

# Toward an Evolutionary System of Systems Architecture

Scott Selberg

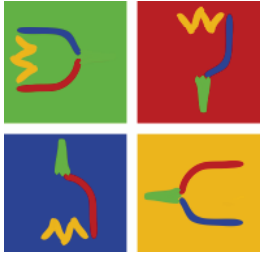


**Agilent Technologies**

Mark Austin



The  
Institute for  
**Systems**  
Research

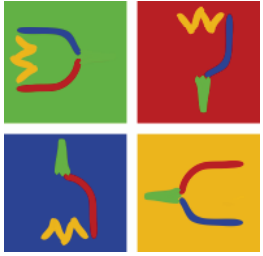


# Observation:



Modern systems are being replaced or transformed from industrial- to information-age capability

- Expanded functionality
- Improved performance



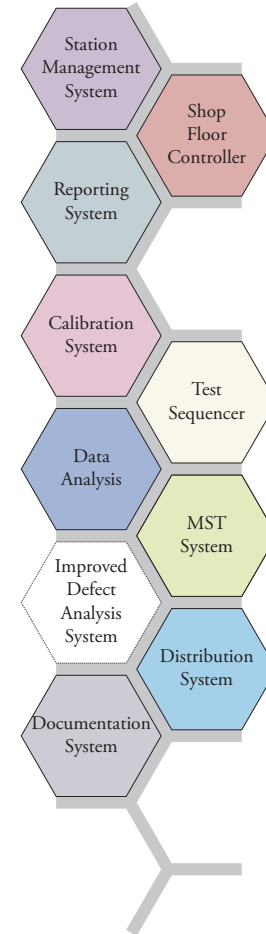
# Systems of Systems

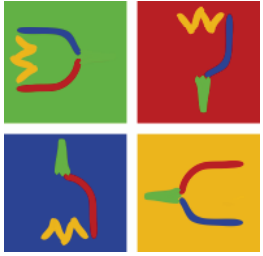


- Fulfill valid purposes in their own right, and continue to operate to fulfill those purposes if disassembled from the overall system
- Are managed (at least in part) for their own purposes rather than the purposes of the whole

“The Art of System Architecting”, Maier 2000

Which implies emergence and evolution!





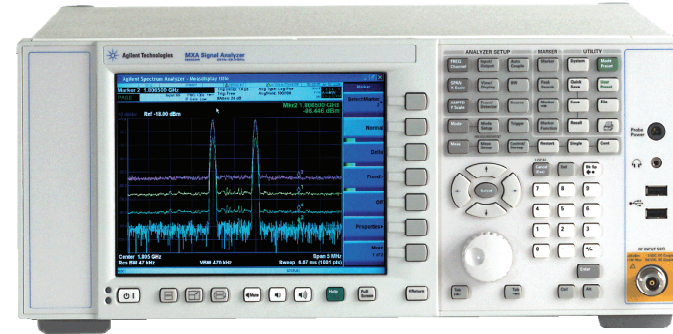
# Agilent's Interest






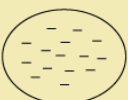






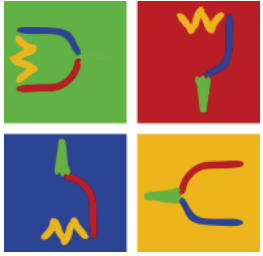
1. Our products are used in production lines and maintenance systems.

