29th Annual INCOSE international symposium

Orlando, FL, USA

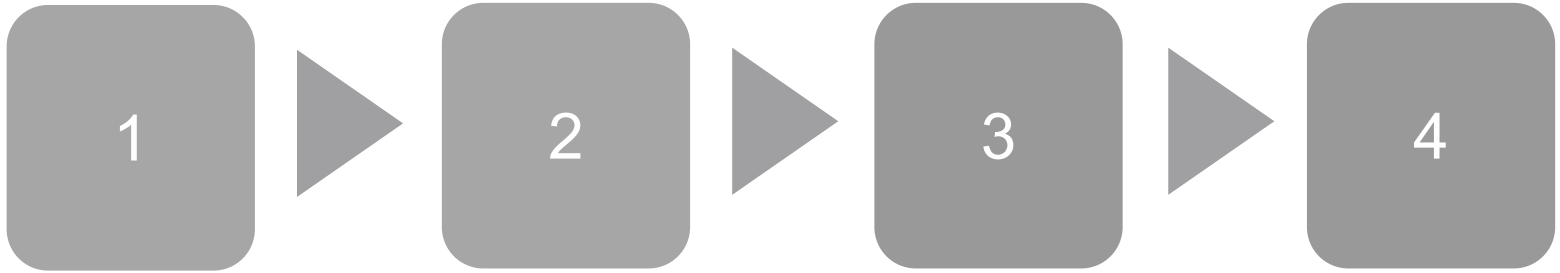
July 20 - 25, 2019

A Subjective Toolbox for Sociotechnical Systems

Kevin Devaney – SRC, Inc., Finger Lakes Chapter

www.incose.org/symp2019

Agenda



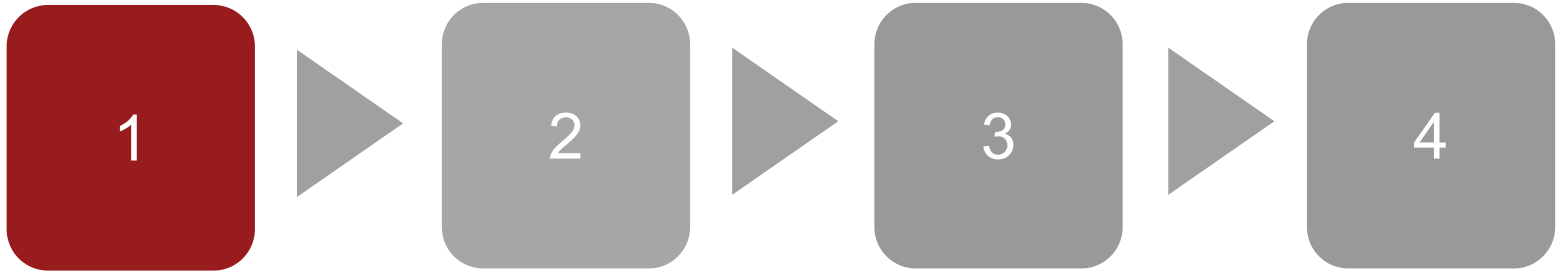
A couple of stories

Arguments for a subjective toolbox

The subjective tools

Summary

Agenda



1. A couple of stories
2. Arguments for a subjective toolbox
3. The subjective tools
4. Summary

Joint Strike Fighter

- In 1997, contracts awarded to Lockheed and Boeing
- Concept demonstration phase
- First flights in 2000

