MOST
CENTRO NAZIONALE PER LA MOBILITÀ SOSTENIBILE

Digital Twins in the Mobility of the Future

Spoke 3 Waterways
Digital Twin Technologies

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Ministero dell'Università e della Ricerca
Finanziato dall'Unione europea NextGenerationEU

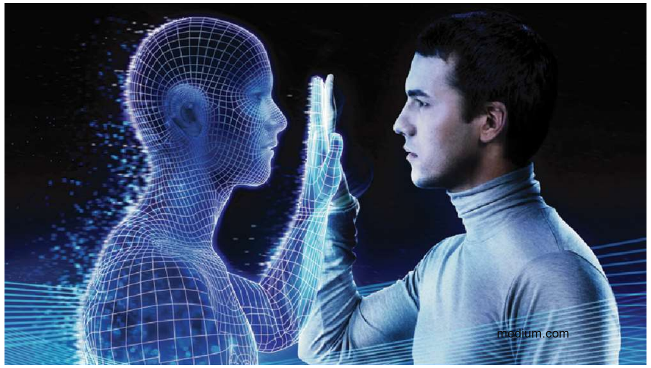
Digital Twin (DT)

What is a *digital twin*?

- "A **Digital Twin is an integrated** multiphysics, multiscale, probabilistic **simulation of** an as-built […] **system that uses the best available physical models, sensor updates** […] **to mirror the life of its corresponding** […] **twin**" (Glaessgen and Stargel 2012)
- "A digital copy of the physical system to perform **real-time optimization**" (Söderberg et al. 2017)

What are its main characteristics?

- **Connectivity**
  - Sensors
  - Internet of Things (IoT)
- **Data fusion and assimilation**
  - Multi-information sources
  - Physics-based and data-driven models
- **Adaptivity**
  - Learn from data
  - Evolve with the real-world twin
- **Modularity**
  - Multiple subsystems

