A Motion-Compensated Robotic Arm For Use On Manned or Autonomous Vessels

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Motion-compensated Robotic Arm (1)

- **Submarine Technology Limited** (STL) is an engineering research and one-off project engineering organisation

- At present, the development of ship-based robotics is the main activity

- Articulated robotic arms have been developed to allow intervention from a vessel to fixed or floating targets offshore

- Payloads carried by the arms (whether a tool, cargo, or personnel) is stabilised in one of two ways:
    1. “Space-stabilisation
    2. “Synchronous-stabilisation”

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SPACE-STABILISATION

- The motion of a floating vessel has six degrees of freedom:

  - 3 rotations: roll, pitch, yaw

  - 3 translations: heave, surge, sway

- With **space-stabilisation**, all of these are removed, so there is no residual motion relative to a frame of reference fixed to the seabed
- A payload can be moved in this stabilised mode from one point to another
- If moved to a stationary target such as an offshore platform or wind turbine, there will be no relative movement between them on arrival

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SYNCHRONOUS STABILISATION

- While space-stabilisation enables engagement with a stationary structure, **synchronous stabilisation** enables engagement with a moving target such as a floating device
- The floating device has its own motion in six degrees of freedom
- To engage, the payload must synchronise its motion with that of the target, so that there is no relative motion between them
- Of course, it is not possible to achieve perfect stabilisation in either mode, but it is possible to approach it closely enough to perform useful tasks

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HOW IS STABILISATION ACHIEVED?

- Five things are needed:

1. **An articulated mechanical device** whose geometry can be changed so that the payload can be placed at any point within a desired 3-dimensional operating envelope
2. **Actuators** to move device components to the needed positions so that the necessary device geometry is achieved
3. **Sensors**, to measure the motion of the host vessel and target and to define the position of device components
4. A real-time **control system** that receives information from sensors, processes it, and outputs instructions to the actuators
5. **A power source**, usually hydraulic or electrical

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ESSENTIALS

- Device **lightness and stiffness** to allow rapid positioning with minimal dynamic deflections
- **Actuators** capable of precise positioning
- Accurate and robust **sensors**
- A fast real-time **control system** that can achieve the required accuracy and dynamic response without instability. This is the heart of the technology and involves both hardware and software
- The **power source**, while conventional, should be light in weight

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APPLICATION 1 is:

- **Personnel access** to fixed offshore structures such as platforms or seabed-mounted wind turbines, and uses **space-stabilisation**
- An articulated arm is installed on the host vessel that maintains its position (e.g., moored, or with dynamic positioning) and carries a 3- or 4-person gondola at its extremity
- The arm lifts off the deck, space-stabilisation is switched on, then personnel are transported to a disembarkation point, typically at a height of 20m+
- The arm is actively compensated. It hovers above or alongside the target laydown area, but does not engage with it
- Gondola movement is less than +/- 10cm

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- Neptune access system during land trials

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Click on following link to view a You Tube video of the Neptune Offshore Personnel Transfer System during land based testing:-

https://youtu.be/OcC9Pr1k8Yo

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Neptune personnel access system on 6 d.o.f. ship-motion simulator

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- Two-part articulated arm mounted on base unit that swivels and compensates for roll and pitch
- Stiff, lightweight steel truss
- Hydraulic cylinders and motors for actuation
- Position and attitude determined using integrated IMU and GNSS
- Weight 12 tonnes (ex HPU)
- Compensation capability suitable for Hs = 3m with 36m vessel

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APPLICATION 2 is:

- **Launch and recovery** of floating devices such as small boats, ROV’s, or AUV’s that have wave-induced motion
- An articulated arm on a host vessel is fitted with a **Remote Sensing System (RSS)** that measures the motion of the floating target
- The arm is fitted with a tool or latch that allows the arm to connect to the target
- For recovery, the arm is deployed outboard and the host vessel manoeuvres to bring the target into the RSS field of view, then synchronous stabilisation is switched on
- The arm moves to the target so that the latch engages with the target, it is lifted from the water, stabilisation is switched off, and the target is parked as required