2. We have a manufacturing line to produce our products.

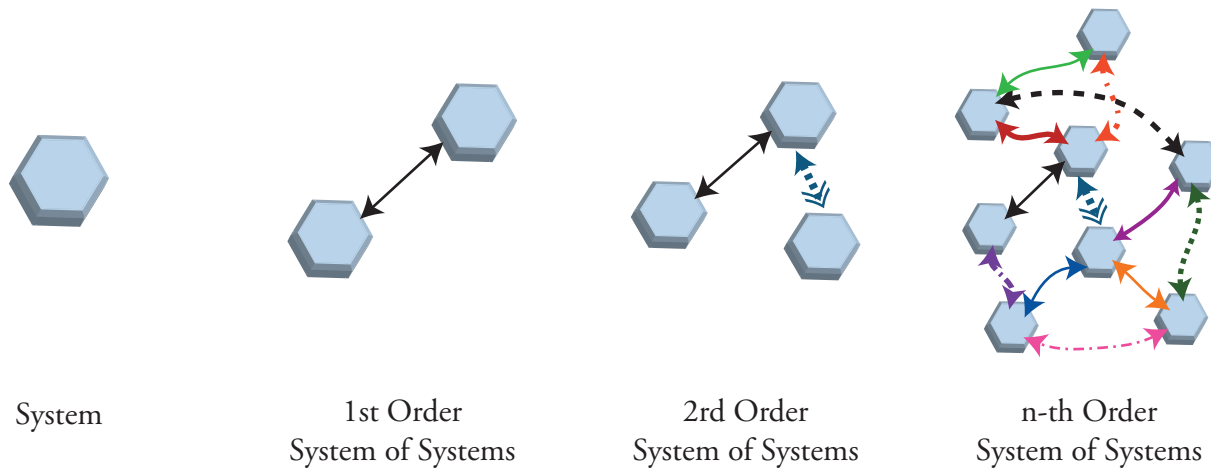
We need to support continuous change in decentralized systems.



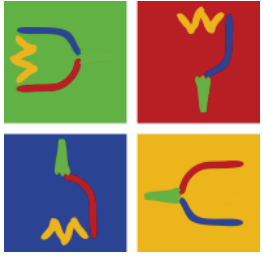
	<i>Generation Description</i>	<i>Physical Appearance</i>	<i>Software Infrastructure</i>
<i>Generation I</i>	<b>Manual Production</b>		
<i>Generation II</i>	<b>Computerized Test</b>		
<i>Generation III</i>	<b>Test Executive</b>		
<i>Generation IV</i>	<b>Process Center</b>		
<i>Generation V</i>	<b>Enterprise</b>		



# Problem: The System of Systems Rat's Nest



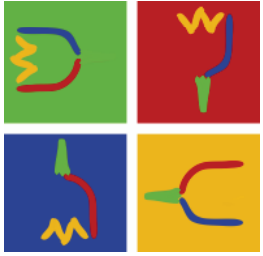
Un-guided System of Systems Evolution:  
What we want to avoid!



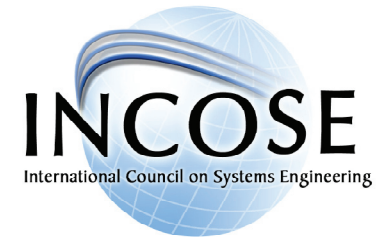
## Key Question:



How do I construct an  
Evolutionary System of Systems  
Architecture?



# Collaboration



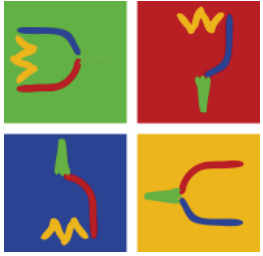
1. It is a hard systems engineering problem.
2. It is not Agilent's core competency.



**Agilent Technologies**



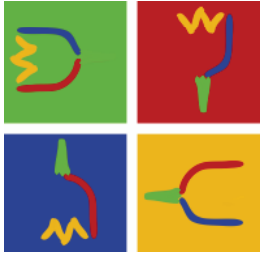
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# Definition: An Evolutionary Architecture



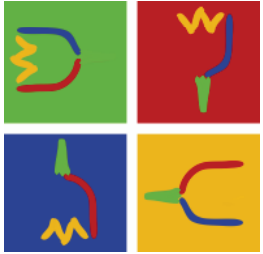
- The constituent systems do not need to be re-engineered as other constituent systems are added, removed, or replaced
- The complexity of the system of systems framework does not grow as constituent systems are added, removed, or replaced.



