Simulation & Testing for Physical Autonomous Systems

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Drone Pathfinder Academic Workshop
Connected Places Catapult
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ORCA HUB
Offshore Robotics for Certification of Assets
Remote Safety and Integrity

Overview

- The ORCA Hub
- (Flight) Simulation in Offshore Hazardous Environments
- Rational Agents in Unmanned Aviation
- Combining Ideas and Toolsets
- Using Unmanned (Aerial) Vehicles for Offshore Inspection
- Concluding Remarks

About the ORCA HUB (1/2)

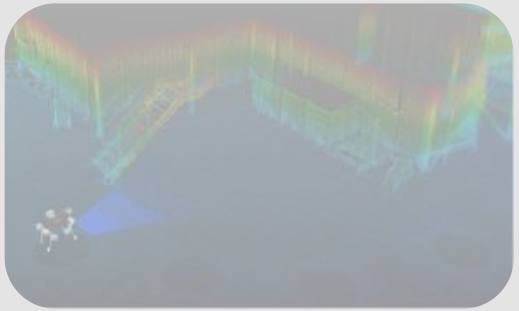
https://orcahub.org/

- Launched in October 2017 with 3 other hubs as part of HMG's £93m R&D funding for 'Robotics and AI (RAI) for Extreme Environments'
- Research programme to develop RAI for the offshore sector
- Supports a long-term offshore industry vision for autonomous & semi-autonomous offshore energy fields; operated, inspected and maintained from shore
- Aim is to translate research and discovery science into commercial products and services to support the UK offshore supply chain

About the ORCA HUB (2/2)

The 4 Themes

Mapping, Surveying and Inspection



Planning, Control and Manipulation

Intelligent Human-Robot Interaction/XAI

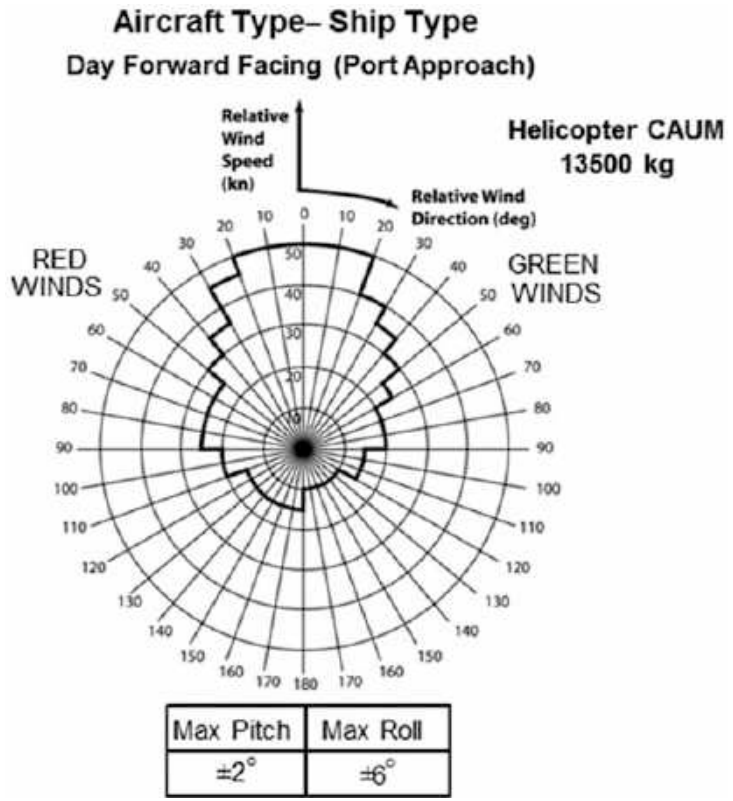
Robot and Asset Self-Certification

(Flight) Simulation in Hazardous Offshore Environments

Helicopter-Ship Dynamic Interface (1/2)

- The 'invisible enemy'
- Qualifying helicopters to safely operate from ships is expensive, time-consuming and dangerous → to establish a Ship-Helicopter Operating Limit (SHOL)

https://youtu.be/I_JEGX9IEgI



(Flight) Simulation in Hazardous Offshore Environments

Helicopter-Ship Dynamic Interface (2/2)

- A requirement therefore exists to try to use simulation and virtual tools to reduce costs and elapsed time to generate a SHOL
- Technique developed at University of Liverpool

https://youtu.be/AtWztq37tiI https://youtu.be/2kjifemgcg0 https://youtu.be/yOyQR3Uponw

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Rational Agents in Unmanned Aviation

When Engineering Met Computer Science (1/3)

- Basic principle (CAP722):

