Enchantment Chapter Monthly Meeting

8 Apr, 2015 – 4:45-6:00 pm:

Design Thinking: What is it and What Does it Mean for Systems Engineering Education?

Cliff Whitcomb, PhD, Professor and Chair Systems Engineering Department, Naval Postgraduate School

Abstract: Design Thinking is a recently defined approach to engineering for product design. The concept began with the commercial company Ideo, and has since become a major part of the design curriculum at the Stanford University d.school. The Naval Postgraduate School in Monterey, CA, has been teaching Design Thinking in the context of engineering education as part of a masters program in systems engineering. This presentation describes Design Thinking in a basic form. The relationship to systems engineering is then explored, particularly as it relates to systems engineering processes and systems thinking. These concepts are then presented in the context of developing systems engineering competencies. Finally, some radical ideas are presented for the education and development of systems engineers into the future.

Download slides from GlobalMeetFifteen file library or www.incose.org/enchantment/library.aspx

NOTE: This meeting will be recorded

A Few Words First

New INCOSE and Chapter web sites are live, same addresses.

Tutorial June 19 – *Systems Thinking* – James Martin.

Tutorial for Quarter 3 or 4 – emailed survey-notice needs your input on:

1) **Applying MBSE to Interface Design & Management – Mathew Hause.**
2) **Designing Agile Systems and Agile SE Processes – Rick Dove.**
3) **Systems Integration – Eric Honour.**
4) **Intro to Transformational Thinking – Scott Workinger.**

Newsletter sent last week outlines chapter kick starter project:

Discovering Principles of Embraceable System Design
60-minute workshops on GlobalMeet once or twice a month.

Contact rick.dove@parshift.com for participation and schedule.

Considering INCOSE SEP accreditation? (see Newsletter for live links)

Make 2015 your year. Gain international certification of your knowledge, experience and skills. CSEP Preparation 4-Day Course will place you in the best possible position to pass the CSEP exam. To learn how to successfully pass the exam and complete the application, join a course near you:

2015 Course Schedule (close by, others available as well):

Apr 27 - 30 | Albuquerque (sold out)
May 11 - 14 | Denver, CO
Jul 06 - 09 | Las Vegas, NV
Aug 17 - 20 | Austin, TX
Nov 02 - 05 | Las Vegas, NV

Design Thinking for SEs and SE Education
Things to Think About

Can creative thinking be practiced as a process?

How is this different than the essence of the Scrum software development process?

What benefits might you obtain with this approach?

Might this approach have application at your place?

Interested in chapter-exploration of application issues?

If so, send interest to rick.dove@parshift.com

Speaker Bio

Dr. Cliff Whitcomb's research interests include model-based systems engineering for enterprise systems, defense systems of systems, naval construction and engineering, and leadership, communication, and interpersonal skills development for engineers. He has more than 35 years experience in defense systems engineering and related fields.

He is the co-author of "Effective Interpersonal and Team Communication Skills for Engineers" published as part of an IEEE Series by John Wiley and Sons, and has published several other textbook chapters.

He is a principal investigator for research projects from the US Navy Office of Naval Research, Office of the Joint Staff, Office of the Secretary of the Navy, and several naval system commands and naval warfare centers.

He is an INCOSE Fellow, has served on the INCOSE Board of Directors, and was a Lean Six Sigma Master Black Belt for Northrop Grumman Ship Systems.

Dr. Whitcomb was previously the Northrop Grumman Ship Systems Endowed Chair in Shipbuilding and Engineering in the department of Naval Architecture and Marine Engineering at the University of New Orleans, a senior lecturer in the System Design and Management (SDM) program at MIT, as well as an Associate Professor in the Ocean Engineering Department, at MIT.

Dr. Whitcomb is also a retired naval officer, having served 23 years as a submarine warfare officer and Engineering Duty Officer. He earned his B.S. in Engineering (Nuclear Engineering) from the University of Washington, Seattle, WA in 1984, M.S. degrees in Naval Engineering and Electrical Engineering and Computer Science from MIT in 1992, and Ph.D. in Mechanical Engineering from the University of Maryland, College Park, MD in 1998.

Design Thinking: What is it and What Does it Mean for Systems Engineering Education?

INCOSE Enchantment Chapter
Seminar

Cliff Whitcomb, PhD
Professor and Chair
Systems Engineering Department
Naval Postgraduate School
Monterey, CA

INCOSE Fellow

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#25
US News and World Report
2015 Best Graduate Schools
Industrial / Manufacturing / Systems Engineering

Outline

- What is Design Thinking?
  - Key Points
- Relationship WRT Systems Engineering
- Design Thinking Examples
  - Stanford
  - NPS
- Development of related competencies
  - SE Competency Model
- Design Thinking - What's Next?
- Implications for Future Education

What is Design Thinking?

- Term used for the combination of the processes, skills, cognitive processes, and attitudes prevalent in design

IDEO

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http://designprogram.stanford.edu/design-thinking.php

Design Thinking at Stanford d.school

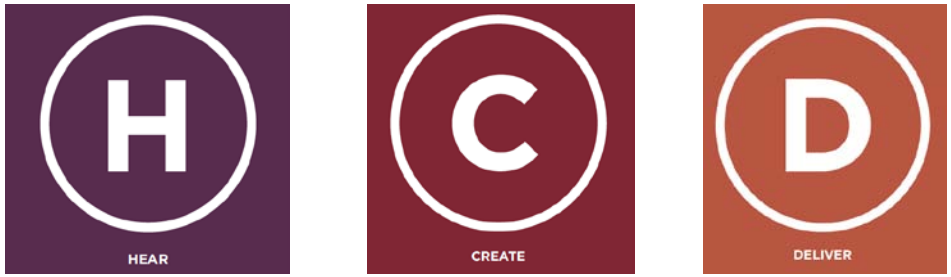
- Building is a new way of thinking
- Using a human-centered design process with rapid prototyping and iterative approach to solve complex problems
- Framing of the problem domain creatively
- Generating a wide array of innovative solutions
- Combining intentionality, design expression and a questioning of larger implications

STANFORD
DESIGN
PROGRAM

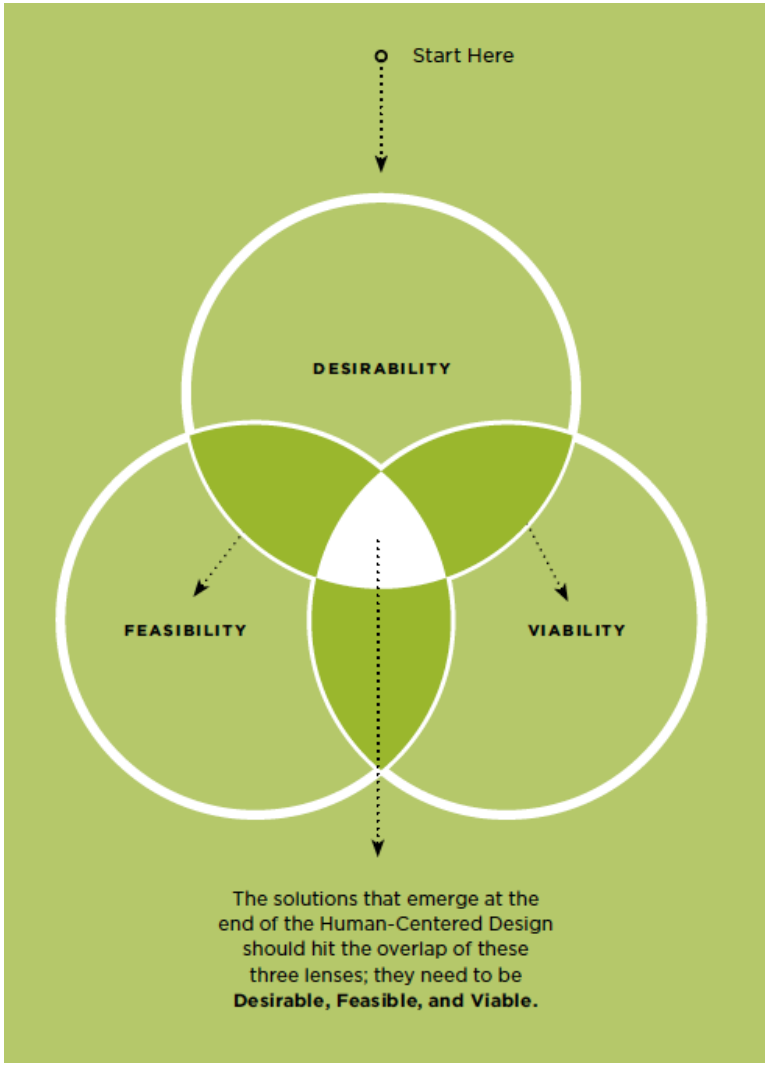
http://designprogram.stanford.edu/projects.php

