Wave tank and wind tunnel experimental campaigns in H2020 LIFES50+ project (GA640741)

German Perez

TWIND Summer School
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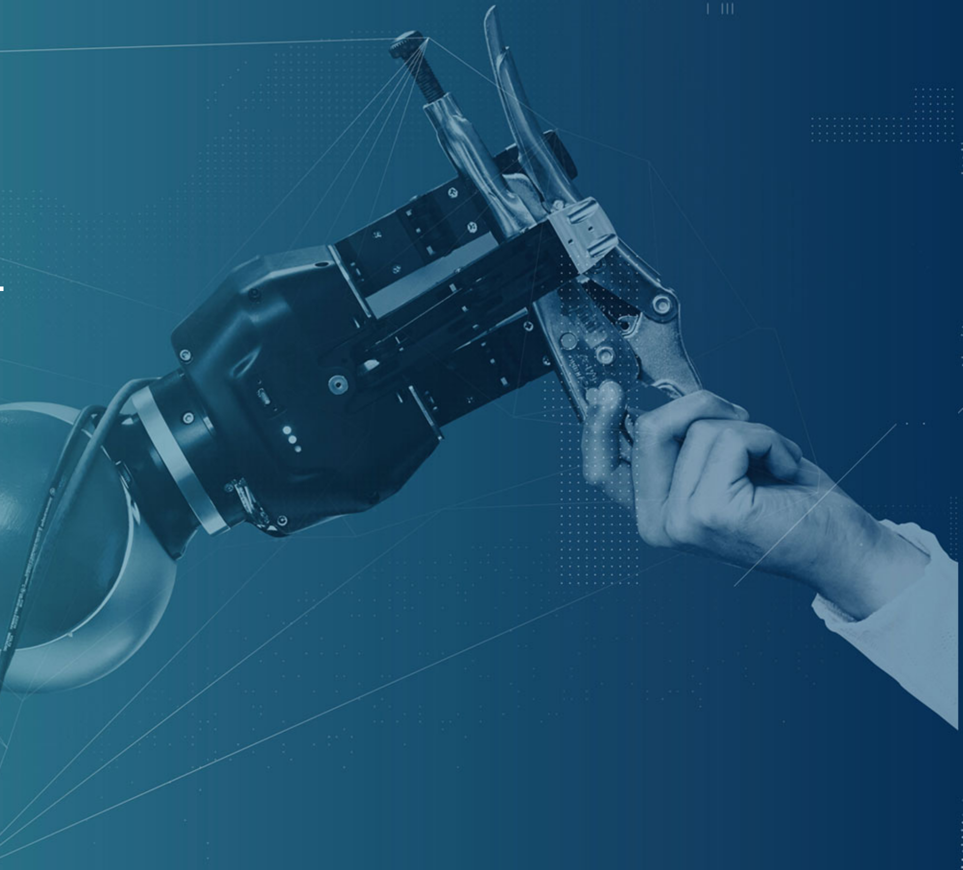
Outline



Project overview

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TWIND OFFSHORE WIND ENERGY

LIFES50+ project overview

Qualification of innovative floating substructures for 10MW wind turbines and water depths greater than 50m

OBJECTIVES:

- Optimize and qualify to a TRL 5, of two innovative substructure designs for 10MW turbines
- Develop a streamlined KPI-based methodology for the evaluation and qualification process of floating substructures

Grant Agreement: H2020-LCE-2014-1-(640741)

FOCUS:

- Floating wind turbines installed in water depths from 50m to 200m
- Offshore wind farms of large wind turbines (10MW) – identified to be the most effective way of reducing cost of energy in short term

BUDGET: 7.3 M€

DATES: 47 months duration, from 01 June 2015 to 30 April 2019.

