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Systems Engineering Complexity in Context

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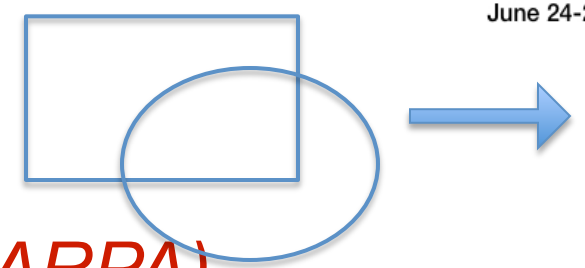
What Is Complexity?

- "See Also: DIFFICULTY"
- "Complicated, intricate"
- *Parts count + Lines of Code (DARPA)*



Subjective ……. Objective

Frustration …… Many interconnected things

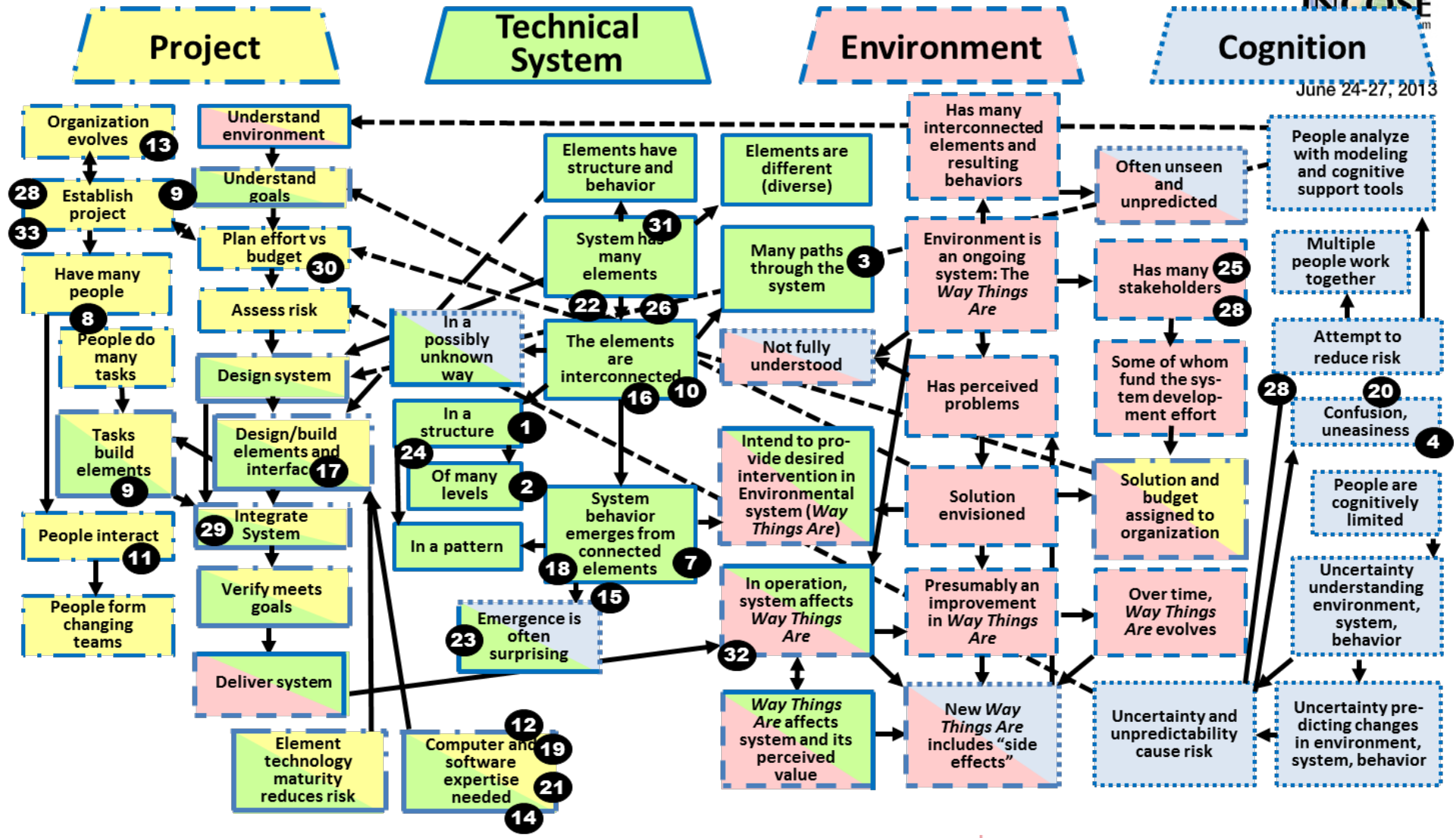
- How use for systems engineering?
- Show on one chart
- 30+ definitions from Young, Farr, and Valerdi* (cataloguing for measurement)