Design Thinking Uses Human-Centered Design Philosophy

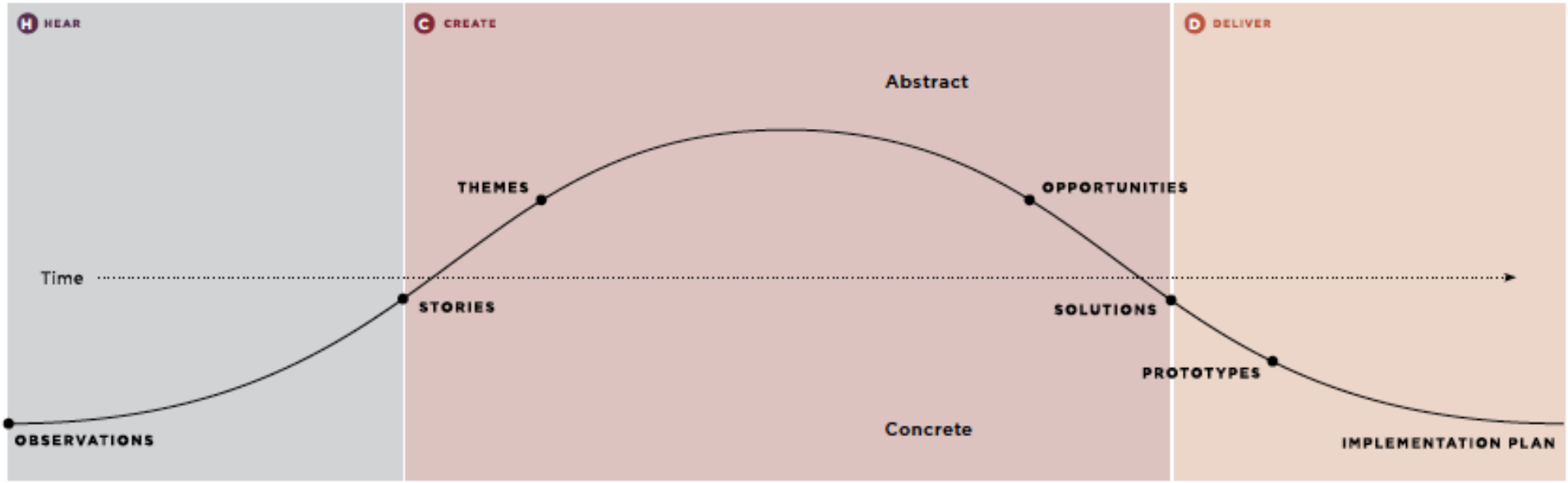
- Process and a set of techniques used to create new solutions for the world.
- Solutions include products, services, environments, organizations, and modes of interaction.
- Starts with the people we are designing for…



Human Centered Design Toolkit (http://www.designkit.org/resources/1/)



HCD Process



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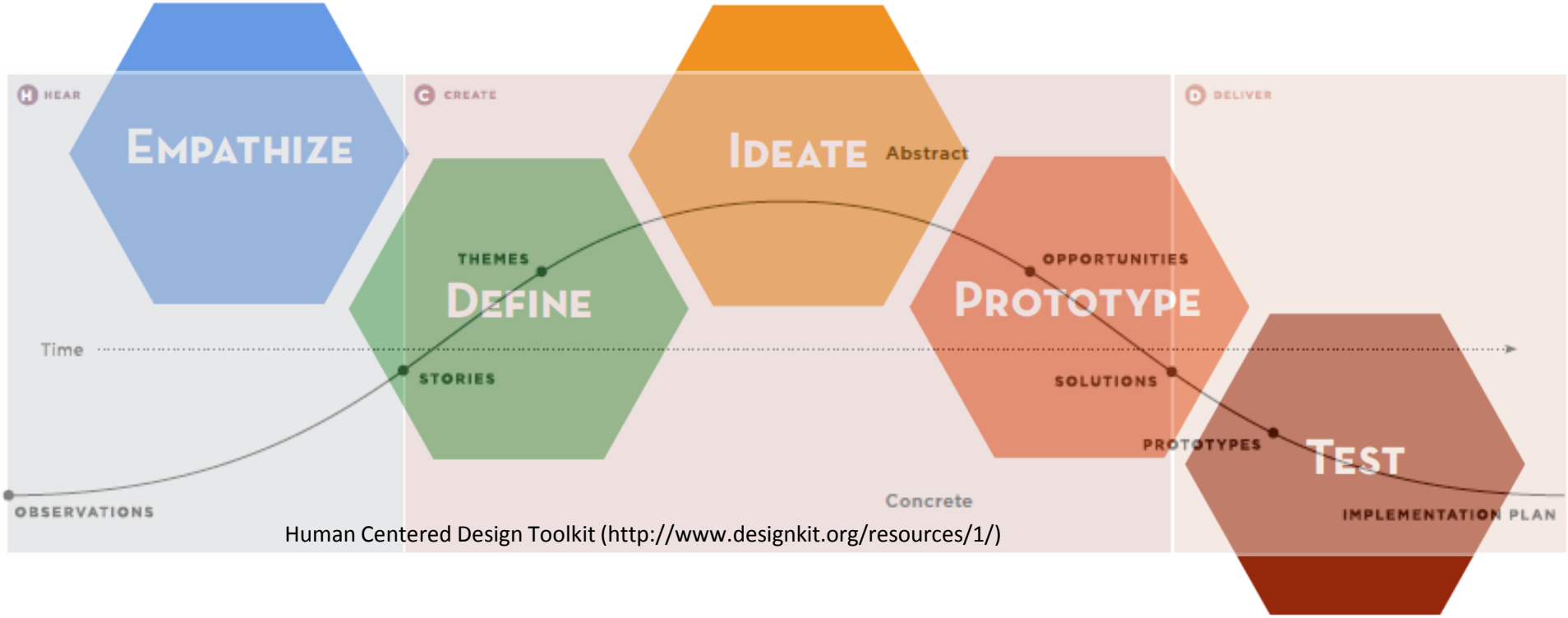
Design Thinking Process



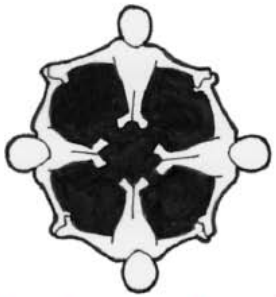
Human Centered Design Toolkit (http://www.designkit.org/resources/1/)

For examples of Design Thinking applications, please see:
http://learni.st/search/boards/design%20thinking

Image from: d.mindsets

Design Thinking Mindset

bias toward action



collaborate across boundries

focus on human values

be mindful of process

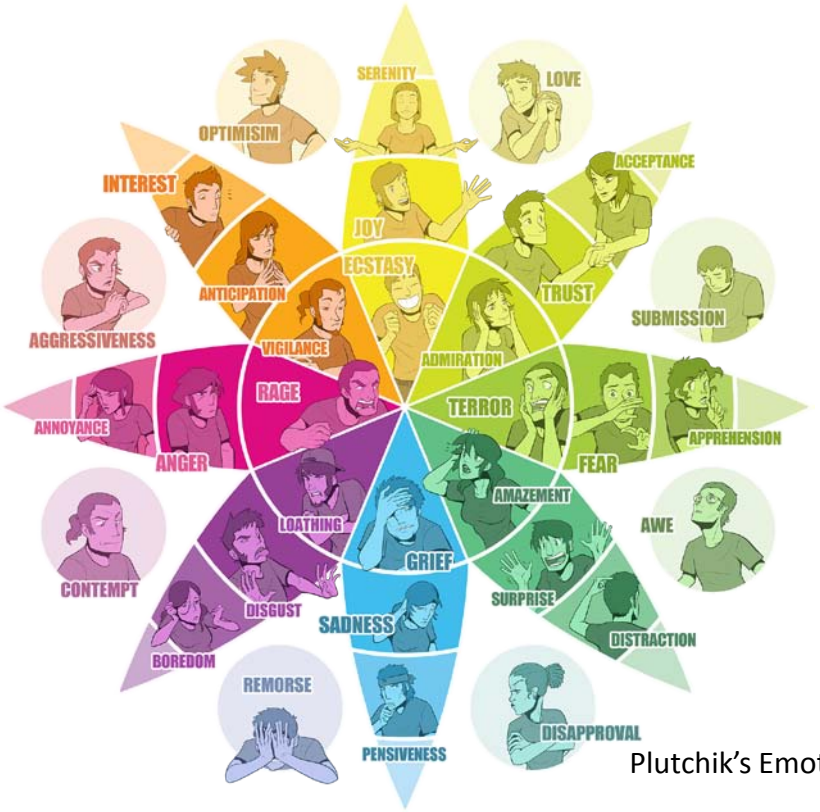
prototype toward a solution

show don't tell

Image from: d.mindsets

Mindset Focus on Human Values: Empathy and Empathetic Design

- Empathy - deep understanding of problems and realities of people you are designing for
- Understand "walk in their shoes'' before the Create Phase
- Understand the problem mentally
- Create solutions from a connection to deep thoughts and feelings



Plutchik's Emotion Wheel

See also: "Spark Innovation Through Empathetic Design", Dorothy Leonard and Susaan Straus, originally published July-August 1997, Breakthrough Thinking, Harvard Business Review

Image obtained from: http://staciapriscilla.com/wp-content/uploads/2013/09/Wheellarge.png

