RAMSSES : WP18

novel cruise ship architecture
6 face cabin with lightweight self-supported floor

Pierrick DELAUNAY

CHANTIERS DE L'ATLANTIQUE

HUTCHINSON®

IRT JULES VERNE

BUREAU VERITAS 1828

SUMMARY

FACTS & FIGURES

One single industrial site for all the processes

CHANTIERS DE L'ATLANTIQUE

ORGANIZATION IN 3 BUSINESS UNITS

Ships

Offshore Energies

Services

CHANTIERS DE L'ATLANTIQUE

FACTS & FIGURES

Key figures

8,000 persons on site

out of which 3 300 employees

100 hectares

60,000 tons/year of steel processed
The largest erection dock in Europe
1,400 t of lifting capacity
1.8 billion € annual turnover

CHANTIERS DE L'ATLANTIQUE

OUR CORE SKILLS

Our expertises

Design

Structure, fabrication and assembling

Cabins

Integration, coordination and trials

RAMSSES WORK PACKAGE 18 OBJECTIVE

WP Goal :

- Design innovative cabins : 6 face with self-supported floor,
- and ship structure interfaces to generate a novel ship structure architecture.

Expected benefits :

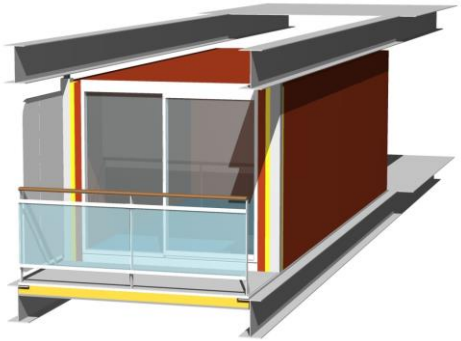
reducing weight, size, costs, production times, maintenance and refurbishement effort. [...]

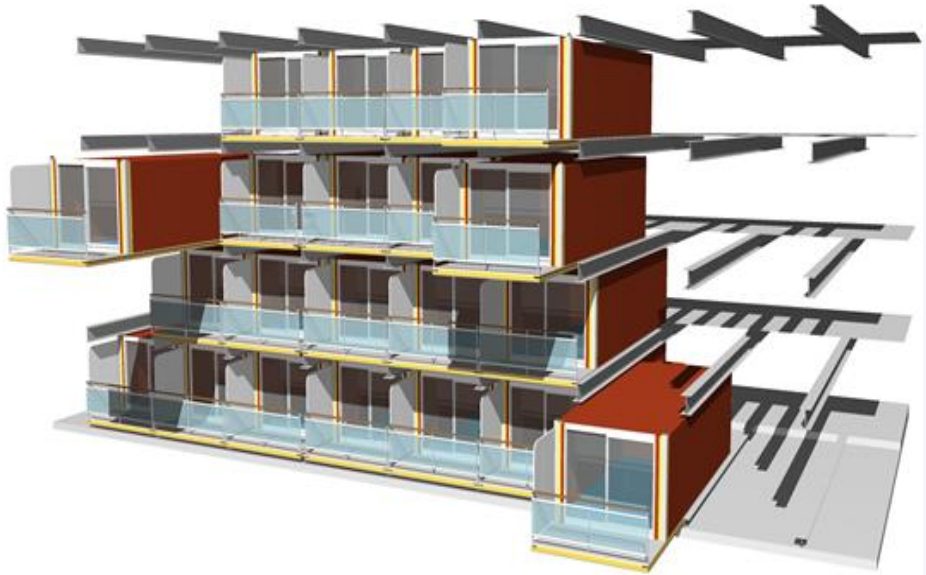
Weight reduction objective = - 400 kgs / cabin

CURRENT SHIP ARCHITECTURE

1. 4 face cabin produced in factory,
2. Bay window installed at bloc / on board stage directly on hull,
3. Cabin installed on board by lift through breaches and rolled inside on steel deck.

RAMSSES CONCEPT

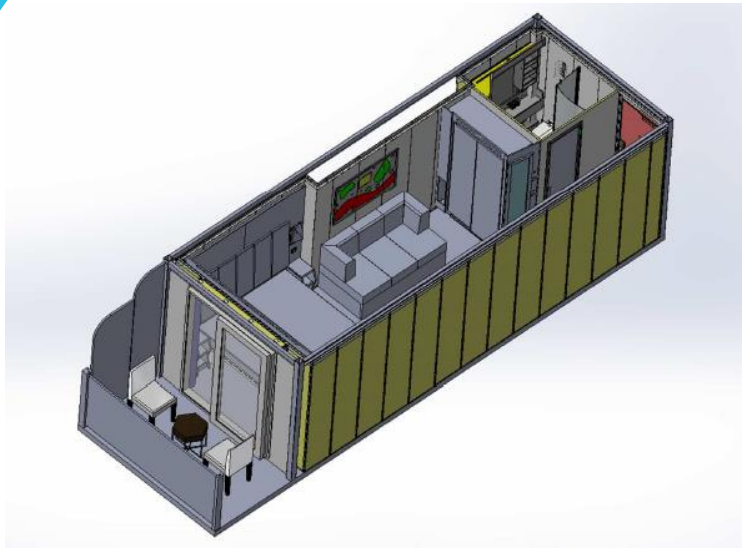




1. 6 face cabin with floor & bay window prefabricated in cabin factory,
2. Cabin installed at the final position from outside by moveable platform,
3. Plug & play networks connection,

No more steel deck under cabin => self supported floor for cabin

DESIGN CHOICES



Component identified with higher potential in term of weight reduction by using composite or lightweight material

=> cabin floor

Design studies :

1. Suitable material and design for floor,
2. Deck removing consequence on ship behaviour,
3. Local ship structure design,
4. Fire integrity.

FLOOR MATERIAL & DESIGN

Specifications for self-supported floor :

- as light as possible,
- design load from regulation = 468 kg/m^2,
- maximum deflection from CdA comfort requirements,

- Fire requirements for floor from SOLAS = A15
  As floor is no more strongly fixed by welding, we need to achieve FRD60 (fire test with load on floor).

FLOOR MATERIAL– investigation on 2 materials

Zaltex from HUTCHINSON

HUTCHINSON®

- Zaltex is a material designed for thermal insulation in the cryogenic industry

- Zatex is a composite and a foam. Thus, it exhibits:
  - Good mechanical properties
  - Low thermal conductivity
  - An adaptable density

  (from 100 kg/m^3 up to 1200 kg/m^3)

- Zaltex can be proposed for applications that require mechanical strength and insulation @ a low density

FLOOR MATERIAL – investigation on 2 materials

Evopreg from COMPOSITES EVOLUTION

- Composites Evolution is a partner from RAMSSES WP10.