*Young, L. Z., Farr, J. V., & Valerdi, R. 2010. "The role of complexities in systems engineering cost estimating processes." Paper presented at the conference on systems engineering research , Hoboken NJ (US), 17-19 March.

33 Definitions

#	Type of Complexity
1	Hierarchical/Structural (# levels)
2	Configuration Complexity
3	Complicatedness/ Functional Complexity
4	Subjective Complexity
5	Statistical Complexity
6	Algorithmic/Deterministic Complexity
7	Aggregate Complexity (interrelationships)
8	Project Complexity (organizational and technological)
9	Project complexity (assembly, system, array)
10	Product Complexity (physical)
11	Structural Organizational Complexity
12	Structural IT Complexity
13	Dynamic Organizational Complexity
14	Dynamic IT Complexity
15	Inter-Component Complexity (can grow exponentially)
16	Interface Complexity (by component)
17	Implementation Complexity (e.g. code)

#	Type of Complexity
18	System-level Complexity (emergent)
19	Structural Complexity (design and structure, persistent)
20	Conceptual Complexity (psychological)
21	Computational Complexity (algorithms)
22	Structural/Combinatorial Complexity
23	Behavioral Complexity (unpredictability)
24	Nested Complexity (technical/socio-technical)
25	Evaluative Complexity (multiple stakeholder viewpoints)
26	Static Complexity
27	Dynamic Complexity
28	Social-Political Complexity
29	Technical Complexity (Systems Integration based)
30	Programmatic Complexity (Systems Integration based)
31	Configuration Complexity (Systems Integration based)
32	Operational Complexity (Systems Integration based)
33	Organizational Complexity (Systems Integration based)


Project
Technical System
Environment
Cognition
Organization evolves 13
Understand environment
Understand goals
28 Establish project 9
33
Plan effort vs budget 30
Have many people 8
Assess risk
People do many tasks
Design system
Tasks build elements 9
Design/build elements and interfac 17
People interact 11
Integrate System 29
People form changing teams
Verify meets goals
Deliver system
Element technology maturity reduces risk
Computer and software expertise needed 12 19 21 14
In a possibly unknown way
In a structure 1
24
Of many levels 2
In a pattern
Elements have structure and behavior
System has many elements 31
22 26
The elements are interconnected 16 10
System behavior emerges from connected elements 18 7
15
Emergence is often surprising 23
Elements are different (diverse)
Many paths through the system 3
Not fully understood
Intend to provide desired intervention in Environmental system (Way Things Are)
In operation, system affects Way Things Are
32
Way Things Are affects system and its perceived value
Has many interconnected elements and resulting behaviors
Environment is an ongoing system: The Way Things Are
Has perceived problems
Solution envisioned
Presumably an improvement in Way Things Are
New Way Things Are includes "side effects"
Often unseen and unpredicted
Has many stakeholders 25 28
Some of whom fund the system development effort
Solution and budget assigned to organization
Over time, Way Things Are evolves
Uncertainty and unpredictability cause risk
People analyze with modeling and cognitive support tools
Multiple people work together
Attempt to reduce risk
28 20
Confusion, uneasiness 4
People are cognitively limited
Uncertainty understanding environment, system, behavior
Uncertainty predicting changes in environment, system, behavior
All these things change over time 13 14 27 31
All these things have information (data) 5 6

Complexity is an Adjective, not a Noun!

