Systems Engineering Research at Wayne State University: An Overview

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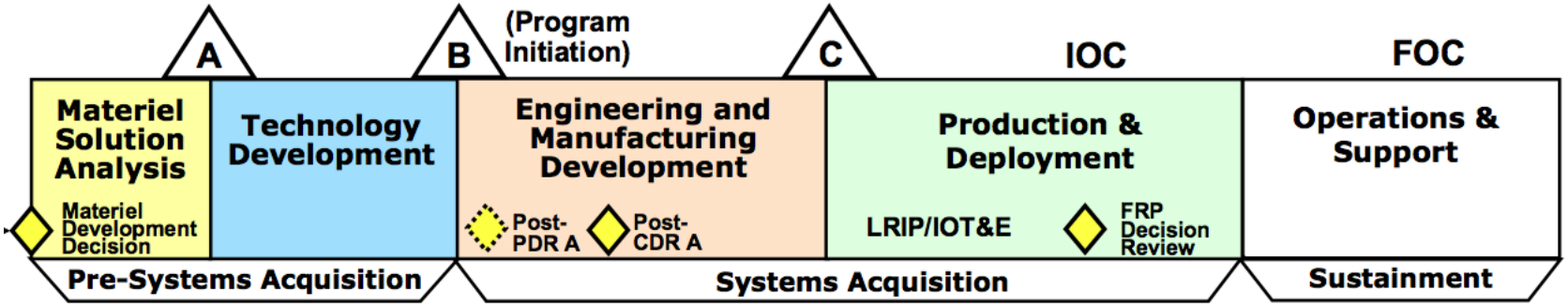
Background

- Wayne State University
  - University Research Corridor
  - In Detroit, the “Arsenal of Democracy”
- Major customer/stakeholders
  - TARDEC & TACOM (all Army ground vehicles)
  - Defense Contractors (e.g. General Dynamics)
  - Domestic Auto Industry
- TARDEC & TACOM responding to SE revitalization
  - WSU’s SE efforts build on long relationship with TARDEC & TACOM

