COMPASS

COMposite super-structures for large PASsenger Ships

Partners

DBI - Danish Institute of Fire and Security Technology (lead)

DBI

Niels Hjørnet Yacht Design

Support: (non-complete list of 9 companies)

Scandlines

MAERSK

DTU Technical University of Denmark

DTU Mechanical Engineering
Department of Mechanical Engineering

DTU Civil Engineering
Department of Civil Engineering

- Lightweight Structures group (Mech)
- Fire Engineering group (Civil)
- Maritime group (Mech)

Funding (2014 and 2015)

DANISH MARITIME AUTHORITY

THE DANISH MARITIME FUND

+ co-funding from DTU and DBI

Challenges

Complicated and time demanding analysis of fire safety according to SOLAS II-2, Rule 17

Barrier for further development and use of FRP in larger civillian vessels

Large potential for retrofit and new-builds of ships using composites

Aims

- KOMPAS aims at making the path easier for design and retrofit of composite super-structures for larger passager ships for
  - yards / design consultants
  - sub-suppliers
  - ship owners
  - authorities

- Adopt a standalized approach through guidelines combined with (pre-) fire proven FRP structural standard components

Work packages

WP 1: Dissimination and distribution of knowledge

WP 2: Structural design, analysis and testing

WP 3: Fire testing and analysis

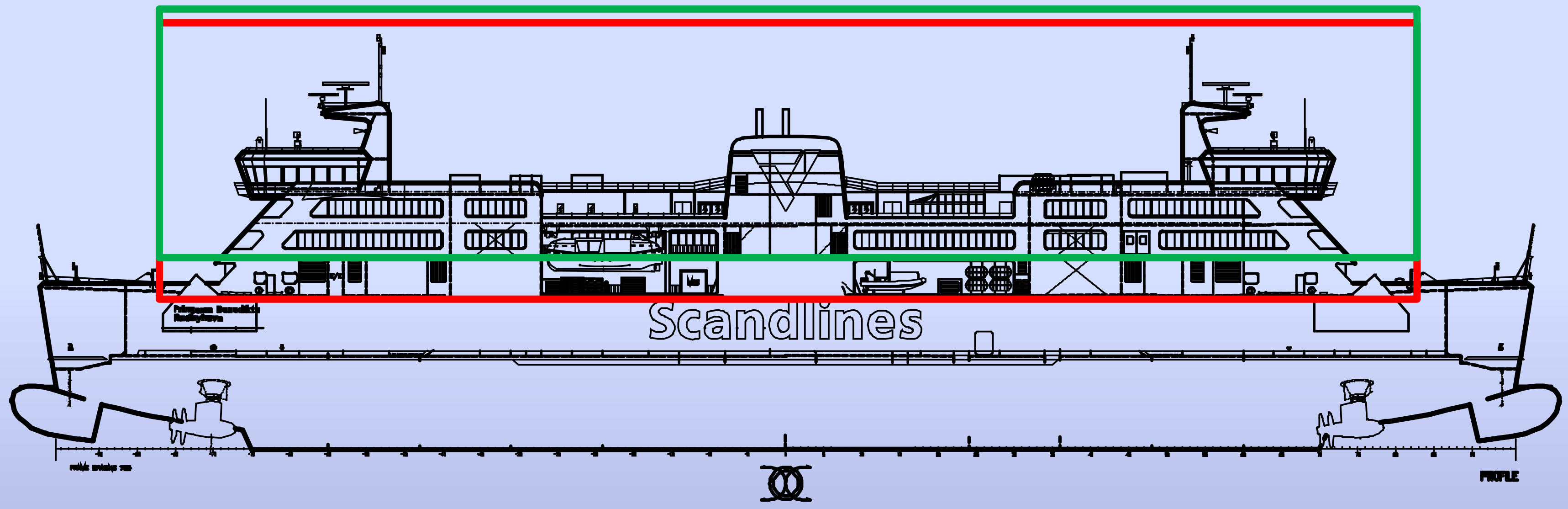
WP 4: Development of Rule 17 guidelines for analysis- and testing procedures

Demonstration Ship: Princess Benedikte

Route	Puttgarden-Rødby
Type	RoPax
Construction year	1997/2003
Gross tonnage	14,822
Shipbuilder	Ørskov Staalskibsværft, Denmark
Flag	Danish
Engines	4 pc Mak, type 8M32 / 1 pc MAN type 6L32 / 44CR
KW	17,440
Length, oa	142 m
Breadth incl. fender	25.4 m
Service speed	18.5 kn
Length, oa	1 track, 118 m
Lanemeter, lorries	580
Lanemeter, cars	1,747
Car capacity	364
Passenger capacity	1,140