- Evopreg prepreg is :

- fire retardant,

- pre-impregnated composite materials based on a polyfufuryl alcohol bioresin (PFA).

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FLOOR MATERIAL TESTS

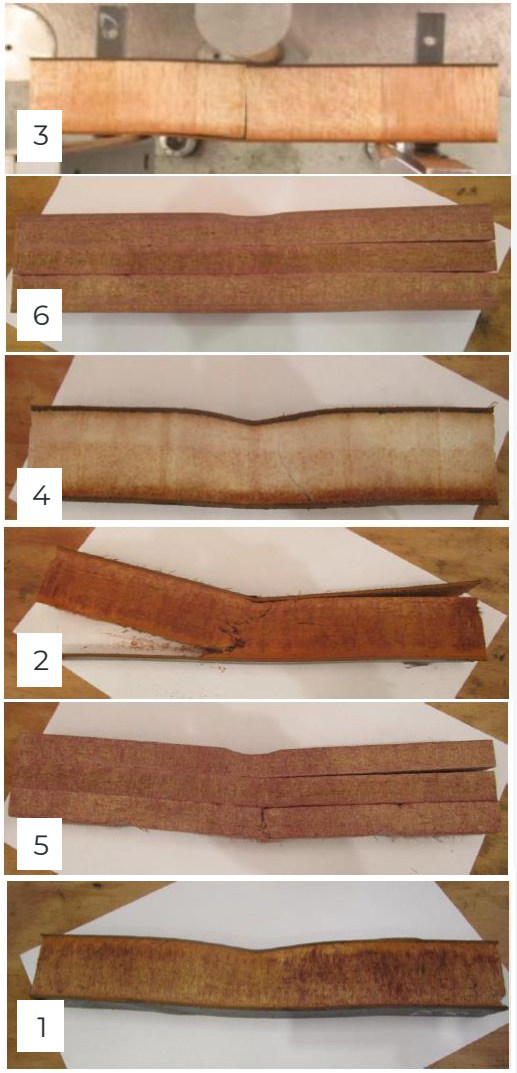
Mechanical characterization of different configurations

Calculations done for Evopreg with 50mm thick balsa core
3 points test (ASTM D 790-81)

		Flexion module (Mpa)	flexural strength (Mpa)	Sandwich Configuration	Failure mode
Type3	Average	**636,9**	**-2,12**	Ecopreg face + core Balsa	core shearing
	Std deviation	13%	12%		
Type6	Average	**154,5**	**-1,27**	Zaltex sandwich with variable density	face wrinkling and core inter-layer debonding
	Std deviation	15%	5%		
Type4	Average	**110,0**	**-0,75**	Ecopreg face + core PET T90 foam	face wrinkling and core shearing
	Std deviation	4%	3%		
Type2	Average	**130,7**	**-0,65**	Ecopreg face + core Zaltex density 1.16	face debonding and core shearing
	Std deviation	16%	3%		
Type5	Average	**54,1**	**-0,54**	Zaltex with homogeneous density	face wrinkling and core layer debonding
	Std deviation	6%	11%		
Type1	Average	**103,2**	**-0,45**	Ecopreg face + core Zaltex	face wrinkling and core shearing
	Std deviation	14%	6%		

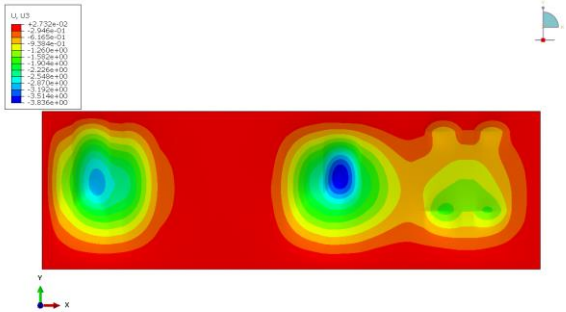
Result : **Ecopreg + balsa** is the most suitable combination for floor

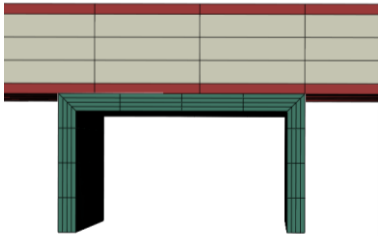
Zaltex needs to be used with stiffeners

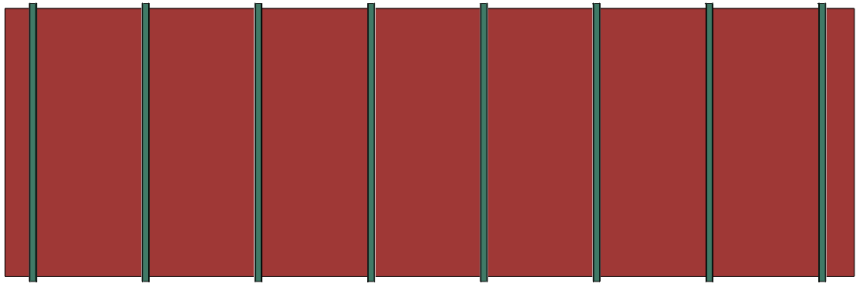


ZALTEX WITH STIFFENERS

1. Zaltex with steel stiffeners

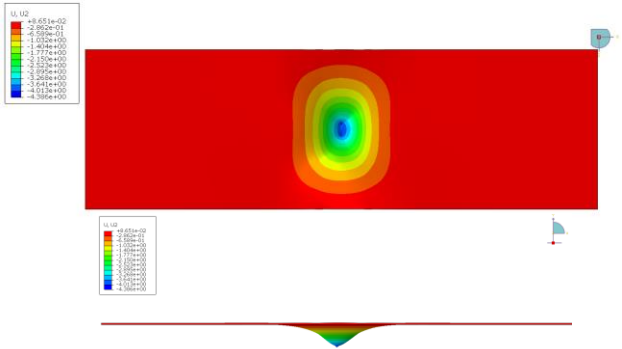


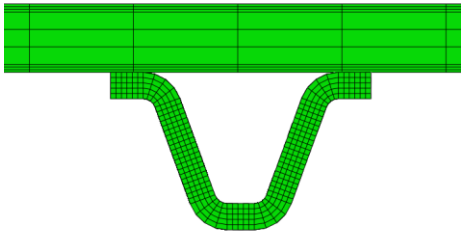




Performances = OK
but solution not suitable, too heavy.

