LIGHTWEIGHT COMPOSITE SHIP CABINS

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WHERE DID IT ALL START?

- May 2009 – A visit to Carnival’s Queen Victoria
- November 2012 – Composites in Ships conference, Southampton: “Composites in Ships, Potential in Cruise Vessels” Richard Vie, Head of New Build, Carnival
- April 2013 – Application prepared under a UK Government TSB grants competition “Vessel Efficiency”
- November 2013 to March 2016 – “Composite Cabin Module Project”

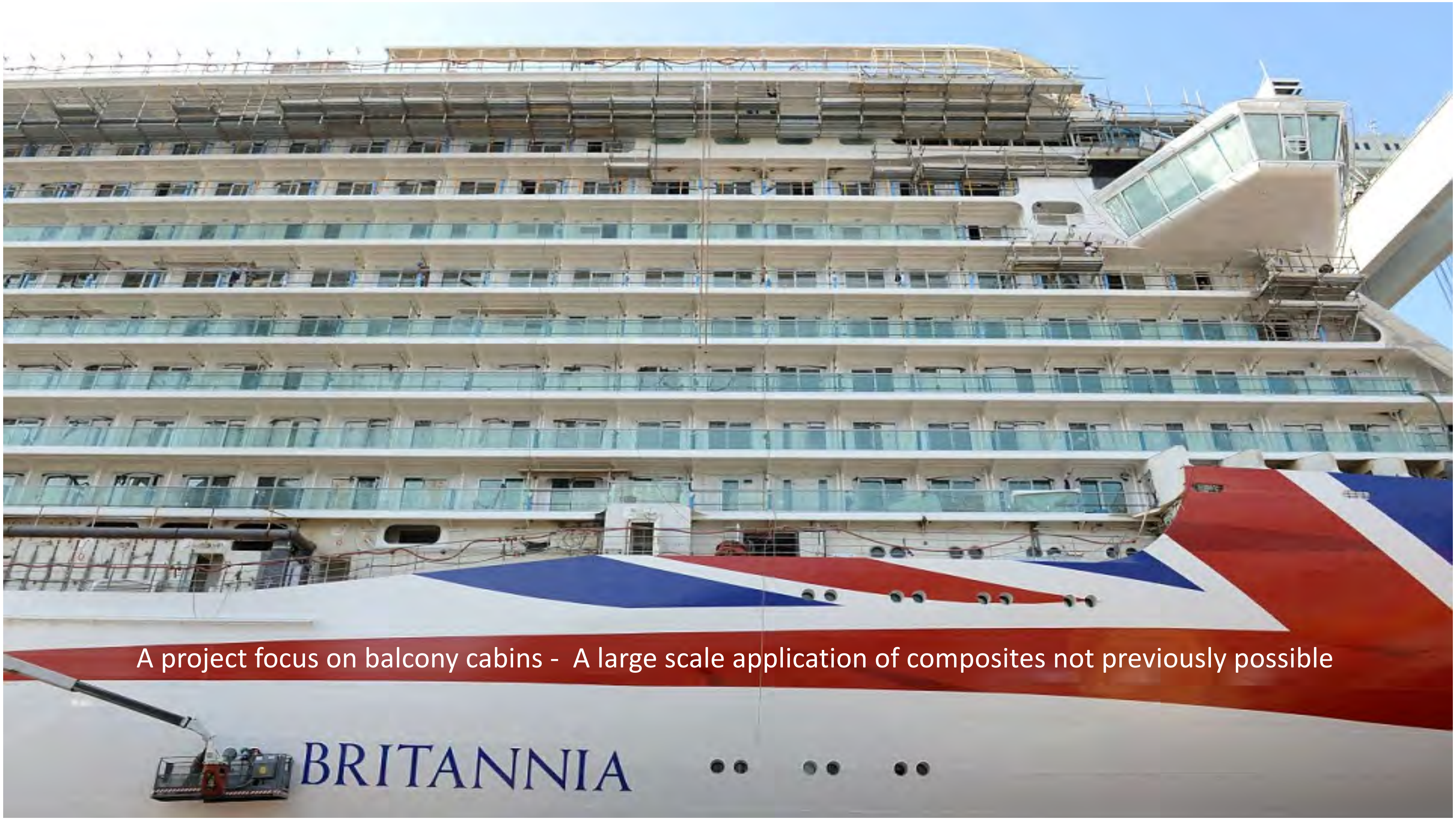
PROJECT SPONSORS

Sponsors

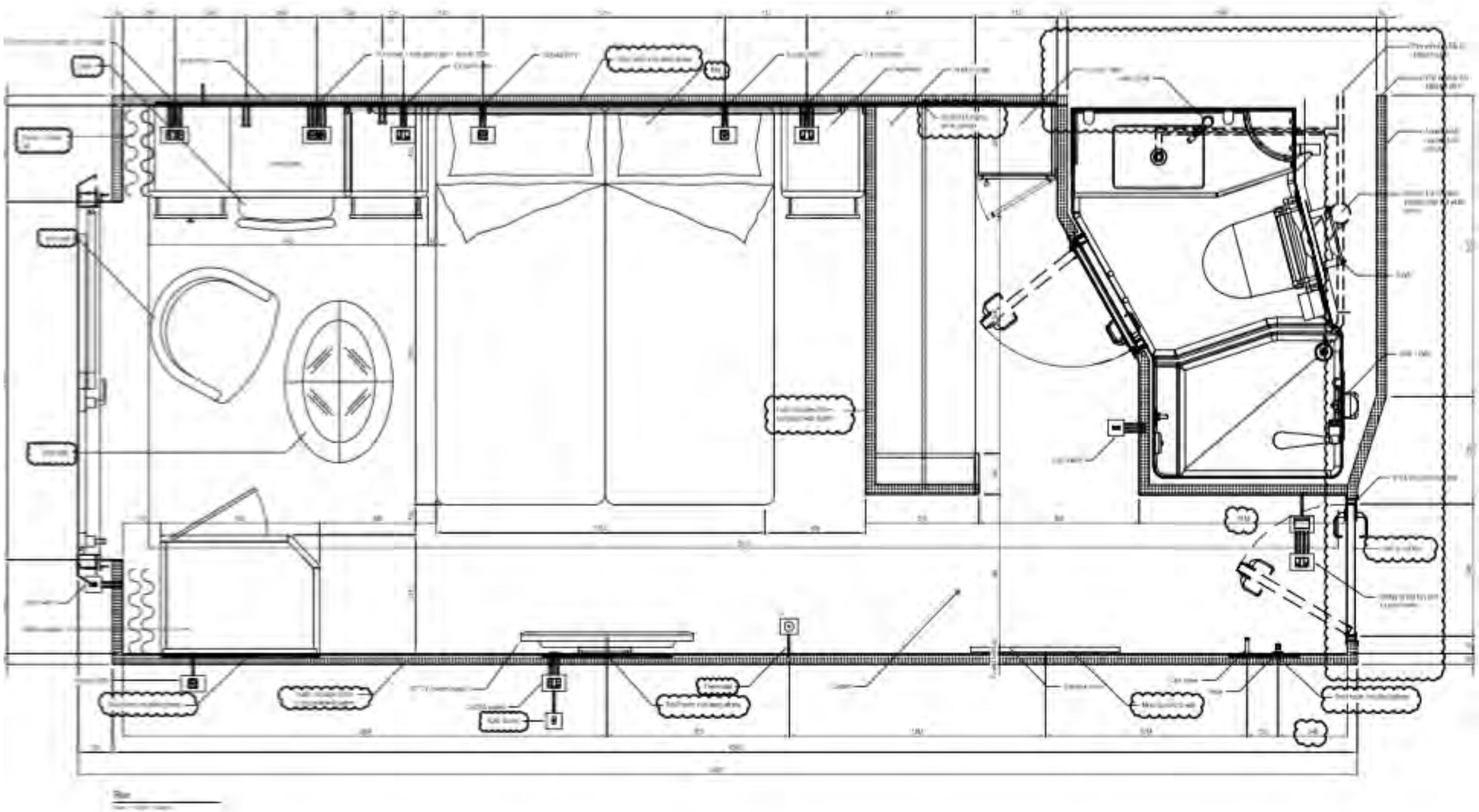
- Innovate UK (previously Technology Strategy Board) - the UK Government's innovation agency
- Defence Science & Technology Laboratory (DSTL) - an executive agency sponsored by the Ministry of Defence. The DSTL ensures that innovative science and technology contribute to the defence and security of the UK.

Consortium Members

- PE Composites Limited - Lead Partner & composites manufacturer
- Carnival Corporation - World's largest cruise company ~100 ships
- Gurit (UK) Limited - Composites structural engineering, materials & components manufacturer
- University of Southampton - Materials search & characterisation, acoustics testing and analysis through their acoustics consultancy ISVR
- Trimline Limited - Marine interior design & fit-out contractor
- Lloyd's Register - Certification body
- Maritime & Coastguard Agency (MCA) - An observing role concerning regulatory requirements and the UK Flag viewpoint


A project focus on balcony cabins - A large scale application of composites not previously possible
BRITANNIA