Scandlines

Superstructure



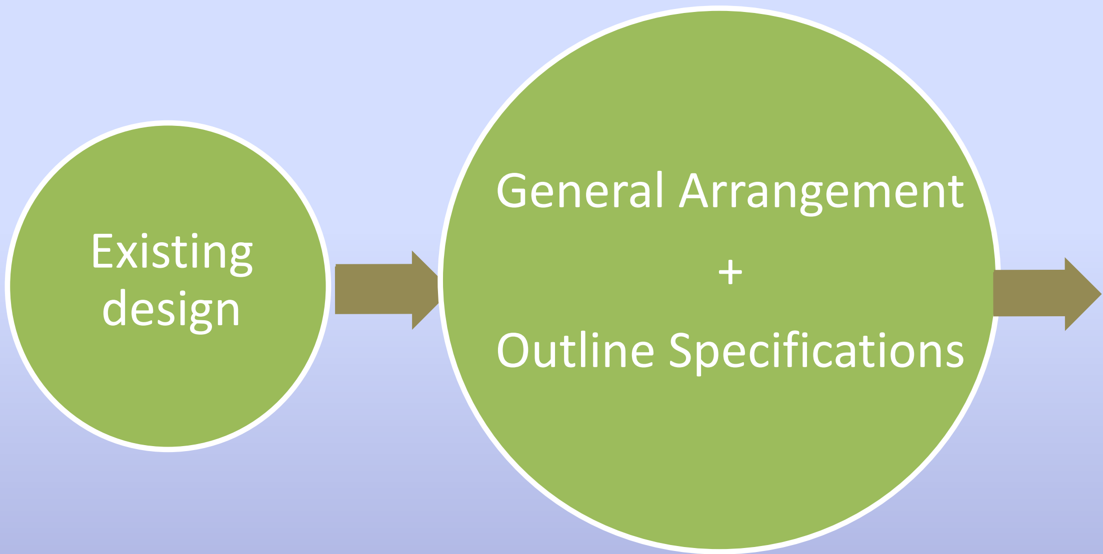
Superstructure

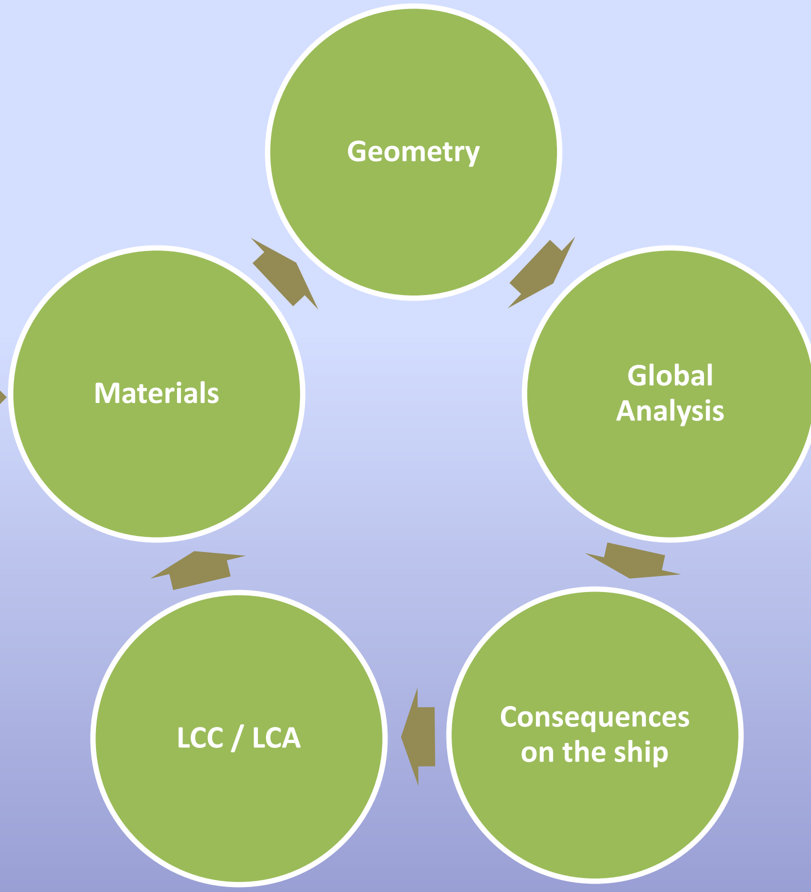
Retrofitting is focused on the passenger Decks
-17700 mm above the Baseline

Comparison between designs

- **Steel Superstructure**
  - Structural Analysis
- **Composite Superstructure**
  - Design
  - Structural Analysis
  - Effects

Superstructure retrofitting design





Geometry

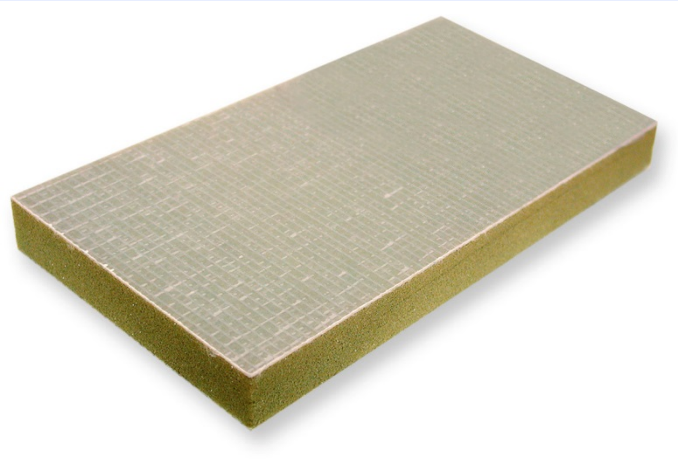
COMPASS project:
Superstructure geometry to remain **unchanged**

Composite Superstructure Design Phase

Composite Materials

<u>Skin material</u>:
Epoxy resin / Glass fibers

<u>Core material:</u>
Divinycell foam (PVC)



