Lloyd's Register Educational Trust

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Systems

by

Professor Vaughan Pomeroy

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Systems

Professor Vaughan Pomeroy
July 2012

Icebreaker

- Think of a ‘system’ that you are familiar with
- What are the boundaries of the system?
- Who has an interest in the design of the system?
- Aim – to challenge your thought processes!

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Introduction to systems engineering

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Origins

- Defence systems – integrated systems for fighter control
- Electronics – radar and navigation
  - Systems reliability
  - Reliability by design
- ‘Systems analysis’ invented by RAND 1956
- MIL Handbooks, Reliability Databanks, modelling methodologies, link to Quantitative Risk Assessment
- Systems thinking
- ISO 15288.2002 and .2008

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Air defence systems

- Introduction of longer range detection
- Coordination of data from detection sites
- Interpretation of data
- Information creation and reaction planning
- Civilian air raid warning
- Activation of fighter response
- Active in-flight vectoring to meet developing scenario
- Recall of responders

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Integrated operational system

Systems engineering process methodology

- Need for formal process to ensure all tasks covered
- Multi-disciplinary aspects
- Encompasses all relevant engineering tools
- Aims to ensure that 'the system' that is delivered meets the needs of the customer and user, whilst satisfying the requirements of all relevant stakeholders

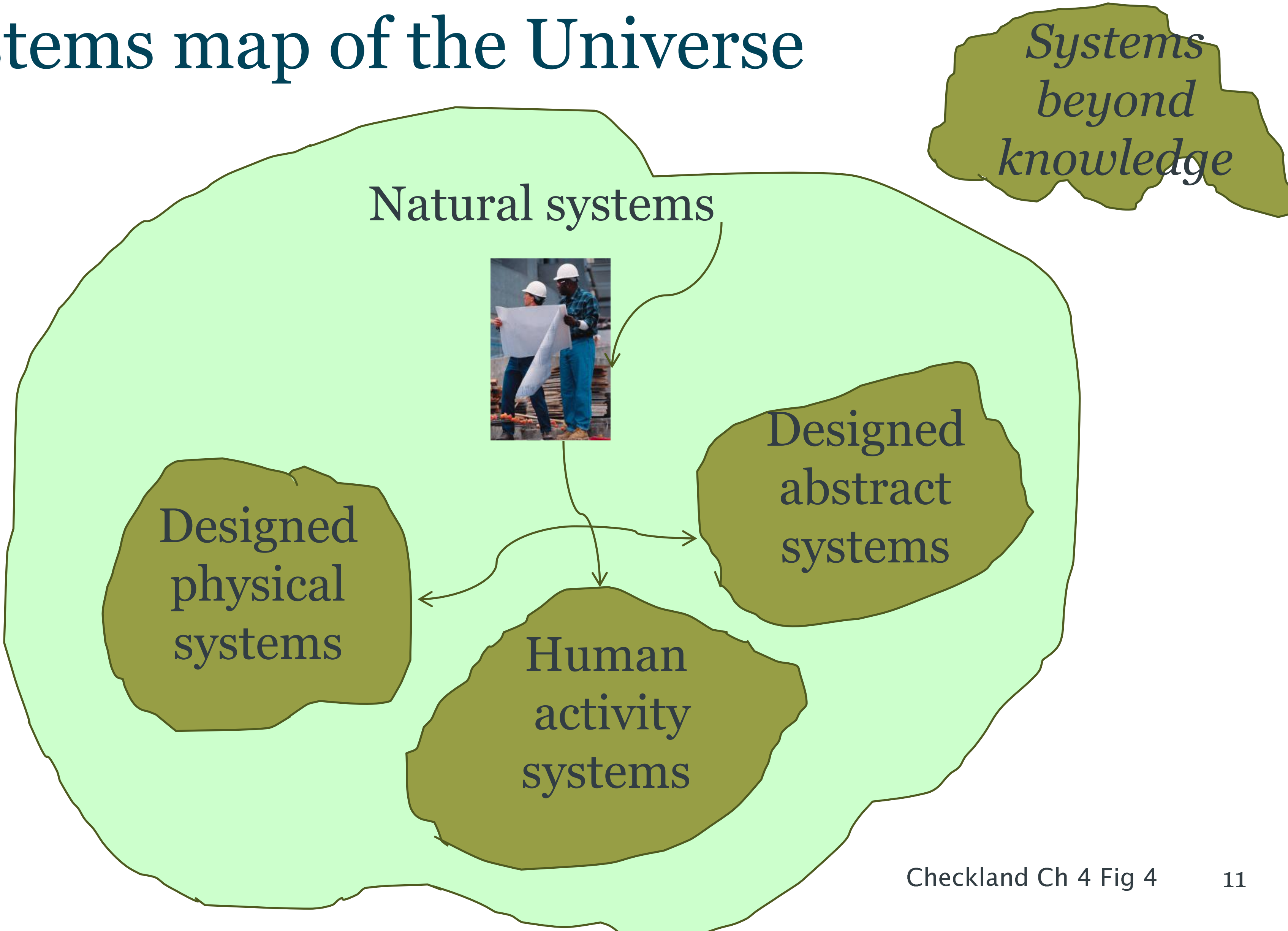
Problem-solving sequence – hard systems

- Problem definition
- Choice of objectives
- Systems synthesis
- Systems analysis
- Systems selection
- System development
- Current engineering

Problem-solving sequence – soft systems