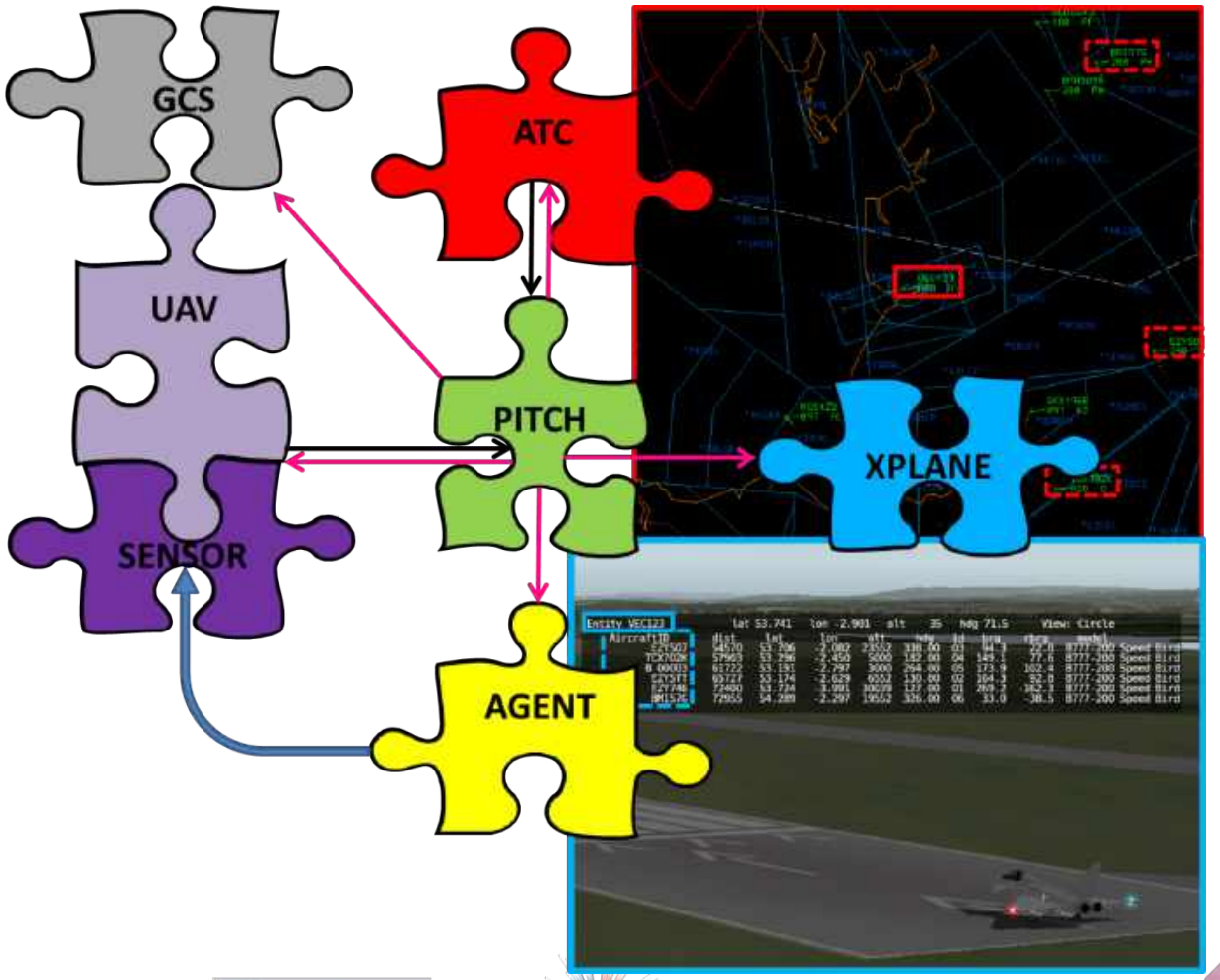
> "…*UAS operating in the UK must meet at least the same safety and operational standards as manned aircraft.*"

- By removing the pilot, the aircraft is deprived of a powerful sensor, processor and decision-maker.
- Technical compliance vs Performance Based?
- Regulations written with the pilot as the 'last line of defence for safety' in mind
- Replace with a 'rational agent'?
- So how to demonstrate safe rational agent performance to complete vehicle missions safely?

