Critical Success Factors for Rapid, Innovative Engineering Solutions*

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* Based upon research conducted by: Dr. Jo Ann Lane, Dr. Barry Boehm, Dr. Mark Bolas, Dr. Azad Madni, and Dr. Richard Turner

Innovation in Engineering

- Definition of innovation (Merriam-Webster):
  a new idea, method, or device
- Combines science and art
  - Make the strange familiar (science)
  - Make the familiar strange (art)
- Innovations that have recently matured
  - Transportation
  - Televisions
  - Personal computer
  - Cell phones/mobile devices

http://donaldsweblog.blogspot.com/2009/06/beam-me-up.html

http://memory-alpha.org/wiki/Replicator

Make the strange familiar

http://www.motherboard.tv/2010/9/11/this-seems-to-be-on-purpose-when-we-realized-what-was-happening-on-9-11-video

http://www.starpulse.com/Television/MacGyver/Pictures/

Make the familiar strange

Today's Innovation Challenges

- Quick start programs
  - Premium on early delivery
  - Perceived as "behind schedule" at the start
- Little time for exploration and innovation
- Results in "yesterday's solutions" for tomorrow's systems
- How to encourage rapid innovation given constraints

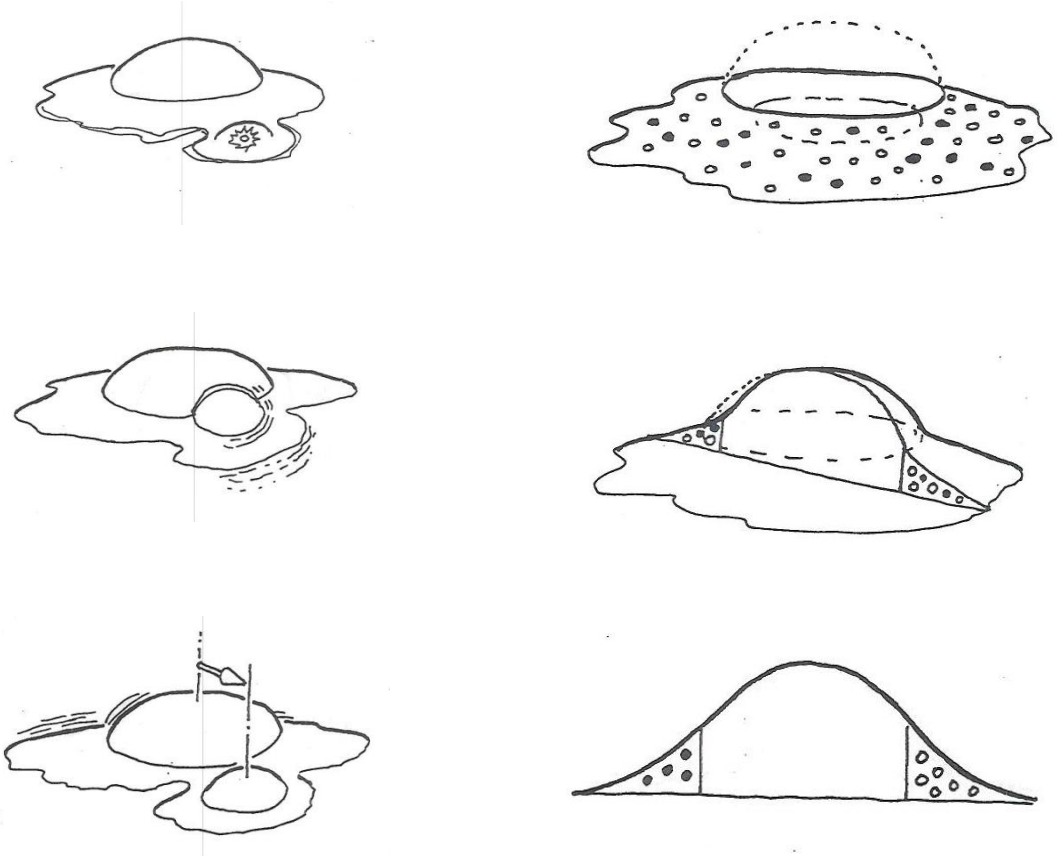
Innovation Space

- Competing and working on the edge using structure chaos
- Problem solving across a group exhibits a Gaussian distribution
  - Some bad
  - Some good
  - A lot within the norm