Army Ground Vehicle SE Concerns



Applications

New Vehicles & Upgrades

Net-centric Ops

Robotic & Manned Vehicles

Combat, Tactical & Support

Functions

Crew Health & Safety

Power & Energy

Mobility

Survivability

C4ISR

Lethality

Attributes

Deployability

Sustainability

Endurance

Capacity

Reliability

Maintainability

Systems Engineering Revitalization at TARDEC

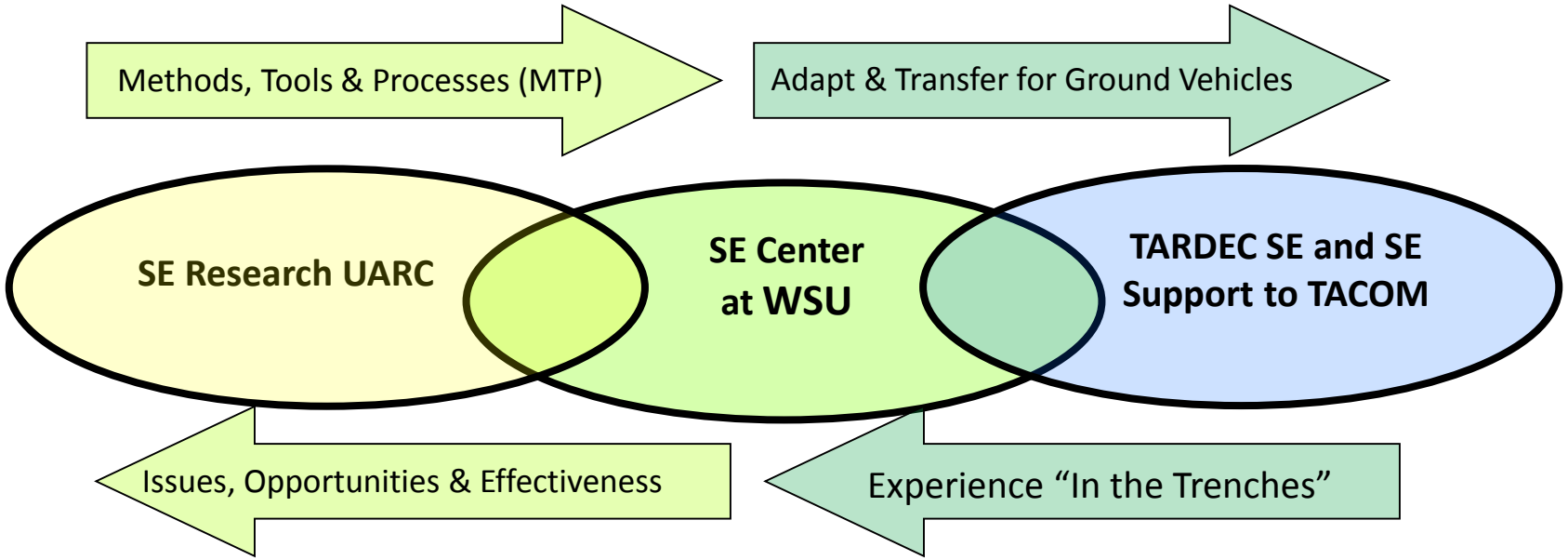
Life Cycle SE

To Predict and Manage

- *Cost*
- *Risk*
- *Schedule*
- *Performance*

SE Revitalization

- *Training*
- *Organization*
- *Corporate culture*
- *Institutionalization*
- *New MTP*



SER UARC Research Strategy Thrusts

- Enterprise Responsiveness
  - Explore advancements in SE MPTs that are responsive to enterprise strategic and program-level needs,
  - Enable agility and responsiveness during program conceptualization, execution, strategic choice & assessment.
  - Support cross-system and enterprise decisions.

- Systems Science and Complexity
  - Advance systems science and systems thinking for application to engineering and management of complex systems and capabilities.
  - Support systems engineering and management of complex systems, SoS, software-focused, & net-centric.

- SE Workforce
  - Explore future SE workforce competencies
  - Explore approaches to cultivate, educate, and prepare the future SE workforce.
  - Consider the nature of the environment, system types, and changes in SE MPTs with respect to competencies.

- Program Management and SE Integration
  - Promote and integrate SE methods, processes, and tools with program execution activities within all aspects of program management to include political issues, cost issues, all other PM tools.
  - Communicate the effectiveness of SE to leadership and PMs so that there will be increased usage of SE.

- Life Cycle Systems Engineering Processes
  - Advance system engineering life cycle technical and management processes.
  - Mature and Advance fundamental systems engineering technical and technical management processes.
  - Evolve fundamentals to consideration security, information age tools, and lean principles.

WSU Systems Engineering Research Thrusts

- Enterprise Responsiveness
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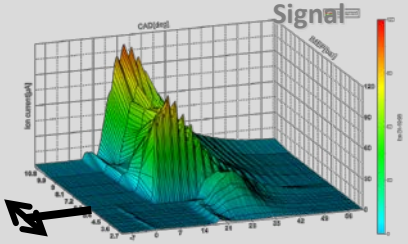
- SE Workforce
- Program Management and SE Integration
- Life Cycle Systems Engineering Processes

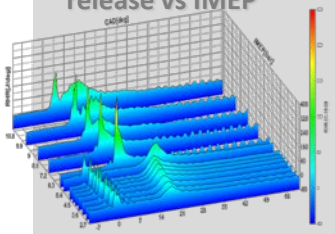
Ground Vehicle Power and Energy Systems

(Bryzik & Henein)

Detection of SOC and Mode of injection using Ion Current Signal



Rate of heat release vs IMEP



WSU Systems Engineering Research Thrusts

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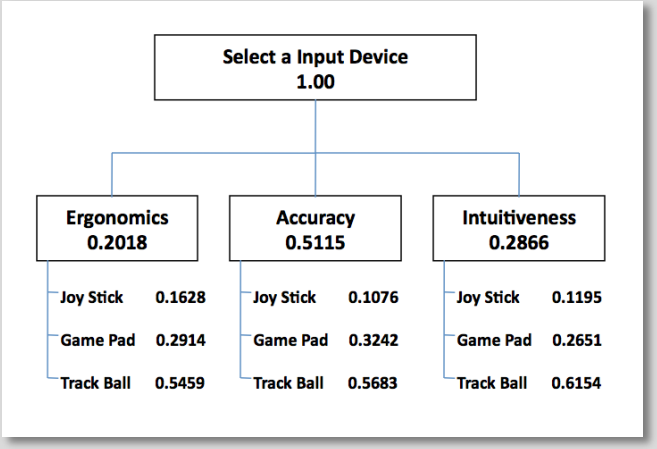
Rapid HFE
Test & Evaluation
to Support HSI in
Technology Development
Projects