Project leader: SINTEF Ocean

DTU Technical University of Denmark
University of Stuttgart Germany
POLITECNICO MILANO 1863
SINTEF
RAMBØLL
CATAPULT Offshore Renewable Energy
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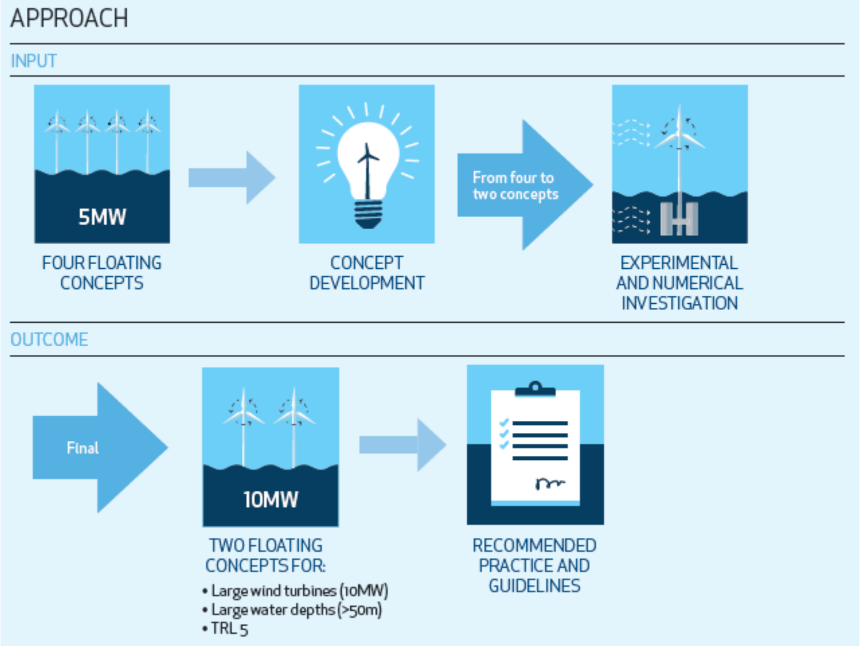
DR. TECHN. OLAV OLSEN
nautilus floating solutions
ideol winning solutions for offshore wind
IREC Institut de Recerca en Energia de Catalunya Catalonia Institute for Energy Research
DNV·GL

External Advisory Group: NREL, EQUINOR, SIEMENS GAMESA

LIFES50+ project approach

First stage: concepts design and evaluation



Second stage: numerical modelling and experiments; recommended practice and guidelines

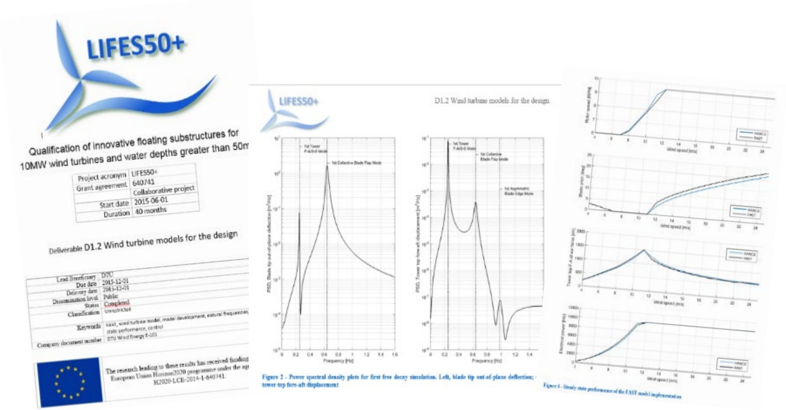
Information for the concepts design

Sites selection and information

	50-year wind at hub height [m/s]	50-year significant wave height [m]	50-year sea-state peak period [s]	50-year current [m/s]	Extreme water level range [m]	Design Depth [m]	Soil Type
Site A	37	7.5	8-11	0.9	1.13	70	Sand/Clay
Site B	44	10.9	9-16	1.13	4.3	130	Sand/Clay
Site C	50	15.6	12-18	1.82	4.2	100	Basalt

Wind Turbine information

- FAST model of DTU 10MW reference wind turbine
- Generic controller for the wind turbine.
- Tower reference design.