First

Second

Third

Fourth

Fifth

Sixth

Environment Elements (1)

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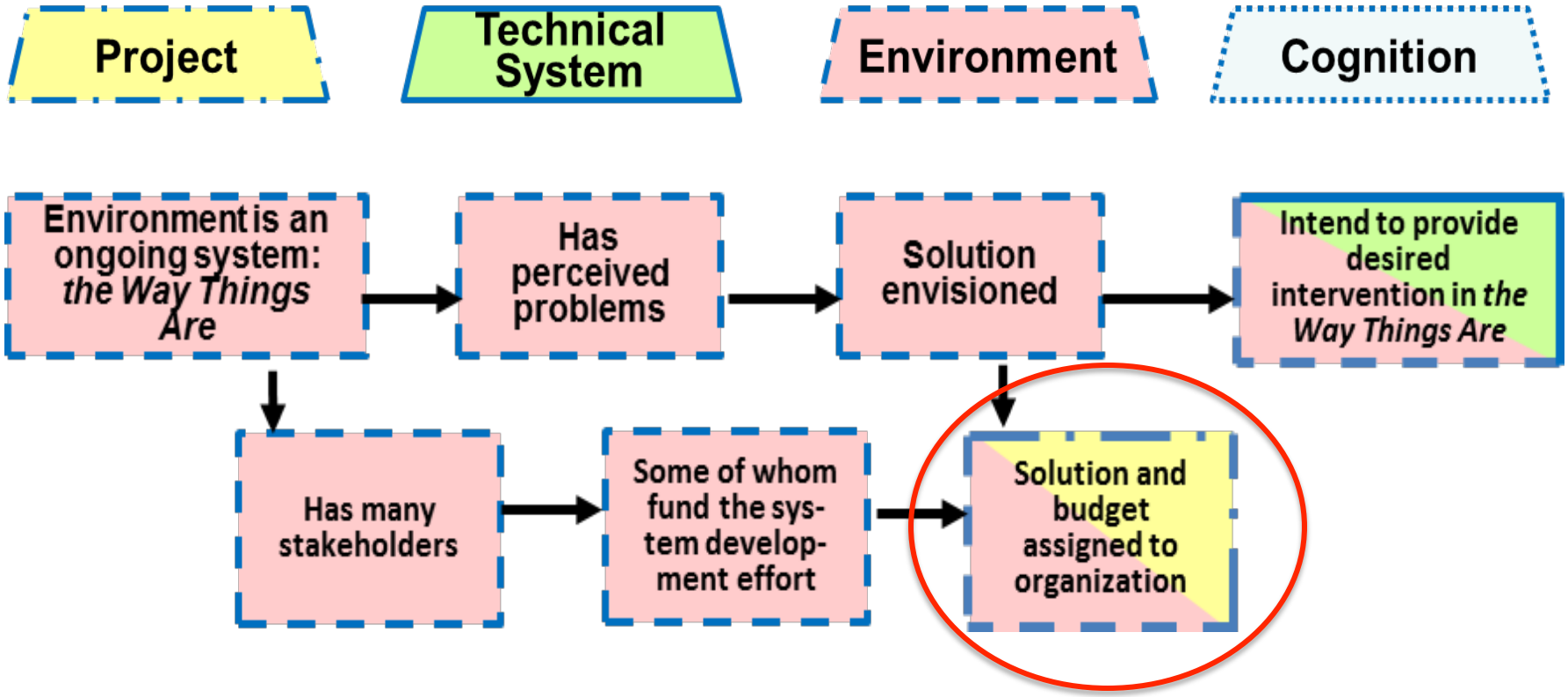
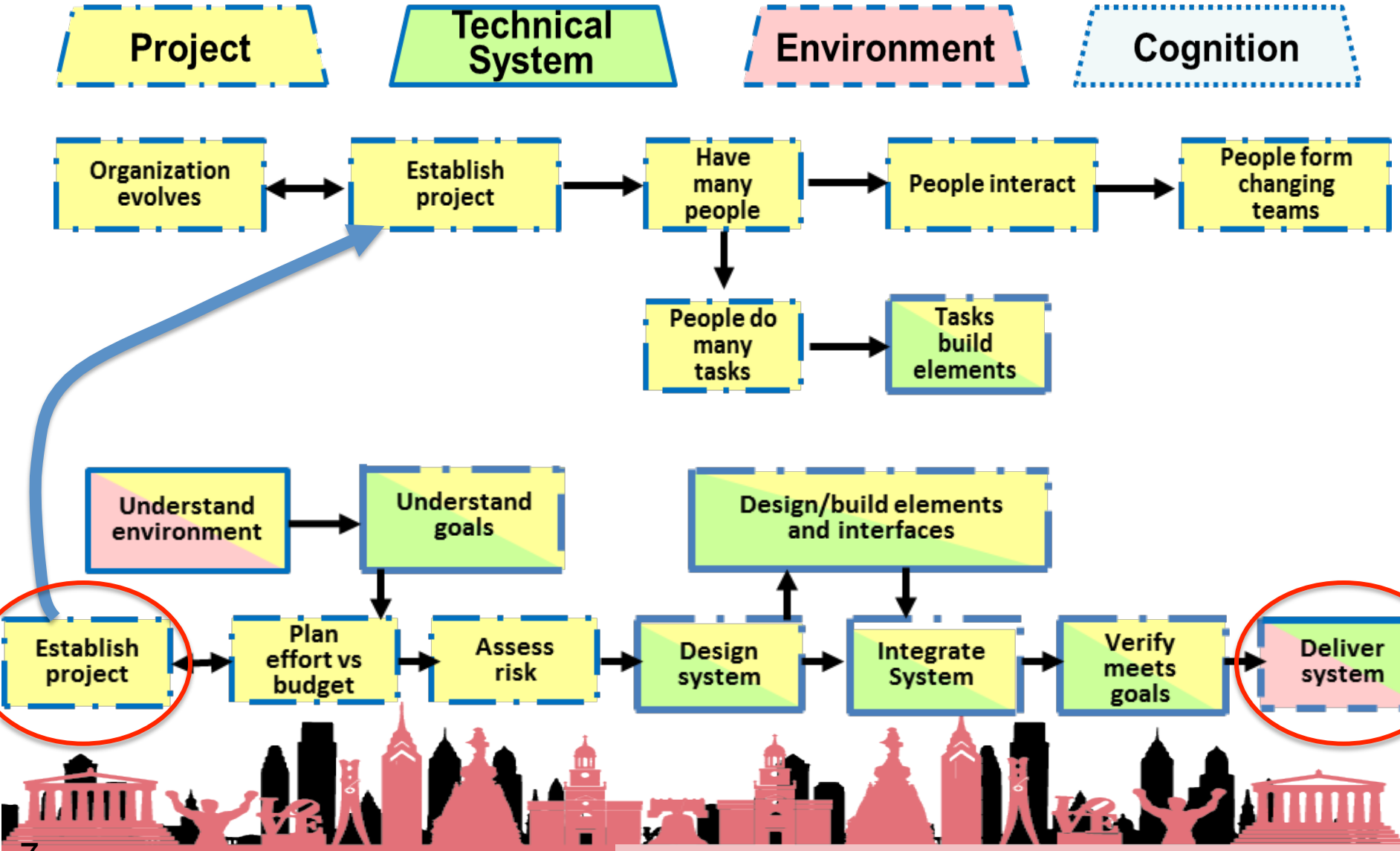
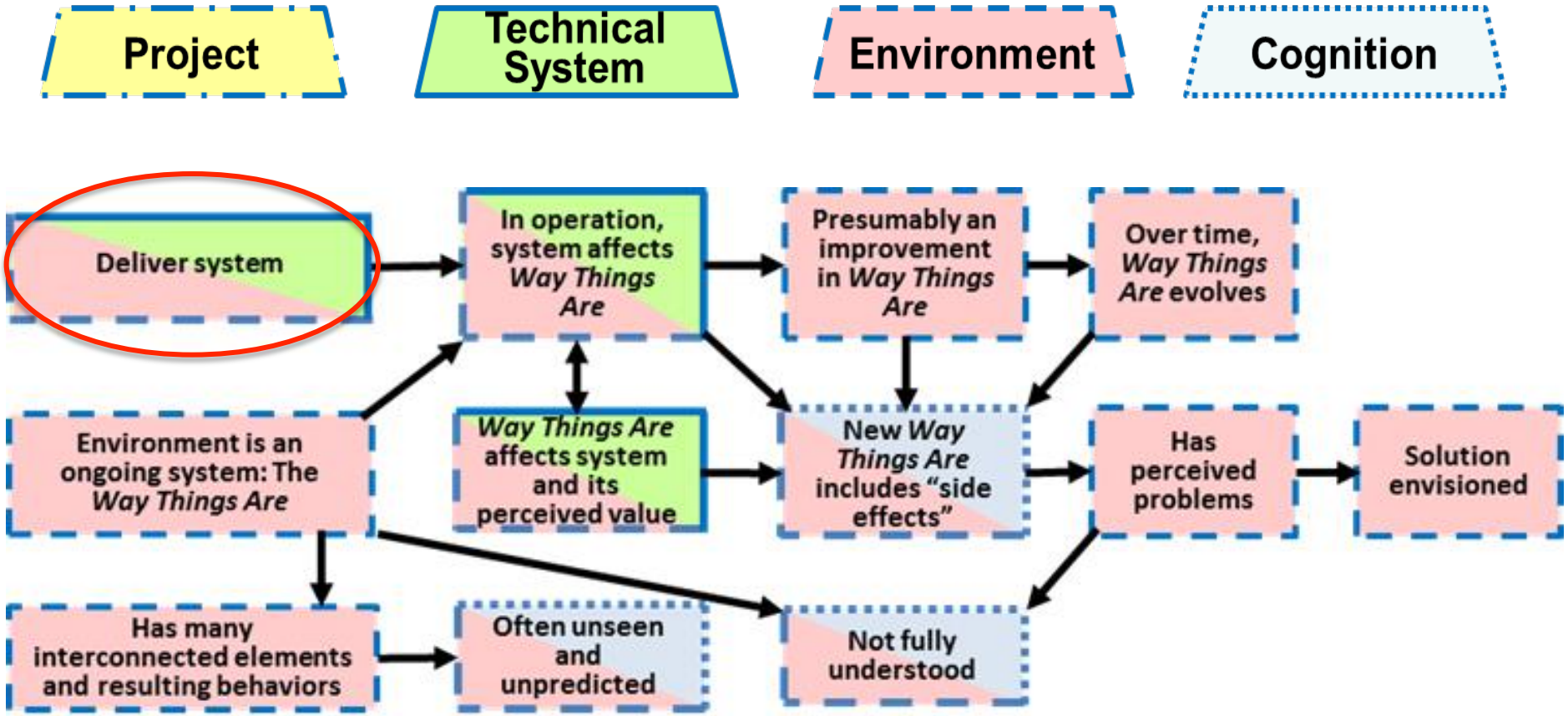


