

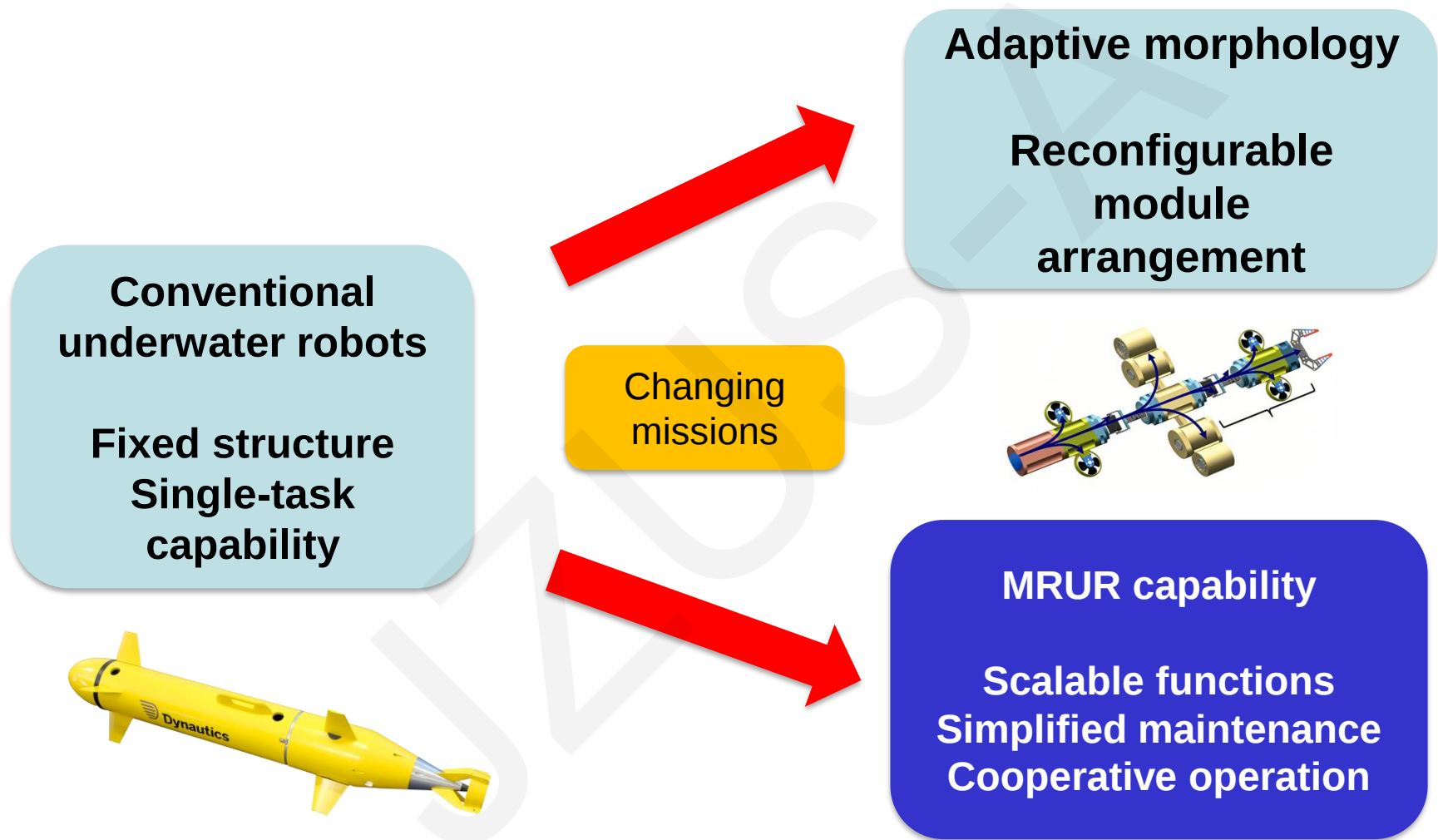
Modular reconfigurable underwater robot (MRUR): a comprehensive review of structure, perception, and control