- Problem situation – unstructured
- Problem situation – expressed
- Root definition of relevant systems
- Conceptual models
- Comparison of models with problem situation
- Determination of feasible, desirable changes
- Action to improve problem situation

Systems map of the Universe



Checkland Ch 4 Fig 4

Summary

- Systems engineering methodologies have developed since 1940, initially in the defence sector
- Methodologies are closely related to safety and risk analysis
- Underlying processes exist to ensure that a robust approach is taken, including all stakeholders
- Recognition that systems engineering activities go beyond
  - Initial design, build and setting to work
  - Involve human activities
  - Involve interactions with natural systems

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System boundaries

System boundaries?

- Need to understand
  - Context of use
  - Interactions with wider systems
  - Interfaces with other ‘sub-systems’
  - Information exchanges
- Includes
  - Operational environment
  - Users
  - Third parties

External environment – ISO/IEC 15288

- Regulatory requirements
- Codes and standards, and other normative documents
- Natural constraints
- Technologies – availability, maturity
- Commercial position – competition, financial conditions, trade restrictions
- Risk – business, technical, legal, political

Global environment

- Climate change – planet warming
- Discharges to air – carbon dioxide, SO_x‘ NO_x, particulates, hydrocarbons
- Discharges to water and land – ballast water, grey water, solid waste

- Impact of maritime technology solutions on the environment
- Impact of the environment on maritime technology solutions

Marine environment

- Impact of maritime operations on:
  - Water
    - Pollution
    - Underwater noise
    - Temperature, locally
  - Seabed
    - Disturbance due to wash, fishing, etc
    - Disruption due to dredging, offshore structures, etc

