IV CONGRESO INTERNACIONAL DE DISEÑO E INGENIERÍA NAVAL

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SHIP DESIGN AND NAVAL ARCHITECTURE

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Why I am Presenting

- The stance of a Naval Constructor
- Over 30 years involvement in naval ship and submarine design and acquisition
- Project Manager and Project Director for - UK Amphibious Programme (incl new Royal Yacht), Concept designs of emerging UK fleet, Trimaran, Future Surface Combatant.

Royal Navy Landing Ship Helicopter
(HMS Ocean)

Future Surface Combatant
(Early Trimaran Concept – by UK MoD Concept Group

Artist’s Impression of a New Royal Yacht

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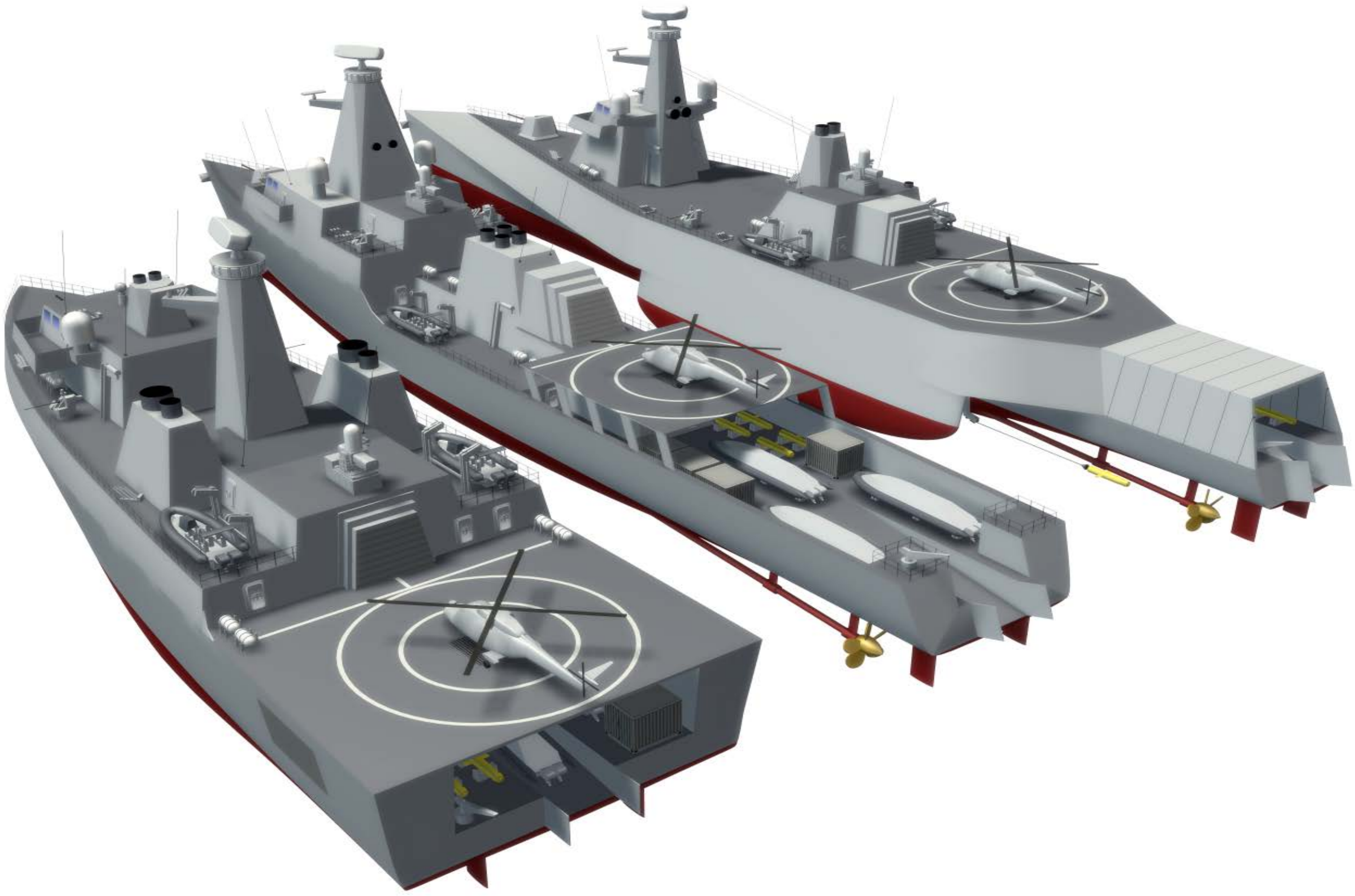
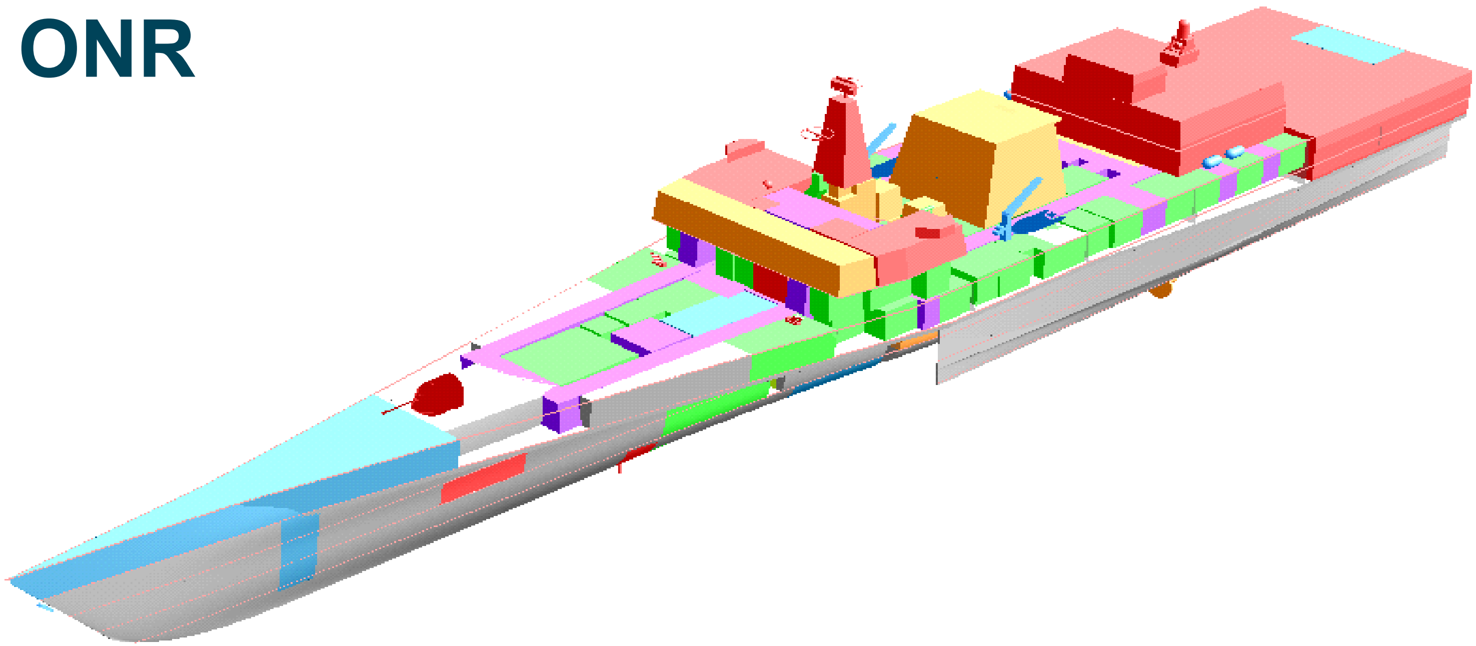
- Analyst of naval ship design and acquisition
- Professor at UCL developing an integrated approach to preliminary ship design – the Design Building Block approach (SURFCON CAD implementation in Paramarine CASD).