X-35

X-32

X-32 Photo credit: US Air Force Public domain

X-35 Photo credit: US Navy / Public domain

X-32

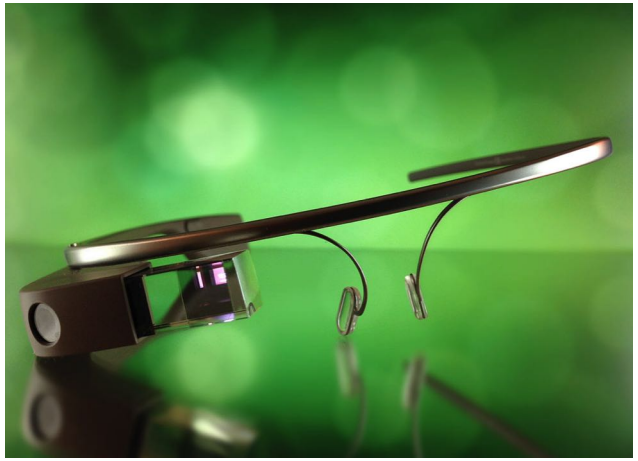
Photo credit: US Air Force / Public domain

Sometimes Beauty Matters

Photo credit: US Air Force / Public domain

Google Glass

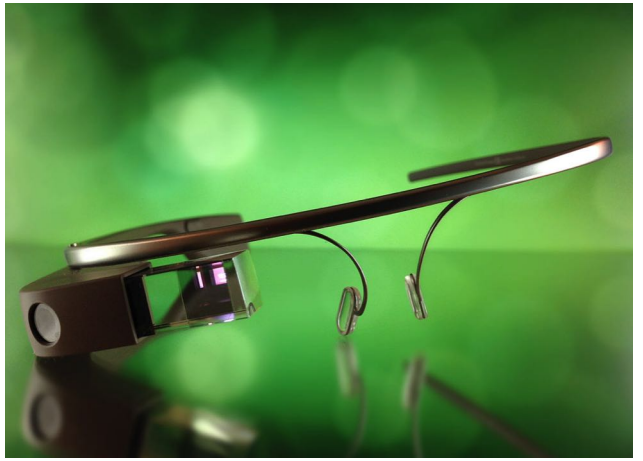
- Smart glasses
  - Head-mounted wearable computer
  - Initial release in 2013
  - Select group of users - 8,000 “Glass Explorers”
- Product ran into problems
  - Voice activation made awkward to use in public
  - Camera created security and privacy concerns
  - Google Glass banned from establishments
  - Early adopters became social pariahs
  - New term coined for users - “Glasshole”
- Google ends Explorer program in 2015



Google Glass

Sometimes Culture Matters

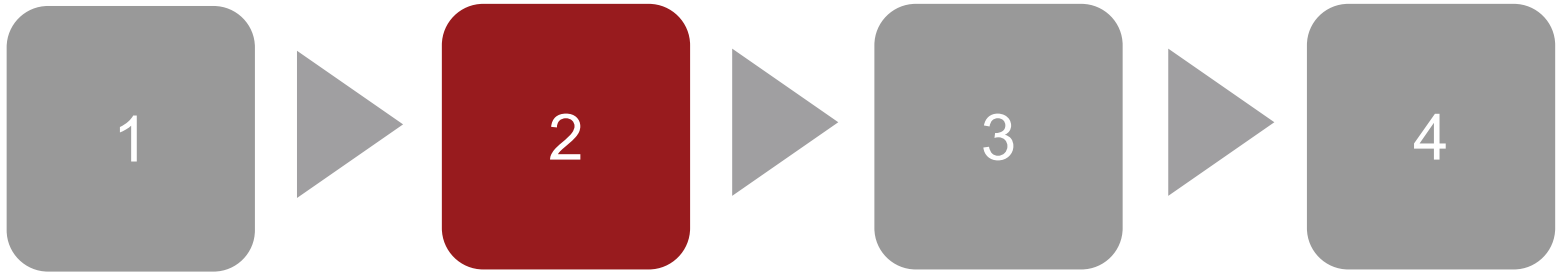
- Google Glass' initial release could have been successful if they had taken cultural issues into account
  - Alternative interface to voice activation
  - Modify camera to address security and privacy concerns