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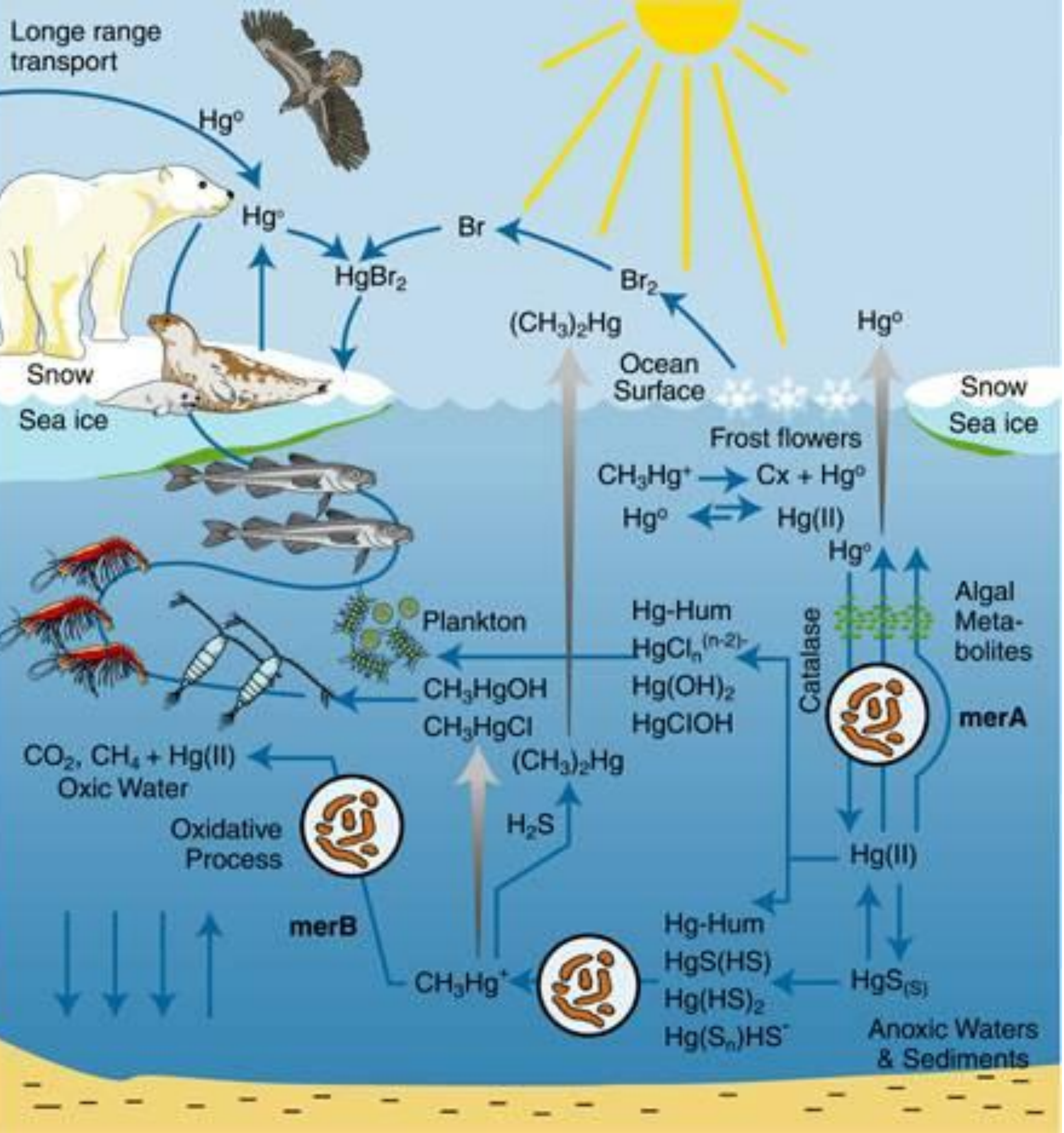
Vanishing sandy beaches



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Marine food chain

www.mim.dk

Systems considerations

- Minimization of risk of damage to marine ecosystem
  - Through permanent change
  - Through intermittent change
- Development of solutions which recognize impacts
  - On ecosystem and marine food chain
  - On seabed

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Users

- Recognition that systems must be usable by averagely competent people
- Usability of interfaces
  - Ergonomics
  - Displays
  - Information presentation
  - Presentation of ‘context’
- Language and terminology to ensure clarity of meaning

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Users

- Recognition that systems must be usable by averagely competent people
- Usability of interfaces
- Presentation of key information for user decision-making
  - Alarms
  - Operating parameters
- Dependability – reflecting reliance by user on system
  - May not be the intention of the designer

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The wider community

- Political factors – regional, national, local
- Regulatory regimes, including planning
- Accident preparedness – response arrangements
- Interaction with other users of marine environment
- Public perception of industry

System boundaries - summary

- Without a clear understanding of where the boundaries are the system design will probably be incomplete
- The Systems Integrator should ensure that at each level the appropriate boundaries are defined and compatible with the next higher level
- The boundaries are case specific

