Done Right, Systems Engineering Drives System Integration to Zero!

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Assertion:

Sufficient SE reduces integration to straightforward assembly.

___Agree?

___Disagree?

___Undecided/Unclear?

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My Perspective

- Humans strive to do what they know how to do instead of what they should be doing.
  - Very innovative at reframing the problem to suit.
- I intend to convince you that SI is NOT a viable focus nor sustainable activity.
- SI obscures SE.
- Since the 1970's:
  - Object Technology has shown that useful systems can be made to appear even when no one knows the whole.
  - SE curricula, standards and "best practices" have not.

Integrated

Principles:

1. Fit for Purpose
2. Parsimony

No unnecessary redundancies, overlaps, gaps, capacities.

Inca wall, built < 1500 A.D.
Spaces too small to fit a knife into.
Larger stones weigh 100 tons.
Quarry was 35 kilometers away.

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Integrated?

Integration?

- Concatenation?
- Tolerance Buildup?
- Rework Centers?
- Value Engineering?
- Willoughby Templates?
- Deployment, Adoption?
- Evaluation and Adaptation?
- Restoration, Enhancement?
- Technology Insertion?
- Re-use?
- COTS Utilization?
- System of Systems?
- Embedding Cognitive SE into SE?

Science strives for, and succeeds through, precise semantics.

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Integration vs. Technology Insertion?

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Ex: #1: (*NALTS*) Navy

- 1990: Submarine had seven systems. Each worked fine. But they couldn't 'lock on' to a target that they could see 'right over there.'
- SE documentation sparse and out of date.
- Used RDD-100 to reverse engineer the subsystems to system-level models.
- Found the gaps, timing aberrations and faults.
- 1994: Modified system works fine.
- OBTW, cost for this SI was about 3 – 5 times what good SE would have cost.

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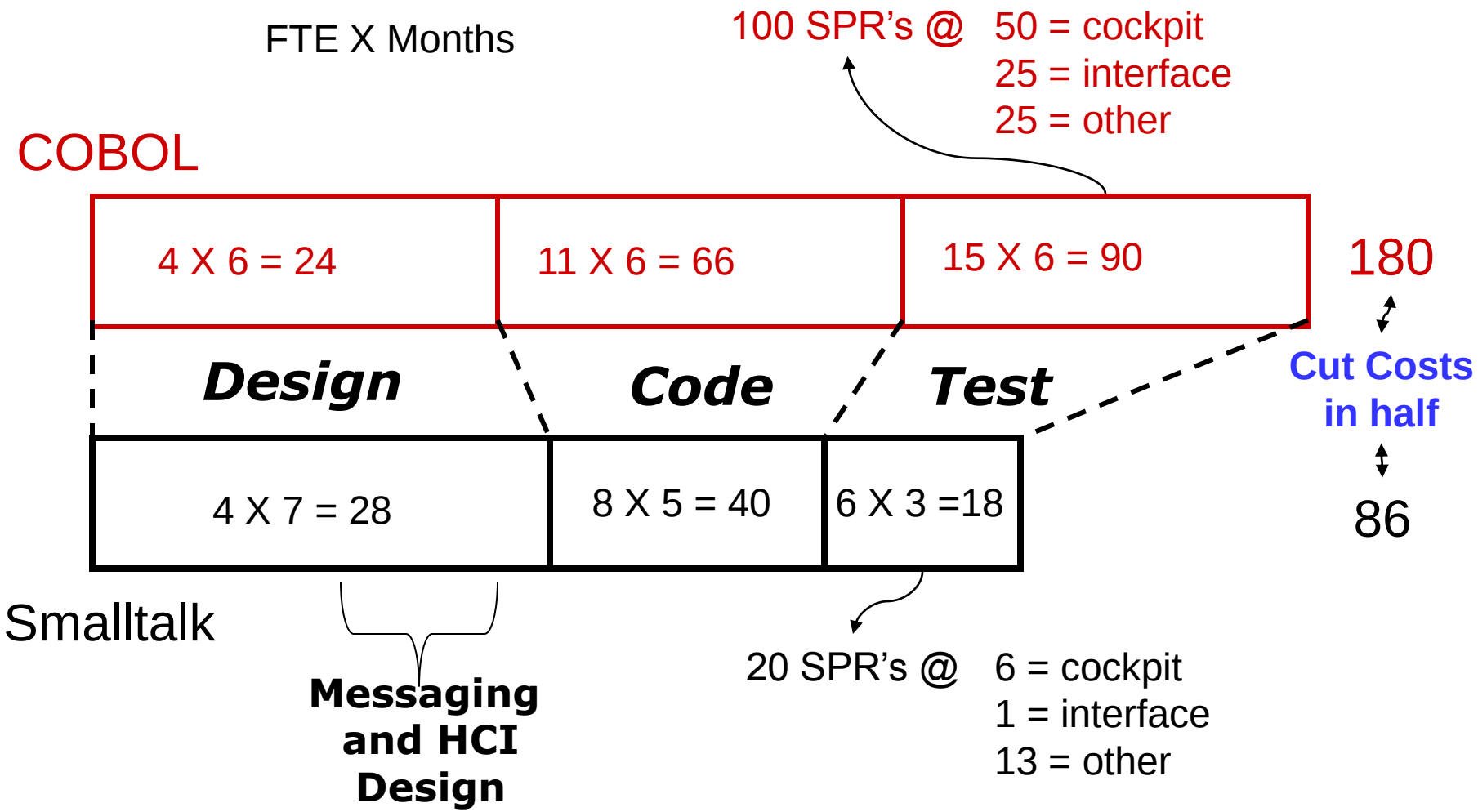
Ex: #2: 1994 Smalltalk Projects



