27th annual INCOSE international symposium

Adelaide, Australia

July 15 - 20, 2017

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Improving the Systems Thinking Skills of the Systems Architect via Aesthetic Interpretation of Art

Thesis

- We can increase the competency of system architects by linking skills and learning methods across the disciplines of systems architecture, systems thinking, and the creative arts.

(Salado and Salado, 2015)

"The aesthetic enjoyment we feel in front of a masterpiece is an exceptional empirical situation to study a key human ability, i.e. how we spot meaningful **patterns** to reduce the **complexity** determined by **ambiguous** information" (Salado, Iandoli, and Zollo, 2016)

“Elegance” in Architecture

Source: Wikipedia

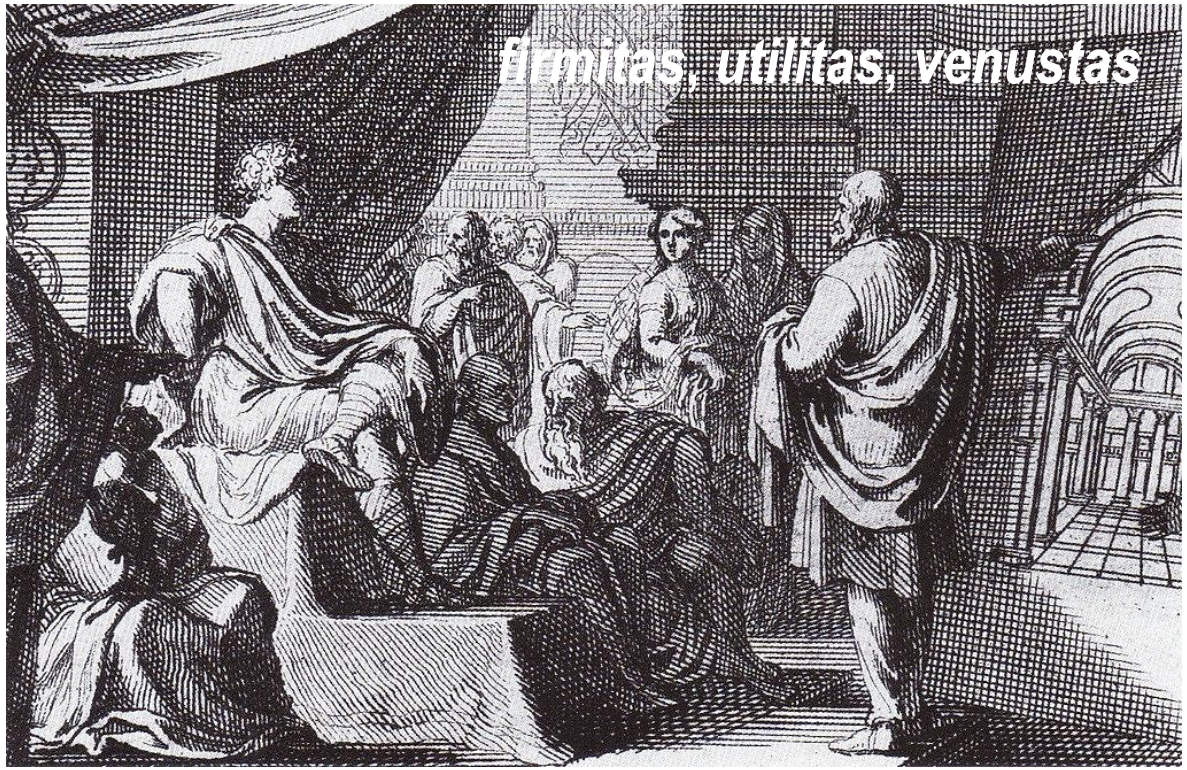
“…a music student who writes a concerto by consulting a checklist of the characteristics of the concerto form, being careful to see that all of the canons of the form are observed, but having **no flair** for the subject, as OPPOSED to someone who just knows roughly what a concerto is like, but has a real feeling for music.”

“The prescription of technique cannot be a substitute for talent and capability.”

“We must bring the sense of art and excitement back into engineering.”

Frosch, R. A. (1969). A new look at IEEE Spectrum, 24-28

“A Good Architecture is Solid, Useful, and Beautiful”



A 1684 depiction of Vitruvius (right) presenting De Architectura to Augustus

Sebastian Le Clerc - Taken from Vitruvius on Architecture by Thomas Gordon Smith, Public Domain, https://commons.wikimedia.org/w/index.php?curid=5859008

“An architect should be ingenious, and apt in the acquisition of knowledge. Deficient in either of these qualities, he cannot be a perfect master.

He should be a good **writer**, a skilful **draftsman**, versed in geometry and optics, expert at **figures**, acquainted with **history**, informed on the principles of natural and moral **philosophy**, somewhat of a **musician**, not ignorant of the sciences both of **law** and **physic**, nor of the motions, laws, and relations to each other, of the **heavenly bodies**.”

Vitruvius, De Architectura (~25BC)

Quote translation: http://penelope.uchicago.edu/Thayer/E/Roman/Texts/Vitruvius/1*.html

“Noise Killing and Meaning Adding”

NK

Subtract details to get the whole
Use **symmetry** to structure experience
Use lists and **groups**
Split information at different levels

Dull and trivial…

MA

Emphasize the differences over the averages
Remix and **reconnect**
Exploit the power of **center**
Contrast and balance