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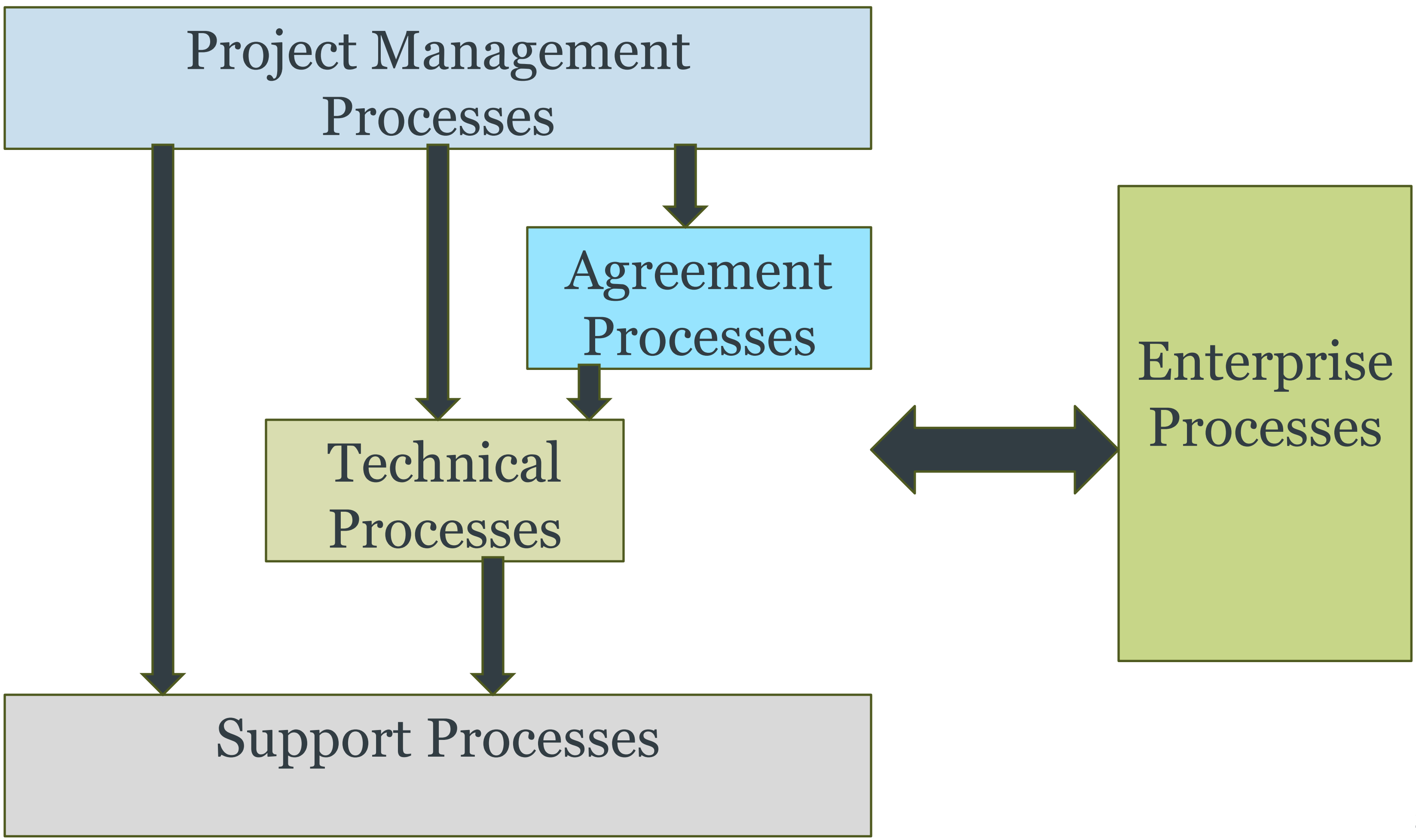