Structural Design

Design Loads

Rules for ships

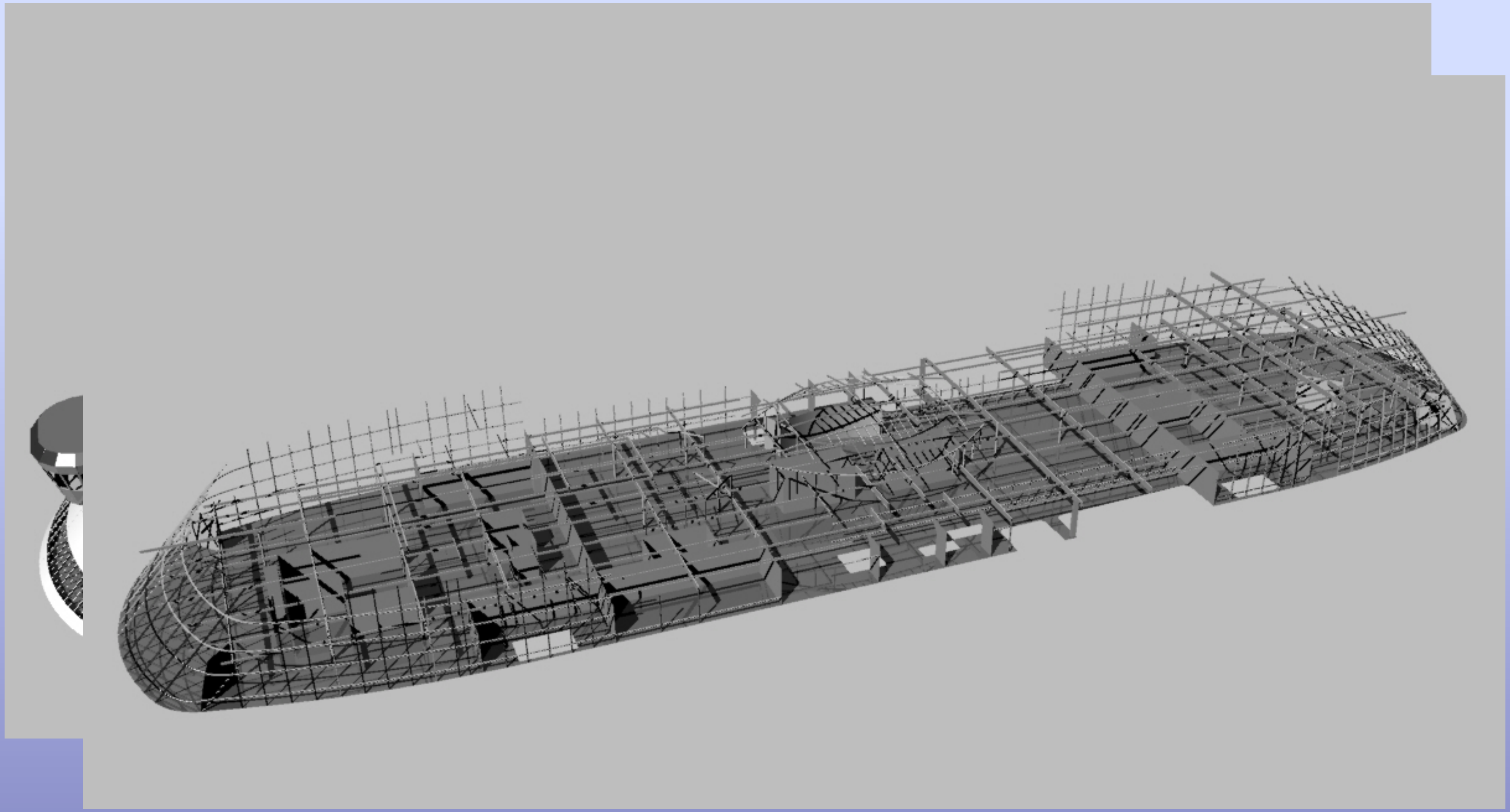
Scantling Calculations

High **S**peed **L**ight **C**raft Rules

Composite Superstructure Design Phase

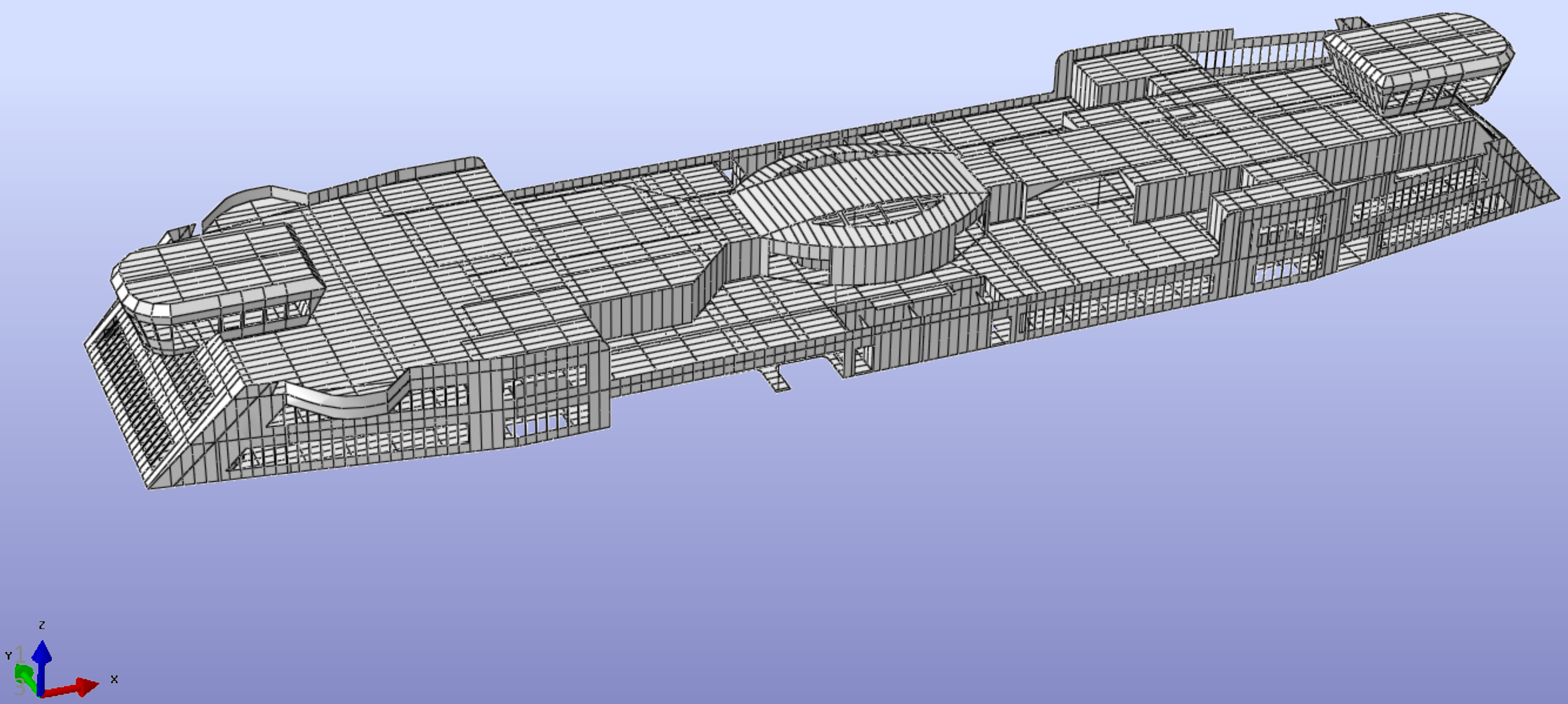
3D CAD Model of the Superstructure

Interior / Composite stiffeners

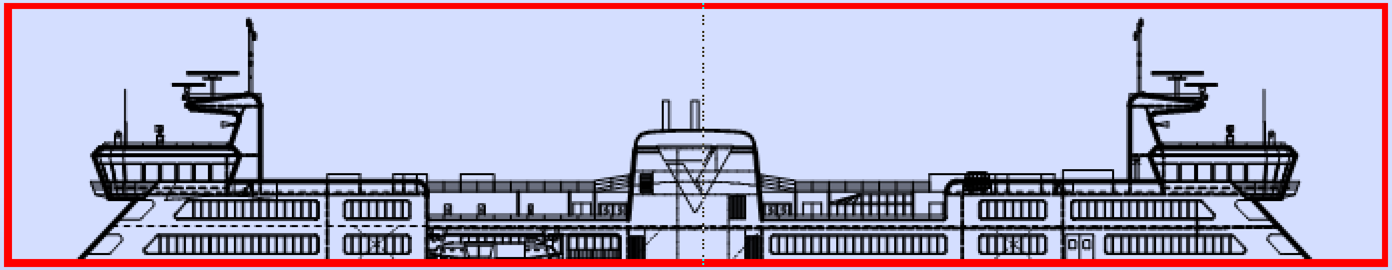


Structural Analysis

3D CAD Model → Global Finite Element Model for both designs under development