# Key Characteristics of an Evolutionary Architecture



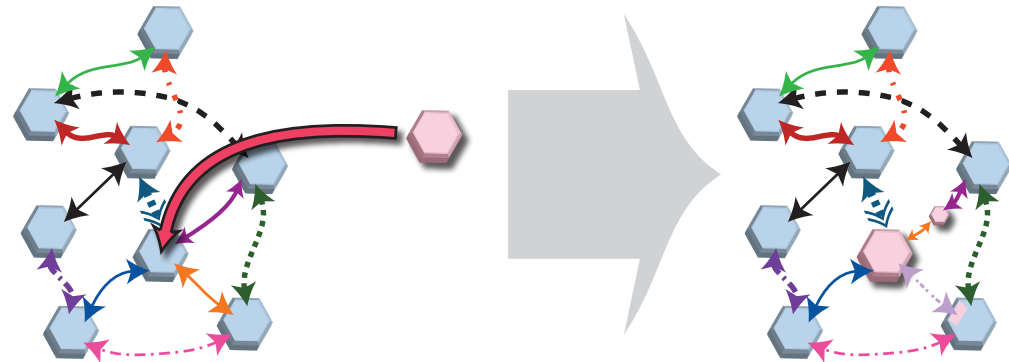
- Standards
- Interface Layers
- Continual Verification and Validation Process



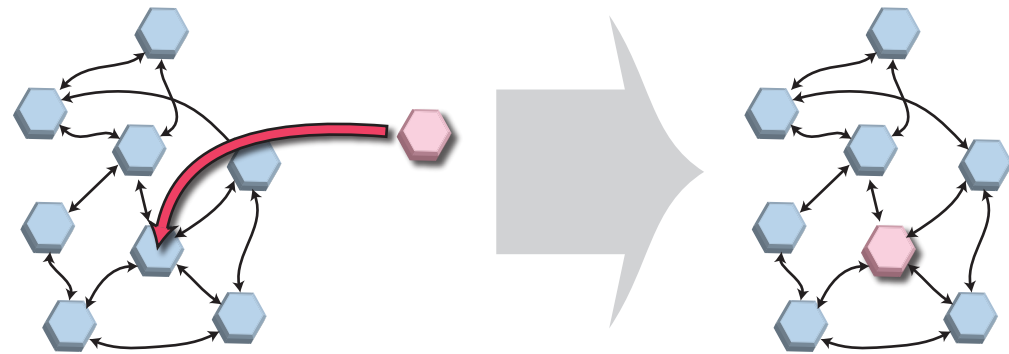
# Standards:

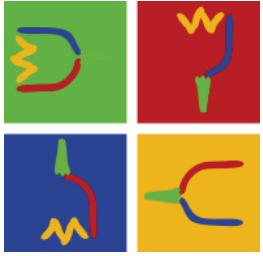


Constituent system replacement in unguided system-of-systems.



Constituent system replacement in with a common communication standard.