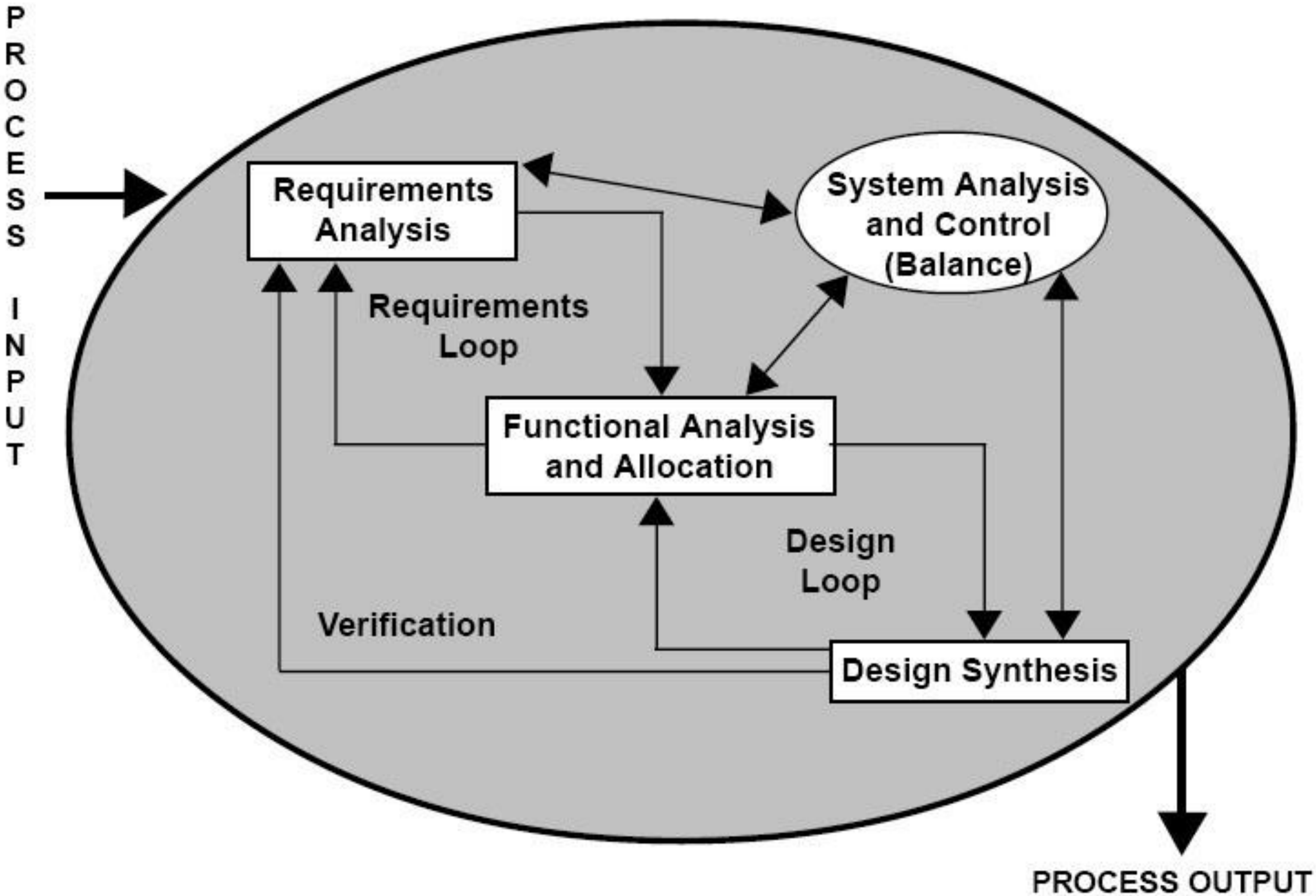
Systems engineering processes