Design basis and DLCs

Main design criteria based on DNV-OS-J103

Public information available on the project's web site tecnalia Inspiring Business

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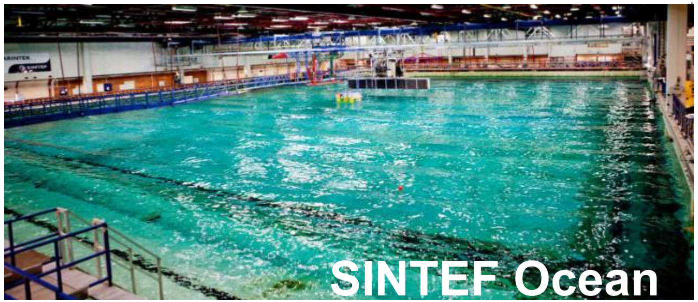
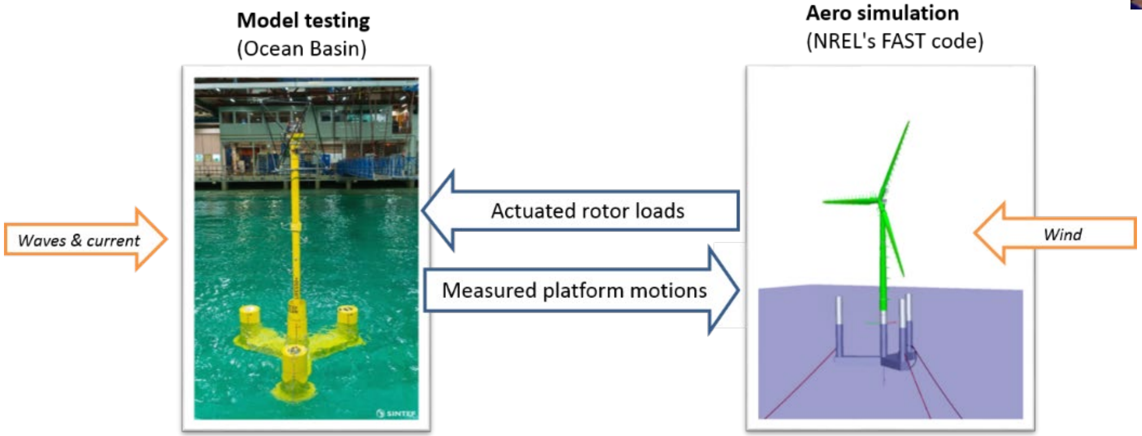
Experiments preparation

Wave tank experiments preparation

Develop Real-Time Hybrid Model testing (Hardware in the Loop) for floating wind turbines:

- Controlled environment
- Flexibility
- Overcome Froude-Reynolds scaling issues





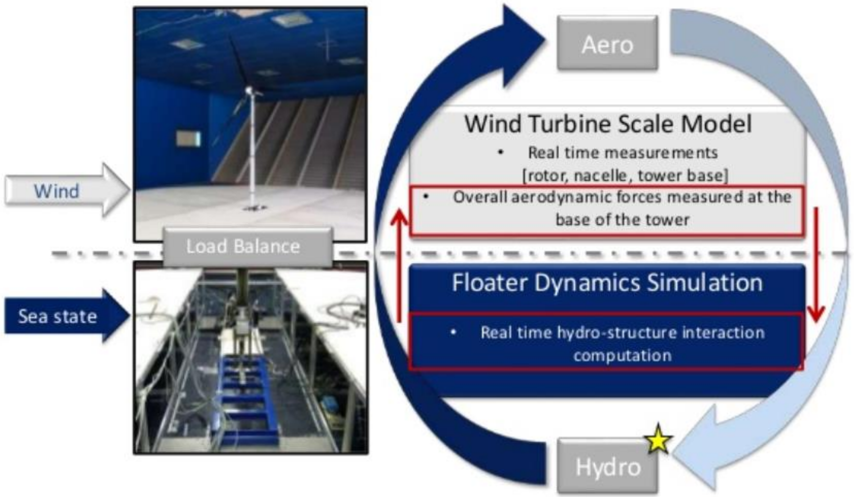
Physical model in ocean basin with physical waves coupled in real-time to aerodynamics simulations (FAST).

The aero loads are applied on the model by use of actuators and the position of the model is measured in the basin and used as input to the numerical simulations.

Wind tunnel experiments preparation

Physical wind and wind turbine connected in real time to numerical hydro simulator.

A 6DOF robot at the tower base imposes the simulated platform motions. The loads at base of tower measured in the wind tunnel are used as input to the numerical simulations. The output of the simulations is the floater position.