Effects on the ship



Composite Superstrusture weight: **136** tons

The effects on the stability of the ship will be calculated

Structural Analysis

Structural loads

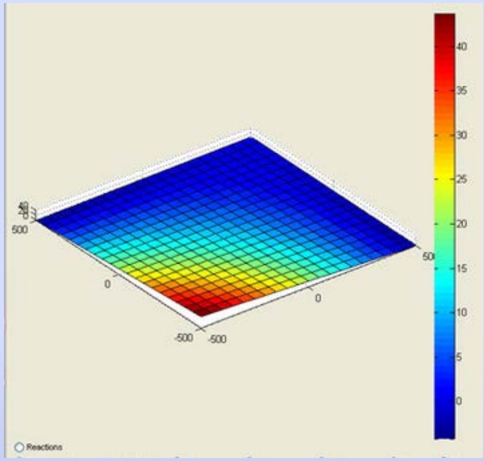
+

Thermal loads

→

Detailed finite element simulations

Experimental testing



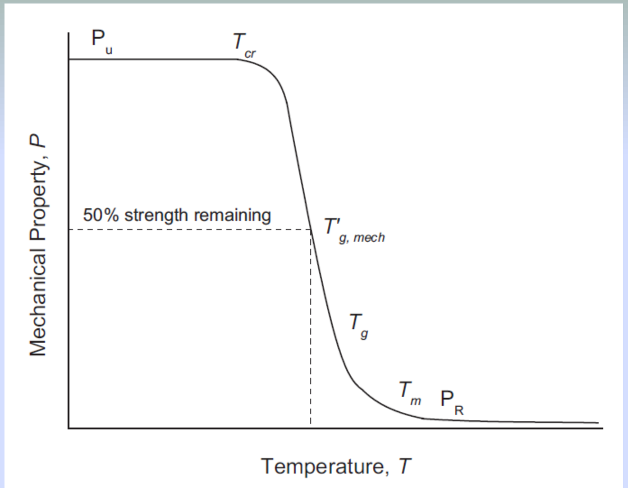
Structural Analysis

Testing is seprated in three phases :