Key terms

- System
  - Combination of interacting elements organized to achieve one or more stated purposes
- System – of – interest
  - System whose life cycle is under consideration
- System Element
  - A discrete part of a system
- Enabling System
  - A system that complements a system of interest but does not necessarily contribute to its operational functioning

Enterprise environment




PROCESS INPUT
Requirements Analysis
System Analysis and Control (Balance)
Requirements Loop
Functional Analysis and Allocation
Design Loop
Verification
Design Synthesis
PROCESS OUTPUT

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Summary

- Processes are not a substitute for good engineering
- IT/software pedigree is a barrier to wider adoption, partly due to belief that the process bureaucracy is counter-productive
- Standards exist, including defence industry architecture frameworks
- Further work is ongoing to improve commonality of language and definitions

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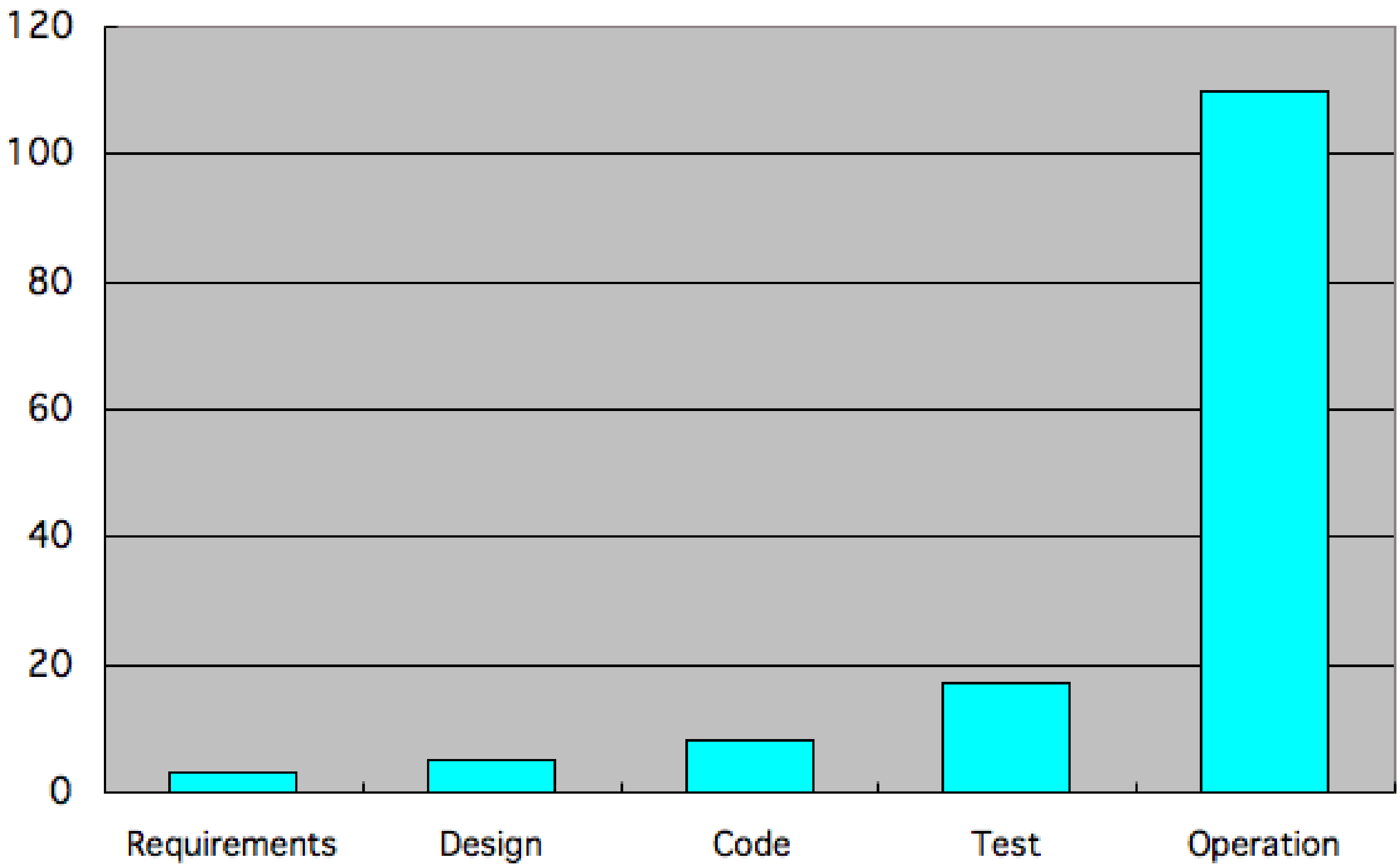
Focus on requirements definition

Requirements definition

- Errors at this stage jeopardize project outcomes
- Rework and change during project execution are expensive
- Cost of rework and change increases exponentially as project moves along timeline

- Insufficient effort is often expended in early stages
- Assumptions are made about ‘user expectations’ which may not be valid

Cost of correction



Who has a view for a maritime project?

- Operator
- Owner
- User
- Maintainer
- Repairer
- Regulator
- Constructor
- Suppliers