Design Thinking Methods & Tools

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EMPATHY FIELDGUIDE

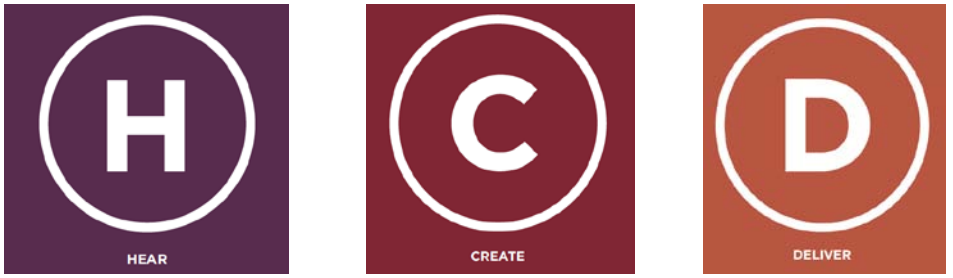
d.bootcamp

WHAT? HOW? WHY?	INTERVIEW PREPARATION	INTERVIEW FOR EMPATHY	EXTREME USERS	SATURATE AND GROUP
EMPATHY MAP	WHY-HOW LADDERING	POINT-OF-VIEW MADLIB	STOKE	BRAINSTORMING
FACILITATE A BRAINSTORM	SELECTION	PROTOTYPE FOR EMPATHY	PROTOTYPE TO TEST	STORYTELLING
I LIKE, I WISH, WHAT IF				

Point of View (POV)

How Might We? (HMW)

Human Centered Design Toolkit



http://www.designkit.org/resources/1/

Design Thinking @ NPS

- Design Thinking Design Challenges
  - How can we help the Army prepare for 2020?
  - How can we redesign the information flow in submarines?
  - How can we create a better thesis processing experience?
  - How can we create a better SE education experience?
  - Mission Assurance Support Tool (MAST) for LANL

Design Thinking Case Study

- Students at d.school conceptualized innovative incubator for premature babies using empathy to gain inspiration and reframe problem

http://learni.st/users/131859/boards/27131-design-thinking-case-studies-and-success-stories

Empathize and Define Framing/Reframing

- Stanford team goes to Nepal
- Makes site visits to observe and collect data from users and experts on the design challenge
- Based on the data collected, frames/reframes design problem
- You don't have an "incubator problem"
- You have "a keeping baby warm while traveling to the hospital problem"

“Incubator Problem” Ideation

- Having reframed the problem, the design team moves into ideation—what **new ideas** can we generate to address this “keeping baby warm problem”?
- One new idea: Envelop the baby in some material to keep it warm.

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“Incubator Problem” Prototyping

- Drawing, sketching what “keeping baby warm” solutions might look like.
- Creating simple models to anchor the team’s deliberations and explorations of alternative solutions.
- Building physical objects for testing and feedback.

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Embrace

The incubator costs around $25 dollars as opposed to the standard $20,000 dollar incubator.

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Embrace: Fits the Context

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NPS Design Thinking Example

Mission Assurance Support Tool (M.A.S.T)

LANL Mission Assurance Project

SE 3201, SE3202, SE3203

Advisor: Dr. Heidi Ann Hahn, LANL

Students: LT Shannon Buckley, LT Ross Eldred, LT Keith Robison, LT Bob Smith, LT Patrick Stone, LT Jordan White

Design Challenge

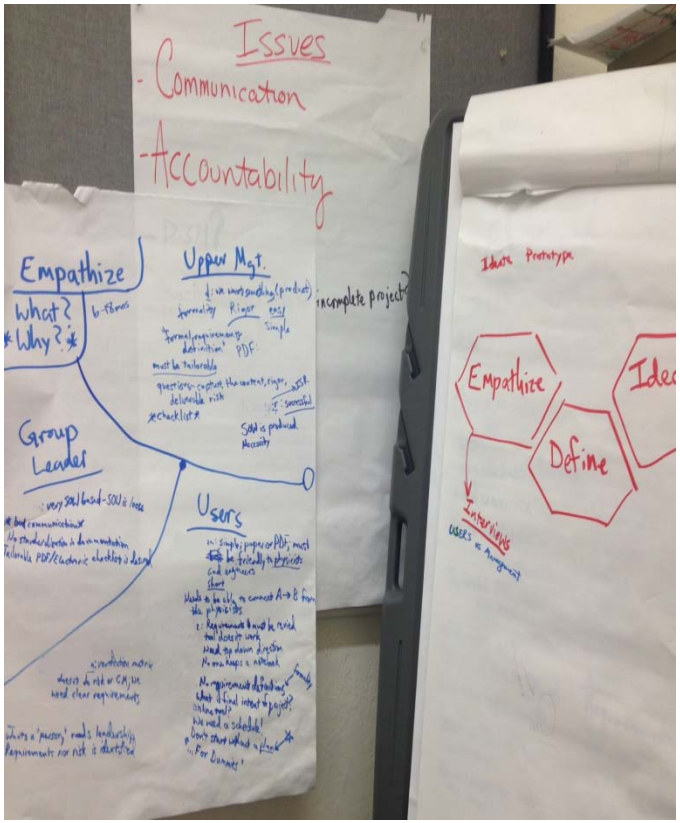
- Enable engineers and applied scientists who have little or no expertise in systems engineering to tailor and apply Los Alamos National Laboratory's (LANL's) mission assurance processes (with emphasis on risk-grading, problem definition, and requirements capture and analysis) to R&D projects ranging from design of apparatus for bench experiments to demonstration of an actual system prototype in an operational environment

Phase 1: Gather, Organize Information with Empathy

- Phone interviewed 11 managers and engineers at LANL
- Took detailed notes on each interview and then created Vision Statements for each interview
  - Example: "An experienced LANL engineer felt frustrated with the lack of fidelity and traceability in LANL projects and hoped to have a system to allow for seamless design with detailed documentation."

Phase 2: Define Issue

- Compiled all the information into like-minded groups
- Analyzed the needs/wants/desires/goals of each group
- Identified any similar threads between groups
- Discussed how this product could meet the needs of each group



Design and Traceability

Phase 2: Define Issue

- Compiled all information gathered in Phase 1 and created “How might we…” statements
  - Reflected top-level requirements, for example that the product be tailorable, scalable, comprehensive, easy to use, and easy to maintain
- Used colored circles to vote on the top issues

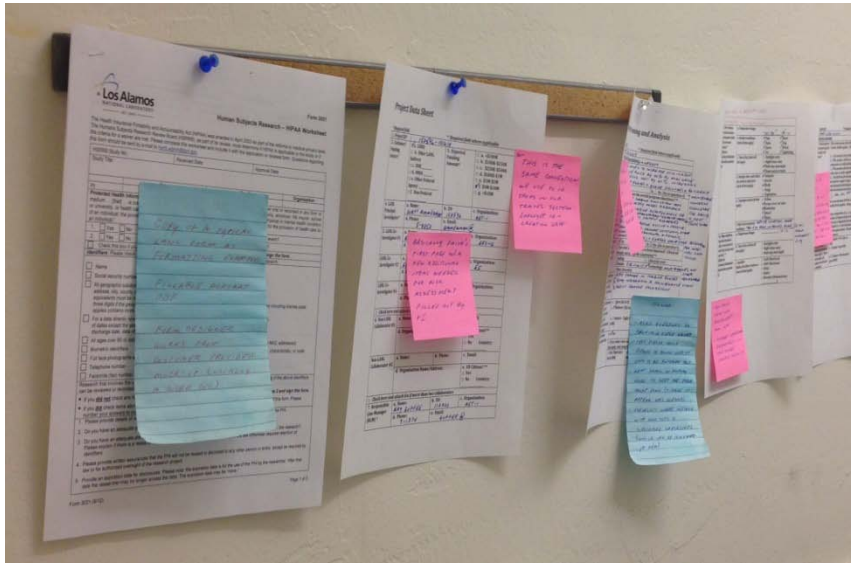
How might we create a document that is applicable to any project and will aid in the design process and ensure all important factors are being considered?