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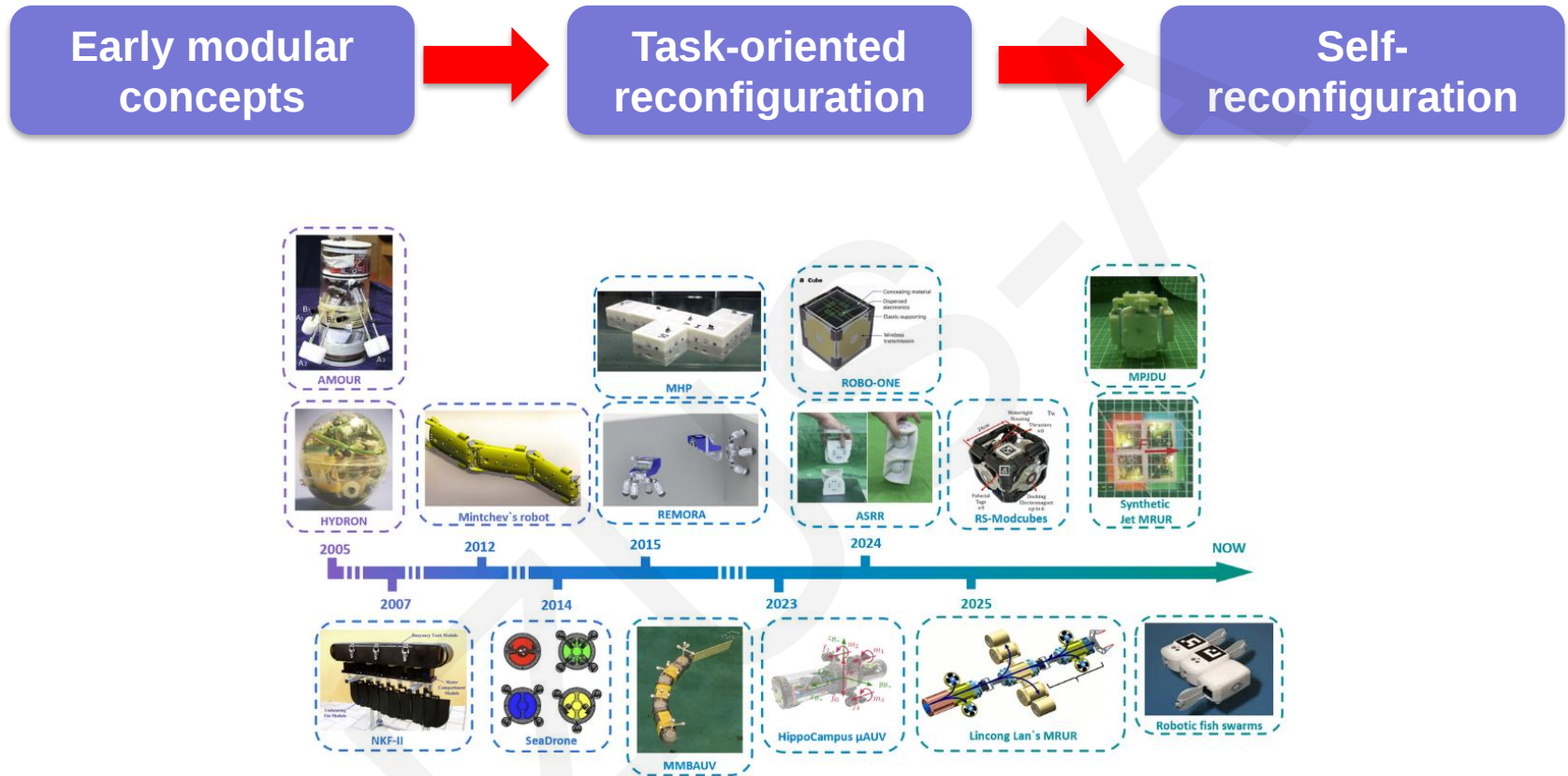
<https://doi.org/10.1631/jzus.A2600131>

Why Modular Reconfiguration?



