Deepwind Conference 2018, Trondheim, Norway

D-ICE Engineering

D-ICE ENGINEERING

Services & Products

Arctic Engineering

Dynamic Positioning
Basin Tests
Full Scale Tests
R&D

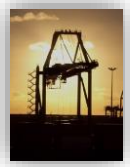
Dynamic Positioning

Design & Simulations
FMEA & Commissioning
Complex Operations
R&D

Offshore Engineering

Hydrodynamics studies (BEM, CFD,...)
Simulations
Design
Metocean analysis
Route Planning

D-ICE ENGINEERING



Drilling Engineering

Drilling Control R&D
Drilling Simulations

Your partner for your innovative projects

Marine Energies

Offshore Wind
Control Systems design
Transport, Installation & Maintenance
R&D

Services – R&D

Control Engineering
System Engineering
Applied Mathematics
IT & Algorithms
Big Data
Simulations
...

OCEANiCS

Ocean intelligent Control Systems

Route Optimization
Advanced Monitoring & Aid-Decision
Autonomous Vessels
Foil Control Systems

Proud Member of

neopolia

Membre PÔLE MER BRETAGNE ATLANTIQUE

POLE AVENIA MEMBRE 2017

About us...

D-ICE ENGINEERING

R&D Company founded in 2015
Offices in Nantes & Paris (France)
11 PhDs & Engineers

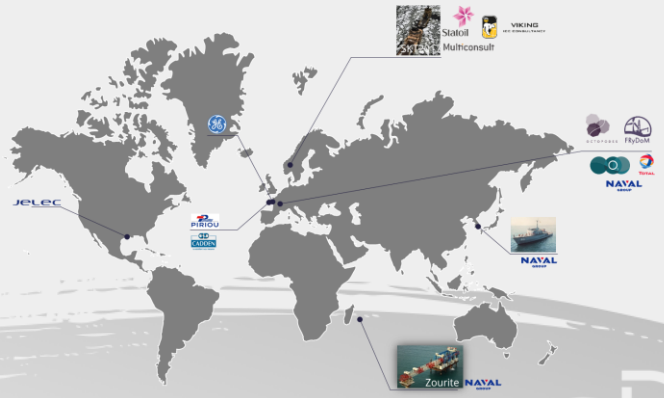
Data Science

System Engineering

Hydrodynamics

Control

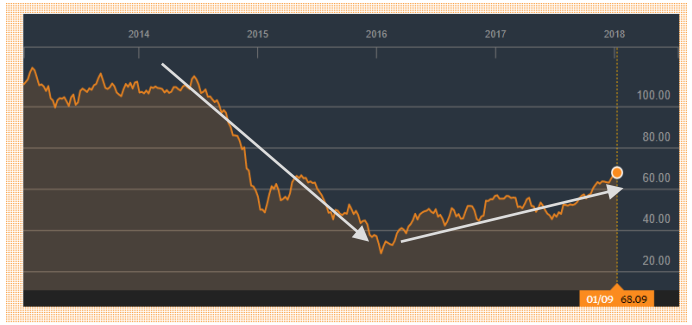
Worldwide Projects



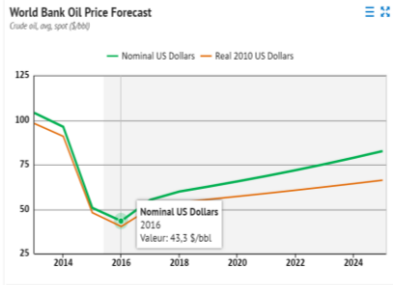
Technological, Economical & Societal Context

Economical Crisis

- Conventional energy has experienced one of the most severe crisis in 2015 (60% of price fall fot the brent crude)
- Slow recover since 2016
- However world Oil demand is still increasing
- But the situation has changed