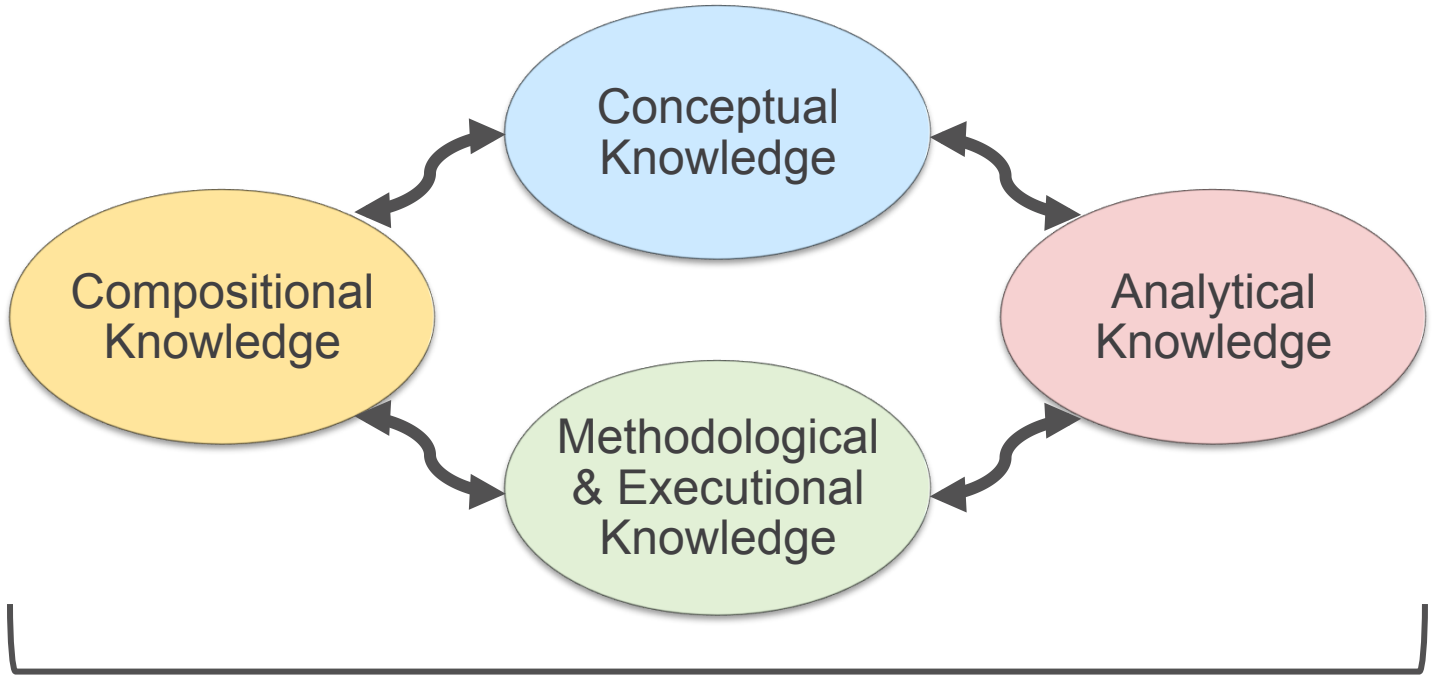
Overwhelming…

Proposed SE Competency Framework

Learning Concepts	Art	Systems Thinking	Systems Architecting
1. Abstraction	Understanding Symmetry between internal context and observed system	Understanding Symmetry between situational context and observed system	Understanding Symmetry between business context and observed system
2. Precedence	Interpreting the Masters Unprecedented Work	Understanding Unprecedented Situations	Studying Unprecedented Architectures
3. Time	Representing Movement	Strategies of Change	Attributes of Change
		Learning across	Learning across
5. Decomposition, Recomposition	Lists & groups, Split, Subtract details, Symmetries, Aesthetics	Causal Relationships, Phenomena, Goals and Strategies	Elements and Interfaces, Attributes, Objectives (requirements) flow-down & derivation, Integration sequences and verification coverage, Purpose
6. Boundary setting	Observing, Framing, Scene-setting	Observing, Framing, Boundary-setting, Mapping, Modeling	Heuristics, Context, External interfaces, Problem formulation, ConOps
7. Simplifying	Subtract Details, Split	Determining Abstraction levels, Lumping or splitting concepts	Determining Abstraction levels, Lumping or splitting components

Learning Concepts	Art	Systems Thinking	Systems Architecting
8. Synthesizing	Remix & Reconnect	Interrelating, Feedback loops	Emergence, Partitioning, Integration, Generic Architectures, Architectural Frameworks
9. Focusing	Emphasize, Power of the Center, Contrast & Balance	Perspective-Making, Boundary setting	Views & Viewpoints, Centralization/ Networked
10. Communicating	Aesthetics, Color/musical palette, Frame/ viewpoint, Title/ description, patterns	Narrative/story, mapping, modeling, facilitation	Domain knowledge, standards, views and viewpoints, documentation/ metadata
11. Analytical Competencies	Domain driven use of materials & media	Use of structured narrative, modeling, & simulation	Domain driven technical & business analysis
12. Methodological & Executional Competencies	Creativity, Use of processes and patterns, Experimentation & risk taking, Ability to engage & keep audience focus	Creativity, Use of processes and patterns, Use of analogy, Ability to engage & facilitate understanding	Creativity, Use of processes and patterns, Use of frameworks, Planning, Managing, Ability to engage & facilitate agreement

Proposed SE Competency Framework



This simple framework is derived from competency guides for college advance placement courses in the arts.

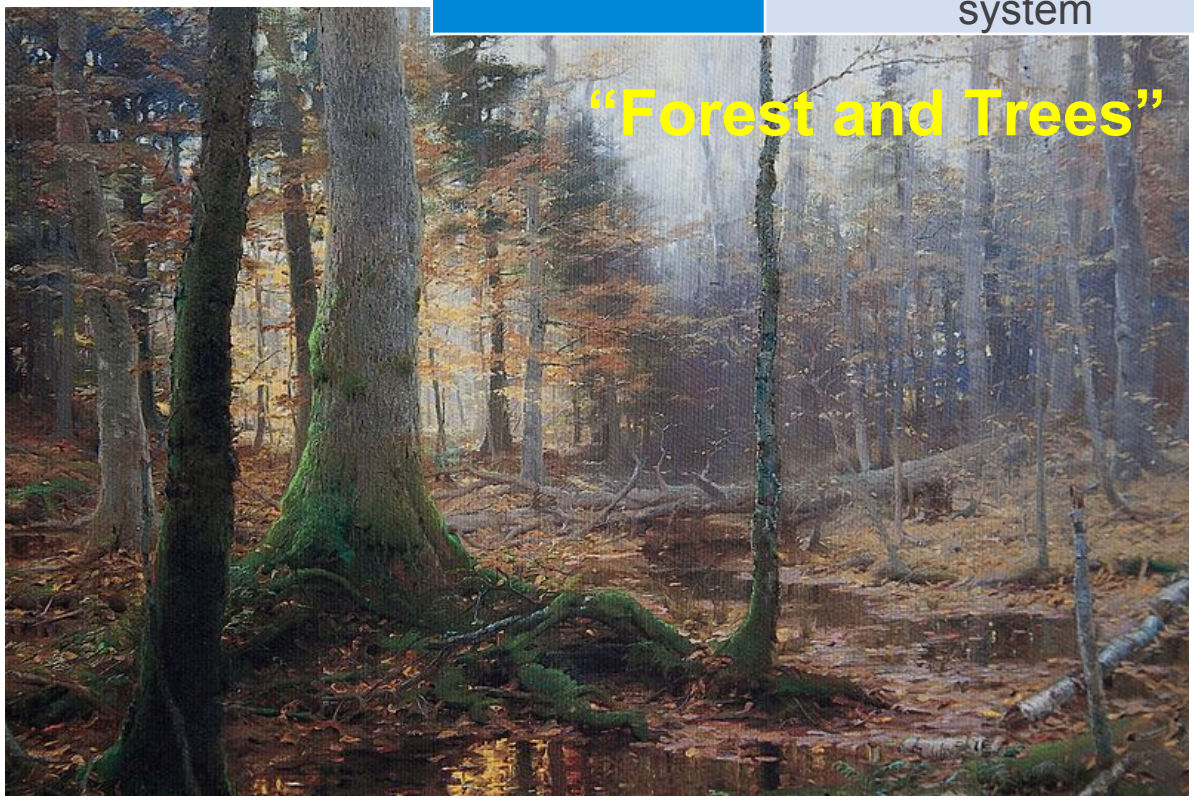
Represents four interrelated competency sets that might separate excellent system architects from poor system architects.