Object Technology makes good designers better --- and bad designers obvious!

Ex #3: IS'04 Panel Summary Results Across 23 Assertions

Poll Choices	Panel Audience (n = 67)	Responding Fellows (n=18)	Panelists (n = 5)	Combined (n = 90)
Yes (Agree)	60%	58%	76%	61%
No (Disagree)	16%	18%	7%	16%
Undecided/ Unclear	24%	24%	17%	23%

IS'04 Panel Audience Agreed that;

4) Need examples and tools for coping with **complexity**. **90%**
3) Need practices for dealing with **complexity and change** in products and in standards and education. **81%**
2) A comprehensive SE practice for minimizing and leveraging **complexity**. **76%**
1) **Complexity** is **observer dependent**. **76%**

15) Research must focus on **needs articulated by practitioners** as well as by management and researchers. **87%**
16) SE **education materials** must address knowledge processing, intuitive decisions and other human sciences. **81%**
13) SE **education venues** must include **laboratory, studio and practicum** settings that academia has not been able to provide. **80%**

20) **'In-scope'** is preferable to **'integrate later.'** SE must include **all subsystems** of a deliverable system (mission, operational availability, operator preparation, test and production). **81%**

9) A **dyad of Project Management and System Management** is key. This dyad should be featured in standards and be happening on projects. **77%**

IS’04 Panel Audience Disagreed with;

18) The universal language of SE must be mathematics. **61% Disagreed**

14) SE research must become a part of every SE project. **52%** Disagreed

Ex #4: IS'04 Panel Audience Most Contentious was:

8) Sufficient SE reduces integration to straightforward assembly.

33% Agreed

49% Disagreed

18% Undecided/Unclear

EX #5: IS'06 Panel Report.