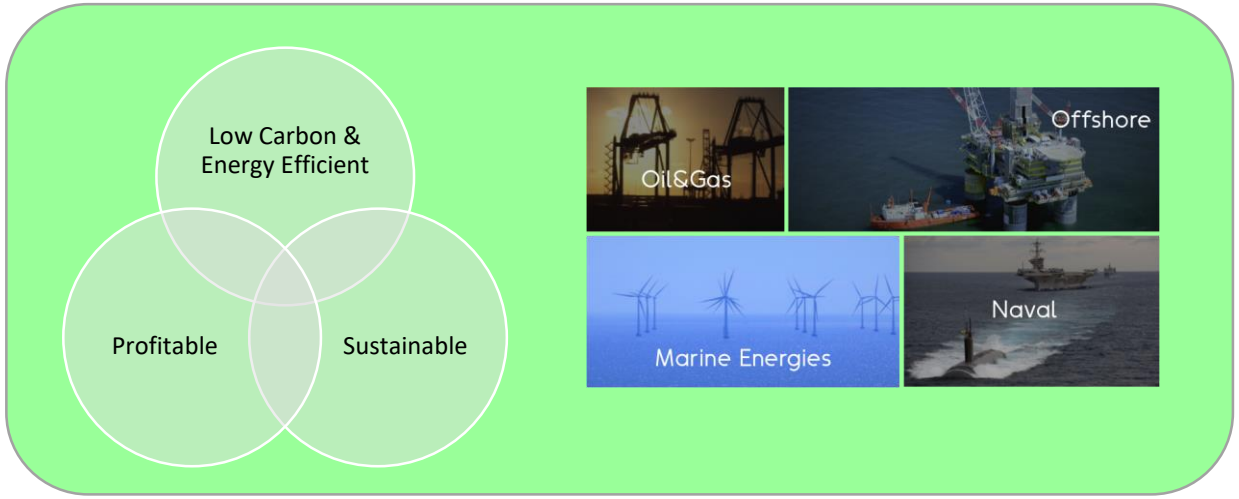


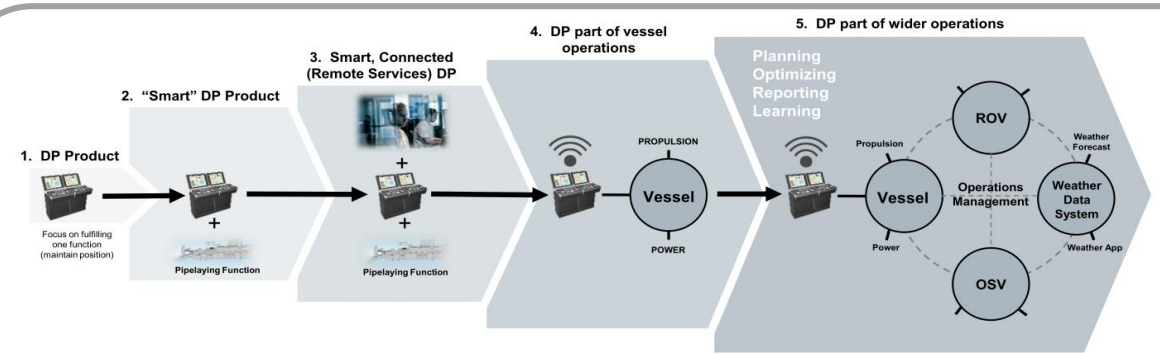
Source : bloomberg



Oil Price Forecast end of 2016
Source : Knoema

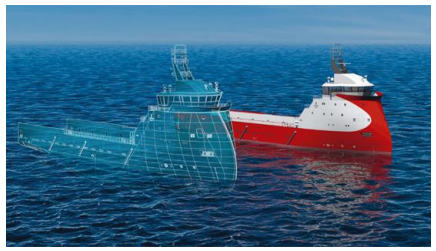
Our Goals





WHO SAID THAT DP DOES NOT RHYME WITH CYBERSECURITY?, Cadet & Rinnan, MTS DP Conference 2016

Digitalization

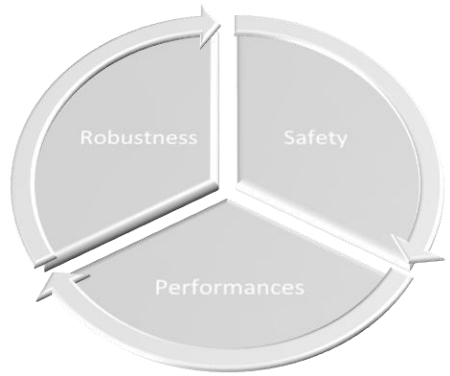


From Digitalization To 2025 by DNV

Source HSB4U

Society Challenges & Changes

Our R&D Activities



Our Philosophy

- Wave Energy
- Tidal Energy
- Offshore Wind turbine
- Floating Wind Turbine
- Autonomous Vessels & Systems

SOFTWIND

CENTRALE NANTES · cnrs · D-ICE ENGINEERING

COFLOWING**

Agence Nationale de la Recherche ANR

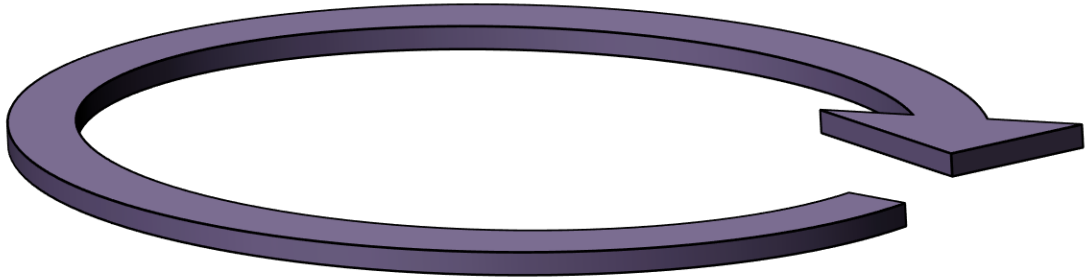
CONTROL

bpifrance

OCTOPODES

FLOATEOLE*

CENTRALE NANTES



SECURITY

MADNESS***

Ellidiss Technologies · université de bretagne occidentale · Lab-STICC · D-ICE ENGINEERING

MODELLING

SIBIS & Sesam-ICE JIP
(DNV, Statoil, Kvaerner, Lundin, Gusto, Hsva, Multiconsult, Total)

FRyDoM

CENTRALE NANTES · cnrs · D-ICE ENGINEERING

T/I&M – OPERATIONS

O_3

NAVAL GROUP · TOTAL · D-ICE ENGINEERING

* *Supported Projects*
** *Proposals*
*** *In Mounting*

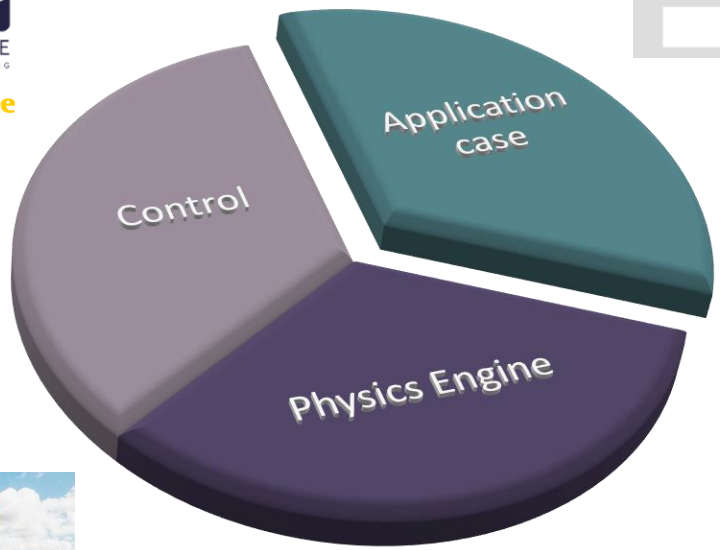
Modelling & Marine Operations

R&D Programs & Roadmap

D-ICE ENGINEERING

Modelling & Marine Operations

Current R&D Programs



DP & Tug Mooring Assist Operations

- Omnipresent throughout the life cycle of EMRs
- Any type of offshore technology involved
- Diversity and complexity + significant cost
- Risk factor (human, material, economic)
- **Important Cost Reduction Lever (LCOE)**

Floating Offshore Wind

Fixed Offshore Wind

Tidal Turbines

Modelling & Marine Operations

A real expertise from full-scale commercial operations

Video credit : NRL | youtube

EXAMPLE OF ZOURITE

DP Jackup Vessel for Offshore Construction Operations in La Reunion [France]

More details in the paper:

Challenging Shallow Water DP Jacking Operations - Design and Operational Feedback, Kerkeni *et al,* MTS DP Conference 2017