Rational Agents in Unmanned Aviation

When Engineering Met Computer Science 2/3

- Build a networked simulation



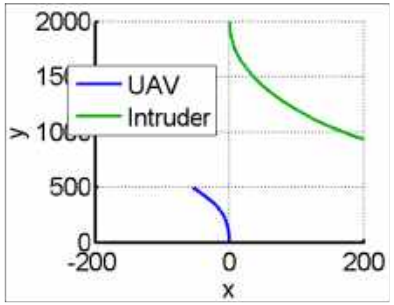
Rational Agents in Unmanned Aviation

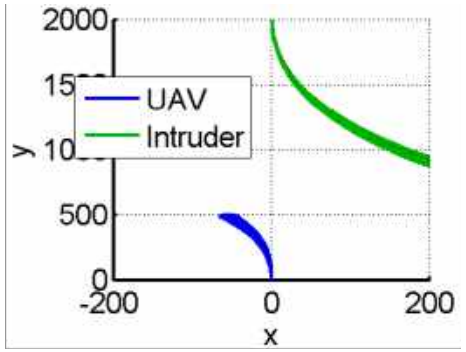
When Engineering Met Computer Science 3/3

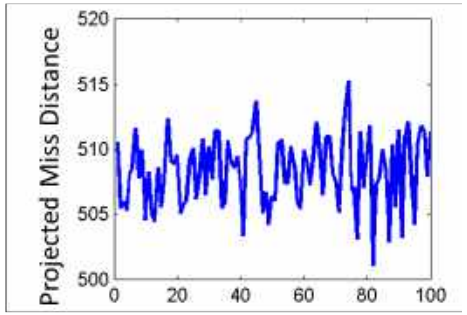
Real-time https://youtu.be/M8AjQjm0nsY

Faster than real-time

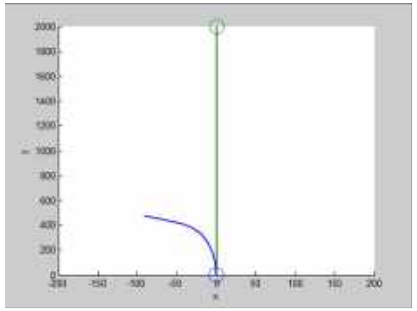
Cooperative

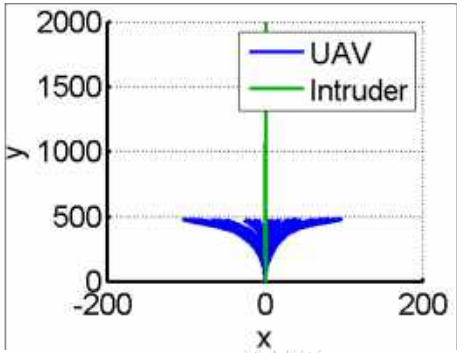


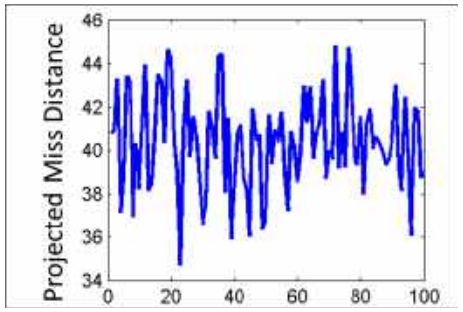




Uncooperative







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Using Autonomous (Aerial) Robots for Offshore Inspection?

Combining the ideas and toolsets

- Could just build and fly but…

https://youtu.be/jyiVgGS1DFo

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Using Autonomous (Aerial) Robots for Offshore Inspection?

Combining the ideas and toolsets

- Could just build and fly but…

Aircraft Mass	Airworthiness Approval	Registration	Operational Authorisation	Pilot Qualification
20 kg or less	No	No (Note 1)	Yes (Note 2)	Yes (Notes 2, 3 & 4)
Over 20 kg	Yes (Note 5)	Yes (Note 5)	Yes - Exemption	Yes (Note 4)
Any Mass – High risk category	EASA approval; or, CAA approval in certain cases (e.g. Annex I aircraft)	Yes	Yes	Yes (Note 4)

"the traditional manned aviation approach"