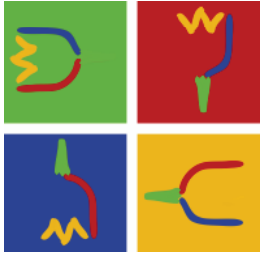


# Standards: Impact on Design Decisions

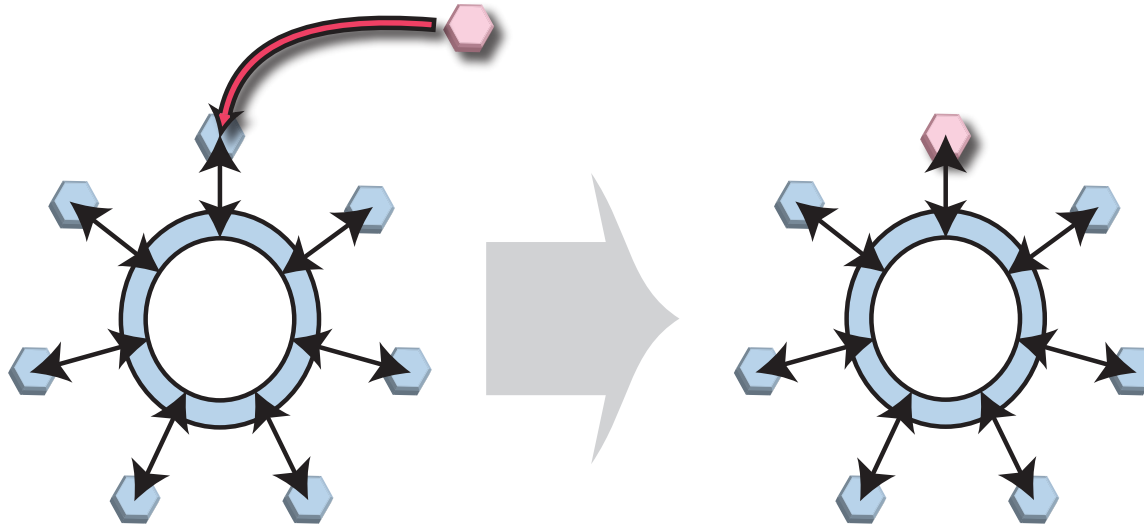


- Microsoft Windows
- LXI: Lan eXtensions for Instrumentation
- SCPI: Standard Commands for Programmable Instrumentation
- SOAP: Simple Objects Access Protocol

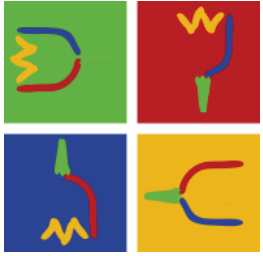
Selecting a standard which is non-ideal for the local task, but more global.



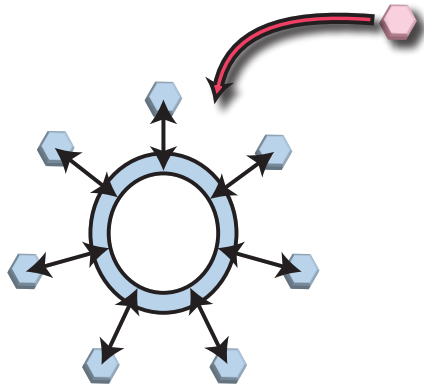
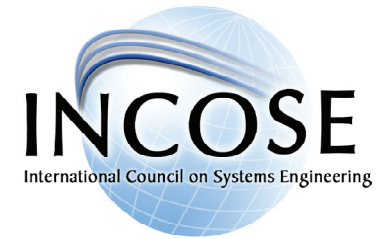
# An Interface Layer



Constituent system replacement  
in with a common communication  
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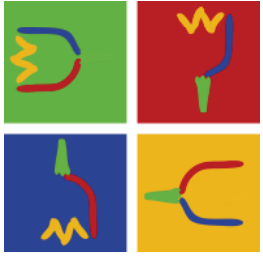


# An Interface Layer

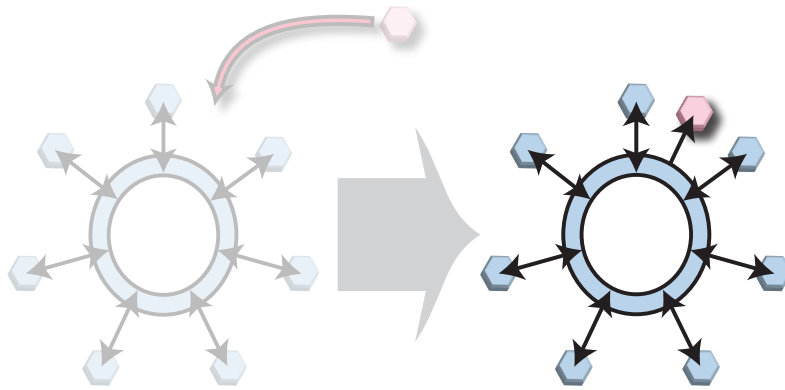


Adding a new system  
to the system of systems.