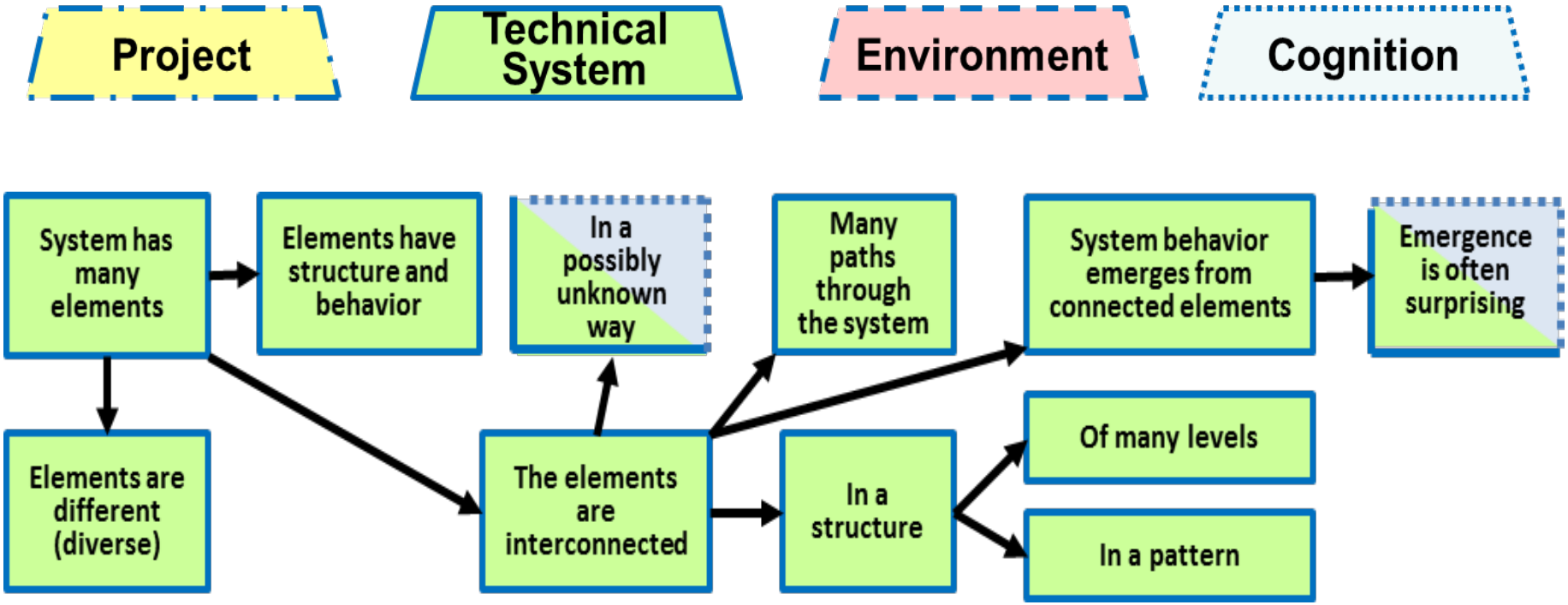
Project Elements(1) and (2)