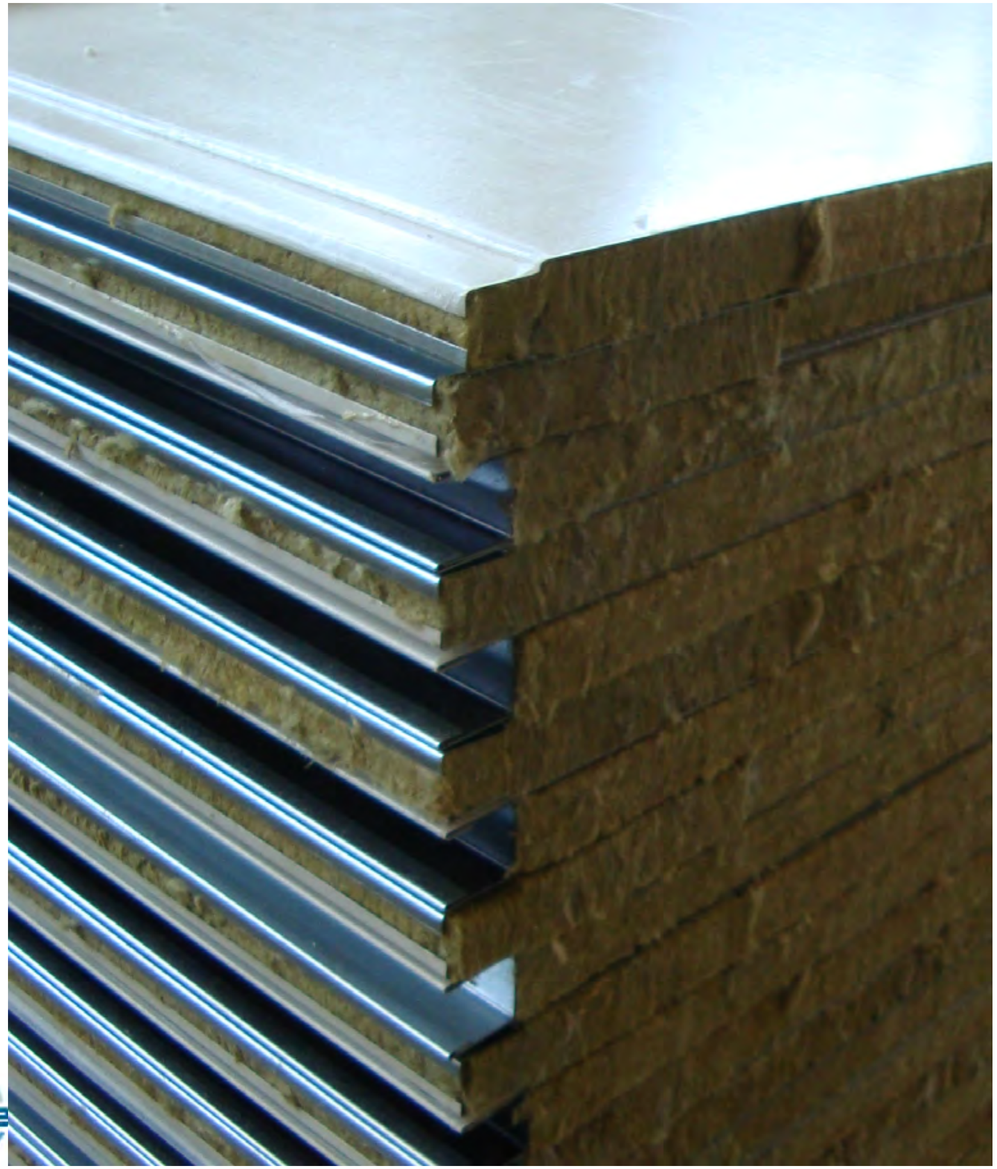
TYPICAL BALCONY CABIN GA

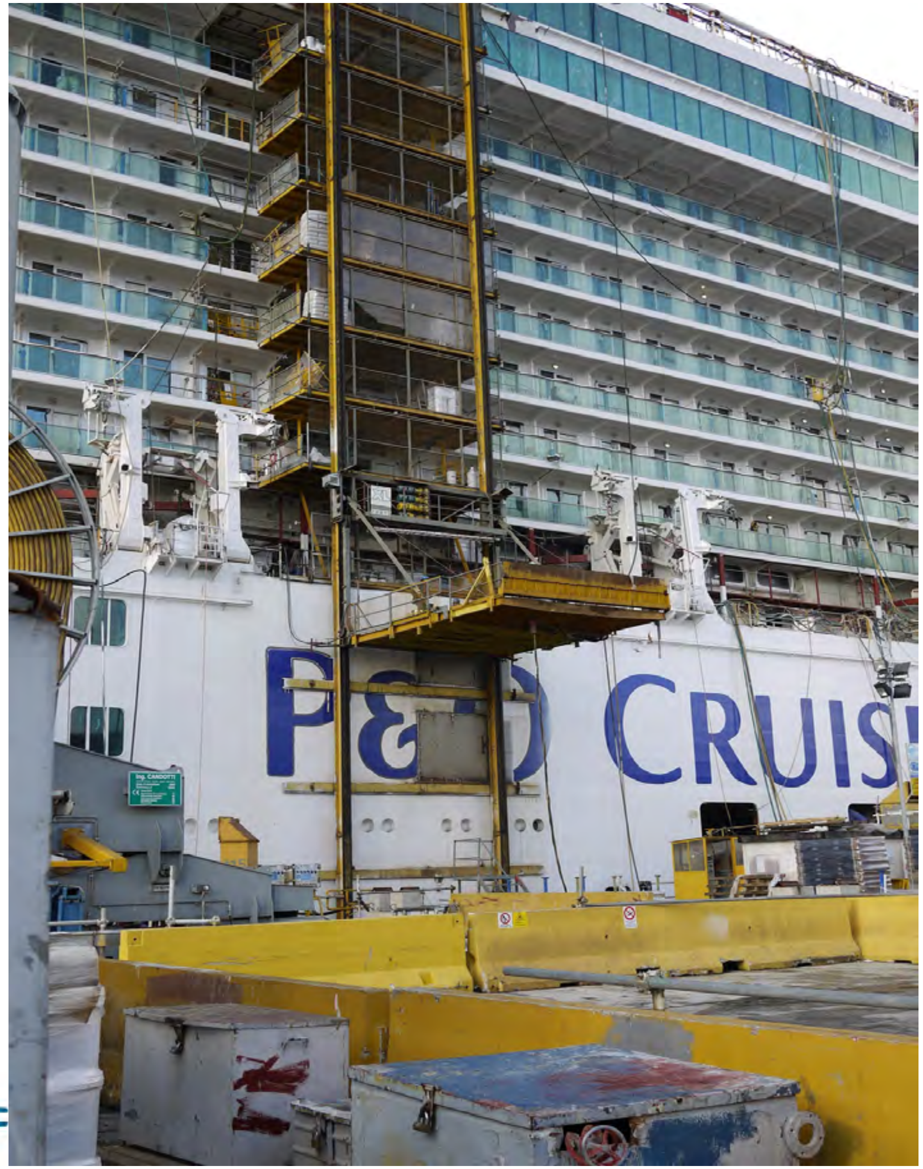


CURRENT CABIN CONSTRUCTION

Typically:

- Panels manufactured from zinc coated mild steel
- Filled with mineral wool typically 20-25mm thickness
- Internal surface finish of approved vinyl film
- Sometimes Steel or Aluminium Foil on the outside surfaces of the cabin
- Modular construction – assembled in situ or pre-assembled
- Wet units are attached as a separate bolt-on unit





Typical present day cabin interiors

WHY CHANGE IT?

- Reduction in topsides weight
  - Improved fuel efficiency = lower emissions
  - Improved stability
  - Increased payload of vessel = more cabins = increased revenue
- Reduced transportation costs, easier handling
- More sustainable / less embodied energy
- Lower carbon footprint
- Easier maintenance
- Quicker repairs

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PROJECT AIMS

The project would design, engineer, manufacture and fit-out a prefabricated accommodation module typical of cabins currently installed on cruise and other passenger carrying vessels.

The cabin would be manufactured from non metallic composite* materials.

The project aimed to reduce weight and reduce the carbon footprint whilst also meeting current prescriptive requirements for incombustibility, thermal boundary, smoke and toxicity & flame spread requirements, etc. as required by IMO SOLAS regulation.

Reducing vessel weight improves vessel efficiency and falls within the scope of the TSB grant competition under which the project sits.

* composite = entirely non metallic polymer composite materials

IMO / SOLAS REQUIREMENTS

Strict requirements for materials forming Fire Boundaries (cabin walls & deckheads)