Constituent system replacement with interface layer. Also allows communication protocol replacement.



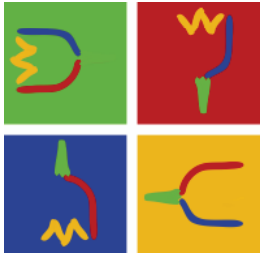
# An Interface Layer



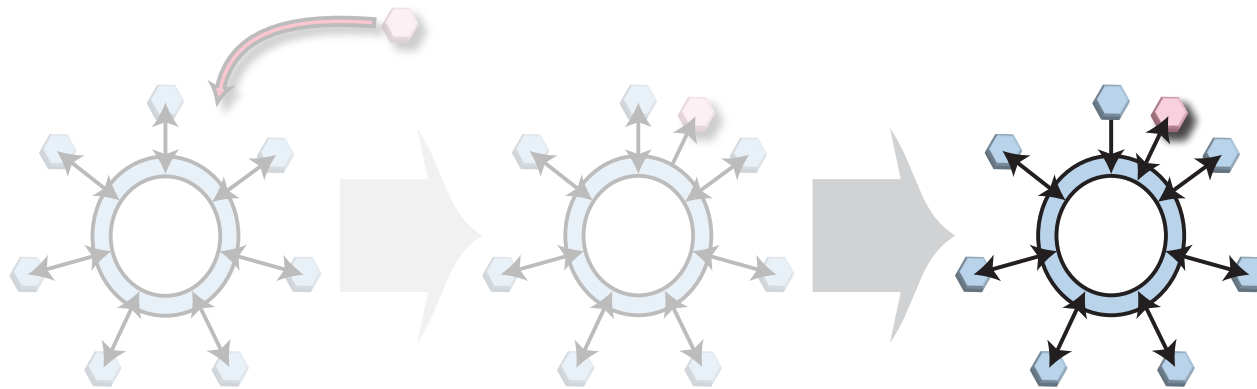
Adding a new system  
to the system of systems.

The original one is  
authoritative, but the  
new one is operating  
in parallel.

Constituent system replacement with interface layer. Also allows communication protocol replacement.



# An Interface Layer

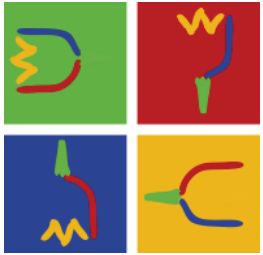


Adding a new system to the system of systems.

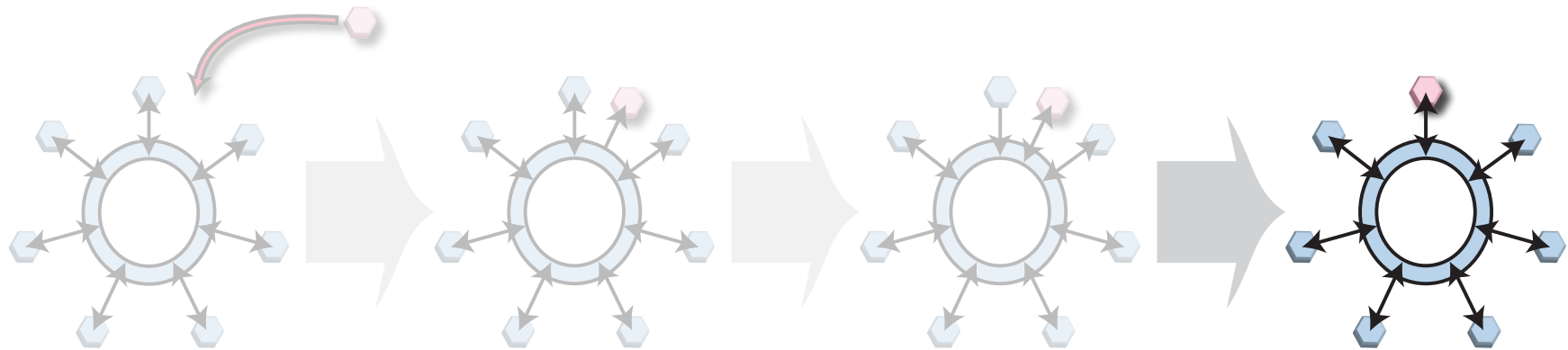
The original one is authoritative, but the new one is operating in parallel.