(Ellis & Witus)



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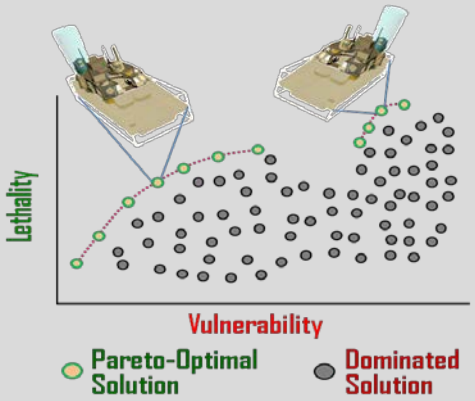
Top Deck Deconfliction: Vehicle KPP Requirements Management through Systems Integration & Optimization

(Chinnam & Murat)



Evaluate Top-Deck Overall Utility

VEHICLE SCORE

Component / Subsystem	Rank	Weight	Utility Score
Forced Protection	1	0.65	0.772
Lethality	2	0.35	0.758
Mobility	3		
HFE	4		
Transportability	5		
Alternative #1: Final Score		100%	0.77

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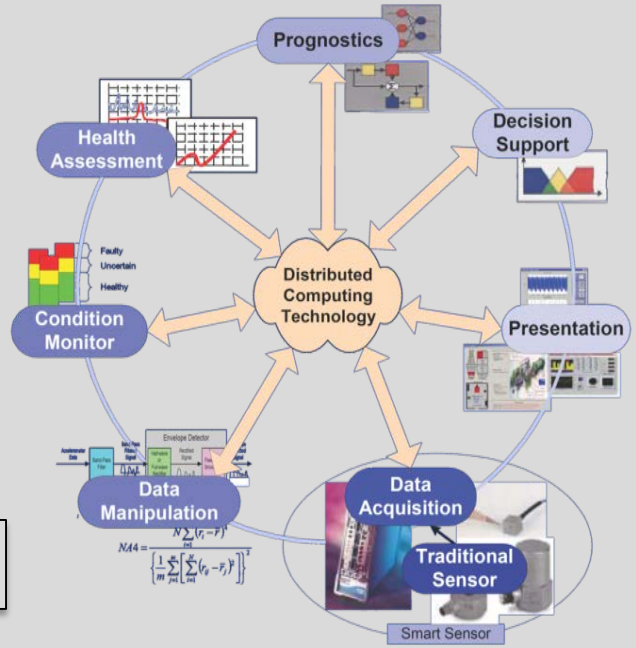
SE Tools for Effective Deployment of Condition-Based Maintenance and Performance Based Logistics

(Chinnam & Murat)



WSU Systems Engineering Research Thrusts

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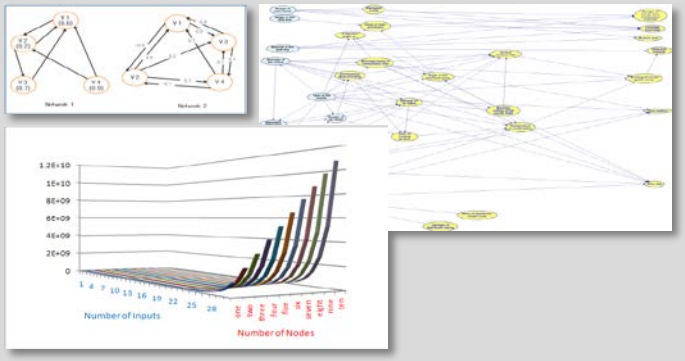
Sustainable System Information Management (SE Informatics):

Causal Knowledge Representation & Analysis

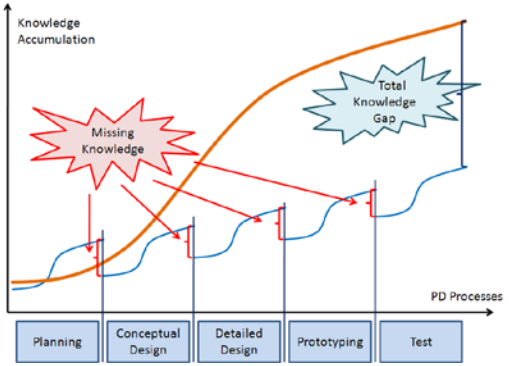
Rough Set-Based Semantic Rule Complexity Reduction