-Material Characterisation

-Mid-scale Testing

-Large scale testing



The tests' specifications for the first two phases have been defined
The experimental setup is being assembled at the moment

Standard fire resistance tests

Scale	Apparatus	Data obtained	Drawbacks
Matter Scale	TG Analyzer,..	Chemical	Not truly fire resistance test
Material Scale	Cone Calorimeter, …	Ignitability, heat release rate, smoke production	
Products Scale	ISO 21367, …	Heat release rate, ignitability, surface spread of a flame, falling droplets/particles and smoke production	
Large Scale	Furnace	Fire resistance (with time-temperature curve ISO 834 and mechanical loads)	Time, High cost, Repeatability

Could be replace by

by avoiding

H-TRIS

H-TRIS: Heat Transfer Rate Inducing System

Thermal loading

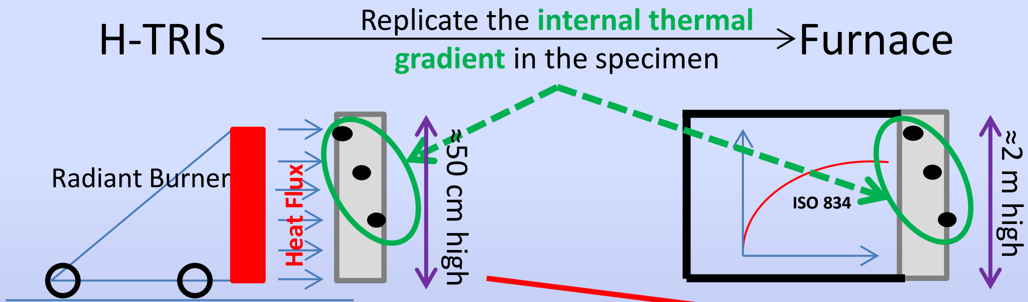
How to replicate the thermal conditions of the furnace test?

With a mobile array of gas-fired high performance radiant heaters, along with a mechanical linear motion system and/or a high precision controller for the heat flux.

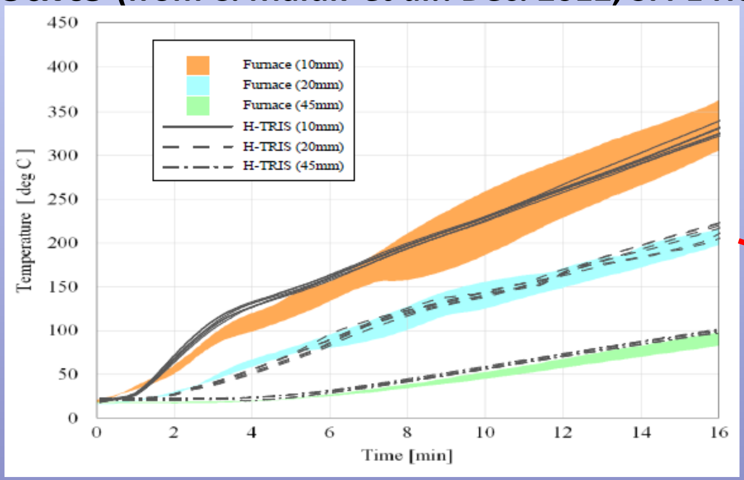
Mechanical loading

How to replicate mechanical stresses experienced by structural elements or assemblies?

With a custom designed mechanical loading frame.



Results **(from C. Maluk *et al.*. Dec. 2012, SFPE Hong Kong.)**



Comparison of concrete specimens' internal temperatures recorded in a furnace as compared against H-TRIS test results.

Finally:

H-TRIS can replicate the thermal conditions of the furnace test and the mechanical stresses

With as benefits:

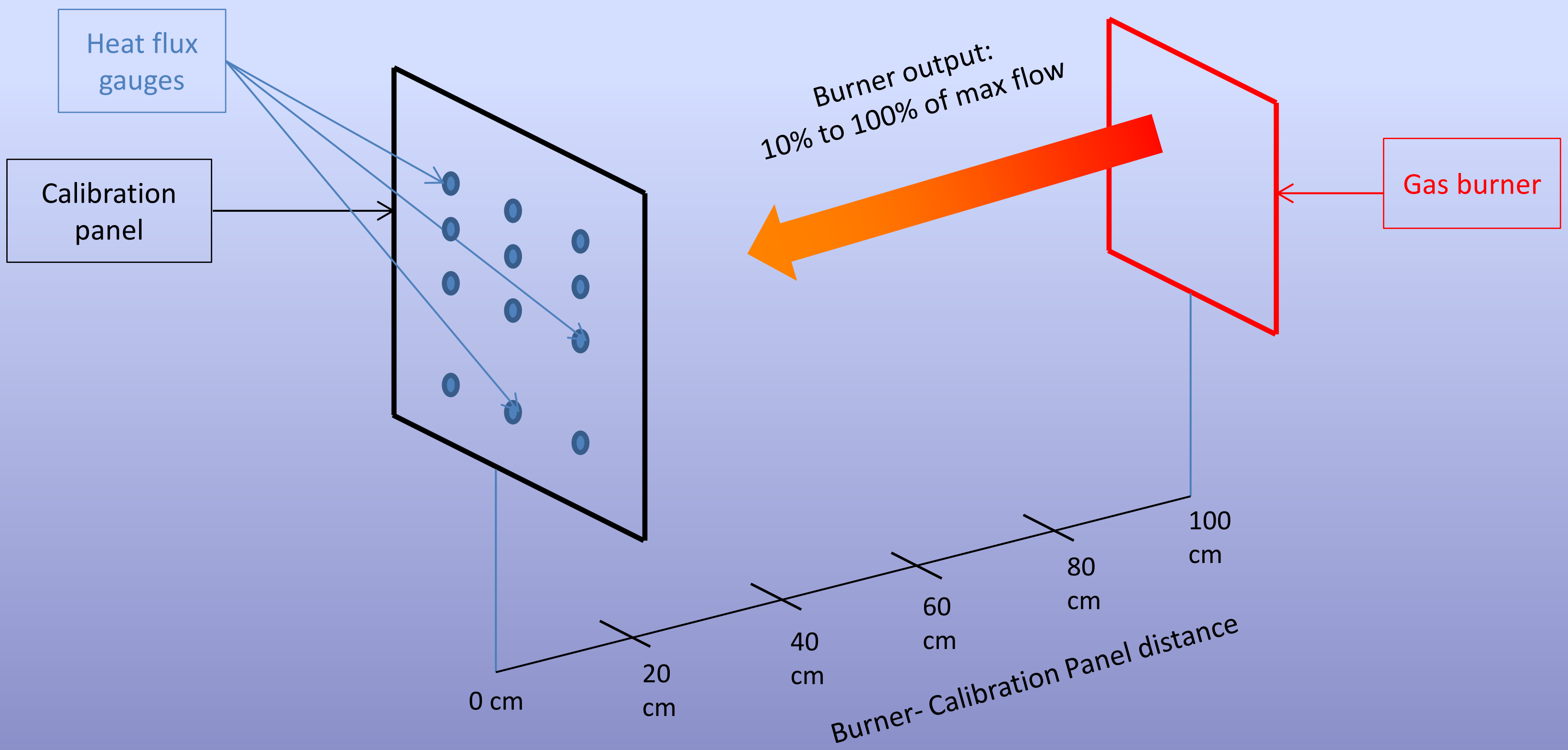
- Low cost, easy and quickly to conduct
- Greater repeatability

Calibration of the burner

Aim of the burner calibration :

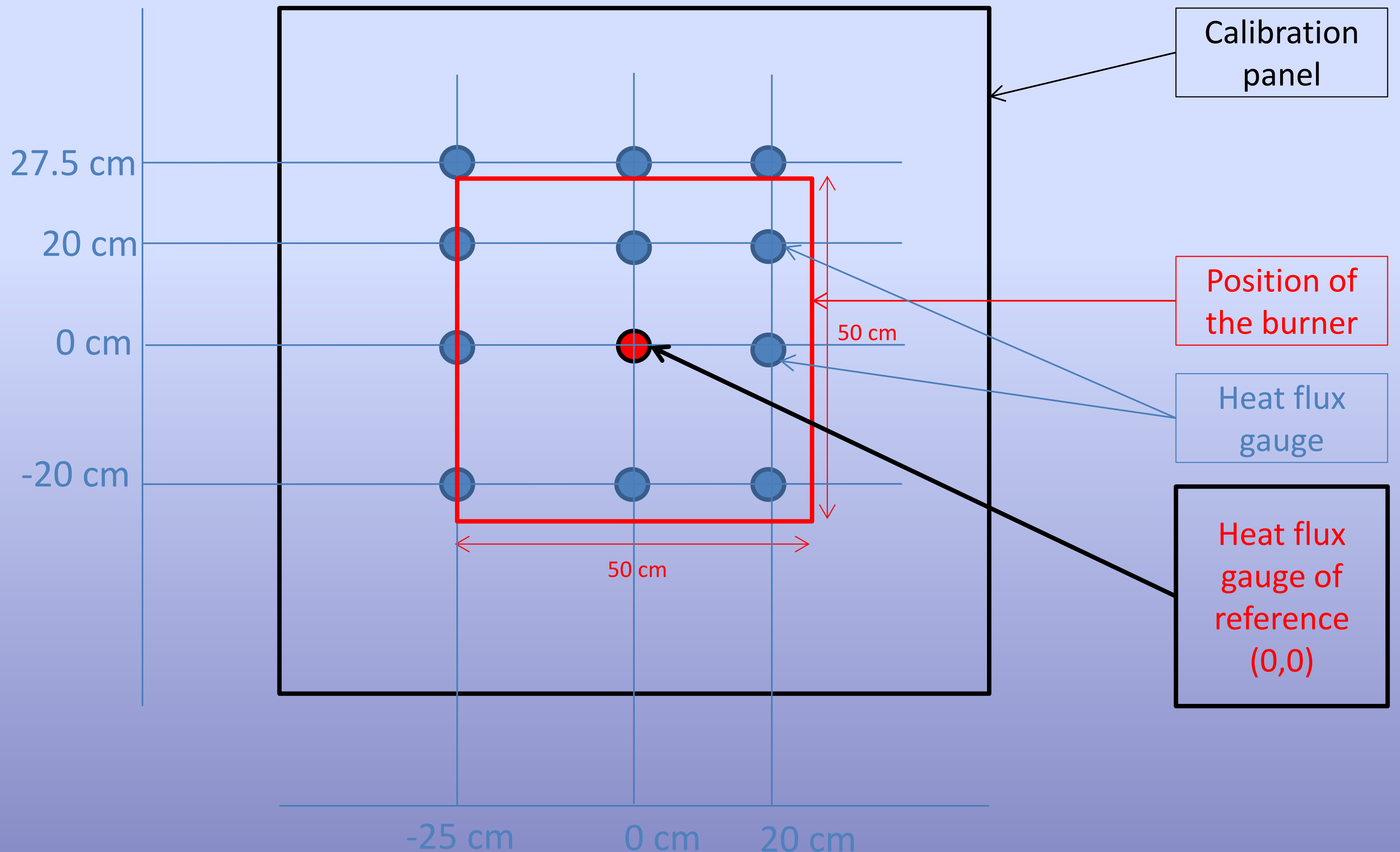
- ✓ To verify the homogeneity of the flux at the target panel
- ✓ To know the position/ heat flux of the burner in order to have the required flux at the target panel
- ✓ To know the time of stabilization during a change of intensity of the burner heat flux or during the change of position of the burner