The Integration Process: An Unresolved Issue for Systems Engineers (extracted from Oct. 2006 INSIGHT)

- The integration process is manageable. Best to start planning very early in the project/product design procedure.
- Integration planning must do the following:
  - Assemble the system from its components/ Subsystems
  - Prove system functionality and qualities (e.g., reliability, safety, availability) [System Test?]
  - Advance system robustness [Parsimony?]
  - Find the engineering faults in the components [Design Review?]
  - Find the faults in the system architecture and interfaces [Design Reviews? c.f. Crosby (next chart)]
  - Discover unplanned emergent properties [Parsimony?]
- The experts [sic] agreed that integration can be optimized by using appropriate models and simulations.

Ex #6: Root Cause Analysis

- 1970's latent bug rate ≈ 3/1200
- Root cause analysis: 50% due to misunderstandings among developers.
- Remedy: Systems Engineering, especially ICWG and ICD.
- 1990's latent bug rate ≈1/1200

Done right, SE can think of everything.

The alternative is dismal.

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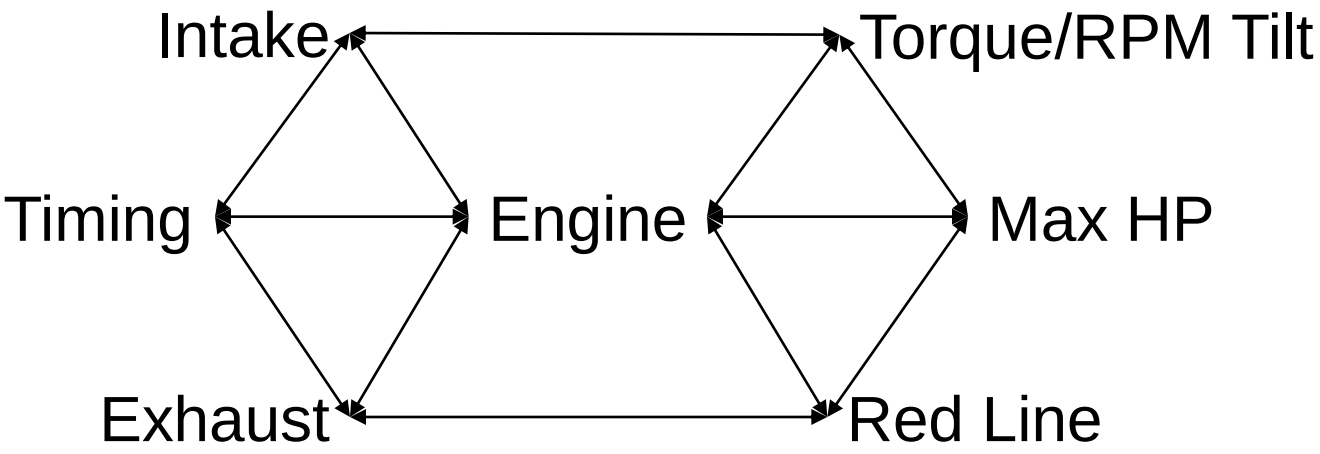
Ex #7: Requirements Management Doesn't

Ex #8: Race Car Engine



Principle: Harmony

INDY: Buick Indy Engine 3/16ths inch too short

NASCAR: Intake wall location error of 0.001 inch = 1 HP
-1 HP in 500 mile race ≈ - 1 lap
2800 RPM = 1 Restrictor Plate

An SI Process?

- **The best process for integration was pointed out by Phil Crosby years ago --- prevention (vs. correction).**
  - **He loved saying, "Better you should avoid quicksand than get a good deal on a tow truck."**
- **You can't make a centipede by gluing ants together. Greg Titus, 1985**
- **OBTW: Introduction of products into Enterprises is a case of Technology Insertion, not *Product Integration*.**

