Systems Engineering Advancement Research Initiative

Massachusetts Institute of Technology

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Collaborative Systems Thinking:

Identifying the enablers and barriers of higher-level systems thinking in aerospace engineering teams

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Committee: Prof. Deborah Nightingale, chair; Prof. Annalisa Weigel; Dr. Donna Rhodes

Biography

Caroline Twomey Lamb is pursuing her doctorate through the MIT Department of Aeronautics and Astronautics. Caroline received her S.B and S.M from MIT in 2003 and 2005 respectively. Her educational philosophy has been to construct a broad tool box of skills and experiences. Upon graduation, Caroline plan to work in the industry as either a design or test engineer.

Related Publications

D.H. Rhodes, C.T. Lamb and D.J. Nightingale (2008). "Empirical Research on Systems Thinking and Practice in the Engineering Enterprise", IEEE International Systems Conference, Montreal, Canada

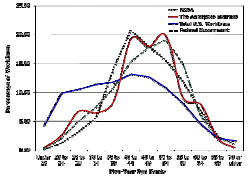
C.T. Lamb and D.H. Rhodes (2008). "Collaborative Systems Thinking Research: Exploring systems thinking within teams", INCOSE International Symposium, Utrecht, Netherlands

C.T. Lamb and D.H. Rhodes (2009). "Collaborative Systems Thinking: Case study research investigating enablers of team-level systems thinking" AIAA Aerospace Sciences Meeting, Orlando, Florida

Motivation

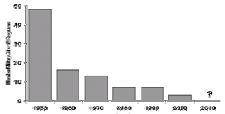
Systems thinking development takes time and experience.

Why then, study team-level systems thinking?

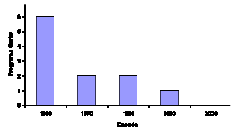


Demographics: 50% of the aerospace workforce, those with the greatest levels of experience, are eligible to retire by 2013.

Program Trends: The aerospace industry has fewer (larger and longer) programs than 50 years ago. This results in fewer opportunities to gain systems experience.



Manned Fighter Program Starts by Decade (Murman et al 2002)



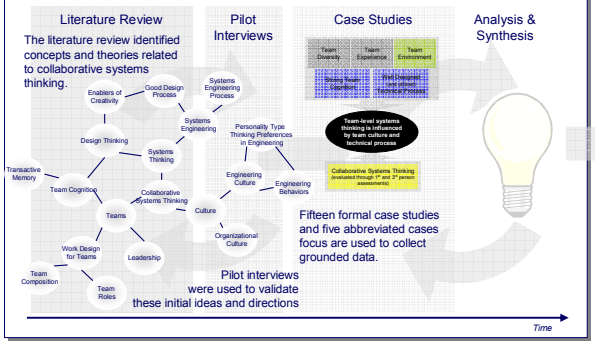
Manned Spacecraft Program Starts by Decade (Neal 1995)

Integrated Design Practices: Integrated Product Development (IPD) improves design through early integration of multiple disciplines. IPD is predicated on *teams* of engineers working closely together on systems-level issues.

Workforce Development: It is hoped that team-level systems thinking will provide the supportive environment and career guidance required to develop good systems thinking engineers.

Research Design

This research follows grounded theory methods and uses surveys and interviews to collect data on the role of culture, process, and team composition in collaborative systems thinking.



Results

Systems thinking teams have three tiers

1) Strong systems leadership
2) Developing systems professionals with functional backgrounds
3) Functional specialists

Systems and design processes are recognized, but not necessarily used

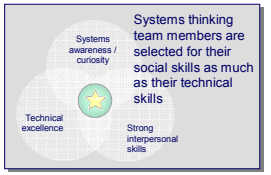
- Experienced systems professionals rely on past experience
- Less experienced teams use discussion of process as means to develop documentation, learn
- Both groups identify with following spirit if not rule of process

Systems thinking teams are diverse

- Past experience
- Variety of earned degrees
- Mix of team roles
- Unique outside interests

Team leaders respect the individuality of team members

- Treat each as unique rather than addressing the minimum common abilities



Systems thinking team members are selected for their social skills as much as their technical skills

Theory

Transactive Memory (Wegner 1985)

1. Transactive memory is a concept that facilitates understanding of group thinking
2. Transactive memory is the combination of individual memory systems and the communications (or transactions) between individuals
3. Individuals with complementary knowledge synthesize new knowledge by interacting

Collaborative systems thinking is a transaction based manifestation of Davidz's definition of systems thinking. Individuals with unique knowledge synthesize a systems perspective through interacting as a team.

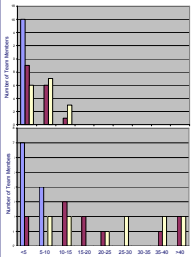
Systems Thinking (Davidz 2006)

Systems thinking is utilizing modal elements to consider the componential, relational, contextual, and dynamic elements of the system of interest.

Design Thinking (Dym et al 2005)

1. Design is a social process
2. Designers think and communicate using design languages (e.g. sketching, modeling, prototyping)
3. Groups utilize divergent and convergent thinking to explore options and choose between alternatives

Case Study Insights



Average team experience is not an indicator of collaborative systems thinking:

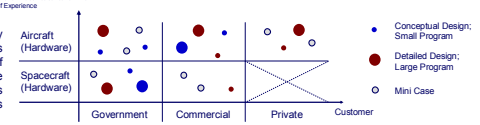
Teams with <7 years of average experience behave similarly to those with >20 years of experience

An internally consistent view of decision making is an enabler of collaborative systems thinking

Teams with higher self-reported and observe CST have more consistently shared views of how decision are made

High collaborative systems thinking team members identify themselves as team players who are reliable performers.

Lower systems thinking teams' members rate themselves relatively higher in detail orientation and coordination



Expected Outcomes and Future Work

Understanding team-level systems thinking

A possible tool for workforce development.

Expected Outcomes

1. An operational definition of collaborative systems thinking
2. Heuristics for enabling collaborative systems thinking
3. Descriptive theory of collaborative systems thinking
4. Data for improving workforce development initiatives

Future Work

1. Tracking members of 'middle tier' to measure effectiveness of participation for systems skill development
2. Longitudinal study to explore relationships between final system performance and and collaborative system thinking in systems architecture teams

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http://seari.mit.edu