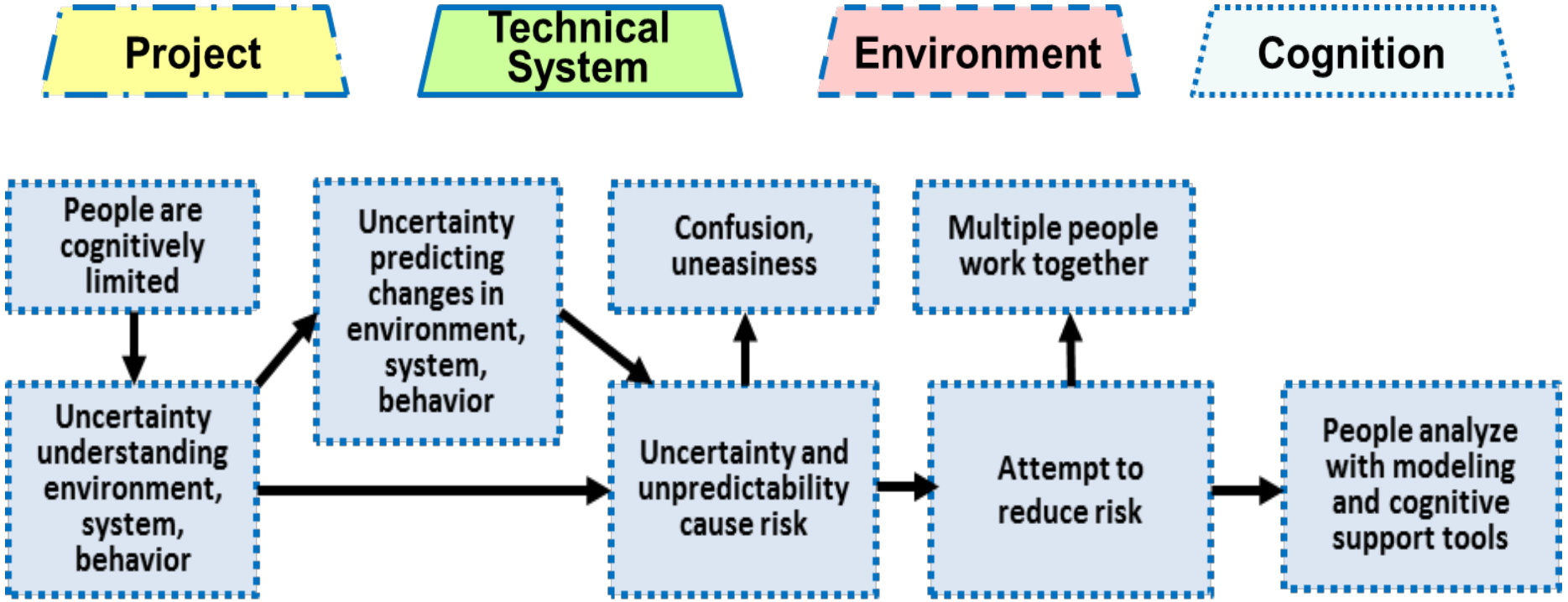
Environment Elements (2)