- Satisfy the prescriptive requirements of the IMO FTP Code
  (Fire Test Procedures Code)
- Fire barriers shall be manufactured from Non-Combustible materials**
  (IMO FTP Code Annex 1 Part 1)
- Thermal boundary classes are also determined by SOLAS II-2

**Polymer composites: Conventional polymer resin systems and some reinforcements are combustible (ISO 1182) even though they can be made with Class 0, fire retardant, low flammability, etc. characteristics. Thus they fail at the first hurdle.

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PIPER ALPHA – 6 JULY 1988

IMO / SOLAS BOUNDARY DEFINITION

The minimum thermal boundary requirement for a cabin wall, regardless of whether there is a minor, moderate, or greater fire risk, is classed as B-0. Also, the minimum thermal boundary requirement for cabin to cabin & cabin to corridor interface is classed as B-15.

Class B Divisions

- Constructed of approved non-combustible materials
- Prevents the passage of flames during at least 30 minutes of the standard test
- Insulated such that the average temperature of the unexposed side will not rise more than 140° C, nor will the temperature at any one point, including any joint, rise more than 225°C above the original temperature, after:
  - B15: 15 minutes
  - B0: 0 minutes (no insulation requirement)

The standard time/temperature curve results in a furnace temperature of 708^{o}C after 15 minutes and 823^{o}C after 30 minutes

PROJECT DEFINITION / SPECIFICATION

Definition → Material Search & Selection → Design & Engineering → Testing → Prototype Build

- General Arrangement Drawing

Four key technical cabin specifications were written:

- Geometry and Architectural Finishes
- Load Cases
- Fire and Acoustic Performance
- Formal Testing Programme