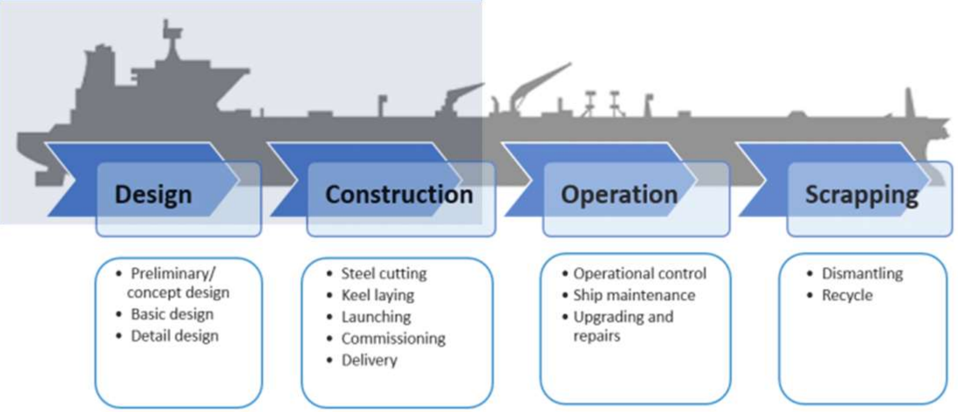


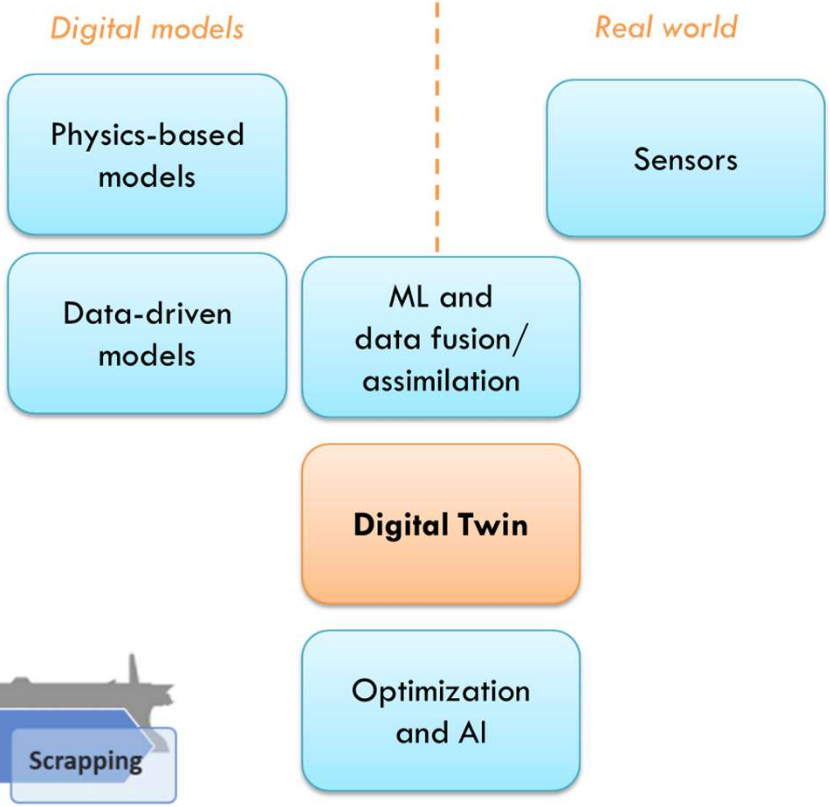
Glaessgen, Edward, and David Stargel. "The digital twin paradigm for future NASA and US Air Force vehicles." In: 53rd AIAA/ASME/ASCE/AHS/ASC Structures, Structural Dynamics and Materials Conference 20th AIAA/ASME/AHS Adaptive Structures Conference 14th AIAA. 2012.

Söderberg, Rikard, et al. "Toward a Digital Twin for real-time geometry assurance in individualized production." In CIRP Annals 66.1 (2017): 137-140.

Main components and enabling technologies of a Digital Twin

- ❑ Physics-based models
- ❑ Data-driven models and machine learning (ML) methods
- ❑ Sensors
- ❑ Digital twinning methods, data fusion and assimilation approaches
- ❑ Optimization and AI
- ❑ Design and construction
- ❑ Management and control
- ❑ Dismantling
- ❑ ICT platform





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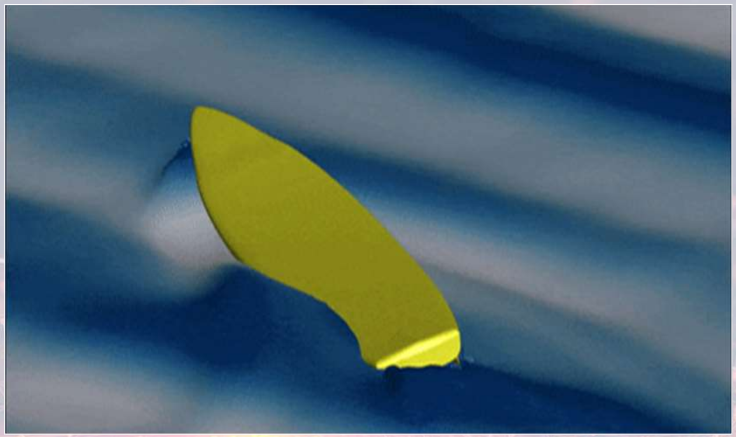

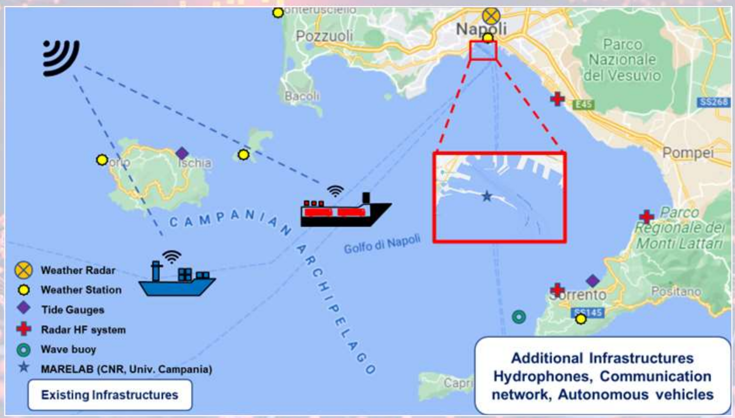

Objectives:
Development of Digital Twins for the ship and her subsystems
- Energy distribution and power systems
- Hydrodynamic and structural responses, predictive maintenance
- Safety in maritime operation accounting for the actual meteocean conditions
- Logistics
- Decision support systems