Experimental device for the calibration of the burner



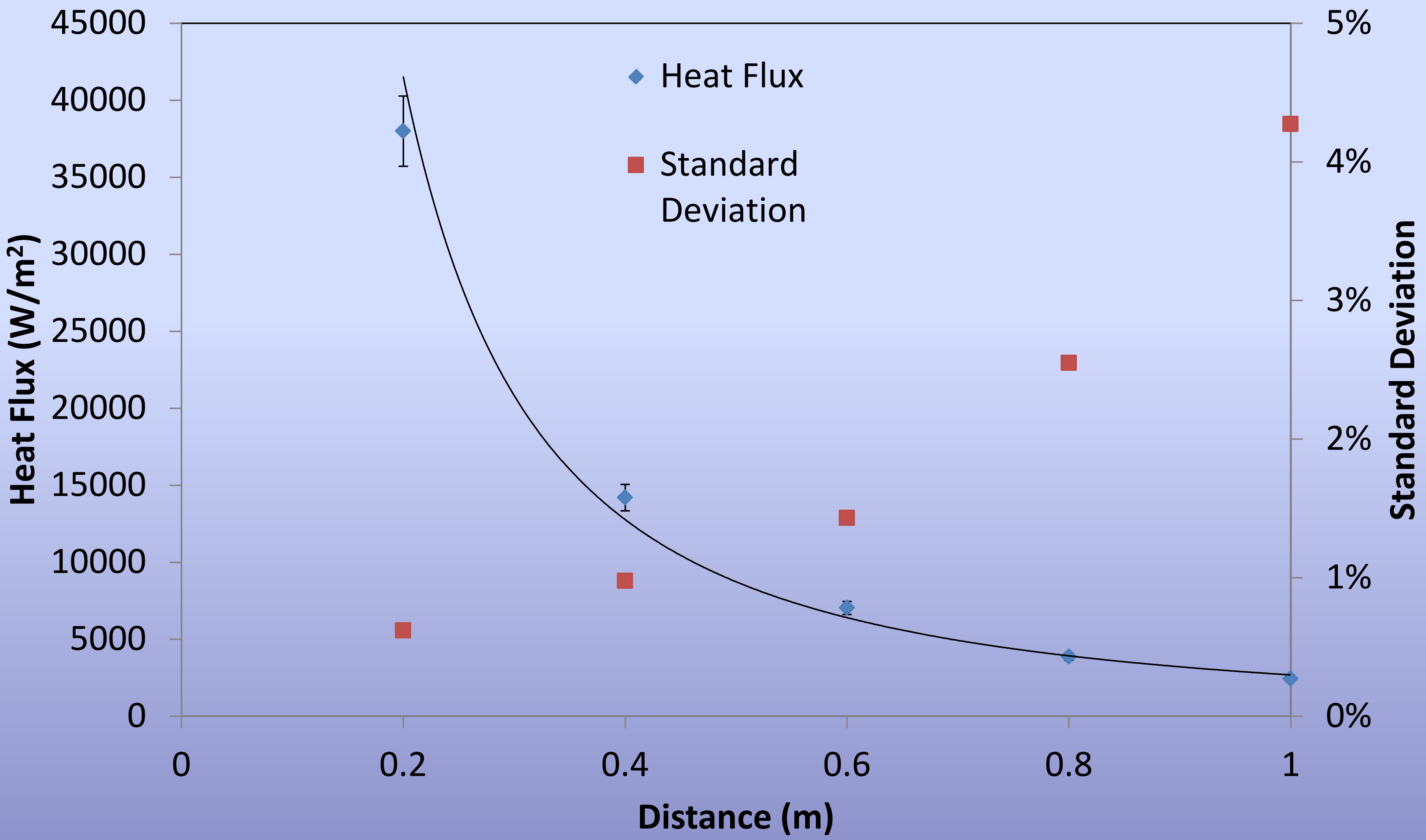
Calibration of the burner

Verification of the homogeneity of the flux at the target panel - Position of heat flux gauges