MATERIALS SEARCH AND SELECTION

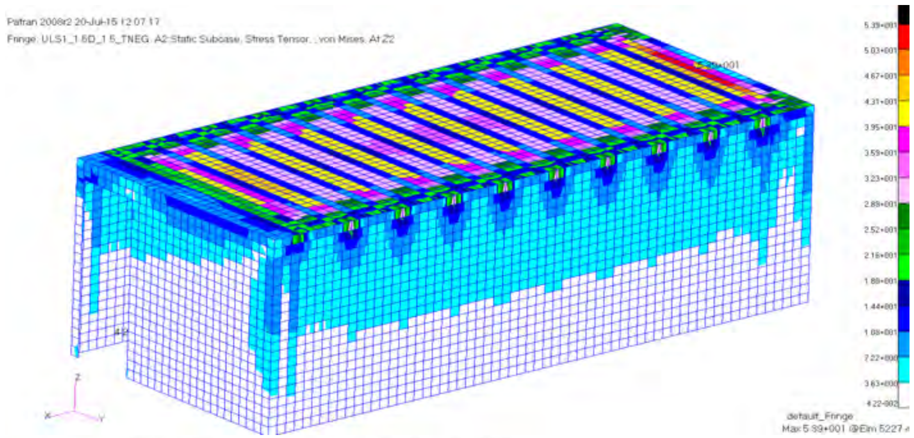
Definition → **Material Search & Selection** → Design & Engineering → Testing → Prototype Build

- Search for materials with potential
  - Weight
  - Mechanical performance, Durability
  - Environmental
  - Compatibility with proposed cabin finishes
  - Capable of being formed into a cabin structure
- Some not yet fully developed
- Characterisation & indicative testing of short-listed option

DESIGN AND ENGINEERING

Definition → Material Search & Selection → **Design & Engineering** → Testing → Prototype Build

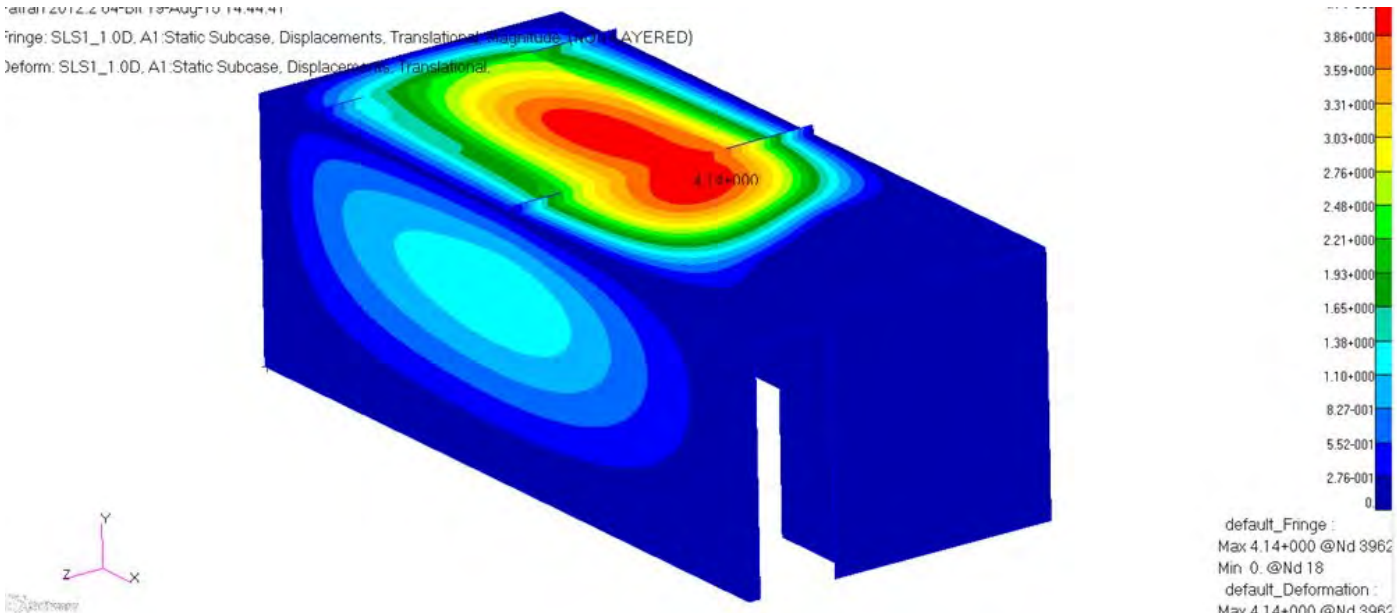
- Reverse engineering a standard cabin
- FE modelling a composite cabin using materials characteristic data collected in the material evaluation phase
- Developing structural concept
- Panel connection details
- Weight study and comparisons
- Running various load cases



DESIGN AND ENGINEERING

Definition → Material Search & Selection → **Design & Engineering** → Testing → Prototype Build

- Ceiling deflection under dead load is 4.1mm compared with 32.5mm for a typical conventional cabin.