MRURs reorganize morphology, actuation, sensing, and functions according to mission requirements.

Evolution and Review Framework



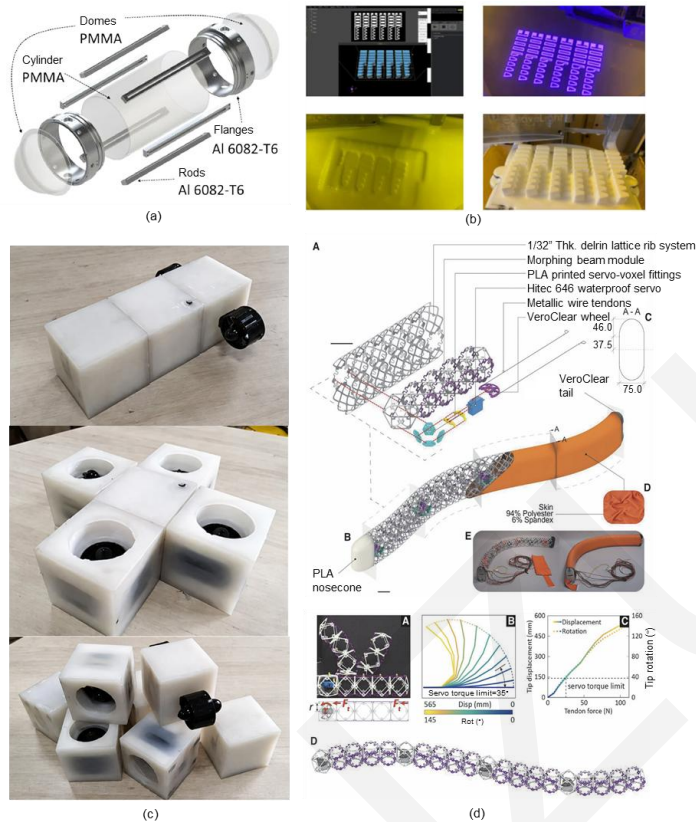
(a) The project development timeline of MRUR

Fig. 1. Development timeline and project characteristics of MRURs.

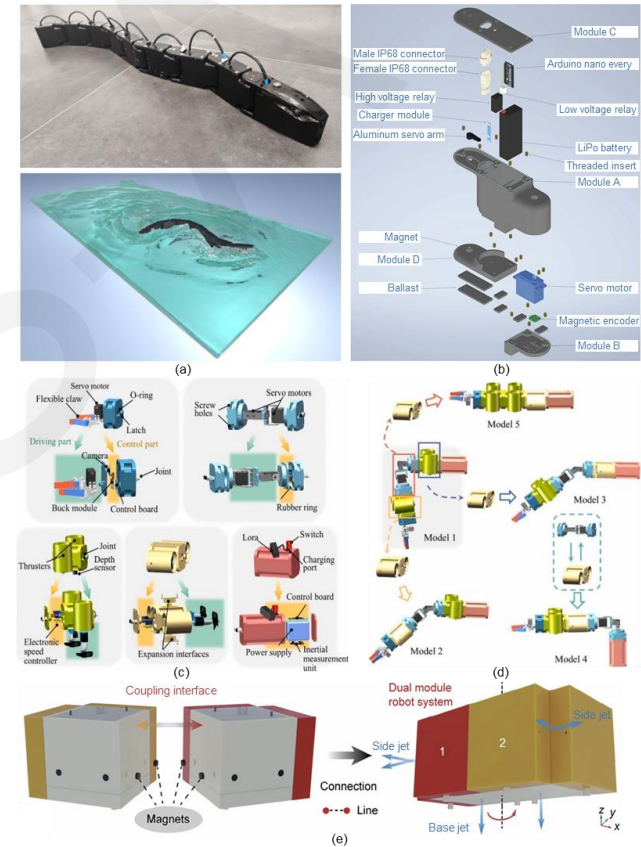
Structure • Sensing & perception • Control

Modular Structural Design

- Pressure tolerance and reliable docking form the engineering foundation



Representative module hull designs and underwater structural materials



Representative underwater module connection methods

Magnetic and hybrid magnetic–mechanical interfaces enable rapid, repeatable assembly.

