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Optimizing Autonomous Operations for underwater and Surface vehicles

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Overview

This topic aims to develop reliable and efficient methods for autonomous high-level mission planning, replanning, and control execution of Autonomous Underwater Vehicles (AUVs) supported by ships and other robotic platforms for long-range operations through the observational pyramid developed by NTNU.

The observational pyramid integrates multiple platforms to provide comprehensive ocean data:

1. Small Satellites (e.g., HYPSO-1): Capture high-resolution images with hyperspectral imagers, providing detailed information beyond traditional RGB cameras.
2. Aerial Drones (UAVs): Collect high-resolution data at lower altitudes using hyperspectral imagers.
3. Autonomous Surface Vehicles (USVs): Carry sensors for acoustic properties and CTD profiles.
4. Autonomous Underwater Vehicles (AUVs): Navigate underwater, collecting multi-depth data with various sensors.
5. Ground Truthing by Biologists: Physical water samples to validate and complement remote data

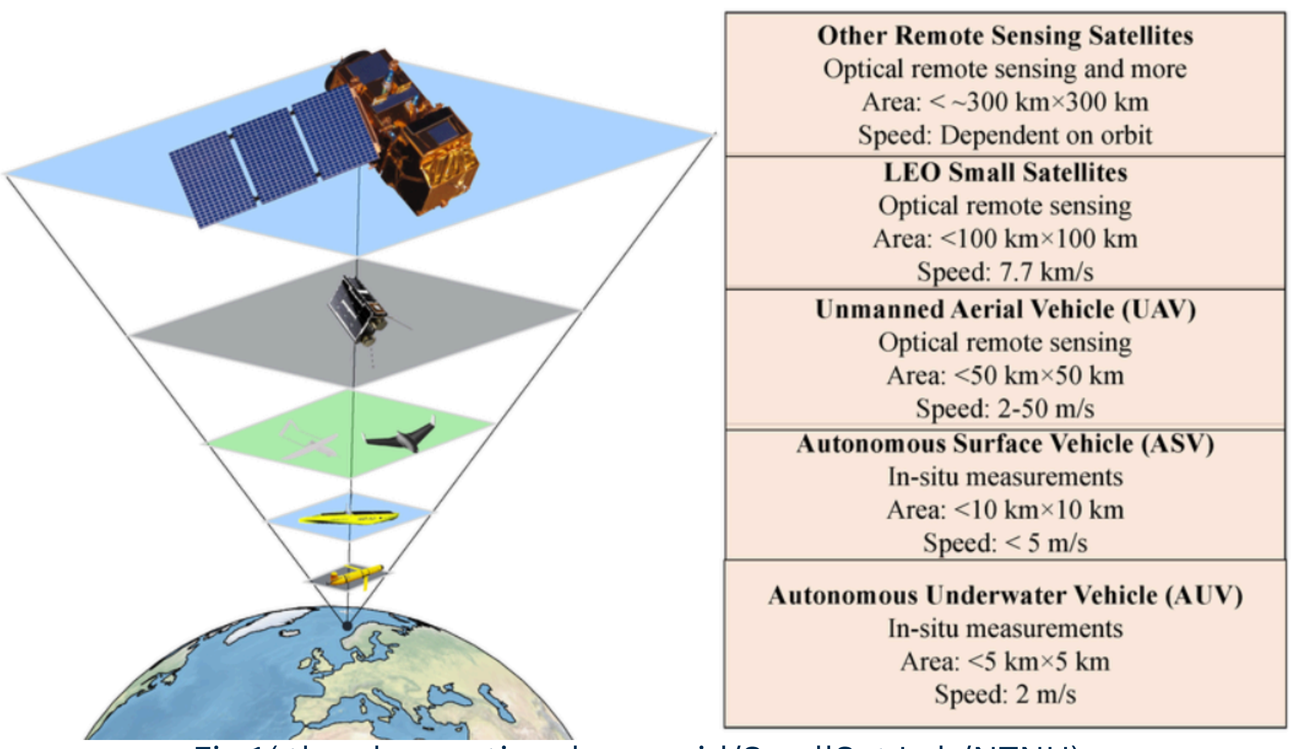

Fig 1(the observational pyramid/SmallSat Lab/NTNU)

Objectives

- **Risk Management:** Creating methodologies for dynamic management of spatio-temporal risk maps and optimizing control actions through advanced risk models.
- **Adaptive Mission Planning:** Utilize Deep Reinforcement Learning for adaptive mission planning, enabling AUVs to react to changing conditions and data inputs effectively.
- **Choosing the right sensors** along with the Deep Reinforcement Learning model for the best performance between the different platforms.