Experimental campaign

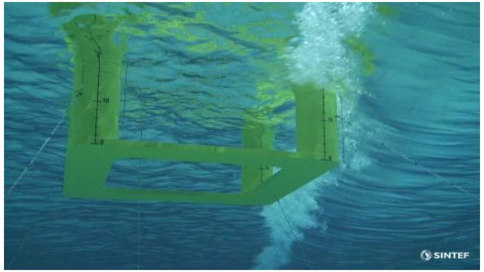
Wave tank experiments

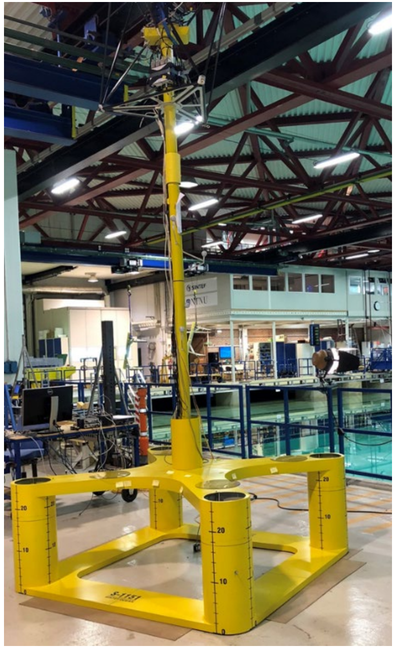
First step: scale models (1:36) preparation for Olav Olsen's OOstar and NAUTILUS semisubmersible concepts.

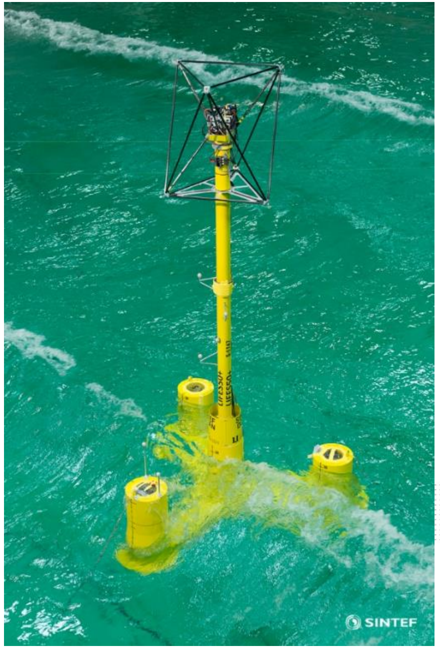
Numerical model adaptation for the Real-Time Hybrid Model testing (ReaTHM® testing) to generate realistic and controlled aerodynamic loads.

Load cases for the experiments.