Using Autonomous (Aerial) Robots for Offshore Inspection

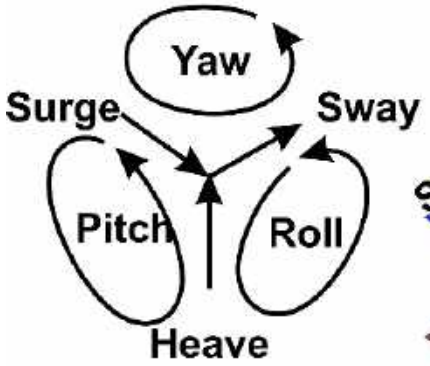
Combining the ideas and toolsets

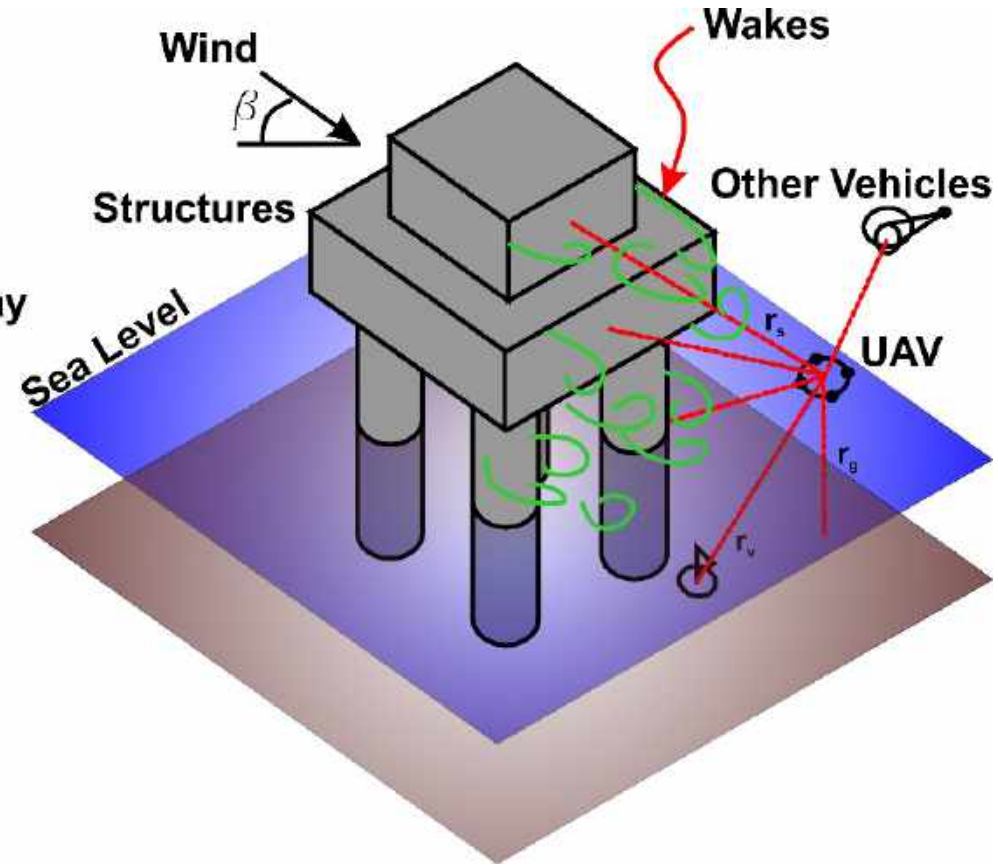
- As part of the ORCA Hub activity, we are building a virtual environment that combines these two ideas
  - test environment plus unsteady environmental conditions
- This is to be used as a proof-of-concept to:
  - Demonstrate agents make safe decisions under ‘stress’
  - Establish likely vehicle performance limits
  - Mission rehearsal/training
- Progress…

Using Autonomous (Aerial) Robots for Offshore Inspection

Scenario

- Inspection mission around offshore asset using an unmanned aerial system
- Challenge – operate safely in an unsteady wake that cannot be ‘seen’