Tools

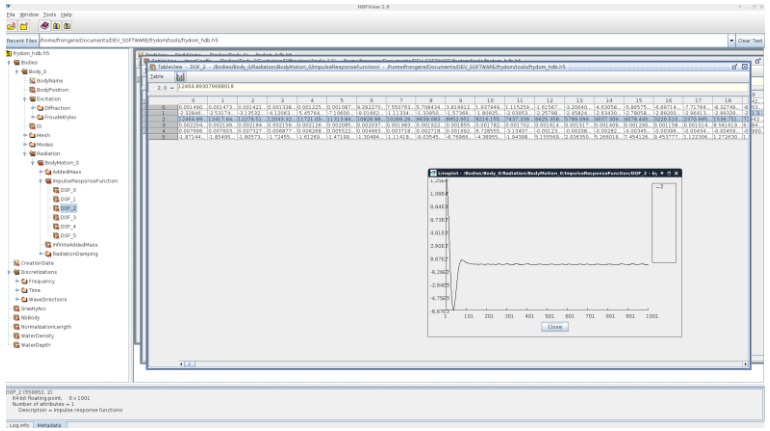
- HOS (ECN)
- Nemoh (ECN)
- FAST (NREL)
- FRyDoM (ECN/D-ICE)
- Capapy (D-ICE)
- OCEANICS (D-ICE)

Modelling & Marine Operations

Unique framework with advanced modelling tools

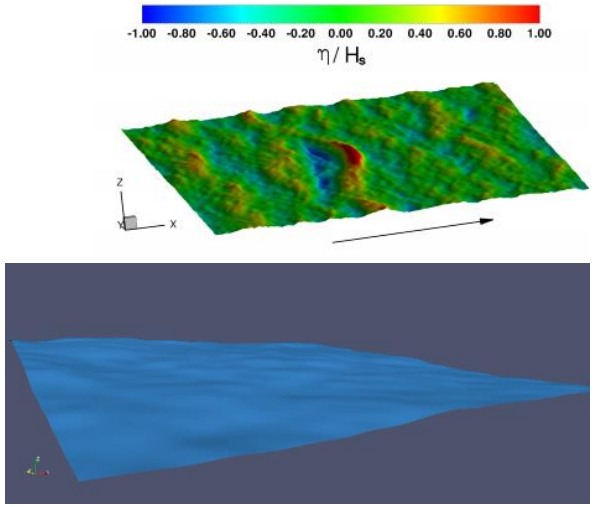
Hydrodynamics

- Hydrodynamic Damping
- Waves effects
  - First Order
  - Second Order Drift
- Current / Wind Interactions
- (Active research area)



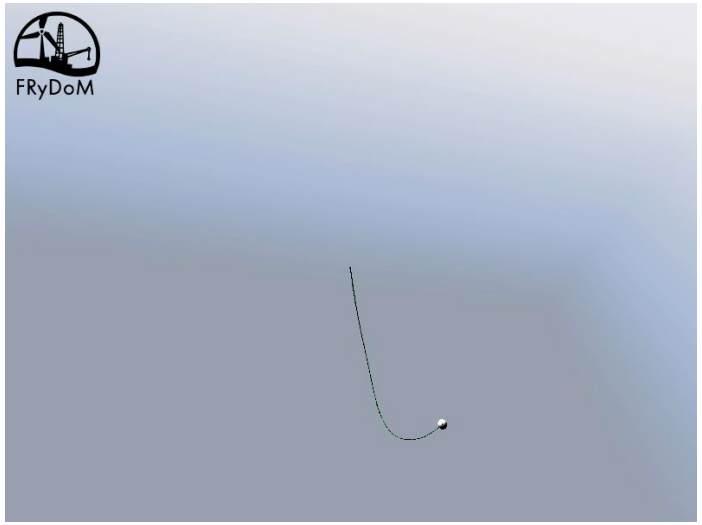
Sea States & Environments

- Linear Sea States
- Advanced Sea States with HOS-OCEAN (LHEEA)
- Wind
- Current



Cables Modelling

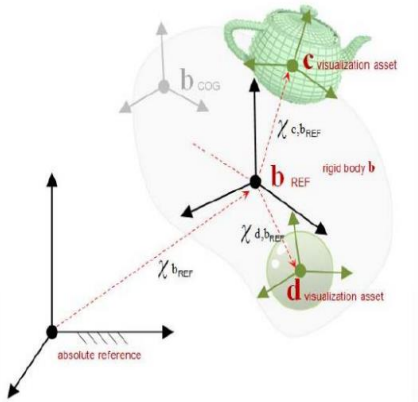
- Absolute Nodal Coordinate Formulation (ANCF)
- Large deformation, FEA

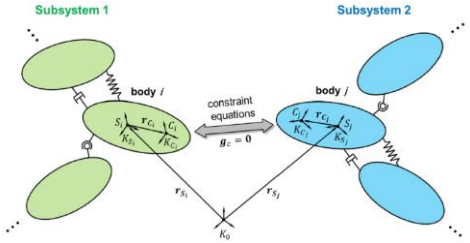


Modelling & Marine Operations

Multibody Dynamics

- Nonsmooth Constraint Rigid Body Mechanics
- Contacts & Friction
- Winch & Cranes





Software Architecture

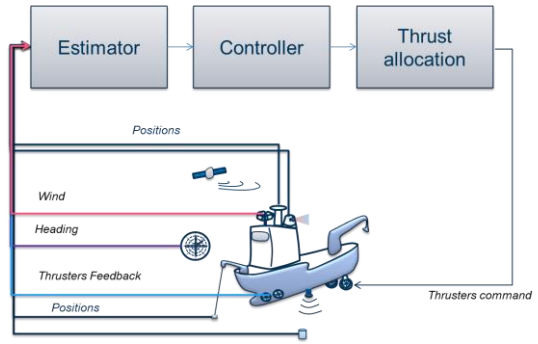
Solid workspace relying on recognized open-source solutions

- Code versioning
- Build chain
- Architecture
- Continuous
- Matrix Algebra
- Cross-platforms
- Professional IDE
- Documentation

Modelling & Marine Operations

Vizualisation

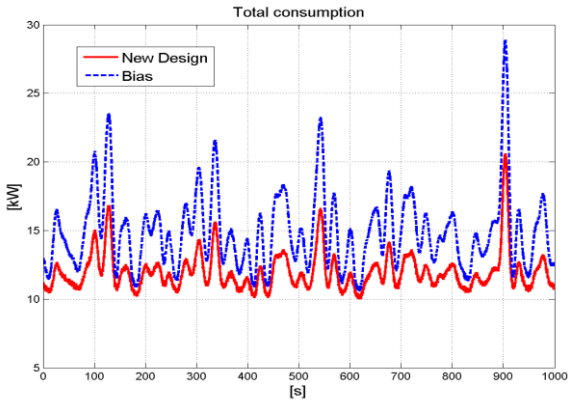
- High Resolution
- Virtual Reality Ready