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APPLICATION 2 (continued)

- To **launch**, the target is lifted from its parked position on the host vessel, space-stabilisation is switched on, and it is swung outboard
- It is lowered into the water and the latch released so that it can float free
- The arm is withdrawn vertically at a speed that ensures the target will not impact it during the following heave cycle
- Space-stabilisation is switched off and the arm restored to its stowed position on the vessel

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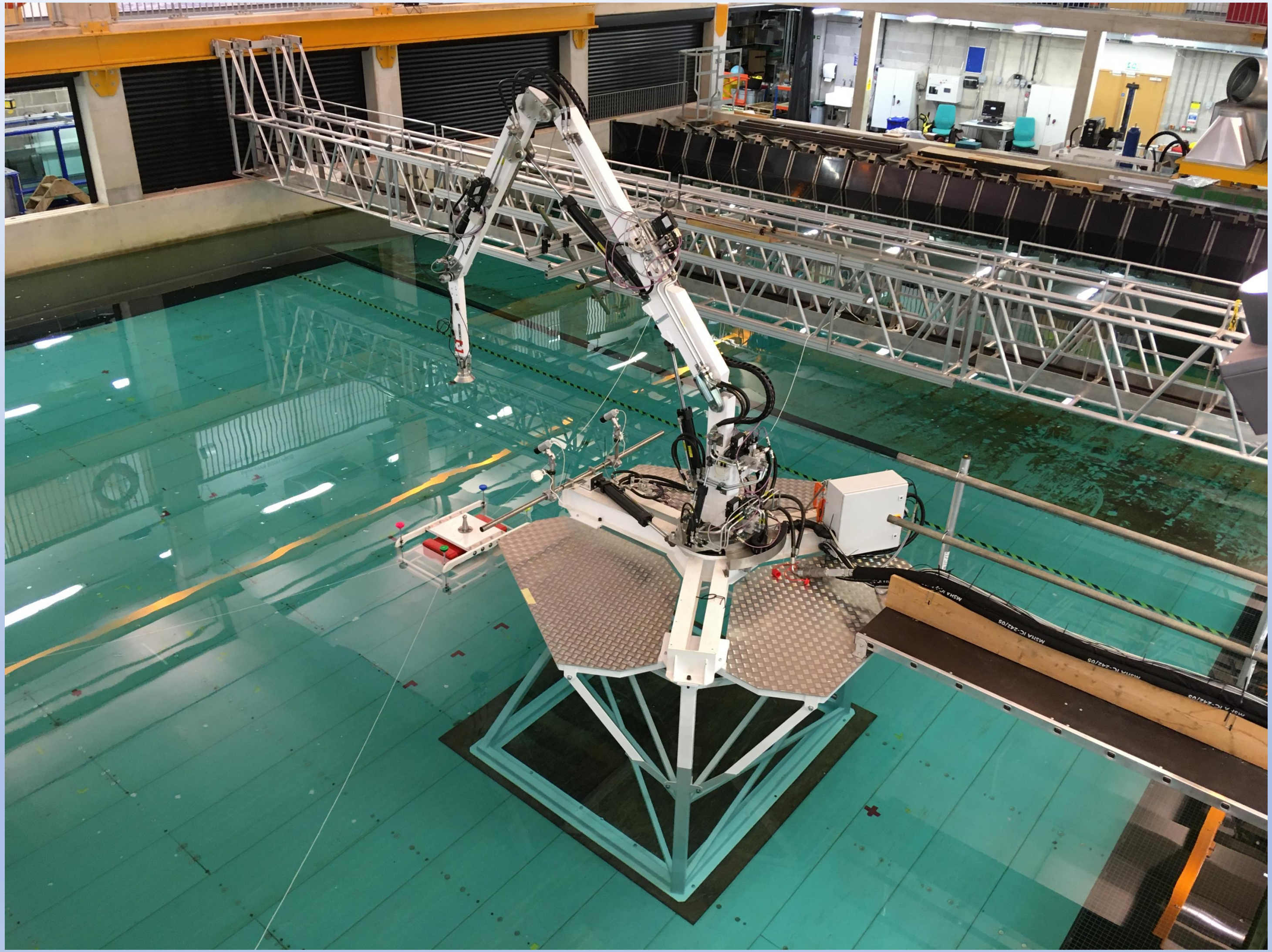
ASSP arm mounted in the Ocean Basin at University of Plymouth COAST Laboratory