(College Board 2014, 2016)

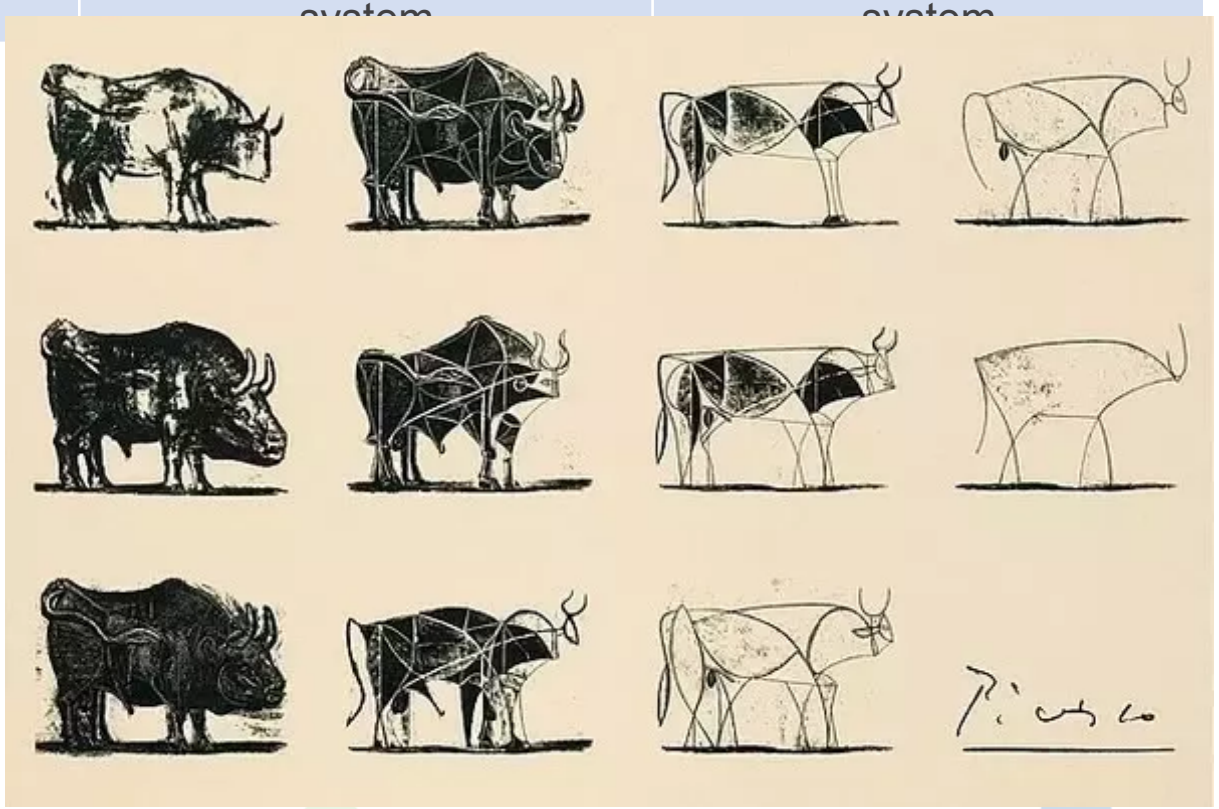
Abstraction in Art

Conceptual Knowledge

Learning Concepts	Art	Systems Thinking	Systems Architecting
1. Abstraction	Understanding Symmetry between **internal context** and observed system	Understanding Symmetry between **situational context** and observed system	Understanding Symmetry between **business context** and observed system



Public Domain en.wikipedia.org/wiki/File:Fallen_Monarchs_1886_by_William_Bliss_Baker.jpg

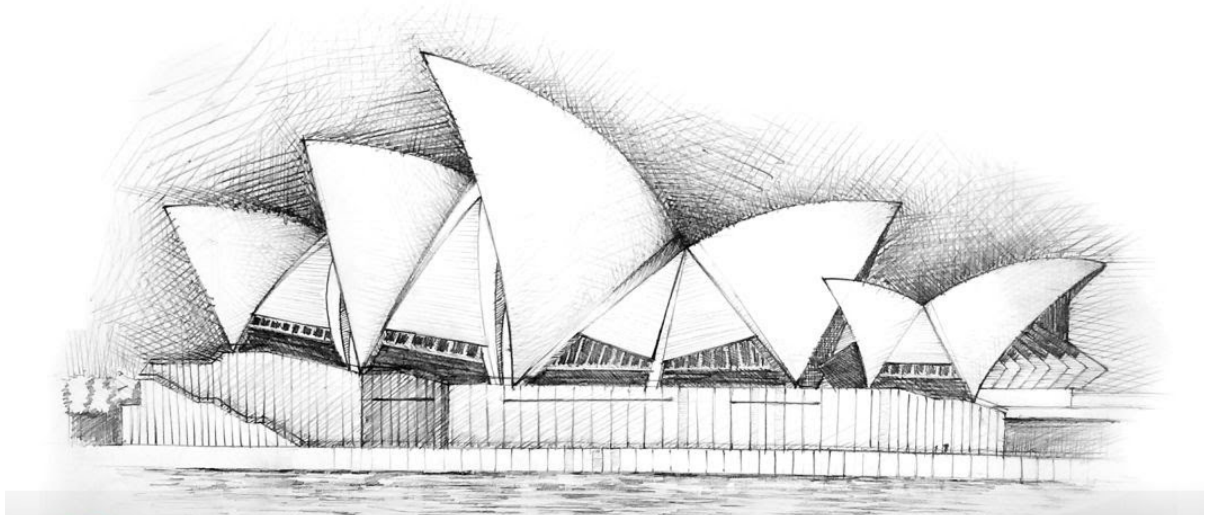


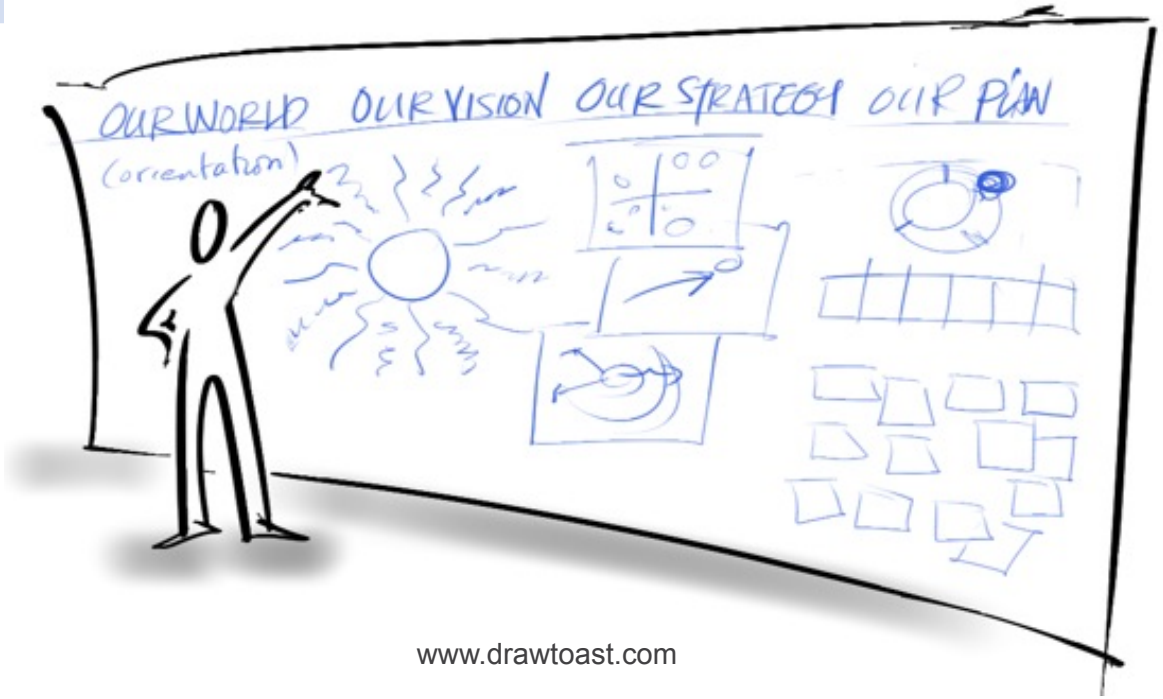
Pablo Picasso, The Bull

Systems Abstraction Frameworks

Conceptual Knowledge

Learning Concepts	Art	Systems Thinking	Systems Architecting
1. Abstraction	Understanding Symmetry between **internal context** and observed system	Understanding Symmetry between **situational context** and observed	Understanding Symmetry between **business context** and observed