Google Glass

Graphic credit: Dan Leveille / CC BY-SA 3.0

Agenda



1. A couple of stories
2. Arguments for a subjective toolbox
3. The subjective tools
4. Summary

Argument #1 - Sociotechnical Systems

- Enterprise systems growing in complexity
  - Manufacturing organizations, nuclear power plants
  - Mix of social and technical elements
- Call for new approaches
  - Account for human aspects, social interactions
- Proposed approaches
  - Soft Systems Methodology, Engineering Systems
  - Limited to use of objective tools and methods
- Claim: subjective tools necessary to address human aspects and values

Philippsburg Nuclear Power Plant, Germany

Photo credit: Lothar Neumann / CC BY SA 2.5

Argument #2 - Limits of Objective Tools

- Work of critics of the systems approach
  - Ida Hoos, *Systems Analysis and Public Policy (1972)*
  - C. West Churchman, *The Systems Approach and its Enemies (1979)*
- In the 1960's, nation looked to systems analysis to solve social problems
  - "If we can put a man on the moon…"
  - Systems analysis applied to poverty, pollution, crime, urban renewal, housing, education, healthcare…
  - By 1980, over $200 billion spent annually on systems analysis applied to public policy

Ida Hoos

C West Churchman

Photo credit: Carol Palmer Graphic credit: UC Press

Systems Approach – Massive Failure

- Showed the limits of quantitative models
  - Distorted how problems are studied
  - Focus was on things that can be measured
  - Ignored things that could not be measured
- 'Model-itis' – analysts become too focused on the model, lose touch with the problem
- Systems approach ignores intangibles and crucial aspects of the problem
  - Leads to useless or harmful results

Photo credit: Leandra Michelle

Two Examples

- A study of waste management in California
  - Solution: develop a centralized authority with dictatorial powers over all resources at all levels
  - Completely ignored local politics (real-world issue)
- San Francisco's Embarcadero Freeway
  - Begun in 1959, designed to be the most effective way to move traffic around the city
  - Abandoned before it was fully completed
  - Ignored several qualitative factors
    - Scarred the urban landscape
    - Marred the beautiful waterfront view
    - Spread noise and auto exhaust around neighboring areas

Garbage Truck

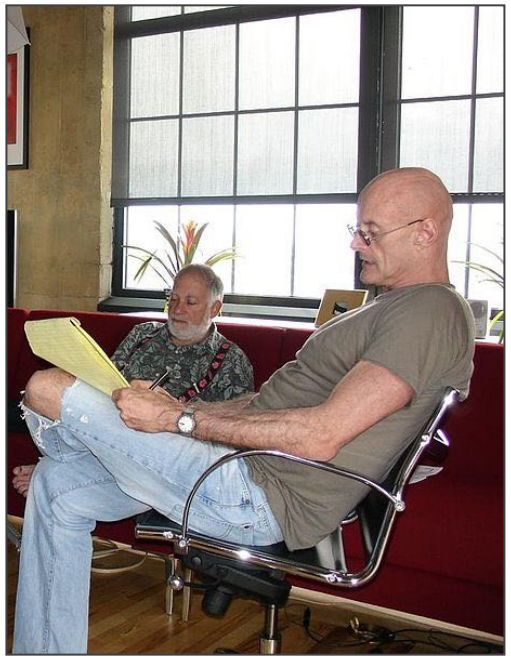
Embarcadero Freeway

Photo credit: Frank Deanrdo / CC-BY-2.0

Photo credit: Dennis Hill / Public domain

Argument #3 – Integral Theory

- Integral Theory
  - School of philosophy founded by Ken Wilber (1970's)
- Goal to integrate all knowledge into a single framework
  - General and comprehensive
  - Popular in organizational development
  - Applied to over 30 other domains
- Integral theory models
  - Four quadrant model
  - Levels of development model



Ken Wilber

Photo credit: Kanzeon Zen Center / CC-BY-2.0

Four Quadrant Model

	Interior	Exterior
Individual	Upper Left (UL) I Intentional (Subjective)	Upper Right (UR) It Behavioral (Objective)
Collective	Lower Left (LL) We Cultural (Intersubjective)	Lower Right (LR) Its Systems, Social (Interobjective)