(Kim)

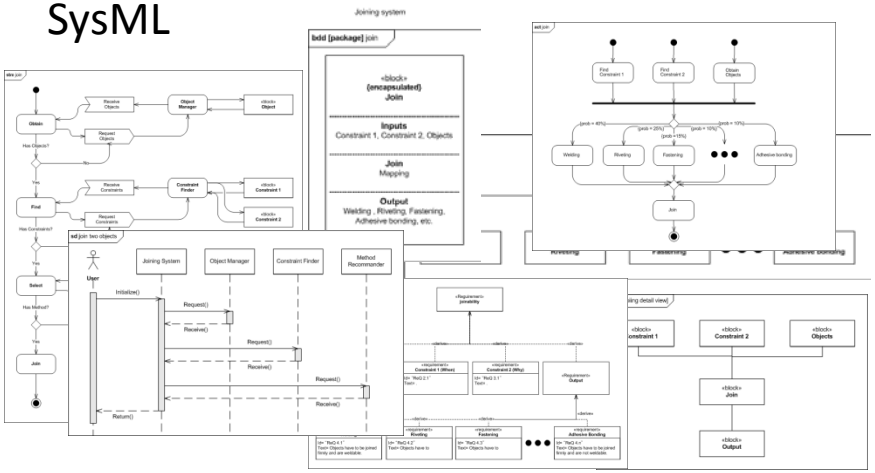


Causal Knowledge Representation and Analysis

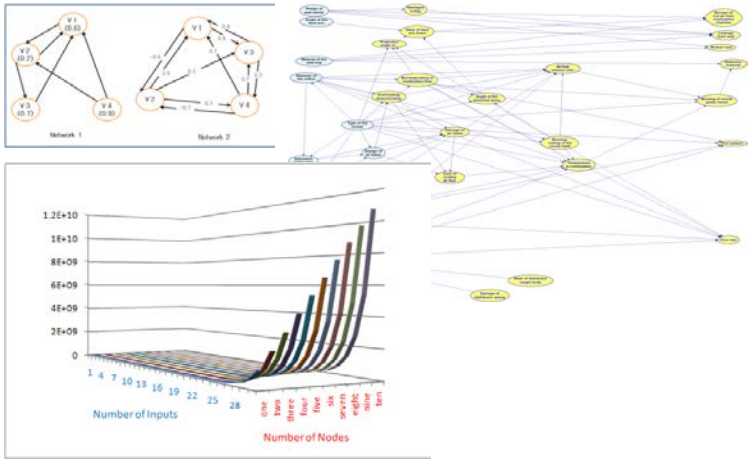
- Current limitations of knowledge systems in systems development & acquisition



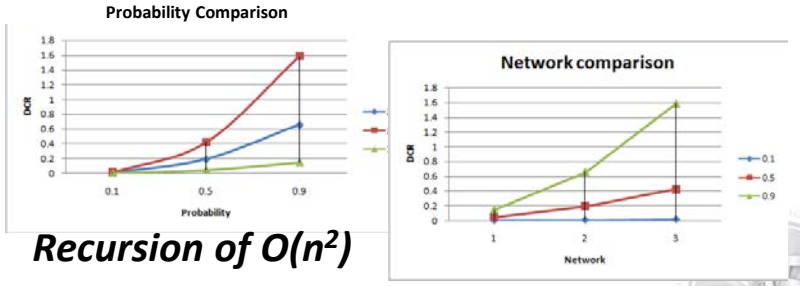
- Causal knowledge representation by SysML



