Standardized Process as a Tool for Higher Level Systems Thinking

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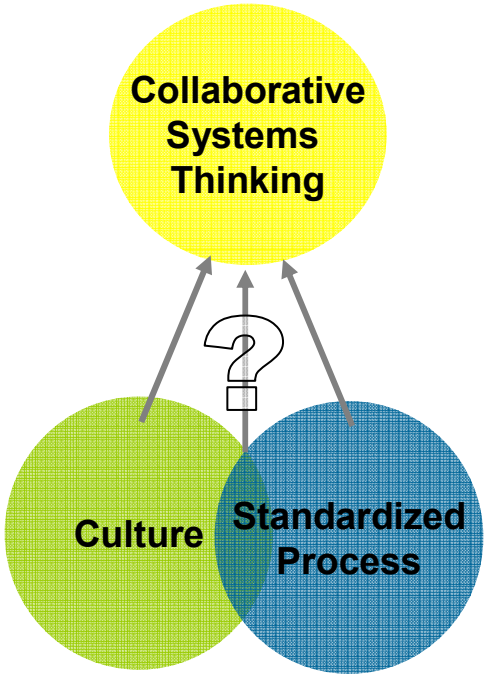
Agenda

- Research Question
- Motivation
- Objectives
- Prior Art
- Constructs and Methods
- Pilot Interview Results
- Moving Forward

Research Question

How do standard processes and culture support the development of systems thinking with engineering teams?



Why process and culture?

- People, process and technology are the three components to be addressed when improving SE practices. (Jansma and Jones, 2006)
- Culture, structure and standard process are important factors in team performance. (Lee, et.al., 2003)
- Recent emphasis on process maturity.
- Using well-documented and successful processes does not guarantee success. (Spear and Bowen, 1999; Dougherty, 1990)
- Address two of identified contributors to development of systems thinking in individual engineers (Davidz, 2006)
  - Specific individual traits
  - Supportive environment
  - Experiential learning

We can lick gravity, but the paperwork's a bit tougher.

-Werhner von Braun

Motivation

- Aging demographics within engineering
  - Average age of engineer within US = 45 (NA Report, 2006)
  - Average age of engineer at NASA = 49 (Lemos, 2006)
- Increasing system complexity and development time
  - 48 military aircraft program starts in 1950's; only 7 in 1990's (Murman et.al., 2002)
  - Similar trends in commercial airframes, manned spaceflight programs and planetary probes.
- Systems thinking an identified skill shortage within aerospace industry

- Prior systems thinking research at level of individual engineer (Davidz, 2006; Frank, 2000)
- Research on team-based design thinking focuses on undergraduate engineering students
- Literature likening people and process as social and technical components of the design system (Pajerek, 2000)

Research Objectives

- Operationalize the construct of collaborative systems thinking
  - Pilot interviews with experts
  - Literature on systems thinking
  - Literature on design thinking in teams
- Identify enablers and barriers to collaborative systems thinking
  - Focus on culture and process
- Contribute to practice by relating “best practices” to cultural contexts

Prior Art

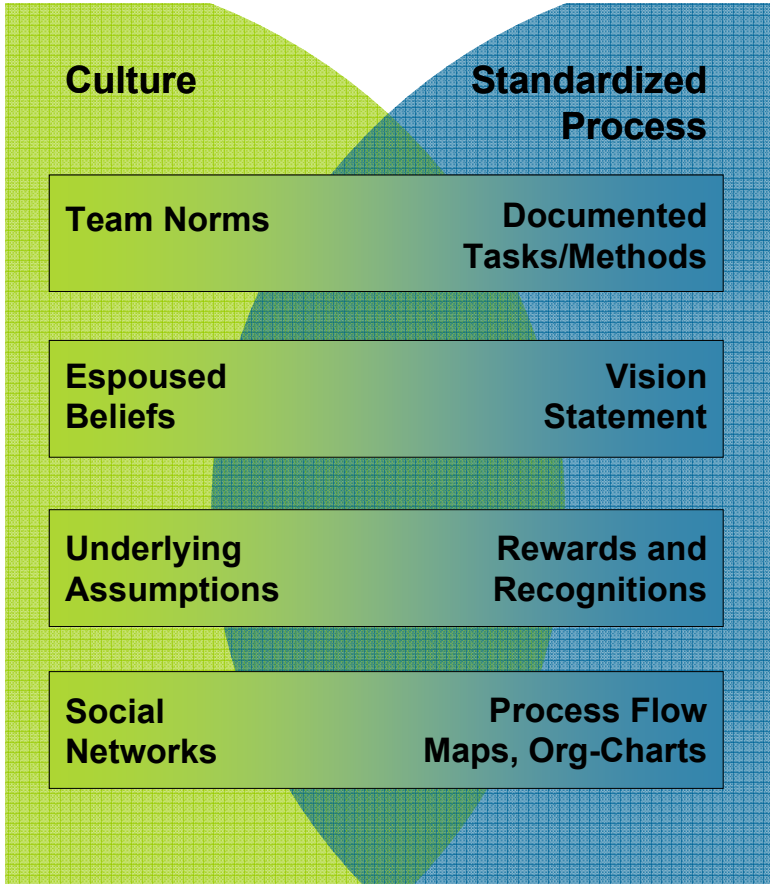
- Systems Thinking as the *Fifth Discipline* (Senge, 2006; Ackoff, 2004)
  - Emphasis on holistic thinking as way to elucidate patterns
  - Based on field of systems dynamics
- Systems Thinking within Engineering
  - Framework for seeing patterns and interrelationships; for seeing the whole (Frank, 1999)
  - The "analysis, synthesis, and understanding of interconnections, interactions, and interdependencies" (Davidz, 2006)
- Design Thinking (Dym, et.al., 2005)
  - Design is a social process
  - Successful teams cycle between divergent and convergent stages
- SE Process (Sheard, 2000; Pajerek, 2000)
  - Should reflect the way an organization works
  - Focus on interactions among individuals and teams
  - Should not be developed without considering the individual and team users