Integral Theory View of Systems Engineering

- SE sees only the right-hand exterior perspective
  - Only the measurable, objective world matters
- Left-hand interior quadrants largely ignored
  - Most parts seen as having little value
  - Some parts mapped into right-hand quadrants
- Wilber calls this limited perspective "Flatland"
  - A fundamental cause of the world's problems
  - Can get better results if use all four quadrants

	Interior	Exterior
Individual		Upper Right (UR) It Behavioral (Objective)
Collective		Lower Right (LR) Its Systems, Social (Interobjective)

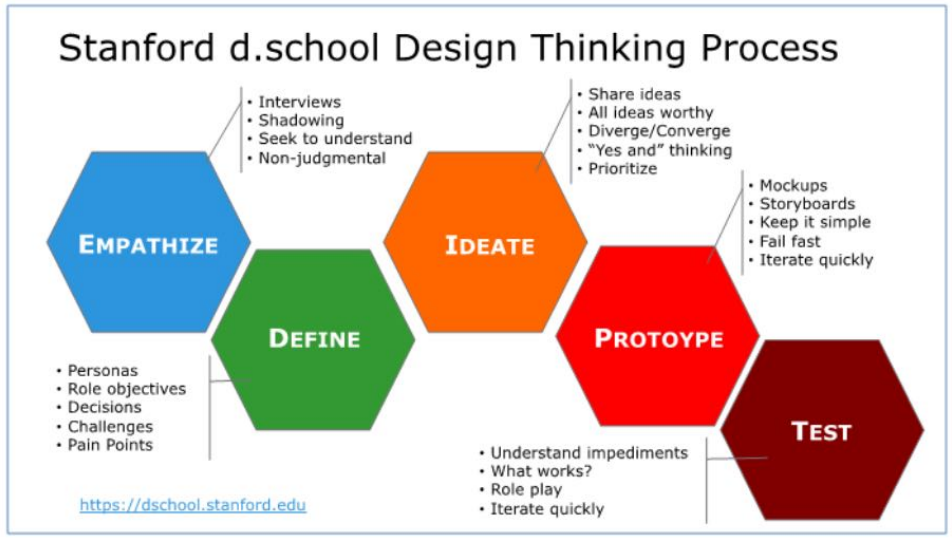
Levels of Development Model

- Mankind moving to higher levels of consciousness or development
  - Moving up implies -
  - Increasing perspective and decreasing egocentrism
  - Wider and longer term perspectives
- Orange level – technical organizations
  - See only the objective perspectives
- Green level – concern for environment, sustainability
  - INCOSE adds disposal to SE lifecycle
- Teal level - people see and use both objective and subjective perspectives
  - Study of Teal organizations – *Reinventing Organizations* (Laloux, 2014)

Level	Color	Perspective
Post Integral	Turquoise	Kosmocentric
Integral	Teal	Planetcentric
Post Modern	Green	Worldcentric
Modern	Orange	Sociocentric
Traditional	Amber	Ethnocentric
Tribal	Red	Egocentric

Argument #4 - Design Thinking

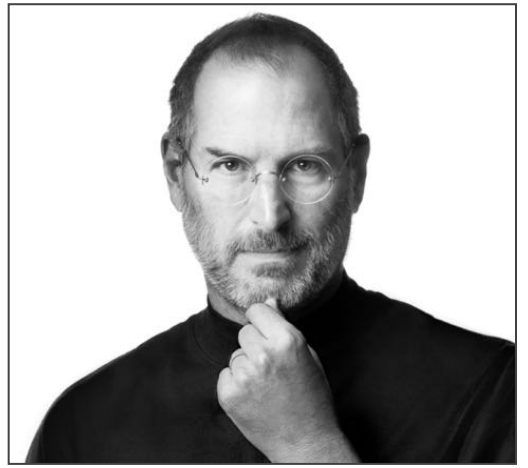
- Important development for systems engineering
  - Being adopted by SE community
  - Enables creative problem solving
  - A more human-centric approach than SE
- Design Thinking makes use of subjective tools
  - Empathy, storytelling
  - Subjective toolbox “starter kit”
- Success of Design Thinking shows the power of subjective tools and perspectives