Sensing and Perception

- MRURs must perceive both the environment and their changing topology

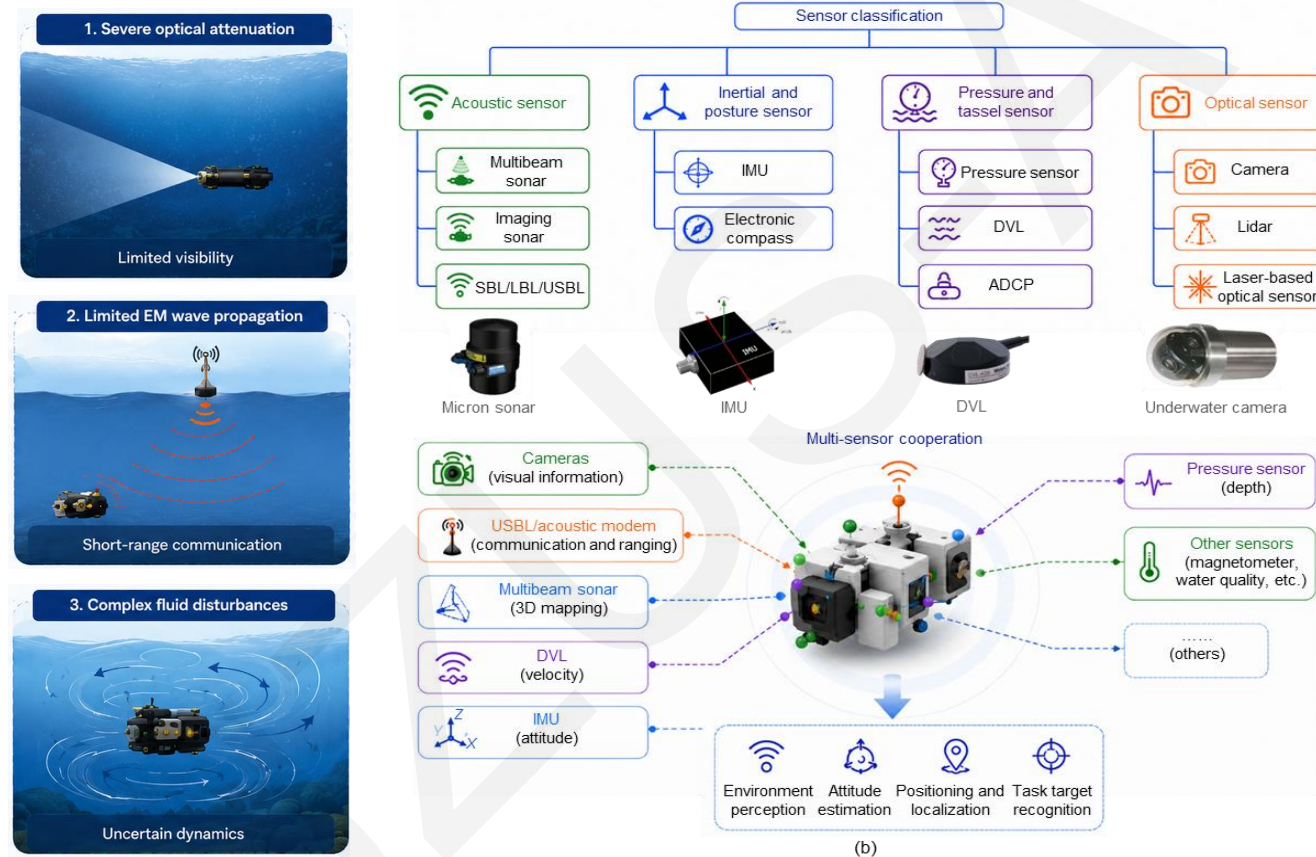
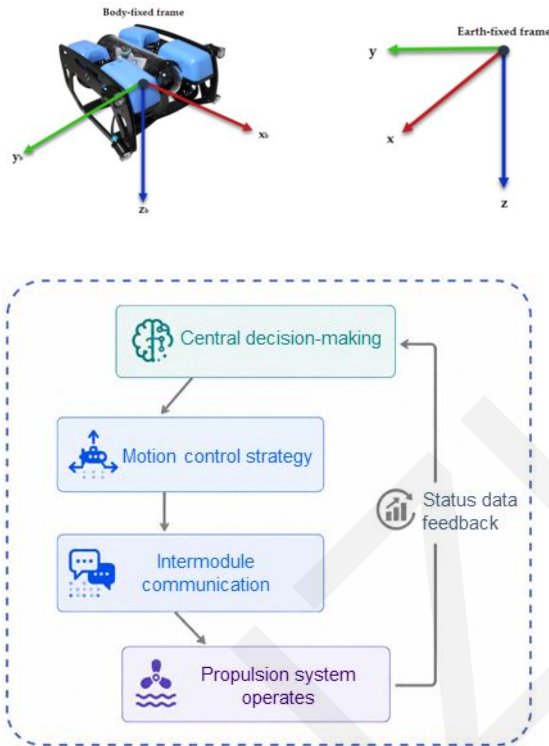