Phase 3: Ideate

- Used the defined problem statement and brainstormed multiple solutions
  - Explored all different mediums the formula could take: Word Document, paper document, .PDF, etc.
  - Extensively thought and discussed how to incentivize workers to voluntarily use the tool
  - Considered the different types of forms that would facilitate detailed design but would still keep the additional work required by the engineers to a minimum

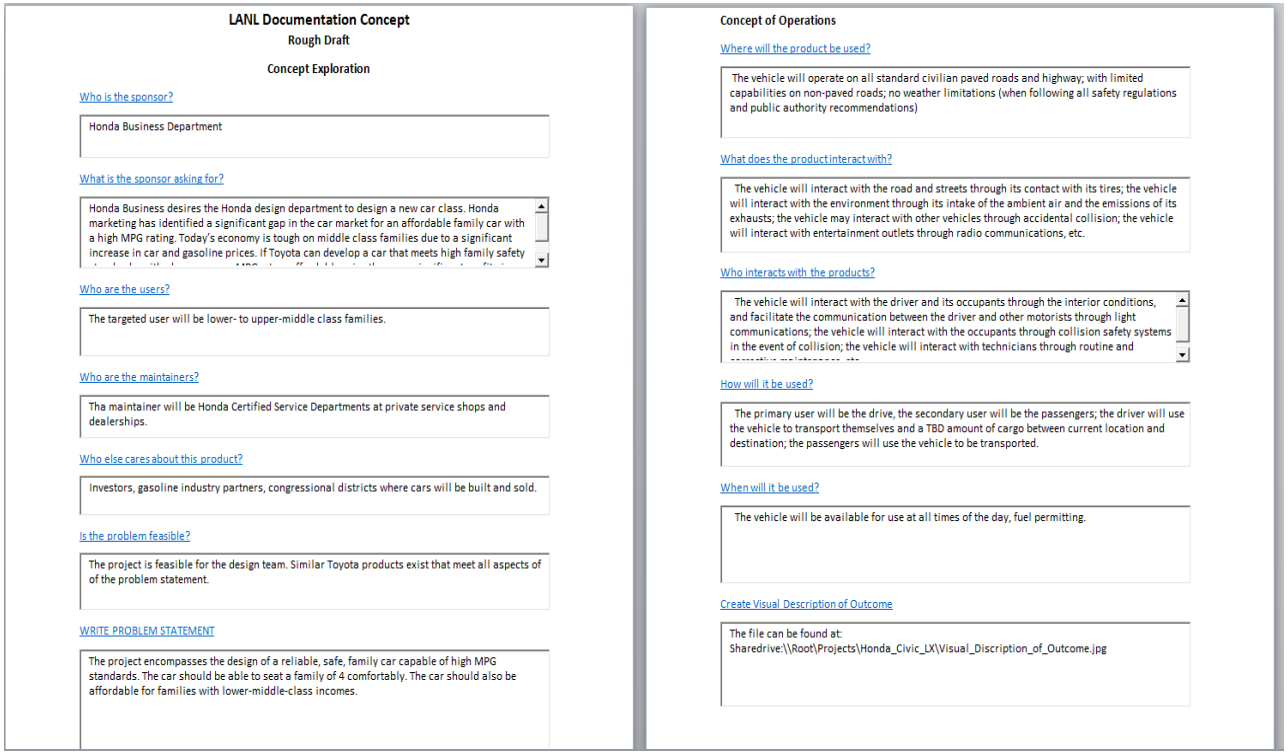
Phase 3: Ideate

- Reviewed alternatives already in place at LANL to determine the benefits/drawback of each
- Determined if any of the already in place alternatives could be tailored to fit the design challenge



Phase 4: Build a Prototype

- Decided on a locked Word Document form
- Brainstormed the questions, detailed explanation of the question, and a working example



LANL Documentation Concept

Rough Draft

Concept Exploration

Who is the sponsor?

Honda Business Department

What is the sponsor asking for?

Honda Business desires the Honda design department to design a new car class. Honda marketing has identified a significant gap in the car market for an affordable family car with a high MPG rating. Today's economy is tough on middle class families due to a significant increase in car and gasoline prices. If Toyota can develop a car that meets high family safety

Who are the users?

The targeted user will be lower- to upper-middle class families.

Who are the maintainers?

Tha maintainer will be Honda Certified Service Departments at private service shops and dealerships.

Who else cares about this product?

Investors, gasoline industry partners, congressional districts where cars will be built and sold.

Is the problem feasible?

The project is feasible for the design team. Similar Toyota products exist that meet all aspects of of the problem statement.

WRITE PROBLEM STATEMENT

The project encompasses the design of a reliable, safe, family car capable of high MPG standards. The car should be able to seat a family of 4 comfortably. The car should also be affordable for families with lower-middle-class incomes.

Concept of Operations

Where will the product be used?

The vehicle will operate on all standard civilian paved roads and highway; with limited capabilities on non-paved roads; no weather limitations (when following all safety regulations and public authority recommendations)

What does the product interact with?

The vehicle will interact with the road and streets through its contact with its tires; the vehicle will interact with the environment through its intake of the ambient air and the emissions of its exhausts; the vehicle may interact with other vehicles through accidental collision; the vehicle will interact with entertainment outlets through radio communications, etc.

Who interacts with the products?

The vehicle will interact with the driver and its occupants through the interior conditions, and facilitate the communication between the driver and other motorists through light communications; the vehicle will interact with the occupants through collision safety systems in the event of collision; the vehicle will interact with technicians through routine and

How will it be used?

The primary user will be the drive, the secondary user will be the passengers; the driver will use the vehicle to transport themselves and a TBD amount of cargo between current location and destination; the passengers will use the vehicle to be transported.

When will it be used?

The vehicle will be available for use at all times of the day, fuel permitting.

Create Visual Description of Outcome

The file can be found at:
Sharedrive:\\Root\Projects\Honda_Civic_LX\Visual_Discription_of_Outcome.jpg

Phase 5: Test

- Obtained IRB approval to distribute the Mission Assurance Support Tool (MAST) to LANL employees along with a detailed description of the tool and a survey
- Obtained 2 responses from LANL employees and management
- Adjusted MAST to incorporate feedback and compatibility issues faced

Lessons Learned

- Rapid prototyping and testing proved difficult based upon geographic distance and the willingness of participants
  - Early face-to-face interaction may have increased responses from LANL SMEs
  - In future, use NPS students as surrogate testers
- Important to remain within the framework of the customer's request and not constrain them within an unnecessary or unstated boundary

Unique Features of Design Thinking

- Starts with the **people** who **need** the product, process, or service and innovates for them
  - Context is critical in the design thinking
- Involves ***embodied learning***—learning to "think with your hands"
  - Prototypes can be anything from a storyboard, to a role play, to an actual physical object

Professor Nancy Roberts, Defense Analysis Department, NPS

Design Thinking provides a structured approach to Stakeholder Needs Analysis.

Design Thinking Prototyping

- P*rototypes* of creative ideas built as early as possible so design team can learn just enough to
  - Generate useful feedback
  - Determine an idea's strengths and weaknesses
  - Decide what new directions to pursue with more refined prototypes
- ***Learn by doing***
  - Give form to an idea
  - Evaluate it against other ideas and ultimately improving upon it
- "***Fail early, fail often***"
  - Prototyping is "***quick, cheap, and dirty***"

Professor Nancy Roberts, Defense Analysis Department, NPS

Design Thinking Working Environment

- *Designers need to work in open configurable spaces* with room to display visuals that chart team's brainstorming, analysis, and problem solving processes
- Spaces need to be *large enough to accommodate all the research materials, visuals, and prototypes* in order to keep them visible and accessible all of the time, not hidden away in files, drawers, and electronic folders

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Design Thinking is a Failed Experiment

- **Design Thinking** has given the design profession and society at large all the benefits it has to offer and is **beginning to ossify and actually do harm**
- Construction and framing of Design Thinking itself has become a key issue
- Companies absorbed the process of Design Thinking all to well, **turning it into a linear, gated, by-the-book methodology** that delivered, at best, incremental change and innovation. Call it N+1 innovation.
- Businesses and consultancies were **hoping that a process trick** would produce significant cultural and organizational change

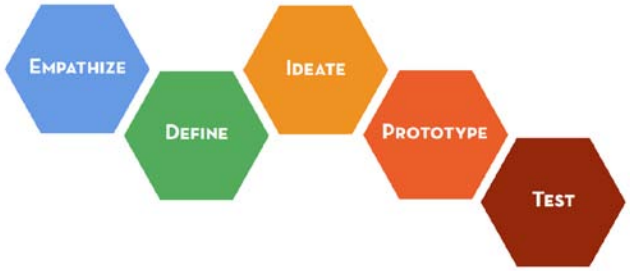
"Design Thinking Is A Failed Experiment. So What's Next?", Bruce Nussbaum, Fast Company, http://www.fastcodesign.com/1663558/design-thinking-is-a-failed-experiment-so-whats-next

Design Thinking: What is Next?