Participants
- CNR
- UniNa
- UniGe
- UniPa
- UniParth
- Fincantieri

Task
- Task 4.1 Digital Twin technologies for ships power systems and efficient operations
- Task 4.2 Digital Twin technologies for hydrodynamic and structural ships responses, maintenance, and safe operations
- Task 4.3 Data integration and Decision Support System
- Task 4.4 Test facilities development

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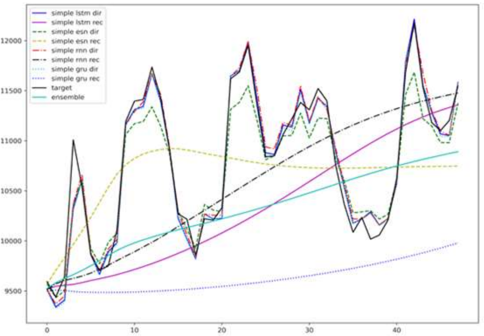
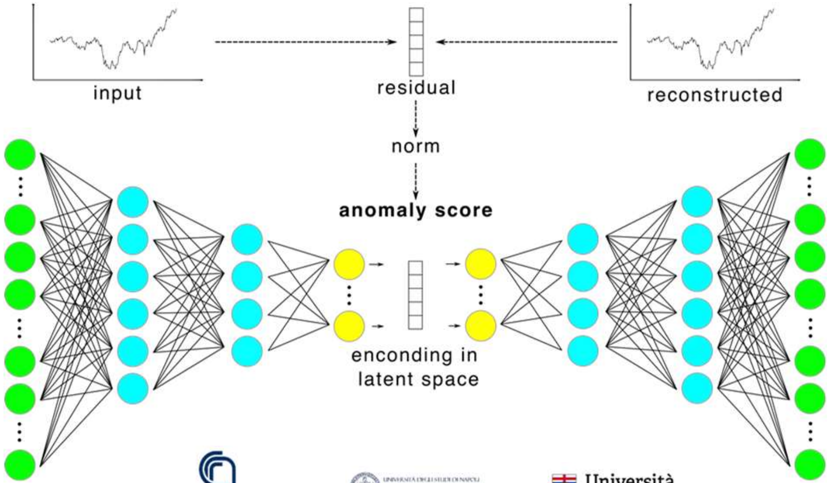
Digital Twin for operational efficiency





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- Modelling of energy subsystems connected to the on board microgrid
- Smart analysis of energy data in real time and short time forecasting of energy needs (hotel loads)
- Anomaly detection on electrical power systems based on machine learning and artificial intelligent systems
- Modeling and real time analysis of power and propulsion systems
- Models for hull-propeller-engine interaction
- Algorithms for the maritime and port logistics

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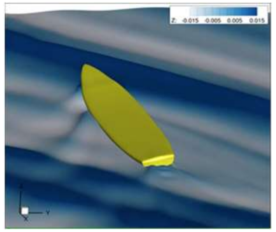
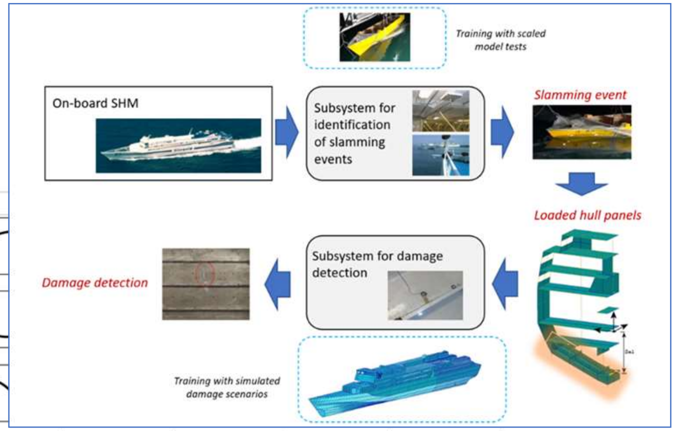
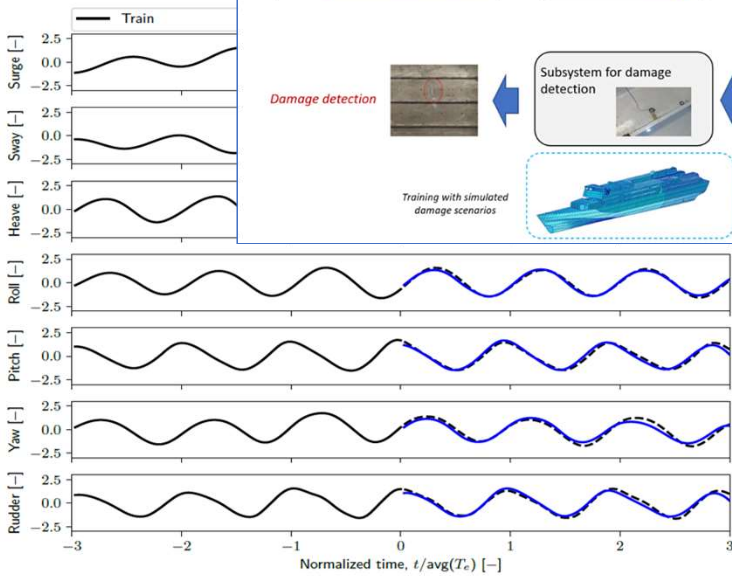
Digital Twinning for safe operation