Research Constructs

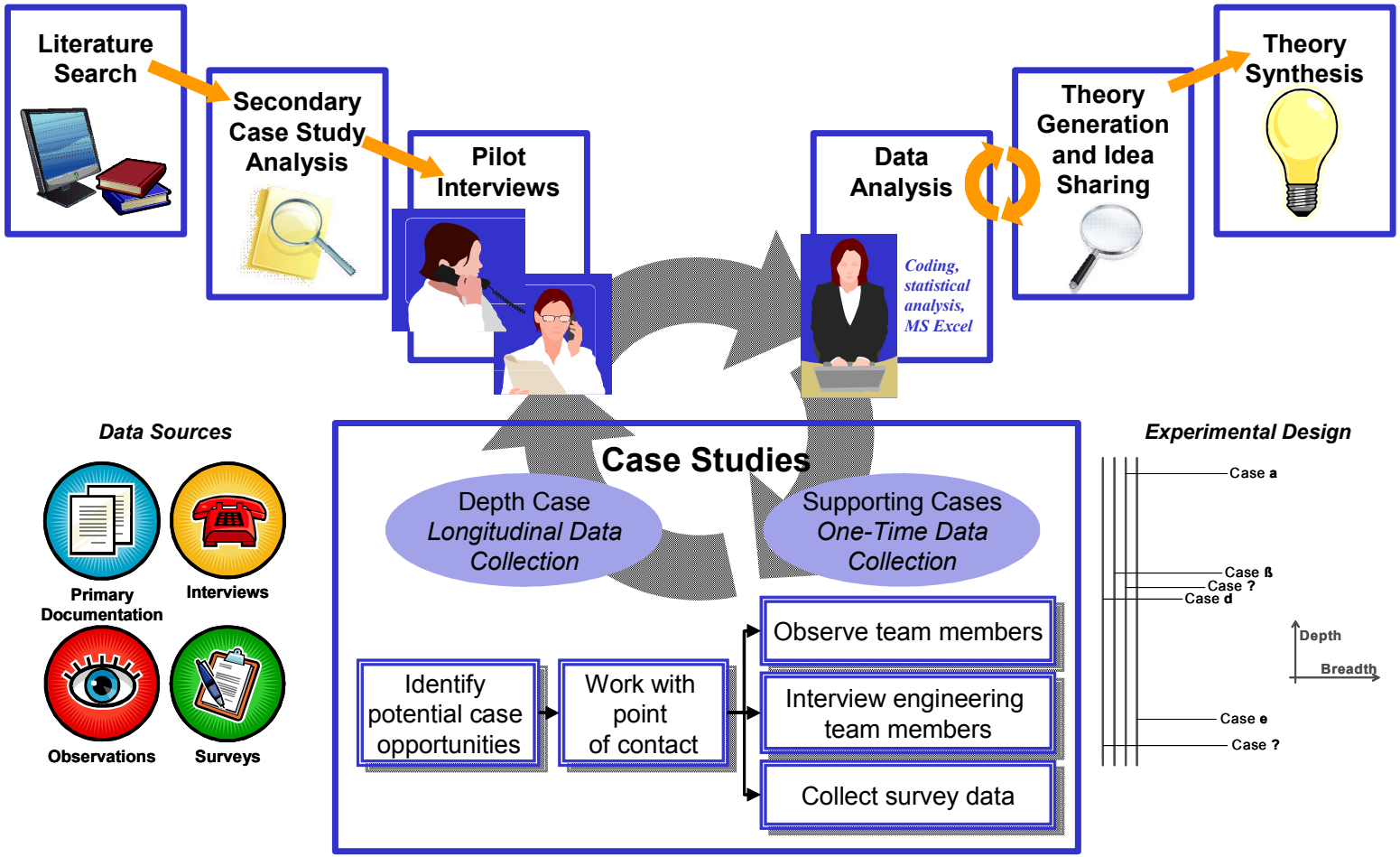
- Team-Based Systems Thinking
  - Emphasis on interconnections, interactions and interdependences within technical, social and temporal spheres (Davidz, 2006)
  - Tendency to communicate in abstractions, using intuition to assign meaning rather than relying solely on sensory inputs (O'Brien, et.al. 1998)
  - Concept of cycling between divergent and convergent thinking (Dym, et.al., 2005)
  - Ability to leverage the various "languages of design" (Dym, et.al., 2005)
  - Termed ***Collaborative Systems Thinking*** to address discriminant validity
- Culture
  - Behavioral norms, espoused beliefs, underlying assumptions (Schien, 2004)
  - Social structure
- Standard Process
  - Documented sequences of tasks executed during engineering design
  - Interested in design stage of lifecycle
- Teams (Hackman, 2002)
  - Common goals
  - Collective action
  - Clear membership