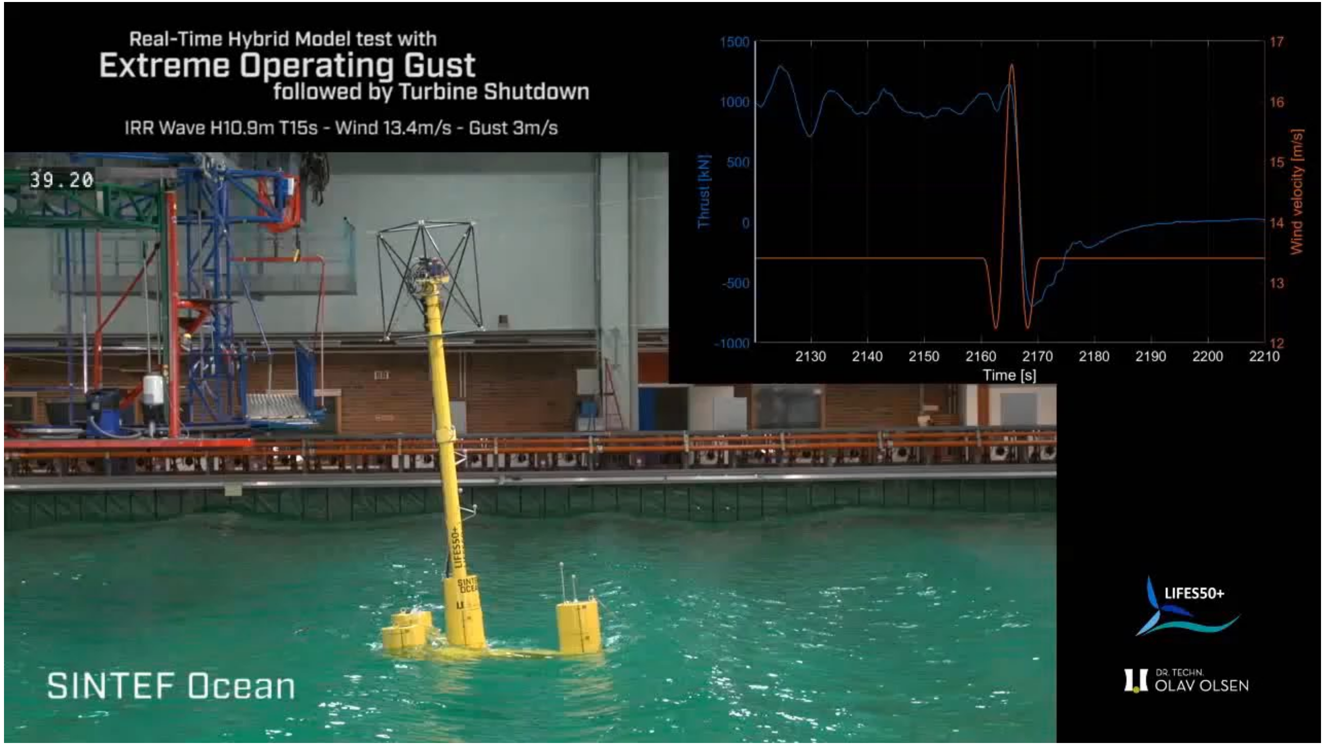
- inclining tests,
- pullout tests,
- decay tests,
- pink noise (white noise) wave spectrum tests and regular wave,
- wind only tests,
- irregular wave tests



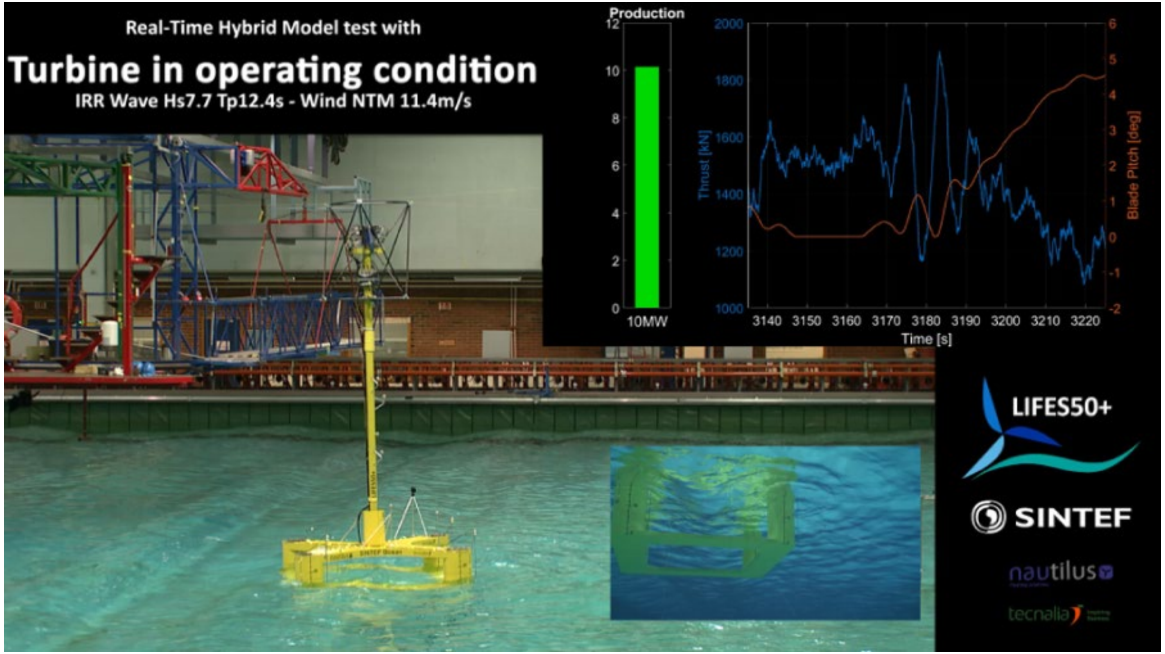




Wave tank experiments



Wave tank experiments



Video. Please, check the recordings of the session.