- Models for real time automated learning of ship dynamics (seakeeping and maneuvering) in severe meteocean conditions
- Machine learning models for the prediction of hydrodynamic loads and ship stability in extreme conditions
- Monitoring and data fusion for the evaluation of ship structure integrity and predictive maintenance
- Methods for the observation and forecasting of meteocean conditions







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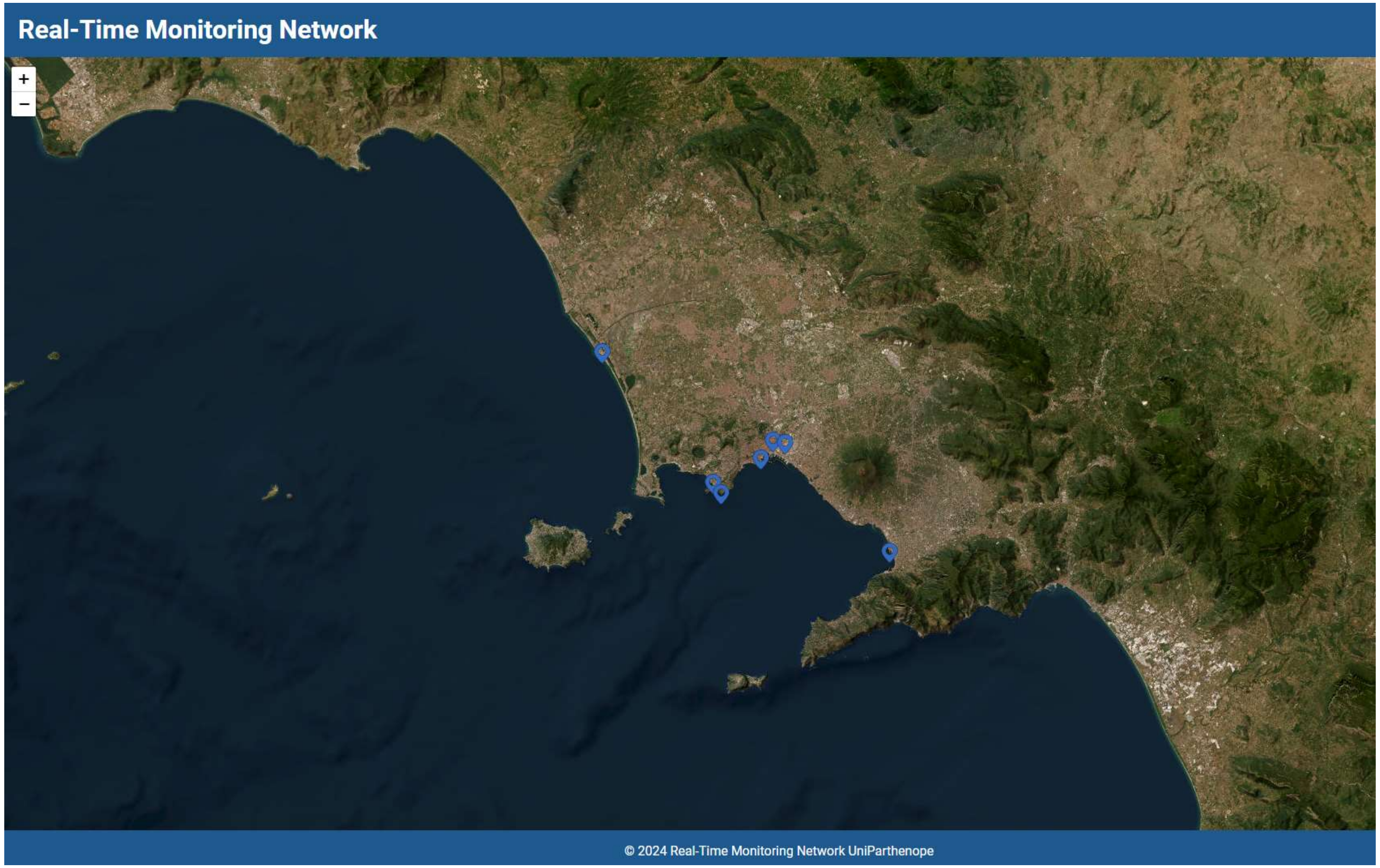
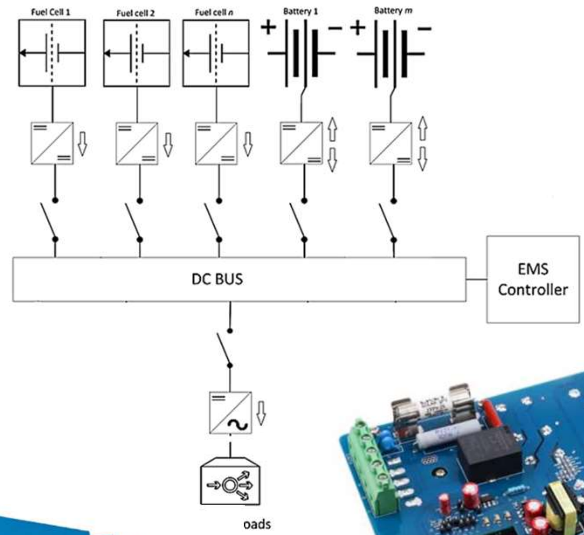
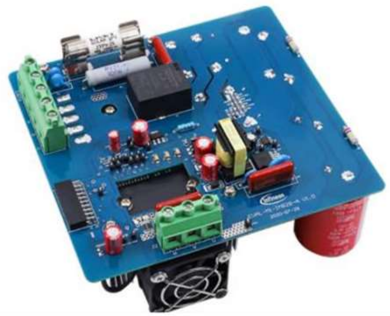