Research Framework

- Grounded theory research
  - Data collection using surveys, interviews, and primary documentation
  - Validation addressed in research design-5 types of validity (Valerdi and Davidz, 2007)
- Levels of Analysis
  - Teams of engineers
  - Individual team members
- Variables of interest
  - Team maturity
  - Stage in design process
  - Team composition
- Research tool goals
  - Team norms
  - Level of process compliance
  - Some amount of interaction data
  - Measure systems thinking characteristics present in team interactions



Research Methods



Pilot Interview Results

- Collaborative systems thinking needs product orientation
  - Teams produce products
  - Product, not process is end-goal
- Divergent opinions on team composition
  - Teams of systems thinkers
  - Teams led by systems thinkers
  - Team of non-systems thinkers expressing systems thinking properties through interactions
- Agreement that culture and process present both enablers and barriers to collaborative systems thinking

Pilot Interview Results, cont

Team culture considerations

- Enablers
  - Willingness to ask and answer questions
  - Ability to engage in divergent and convergent thinking
  - Identifying with product
- Barriers
  - Team polarization
  - Misalignment between team goals and individual reward systems
  - Identifying with discipline
  - Failure to consider social dimensions when forming teams
  - Resistance to change

Moving Forward

- Finalize case study design
  - Finalize case study tools
  - Conceptualizing ways to analyze and communicate results
- Identify cases
  - This is where your help is appreciated
  - Collect and analyze data
- Return next year with results

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Backup Slides

Construct Definitions

Standardized Process

Process: a logical sequence of tasks performed to achieve some objective. Process defines what is to be done without specifying how it is to be done.

--James Martin, 1997

- **Codify best practices and facilitate effective coordination and communication.**
- **Drive interactions within teams and between teams**
- **Reduce ambiguity and unpredictability (Schein, 2004)**
- **TPS based on strict standardization**
- **Process alone insufficient to guarantee success in product development (Dougherty, 1990; Spear and Bowen, 1999)**

Culture

Culture: a dynamic phenomenon and a set of structures, routines, and norms that guide and constraint behavior.

--Edgar Schein, 2004

- **Components of culture**
  - **Norms of behavior**
  - **Espoused beliefs**
  - **Basic underlying assumptions**
- **Effective team norms do not evolve naturally and must be fostered (Hackman, 2002)**
- **Team norms constitute unwritten set of standardized processes**
- **Culture a differentiator between successful and unsuccessful organizations**

Systems Thinking

Systems thinking: the analysis, synthesis, and understanding of interconnections, interactions, and interdependencies that are technical, social, temporal, and multi-level.

--Heidi Davidz, 2006

- **Experientially developed skill that facilitates system design (Davidz, 2006)**
  - **Improved ability do handle complexity**
  - **Saves development time**
  - **May promote process optimization**
- **Evaluating systems thinking of group more important than individual**
  - **Teams design systems**
  - **Teams responsible for managing and maintaining systems**

