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IMPROVING OFFSHORE WIND FARM UNMANED MAINTENANCE: EAGLE PROJECT

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- Introduction.
- VolturnUS seakeeping performance.
- Short term motion prediction using ANN.
- Conclusions.

- Drones have become a common tool for wind farm maintenance.
  - Speed of take-off.
  - Avoid great heights work environment.
  - Ease of use and reduced operating time.
- Sector is leading to autonomous drone operations.
  - Less onsite personnel.
  - Cost – reduction
  - Increased safety.
- Difficulty of autonomous landing and take-off manoeuvres.

Photo: Vattenfalls

- EAGLE is a **coordinated** project funded by the 2021 TED Projects (Ministry of Science, Innovation and Universities, Spain).
- **UVIGO, UDC, CATEC**.
- Digitizing the air and marine space to optimize the operation of drones applied to the maintenance of offshore wind farms.
- EAGLE **ENVIRONMENT**, EAGLE **MARINE** and EAGLE **FLY**.

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- EAGLE **ENVIRONMENT**
  - Modelling of the **environment** in which the drone operates.
- EAGLE **MARINE**
  - Modelling the floating **wind turbine and support vessel motions** under wind and waves.
- EAGLE **FLY**
  - Optimising the **take-off, landing and flight manoeuvres** of the drone from mobile platforms (ship decks and nacelles of floating wind turbines) and flying close to wind turbine infrastructures.

- EAGLE **MARINE** main research lines:
  - Motion analysis of a VolturnUS concrete 15 MW floating wind turbine.
  - Pitch and heave motion forecasting using ANN of a 30 m wind farm support vessel.

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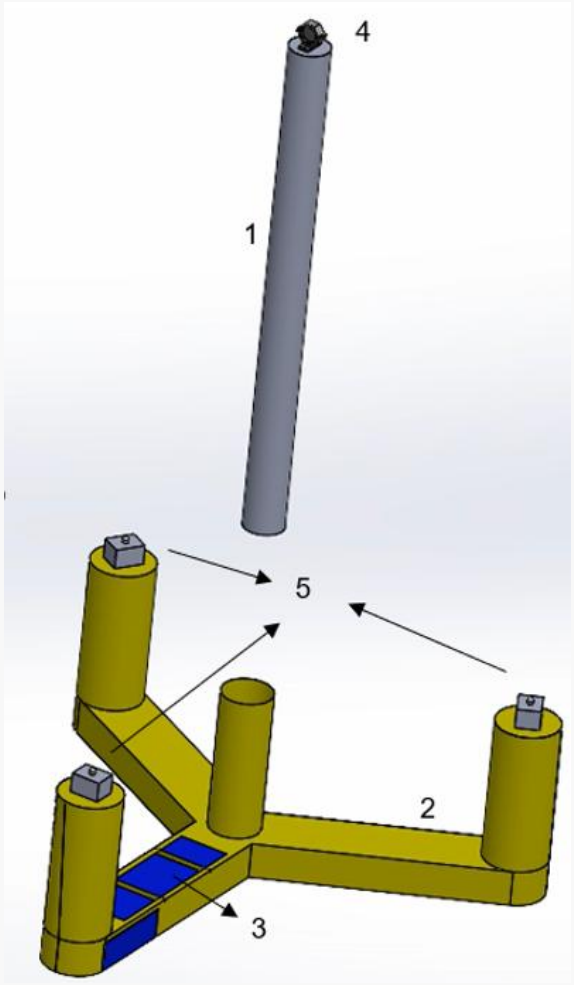
- **VolturnUS** UMaine design.
- Semisub concrete platform.
- IEA WTC Benchmark case.
- Base for 15 MW reference wind turbine.

