

 NTNU

Norwegian University of Science and Technology

Romanian - Norwegian Strategic Cooperation in Maritime Higher Education for enhancement human capital and knowledge base in field of marine intelligent technologies

M1. Workshop on “Cooperation and partnerships between education and labour market on marine intelligent technologies”

Researches in NTNU IHB


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1


 NTNU

Outline

- NTNU IHB labs
- NTNU IHB research facilities

2

2



NTNU

Three profession groups

Maritime technology

Ship and Nautical operations

Smart infrastructure


- System & vessel design
- Control and optimization
- Simulation and co-simulation
- Intelligence system
- Ship intelligence
- Renewable energy
- Type approval
- ...

- Risk management
- Operational planning
- Troubleshooting
- Training
- Human factors
- Integration, testing and acceptance
- Interface management
- Change Management
- Commissioning support
- Certification & Classification
- ...

- Smart water
- Structural engineering
- Smart building
- Structural dynamics
- Asset management
- ...

3

3



NTNU

Core technology

Maritime technology

Ship and Nautical operations

Smart infrastructure

Modelling and simulation

Visualization

Data Driven

Control & optimization

Digitalization

AI

IoT

Big data

Cyber Security

Sensor fusion

Human factor

4

4



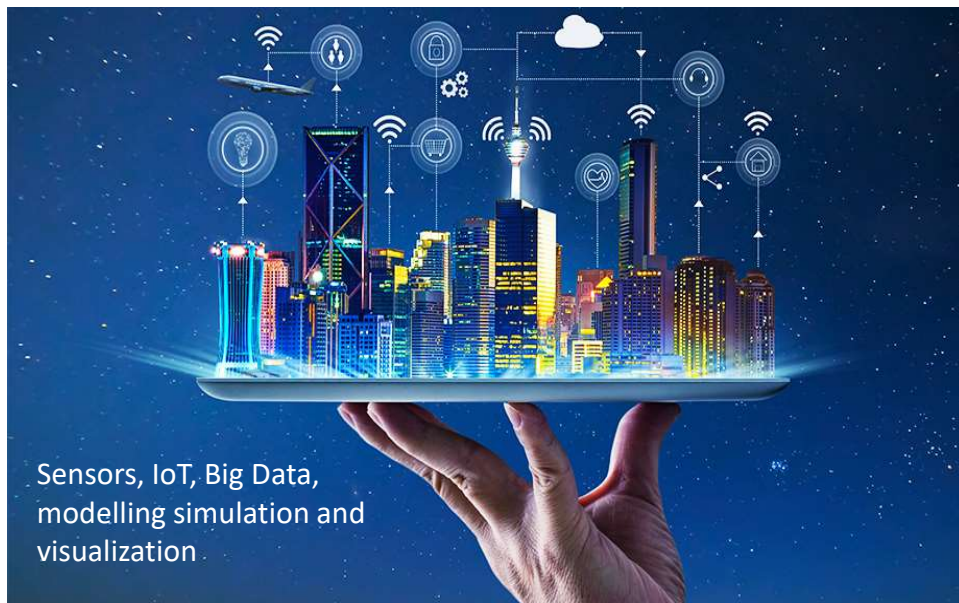
Research from profession groups

- Smart infrastructure
- Shipping and nautical operations
- Maritime technology

5



Digitilizing infrastructure for future smart cities



Sensors, IoT, Big Data,
modelling simulation and
visualization

6

6



Smart Water

- * Stormwater Management
- * Smart Water and Wastewater Tech
- * Infrastructure Asset Management
- * Digital Twinning of Water infrastructure
- * Climate Resilient Water infrastructure
- * Smart Water Quality Monitoring
- Smart Water Buildings
- Waste- Energy buildings and cities
- Lab-on-chips



7

7



Structural Dynamics

- Structural dynamics
- Force and response identification
 - Structural health monitoring
 - Ice-induced vibrations
 - Ice-structure interaction