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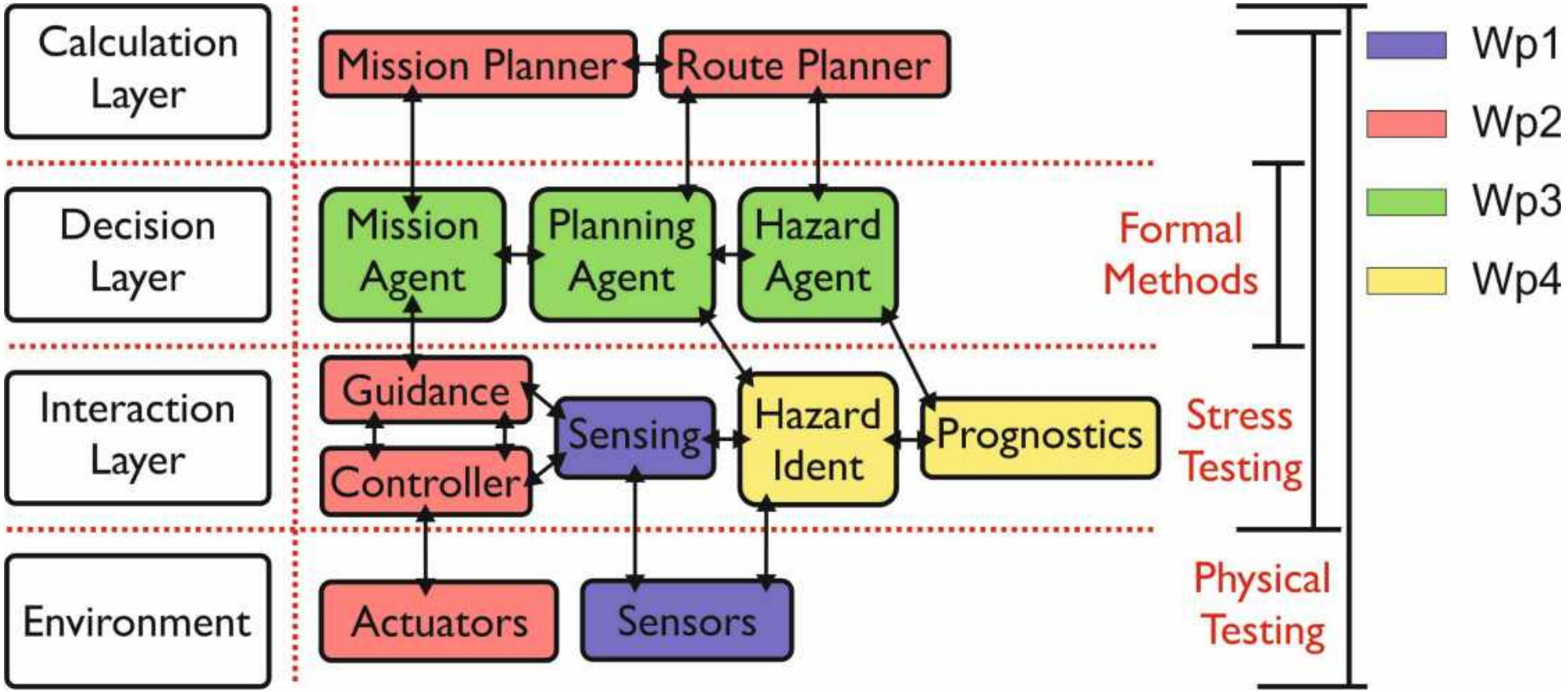
Using Autonomous (Aerial) Robots for Offshore Inspection