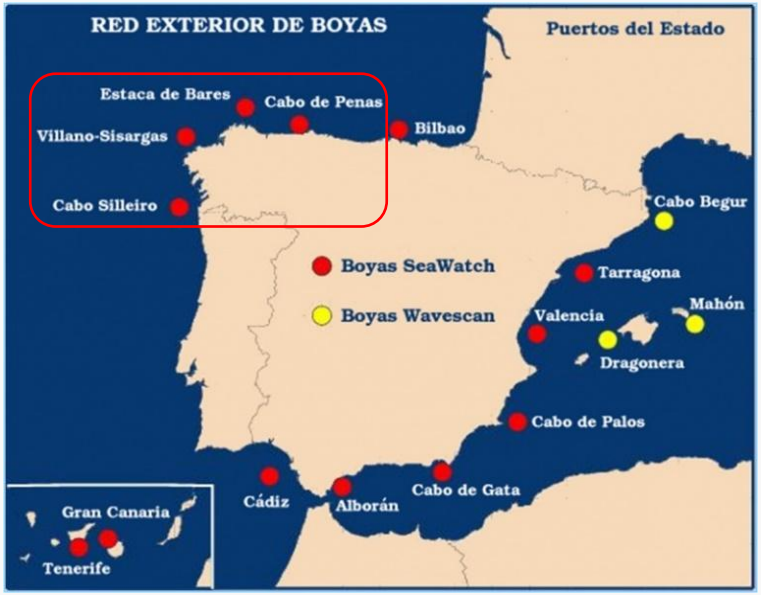
Platform length	90,1 m
Platform beam	102,1 m
Platform depth	35 m
Platform draft	20 m
Maximum height	290 m
Nacelle height	135 m

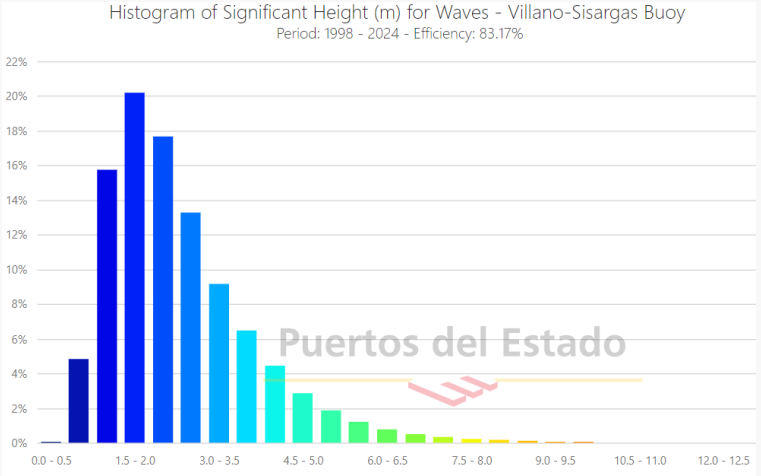
Photo: Umaine


4
1
5
2
3

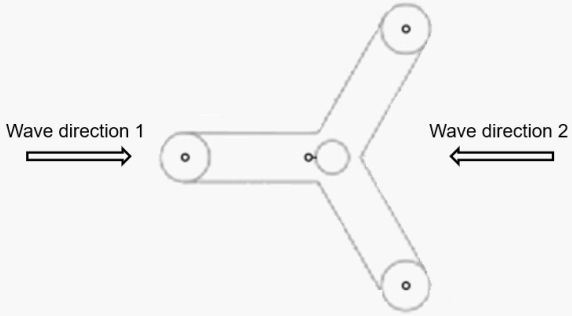
Wave conditions:

- Parque Nordés location.
- SeaWatch buoy “Villano Sisargas”, 26 years historical data.
- Most frequent combinations of (T_p, H_s).
- 12 cases regular waves, 4 irregular waves, 2 directions, with and without wind.