NDP OPV Studies (Pawling & Andrews RINA Warship 2010)



UCL DBB study of USN LCS for ONR



Number of DBB	343 (in c. 25 SBBs and 11 grouped BBs)
Displacement	3212te
Enclosed Volume	19500m3 (R) 2600m3 (A)
Length, main hull, waterline	136.3m

SHIP DESIGN AND NAVAL ARCHITECTURE
Outline

- **Ship Design – S5 - Style**
- Naval Architecture as an Engineering Discipline
- NA as Science applied to Ship design – S4
- Ship Design as a special case of engineering design – NSD
- The critical importance of the Concept phase of NSD
- Why the concept phase of Naval Ship Design must and can be architecturally led - Design Inside Out

S5

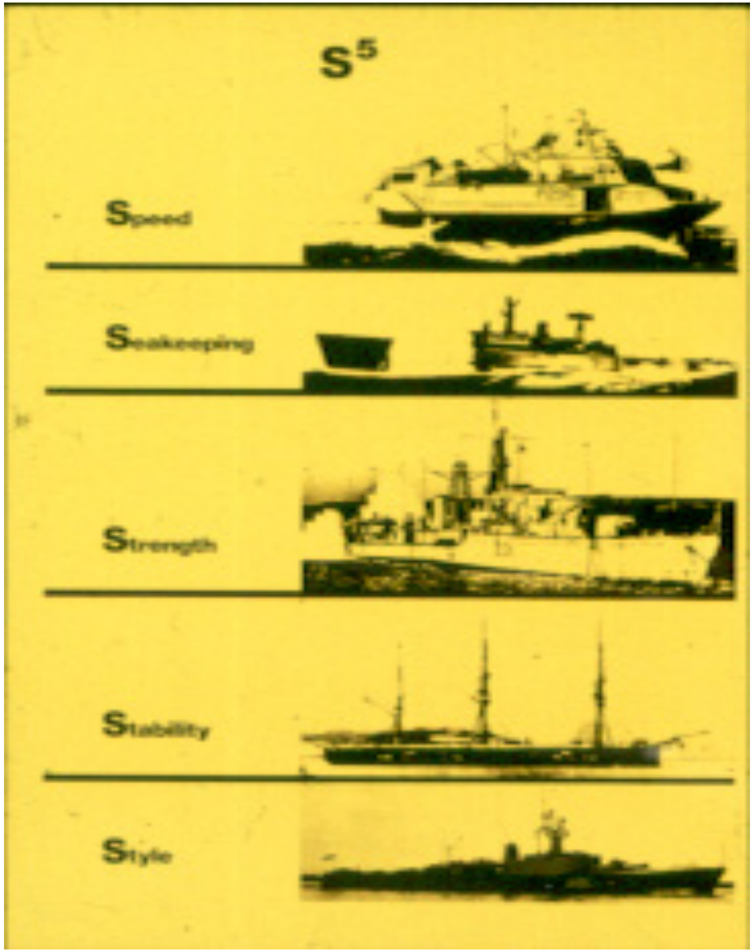


Table 1. Listing of style topics relevant to a naval combatant design

Stealth	Protection	Human Factors	Sustainability	Margins	Design Issues
Acoustic signature	Collision resistance	Accommodation standards	Mission duration	Space	Robustness
Radar cross section	Fire fighting	Access policy	Crew watch policy	Weight	Commercial standards
Infra-red signature	Above water weapon effect	Maintenance levels	Stores level	Vertical centre of gravity	Modularity
Magnetic signature	Underwater weapon effect / shock	Operation automation	Maintenance cycles	Hotel Power	Operational serviceability
Visual signature	Contaminants protection	Ergonomics	Refit philosophy	Ship Services	Producability
	Damage control		Upkeep by exchange	Design point (growth)	Adaptability
	Corrosion control		Replenishment at Sea	Board Margin (upgrades)	Aesthetics

Examples of Style

- Signatures – RN Type 23 Frigate
- Accommodation – USN “Super Carriers”
- Margin Policy – Future Aircraft on RN INVINCIBLE Class
- Adaptability – Mission bays

Figure 3 Mission Bay Arrangement for an RN Type 26 Design Study

(Broadbent & Binns 2006)