8

8



Research from profession groups

- Smart infrastructure
- Shipping and nautical operations
- Maritime technology

9



Focusing on central developments creating operative challenges in the maritime sector

- Our projects have an operative angle to understand ramifications of developments like
 - Increased focus on autonomy
 - Challenges arise as new divisions of work between land and shore develop
 - New questions concerning situational awareness emerges
 - New business models due to possibilities created through digitalization
 - Creates challenges in terms of organizational structures and professional practice
 - How technological developments creates new challenges in respect to (cyber)security
- New competence requirements emerges as an effect of changes in the industry
 - Important drivers are emphasis sustainability, circular economy, digitalization and so forth

10

10



Situational awareness

- Focusing on demanding marine operations **situational awareness** permeates research questions of master thesis, PhD projects and research projects in general.
 - In real life situations and simulations



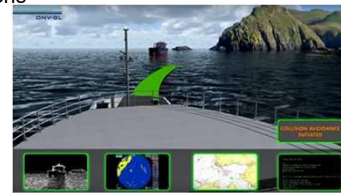
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11



Operative challenges in the wake of technological developments towards increased autonomy

- Research angles to this topic include:
 - **Man- Machine interaction**
 - 1) With a cross-disciplinary focus on hydrodynamics and human factors is adopted to improve simulation of nautical operations
 - 2) Understanding human performance within such systems
 - **Coordination and control systems**
 - How are coordination and control in established maritime systems challenged by autonomy?
 - How to do design control centers which ensures capable operators with a good situational awareness?
 - How to ensure a focus on the human element in the various discussions of autonomy?



12

12



New business models have organizational and professional ramifications

- Research projects on the relationship between digitalization and organization include a focus on:
 - Human perspective
 - How are the work of the professional practitioner affected?
 - What are the human consequences?
 - Organizational structure and power
 - What will be the future shipping office?
 - How to develop dispersed teams divided by shore and land?
 - How do business models like «Power by the hour» affect organizational relationships between supplier and ship owner?
 - Work and coordination
 - How does market change affect work practices, and can augmented reality solutions facilitate the information flow?



13



Research from profession groups

- Smart infrastructure
- Shipping and nautical operations
- Maritime technology

14



Research labs (Marine technology group)

- Machinery System Lab (Æsøy)
- Intelligent System Lab (Zhang)
- Ship Operation and Design Lab (Halse & Gaspar)

15

15



Maritime technology

- Renewable energy and Green shipping
 - Low emission propulsion (alternative fuels, abatement technologies...)
 - Zero-emission power systems (batteries, hydrogen)
 - Hybrid power systems and renewables
- Digitalization and knowledge transformation
 - Smart water, smart building and smart city
 - Twinship
- Demanding marine operations
 - Smart sensors and digital twins
 - FEA, CFD -
 - Early warning, prediction, and optimization
- Industry 4.0
 - Lean manufacturing - MANULAB

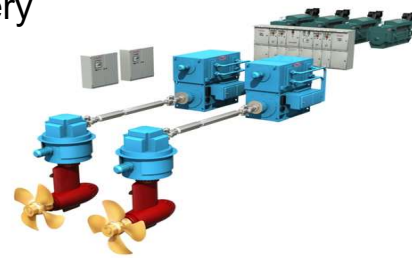
16

16



Machinery System Lab

- Integrated Machinery Systems – modelling and simulation
- LNG fuel systems dynamics and combustion processes
- Propulsion machinery – ice interactions
- Energy management system optimization
- Modelling and simulation of machinery
- Ballast water treatment and management (MNFF)
- Bio-fuels and synthetic fuels
- Waste heat recovery