DESIGN AND ENGINEERING

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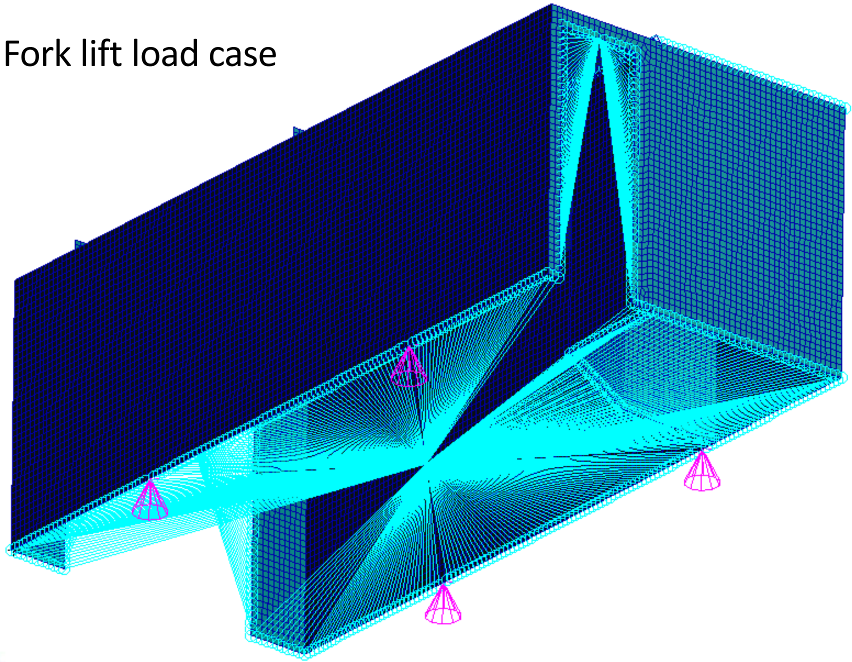

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FORMAL TESTING - FIRE

Definition → Material Search & Selection → Design & Engineering → **Testing** → Prototype Build

- Following on from characterisation, indicative and in-house small scale tests
- Panel system shown to satisfy the prescriptive FST requirements for this application after completion of the testing phase
- Testing at IMO approved test houses & verified by Lloyd's Register
- Testing strictly in accordance with the FTP Code
- No Wheelmark or Type Approval sought at this stage for the prototype
- Also undertook additional tests designed to verify elements of cabin construction not tested during FTP Code testing

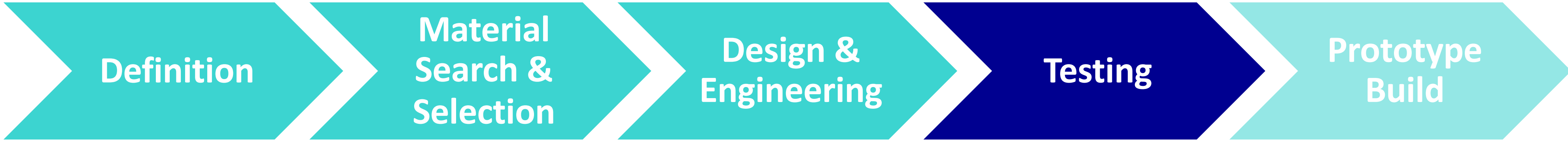
FORMAL TESTING - ACOUSTICS

Definition → Material Search & Selection → Design & Engineering → **Testing** → Prototype Build

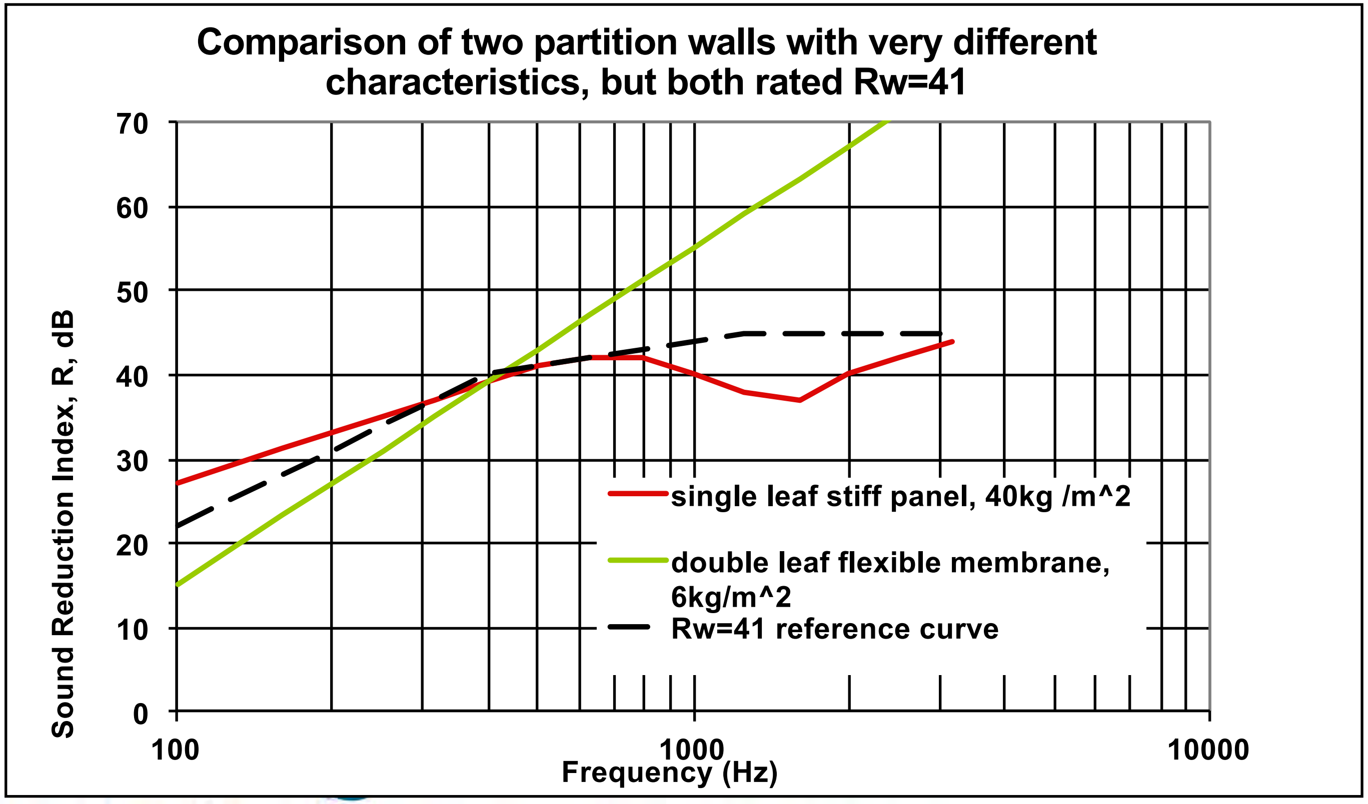
REQUIREMENT	**ISO 717-1:1996**	**CARNIVAL**
Cabin to Cabin	Rw 35dB	Rw 41dB
Cabin to Corridor	Rw 30dB	Rw 35dB