Calibration of the burner

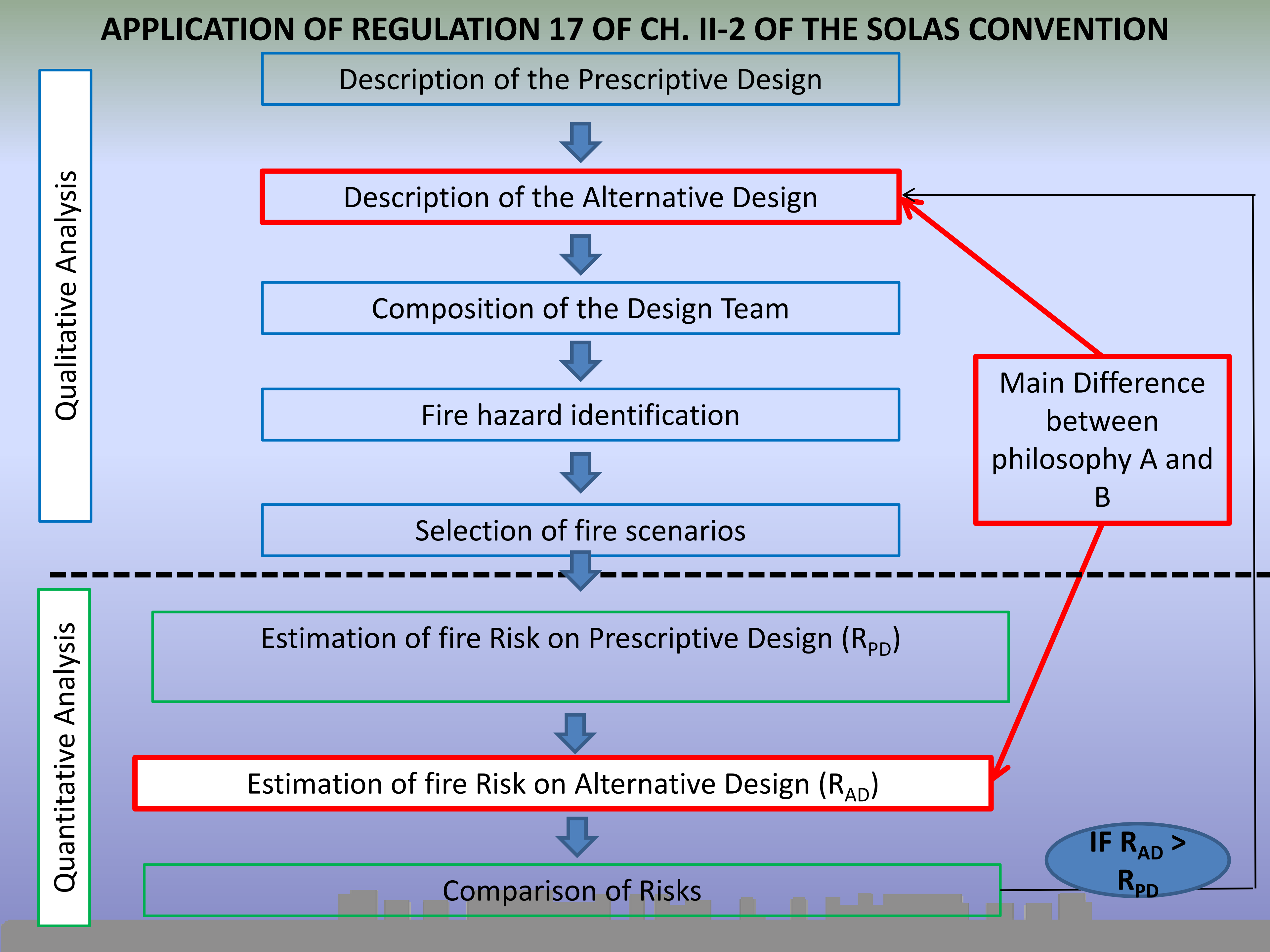
the position/ heat flux of the burner in order to have the required flux at the target panel – Results (50% of max burner intensity)



APPLICATION OF REGULATION 17 OF CH. II-2 OF THE SOLAS CONVENTION

- **Philosophy A:** Staying as close as possible to the prescriptive regulations by making conservative equivalences in terms of passive protection compared to an equivalent prescriptive design (Eco-Island ferry).
  - Pros: Fairly straightforward, also testing-wise
  - Cons: Faces the “non-combustibility” challenge (i.e. direct comparison with steel)

- **Philosophy B:** Adapting the protection to the level of risk in a given compartment, combining both active and passive protection (MP08 project).
  - Pros: Freedom of design
  - Cons: Requires more engineering to begin with



APPLICATION OF REGULATION 17 OF CH. II-2 OF THE SOLAS CONVENTION
Qualitative Analysis
Description of the Prescriptive Design
Description of the Alternative Design
Composition of the Design Team
Fire hazard identification
Selection of fire scenarios
Main Difference between philosophy A and B
Quantitative Analysis
Estimation of fire Risk on Prescriptive Design (R_{PD})
Estimation of fire Risk on Alternative Design (R_{AD})
Comparison of Risks
IF R_{AD} > R_{PD}

Immediate actions

- Test relevant composite materials
  - Does anybody want to partner with us?
- Increased interaction between FEM results and Fire test results
- Continued work on method for application of Rule 17

COMPASS: Contacts

Dan Lauridsen, MSc DBI	dhl@dbi-net.dk
Jørgen Juncher Jensen, Prof., Dr. Techn. DTU Mechanical Engineering	jjj@mek.dtu.dk
Christian Berggreen, Associate Prof. DTU Mechanical Engineering	cbe@mek.dtu.dk
Grunde Jomaas, Associate Prof. DTU Civil Engineering	grujo@byg.dtu.dk
Niels Kyhn Hjørnet, Naval Architect	nkh.yacht@gmail.com
Claus Langhoff, Project coordinator DBI	cll@dbi-net.dk

We invite any interested companies and partners to make contact with the group throughout the project to share input and results.