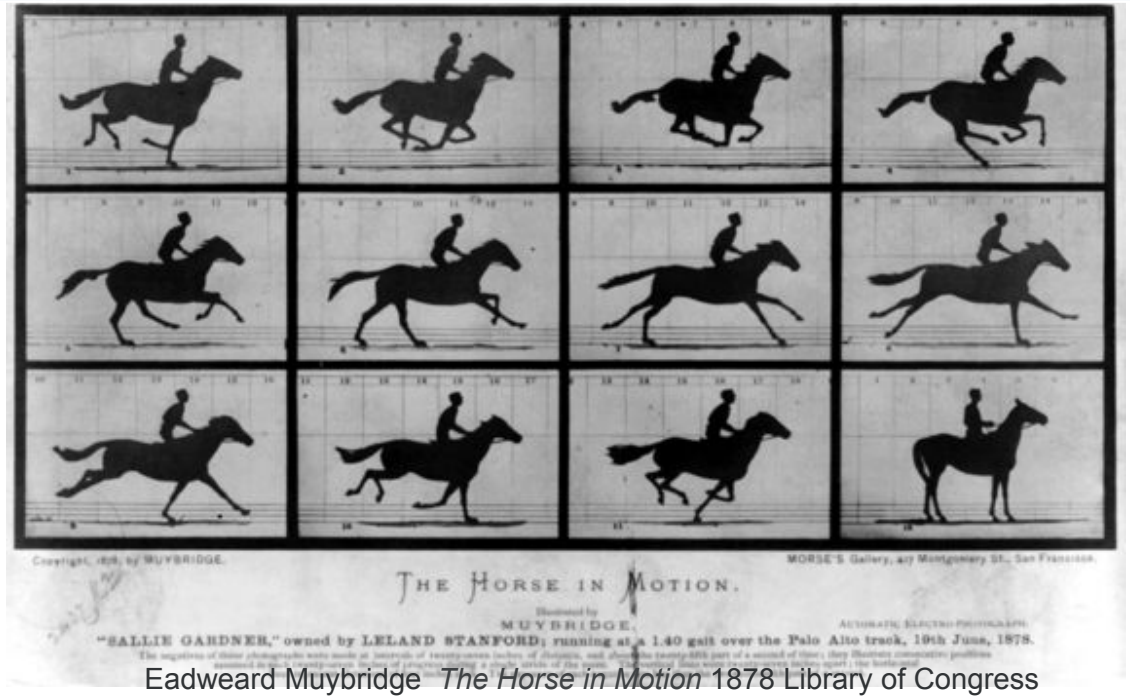
www.drawtoast.com

Communicating: Sketches link context, observation, and meaning

Time and Movement in Art

Conceptual Knowledge

Learning Concepts	Art	Systems Thinking	Systems Architecting
3. Time	Representing Movement	Strategies of Change	Attributes of Change



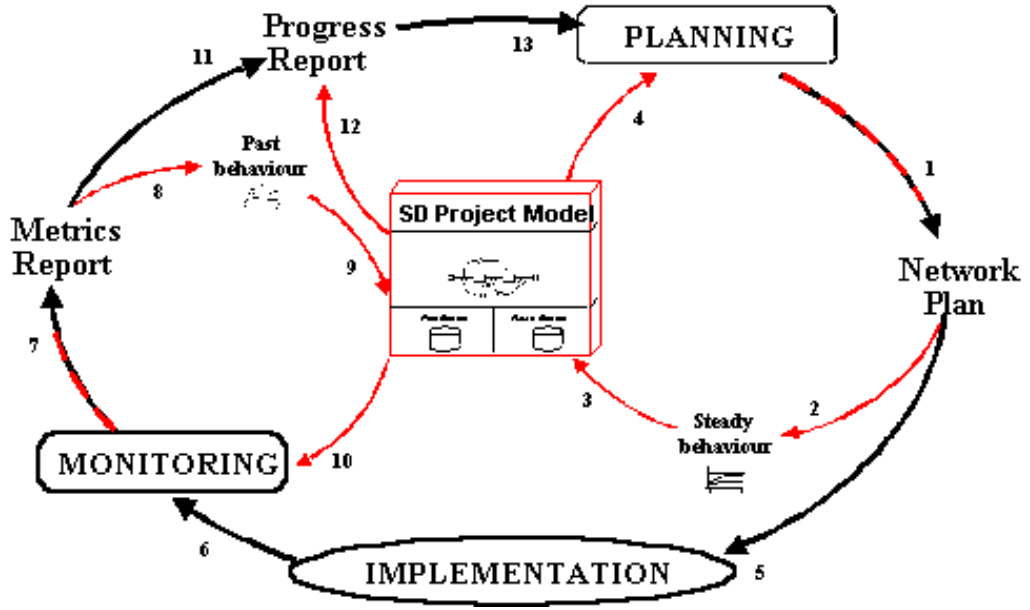
Eadweard Muybridge *The Horse in Motion* 1878 Library of Congress Prints and Photographs Division; http://hdl.loc.gov/loc.pnp/cph.3a45870