DP General Block Diagram

Control Systems

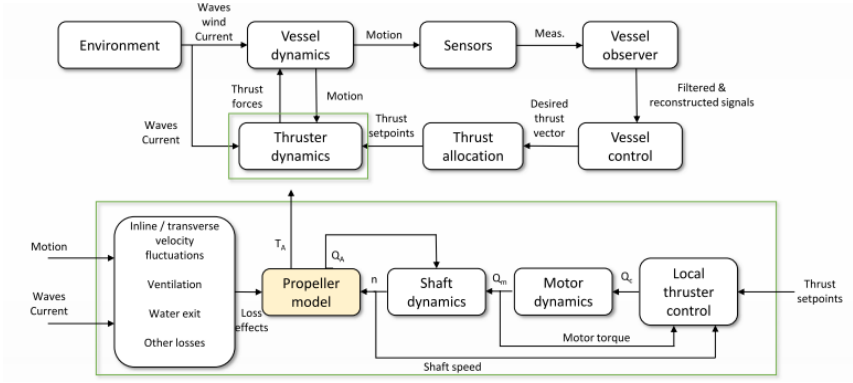
- Autopilots
- DP
- Advanced Control
- Nonlinear Filtering
- Optimization



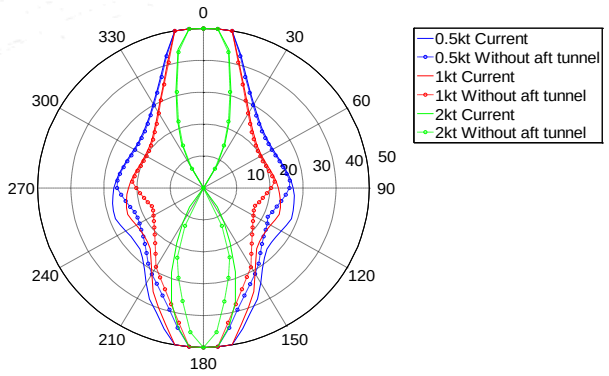
"IMPROVED COST EFFICIENCY OF DP OPERATIONS BY ENHANCED THRUST ALLOCATION STRATEGY", Kerkeni *et al.*, MTS DP Conference 2014

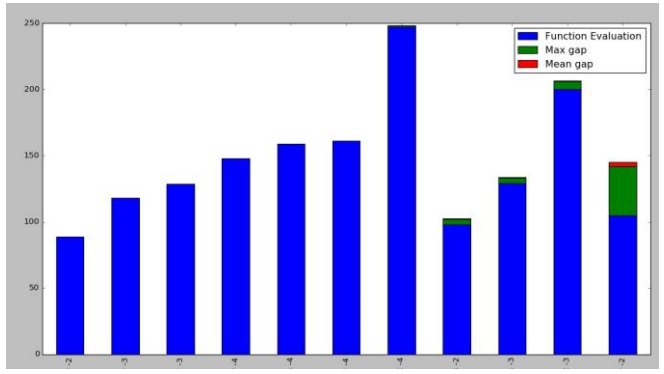
Propulsion & Thrusters

- Advanced Modelling of Thrusters
- Different Types of thrusters (azimuths, tunnels, propellers, rudders, foils)



Modelling & Marine Operations





CapaPy

OCTOPODES

*Development of advanced engineering software suite during the research project OCTOPODES – Inn**o**vative **C**on**t**rol of **O**ffshore **P**latforms, **O**ptimization and **D**esign of Marin**e** Operation**s**.*

Advanced knowledge in Hydrodynamics, Control Systems and Mathematics have then been embedded in **CapaPy**, a versatile optimization software suite dedicated to capability plots calculations. The software is based on state of the art of advanced solvers for nonlinear optimization problems.

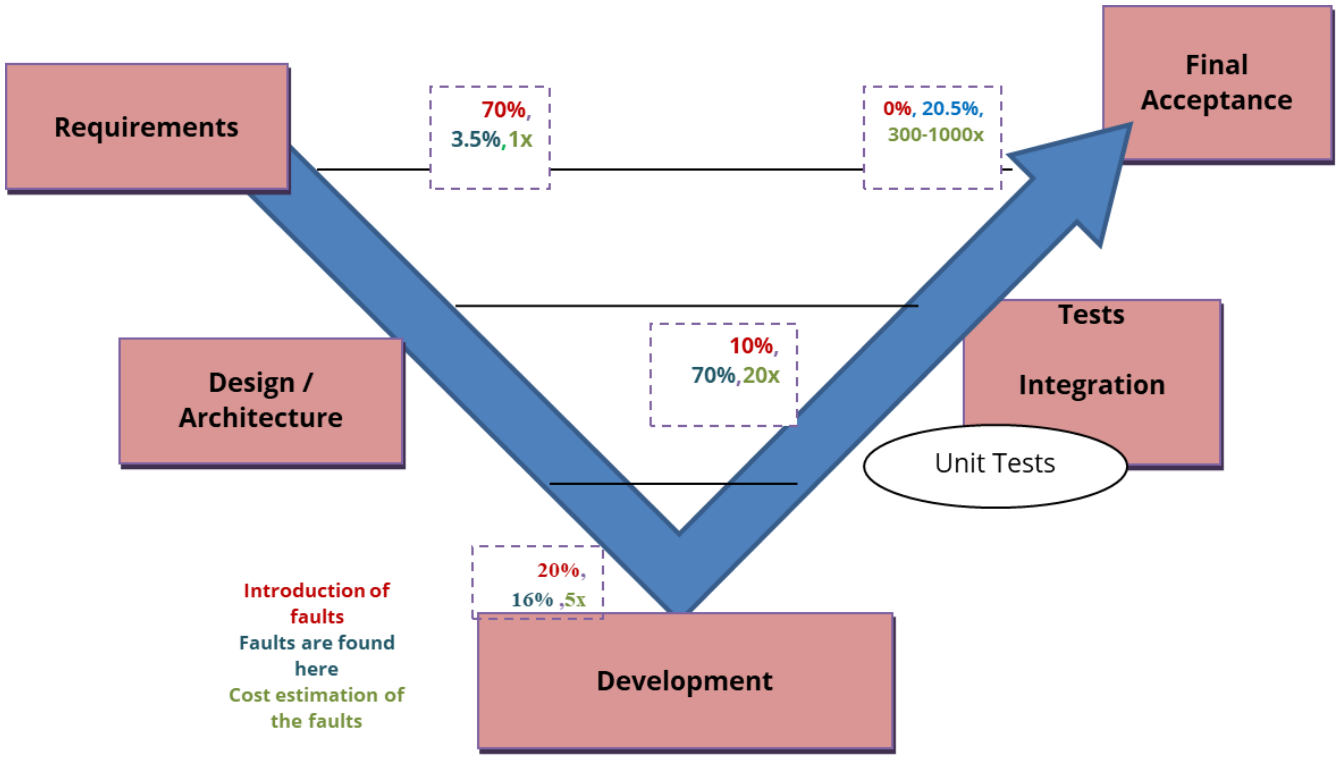
- CapaPy can solve **complex nonlinear problems** with **nonlinear constraints**.
- Written in Python, cross-platform, powerful features and a maximal flexibility.