Graphic credit: Stanford d.school

Argument #5 – Steve Jobs and Apple

- Shows the value of left-hand quadrants in designing products
- Emphasis on beauty and people-friendly products



Steve Jobs

Photo credit: Mark Guadalupe / CC-BY-2.0

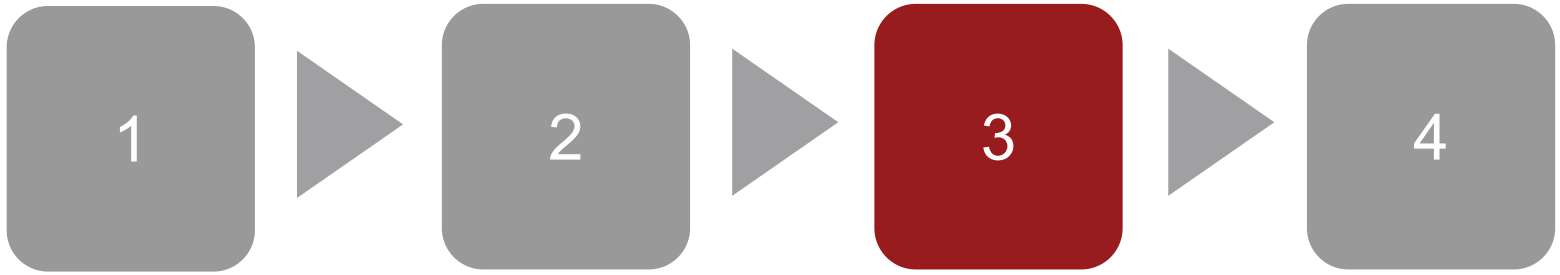
Steve Jobs' Design Principles

Design Principles from *Fast Company* blog
Cliff Kuang, 2011

- Craftsmanship
  - Emphasis on craftsmanship and creating beautiful products
- Empathy
  - Make an intimate connection with the feelings of the customer
- Focus
  - In order to excel, eliminate everything that is not important
- Image
  - Everything you do must be congruent with the company image
- User-friendliness
  - Build user-friendly high-tech products
- Metaphors
  - Use metaphors that are part of the culture and easily understood

	Interior	Exterior
Individual	Craftsmanship Beauty User-friendliness	Focus
Collective	Empathy Impute (Image) Metaphors	

Agenda



A couple of stories

Arguments for a subjective toolbox

The subjective tools

Summary

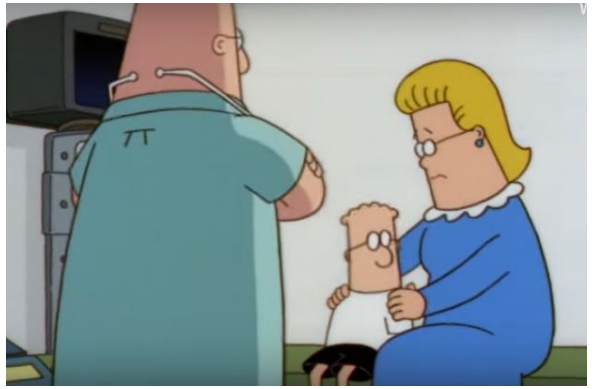
Subjective Toolbox

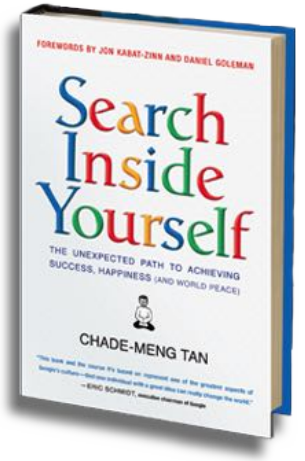
- Proposed tools - design, empathy, culture, beauty, storytelling, judgment, heuristics
- Some of these tools have been presented at previous INCOSE conferences
  - Beauty - 2016 INCOSE IS
  - Storytelling - 2017 INCOSE IS
  - Judgment (in risk assessment) - 2016 INCOSE IS
  - Heuristics - 2018 Great Lakes Regional Conference