Architecture



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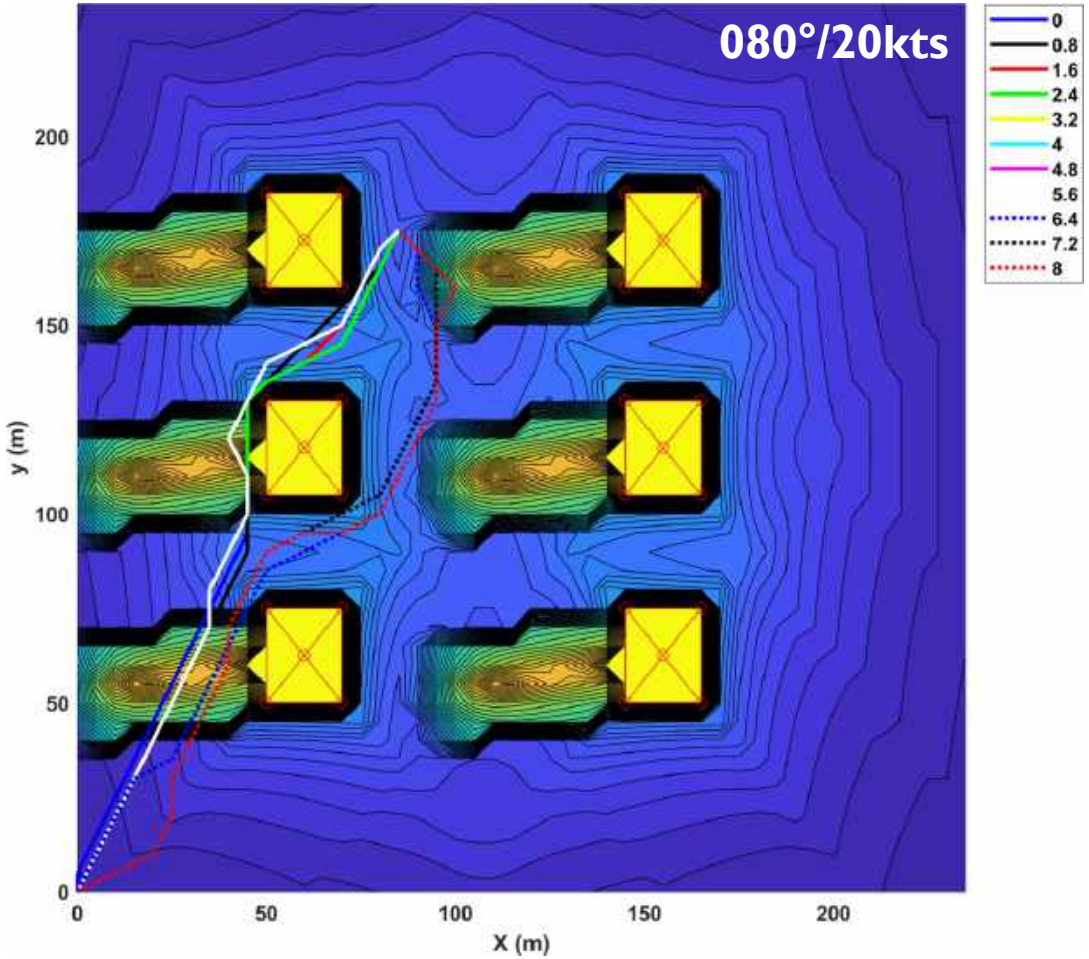
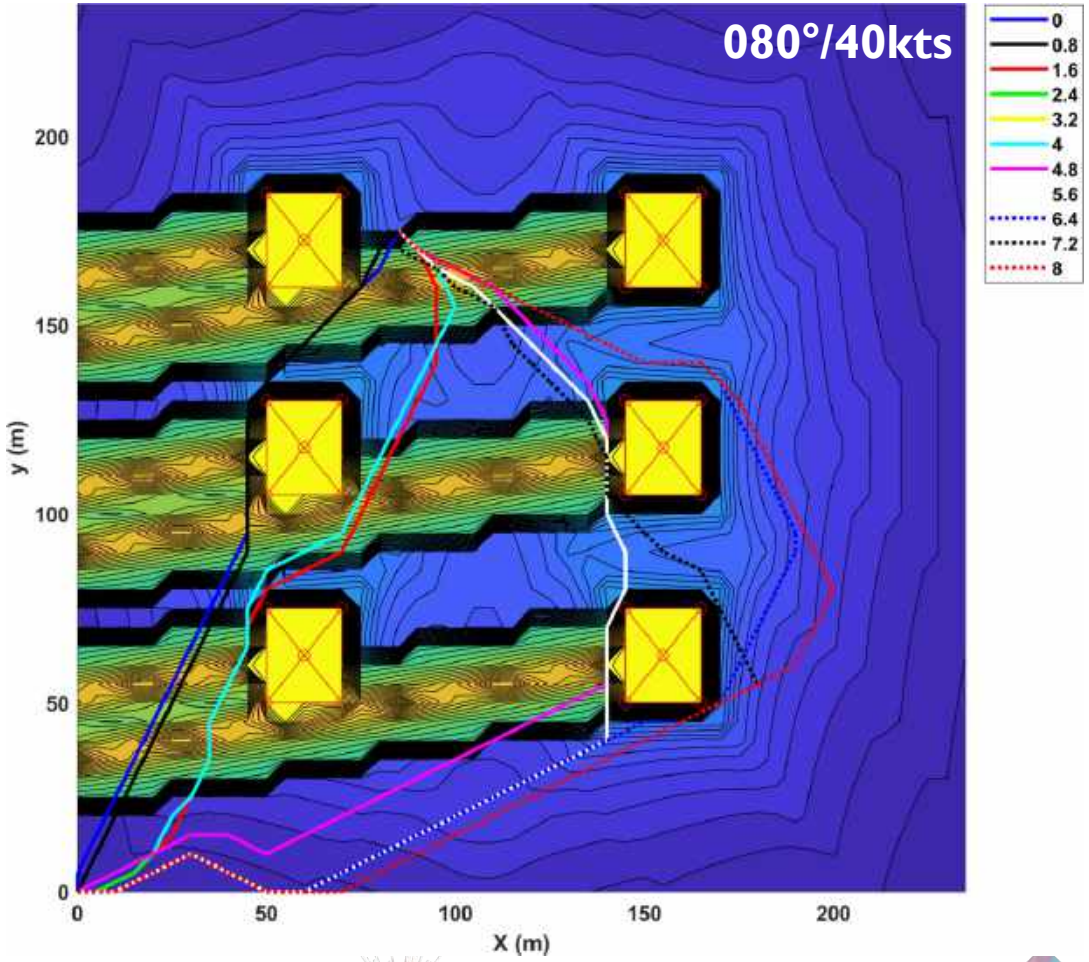
Using Autonomous (Aerial) Robots for Offshore Inspection