References : O&G Majors, Shipyards, Ship Owners, etc.

SECURITY OF EMBEDDED SYSTEMS

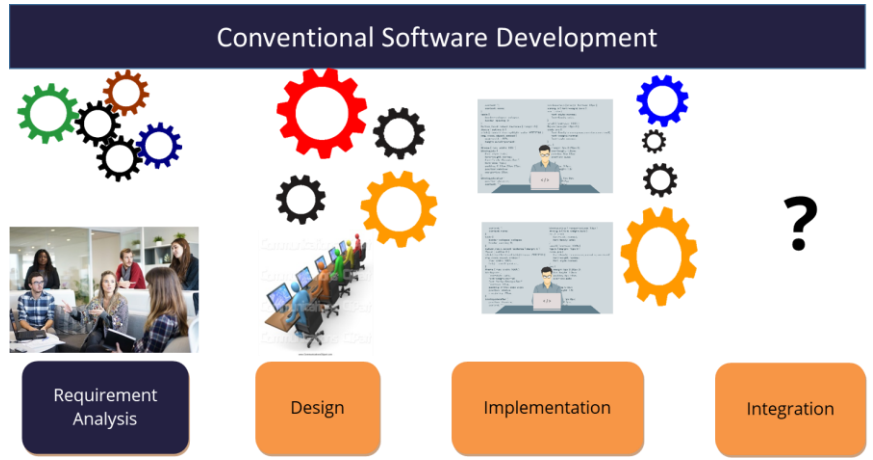
D-ICE ENGINEERING

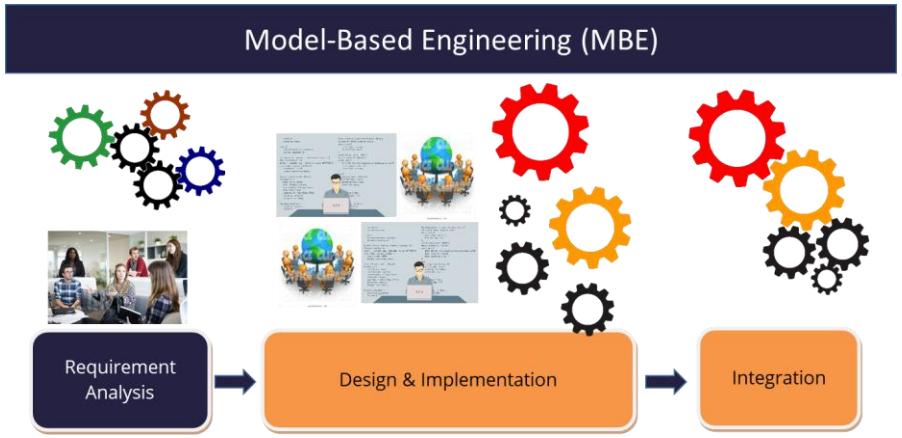
Security of Marine Embedded Systems



Experience from aeronautics sector

G. Tassey, "The economic impacts of inadequate infrastructure for software testing. National Institute of Standards and Technology, RTI Project, 7007(011).," 2002.