Subjective Tools
Design
Empathy
Culture
Beauty
Storytelling
Judgment
Heuristics

Empathy

- Empathy
  - Putting yourself in another person's shoes
  - Help engineers be more sensitive to user needs
  - Gain deeper insights, greater understanding
- Engineers not known for being empathetic
  - Example – Dilbert and "The Knack"
  - The Knack – extreme intuition about all things mechanical and electrical and utter social ineptitude
  - Some studies have shown that analytic work reduces capacity for empathy
- Some organizations see value of empathy
  - Google developed emotional intelligence class, book
  - *Search Inside Yourself* by Chade-Meng Tan (2014)



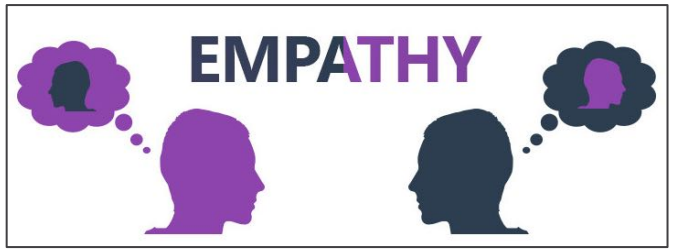


Graphic credit: Scott Adams

Graphic credit: HarperOne

Using Empathy as a Tool

- A popular tool – the composite character profile
  - Create a semi-fictional character who embodies typical user characteristics
  - Puts a human face on quantitative data gathered during requirements development
  - Tool used in Design Thinking
- Kouprie and Visser (Delft University, Netherlands) created an empathic design process
  - Four steps: discovery, immersion, connection and detachment
  - Step into the user's shoes, wander around, step out



Culture

- Social and cultural issues often overlooked in the design of systems (e.g. Google Glass)
  - Not enough just to understand the user, need to consider the culture the user operates in
- A couple of cultural tools
  - Ethnographic study - observation, interviews, direct participation and the collection of artifacts
  - Participatory design – users act as co-designers
- New fields like design anthropology emerging to address cultural issues
  - *Design + Anthropology*, Christine Miller (2017)
  - *Design Anthropology: Theory and Practice,* Wendy Gunn and others (2013)
  - *What is Techno-Anthropology?* Tom Borsen & Lars Botin (2013)

Graphic credit: Cabrera Photo / CC BY-SA 2.0

Storytelling

- Storytelling is a powerful communication tool
  - Stories grab people's attention, engage their emotions and connect with shared passions and experiences
  - Stories bundle together information, knowledge, context and emotion in a single, compact package
- Currently used in
  - Agile software development (user stories)
  - Design thinking
- Storytelling in systems engineering
  - For non-functional requirements – use stories instead of trying to quantify the qualitative
  - For communicating designs – use stories explain complex design to non-technical people
  - For testing – use stories to advocate for scarce resources at end of project

Fishermen telling stories

Graphic credit: William Marsh/ Public domain

Three Other Useful Stories for SE

- Origin stories
  - Explain how the profession came to be
  - Share early history and founders
  - Help understand its place in the world
  - Share the profession's culture and core values, instill pride in the profession
- Success stories
  - Help promote best practices, profession of SE, by sharing success stories
- Vision stories
  - Share compelling stories of a brighter and better future (project, company, profession)
  - Inspire people to reach higher, go further

