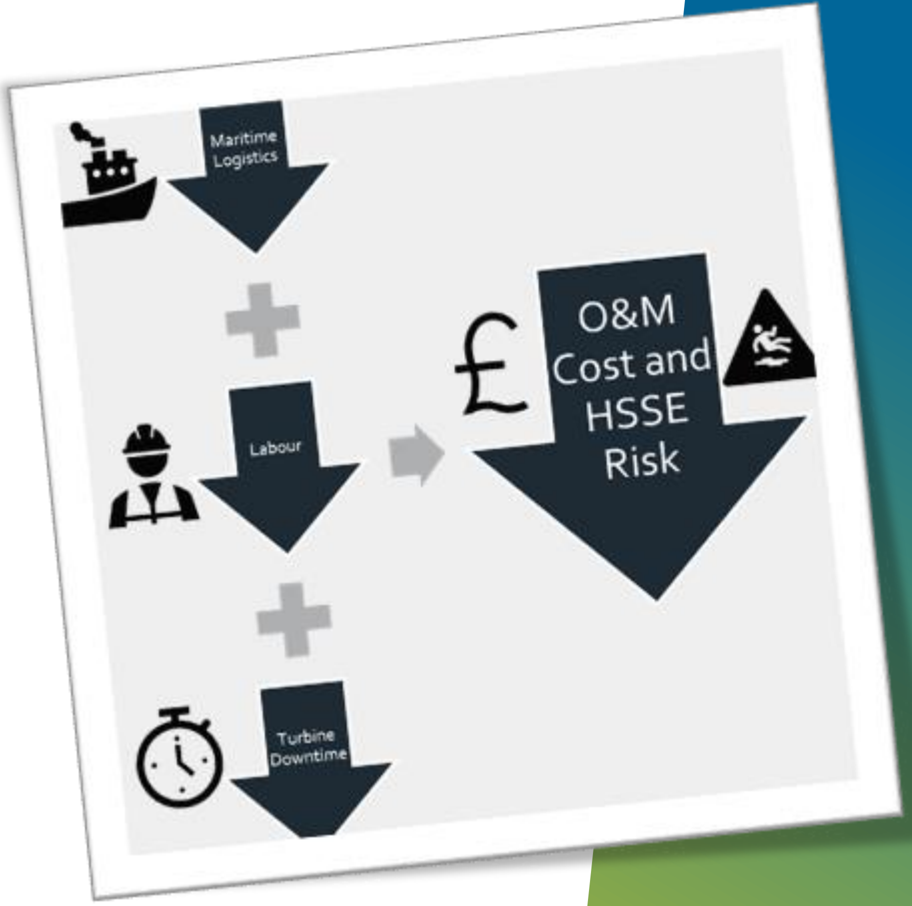
Limitations and Ambitions of Conventional Wind Turbine Blade IMR

- Still requires attendance of two drone technician(s) to attend site.
  - Manned vessel limitations
  - Exposure to harsh environment

- Maintenance and repair capabilities
  - Rope access can perform light repairs during inspection
  - Other maintenance tasks associated with blades

- Fully-integrated, unmanned Inspection, Maintenance and Repair (IMR) of wind turbine blades
  - Eventual ambition
  - Important to examine possibilities at this stage



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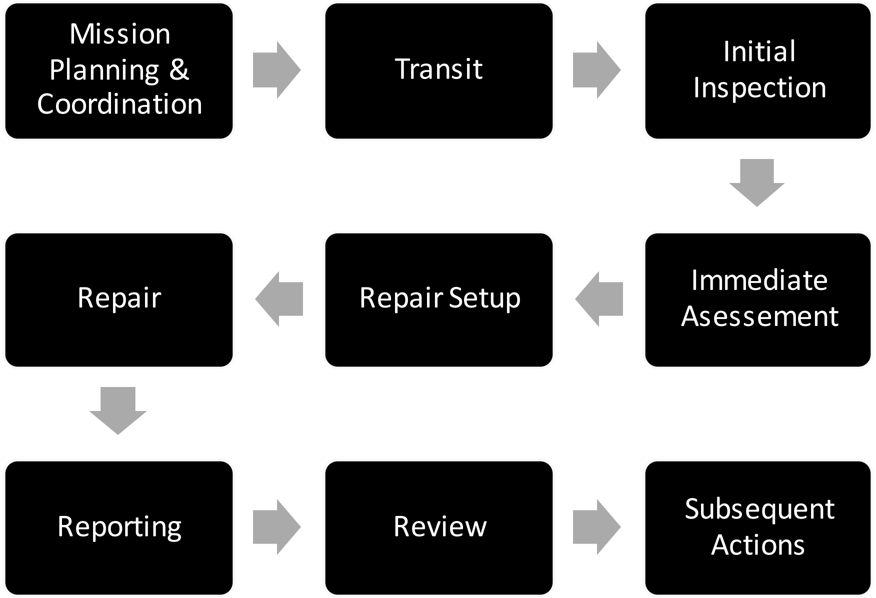
MIMRee System and Subsystems

