AGENT-BASED SIMULATION OF AIRBORNE OFFSHORE WIND FARM LOGISTICS AS A SYSTEM OF SYSTEMS

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The growing offshore wind energy capacity in the German North Sea and beyond requires efficient, cost-effective logistics for installation, maintenance and emergency response. Innovative solutions are therefore in demand to overcome the limitations and high costs of traditional Crew Transfer Vessels (CTVs) and helicopters. Uncrewed Aerial Vehicles (UAVs) are currently being explored for supplying wind turbines with maintenance tools and spare parts [7]. Agent-Based Modeling (ABM) is used to simulate airborne logistics and their interaction with offshore wind infrastructure. Based on these simulations, tailored TLARs for UAVs are developed to match the operational needs.

The DLR System of Systems Inverse Design (SoSID) Toolkit has already been successfully employed for the ABM of Urban Air Mobility networks, aerial wildfire suppression, and multimodal simulations [1][2][3][4]. Agent-based modeling has also enabled maritime applications such as search-and-rescue missions in the Barents Sea and piracy-risk simulations in the Arabian Sea [5][6].

To implement the new environment and scenario, the SoSID-Toolkit was extended with a helicopter agent model, since existing VTOL and fixed-wing agents did not capture their flight performance and fuel consumption precisely. An offshore weather modul based on the NORA3 dataset was integrated to reflect wind and sea conditions. An energy-production module quantifies wind turbine output and production loss scenarios, while enhanced dispatcher and maintenance-inspection modules dynamically generates task demands, including spontaneous fault responses and spare-part needs. Multimodal logistics with vessels, helicopters, and unmanned aerial vehicles should be simulated within realistic environmental and operational constraints.

Agent based modeling provides a framework for representing the diverse elements of offshore logistics, each endowed with localized decision making in response to environmental conditions. By specifying vehicle performance and operational rules at the agent level, ABM enables emergent behavior and uncovers inefficiencies invisible to vehicle-only approaches.

The simulations are expected to yield quantitative performance metrics at both the system level such as total energy generation and total energy consumption and the vehicle level, like the aircrafts deadhead ratios and load factors, leading to optimized TLARs and fleet compositions. These insights will support planning of resilient, cost-efficient, and fast logistics frameworks for the expanding offshore wind sector.

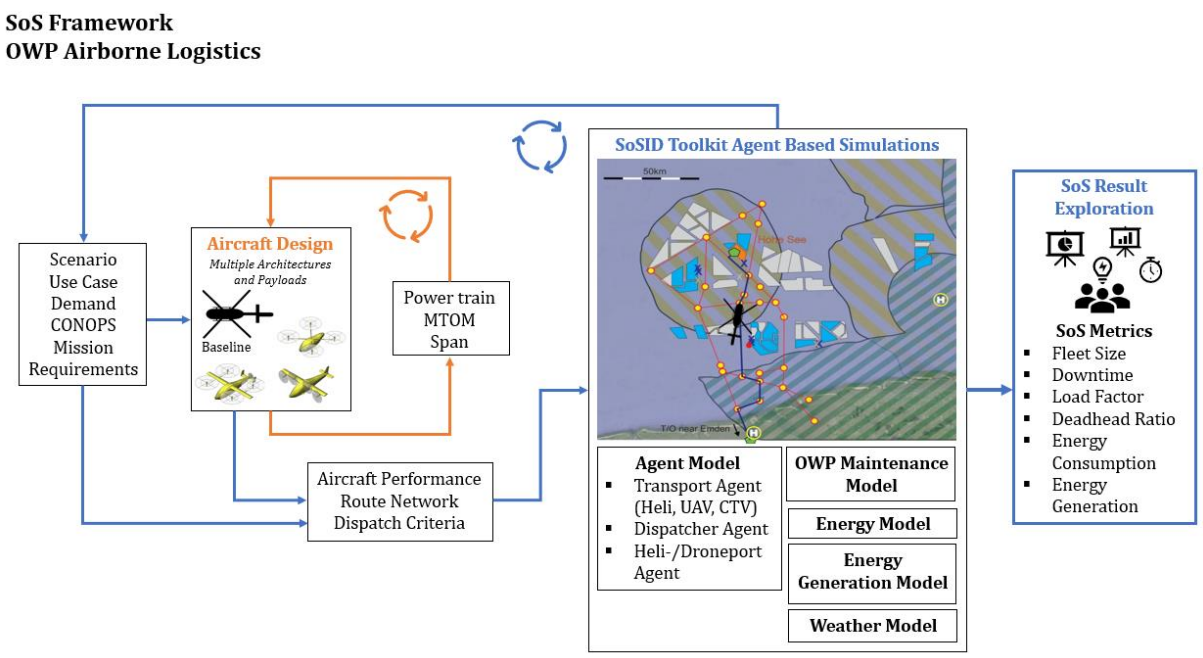

Figure 1: Adapted SoS Simulation Framework for Offshore Windpark (OWP) Logistics, map from [7]

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