2. Zaltex with carbon fiber stiffeners





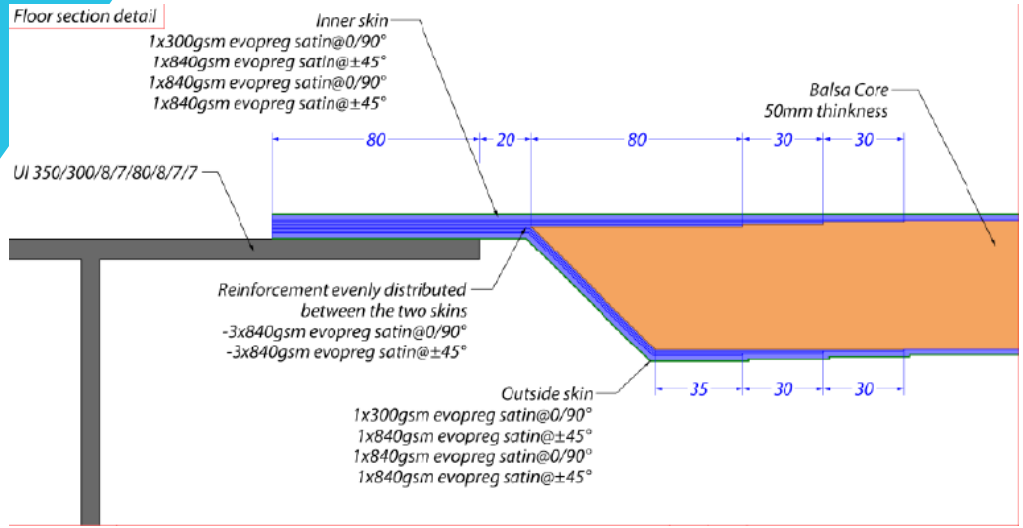
- Performances OK,
- Good potential for weight reduction,
- Price ?

ZALTEX - Large samples for test

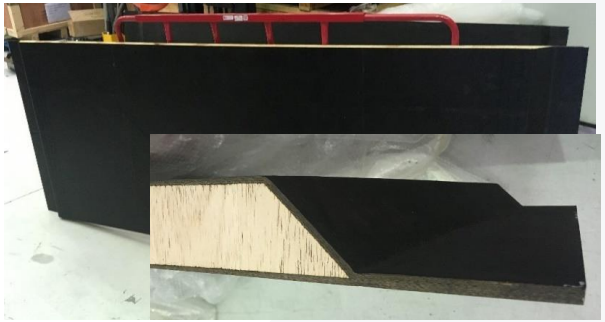
Production of 2 large samples with carbon fiber reinforced stiffeners for mechanical & fatigue tests

Dimensions = 1m * 2,69m (final cabin width)

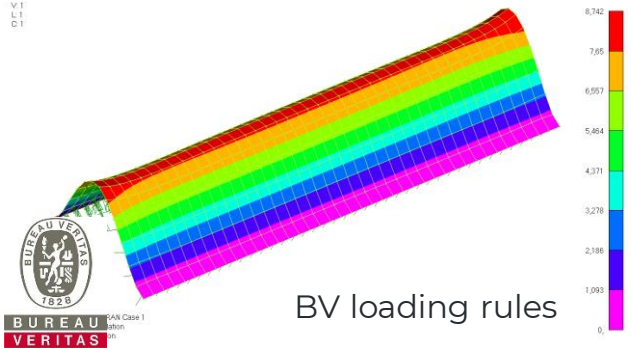
EVOPREG FLOOR



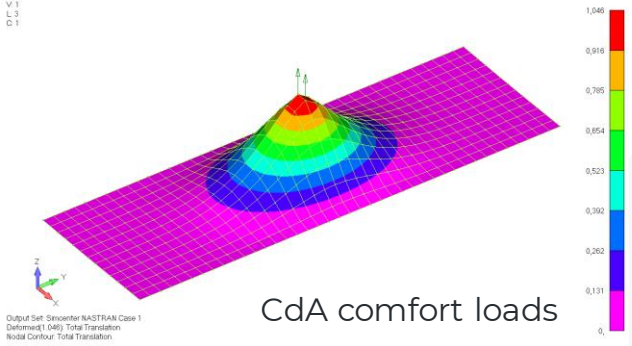
Design & production of Evopreg + Balsa large samples



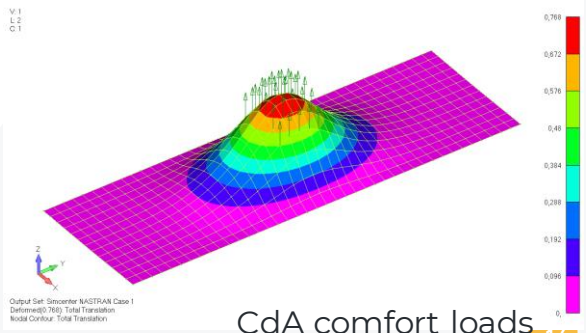
Design validation by Bureau Veritas calculation



BV loading rules



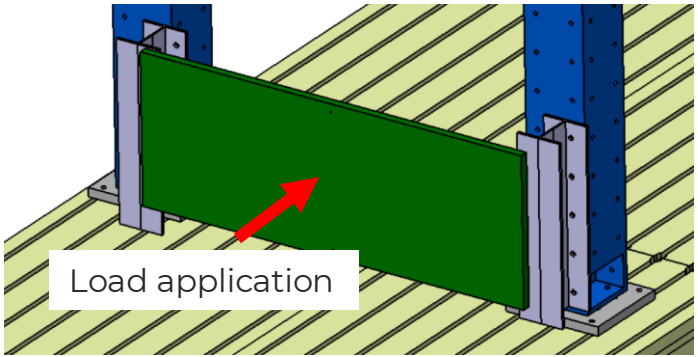
CdA comfort loads

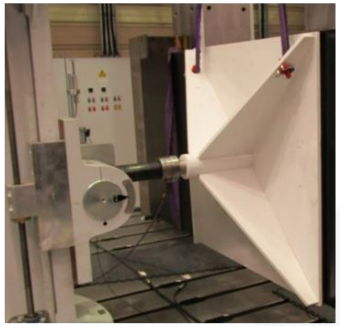
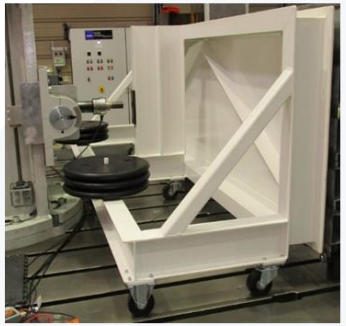