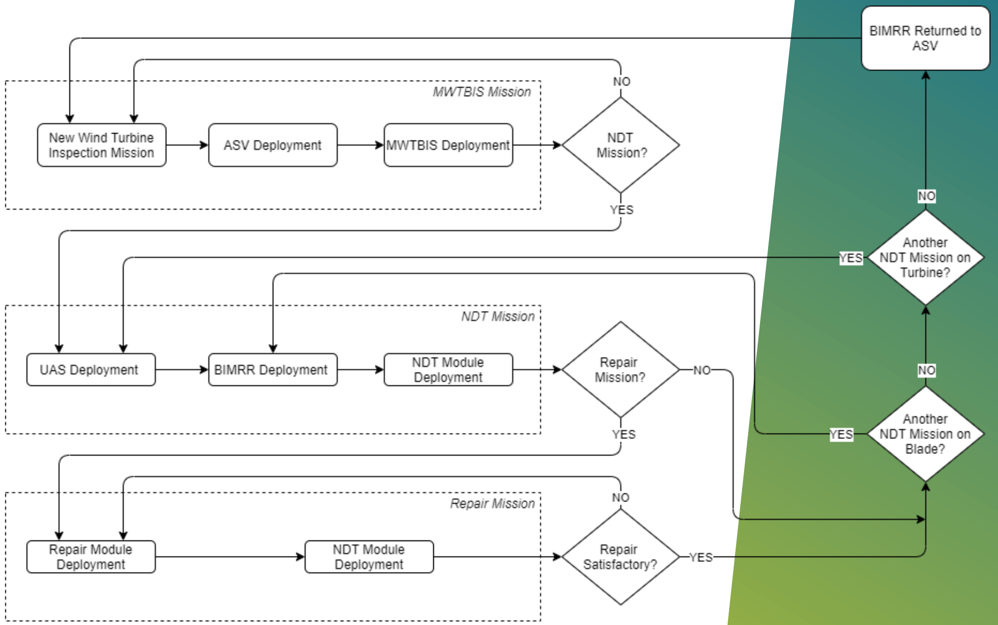
Mission Planning and Optimisation

- **Autonomous Surface Vessel**
  - Maritime Operations
  - Moving Wind Turbine Inspection System (MWTBIS)
- **Unmanned Air System**
  - Flight Operations
  - IMR robot deployment and retrieval
- **Inspection Maintenance and Repair Robot**
  - NDT Inspection
  - Repair Module
  - Blade surface characterisation

MIMRee Project

- Large consortium utilising academic and cross-sector expertise
- Scrutinise building blocks of full scenario
  - Barriers to full integration
  - Commercial considerations –full process
- Ambitious 2-year development programme
  - Concepts to prototypes
  - Prioritise innovative aspects of storyboard





Autonomy Considerations

- Trust/Confidence across a range of stakeholders
  - Verification and Validation essential
- Fully autonomous operations unlikely
  - Human-in-the-loop essential
  - Manual override a necessity
- Tuned autonomy in certain scenarios
  - Transit out to turbine – highly automated
  - Mission tasks – approval requests
- Cybersecurity
  - Integration with turbine
- Multiple vehicle coordination
- Integration with global O&M planning
  - Overhaul of existing philosophy

PACT Level	Description
5b	System does everything autonomously
5a	System chooses action, performs it and informs operator
4b	System chooses action and performs it unless operator disapproves
4a	System chooses action and performs it only if operator approves
3	System suggests options to operator and proposes one of them
2	System suggests options to operator
1	Operator asks system to suggest options
0	Operator controls system

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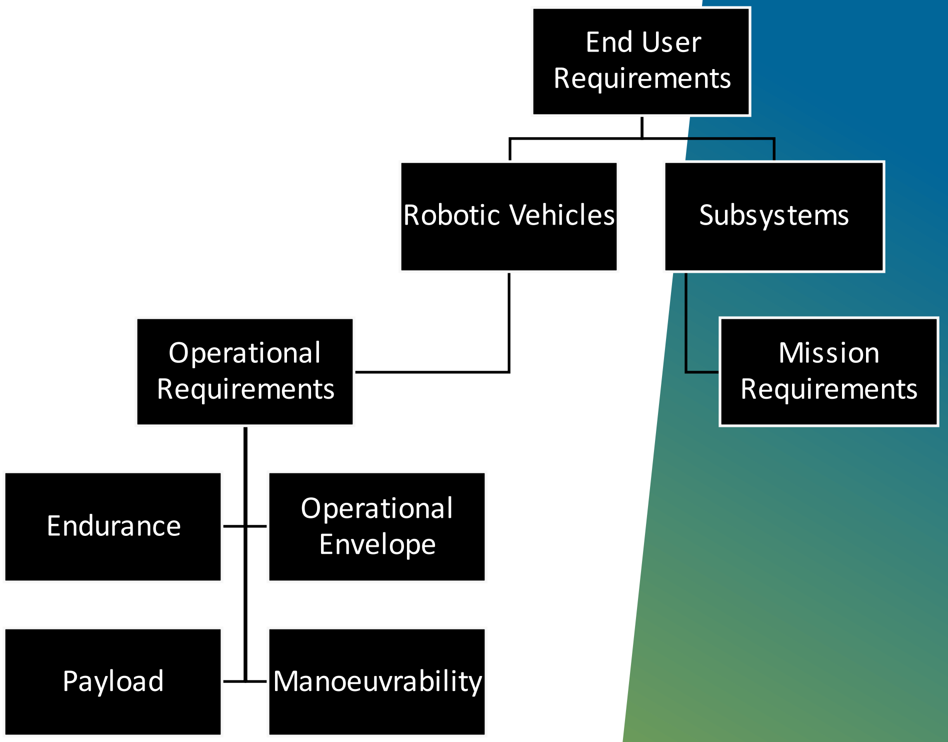
MIMRee Project Outcomes

- Full MIMRee scenario still a future prospect
  - Successful modular demonstrations proving the feasibility of unmanned operations and multi-vehicle coordination by a global mission planner.
  - Subsystems outside of full MIMRee scenario separately exploitable
- Identification of barriers to integration and realisation of full concept
  - Technical
  - Practical – regulatory, commercial, societal…
  - Cost competitive with existing methodologies
- Refinement of MIMRee scenario
  - Technologies at different TRLs and states of advancement
  - End user requirements
  - Roadmap of development/exploitation



To find out more information and discuss some possible applications don’t hesitate to contact us.

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