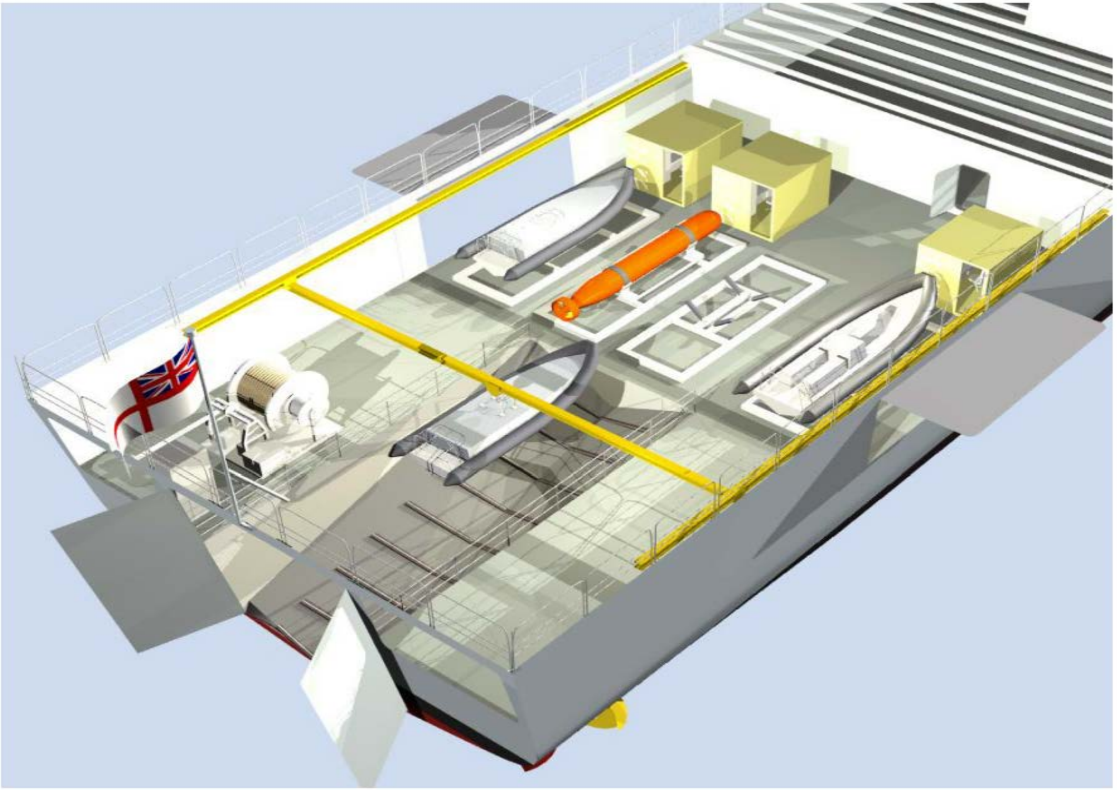


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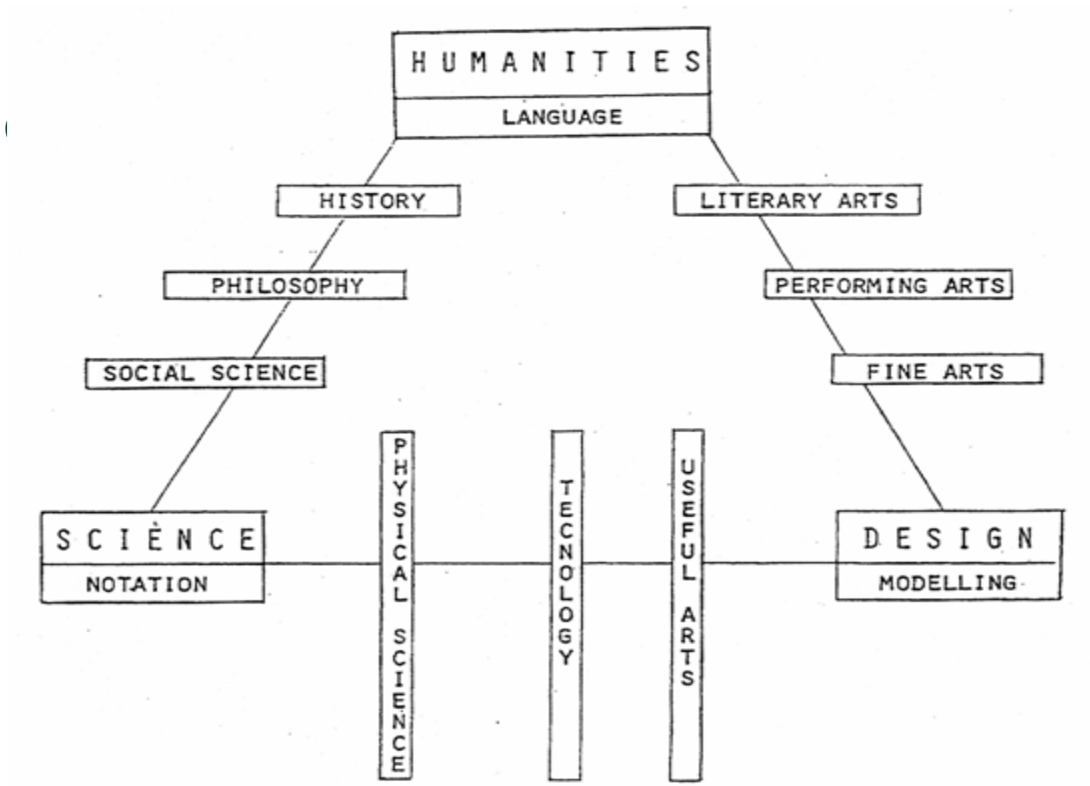
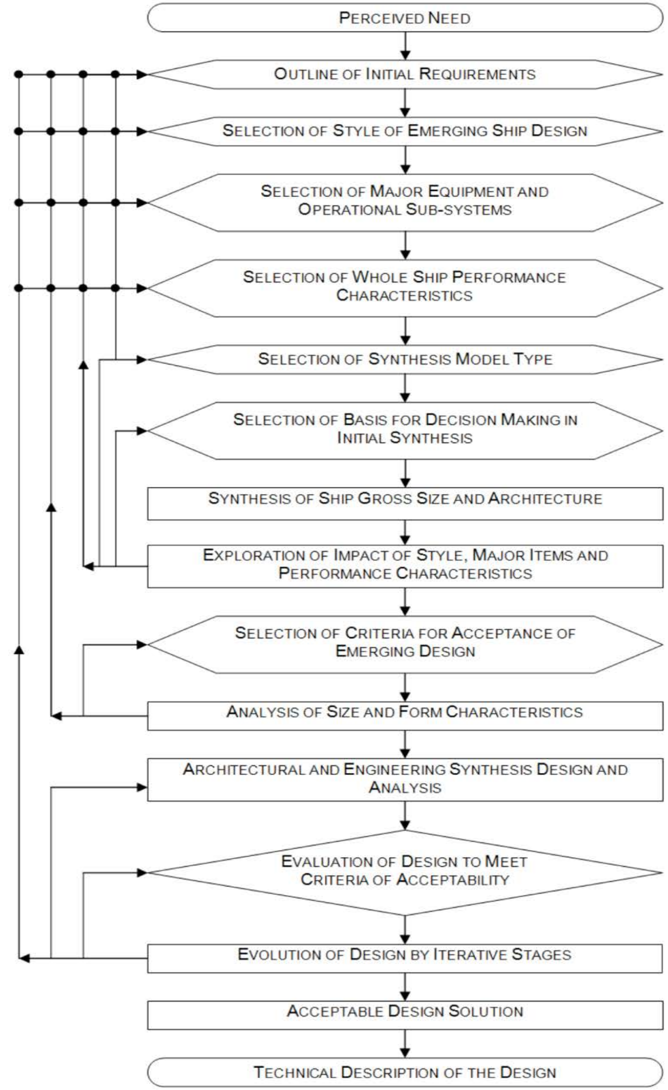
Figure 4
Bruce Archer's Representation
Design as the Third Culture



Modelling the Ship Design Process

A representation of the full preliminary ship design process with continual feedback , showing not just design activities but also "decisions/ selections" (conscious or not)

(full description Andrews COMPIT 2013)



Modelling the Ship Design Process

A Simple Numeric Ship Sizing Iterative Sequence with Feedback

ASSUMPTIONS & SOURCES

(Andrews 1986)

