

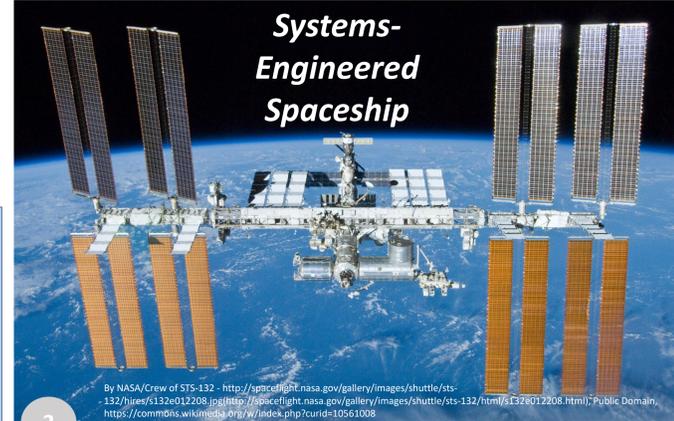
Spaceship Earth – from attractive metaphor to architectural analogue

Grateful acknowledgements to:
Bruce McNaughton, Luke Moffat and Lewis Bowick, INCOSE UK Energy Systems Interest Group
Morris Bradley and other members of the Edinburgh USA Climate Change Group



The Economics of the Coming Spaceship Earth
Kenneth E. Boulding
In H. Jarrett (ed.) 1966. Environmental Quality in a Growing Economy, pp. 3-14. Baltimore, MD: Resources for the Future/Johns Hopkins University Press.
First presented by Kenneth Ewart Boulding at the Sixth Resources for the Future Forum on Environmental Quality in a Growing Economy in Washington, D.C. on March 8, 1966.
We are now in the middle of a long process of transition in the nature of the image which man has of himself and his environment. Primitive men, and to a large extent also men of the early civilisations, imagined themselves to be living on a virtually illimitable plane. There was almost always somewhere beyond the known limits of human habitation, and over a very large part of the time that man has been on earth, there has been something like a frontier. That is, there was always some place else to go when things got too difficult, either by reason of the deterioration of the natural environment or a deterioration of the social structure in places where people happened to live. The image of the frontier is probably one of the oldest images of mankind, and it is not surprising that we find it hard to get rid of.

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Unlimited space and resources – unlimited sink for waste – “open planet” – image of the frontier → Limited space and resources – “closed planet” – image of the spacecraft



- World is chaotic, **act-sense-respond**
- Extract, exploit, consume, move on to pastures new
- Move fast and break things!
- No limits to growth, no problems I can't deal with,
- Challenge and test boundaries
- Plan B is for wimps!
- Competition, winner takes all
- Self-actualisation through accumulating wealth and status at the expense of
 - others,
 - nature

Economics of Spaceman era for the Anthropocene??

- Focus on wellbeing and harmony,
- Focus on conserving stock,
- Maintenance is vital
- Produce good social outcomes:

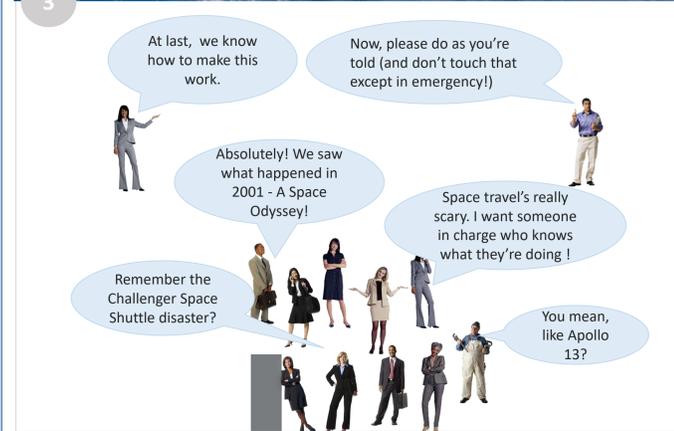
Economics of Frontiersman era don't work in the Anthropocene –

- Focus on production/consumption/growth,
- Focus on maximising flow
- Maintenance is viewed as deferrable cost
- Poor social outcomes:

- Capitalism** leads eventually to monopoly and inequality (“success to the successful”, trickle-down doesn't prevent rising inequality);
- focus on in-year profit and high discount rates lead to short termism, tragedy of the commons

- Communism** ignores human nature, suppresses self actualisation, allocates resources inefficiently

- A third way for economics?
 - Circular economy?
 - Doughnut economics?
- Avoid excesses of both Capitalism and Communism.
- Focus on “whole mission”, Consider future generations
- Continue to offer opportunities for self actualisation, but that don't harm others,
- How do we design a spaceship for 9 Billion people?
- How do we keep a crew of 9 billion content?



Systems Engineering is a transdisciplinary and integrative approach to enable the successful realization, use, and retirement of engineered systems, using systems principles and concepts, and scientific, technological, and management methods.

We use the terms “engineering” and “engineered” in their widest sense: “the action of working artfully to bring something about”. “Engineered systems” may be composed of any or all of people, products, services, information, processes, policies, and natural elements.