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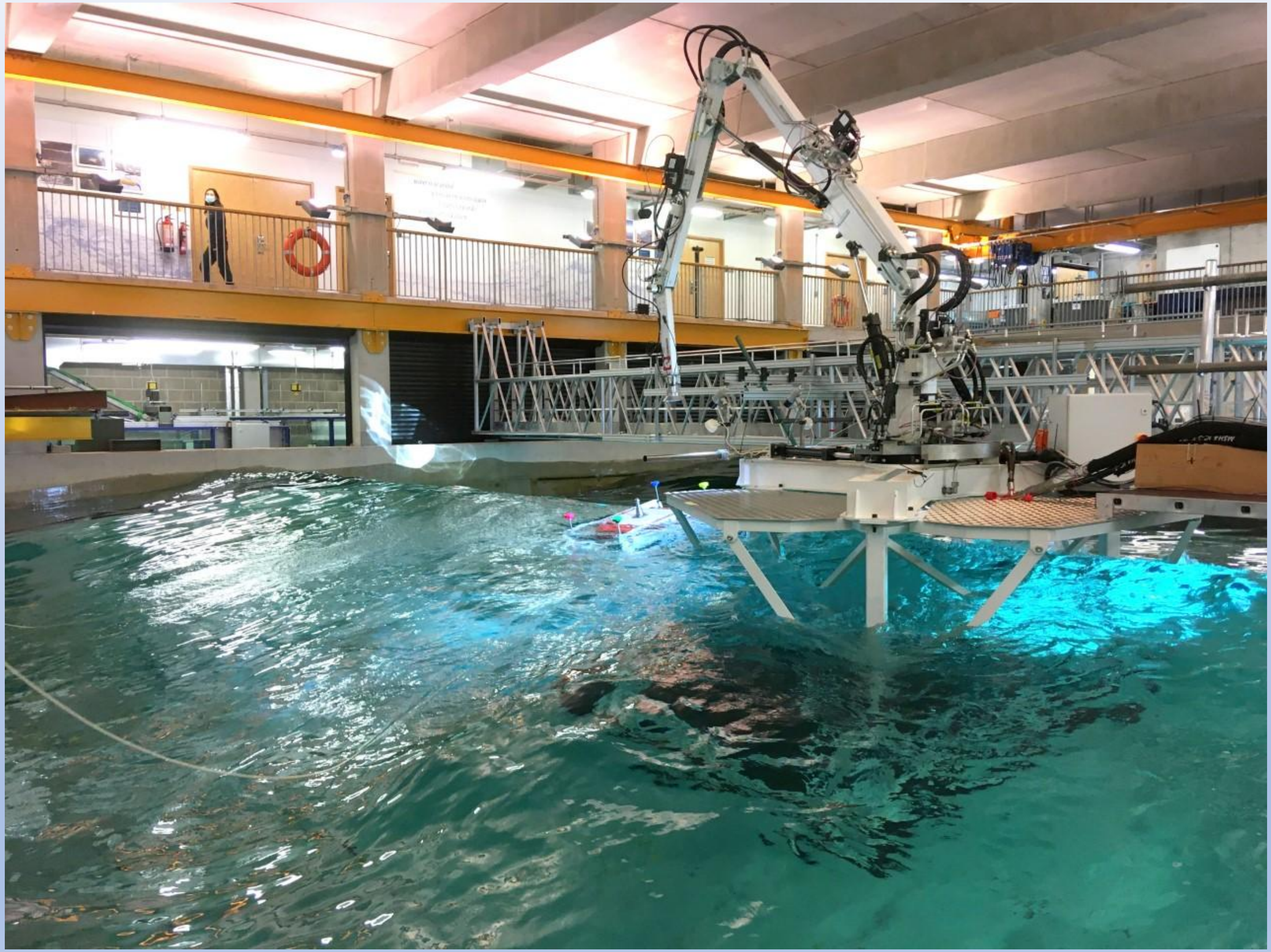
ASSP arm and the model ROV being recovered with the wave generator active