CdA comfort loads

MECHANICAL & FATIGUE TESTS

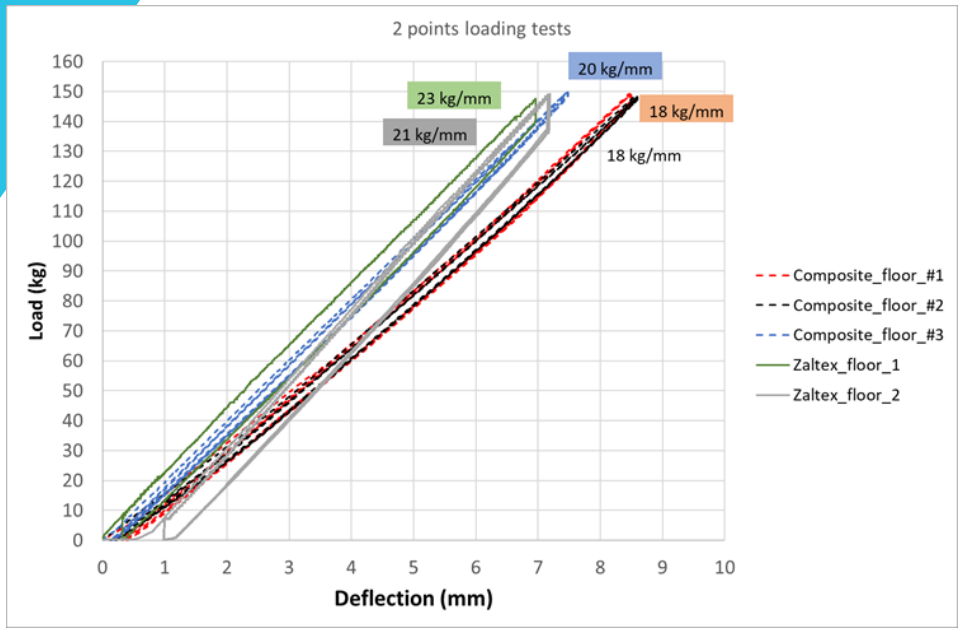
Mechanical & fatigue tests performed on large panels (2,69m x 1m), ie final floor width
Testing program done at IRT Jules Verne Angers for Evopreg & Zaltex

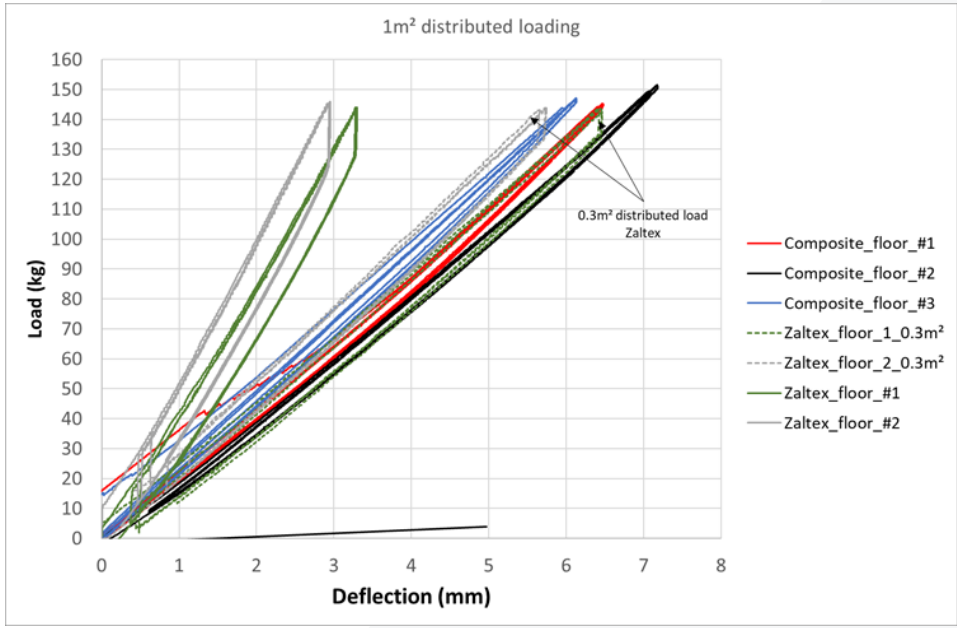


		
2 points	1m² distributed load	Total distributed load
Maximum deflection of 4,5mm under 2x75kg pressure CdA comfort requirement	Maximum deflection of 4,5mm under 150kg pressure CdA comfort requirement	No mechanical damage under 468daN/m² Regulation requirement with acceleration