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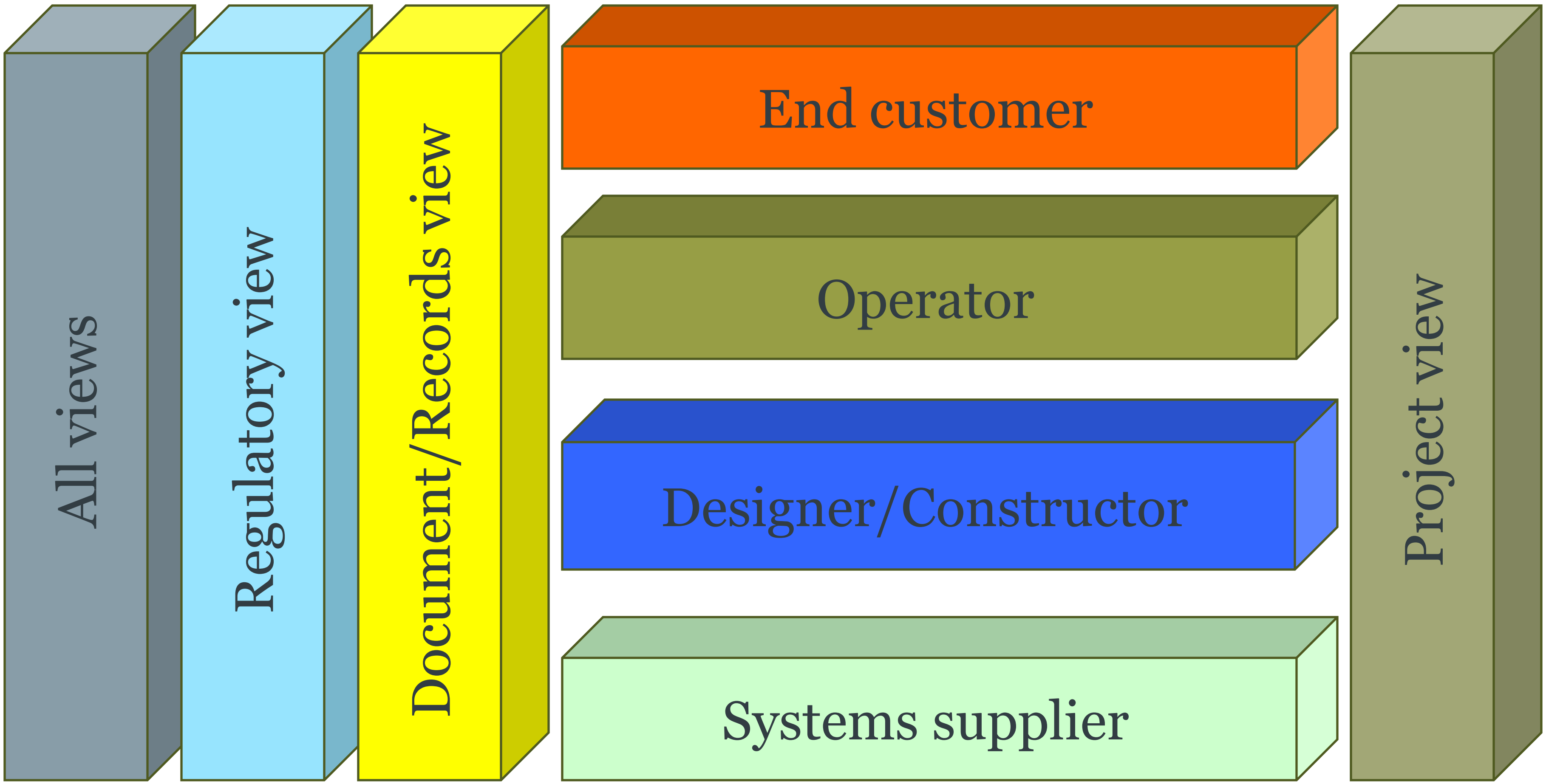
Architectural framework - maritime



Viewpoints – what influences these?

- Experiences
  - Individuals
  - Organizations
  - 'race memory'
- Expectations
  - Immediate exploitation prospect
  - Future prospects
  - End-of-life prospect


People
Cost
Investment
Charter Party
Company accounts
Protection & Indemnity Statement
Loss Prevention bulletin
Alert
P & I CLUB

Requirements definition

- Process of elicitation
  - To extract input from all stakeholders
  - To challenge to determine importance – must have, should have, might have, nice to have
- Process of consolidation
  - To derive a common solution
- Process of validation
  - To test the solution against the various viewpoints
  - To identify significant conflicts and feed reassessment – if necessary

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Summary

- Key to successful outcome
- Without a clear and shared view of requirements
  - No certainty that outcome will meet client expectations
  - Cascade to lower tiers in supply chain is problematic
- With a clear view of requirements
  - Translating requirements throughout supply chain is robust and consistent
  - Validation and verification can be against clear and consistent criteria – relevant to a successful outcome

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Approaches to resolving issues

Structured approaches

- Collate inputs
- Analyze
- Sort according to value to project
- Document decisions and rationale
- Monitor progress
- Revisit decisions where necessary – but maintain logical construction
- Archive for future use


SHORE LEAVE
HEALTHY MIND LEADS TO A HEALTHY BODY
DRUG AND ALCOHOL POLICY
MY ALERT! TOP SHIP FOR SAFETY
CREW MEDICALS
Alert

Brainstorming

- All ideas are potentially valuable
  - Keep the 'baby ideas'
  - Solutions need imagination
- Need to collect all ideas, however unlikely
- Group ideas into similar insights
- Recognize that balance will be 'participant specific'
- Remember – need to generate a shared vision based on several viewpoints

Hazard identification

- Identifying potential hazards is essential to understanding risks
- Effectiveness is improved with right participants
- Operators and users have a lot to contribute
- Must go beyond accumulated experience
  - Hazards should not be dismissed because no evidence of occurrence
  - Elimination because 'it shouldn't happen' is usually invalid