- Untreated cabin to cabin achieves Rw 32dB due to its low mass
- Specialist approved materials are added to this to achieve the desired rating – this adds weight to the cabin but our estimates include an allowance to achieve typical user ratings
- Analysis work undertaken on the test results and cabin models developed demonstrates that a lightweight attenuation solution can be achieved. IMO requirements still have to be met.
- However, the project suggests that the standard Rw curves designed for general usage in buildings are not best suited for use on-board cruise ships – custom attenuation curves should be developed

FORMAL TESTING - ACOUSTICS



Rw curves were not developed for ships. The plot to the right compares two different panel systems both achieving an Rw rating of 40dB. These two systems have completely different acoustic performances at high and low frequencies. One may be more suitable for use than the other – but how will you know?
Is the Rw measure relevant to cruise vessels?



FORMAL TESTING - SUMMARY

Definition → Material Search & Selection → Design & Engineering → **Testing** → Prototype Build

- FST06 Non combustibility of fire barrier material
- FST07 Calorific value (max heat release) of internal finish
- FST10 1.5m vertical test to prove penetrations
- FST11 3m vertical furnace test with finish skins applied
- FST18 3m horizontal deckhead test
- FST19.1 1.5m horizontal furnace test to prove coffer construction
- FST19.2 1.5m horizontal furnace test without coffer
- FST21-23 (FTP Code Parts 2 & 5) Smoke, Toxicity, Flammability
- FST25 Full scale cabin fire test at FPA
- APT5 & 10 Acoustic testing at ISVR, on-board Arcadia and at Trimline

PROTOTYPE BUILD

Definition → Material Search & Selection → Design & Engineering → Testing → **Prototype Build**

- Two cabins manufactured
- Both mounted on transportation frames
- Allowed cabin to cabin acoustic testing using different materials
- One show cabin which is available for viewing
- One cabin for fire testing (not required by the regulations)

- The furniture in the show cabin is constructed using the same lightweight non combustible materials with veneers etc. added as required.
- The fire test cabin was a mock-up of a standard fit-out using IMO / SOLAS approved materials – FR MDF, approved mattress, underlay, carpet, etc.

FORMAL TESTING - REQUIREMENTS

- IMO SOLAS Regulation does not require a large scale test of the accommodation module

  [Note: However, high Speed Craft rules (IMO 2000 HSC Code, Chapter 7) use the Room Corner Test ISO 9705, EN 14390]
- We worked with the UK Fire Protection Association (FPA) and developed our own test procedure to closely represent a typical cabin fire and representative heat load
- We wanted to prove the integrity of our methods of construction which were not tested in the previous formally defined test regime
- The test was witnessed by Lloyd's Register

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ALL-UP WEIGHT DATA

- Typical present day fitted-out cabin weight: (project base case)

  1,935kg

- Project cabin all-up weight: (shell, wet unit, fitted-out)