Communicating: Curved lines and frames represent motion and passage of time

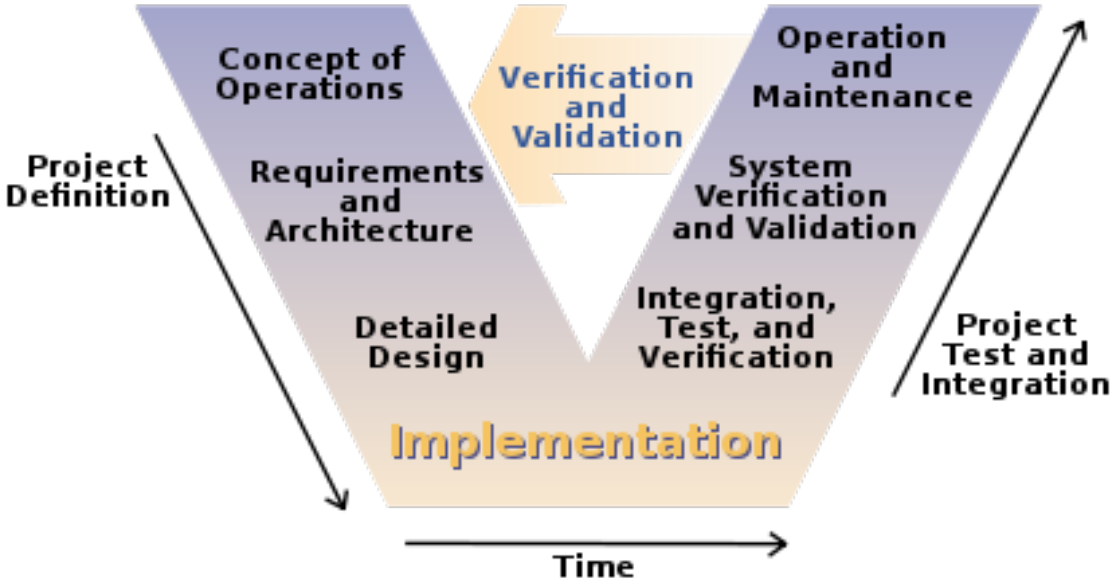
Time and Movement in Systems

Conceptual Knowledge

Learning Concepts	Art	Systems Thinking	Systems Architecting
3. Time	Representing Movement	Strategies of Change	Attributes of Change



www.systemdynamics.org



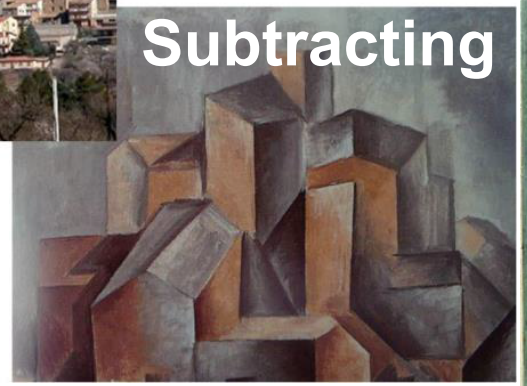
www.sebok.org

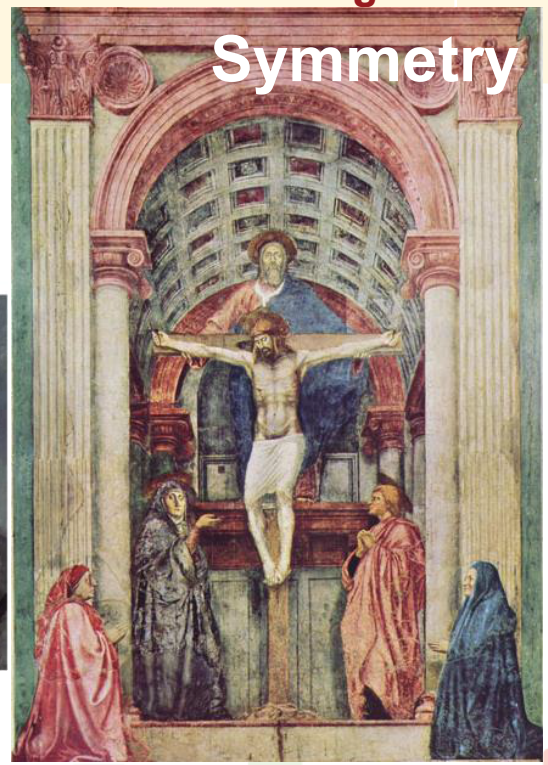
Communicating: Curved lines and frames represent motion and passage of time

Decomposition/Recomposition in Art

Compositional Knowledge

Learning Concepts	Art	Systems Thinking	Systems Architecting
5. Decomposition, Recomposition	Lists & groups, Split, Subtract details, Symmetries, **Aesthetics**	Causal Relationships, Phenomena, **Goals and Strategies**	Elements and Interfaces, Attributes, Objectives (requirements) flow-down & derivation, Integration sequences and verification coverage, **Purpose**