IRT JULES VERNE

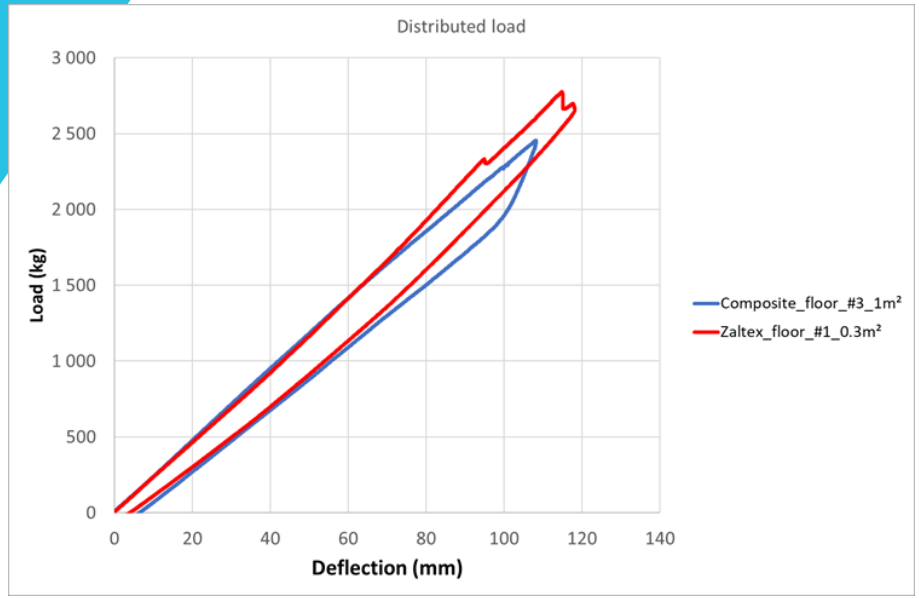
TEST RESULT



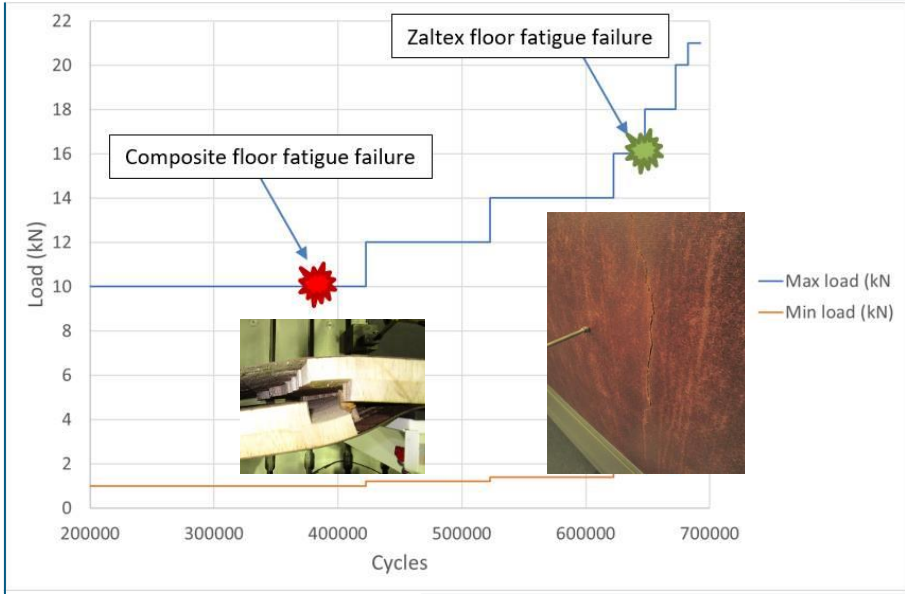


Evopreg + balsa floor is showing higher deflection compared to calculation

ULTIMATE & FATIGUE TEST



- Ultimate load > design load (468 kg/m²)
- Both material suitable for regulation

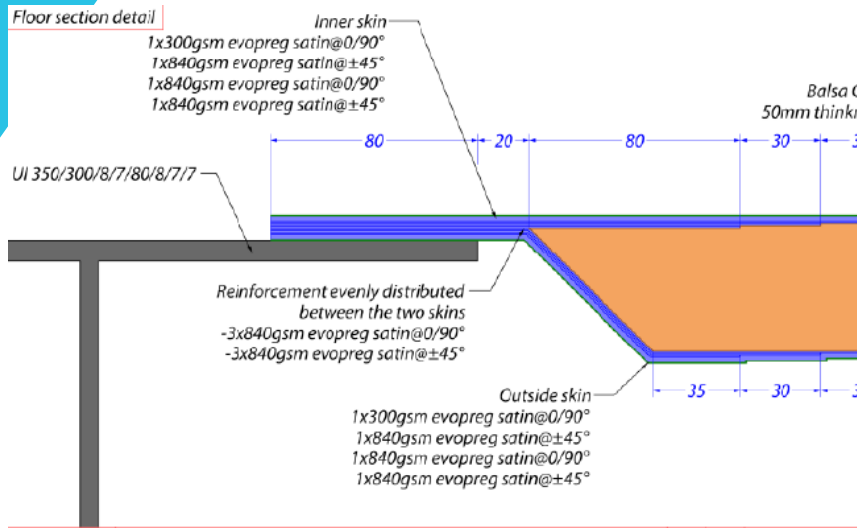


Evopreg = delamination failure
Zaltex = propagation of local crack

400.000 cycles > floor cycle life

Only one test on fatigue
Does not represent final result

EVOPREG FLOOR - recalculation + weight balance



	100% roving		
	angle	épaisseur (mm)	masse en kg/m2
roving 300g/m2	45°	0.25	0.45
roving 840g/m2	0°	0.69	1.24
roving 840g/m2	0°	0.69	1.24
roving 840g/m2	0°	0.69	1.24
roving 840g/m2	0°	0.69	1.24
balsa		50	4.80
roving 840g/m2	0°	0.69	1.24
roving 840g/m2	0°	0.69	1.24
roving 840g/m2	0°	0.69	1.24
roving 840g/m2	0°	0.69	1.24
roving 300g/m2	45°	0.25	0.45
	TOTAL	56.02	15.6

With high density balsa (7,7kg/m²), Total = 18,5kg/m²

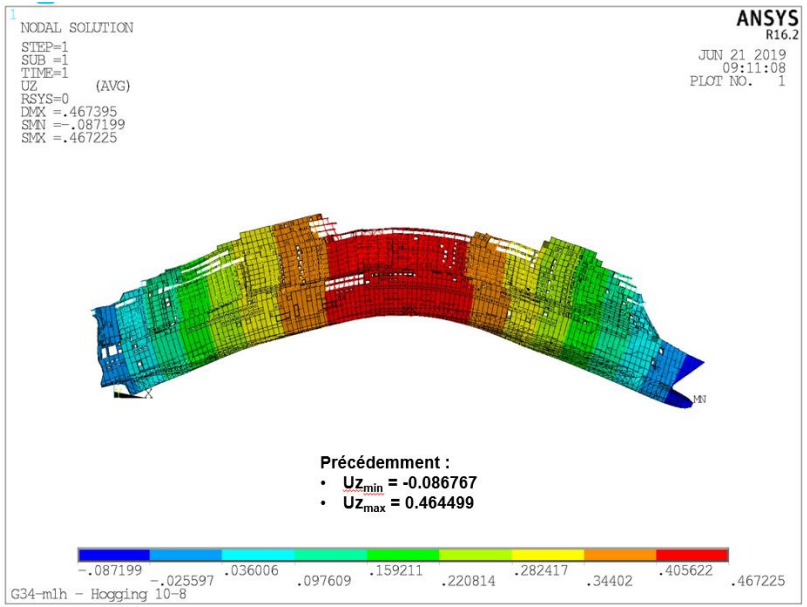
Echantillonnage	Flèche calculée (mm)	Critère (mm)	Taux d'utilisation (%)
100% Roving 16.5kg/m²	4.4	4.5	98%
100% Roving 15.6kg/m²	4.7	4.5	104%