state of the art

1. **Deep Reinforcement Learning (DRL):** Advanced DRL models like Deep Deterministic Policy Gradient (DDPG) and Proximal Policy Optimization (PPO) are used for adaptive mission planning and real-time decision-making in dynamic underwater environments.
2. **Multi-Agent Systems:** Multi-Agent Deep Reinforcement Learning (MADRL) facilitates the coordination and task allocation among multiple AUVs, enhancing cooperative control and mission efficiency.
3. **Advanced Sensing Technologies:**
   - **Active Sonar:** High-resolution mapping and obstacle detection.
   - **IMUs**: Precise orientation and motion tracking.
   - **DVLs**: Accurate underwater navigation.
   - **Environmental Sensors**: Monitoring water conditions like temperature and depth.
4. **Optimization Algorithms:**Genetic Algorithms (GA) and Particle Swarm Optimization (PSO) are employed for efficient path planning and mission optimization, considering various constraints and objectives.
5. **Dynamic Risk Management**:Developing and updating spatio-temporal risk maps to ensure safe operations, incorporating real-time risk assessment and mitigation strategies.
6. **Simultaneous Localization and Mapping (SLAM):**SLAM techniques allow AUVs to build and update maps while tracking their location, essential for navigating complex environments.

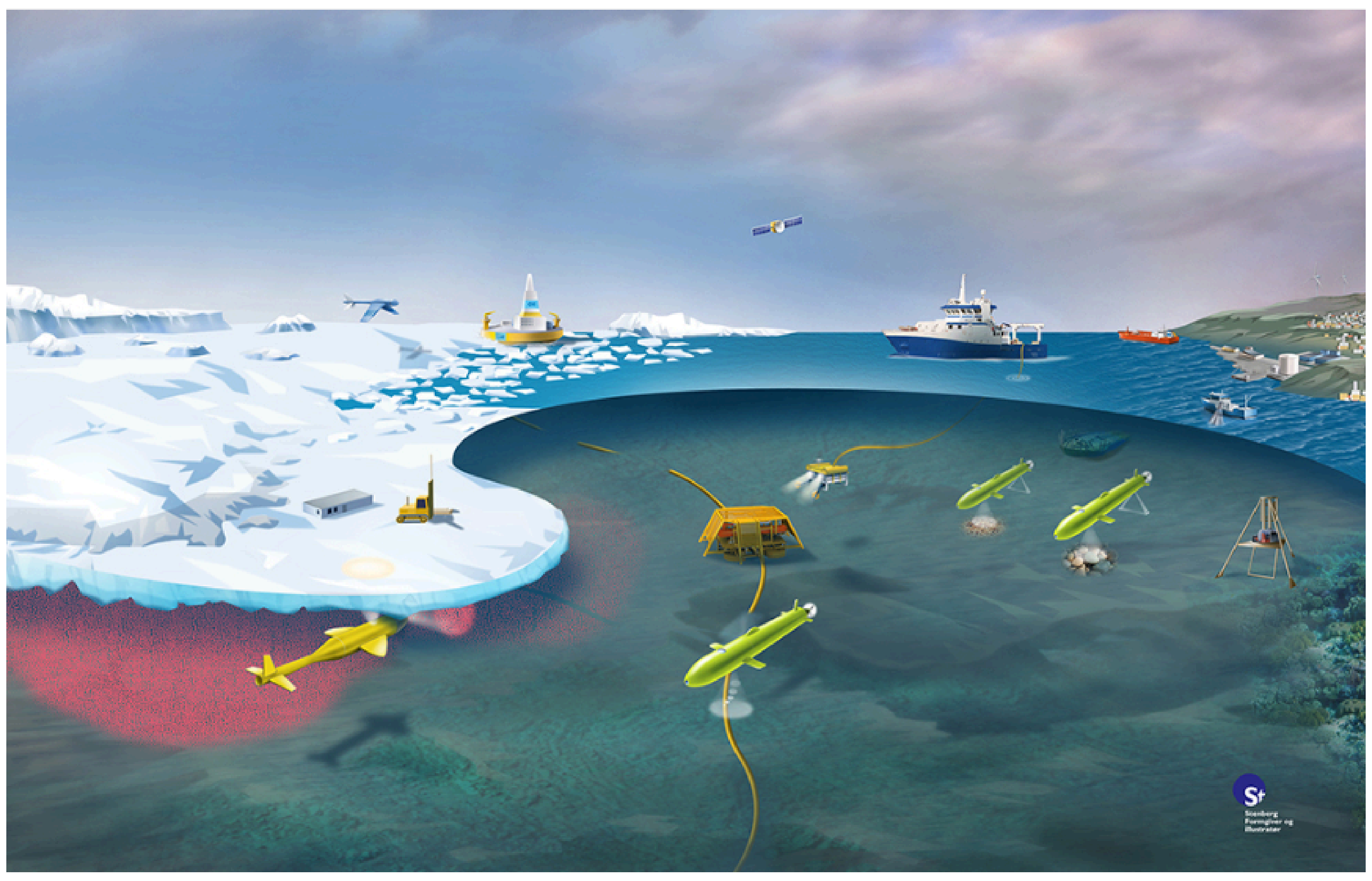

Fig2(NTNU/AMOS/Stenberg The technology in the observation pyramid)

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