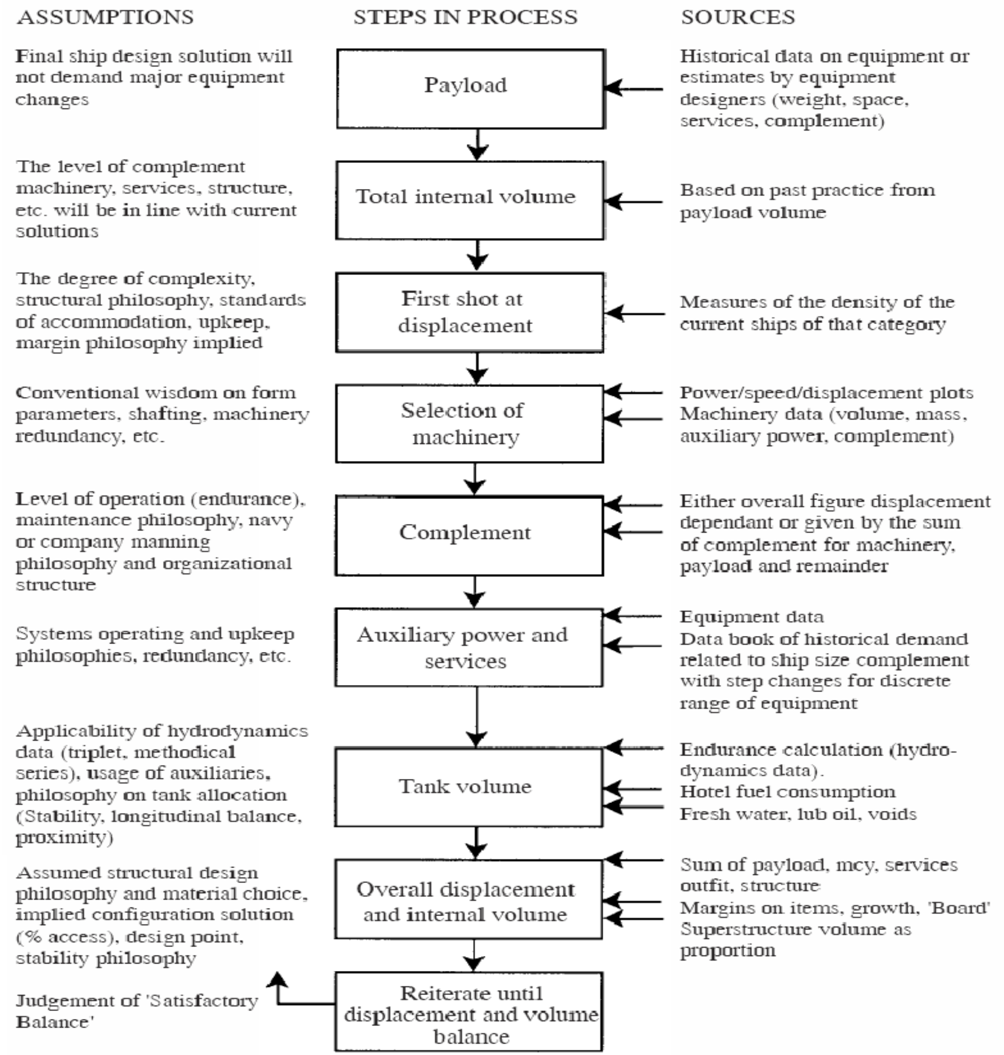


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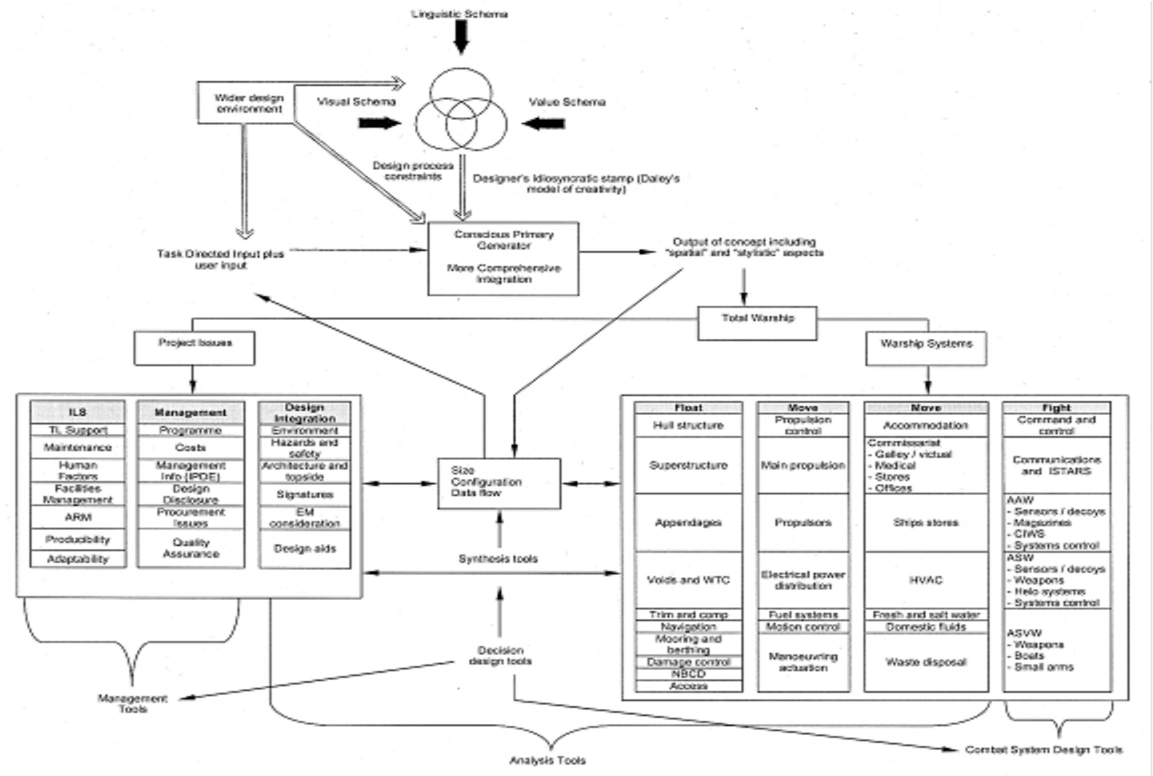
Figure 7
A (partial) representation of the ship design process and ship definition
(Andrews 2003)



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Naval Ship Design is Unique

- There is no prototype
- The warship is a multirole, virtually self sufficient entity, with sustained habitation in extreme conditions – so a level up in system complexity
- Most ships are an assembly of many systems and equipments - selection and integration comes after the capability, provided by the overall design, has been frozen
- Much of the capability (e.g. susceptibility, survivability, mobility, seakeeping) comes from the gross ship characteristics – defined early and hard to demonstrate

The Nature of NSD

- Diversity of ship types, seen in terms of design complexity and usage
- the many issues that ship designs have to address – so bespoke
- Difficulty, particularly for multirole naval combatants, of requirement identification or elucidation
- The multitude of ship performance issues, alongside the main operational mission(s) that the design must address, including “style”
- The naval architect is both the “hull engineer” and the ship’s overall architect
- Political environment in which naval ship procurement operates

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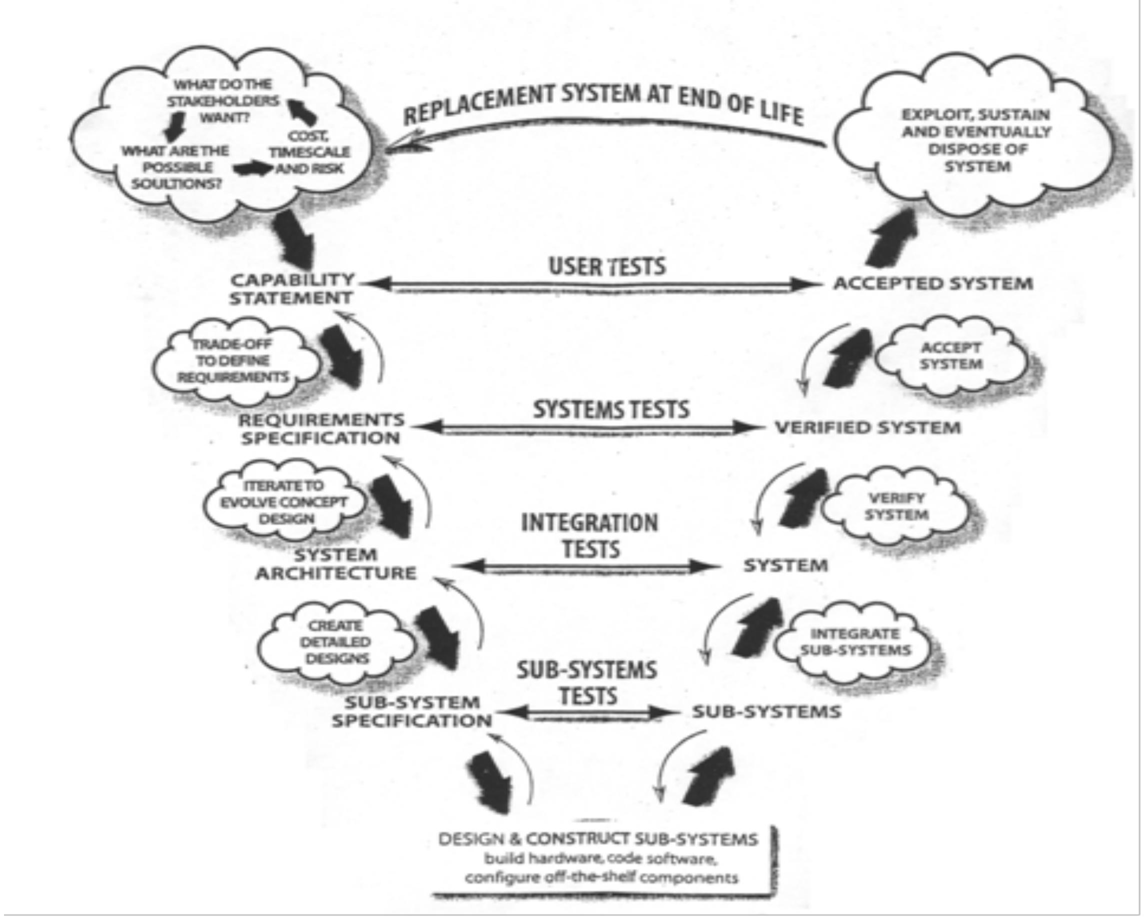
The Concept Phase is Different