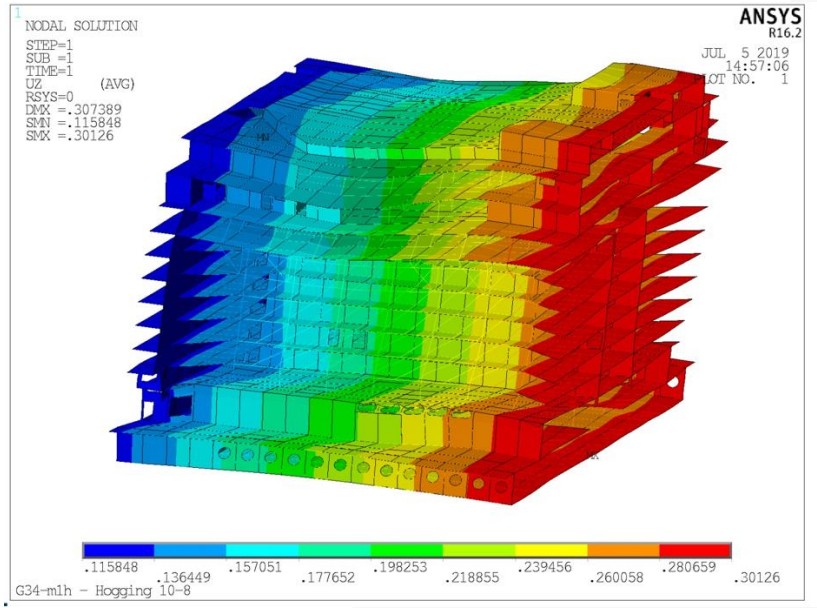
New calculation performed with Evopreg to reach deflection criteria,
Different cases studied : fiber orientation, additional stiffeners,...

Best result obtained by **changing fiber orientation + using higher density balsa**

SHIP BEHAVIOUR without cabin deck

Calculation on MSC Grandiosa by removing cabin deck on model





Similar ship behaviour with small increasing of displacement
+ 0,003m for flexion ; total flexion is 0,551m.

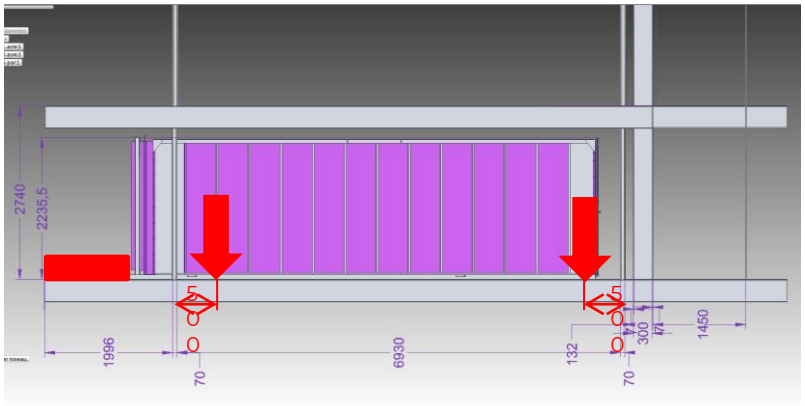
LOCAL STRUCTURE DESIGN

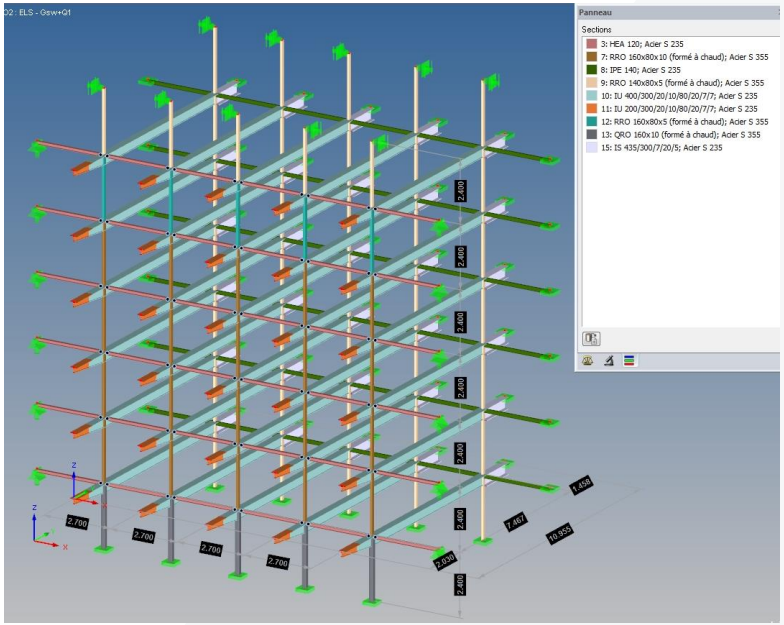
With RAMSSES architecture, local steel structure can be optimized and designed to only support cabin.

If considering linear contact with cabin floor, beam section has to be stronger to avoid torsion when loading only 1 cabin.

Solution found to light weight local steel structure =

Cabin supported only by 4 points on transverse beam

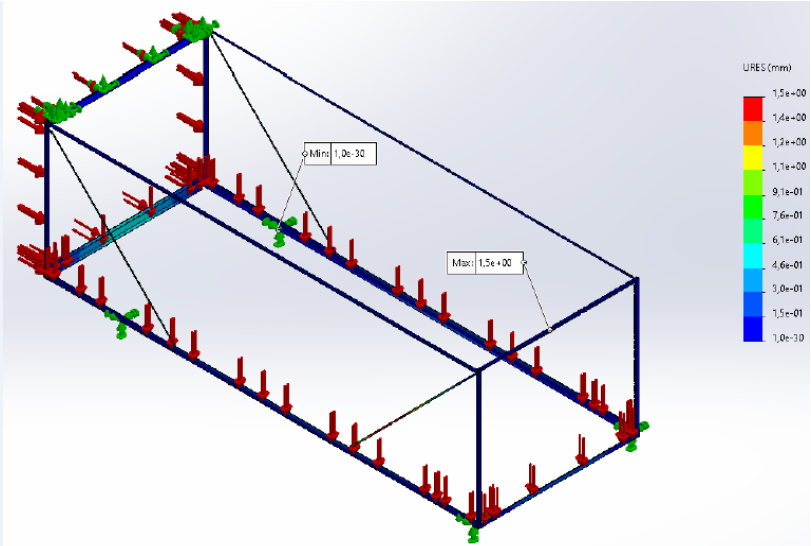




No floor solution with properties to be supported by only 4 points => **cabin frame**

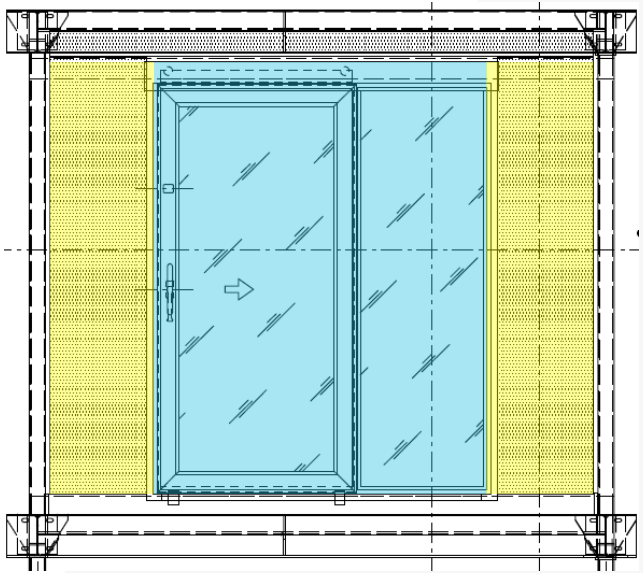
CABIN FRAME

Design of cabin frame (ie container) to support floor with only few points (4) of contact with ship transverse beams