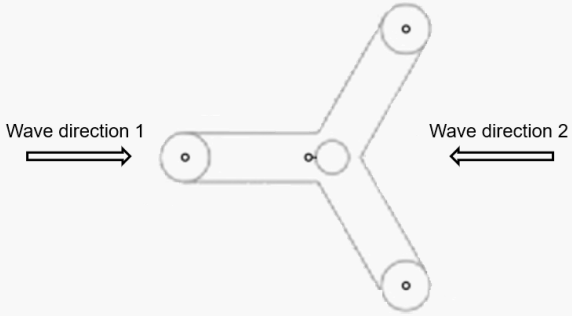


Pitch Motion Results:



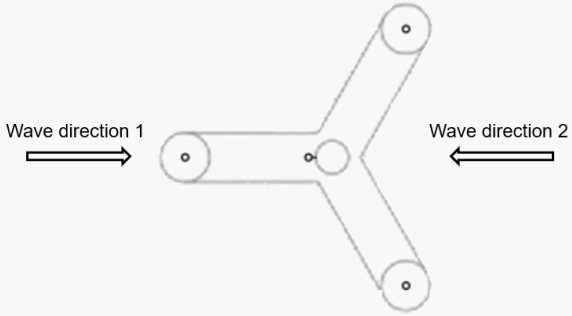
Test	Real Scale		Model Scale	
	H_W (m)	T_W (s)	H_W (m)	T_W (s)
TEST 1	3,25	10	0,05	1,2
TEST 2	4	9	0,06	1,1
TEST 3	4,5	9	0,07	1,1
TEST 4	4,5	11	0,07	1,4
TEST 5	5	11	0,08	1,4

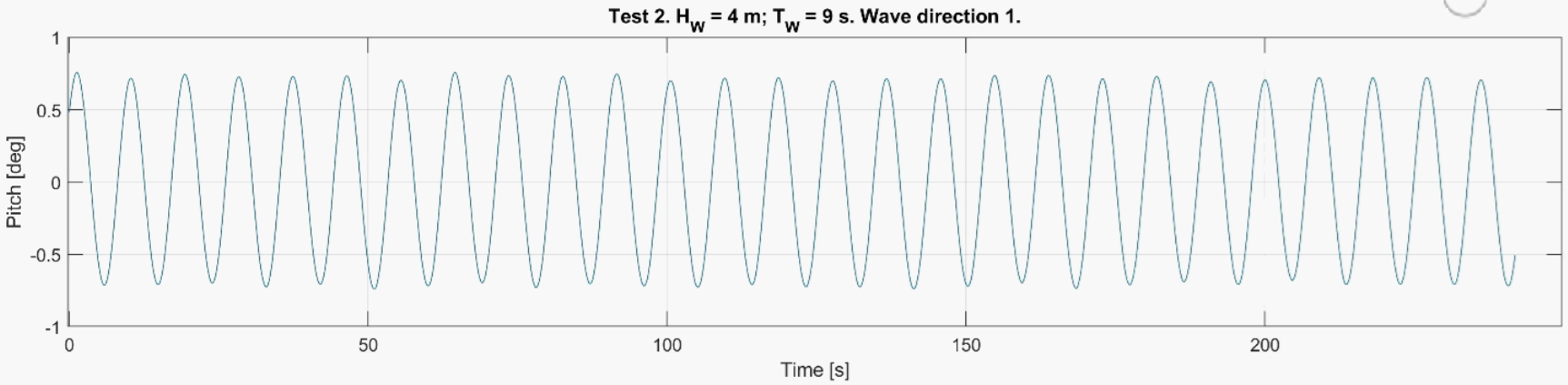
Pitch Motion Results:

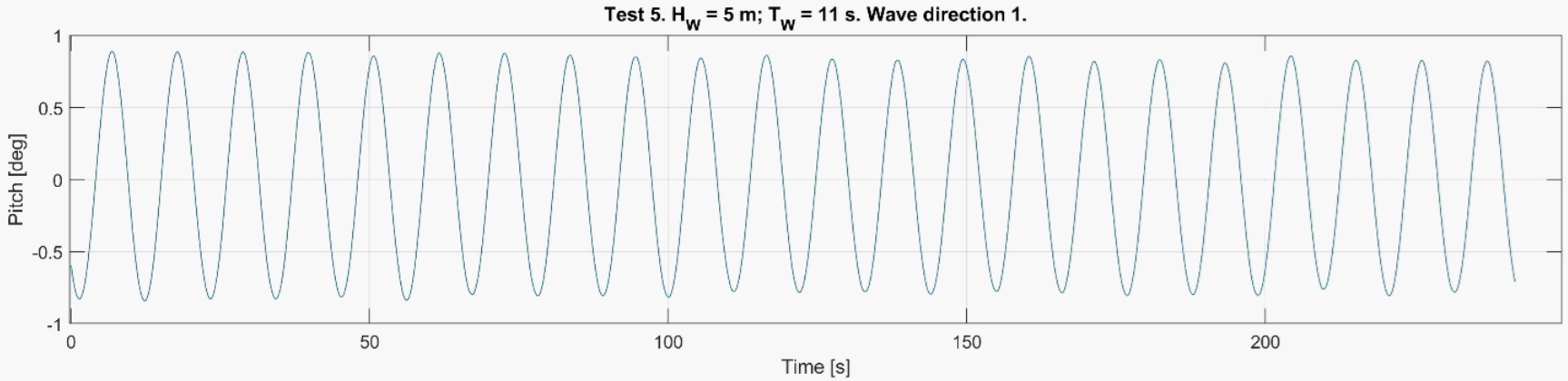


Test	Real Scale		Model Scale		Mean Pitch Amplitude (deg)	Pitch Standard Deviation (deg)
	H_W (m)	T_W (s)	H_W (m)	T_W (s)		
TEST 1	3,25	10	0,05	1,2	0.5986	0.0170
TEST 2	4	9	0,06	1,1	0.7185	0.0169
TEST 3	4,5	9	0,07	1,1	0.7963	0.0207
TEST 4	4,5	11	0,07	1,4	0.7515	0.0257
TEST 5	5	11	0,08	1,4	**0.8266**	**0.0345**

Pitch Motion Results:







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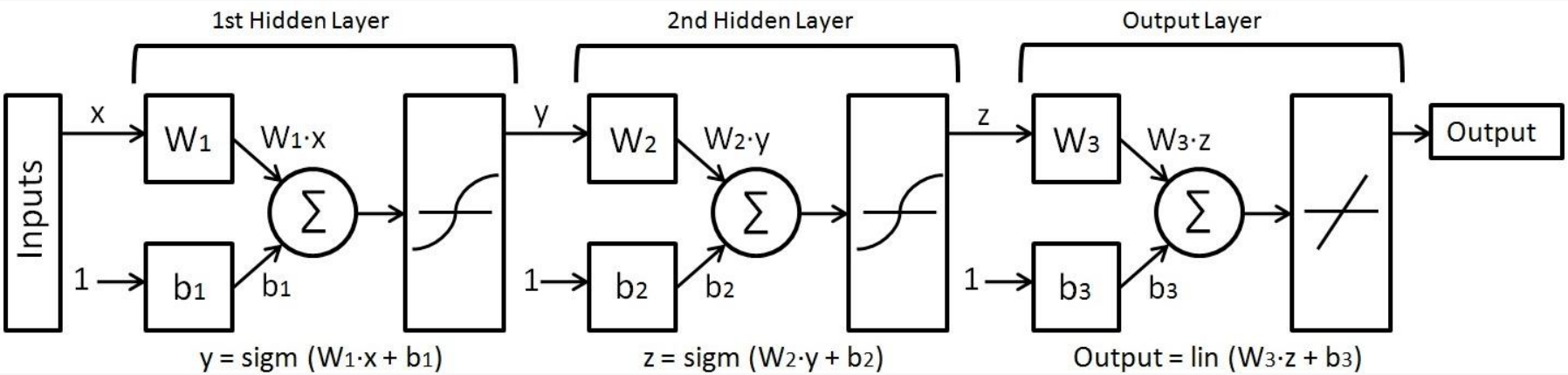
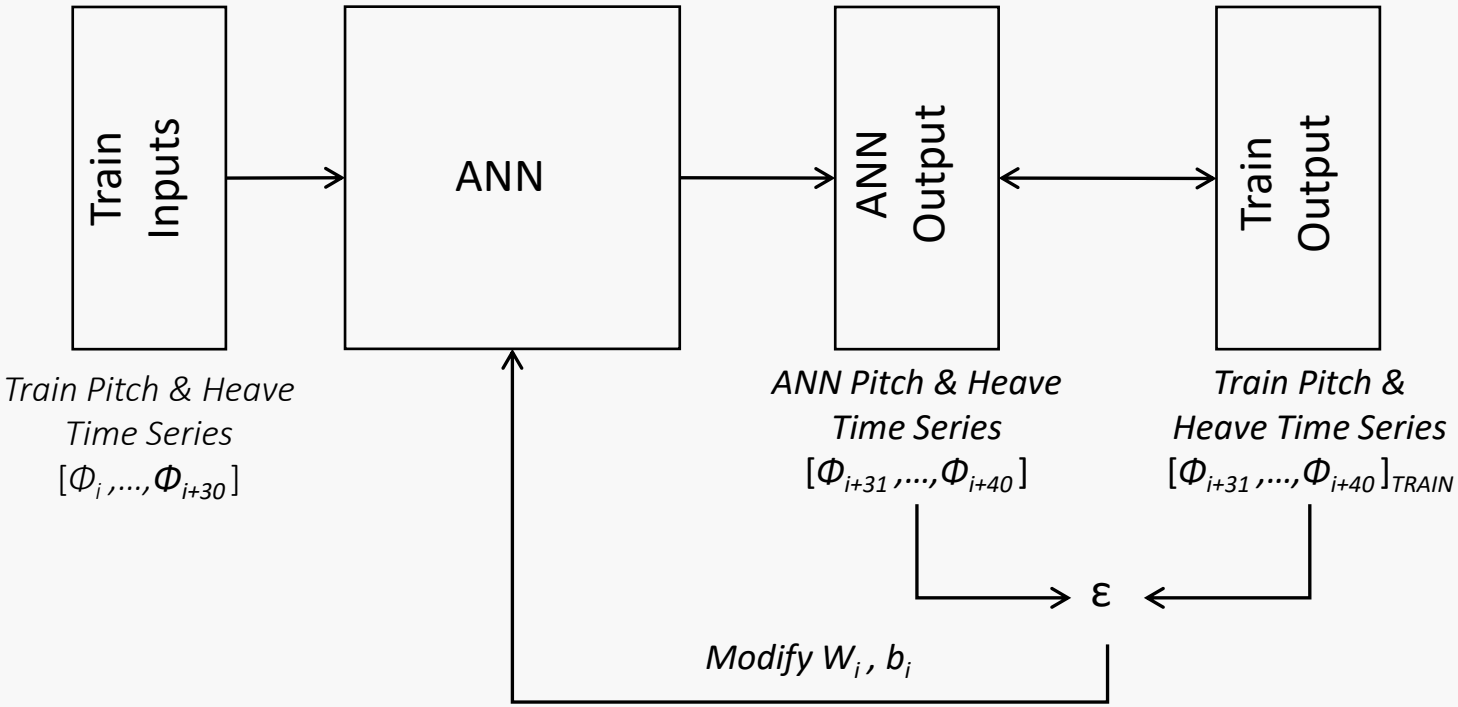
- Optimization of **drone take off and landing** operations from drone launching vessels.
- Being able to know, in advance, the **trajectory of the landing platform**, thus optimizing the performance of the drone control algorithms.
- **Predict**, in the short term, the **pitch and heave motions** of the vessel landing deck, ensuring:
  - Low cost (no need for expensive sensors or wave radars).
  - Unmanned operation.