- The process is characterised as a **wicked problem**
- This is a key phase where major decisions are made
- The need to ensure that a comprehensive and challenging concept design process has been conducted, before commencing trade-off studies
- crucial aspect is identification of style - advances in computer highlight ‘softer” design concerns
- The final aspect is that of **requirement elucidation**

The “V Diagram”
(R A Eng Guide (2007) - “Creating Systems that Work”



The Nature of Ship Concept Design – the implications for Concept Tools

- **Believable** solutions should be produced, i.e. solutions which are both technically balanced and sufficiently descriptive;
- Solutions should also be **coherent**, meaning that the dialogue with the customer should be more than merely a focus on numerical measures of performance and cost, and should include a comprehensive visual representation;
- The method should be **open**, in other words the opposite of a 'black box' or a rigid/mechanistic decision system, so that it is responsive to those issues that matter to the customer, or capable of being elucidated from customer/user teams;
- It should also be **revelatory**, so that likely design drivers are identified early in the design process to aid design exploration in initial design and beyond;
- Finally it should be **creative**, in that the method facilitates as wide an exploration as possible to ensure the eventual choice emerges from a divergent investigation rather than predisposed solutions.

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Why Ship Synthesis has been 2 Dimensional (at best)

- Initially computers speeded up iterative balance of weight and space
- More numerical options generated
- Computerised naval architecture
- Better analysis but insufficient good data?

Why Ship Synthesis can be 3 Dimensional

- Computer Graphics
- Hull form generation and IPM
- Optimisation - do it because we can - should be more about insight than precise answers
- Future – approach to ship design –

should be responsive to a demanding need

(better, cheaper, faster into service)

Why Ship Synthesis should be 3 Dimensional - Wider issues

- Many issues ought to be addressed? – Does synthesis become too complex?
- If adopt 3-D approach should you move more quickly to greater detail?

  – No, better to see the design evolve through the steps.
- Is it better to invest in first principles NA at concept?

  - What is more important to the user?

  Better NA early or operational factors being addressed from the start?
- The real need is to improve design exploration and to de-risk ship concept design by early avoidance of potential problems downstream.

Why Ship Synthesis should be 3 Dimensional - Improve Initial Design

- **Naval ships need to be less costly - need to better understand what is wanted - achieve through 3-D informed dialogue**

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- **More information rich to avoid mistakes by better articulation through 3-D dialogue**

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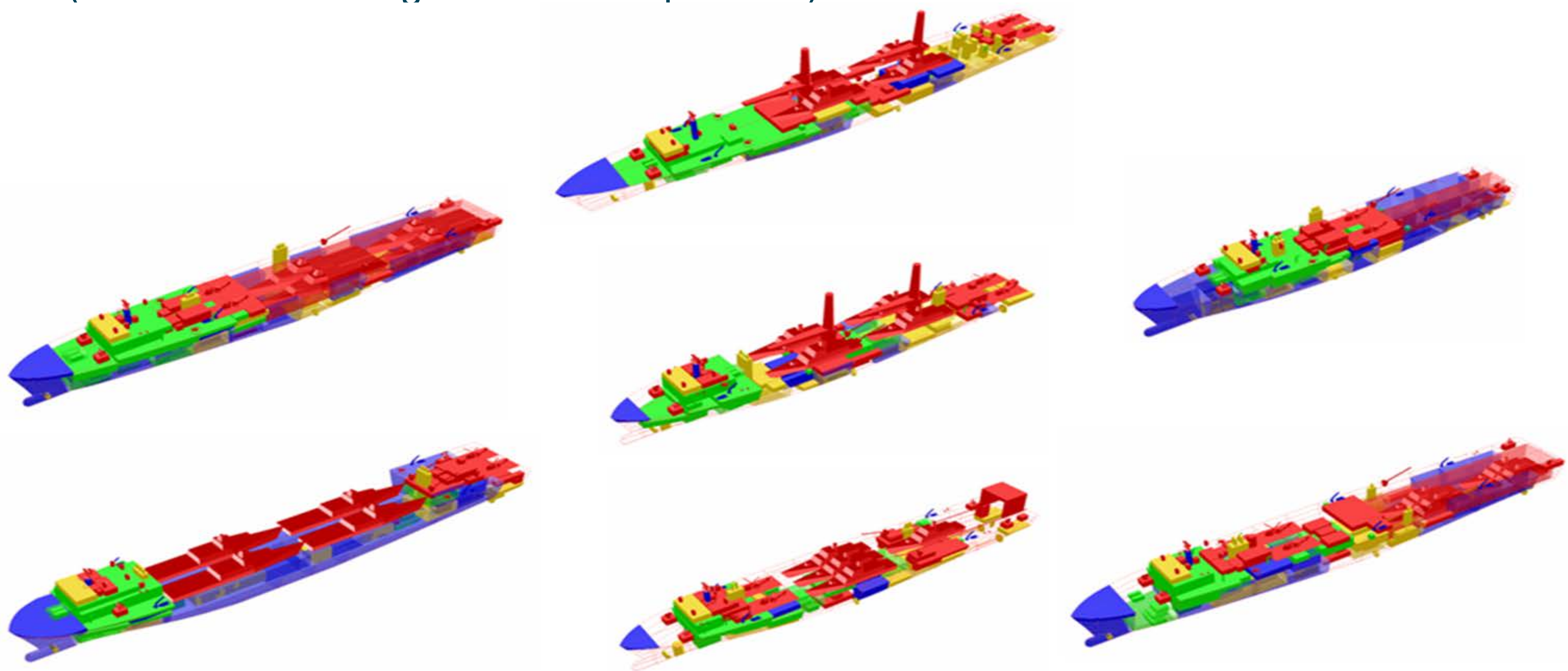
- More information rich to avoid mistakes by better articulation through 3-D dialogue
- **Better articulate design issues to wider world**

  (Stakeholders - wider Navy, Defence, the rest of government and to parliament, the media and the public)

UK FSC Mothership Studies
(Andrews & Pawling RINA Warships 2004)



Why Ship Synthesis should be 3 Dimensional - Improve Initial Design

- Naval ships need to be less costly - need to better understand what is wanted - 3-D informed dialogue
- More information rich to avoid mistakes by better articulation through 3-D dialogue
- Better articulate design issues to wider world (Stakeholders)
- **Improve Ship Design professionals status –**