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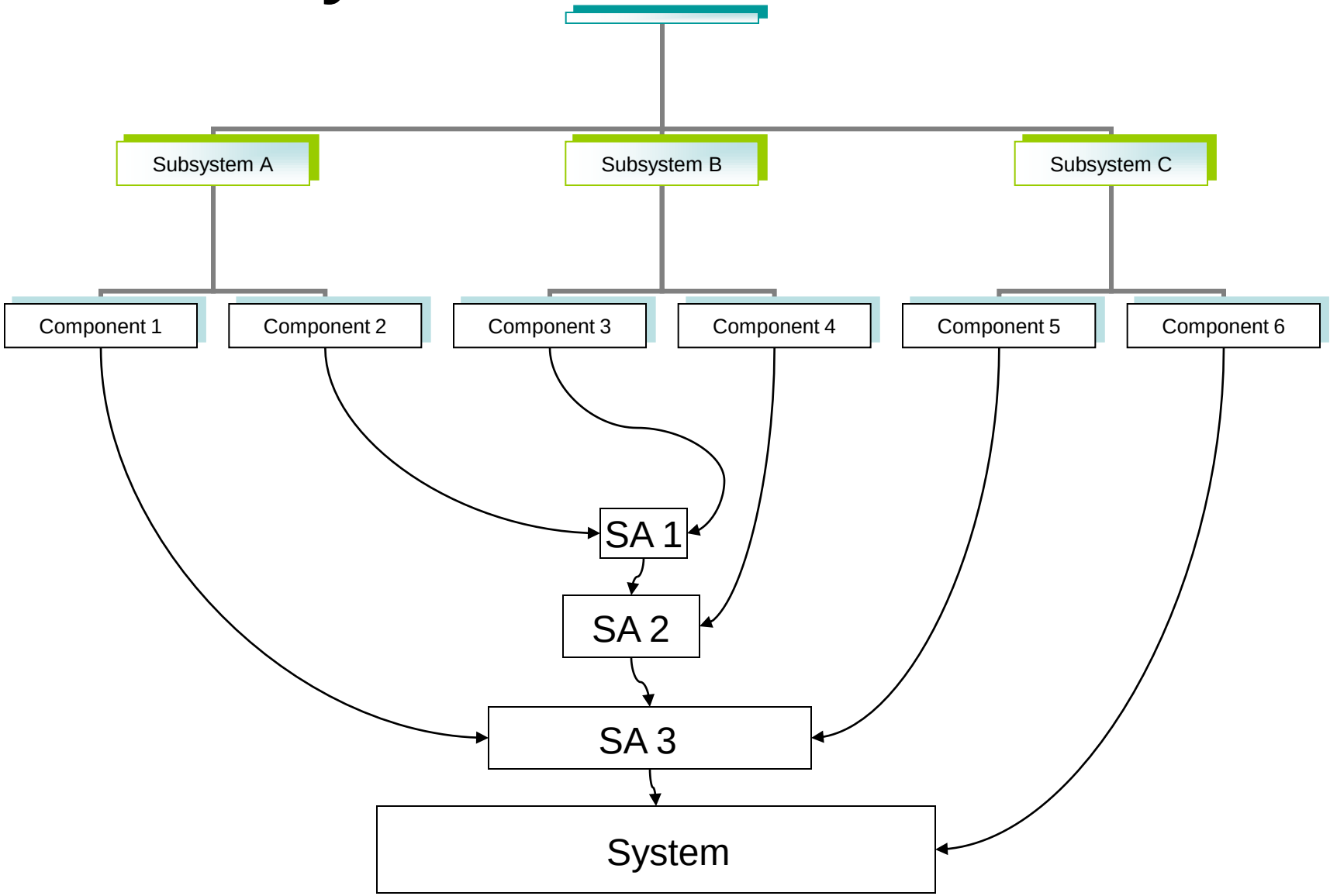
System Realization