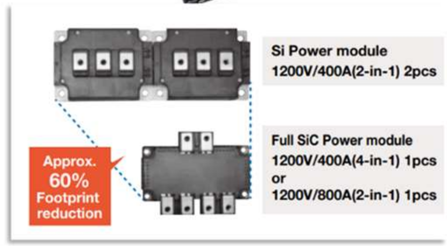
Specific applications – Energy Roadmap

Objectives
- Technology transfer of methodologies for design and smart energy management of ship microgrids and low carbon energy sources
- Technology transfer of techniques for improved and more efficient management of electrical systems on board

Approach
- Optimal design and energy management of hybrid sources (FC/ESS) and efficiency oriented control of variable velocity actuators







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- Di Piazza M.C., Pucci M., Techniques for Efficiency Improvement in PWM Motor Drives, Electric Power Systems Research, 136 (2016): 270-280

Specific applications – Logistics

Objectives

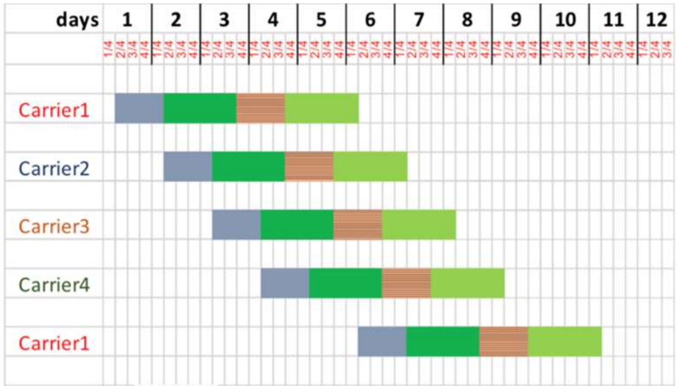
- Technology transfer of optimization methods for port logistics

Approach

- Exact and heuristic methods for the solution of problems connected with berth scheduling aimed at synching the operations at the ports

References

- Cervellera, C., Gaggero, M., Maccio, D. (2019). A Receding Horizon Approach for Berth Allocation Based on Random Search Optimization (pp. 1-12). Advances in Optimization and Decision Science for Society, Services and Enterprises, AIRO Springer Series 3.



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