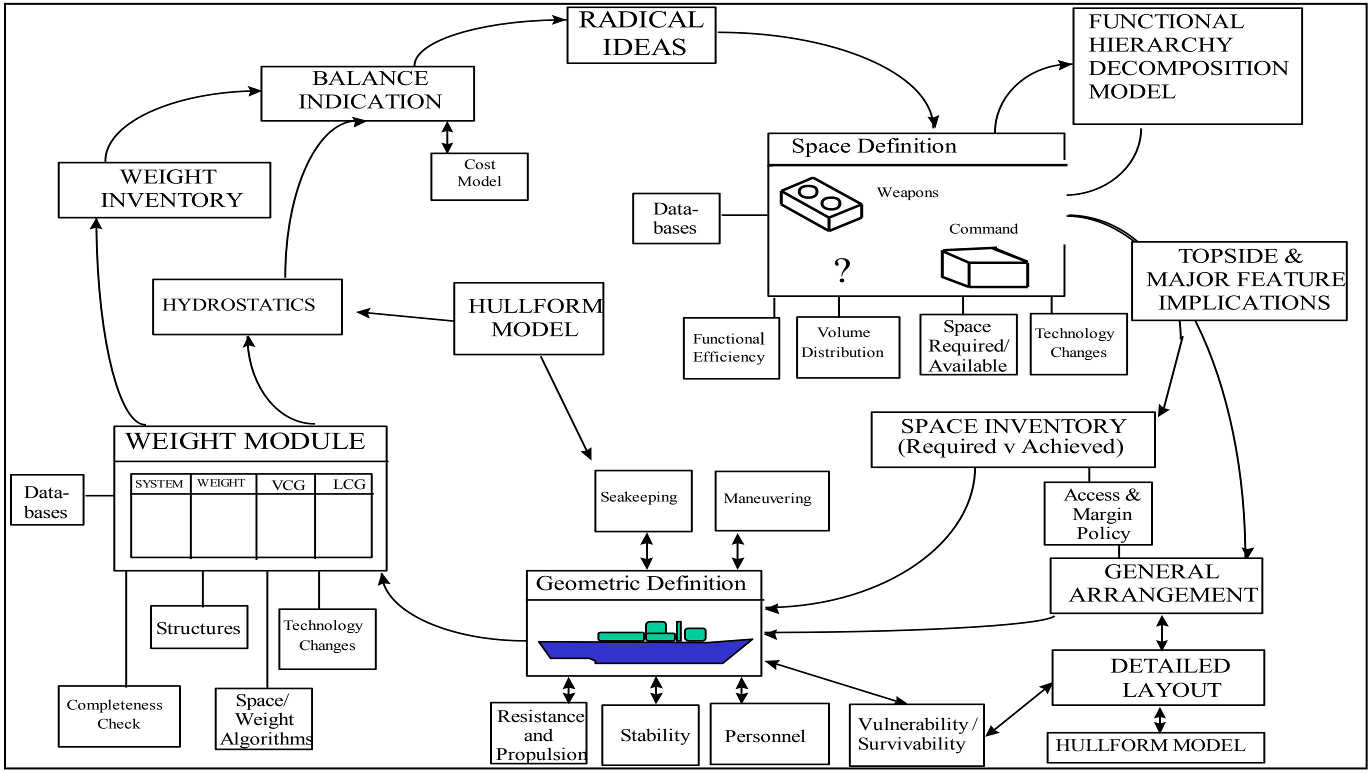
  Naval Architect first amongst equals in Ship Design - true Total Ship Systems Engineering –

  the conclusion from Systems Architecture

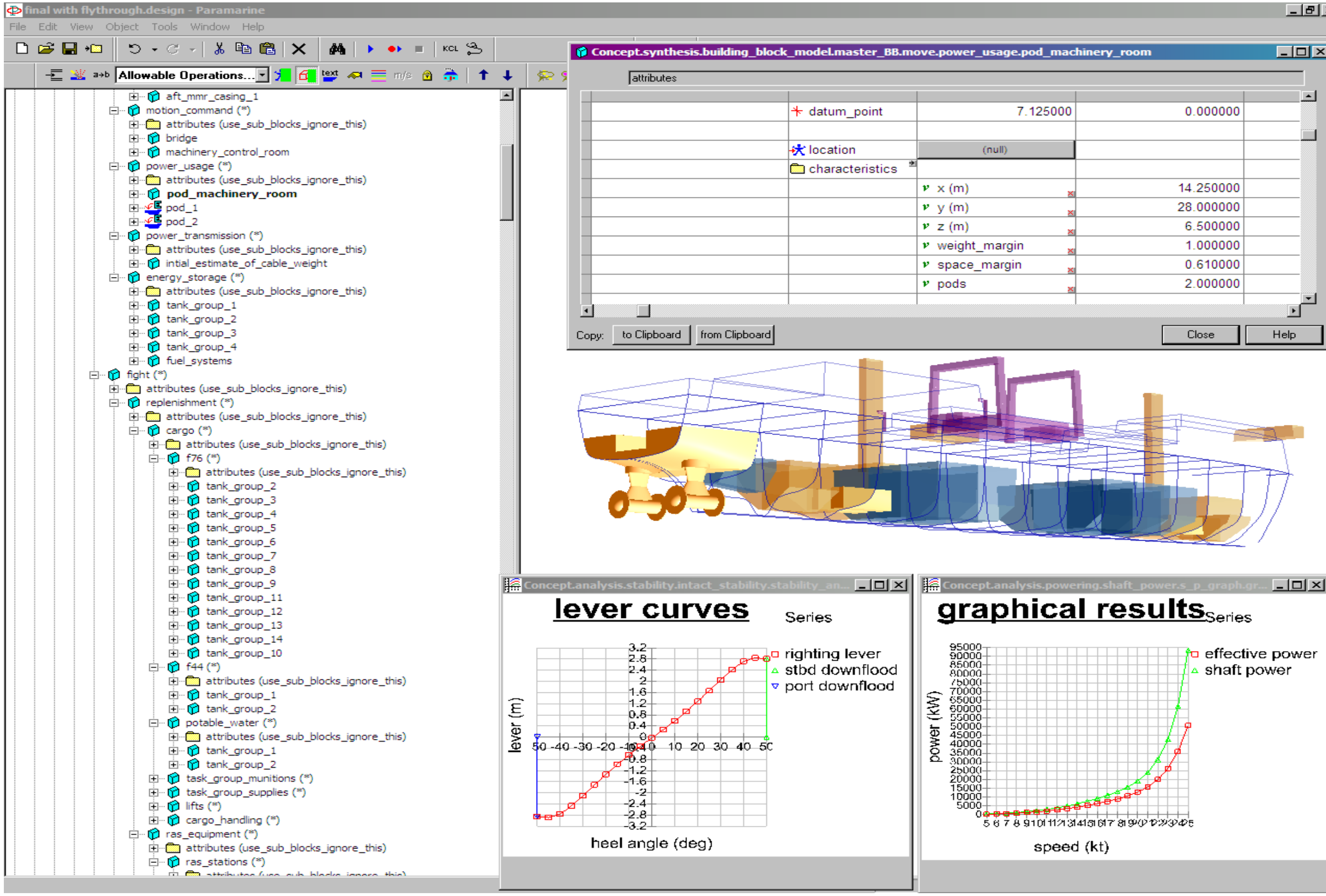
Why Ship Synthesis should be 3 Dimensional - Improve Initial Design

- Naval ships need to be less costly - need to better understand what is wanted - 3-D informed dialogue
- More information rich to avoid mistakes (see DJA UK list) by better articulation through 3-D dialogue
- Better articulate design issues to wider world (Stakeholders)
- Improve Ship Design professionals status - NA first amongst equals in SD - true TSSE
- **But also need to be Creative**

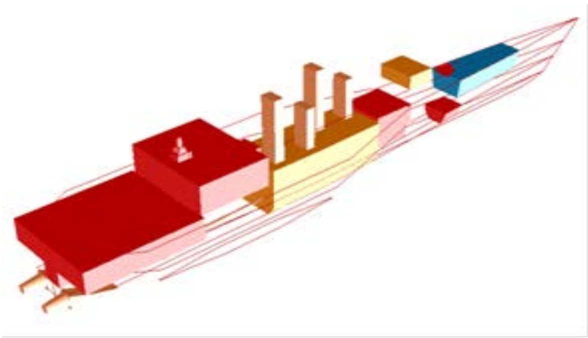
A Synthesis of Art and Science
The UCL Design Building Block approach

