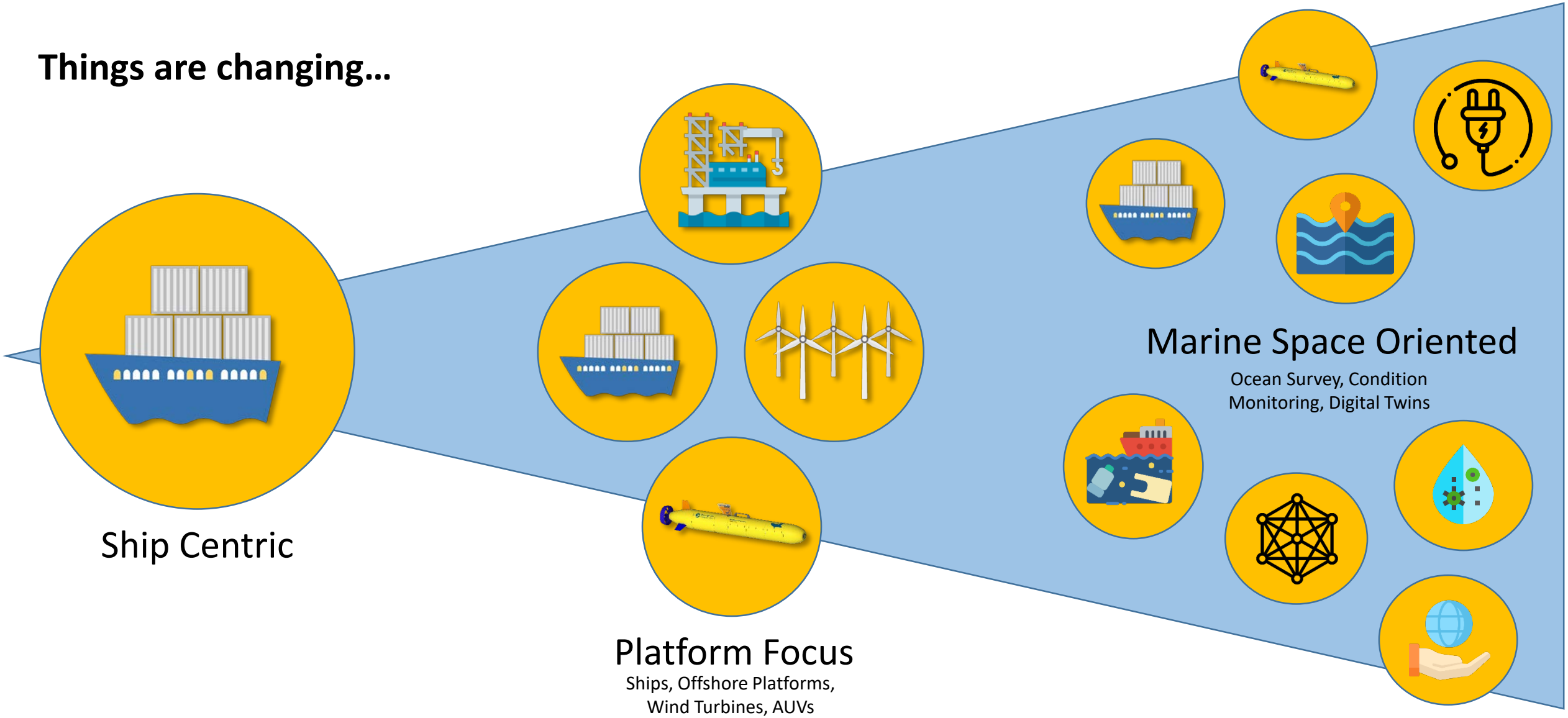
Automation and Control Systems in Marine Engineering Education

Jing Sun, Michael G. Parsons Collegiate Professor and Chair

NAVAL ARCHITECTURE
& MARINE ENGINEERING
UNIVERSITY OF MICHIGAN

Transformation in the NAME Fields

Things are changing…



Ship Centric

Platform Focus

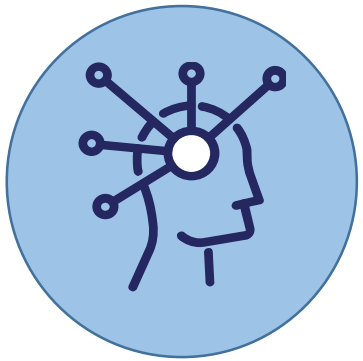
Ships, Offshore Platforms,
Wind Turbines, AUVs