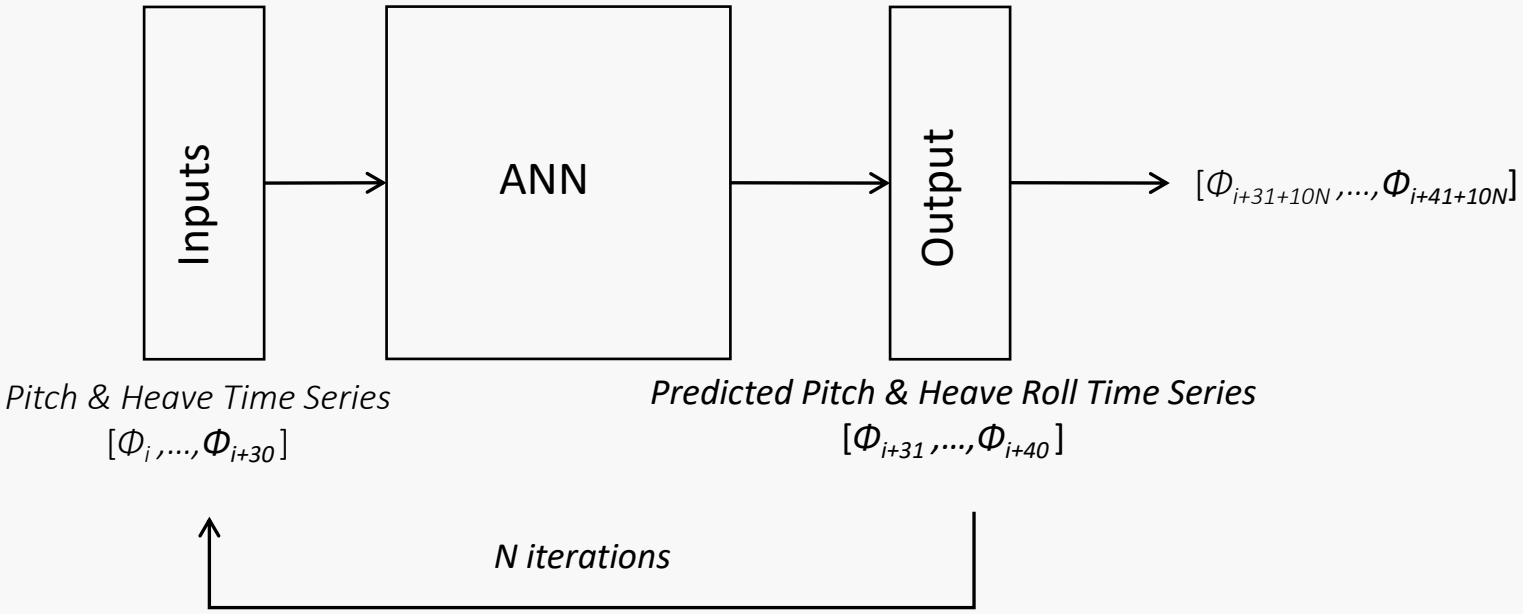
- Use of Artificial Neural Networks.
- Biological – Like systems.
- Able to learn nonlinear behaviours from a given pattern (during a “training” process).
- Multilayer perceptron structure has been selected.



- Training process



- Forecasting process



- Case study:
- Mid sized wind farm support vessel.
- Training done with strip theory code 200 s time series (irregular waves).
- [1 - 3] m H_S, different T_P, [0 – 360] deg headings, [0 – 25] knts.

Overall length	32,2 m
Beam	6,5 m
Lightship displacement	94 t
Design displacement	110 – 120 t
Maximum displacement	146 t

SHORT TERM MOTION PREDICTION USING ANN.

