The Digital Twin Research Infrastructure ShIL - Ship In the Loop -

Prof. Michele Martelli





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UNIVERSITY OF GENOA

35000 Students 1300 Teaching Staff 1400 Administrative & Technicians Staff

5 Schools Math, Phys & Chem Medicine Economy and Social Sciences Literature & Languages

Polytechnic school



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Polytechnic school 5 Departments DIBRIS DICCA DIME DAD DITEN **Electronics Electrical** Engineering Engineering **Naval Architecture & Marine Engineering**



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Naval Architecture & Marine Engineering Historical background

"Regia Scuola Superiore Navale", founded in 1870 in 1924 transformed into "Regia Scuola di Ingegneria Navale", which represented the very beginning of the future Faculty of Engineering in Genoa.



Benedetto Brin - il padre della Regia Marina (US della Marina Militare).



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Naval Architecture & Marine Engineering Section

19 Teaching Staff4 Technicians15 PhD and contract researchers

450 Students (BsC, MsC) – Genova Naval Architecture & Marine Engineering

450 Students (BsC, MsC) – La Spezia Pleasure Craft Engineering & Yacht Design

50 Students (BsC, for Navy Cadets) – Livorno Naval Architecture & Marine Engineering









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Locations





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The ShIL Project

- The ShIL (Ship-In-the-Loop) research infrastructure is a project developed by DITEN, DIME and DIBRIS departments of the University of Genoa and DTLM.
- ShIL is a co-simulation Power-Hardware-In-the-Loop (PHIL) environment in which ship board microgrid, port, cyber range ar ship dynamic behaviour tests can be drive simultaneously.
- The project, started in 2020 is co-founded by Regione Liguria.



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The ShIL Project

- The project is based on 3 infrastructures located in Genova, Savona and La Spezia
- 4 macro areas that are managed by the University of Genova,
- the 4 macro-areas are: Electrical, Marine, Mechanic and Telecommunication Eng.





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The ShIL Research Infrastructure





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The ShIL Research Infrastructure



Control room k[®] ⊜ 🤎 Full bridge simulato Ship Model Testing UniGe DITEN polo Elettrico JniGe DITEN polo Nava N 🗎 🖷 GRAAL N 🗎 🖤 niGe|DITEN polo Elettrico 5G - Fog Computing Electricmarine Lab Inal-PT real time sin IR cat. iniGe | DIBRIS Battery Energy Storage Sys DUIN UltraCapacitor Storage Photovoltaic System Com Std Network mart protection des OPC UA (62541) Analog I/O IEC - 61850 Cloud wer amplifier and nower **IEEE 1516 (HLA)** Digital I/O WAN LAN Powe connection UniGe | DIBRIS **TPG Fuel Cell** IR cat.II IET 5G TNT Lab. CsecLab Cyber range and IoT External UniGe DIM UniGe DITEN polo IC Supply **IR cat.II VINC** IniGe Campus di

- The bridge simulator is the hub of the project
- It allows to model the entire development framework (considering human interaction) and it is linked with all the simulators and emulators.
- The bridge facility will simulate a realistic operative condition in a co-simulation real time between all the infrastructures.



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Intro - Ship model testing

The testing facilities is composed of three different connected and cooperative subsystems:

- (i) Bridge simulator class C
- (ii) Model-scale ships

(iii) Sensors (Camera, Lidar, IMU, GPS)





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Intro - Ship model testing

Hardware and software infrastructure to simulate in the time domain the behaviour of a complex system such as a ship.

It allows the study, development and testing of new solutions both in a controlled environment (indoor) and on the field (outdoor):

Possible use during the whole ship life cycle:

- Preliminary Design
- Construction
- Operations





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COMPASS Lab







Ship Bridge
 Simulator
 Towing tank and pools









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Remote Control
 Stations

Model-Scale Ships

NAVAL ARCHITECTURAL SERVICES



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This project has received funding from the European Union's Horizon 2020 research and Innovation programme. Project No. 856887

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Model Based Design

Support for innovative projects:

- Development of *ad-hoc* mathematical models (or use of already validated libraries)
- Implementation and integration in the simulator
- Creation of realistic scenarios for testing before to ship availability
- Performance evaluation and optimisation



OPTIMIZE

DESIGN

MODELLING





TEST



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Autonomous Navigation

Supporting the digital transition:

- Development of decision
 support tools
- Propulsion control logic
- Ship motion control systems
- Remote control





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Case Study: Simulator Development

Development of time domain simulators for the design of propulsion systems and the study of manoeuvring characteristics:

- Development and testing in a controlled environment of new design solutions
- Comparison of design solutions
- Performance evaluations



Case Study: Decision support system

- Decision support tools to increase the level of ship autonomy:
- Development of dedicated control logics
- Parameter tuning and optimisation
- Testing in realistic scenarios of manoeuvring in restricted waters





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Case Study: Collision Avoidance

Development and testing of advanced navigation systems:

- Verification via navigation simulator of algorithms and their compliance with international rules (i.e. COLREGs)





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Case Study: Obstacles detection

On-site preliminar testing







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Case Study: Situational Awarness

Testing in relevant enviroment (onboard) of complex system





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Stakeholders

- Shipyards
- Automation Provider
- Classification Societies
- Authorities
- Universities & Research centers



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Thank you for your attention!

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