Virtual Environment Outputs





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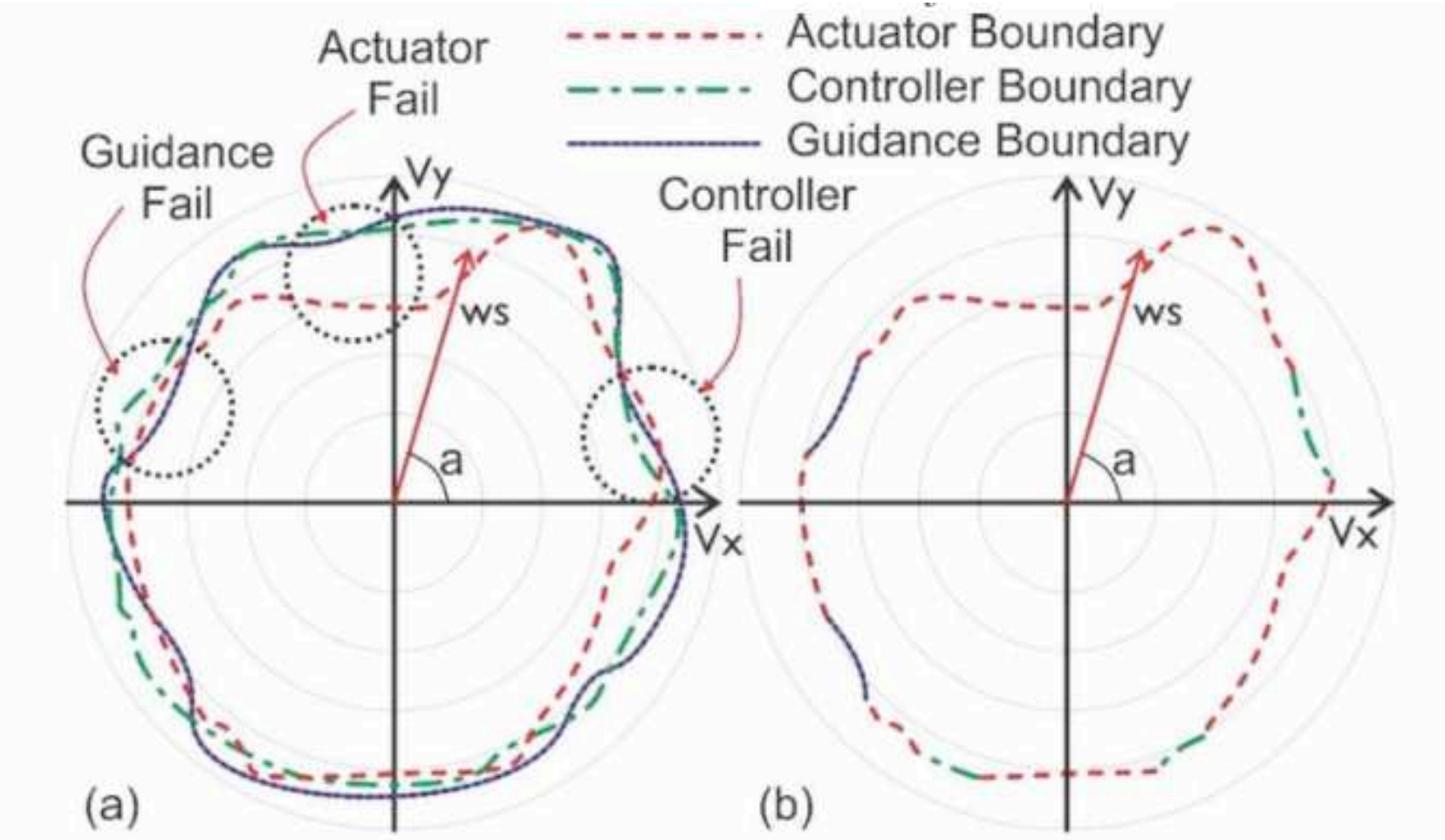
Using Autonomous (Aerial) Robots for Offshore Inspection