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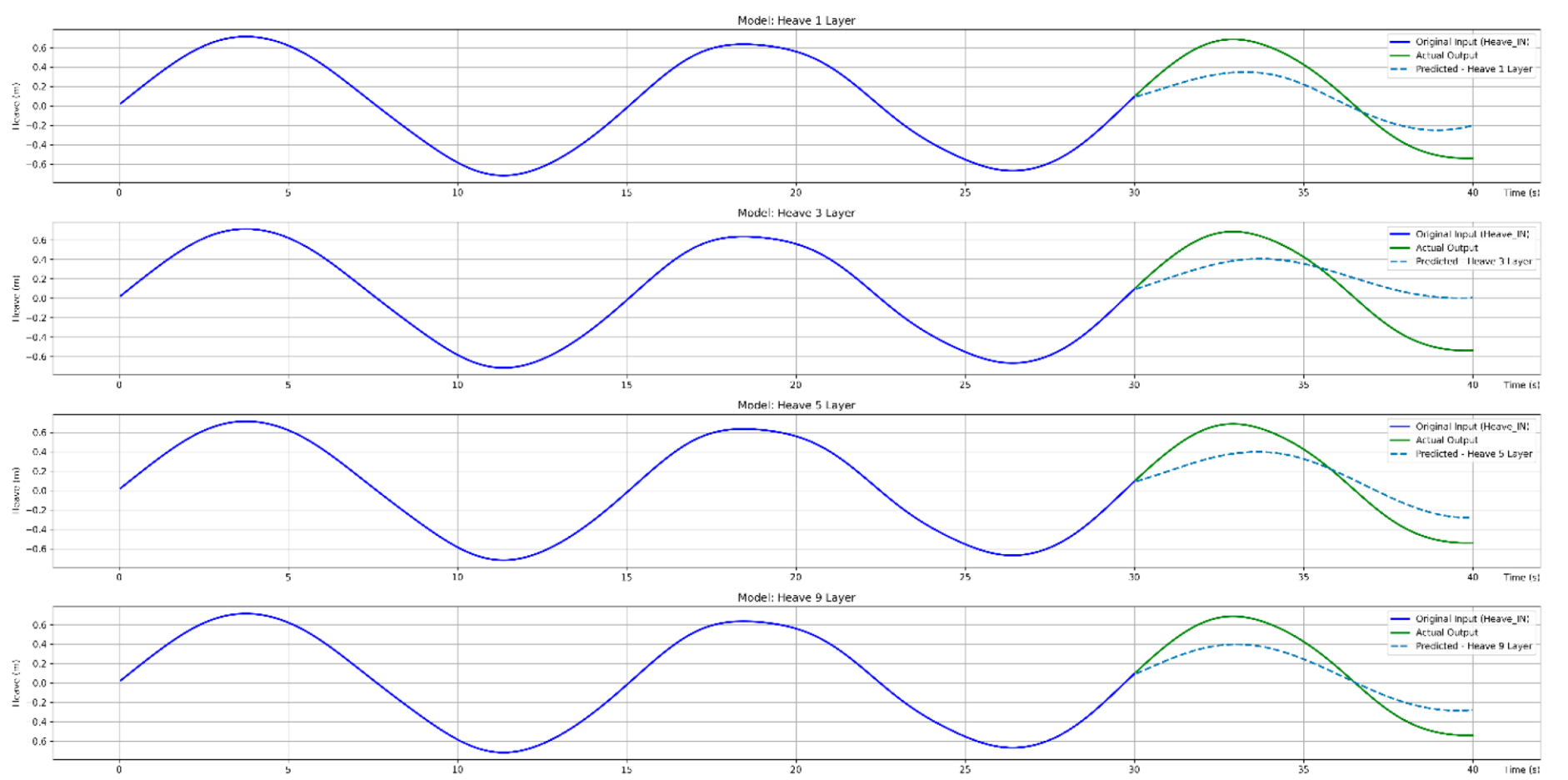

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- The main objective of the project EAGLE Marine is **improving the autonomous operations of aerial drones** used in maintenance tasks of offshore wind farms.
- Maximum nacelle amplitudes of VolturnUS were investigated to analyse **viability of drone maintenance operations** in different wave conditions.
  - Process all available data to generate operational limitations diagrams.
- AI tools were proposed to **optimize autonomous drone landing** capabilities through support vessel motion forecasting.
  - Improve training and testing using towing tank experiment results.

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