Fig. 5. Sensor classification and multi-sensor cooperation for MRURs.

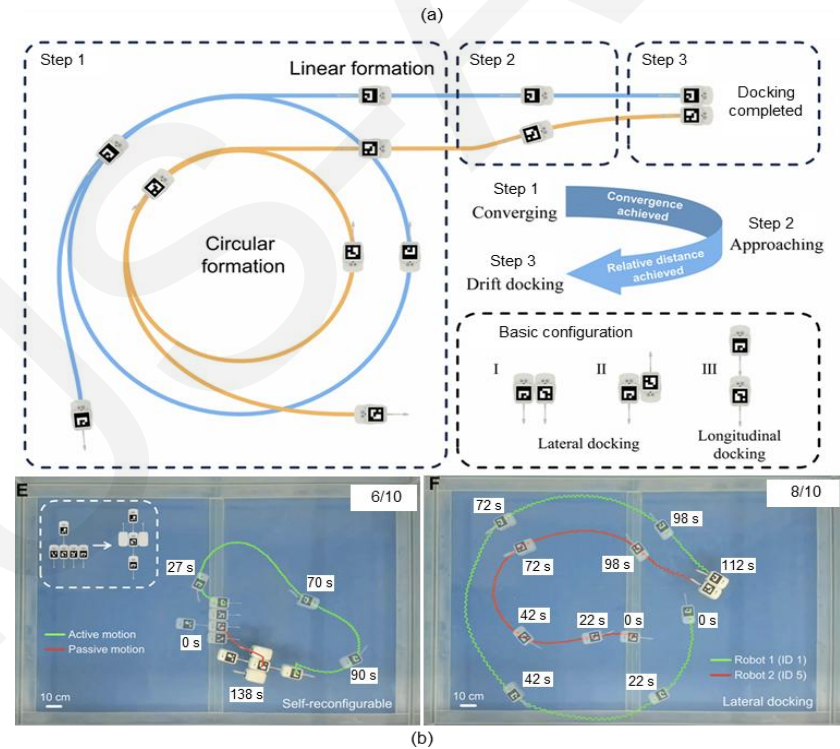
Topology recognition • Docking perception • Distributed perception

Control Strategies

- Control must remain coherent as topology, dynamics, and actuation change



Overall control framework diagram for MRUR systems



Example of autonomous docking for self-reconfiguration

Topology control • Docking & separation • Propulsion redundancy • Distributed coordination

Conclusions & Future

- MRURs overcome fixed-configuration limitations through structural reorganization and functional expansion.
- Reliable pressure-resistant structures, sealing, and underwater connectors are prerequisites for engineering deployment.
- Perception and control must accommodate topology changes, docking, redundancy, and distributed coordination.

From reconfigurability to self-reconfiguration, self-adaptation, and cooperative autonomy

Future MRURs are expected to achieve intelligent control and cooperative autonomy in complex underwater environments.