Marine Space Oriented

Ocean Survey, Condition
Monitoring, Digital Twins

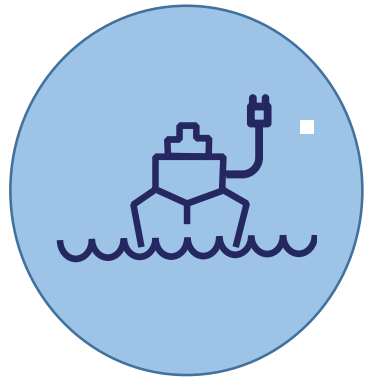
Shifting Paradigms in the Marine World

Autonomy

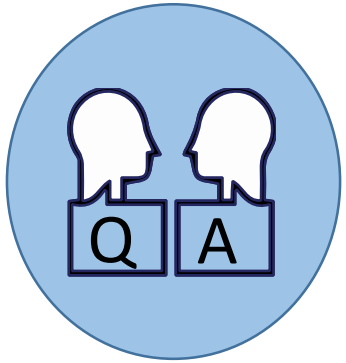


Sensing

Active Control



Electrification



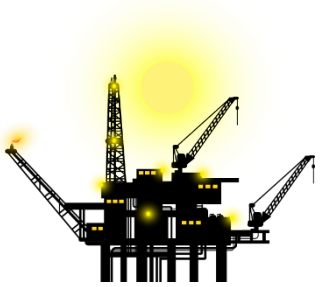
Real-Time
Decision Support

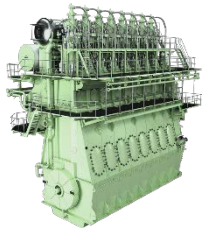
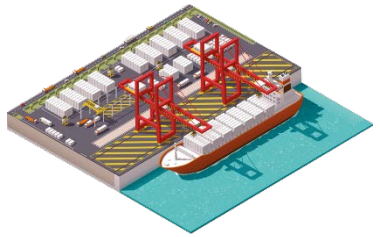
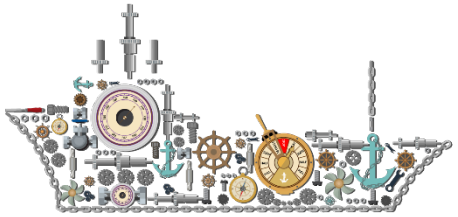
Control and Automation

- Multi-disciplinary nature

- Generic design principles applied to specific domain
  - Feedback
  - Dynamics
  - Estimation/perception
  - Real-time optimization
  - …
  - Hydrodynamics
  - Structures
  - Power and energy systems
  - Underwater vehicles
  - …

- Control as the “integrator!”




Control Engineering Foundations and Applications

- Foundations:
  - Math
  - Signals and systems
  - Estimation and optimization

- Applications
  - Domain knowledge in AERO, CEE, ChE, EE, ME, **NAME**
  - Mechatronics
  - Software and coding skills

Control Engineering Education

- Control curriculum
  - Engineering generic vs. domain specific
  - Undergraduate vs. graduate

- Control courses at the University of Michigan

Control Engineering Course Offering at UM

	General	Domain Specific
UG	Modeling and Control of Dynamic Systems (ME) Control Systems Analysis and Design (co-listed)	Flight Dynamics and Control + 2 others (AERO) Electric Machines and Drives, Power Electronics (EE) Autonomous Robotics Embedded Control (EE) Power System Design and Operation (EE) **Marine Control Systems (NAME)**
G	Control Systems Analysis and Design (co-listed) Linear Feedback Control (co-listed) Nonlinear Systems and Control (co-listed) Stochastic Control (EE) Design of Digital Control Systems (co-listed) **Adaptive Control (NAME)** Reinforcement Learning Theory (EE)	Dynamics and Control of Spacecraft + 5 other (AERO) Dynamical Infrastructure Systems (CEE) Analysis of Electric Power Distribution Systems and Loads (EE) Control of Advanced Powertrain Systems, Vehicle Dynamics and Control, Hybrid Electric Vehicles, Battery Systems and Control (ME) Introduction to Robotics, Robot Kinematics and Dynamics, Robotics Systems Laboratory (ROB) **Marine Robotics (NAME)** **Mobile Robotics (NAME)**

Other Training and Development Opportunities

- Other transportation system industries:
  - Automotive

  - Aerospace

- Professional Societies
  - IEEE Control System Society (8000+ members)
  - ASME Dynamic Systems and Control Division

Concluding Remarks

- Marine systems are becoming more “control-intensive”
- Control and other “soft-engineering” skills are becoming essential for marine engineers to succeed in the new digitalized, electrified, and automated marine world
- Feedback and dynamics are two key foundational subjects, as essential as math
- The multi-disciplinary nature requires us to leverage resources across disciplines, institutions, professional societies in education and workforce training.