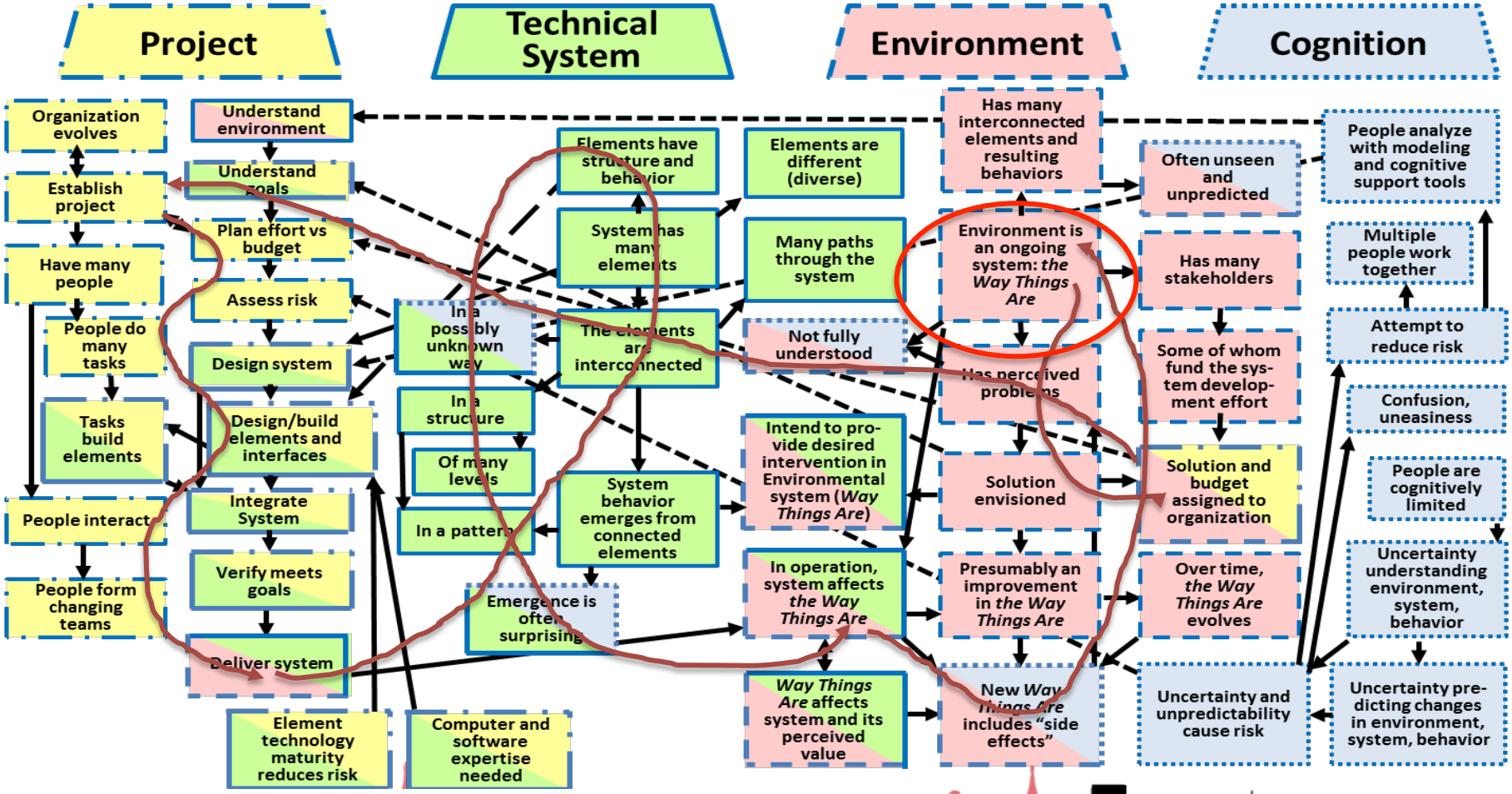
System Activities



Cognitive Activities



A System Life Cycle?