- Design Thinking was scaffolding for the real deliverable: **creativity**
- In order to appeal to the business culture of process, it was denuded of the **mess**, the **conflict**, **failure**, **emotions**, and **looping circularity** that is part and parcel of the **creative process**
- **Contributions** of Design Thinking to the field of **design** and to **society** at large are **immense**
- By **formalizing** the **tacit values and behaviors of design**, Design Thinking was able to move designers and the power of design from a **focus** on artifact and aesthetics within a narrow consumerist marketplace to the **much wider social space of systems and society**

"Design Thinking Is A Failed Experiment. So What's Next?", Bruce Nussbaum, Fast Company, http://www.fastcodesign.com/1663558/design-thinking-is-a-failed-experiment-so-whats-next

Characteristics Relationship



Design Thinking

- Design Processes
- Skills
- Cognitive processes
- Attitudes

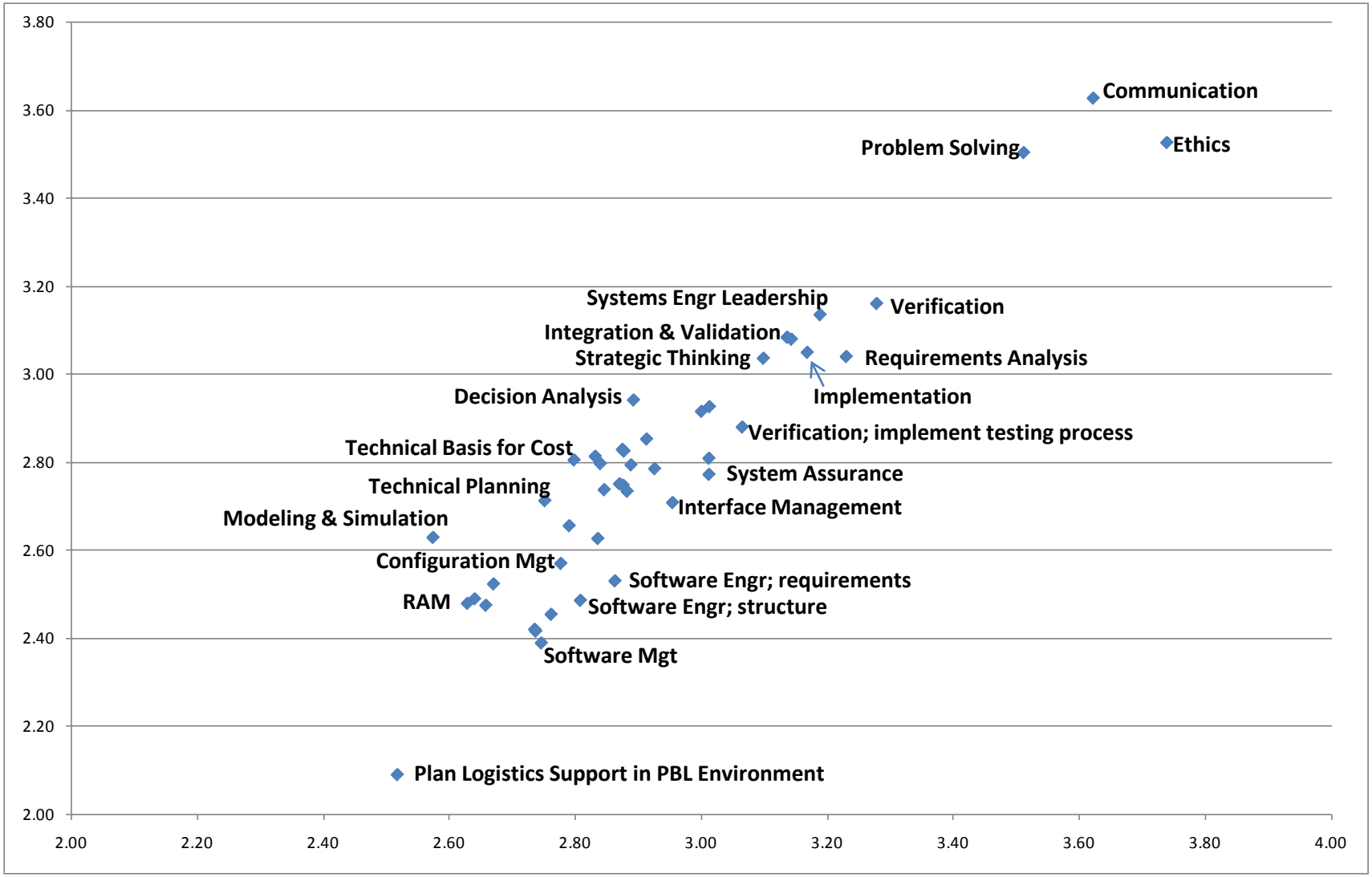
What competencies and knowledge, skills, and abilities - are needed to develop a systems engineer today?

Systems Engineering

- Lifecycle Processes
  - Conceive
  - Design
  - Implement
  - Operate
- Competencies
  - Knowledge, Sills, Abilities
- Cognitive processes
- Affective processes

OSD SPRDE/PSE Competency Survey

Scale 1 – 5; 5 = very proficient, very mission critical



DoD SE Competency Model

Technical (Includes Management)

Number	Competency
1.0	Mission-Level Assessment
2.0	Stakeholder Requirements Definition
3.0	Requirements Analysis
4.0	Architecture Design
5.0	Implementation
6.0	Integration
7.0	Verification
8.0	Validation
9.0	Transition
10.0	Design Considerations
11.0	Tools and Techniques
12.0	Decision Analysis
13.0	Technical Planning
14.0	Technical Assessment
15.0	Configuration Management
16.0	Requirements Management
17.0	Risk Management
18.0	Data Management
19.0	Interface Management
20.0	Software Engineering Management
21.0	Acquisition
22.0	Problem Solving
34.0	Cost, Pricing and Rates
35.0	Cost Estimating
36.0	Financial Reporting and Metrics
38.0	Capture Planning and Proposal Process
39.0	Supplier Management

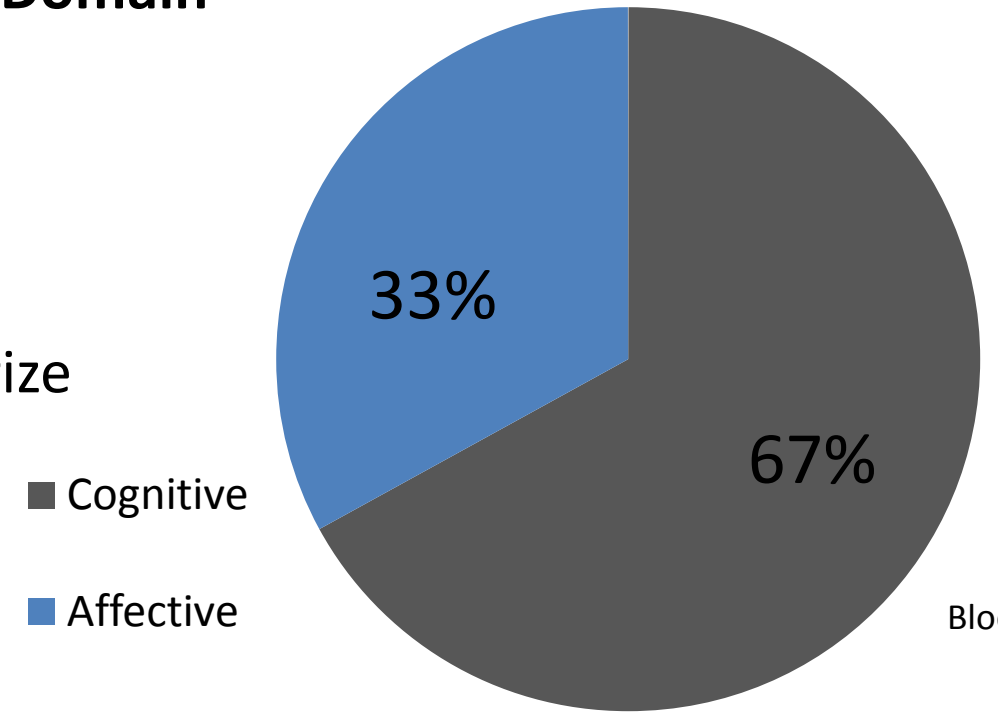
Professional

Number	Competency
23.0	Strategic Thinking
24.0	Professional Ethics
25.0	Leading High-Performance Teams
26.0	Communication
27.0	Coaching and Mentoring
28.0	Managing Stakeholders
29.0	Mission and Results Focus
30.0	Personal Effectiveness/Peer Interaction
31.0	Sound Judgment
32.0	Industry Landscape
33.0	Organization
37.0	Business Strategy
40.0	Industry Motivation, Incentives, Rewards
41.0	Negotiations

Office of the Secretary of Defense (OSD)
ENG Career Field SE Competency Model
Defense Acquisition University

SE Career Competency Model (SECCM) KSA in Bloom's Taxonomy

Affective Domain
Receive
Respond
Value
Organize
Characterize



Cognitive Domain
Remember
Understand
Apply
Analyze
Evaluate
Create

Bloom's Taxonomy (from Krathwohl 2002)

Approximately 3000 KSA elements mapped to the 41 competencies of the DOD model, defined in terms of Bloom's Taxonomy.