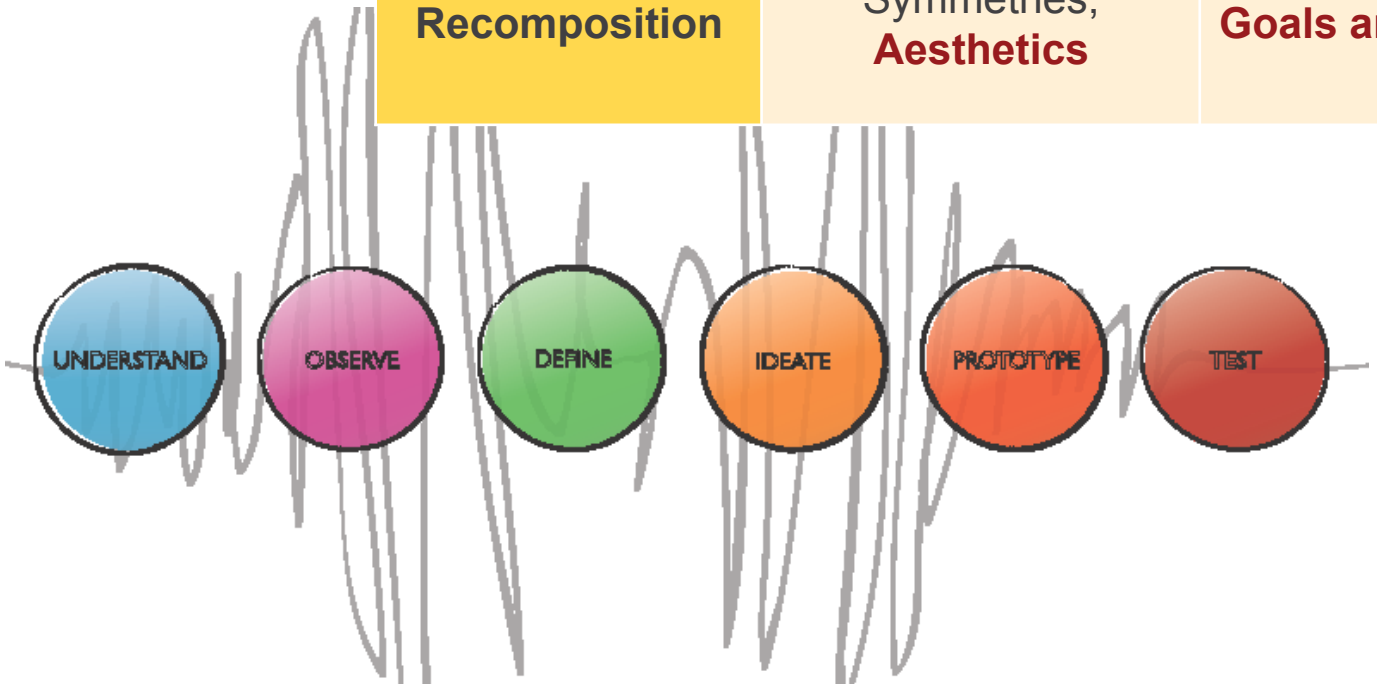




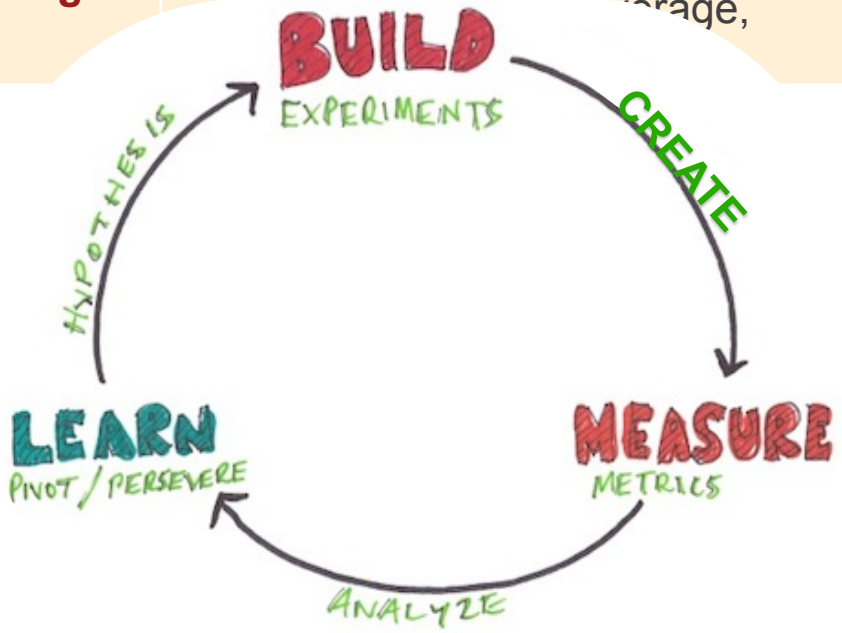
Decomposition/Recomposition in Systems

Compositional Knowledge

Learning Concepts	Art	Systems Thinking	Systems Architecting
5. Decomposition, Recomposition	Lists & groups, Split, Subtract details, Symmetries, **Aesthetics**	Causal Relationships, Phenomena, **Goals and Strategies**	Elements and Interfaces, Attributes, Objectives (requirements) flow-down & derivation, Integration sequences



www.dschool-old.stanford.edu

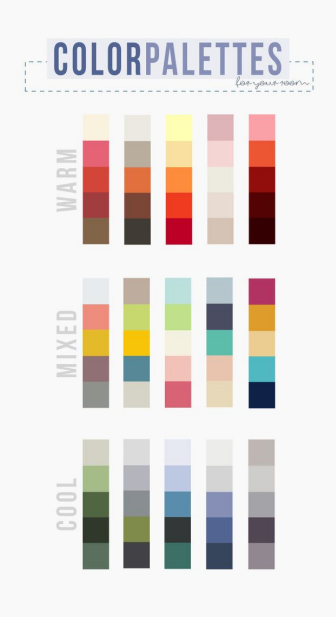


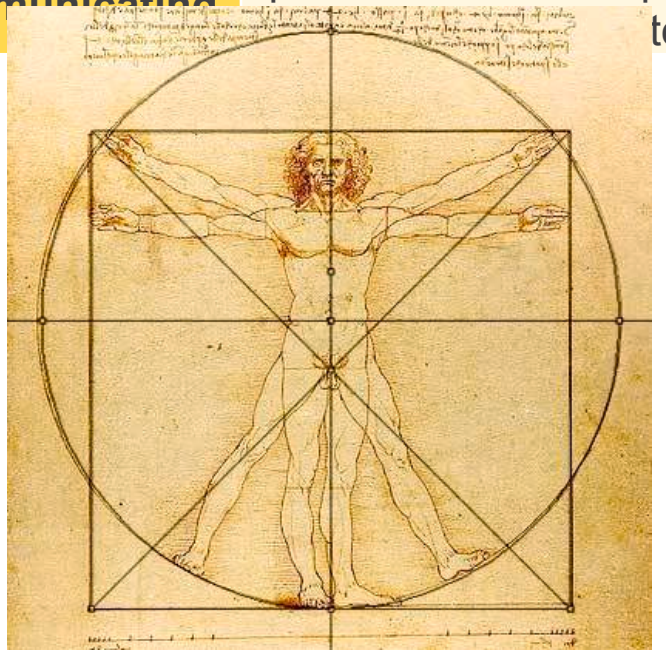
Communicating: Iteration to agree on Purpose and Meaning

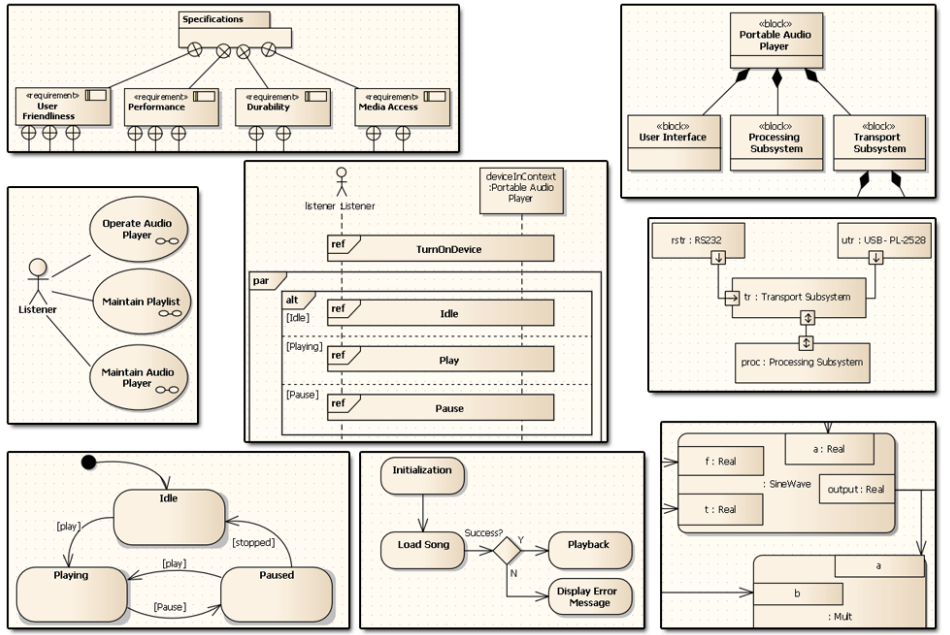
Focusing and Communicating

Compositional Knowledge

Learning Concepts	Art	Systems Thinking	Systems Architecting
9. Focusing	Emphasize, Power of the Center, Contrast & Balance	Perspective-Making, Boundary setting	Views & Viewpoints, Centralization/ Networked
10. Communicating	**Aesthetics**, Color/musical palette, Frame/viewpoint, terns	**Narrative/story**, mapping, **modeling**,	Domain knowledge, standards, **views and viewpoints**,