Virtual Environment Outputs

https://youtu.be/gkoRYSPAUnY

Using Autonomous (Aerial) Robots for Offshore Inspection

Offline Use



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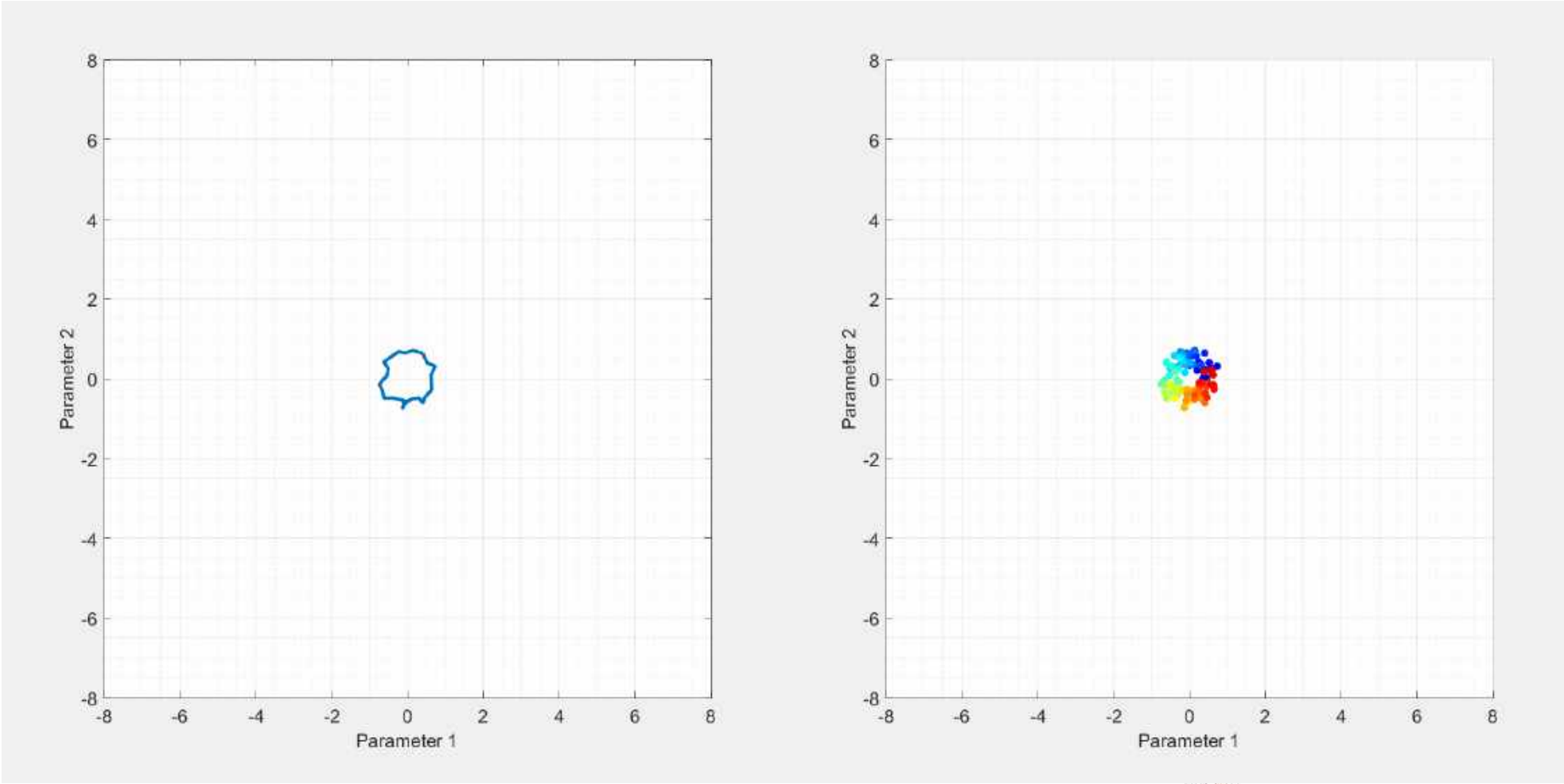
Offline Use



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Concluding Remarks

- All models are wrong, some are useful
- More complex unmanned air system operations will need to be certified as airworthy via "traditional" aerospace techniques
- Simulation and virtual engineering are key current techniques
- ORCA Hub is building a prototype virtual test environment for unmanned air system missions in offshore environments
- This technique is a suggested means to provide (some) evidence that will provide confidence in a mission systems capabilities prior to real flight testing

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Further Reading

- Page, V., Webster, M. P., Fisher, M., & Jump, M. (2019). Towards a Methodology to Test UAVs in Hazardous Environments. In ICAS 2019, The Fifteenth International Conference on Autonomic and Autonomous Systems
- Webster, M., Cameron, N., Fisher, M., & Jump, M. (2014). Generating Certification Evidence for Autonomous Unmanned Aircraft Using Model Checking and Simulation. JOURNAL OF AEROSPACE INFORMATION SYSTEMS, 11(5), 258-278. doi:10.2514/1.I010096

Thank you for listening.
Any Questions?