Florence Nightingale

Design Thinking saves LM $25M per satellite

JFK announces goal to go to moon

Beauty

- Beauty matters
- Story of the Joint Strike Fighter

X-35

X-32

X-32 Photo credit: US Air Force Public domain

X-35 Photo credit: US Navy / Public domain

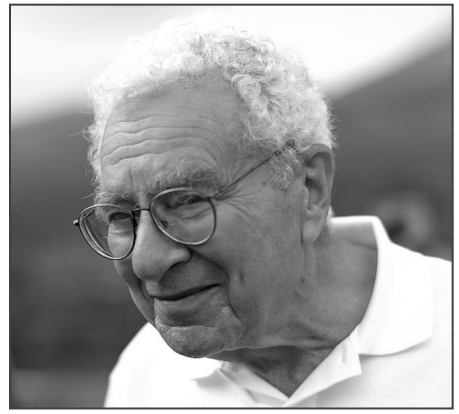
Aesthetic Usability Bias

- Aesthetic designs
  - Are perceived as easier to use
  - Foster more positive attitudes
  - Have a higher degree of acceptance
  - Make people more tolerant of design flaws
  - Promote feelings of affection and loyalty
- Benefits in a military application
  - Take better care of equipment
  - Helps recruiting and retention

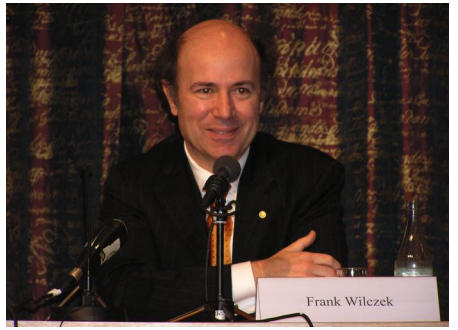
Macintosh Computer

Beauty as a Guiding Principle

- Beauty has been shown to be a useful guiding principle in science
  - Galileo, Kepler, Newton, Maxwell, Gell-Mann all used beauty to help guide their work
  - Murray Gell-Mann –"In fundamental physics, a beautiful or elegant theory is more likely to be right than a theory that is inelegant"
- Beauty is evident in nature's style
  - Symmetry, a love of harmony, balance and proportion
  - Economy, producing an abundance of effects from limited means
- *A Beautiful Question, Finding Nature's Deep Design,* Frank Wilczek (2016)



Murray Gell-Mann



Frank Wilczek

Photo credit: Joi Ito / CC BY 2.5

Photo credit: Amity Wilczek

If Beauty is Useful in Science…

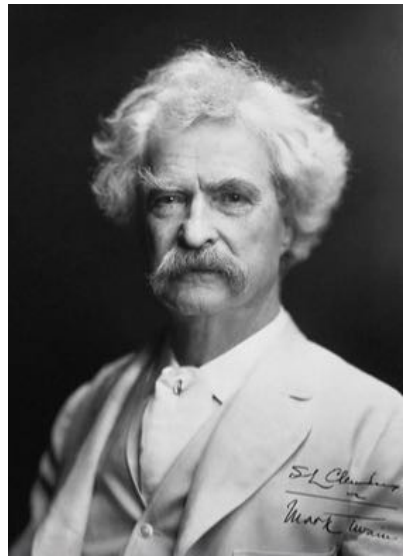
- Use beauty as a guiding principle in systems engineering
  - Follow nature's style – symmetry and economy
- Some previous work in "elegant design" in SE
  - Example – Azad Madni of USC (*Elegant Systems Design, 2011)*
  - Elegance metrics – purposivity, parsimony, transparency, scalability, sustainability, bonding, efficiency, evolvability, etc.
- Propose to use beauty throughout SE process
  - Not just architecture and design
  - Requirements, implementation, integration, test
  - O'Reilly series (e.g. *Beautiful Code*) explores idea in software