Still operating in parallel, the new one is now authoritative.

Constituent system replacement with interface layer. Also allows communication protocol replacement.



# An Interface Layer



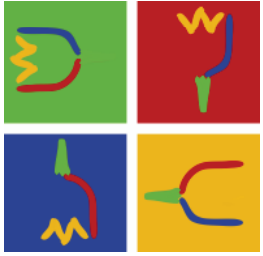
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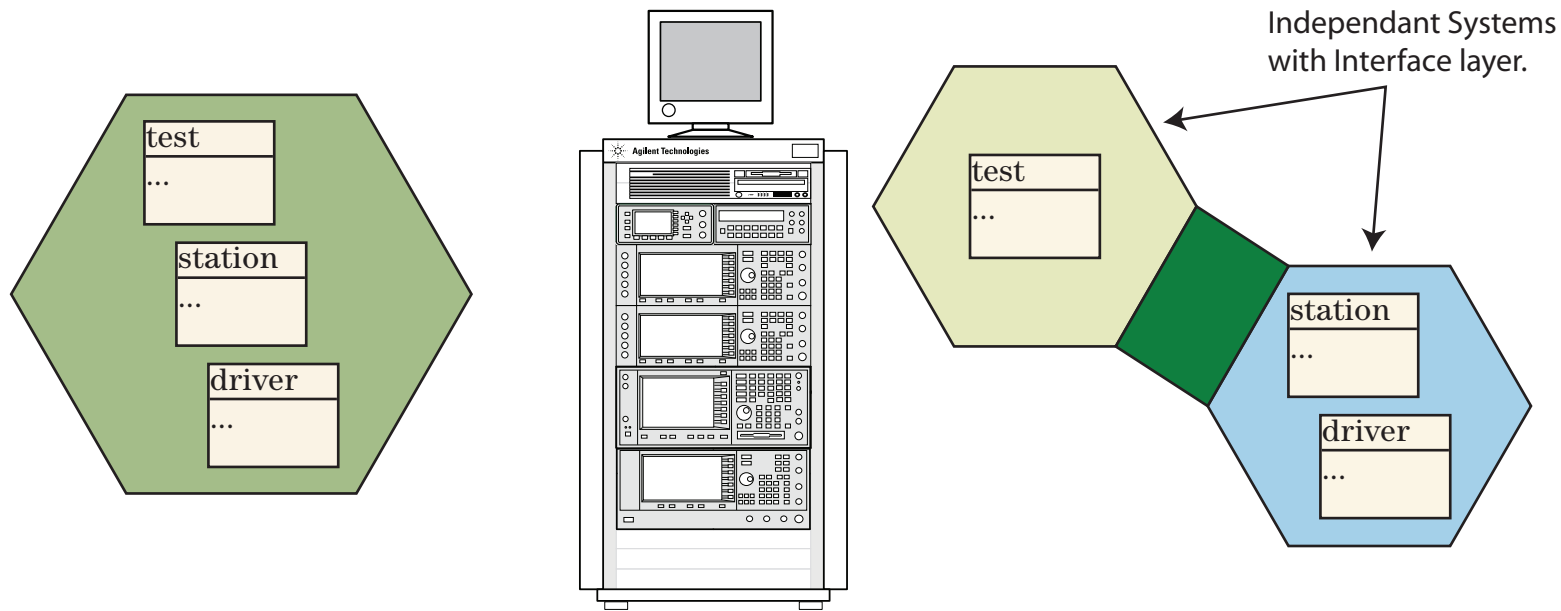
Still operating in parallel, the new one is now authoritative.