Integrated Systems Modeling

Doors

SysML

3SL

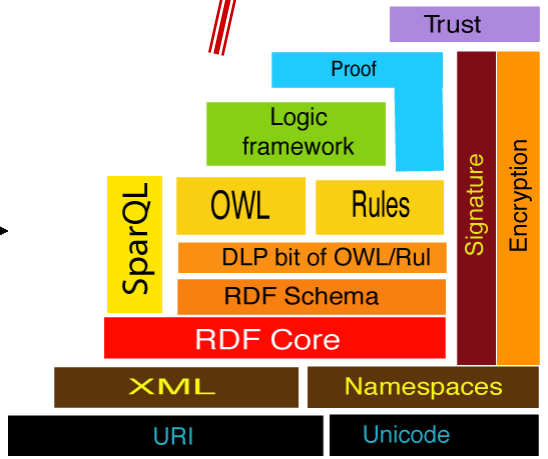
PDM

CORE

AP233

MATLAB

The other 70%



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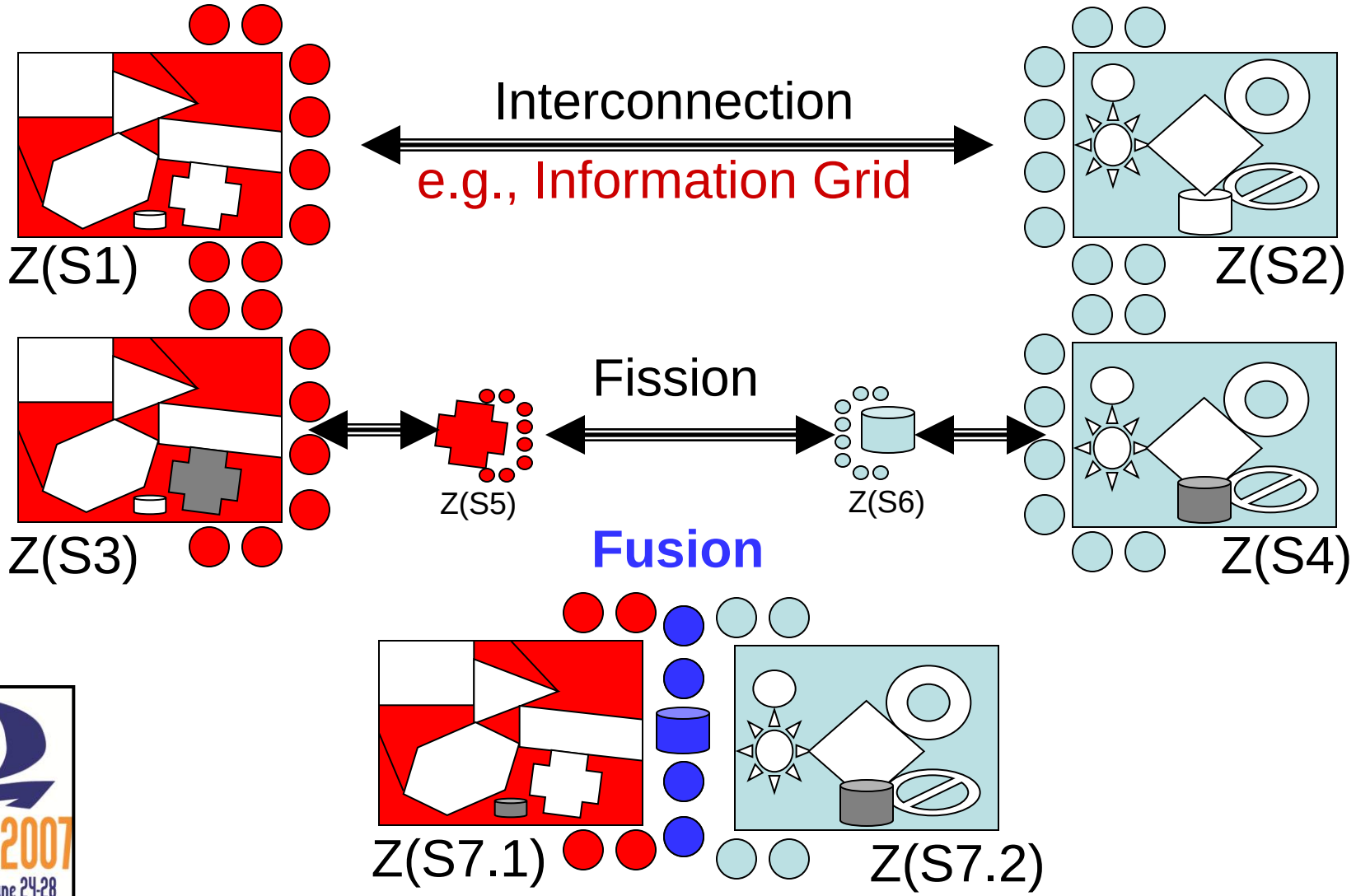
SI Will NOT Yield Viable SoS's (e.g., Net-centric Warfare)