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Click on following link to view a You Tube video of the STL Robotic Arm demonstrating Synchronous Launch and Recovery:-

https://youtu.be/jO4D_Yl8bXQ

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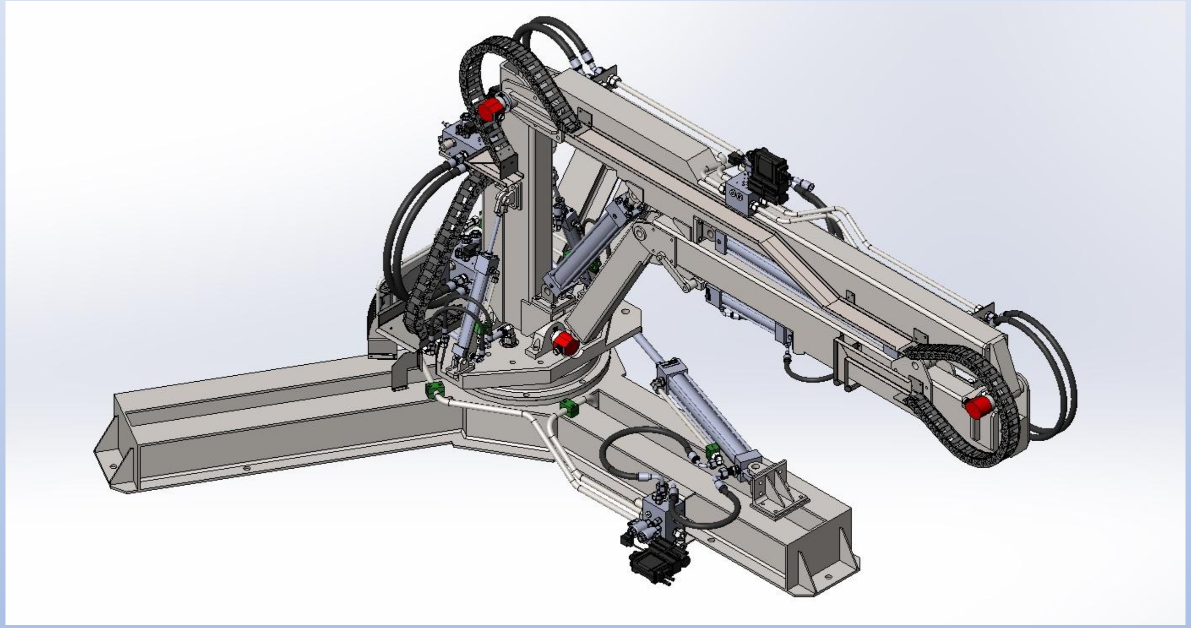
- Three-part articulated arm
- Hydraulically actuated
- Reduced-scale development unit with 100 kg payload limit
- Tested with model ROV based on SeaEye Falcon and model AUV based on Teledyne Gavia
- Technology can be applied to larger units like the Neptune arm shown previously



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SUMMARY

- **Space-stabilisation** and **synchronous stabilisation** capability has been developed to a level where it can be applied to ship-based robotics to undertake useful practical tasks
- Stabilisation is autonomous once activated. On manned vessels, an operator can supervise and sequence the stages of an application
- The technology could easily be applied to remote operation.
- For fully autonomous operations with unmanned vessels, the robotic arm and host vessel will need to be integrated into a single system
- Certain aspects of the technology, such as the machine vision used for remote sensing, need to be developed to a point where adequate robustness and reliability offshore is demonstrated

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THANK YOU FOR YOUR INTEREST

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