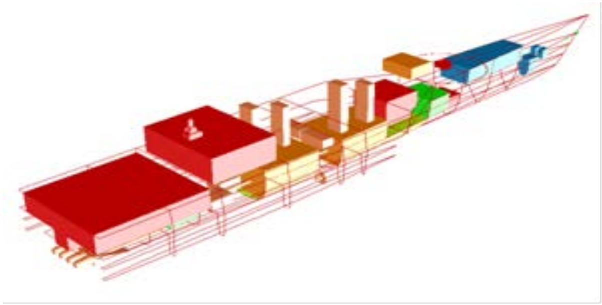


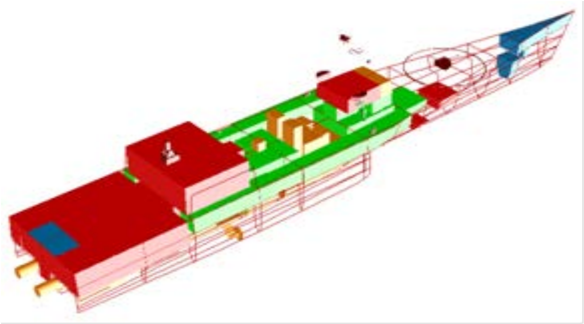
The Paramarine Realisation of the UCL Design Building Block approach

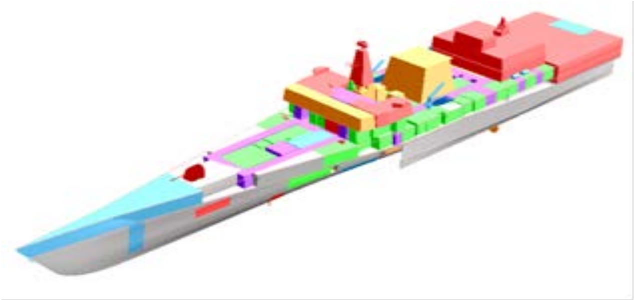


Architectural representations for the LCS study at the end of each DBB design stages







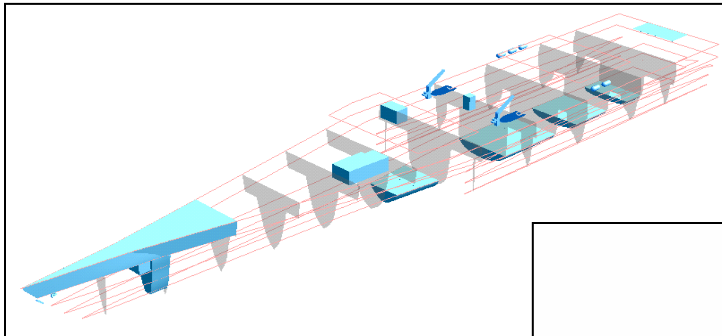


The Stages of the UCL architecturally driven Design Building Block ship synthesis

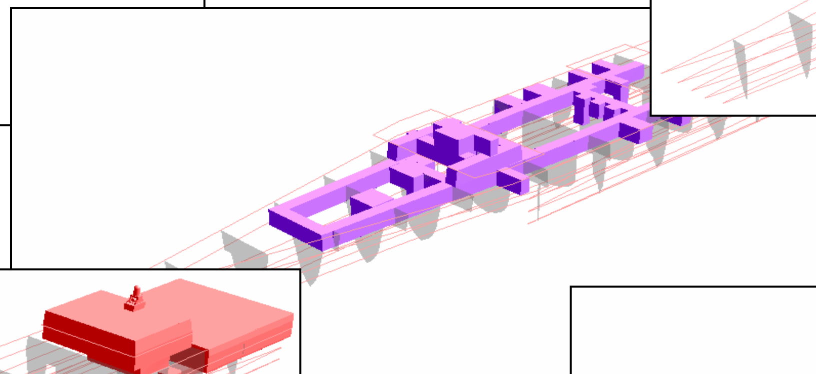
(Andrews & Pawling IJME 2009)

Design Preparation
Selection of Design Style
Topside and Major Feature Design Phase (18 to 47)
Design Space Creation
Weapons and Sensor Placement
Engine and Machinery Compartment Placement
Aircraft Systems Sizing and Placement
Superstructure Sizing and Placement
Super Building Block Based Design Phase (47 to 110)
Composition of Functional Super Building Blocks
Selection of Design Algorithms
Assessment of Margin Requirements
Placement of Super Building Blocks
Design Balance & Audit
Initial Performance Analysis for Master B.B.
Building Block Based Design Phase (110 to 343)
Decomposition of Super Building Blocks by function
Selection of Design Algorithms
Assessment of Margins and Access Policy
Placement of Building Blocks
Design Balance & Audit
Further Performance Analysis for Master B.B.
General Arrangement Phase
Drawing Preparation