Wind tunnel experiments

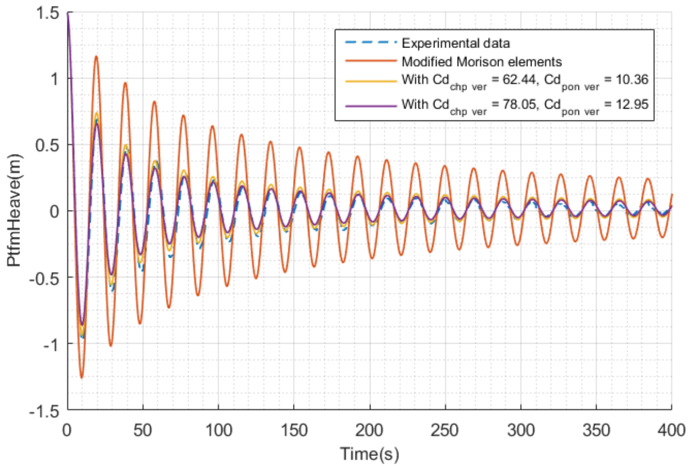
Video. Please, check the recordings of the session.

Numerical modelling & design practices

Numerical Modelling

Numerical models calibration using experimental results

- Benchmark of the numerical tools against physical tests –wave tank-
- Assessment of the state-of-the-art and simplified numerical models for the two public floaters of the LIFES50+ project: Olav Olsen's OOStar and NAUTILUS semisubmersible floating structures.
- Identification of the driving design load cases –DDLCs- and calibration for those cases.
- Public deliverable: D4.6 Model validation against experiments and map of model accuracy across load cases.
    - Calibration of hydrodynamic coefficients in time domain simulations is essential to achieve sufficiently accurate load predictions.
    - Simplified QuLAF and SLOW models provide a big benefit for concept and design studies in the initial stages of the design.

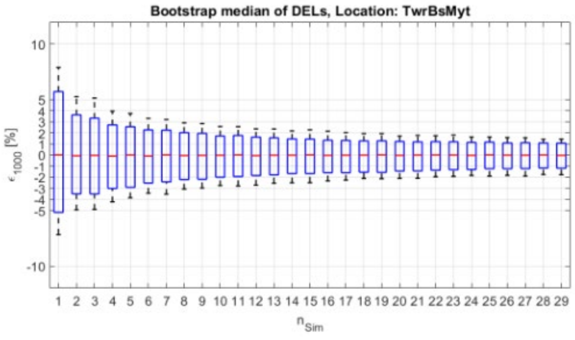


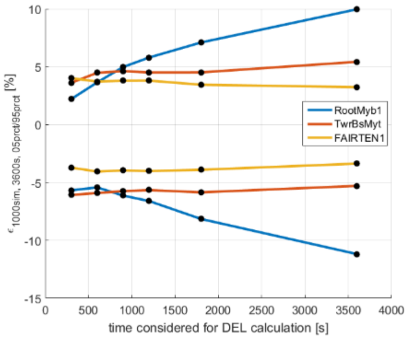
Comparison of heave decay simulation with experimental data for different FAST models - NAUTILUS concept -

Design Practices

Determination of relevant simulation settings

- Provides recommendations on how to verify the load simulation set up.
- Focus on DLC 1.2, 1.6, 6.1.
- Based on statistical analysis.
- Analysis of the effect of simulation length





1 - Pre-simulation initial conditions

- Set up of initial conditions for a simulation

2- Run-in time

- Simulation time to be later disregarded due to initial transients

3 - Sensitivity to environmental parameters

- Determination of the important parameters for load calculations
- Separate: peak shape parameter, marine growth

4 - Number of seeds needed

- Variation of seed for fatigue load calculations

5 - Effect of simulation length

- Trade-off between shorter simulations on the results of the ultimate and fatigue load

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GRACIAS
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German Perez - german.perez@tecnalia.com

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