Radical Ideas for Reinventing College, From Stanford's Design School

- How to keep the on-campus experience relevant in an age where online learning is becoming increasingly common
  - Studied learning in it's essence
  - Project 10-15 years into the future
- This is a generation of students who are incredibly highly structured, but they're going to be entering an increasingly ambiguous world
  - Basically today's higher education system makes way for a bunch of well-trained sheep

One year study applying Design Thinking to Reinventing Higher Education

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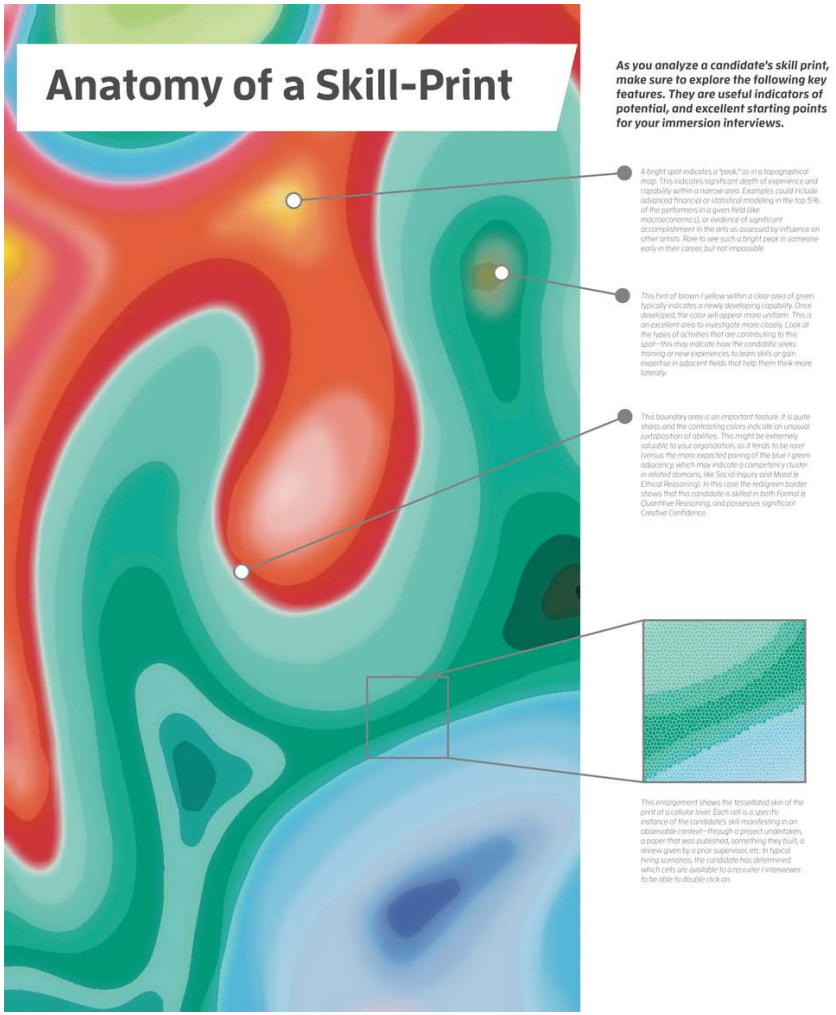
Reinventing higher ed, Sarah Stein Greenberg (http://www.wired.com/2014/11/radical-ideas-reinventing-college-stanfords-design-school/)

What Could Happen If…?

4 Ideas to Start Conversations

- Open Loop University
  - College lasts a lifetime
  - 6 years of college to use as you wish over career, instead of
  - Not all avocados ripen in 8 weeks… so are all students ready for college at 18 years of age
- Paced Education
  - Move through college at your own pace
  - Arbitrarily divided into 4 years, so abolish the class year
  - Students find their own rhythm: explore, focus and deepen, practice – **try, fail, try again**
- **Axis Flip**
  - **Develop competencies and skills**
  - **Not just information assimilation**
  - **Develop a Skill Print**
- Purpose Learning
  - Declare missions not majors
  - Students apply to the “School of Hunger” or the “School of Energy”

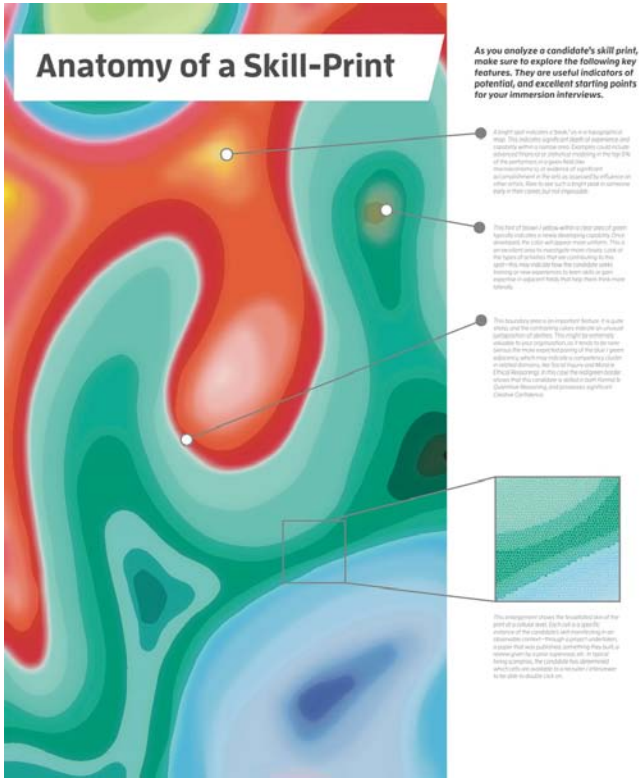
Reinventing higher ed, Sarah Stein Greenberg (http://www.wired.com/2014/11/radical-ideas-reinventing-college-stanfords-design-school/)



http://www.stanford2025.com/axis-flip-archive/

Moving Forward

- Design Thinking Offers Formalized Approach
  - Formalized method for Stakeholder Needs Analysis
  - Empathy-based understanding
  - Body-based prototyping
  - Feeds a shift in engineering education approaches
  - Social and holistic approach fits well with development of System Engineers
- Integrate into SE Education
  - Include the “mess, the conflict, failure, emotions, and looping circularity that is part and parcel of the creative process”
  - Focus on the learning outcomes
  - Develop competencies



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Reference Links

http://designprogram.stanford.edu/design-thinking.php

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Conceive – Design – Implement – Operate: http://www.cdio.org

Reinventing higher ed, Sarah Stein Greenberg:
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Might this approach have application at your place?

Interested in chapter-exploration of application issues?

If so, send interest to rick.dove@parshift.com

Please

The link for the online survey for this meeting is

www.surveymonkey.com/r/4_08_15_GM

www.surveymonkey.com/r/4_08_15_GM

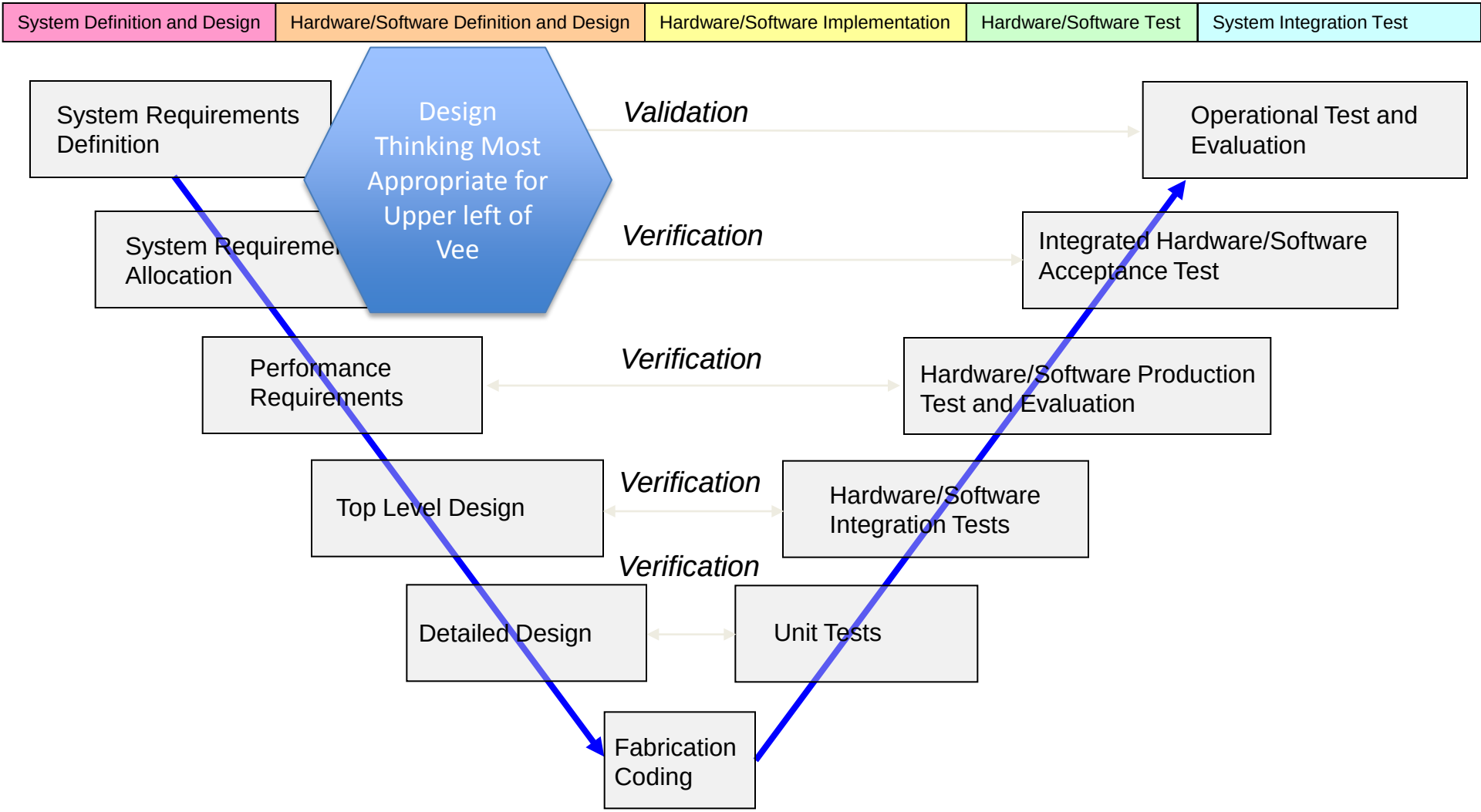
Slide presentation can be downloaded now/anytime from:

www.incose.org/enchantment/library.aspx

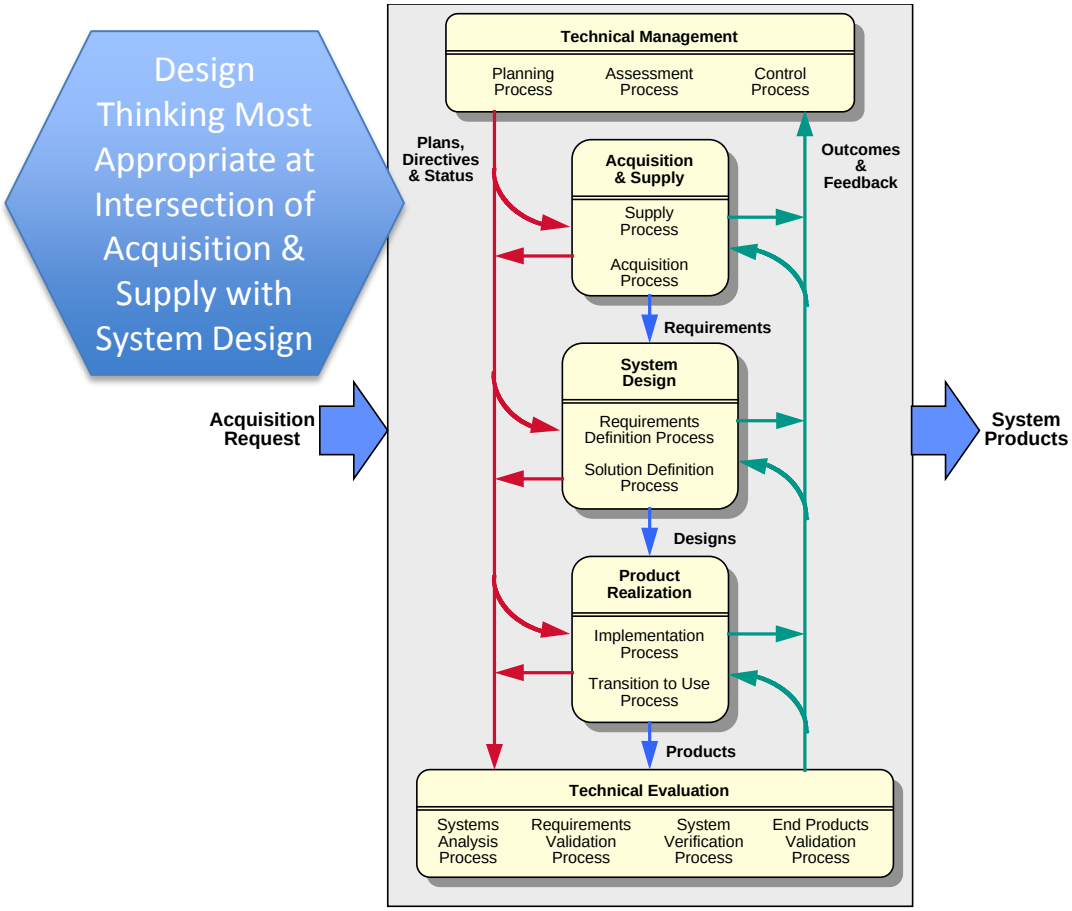
Recording will be in library tomorrow.

Back Up Information

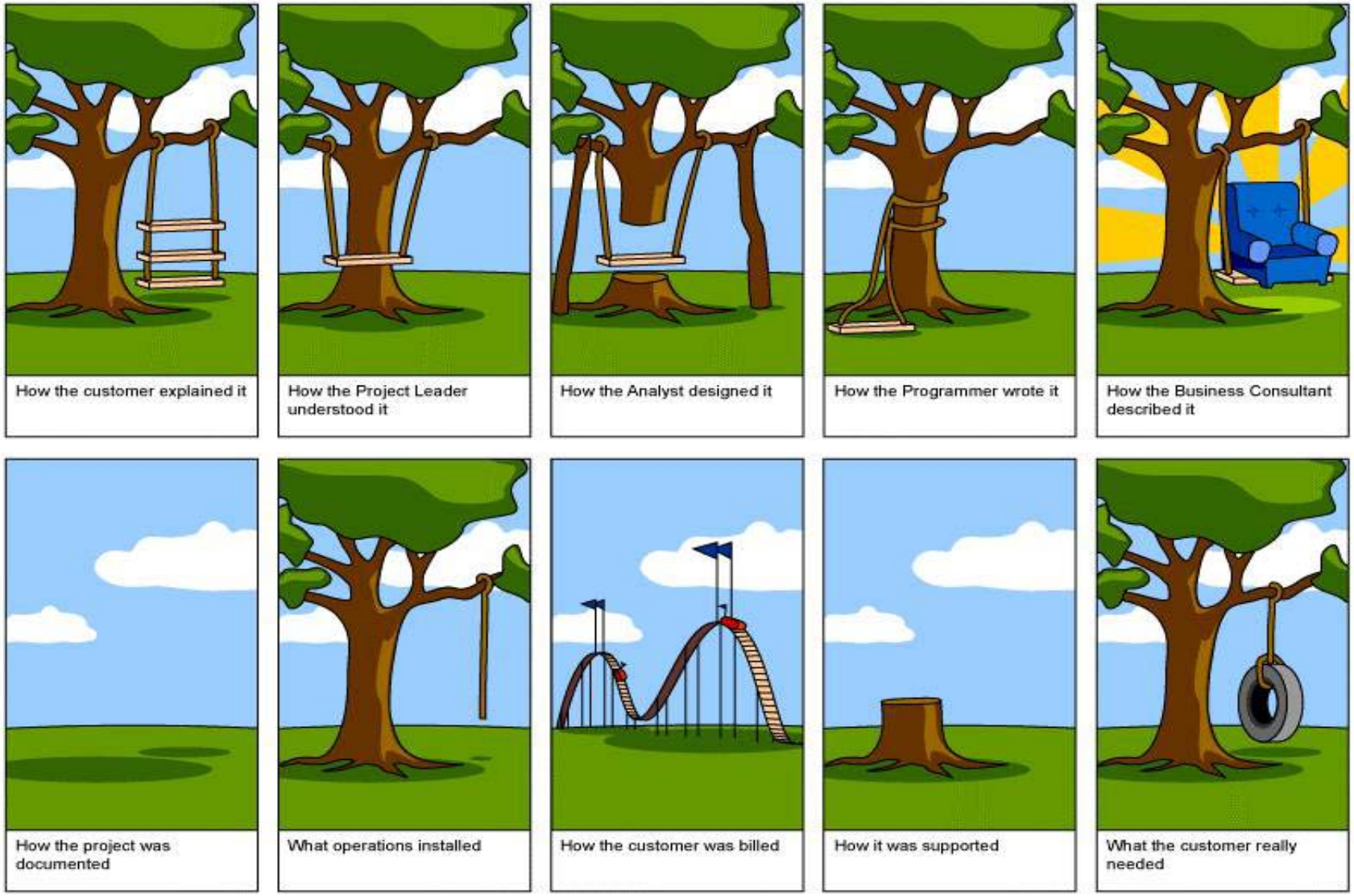
Processes: Design Thinking WRT SE "Vee" Model