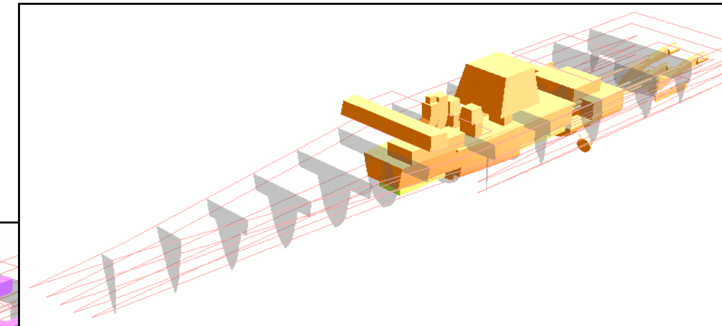
Final Design Functional Groups



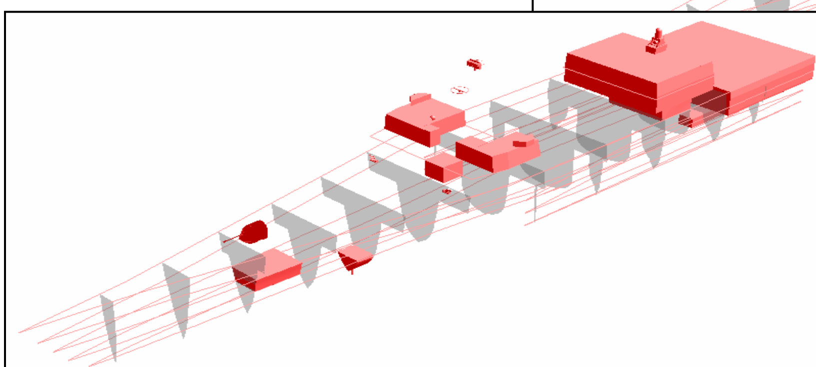
Float



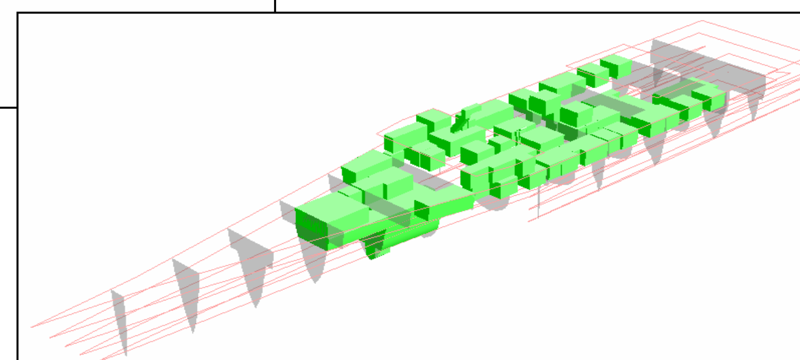
Access



Move



Fight



Infrastructure

Paramarine-SURFCON Carrier Representation

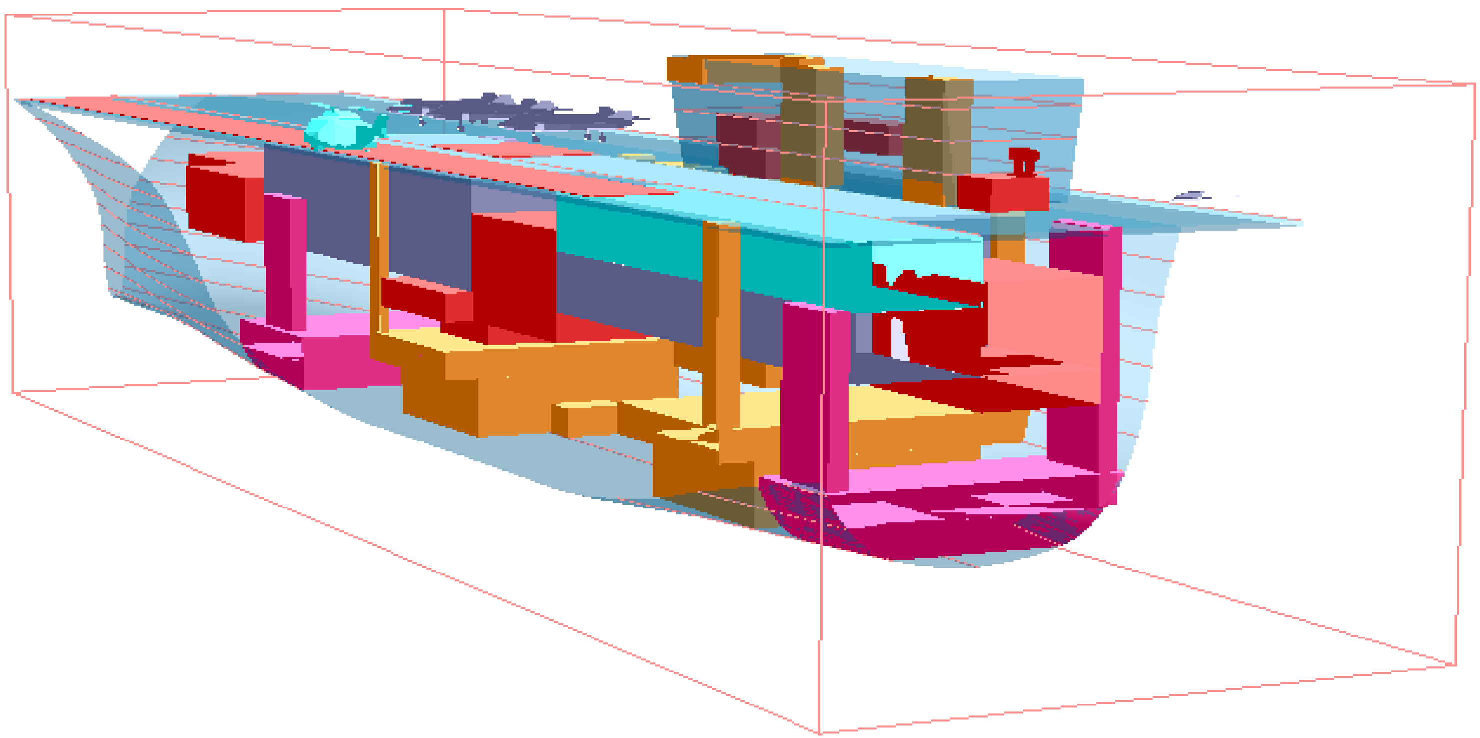
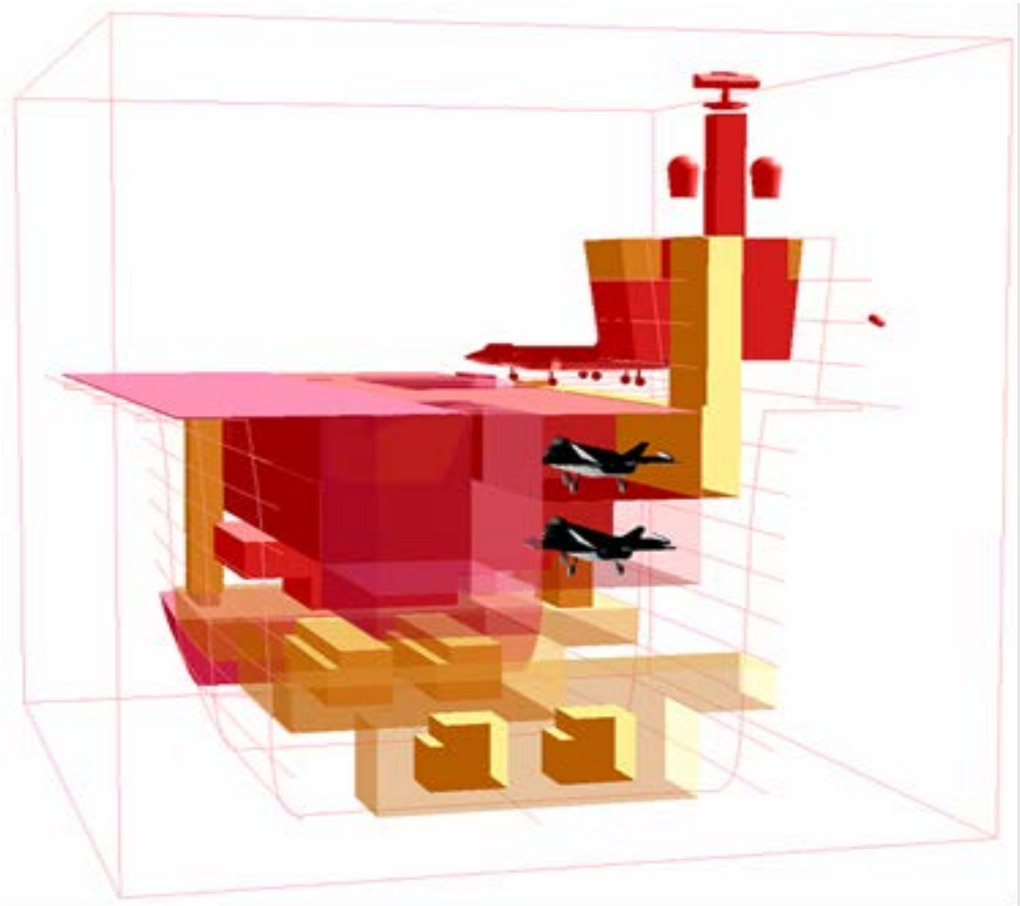


Figure 11.
A section through the carrier concept showing the three dimensional conflicts between hangar, machinery and air ordinance lift arrangements (Andrews 2004)



DRC Research Areas

Survivability

Vulnerability & Full Safety Aanalysis

Recoverability

Commercial Style

Design Methods & Tools

GUI Development + Design Sketching

Layout Tools + Submarine Configurations

Costing Efficiency

Simulation in Design

Dfor Production

Personnel Movement

Machinery Impact

EMI & Topsides

Fire Safety: FIREPROOF

The UCL Design Research Centre

- Focus on the Design Building Block Approach
  - Architecturally centred configurational model
  - Interactive graphical display
- Rapid concept design studies
- Detailed technical studies
- Long term research projects in last decade (**bold current projects)**
  - Design for production (SSA DTi – VT/Ferguson/Tribon/GRC)
  - Simulation integration (Joint EPSRC – SSG partner)
  - CASD (ONR NICOP- NAVSEA)
  - FIREPROOF (EU FP7 - 12 partners)
  - Commercial style (BMT DSL - CASE)
  - Survivability (Dstl - CASE)
  - **Topside (UCL Impact - NDP)**
  - **Sub UUV Mothership (UCL Impact – Babcock)**
  - **FAROS (EU FP7)**
  - **DfLayout (ONR NICOP – UMich, TUDelft)**
  - **GT for Shipping (RR Marine CASE) – Df Support/UXV studies (BAES CASE)**

Thank You

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