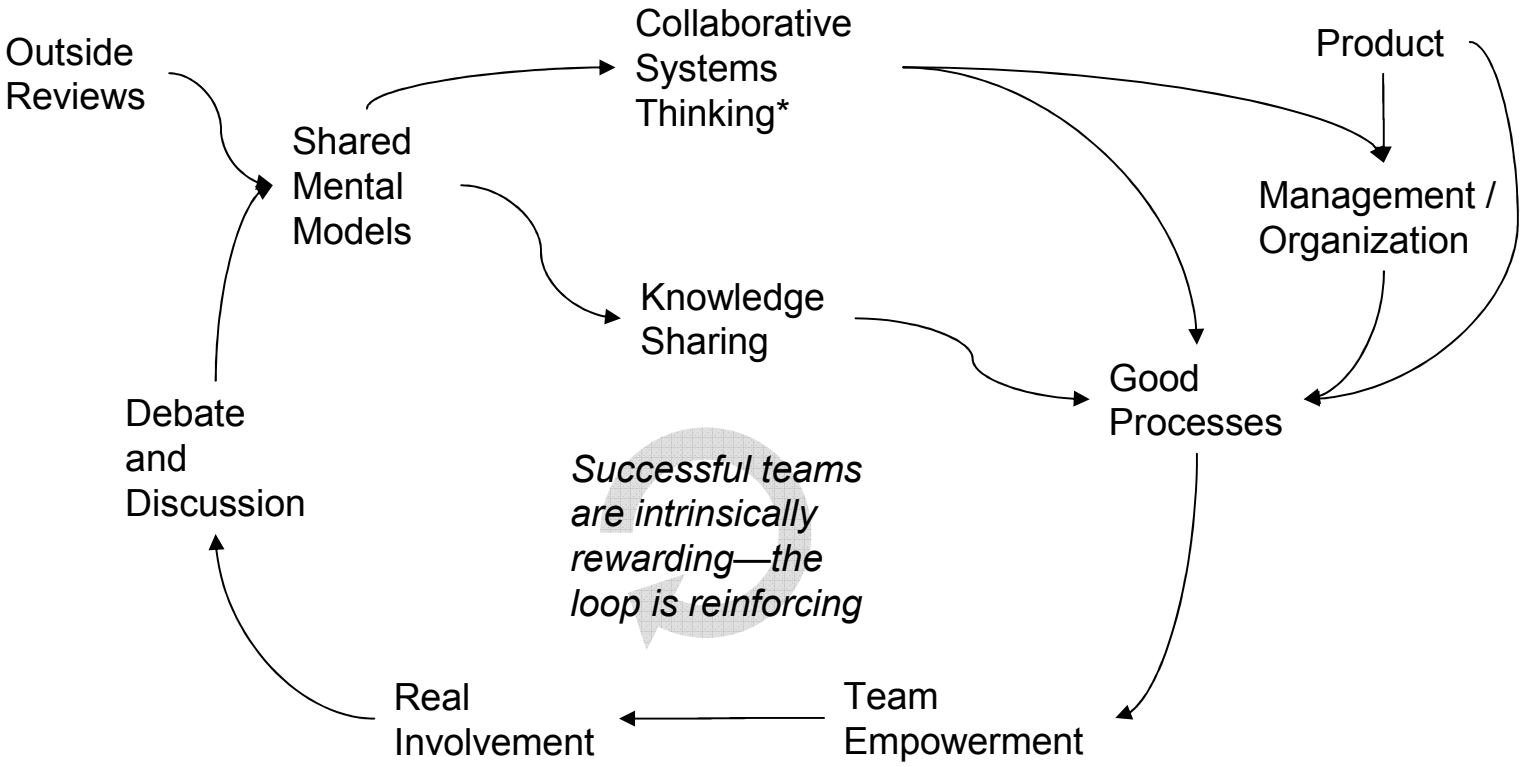
Collaborative Systems Thinking

Collaborative systems thinking: systems thinking as a property of an engineering team or organization.

- **Term coined to refer to higher-level systems thinking in engineering contexts**
- **Systems thinking likely linked to context**
  - **Necessitates looking at team and organizational levels**
- **How might collaborative systems thinking differ from individual systems thinking?**
  - **Teams and organizations produce products**
  - **Borrow ideas of value and efficiency from lean thinking**

Secondary Case Study Analysis

- Based on 12+ cases published through AIAA, IEEE and LAI looking at 'non-technical' aspects of complex product design



* Successful, multidisciplinary teams demonstrating meaningful exchanges of information were used a proxy for CST

Secondary Case Study Analysis

- General Observations
  - Systems thinking enables change
  - Team design important (selecting correct people)
  - Richness and completeness of communication important
  - Must allow and expect participation from all team members (real involvement)
  - Team membership improves knowledge and skill of participants
  - Communication must serve the problem
  - Well designed processes empower the user
- ENABLERS
  - LEADERSHIP
  - Identification with product enabler
  - Empowerment—freedom and ability to make meaningful decisions
  - Real and meaningful responsibility
  - Separating ideas from individuals—allowing for debate and critical analysis
  - Articulating team norms (beyond SP)
- BARRIERS
  - Complexity of product is a barrier to change in methods
  - Identification with function is barrier
  - Hero-based culture a barrier
  - Visionary leader encapsulating tacit knowledge of project
  - Failure to align team involvement with career advancement