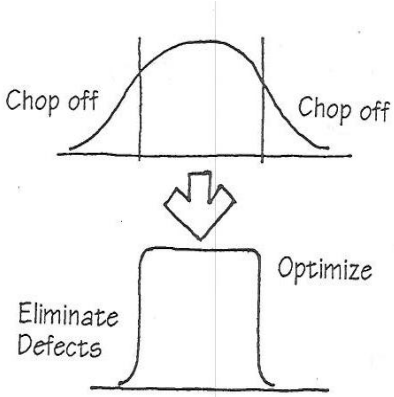
Innovation areas

- "Goodness" and "badness" often
  - Subjective
  - Requires further investigation

Example: Using an Egg to Understand Innovation*



Tendency is to focus on The norm and chop off the potential innovative ideas…



* Faste, Rolf, "A Visual Essay on Invention and Innovation, *Design Management Journal,* Spring 1995.

Innovation space *(continued)*

- "Can-do" teams must be able to
  - Experiment and have self-adapting processes
  - Re-organize to deal with new information
  - Learn and create options
  - Be mission/vision driven
  - Have "just enough" process

Apollo 13: Innovation in the box
http://ic-pod.typepad.com/design_at_the_edge/2007/06/the-last-judgem.html

Henry Ford quote
http://info.topcoder.com/blog/bid/35817/How-Necessity-Drove-Mobile-Innovation-and-Reshaped-the-Web

Current Research Efforts

Organizations Contributing to Research

Concept Design Center

Skunk Works

University of Southern California

Futures Lab

- Plus a commercial rapid development company

Areas Probed

- Type/scope of rapid, innovative projects
- Processes used to foster rapid innovation
- Methods/methodologies used
- Product characteristics
- Tools to support rapid innovation
- People/team characteristics
- Workspace environment
- Organizational key success factors

Findings

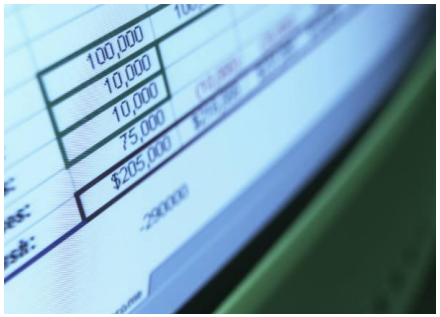
- Early concept exploration and feasibility assessment
- Value-adding tools
- The right people
- Supportive work environment
- Proactive management

Findings: Early Concept Exploration and Feasibility Assessment

- Investment in innovation environment
  - Include responsible play
  - Focus on team rewards
  - Use both science and art
  - Make it OK to fail
  - Leapfrog
  - Multi-sourcing
- Root cause analysis of customer problem
- Reality confrontation
- Customer or sponsor commitment and participation

Findings: Value-Adding Tools

- Tools are required
  - Must be the right tools
  - Users must be experienced with tools
- Tools don't need to be the best or most sophisticated
- More often, it is the simple, stable tools that work best



Findings: The Right People

- Empower the best
- Enable holistic concurrency
- Identify a keeper of the “holy vision”

Findings: Supportive Work Environment

- Large, unstructured open space to encourage
  - Collaboration
  - Experimentation
- People frequently tapped for intense rapid-response effort require help with outside lives
  - Rewards
  - Family, external commitments
- Innovation eludes overly-stressed people

Findings: Proactive management

- Believes in small agile teams
- Provides a culture that supports innovation
- Encourages responsible “play” to investigate candidate solutions

Technical specialists confer about a study in progress at a Concept Design Center facility.
http://www.aero.org/publications/crosslink/winter2001/01.html

Summary of Contributions by Organization

Contributing Organizations / Findings Area	Aerospace Corporation's Concept Design Center	Institute for Creative Technologies	Lockheed Martin Corporation's [illegible]	Northrop Grumman's Futures Lab	Commercial rapid-development company
Early Concept Exploration and Feasibility Assessment	♦	♦	♦	♦	♦
Value-Adding Tools	♦	♦	♦	♦	♦
The Right People	♦	♦	♦	♦	♦
Supportive Work Environment	♦	♦	♦	♦	♦
Proactive Management	♦	♦	♦	♦	♦

Conclusions and Implications Going Forward

- Successful innovative organizations
  - Driven by business value and invest accordingly
  - Exploit opportunities
  - Follow concurrent engineering practices to accelerate cycle times
  - Focus on core business areas

- Innovation at work: http://wimp.com/robotbird