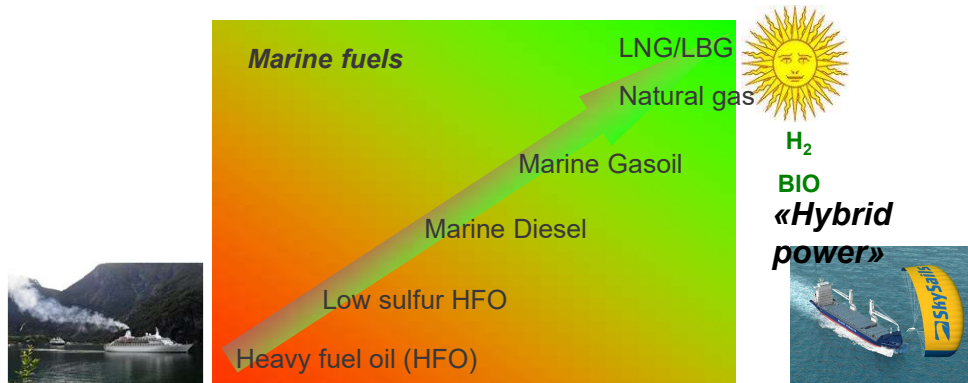
17

17



Renewable energy

- Cleaner and Smarter Propulsion systems



Renewable
alternatives... ?

Wind, solar, wave, current

18

18



Manufacturing Lab

- Sustainable manufacturing
- Manufacturing process design
- Process monitoring, machine learning and machine vision
- Prototype verification
- Industry 4.0



21

21



Intelligent System Lab

- Digitalization and automation of marine operation
- Modeling and simulation
 - Dynamic models
 - Co-simulation
- Decision support systems
 - AI and machine learning
 - Human-in-the-loop control
 - Human machine interaction



22

22



Outline

- NTNU IHB labs
- NTNU IHB research facilities
- Intelligent systems lab

23

23



NTNU R/V Gunnerus ship

- R/V Gunnerus ship was put into operation in spring 2006
- Gunnerus is used for a variety of research activities within biology, technology, geology, archeology, oceanography and fisheries research
- Gunnerus is equipped with various onboard sensors
 - Radar
 - GPS
 - Compass, gyro
 - AIS
 - Heading, attitude, positioning sensor
 - ...



Parameter	Description	Value
m	Mass of vessel	370 t
DWT	Deadweight	107 t
L_{pp}	Length between perpendiculars	28.9 m
Bm	Breadth middle (m)	9.6 m
dm	Draught (m)	2.7 m

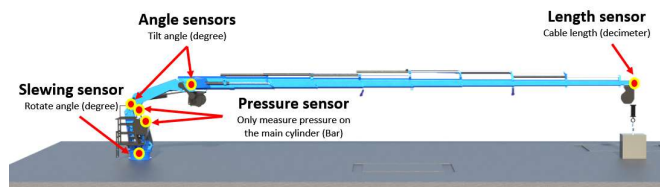
24

24



NTNU R/V Gunnerus ship

- Shipboard crane
 - Palfinger crane PK65002M
- Onboard sensors
 - Slewing sensor
 - Angle sensor
 - Pressure sensor
 - Outer boom length sensor



Parameter	Value
Max. lifting moment	62.0 mt
Max. lifting capacity	22000 kg
Max. hydraulic outreach	20.4 m
Slewing torque with 1 gear	4.5 mt
Stabilizer spread (std)	8.6 m
Max. operating pressure	365 bar
Dead weight (std)	5040 kg

25

25



NTNU R/V Gunnerus ship

- Main generators
 - 3 x Nogva diesel engines
- Measurements
 - Engine speed
 - Temperature
 - Pressure
 - Fuel consumption
 - ...