Cabin frame is also designed (wind pressure) & used to support :

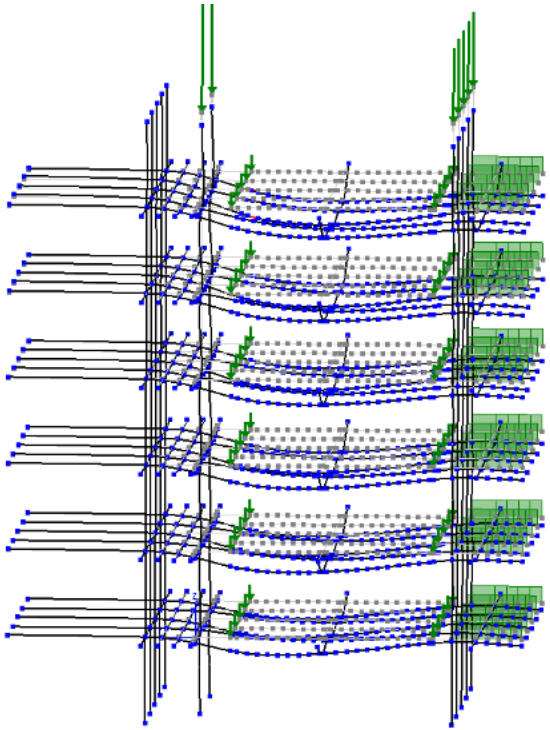
- Bay window (blue),
- A0 panels (yellow).

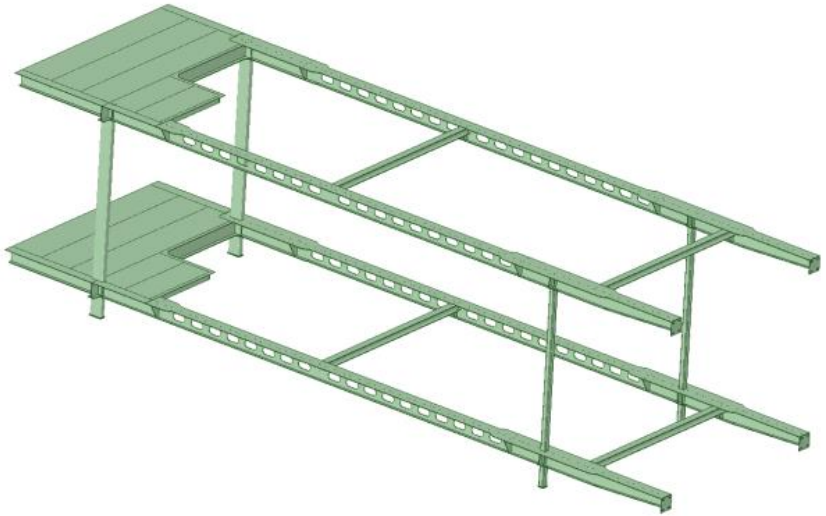


LOCAL STRUCTURE - optimisation

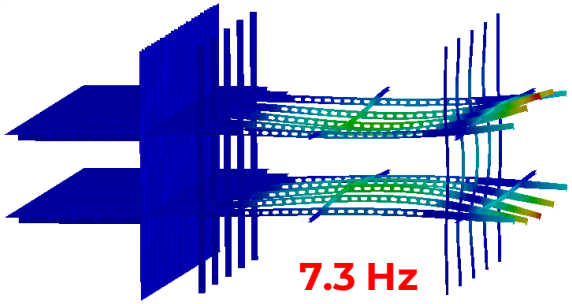
For demonstrator, structure has been designed and calculated to be :

- As light as possible,
- Taken into account CdA industrial process.

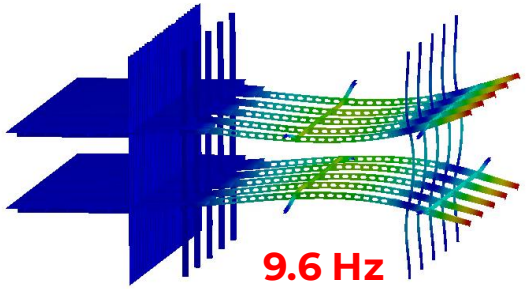




LOCAL STRUCTURE - Dynamic analysis



Lumped masses



Rigid connexions

Structure should have eigen mode over 12 Hz to avoid excitations from engine.

Cabin behaviour is unknown, but calculation is showing potential issue.

Solution is known :

- Increase beam height => +150 kg/cabin

Demonstrator produced with optimised steel structure :

- To measure real cabin behaviour,
- To try to validate the lightest structure

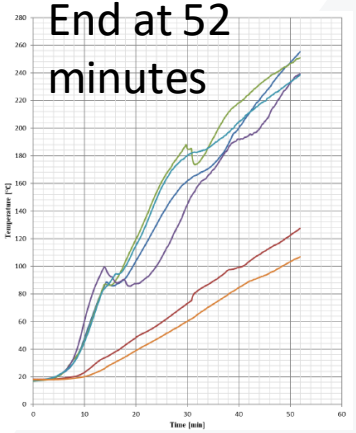
FIRE INTEGRITY

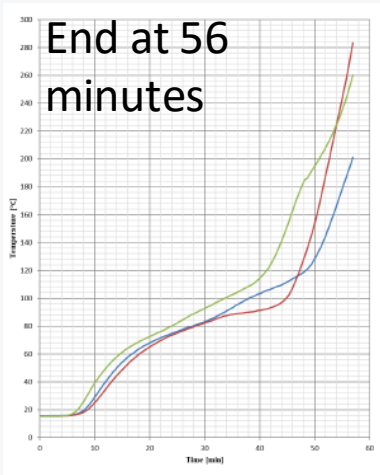
SOLAS requirement :
A15 between 2 welded steel decks,

RAMSSES design :
FRD60 – load bearing test

Small scale furnace test
performed with both material with similar result :