Communicating: Golden rules convey beauty, color palettes convey feelings

Domain Knowledge and Communication

Analytical Knowledge

Learning Concepts	Art	Systems Thinking	Systems Architecting
11. Analytical Competencies	Domain driven use of **materials & media**	Use of structured **narrative, modeling, & simulation**	Domain driven **technical & business analysis**

fusionanomaly.net/matrixreloadedarchitect.jpg

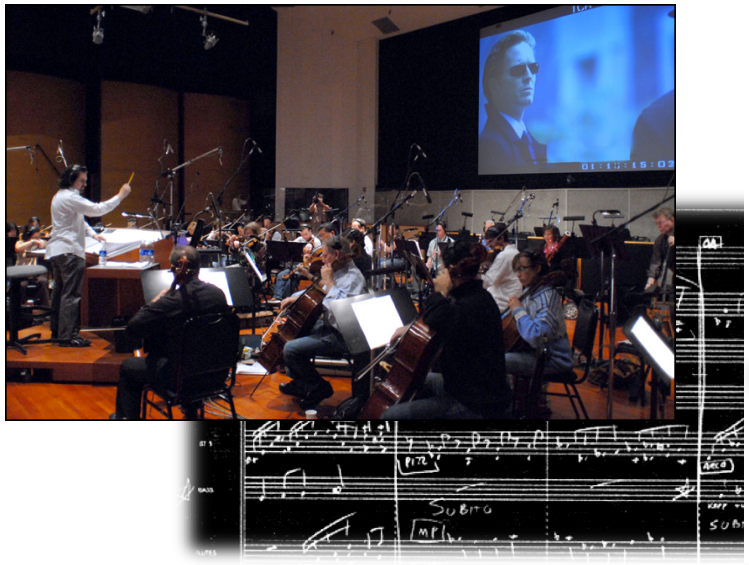
Communicating: A day in the life of an architect

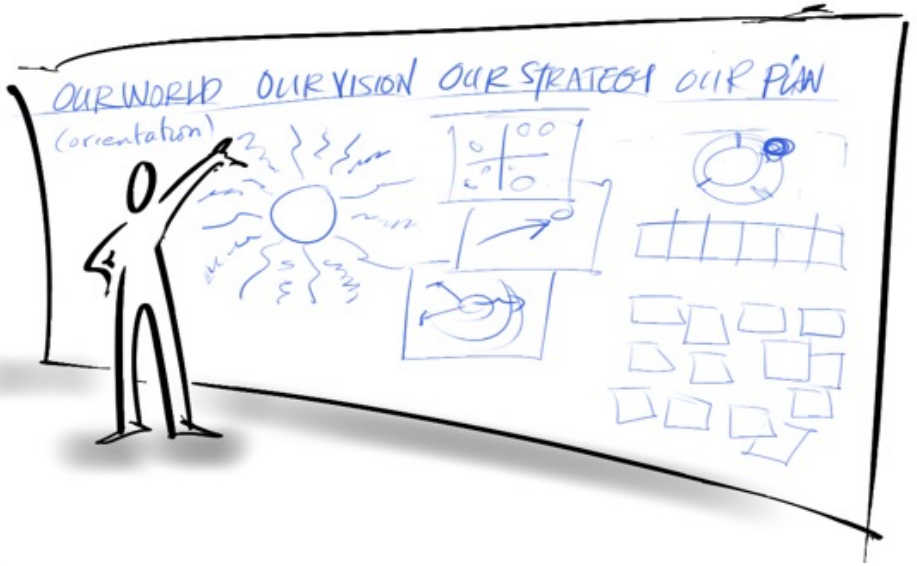
www.rediff.com/getahead/2005/feb/09arch.htm

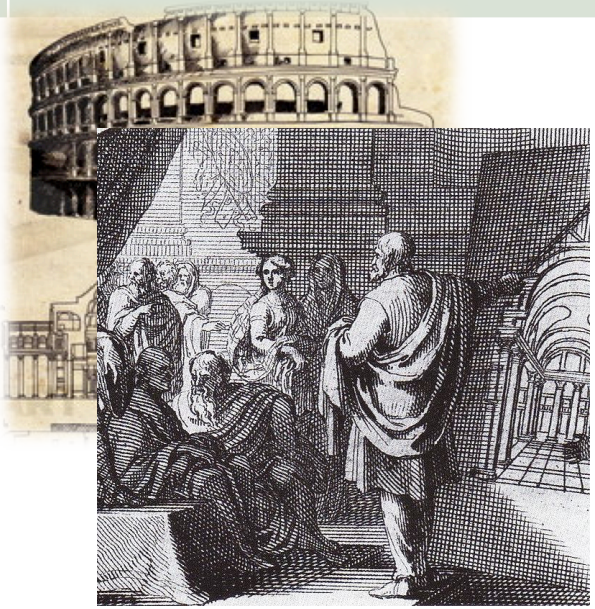
Domain Knowledge and Communication

Methodological Knowledge

Learning Concepts	Art	Systems Thinking	Systems Architecting
12. Methodological & Executional Competencies	**Creativity**, Use of processes & patterns, Experimentation & risk taking, Ability to engage &	**Creativity**, Use of processes & patterns, Use of analogy, Ability to engage & **facilitate**	**Creativity**, Use of processes and patterns, Use of frameworks, Planning, Managing, Ability to engage & **facilitate agreement**