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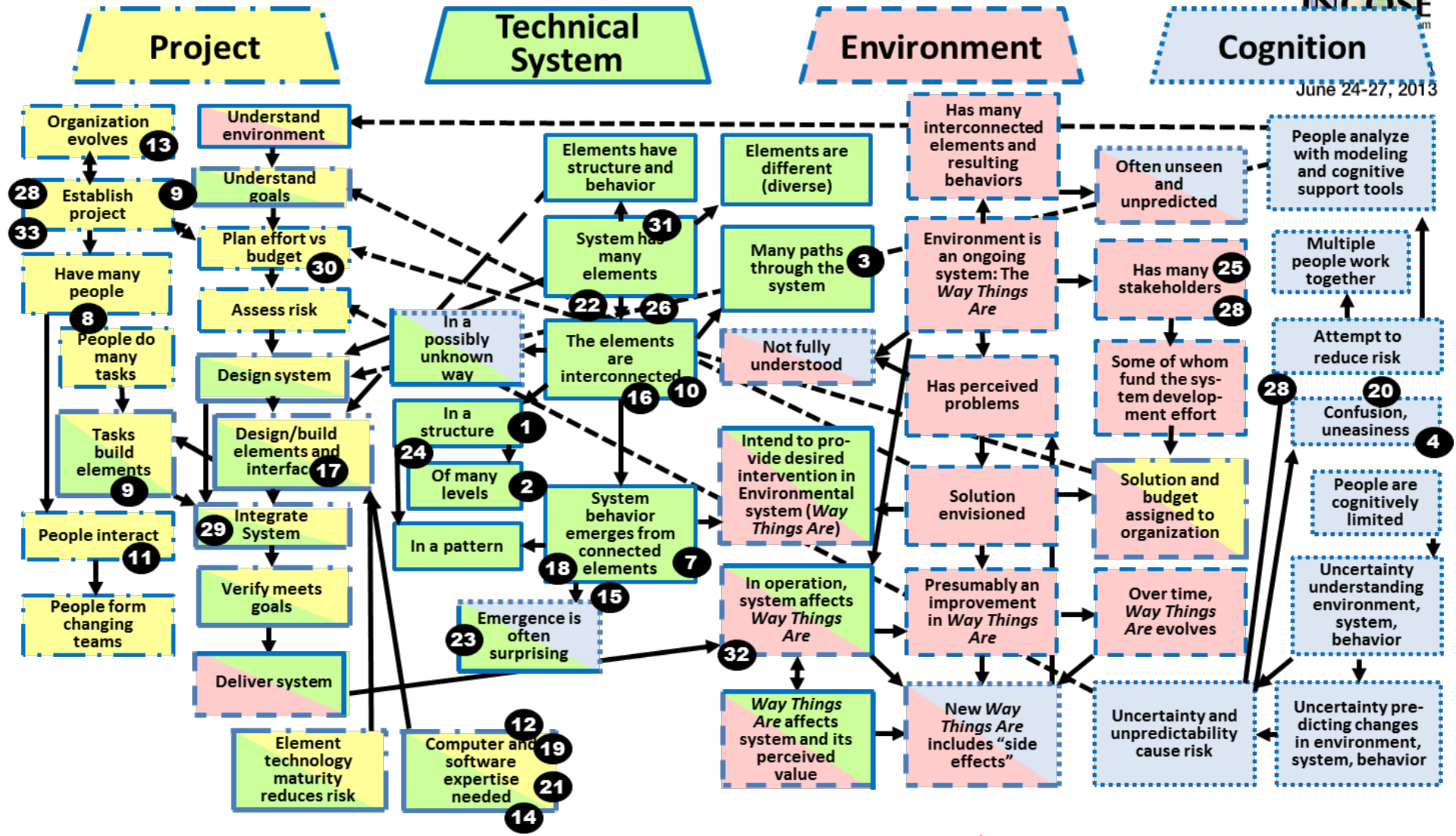
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Takeaways

- Complexity is an adjective
- More than just the system, or the project, is important
- Sometimes you can't control but you can influence; sometimes just work around
- Test your idea of "all" against someone else's collection

Summary

- Complexity refers to many entities and has both technical and cognitive aspects
- A system 'lifecycle' that includes the environment and the project can address, *or at least recognize*, most types of complexity
- Not all views on one chart

Contact Information

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