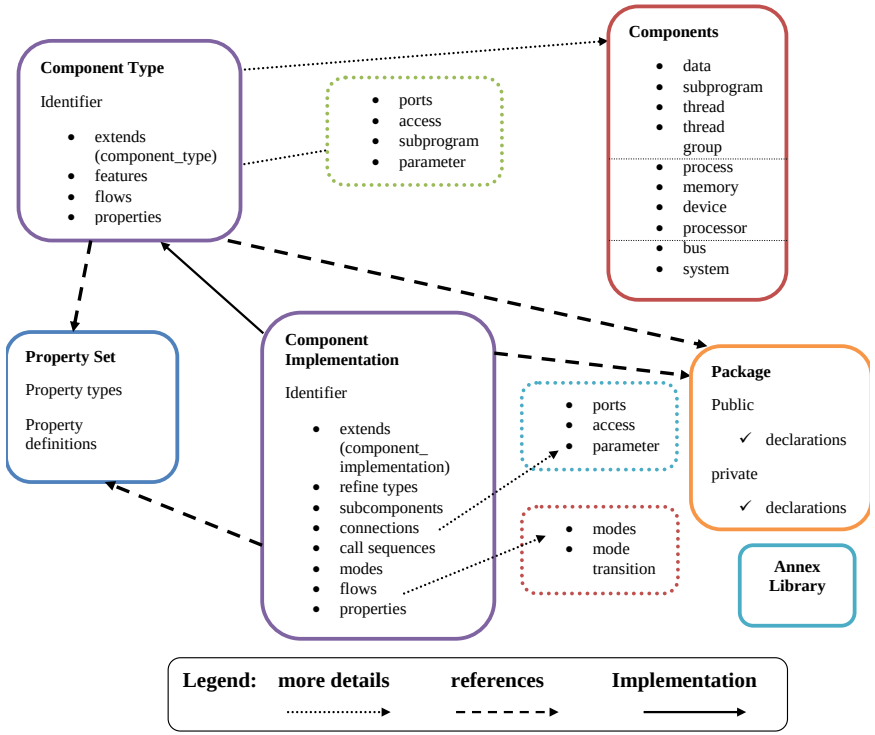


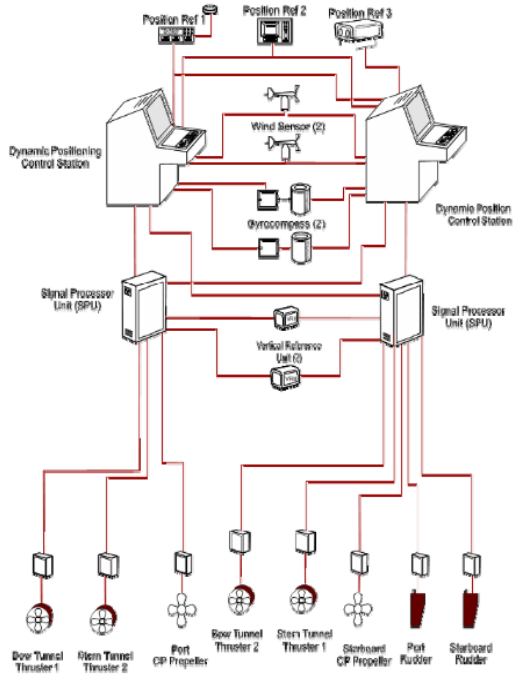


MRE Focus

- Offshore Operations are today more and more complex
- Embedded systems of increasing complexity (Hardware / Software)

Security of Marine Embedded Systems





Generic DP 2 system

```
package Library::Sensor
public

with EMV2;
with Library::Errors;

device Sensor

features
        signal : out data port;
annex EMV2 {**
        use types Library::Errors;
        use behavior Library::Errors::simple;
        error propagations
                signal : out propagation {BadValue};
        flows
                ef : error source signal{BadValue};
        end propagations;
        properties
                emv2::hazards =>
                        ([      crossreference => "N/A";
                                failure => "BadValue";
                                phases => ("all");
                                severity => ARP4761::Minor;
                                likelihood => ARP4761::Probable;
                                description => "Bad value from the sensor";
                                comment => "Alarm would be initiated but no immediate effect on
                                position keeping capabilities because of presence of alternative
                                sensors.";
                        ])
                        applies to ef.BadValue;
**};
end Sensor;
end Library::Sensor;

device implementation Sensor.impl
end Sensor.impl;
```

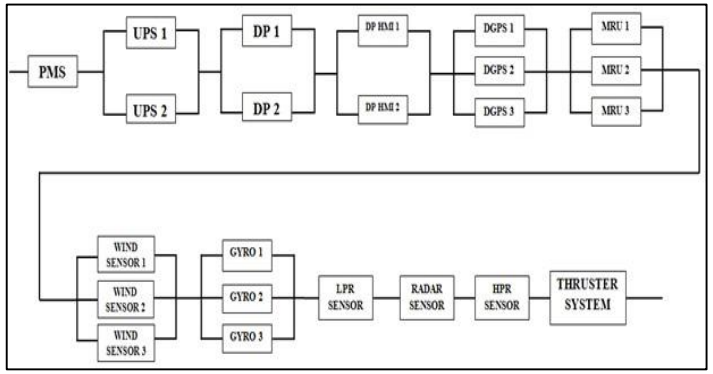
Extract of Modelling with AADL

AADL

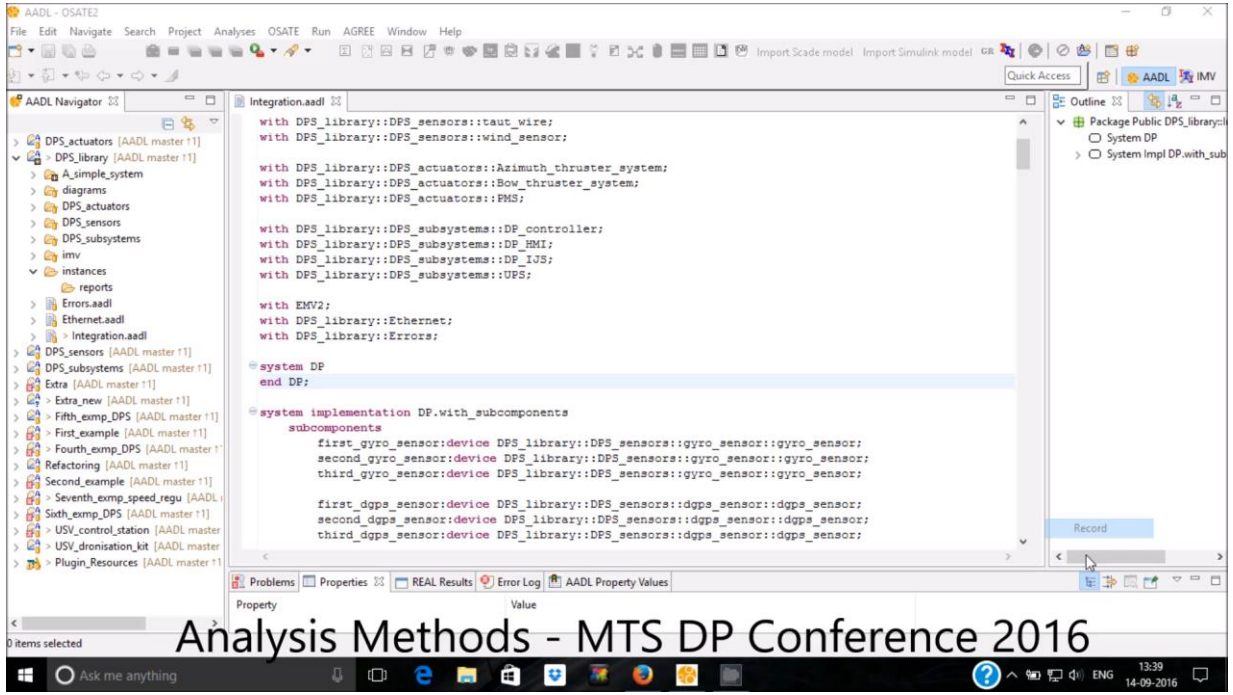
- Initiated by SAE (Society of Automotive Engineers)
- First release of OSATE (Open Source Architecture Tool Environment) in 2004 developped and maintained by Software Engineering Institute (SEI), Carnegie Mellon University
- Active community and strong ongoing works today