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26

26



NTNU research lab at Ålesund

- We have built a research lab for the Gunnerus ship:
 - Professional immersed simulators
 - Data transmission and storage
 - Remote access capabilities
 - Teaching & research activities



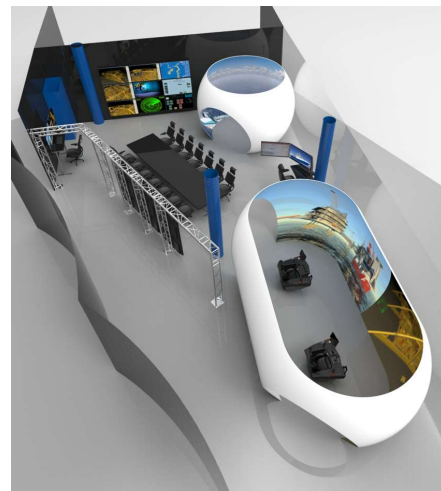
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27



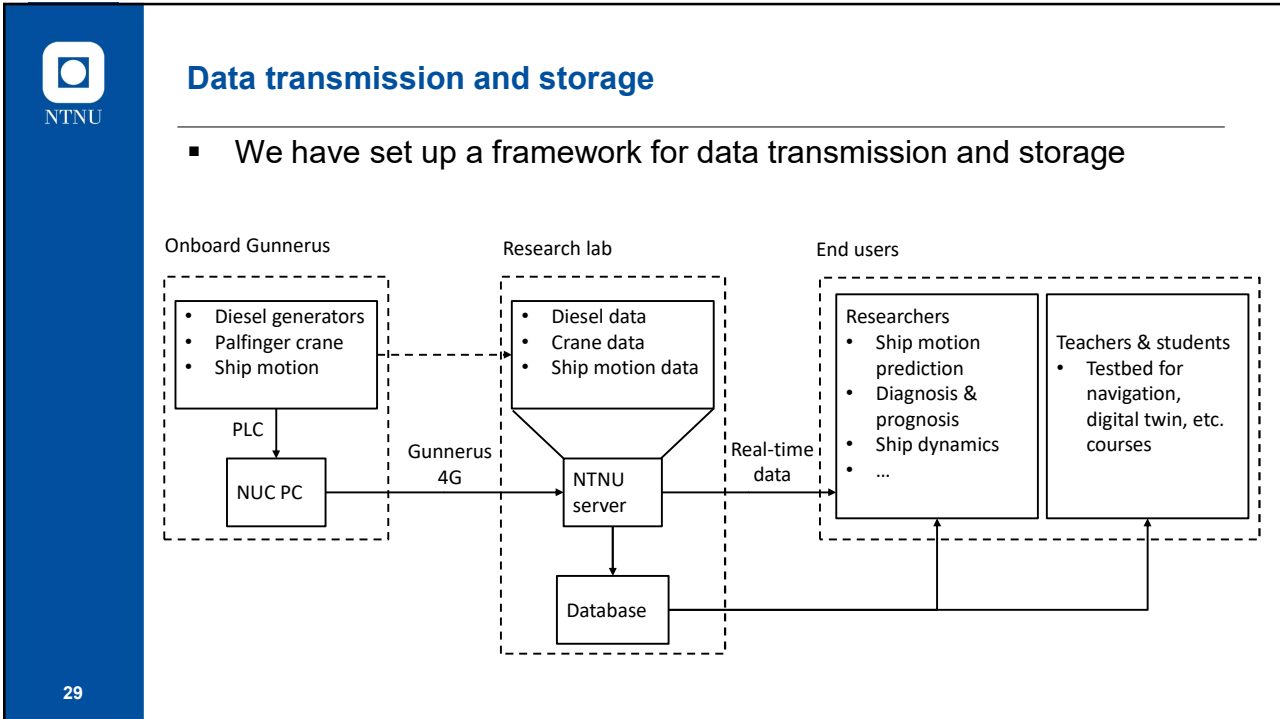
Professional immersive simulators

- Provided by Offshore Simulator Centre AS (OSC)
 - Real physics
 - Professional visualization
- Two domes in the lab
 - Stretch dome
 - Marine operation
 - Small dome
 - Navigation