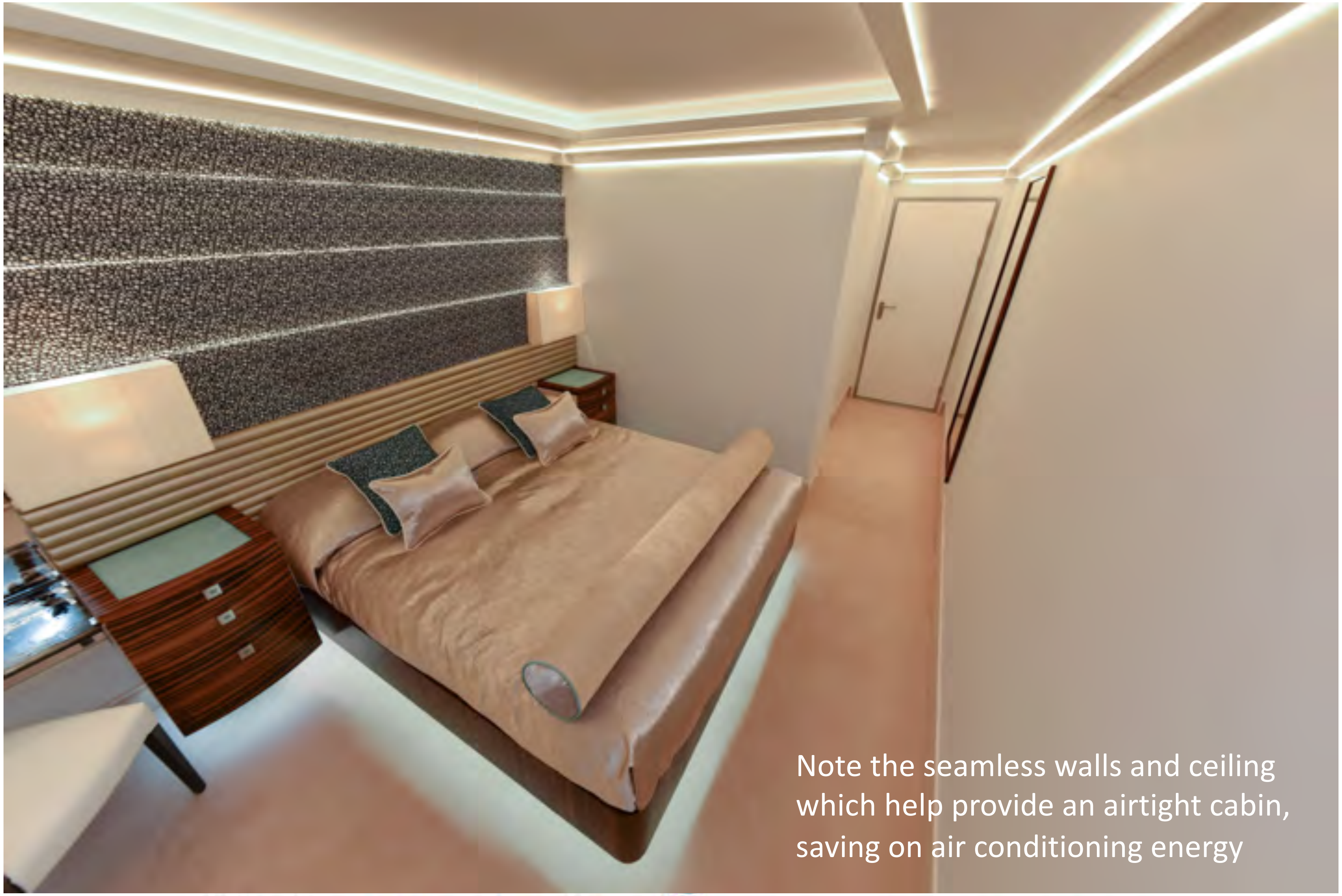
  972kg ~49% reduction

Note: Weights of present day cabins, wet units and fit-out vary enormously between manufacturers and specification.

For accurate weight data supply us with a drawing and your particular specification / requirements. Typical weight saving is expected to be 40% - 50%.

WHAT WE REALISED

- A significantly lighter panel system (40% - 50%)
- Structurally equal to the present steel system
- More resistant to dents and scrapes
- Easier and faster repairs - able to restore the original cabin finish in the short windows of time available
- Air tight construction could reduce air conditioning costs
- Expected to be cost competitive when produced in quantity
- Able to customise the acoustic performance of the cabin
- Capable of being type approved with further development
- Patents applied for



Note the seamless walls and ceiling which help provide an airtight cabin, saving on air conditioning energy

SMM 2016 where the cabin received very considerable interest

FREQUENTLY ASKED QUESTIONS

- How thick is the panel? <20mm
- Is it certified? No. There is no MED / Wheelmark certificate yet.
- Can I have a copy of all the test certificates? We did not ask Lloyd's to certify the tests, only witness them, thus all we have are the detailed test reports from the IMO approved laboratories. These are not available for public review but can be made available to certifying bodies who may be involved in approving the installation of cabins on-board a particular vessel.
- Is the cabin on sale now? Small quantities can be supplied within a few months time but these will carry a cost penalty as they will be hand built. A pilot production plant is planned and this will reduce purchase costs but only when a full plant is built will costs be closer to those of steel cabins.

WHAT'S NEXT FOR SOLAS VESSELS?

- Amended or new regulations to specifically address the use of non metallic materials
- Develop NEW MATERIALS which comply with present regulations
- Breaking down the roadmap approach into bite sized pieces:
  - Non structural elements – B15 partitions
  - Secondary structure – balconies, masts, towers
  - Primary structure – topsides
  - Complete vessels
- Composites for fire doors – lighter and safer

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Contacts

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Keen to be involved in other challenges utilising composites on-board

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