Security of Marine Embedded Systems

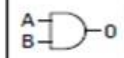
Reliability Block Diagram

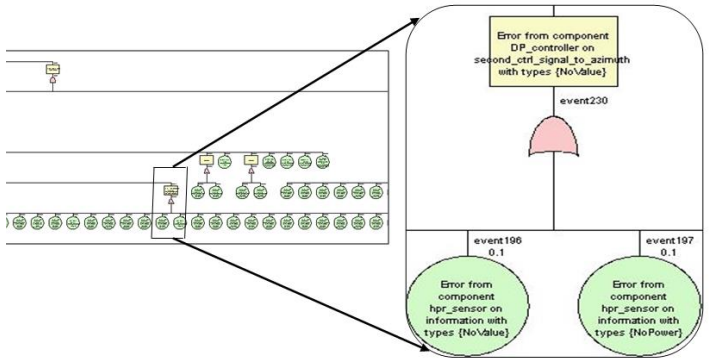


Failure probability: 0.23053600000000002
Components involved:
* PMS (device)
* first_UPS (device)
* second_UPS (device)
* first_DP_controller (device)
* second_DP_controller (device)
* first_DP_HMI (device)
* second_DP_HMI (device)
* first_dgps_sensor (device)
* second_dgps_sensor (device)
* third_dgps_sensor (device)
* first_gyro_sensor (device)
* second_gyro_sensor (device)
* third_gyro_sensor (device)
* first_wind_sensor (device)
* second_wind_sensor (device)
* third_wind_sensor (device)
* hpr_sensor (device)
* lpr_sensor (device)
* radar_sensor (device)
* first_mru_sensor (device)
* second_mru_sensor (device)
* third_mru_sensor (device)
* first_bow_thruster (device)
* second_bow_thruster (device)
* first_azimuth_thruster (device)
* second_azimuth_thruster (device)



Fault Tree Analyses

Description	Picture	Truth table		
The "and" gate indicates the output occurs if all the input events are present.		Input A	Input B	Output
		T	T	T
		T	F	F
		F	T	F
		F	F	F
The "or" gate indicates the output occurs if at least one of the input events is present.		Input A	Input B	Output
		T	T	T
		T	F	T
		F	T	T
		F	F	F



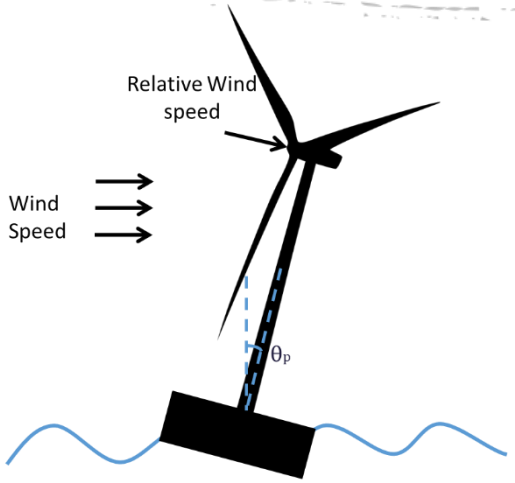
- Complex Systems Architecture Modelling
- Multi-objective optimization
- Automatic analyzes
- Automatic FMEA
- Enhanced Methodology
- Safer systems

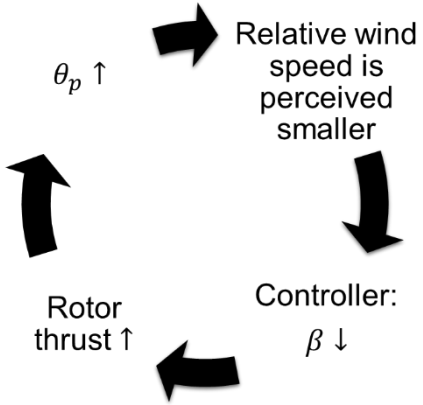
Floating Wind Turbines Activities and R&D

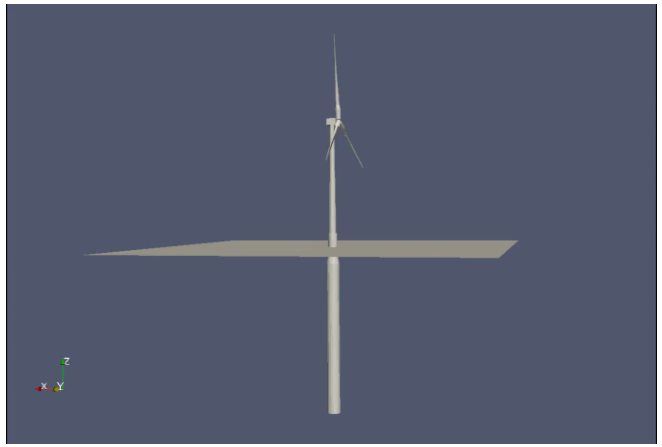
D-ICE ENGINEERING

Floating Wind Turbine Control

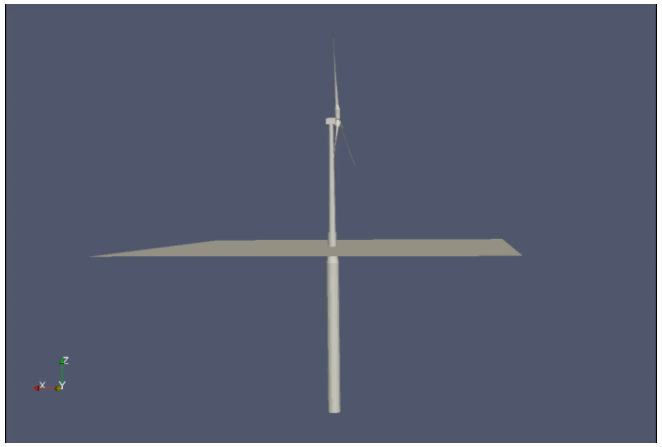
- Main Known Issue : Negative Damping
  - Severe effects
  - Structural fatigue
- Tailored and Better Control can
  - Optimize platform responses
  - Anchor systems design
- Main Actual Field of Research
  - Wind / Sea-State Estimation
  - Advanced Model-Based Control