The old system is retired.

Constituent system replacement with interface layer. Also allows communication protocol replacement.

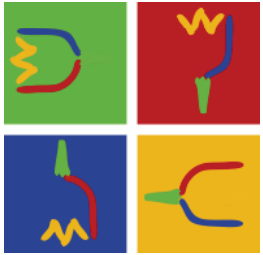


# Interface Layer Example Test Station Architecture



System Thinking

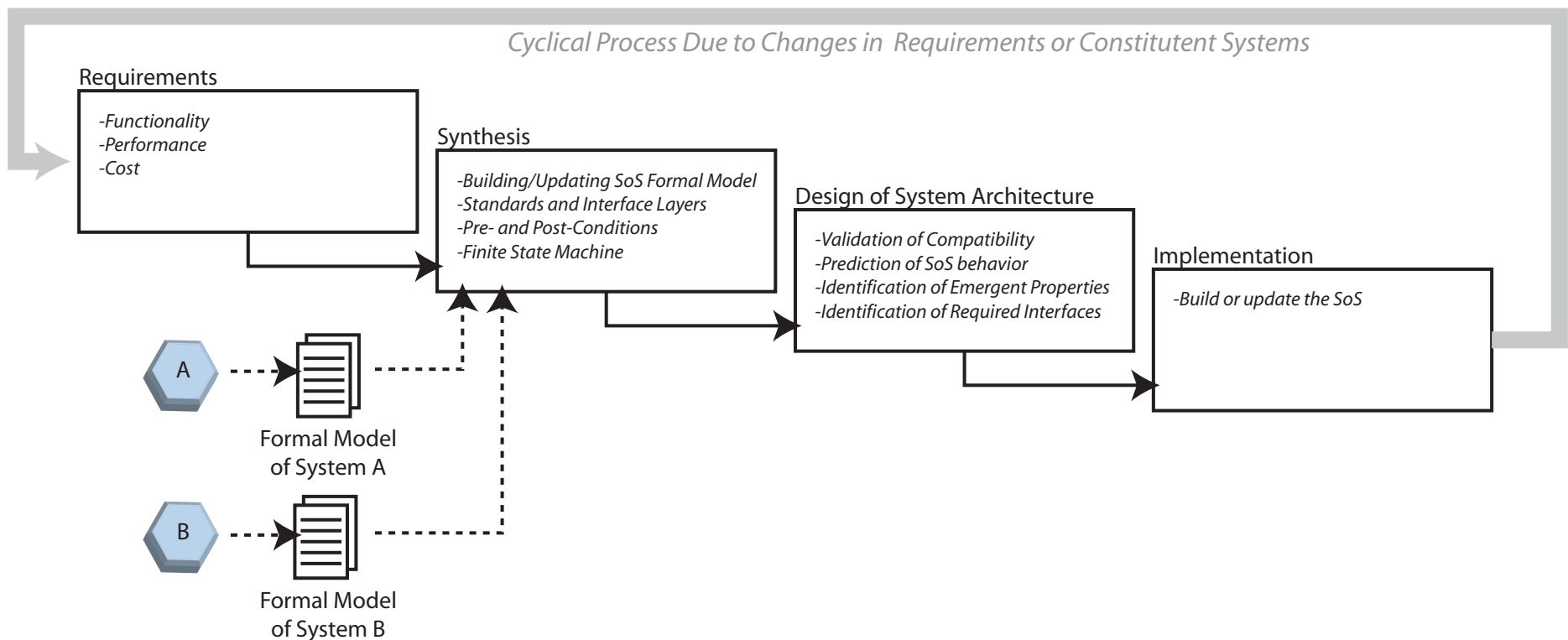
SoS Thinking

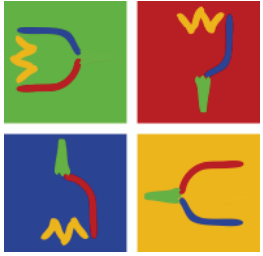


# Continual Verification and Validation



To make the system “change iteration time” economically feasible, this must be automated for complex systems.