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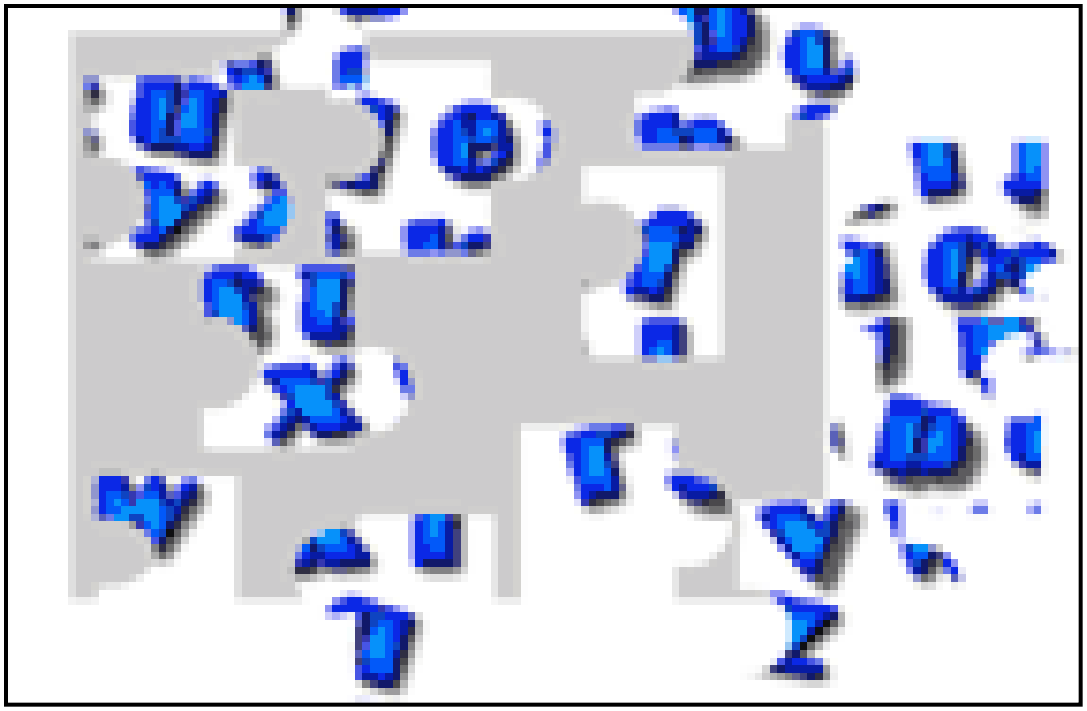
What's in YOUR System?



If you are starting with edicted components then GO BACK, do the SE work, then GO FORWARD

Please tell me ---

1. Can rigorous semantic precision @ interfaces & interoperability really net a reduction in overall realization project cost? >10%__? >20%__? >30%__?
2. How shall we agree on what Integration should mean?
3. What's in YOUR SE Wallet?

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Where is the Outrage?

If you ARE doing **SI**

then somebody DID NOT do **SE**.

Questions?

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