Conventional Control Strategy

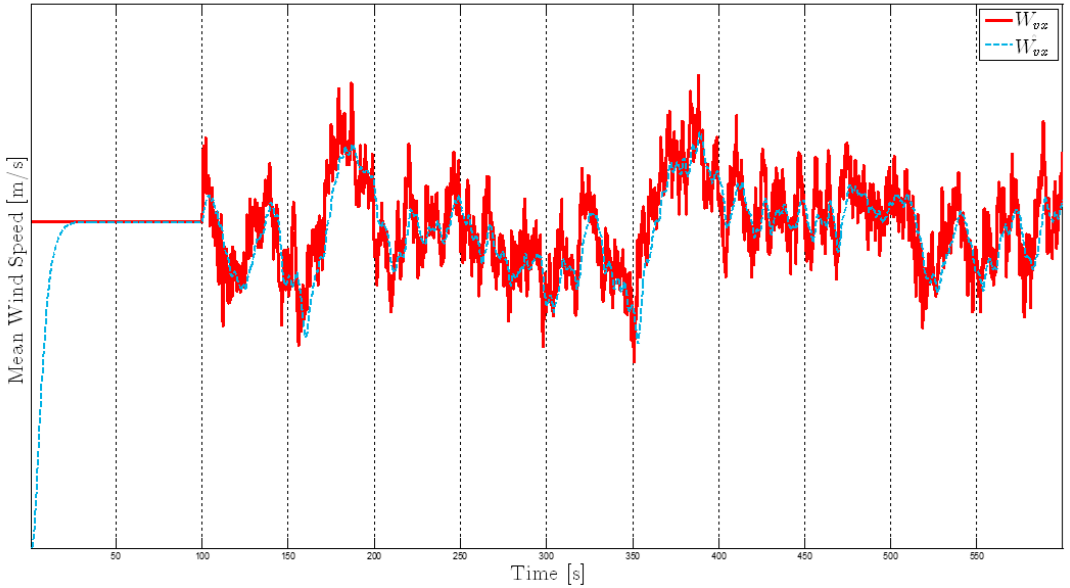


Adapted Control Strategy

Floating Wind Turbine Control

- Main Contributions
  - Modelling
    - For Validation purposes
    - For Control purposes
  - Controller Scheme & Structure
    - Estimator
    - Advanced Control
  - Tuning Procedures & Design Methodology for the controller

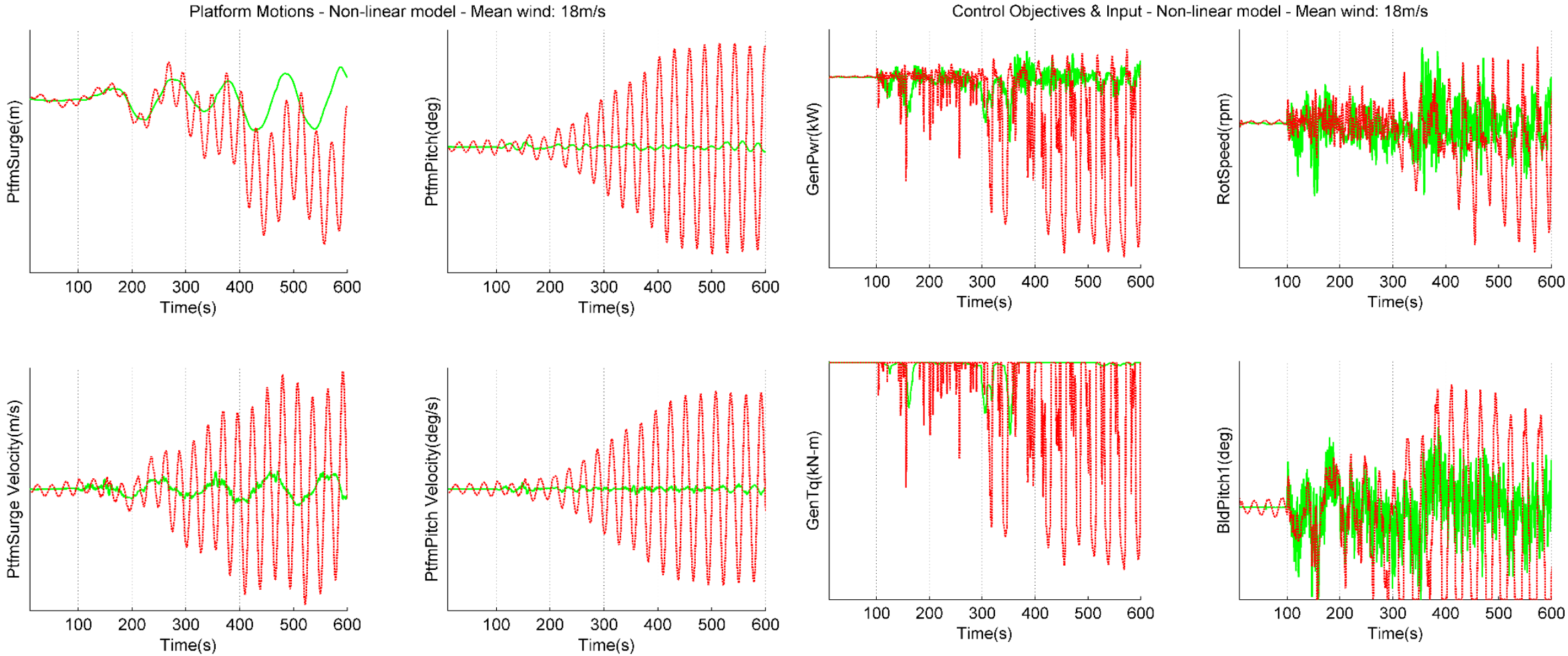
- Wind Speed Estimation



Actual simulated wind (red) & Estimation without wind sensor (blue)

- Nonlinear Kalman Based Estimator
- Model Based Estimation & Homotopy-Based Moving Horizon
- Optimality
- Online & Fast estimation
- Numerical efficient formulation

Floating Wind Turbine Control



State of the Art Control

D-ICE Control

Turbulent Wind 18 m.s^{-1}

Floating Wind Turbine R&D

- R&D Roadmap FOWT
  - Advanced Wind speed estimation
  - Advanced Sea-State estimation
  - Fully Coupled Nonlinear Control strategies (COFLOWING**)
  - Advanced Nonlinear Hydrodynamics
  - Artificial Intelligence & Big Data
  - Fatigue & Structural Analyses
  - Basin Tests (SOFTWIND - 2018)
  - Full scale implementation
  - Advanced Designed Wind Farms
  - High Power Floating Wind Turbines
  - Advanced Design & Farm Effects (FLOATEOLE)
  - T/I&M (FRyDoM)
  - Decomissioning (FRyDoM)