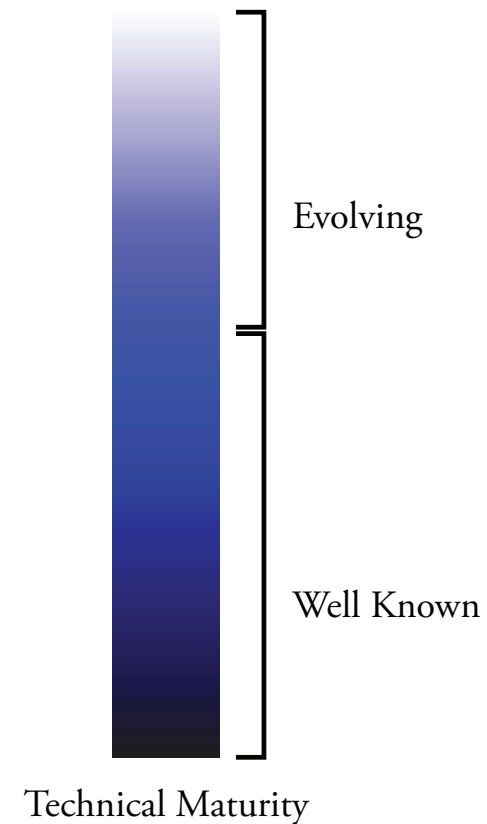
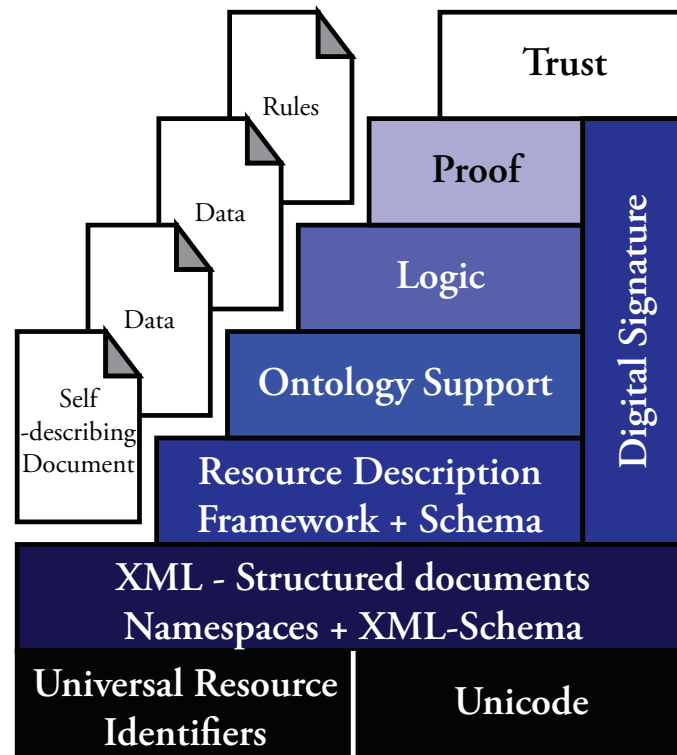


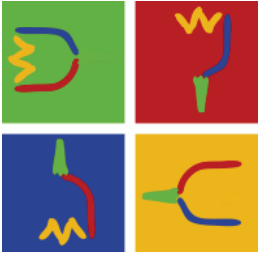
# Automated V&V Approach: Leverage the Semantic Web



## Semantic Web Layers

JESS  
OWL





Questions or Comments?