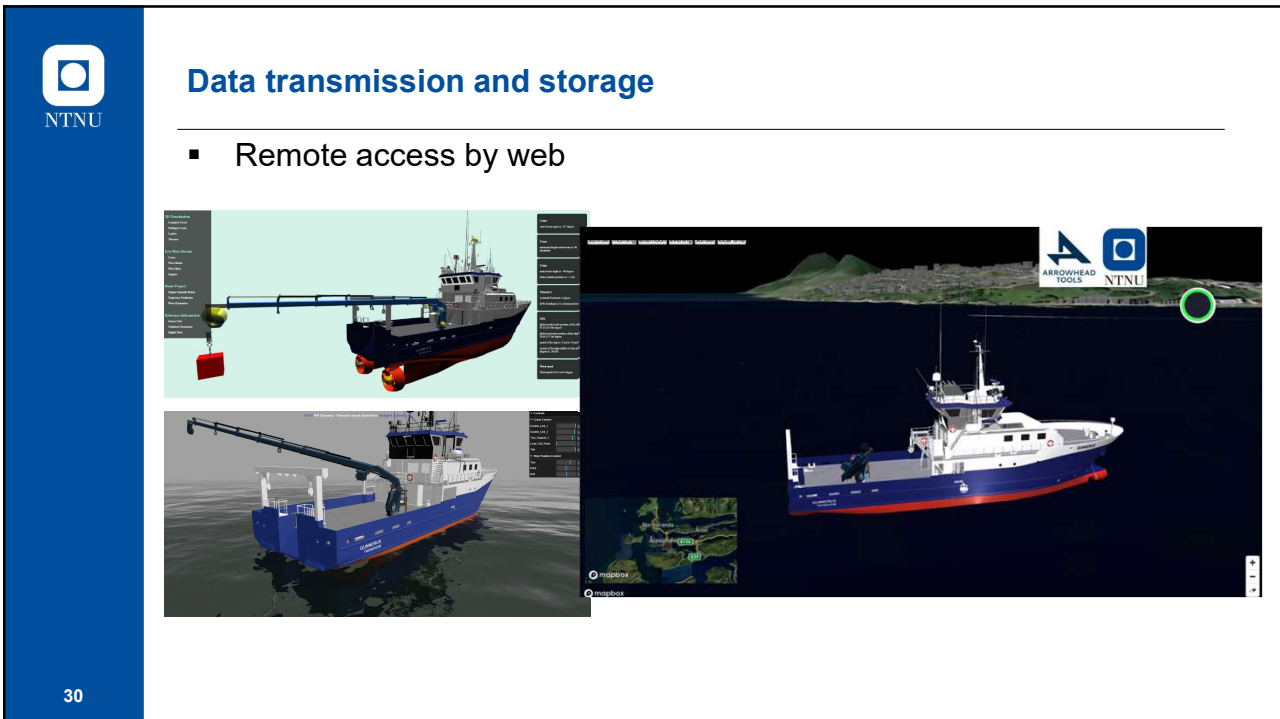
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28



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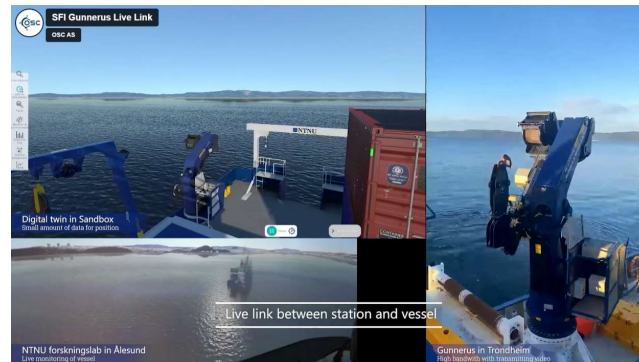
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30



Remote access capability

- The simulators can receive remote sensor data and monitor/visualize Gunnerus operations
 - 4G signal
 - Real-time transmission



31

31



Teaching & research activities

- Teaching activities
 - Navigation tasks for nautical students
 - Experimental testbed for new courses
- Research activities
 - Development of onboard support tools
 - Sea trials test for model parameter identification
 - Human factor related research

32

32