Azad Madni

Photo credit: USC

Judgment

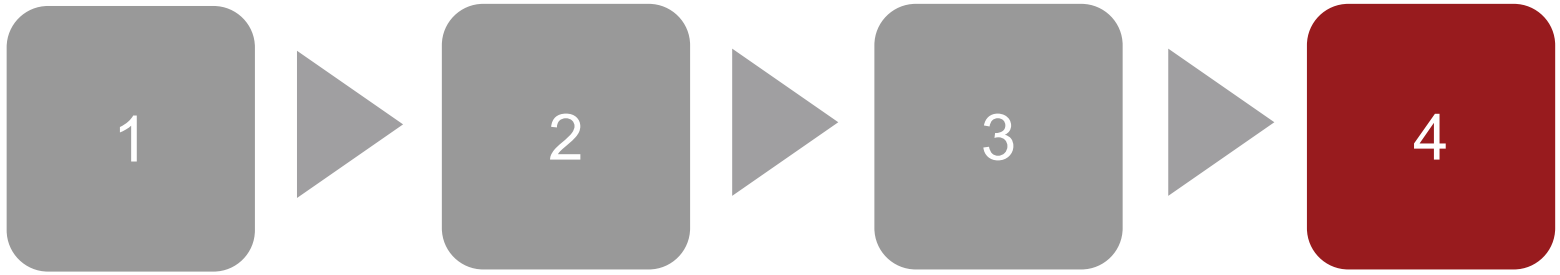
- Judgment needed in working with quantitative models
  - Constructing model – what goes in, what does not
  - What assumptions or simplifications are appropriate
  - Interpreting model results
- Judgment needed in executing projects
  - Deciding what's important
  - Selecting the right problem to solve
  - Establishing performance criteria
  - Deciding how much margin to put in design
  - Anticipating problems
  - Recognizing when things are going south
- Judgment not given much attention in SE
  - Focus on objective methods, quantitative models
  - One article in SE Journal (20 yrs) with "judgment" in title (2013)
  - Proposes to replace human judgment with quantitative model



Good judgment comes from experience. And where does experience come from? Bad judgment.
– Mark Twain

Photo credit: Eric Feng / CC BY-SA 2.0

Agenda



1. Three stories
2. Arguments for a subjective toolbox
3. The subjective tools
4. Summary

Summary

- Sociotechnical systems require attention to human elements
- SE currently limits itself to objective tools and perspectives
  - Objective tools are limited in what they can do
- Subjective tools are imperfect, but are still valuable
  - Design Thinking shows the value of subjective tools (e.g. empathy)
- Integral Theory calls for use of both objective and subjective tools
  - Using both is more effective
  - Human-centric approach to systems

	Interior	Exterior
Individual	Beauty Design thinking Empathy Heuristics Judgment	Quantitative analysis Performance metrics Requirements analysis
Collective	Culture Storytelling	Context diagrams Systems thinking System models Integration and testing

Ask Grad Students to Consider Integral Theory

- If doing work in Design Thinking & SE, consider expanding perspective
  - Apply Integral Theory to project
  - Use more of the subjective toolbox
  - Enable more human-centric approach, more effective solutions
- Look at what has been done in architecture and healthcare
  - *Integral Sustainable Design,* (DeKay, 2011)
  - *Holistic Nursing,* (Dossey, 2015)

	Interior	Exterior
Individual	Upper Left (UL) I Intentional (Subjective)	Upper Right (UR) It Behavioral (Objective)
Collective	Lower Left (LL) We Cultural (Intersubjective)	Lower Right (LR) Its Systems, Social (Interobjective)

Four Quadrant Model

Level	Color	Perspective
Post Integral	Turquoise	Kosmocentric
Integral	Teal	Planetcentric
Post Modern	Green	Worldcentric
Modern	Orange	Sociocentric
Traditional	Amber	Ethnocentric
Tribal	Red	Egocentric

Levels of Development Model

29th Annual INCOSE international symposium

Orlando, FL, USA

July 20 - 25, 2019

www.incose.org/symp2019