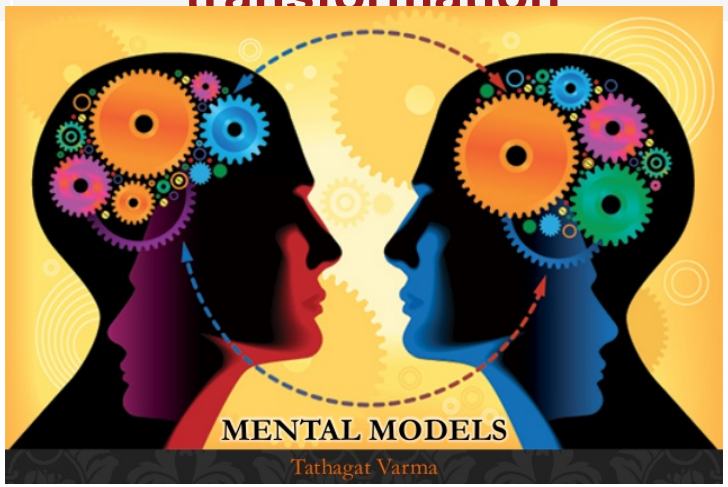


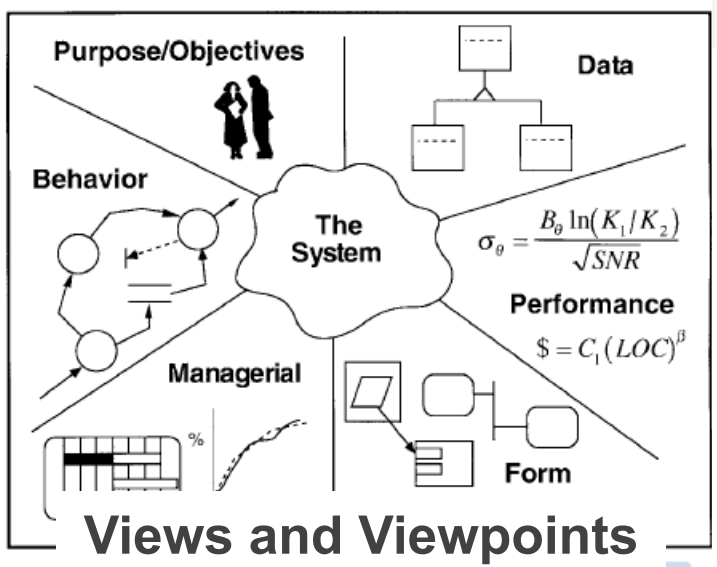


Communicating: Creative expression leads to understanding and agreement

Learning Outcomes

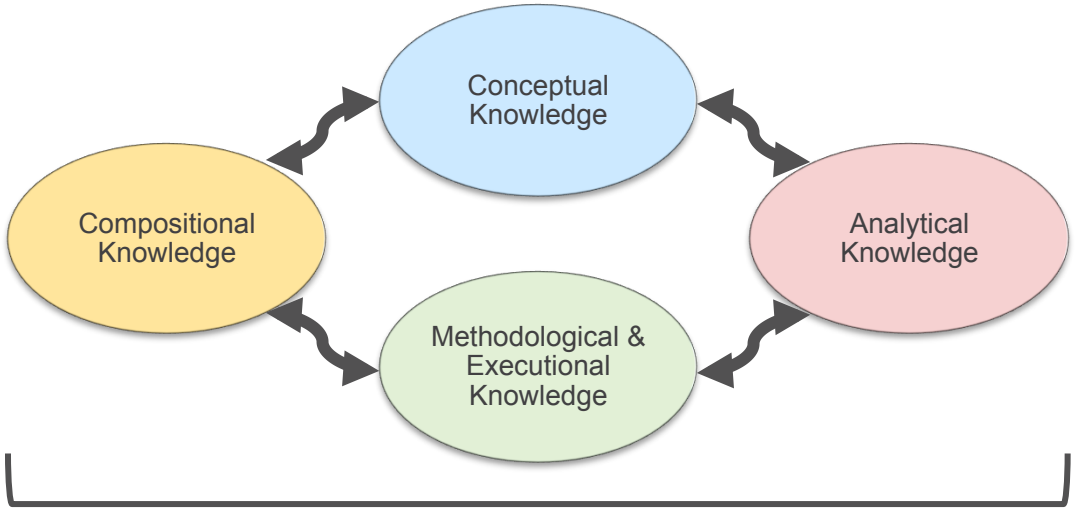
	Art	Systems Thinking	Systems Architecting
	Understanding of composition, inventive design, risk taking, creative expression, breadth of work, **individualized transformation of concepts**	Holism, **composition of mental models**, creative thinking, framing complexity, breadth & depth, **group strategies of transformation**	**Composition of operational & technical design**, methods & execution, planning, breadth & depth, **group communication of transformation**





Views and Viewpoints

Gap Analysis



- We want systems engineers to develop "T-shaped" skills: **conceptually** broad yet still **analytically** and **methodologically** deep.
- **Compositional knowledge** in technical disciplines it not explicitly taught.
- Understanding of composition, creativity and expression, and the ability to describe and communicate the envisioned transformation are core to the portfolios of accomplished

There is a gap in breadth across compositional methods, particularly in the architectural design of engineered systems, which leads to poorly conceived or "inelegant" solutions

Conclusions and Next Steps

The NK/MA model is essential to systems thinking

FUTURE

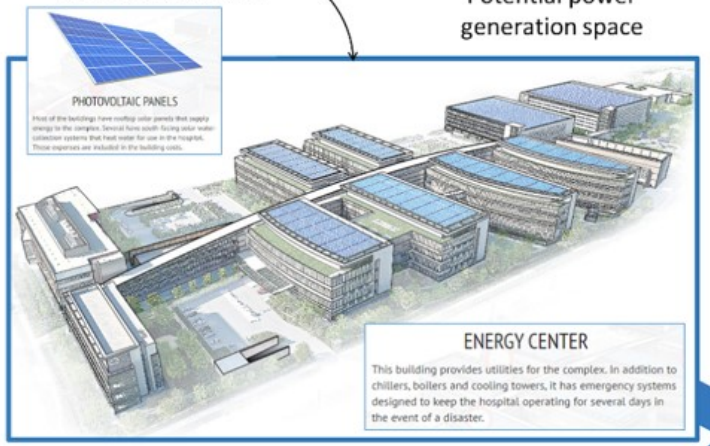
- Map competency models of systems thinkers, systems architects, and artists
- Learning improvement of system architecture via aesthetic interpretation of art
- What makes one artist better than another, and how can we capitalize the answer?

Incorporate breadth across the creative arts and systems thinking in engineering

Incorporate "engineering composition" focusing on elegant architectures

Hospitals/Medical Centers Consumers

Potential power generation space

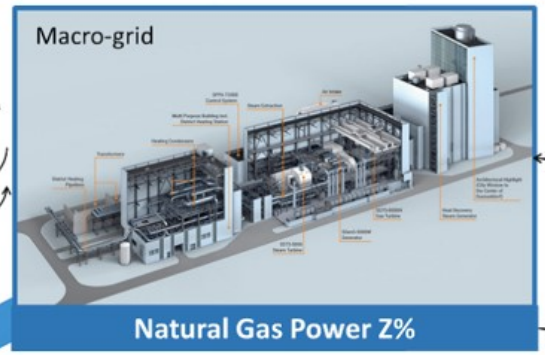


Power Distribution Network

Lite Industry Consumers; Potential power generation space

Diverse power sources

Macro-grid power distribution connectivity



Natural Gas Power Z%

Energy flow from/to Macro-grid

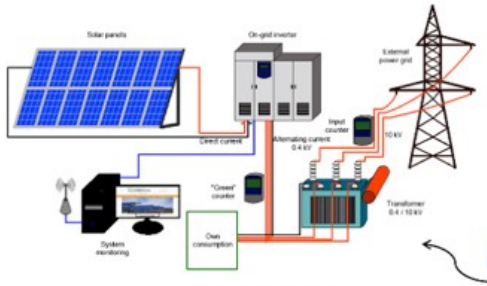
Factories

Business, Private and Public Transportation Consumer; Out of scope?

Electric Vehicle

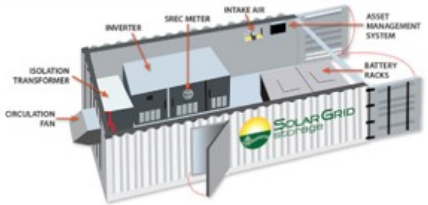
City & Buildings

Retail/Business Consumers; Potential power generation space



Generation

Storage



Solar Power Plant

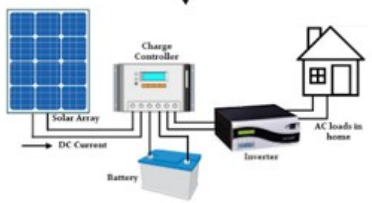
Solar Power X%

Distributed power generation; redundancy

Smart Grid Network

Smart Houses

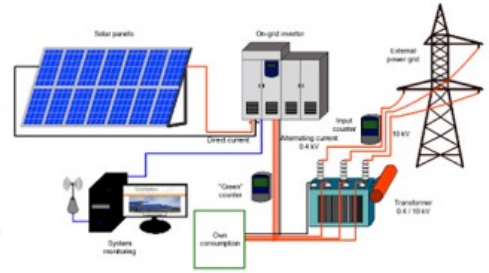
Residential Consumers



Solar Power Plant

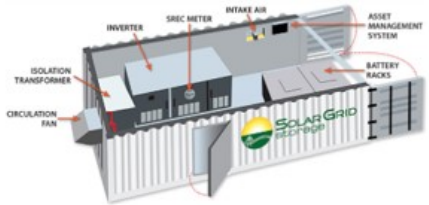
Solar Power Y%

Distributed power generation; redundancy



Generation

Storage



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www.incose.org/symp2017