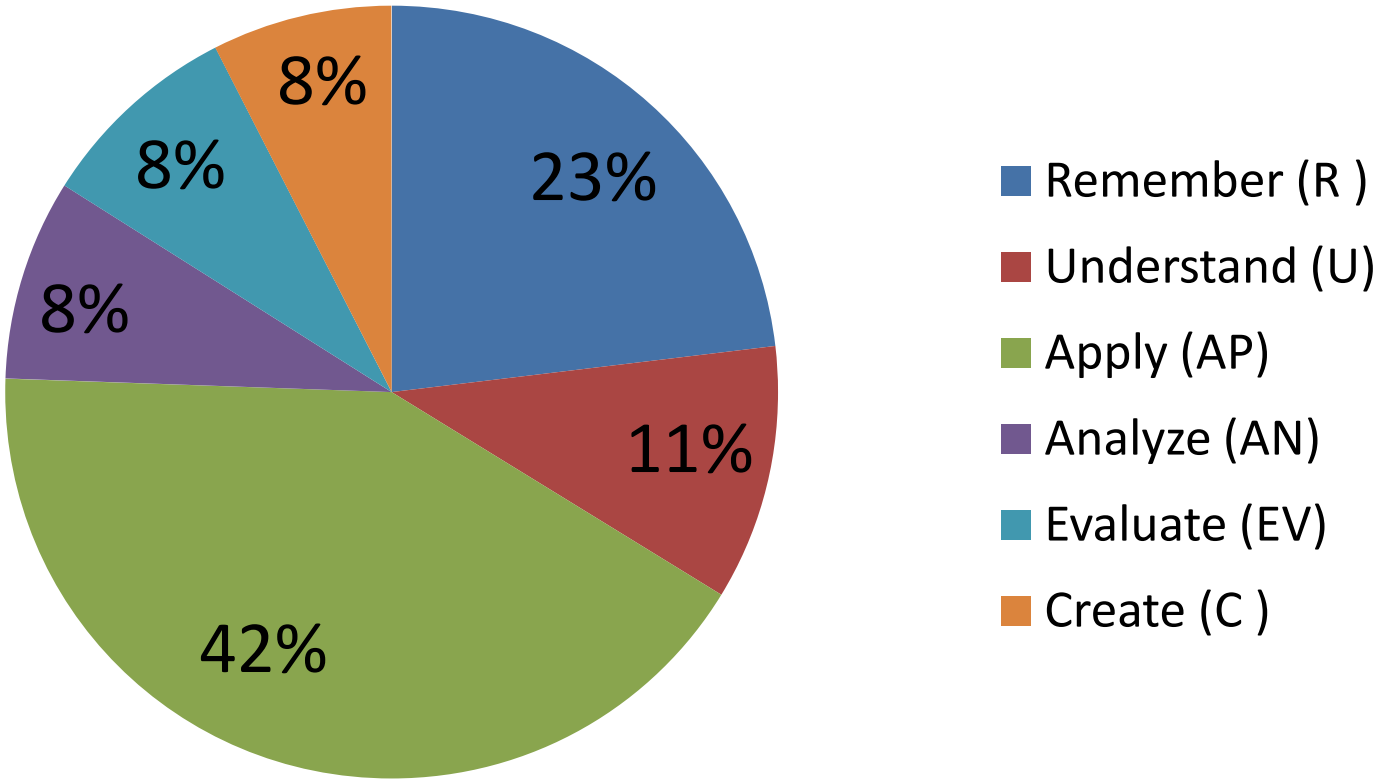
Processes: Design Thinking WRT EIA-632 SE Model



Both Design Thinking and SE Try to Avoid These Problems

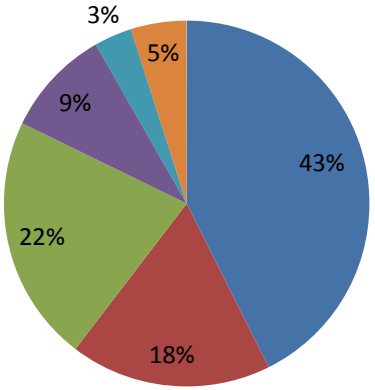


SECCM Cognitive Domain KSA Distribution

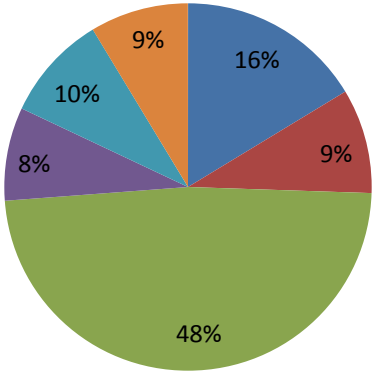


Cognitive Domain Level Shift Through Career

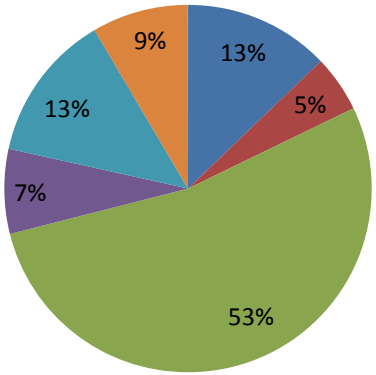
Bloom's Cognitive Levels within the SE-01



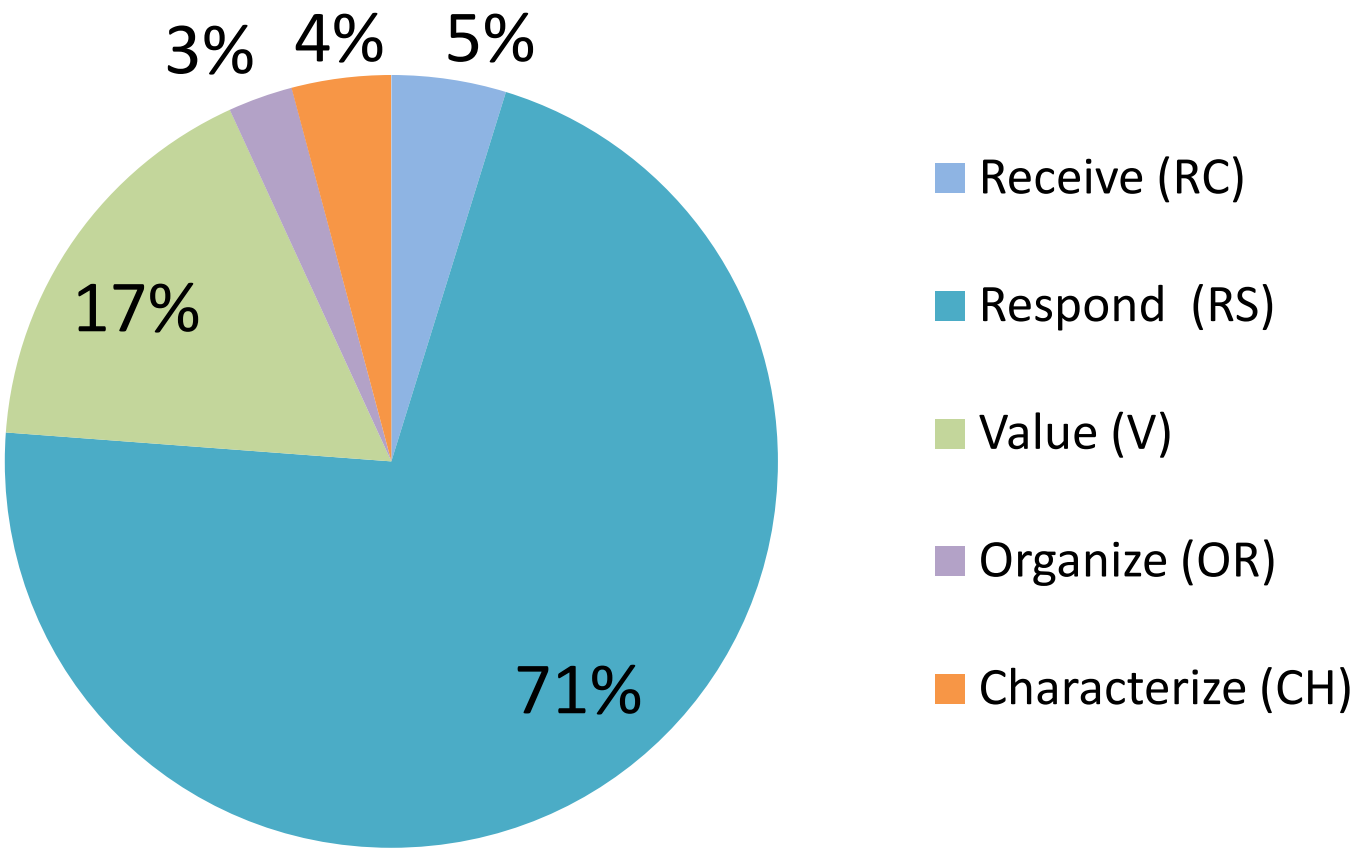
Bloom's Cognitive Levels within the SE-02



Bloom's Cognitive Levels within the SE-03

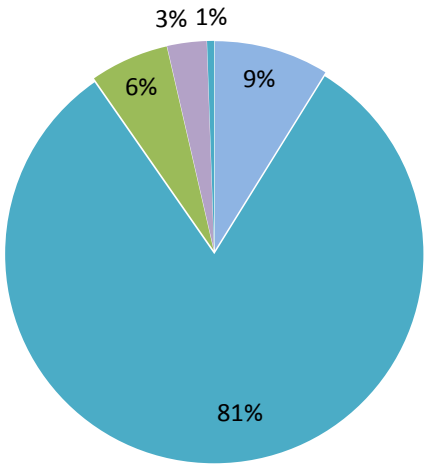


SECCM Affective Domain KSA Distribution

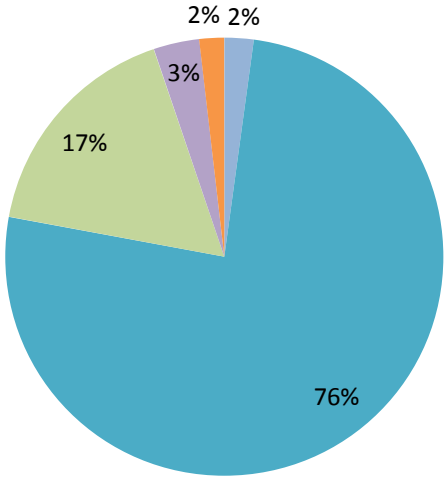


Affective Domain Level Shift Through Career

Bloom's Affective Levels within the SE-01



Bloom's Affective Levels within the SE-02



Bloom's Affective Levels within the SE-03