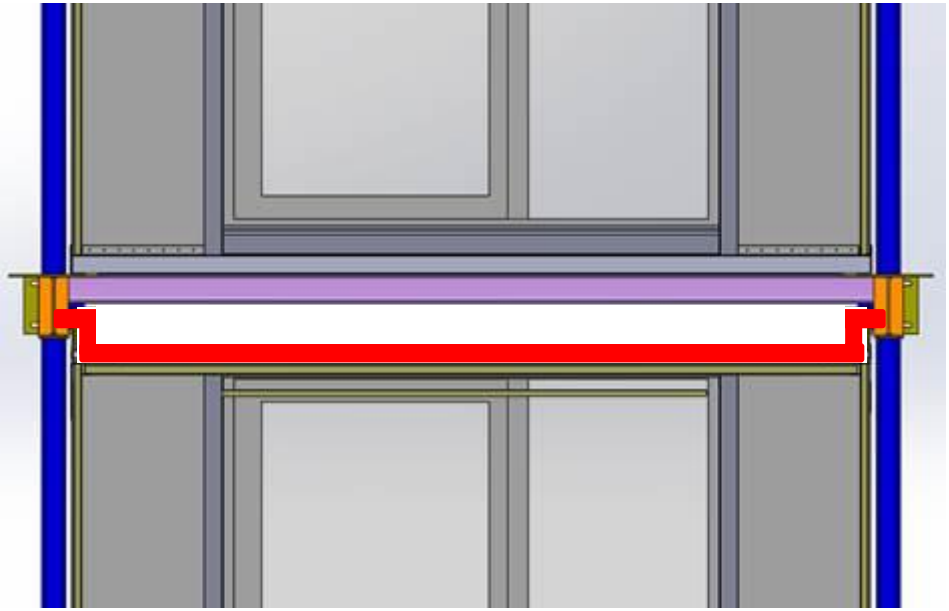
- Additional insulation under floor is needed,
- Confirmed by HDT measure done by Composites Evolution

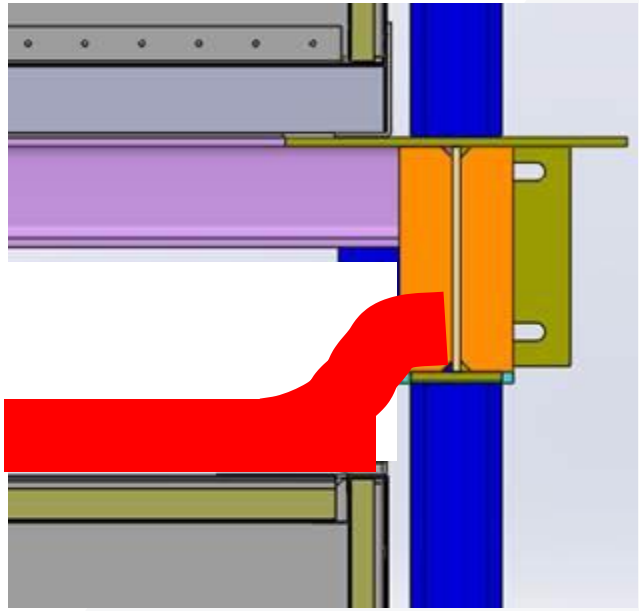




FIRE INTEGRITY

Design choice to apply additional fire wool on cabin ceiling for process reason.





FRD test still to conduct with Evopreg floor in 3rd quarter 2021 by RISE.

WEIGHT BALANCE + SHIP BENEFIT

weight (kg)	Zaltex floor + carbon fiber stiffeners	Ecopreg floor	Ecopreg + savings	reference ship
Cabin	2020	2020	2020	2020
Bay window + panels	216	216	216	216
Balcony	193	193	193	229
Steel ship structure	768	768	768	2039
Balcony floor	69	69	69	
Cabin floor	352,28	461,39	461,39	
Cabin frame	165	165	165	
Insulation	100	100	100	0
PU pads	1	1	1	0
Patching	0	0	0	94
Weight reduction (floor with integrated functions)			-289	
Total	3884	3993	3704	4496
weight reduction versus reference ship	14%	11%	**18%**	
	612	503	**792**	

Solution with best potential is **Evopreg floor**.
Composite material can offer to mold additional parts directly in the floor (bathroom floor, walls and furniture supports, ...) to optimise RAMSSES design.

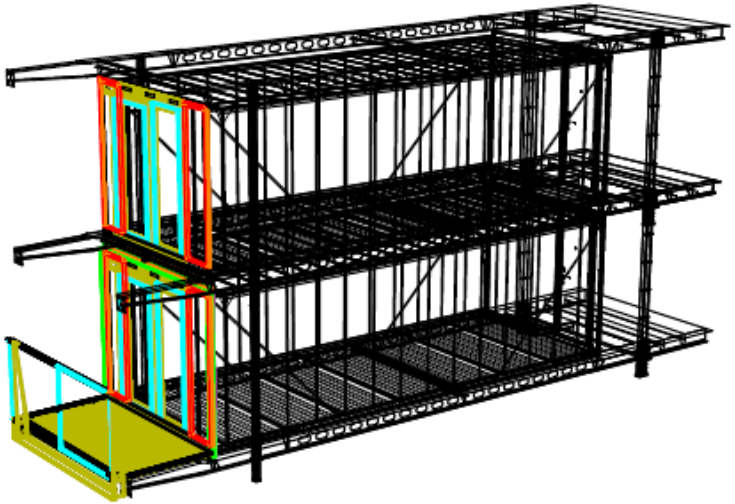
WEIGHT BALANCE + SHIP BENEFIT

Potential benefits to apply RAMSSES architecture on small cruise vessel (500 cabins):

- ↘ weight reduction with same cabins quantity
  - ➡ ~ -0,5% of energy consumption
- ↗ more cabins for some weight / center of gravity
  - ➡ +7% to +9% cabins

➡ **Opportunities for new ship architectures**

RAMSSES Demonstrator



2 cabins one above the other :

- Comfort measurements

1 prefabricated balcony with floor in aluminum profile :

- No benefit to share one floor for cabin and balcony

Validation of assembly concept

RAMSSES Demonstrator

NEXT STEPS & CONCLUSION

Last project steps :

- Insitu measurements by IRT Jules Verne & CdA NVH department,
- Industrialisation study to finalise,
- Cost study to finalise,
- LCPA study to update with final design,
- FRD fire test to succeed.

Conclusion :

- Current results are showing great potential for this new architecture,
- Design can be easily adjusted to different material for floor.

RAMSSES project was a wonderful opportunity to validate and develop this concept.

There are still works to perform before offering this architecture to ship owner, and we will surely continue project after RAMSSES.