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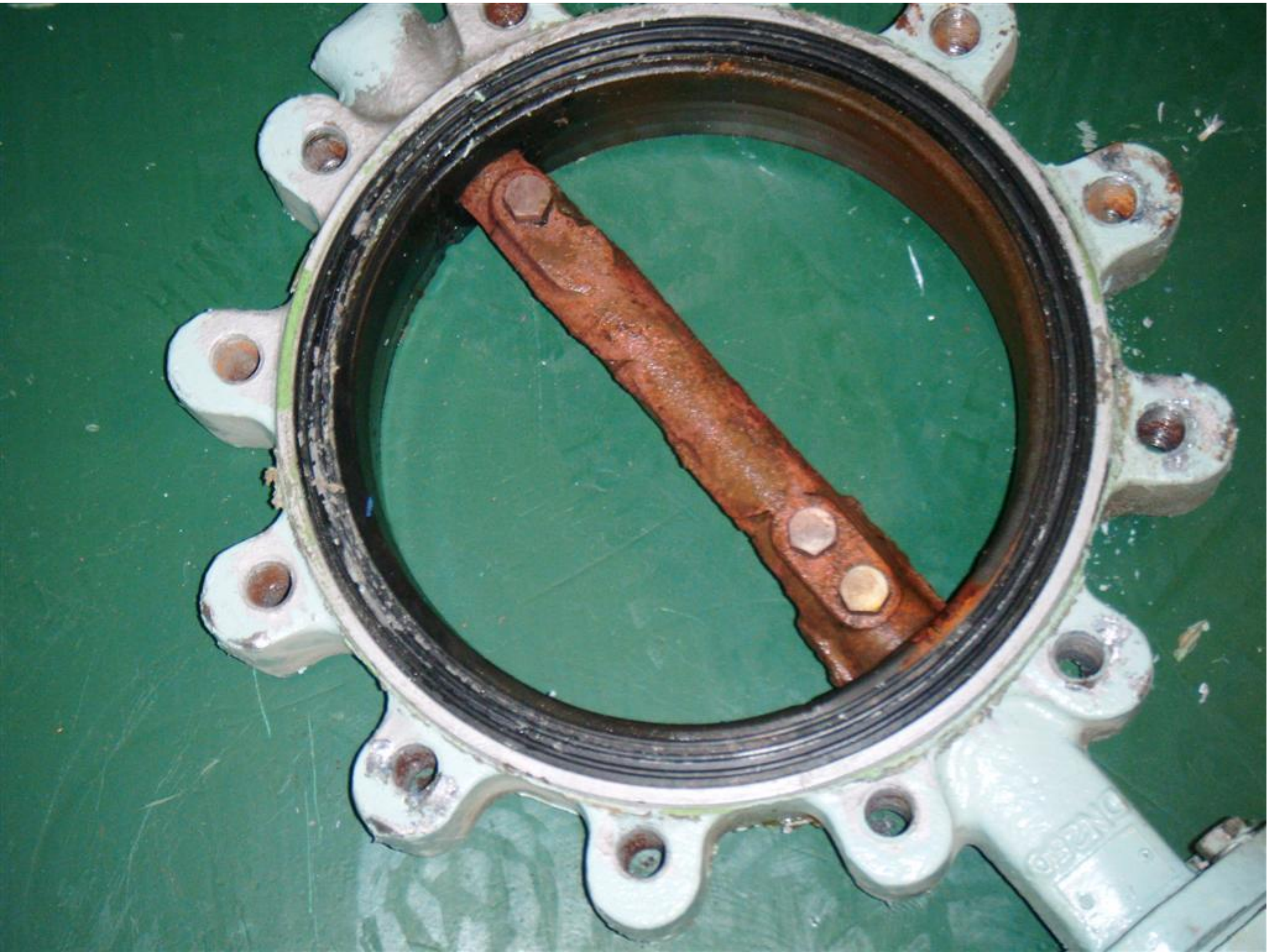
These things do happen



Concept of Operations

- What is the purpose of the asset?
- Who will use it?
- How will it be used?
- Where will it be used?
- How will the asset REALLY be used
  - Change of operating area?
  - Change of operational mode?
  - Change of operators?


Configuration
Human factors
Interactions
Complexity
Contradictions
Threat environment

The way forward

- Think about the issues that have been discussed
- Seek out issues relevant to your role where Systems Engineering could be beneficial
- Test out the principles that have been presented, using the standards and methods
- Look beyond disciplinary boundaries and look for gains in performance – environmental, safety, commercial

Icebreaker

- Think of a 'system' that you are familiar with
- What are the boundaries of the system?
- Who has an interest in the design of the system?
- Has your view changed? Yet??

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Professor Vaughan Pomeroy
r.v.pomeroy@soton.ac.uk