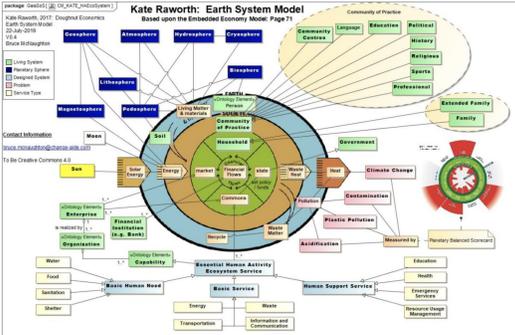
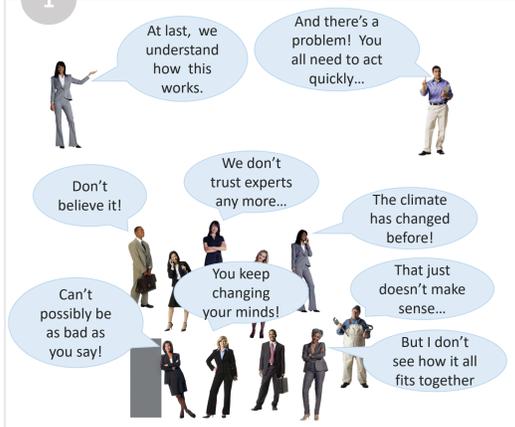
An **engineered system** is a system designed or adapted to interact with an anticipated operational environment to achieve one or more intended purposes while complying with applicable constraints.

Thus, an “engineered system” is a system – not necessarily a technological one - which has been or will be “systems engineered” for a purpose. A very general and inclusive definition of “system” is the following:

A **system** is an arrangement of parts or elements that together exhibit behaviour or meaning that the individual constituents do not.

A physical system exhibits **behaviour**
A conceptual system exhibits **meaning**

(Sillitto et al, INCOSE Fellows' Definitions report, 2019)

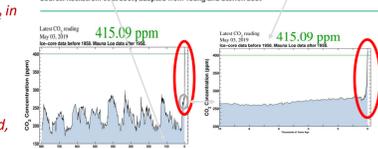
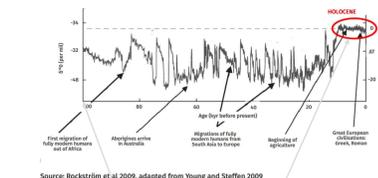


Performance and safety envelope, dynamic and integrity limits

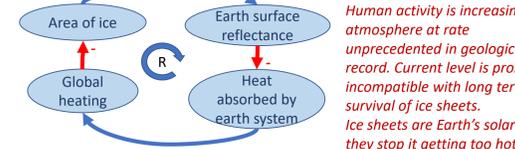
Holocene conditions are UNPRECEDENTED in human existence, and possibly in the geological record.

There is **NO EVIDENCE** that complex human civilisations can exist in conditions other than Holocene.

FIGURE 13: RECORDED HUMAN HISTORY HAS OCCURRED OVER A PERIOD OF UNIQUE ENVIRONMENTAL STABILITY.
Delta-O-18 (an indicator of temperature) over the previous 100,000 years. The stable Holocene epoch occurred over the last 11,700 years.

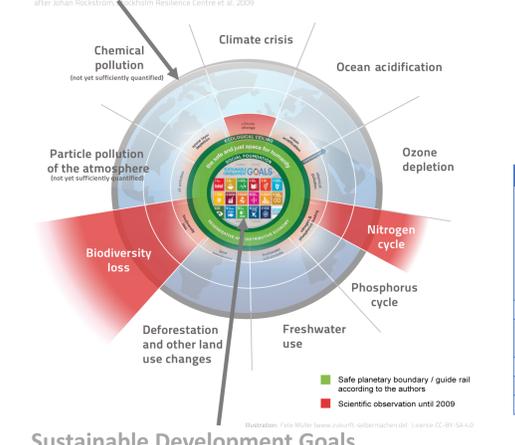


Sea Ice Extent
Ice loss is **EVEN WORSE** than the area data in these graphics suggests, because ice thickness and age are decreasing as well as area. There is less old thick ice!

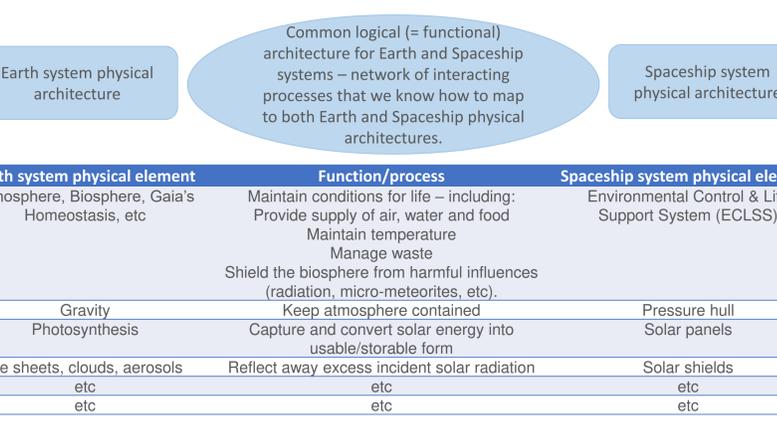


The Doughnut (Kate Raworth) – safe operating space for human civilisation

7 The Doughnut – balanced scorecard for Spaceship Earth



8 Spaceship Earth Architectural Concept



9 Next steps:

Move “spaceship earth” from an attractive metaphor, to a precise and widely understood and used formal analogue. This is so we can

- draw precise, and ideally quantitative, parallels between earth system issues and spaceship system issues,
- use ‘familiar’ spaceship analogies to explain the hard-to-understand Gaia systems and how to restore planetary health.

- Is this worth doing?
- If so, how to do it?
 - Research programme?
 - Open source collaboration?
 - Competition with cash prizes?
 - c followed by a or b?
 - And then...???

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Minor changes from version 1.0, which was Presented at Lovelock Centenary Conference, Exeter, 29-31 July 2019