- Causal Knowledge network



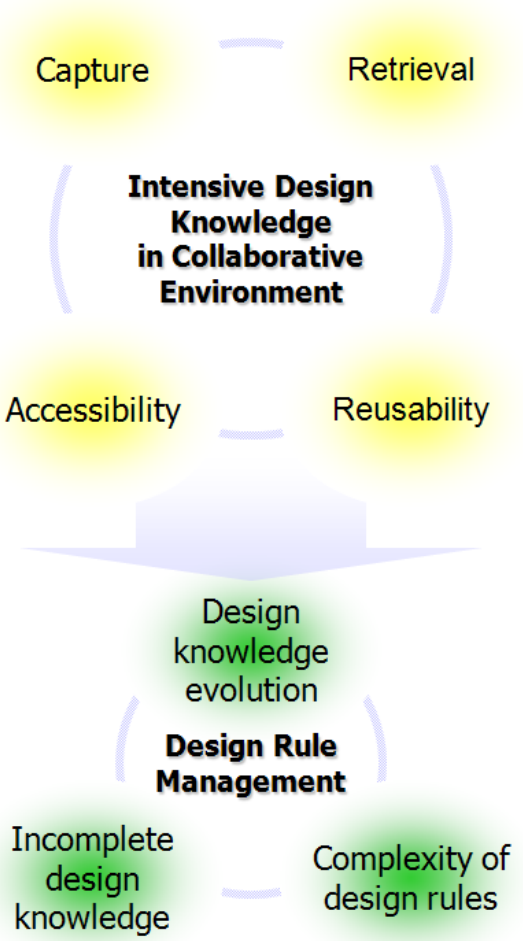
- Degree of Causal Representation (DCR) is a causal representation measure, which is combined with
  - Causality (C), Network Connectivity (NC), Weighted Network Connectivity (WNC)



Recursion of $O(n^2)$

Rough set based semantic rule complexity reduction

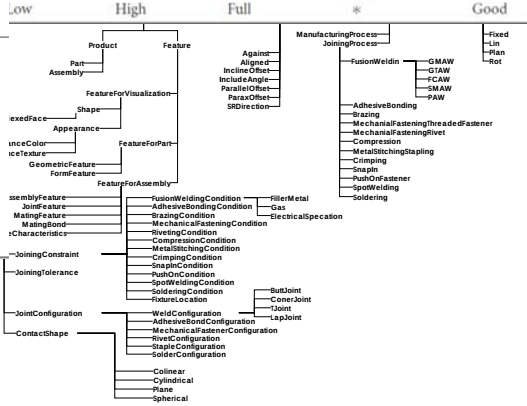
- Intensive design knowledge in collaborative environment
- Efficient design rule management methodology required



- Incomplete information and complexity issues

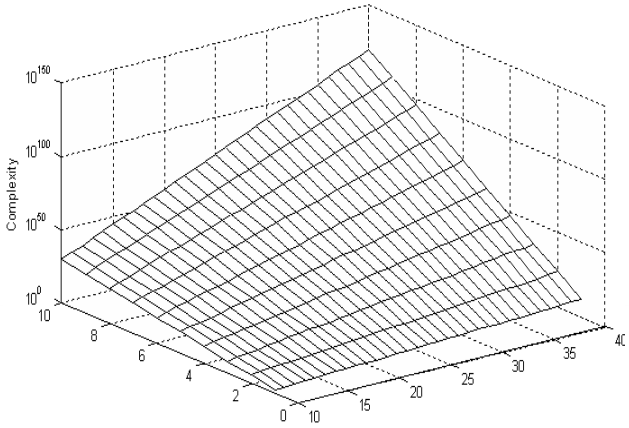
Car	Price	Mileage	Size	Max speed	D
1	High	High	Full	Low	Good
2	Low	*	Full	Low	Good
3	*	*	*	High	Poor
	High	*	Full	High	Good
	*	*	Full	High	Excellent
	Low	High	Full	*	Good

	Attributes			Decision
Case	Capacity	Noise	Size	Quality
1	two	–	compact	high
2	four	*	*	high
3	?	medium	medium	low
4	+	low	compact	low
5	four	?	medium	high
6	–	medium	full	low
7	five	low	full	high



Fusion welding	$xJ_{fw}y :=$ ∃w {(wOx ∧ wOy) ∧ (wStj ∨ wXj)}	•individual(?x) ∧ individual(?y) ∧ individual(?w) ∧ is_joiningEntity(?j) ∧ overlap(?w, ?x) ∧ overlap(?w, ?y) ∧ straddle(?w, ?j) → fusionWelding(?x, ?y) •individual(?x) ∧ individual(?y) ∧ individual(?w) ∧ is_joiningEntity(?j) ∧ overlap(?w, ?x) ∧ overlap(?w, ?y) ∧ cross(?w, ?j) → fusionWelding(?x, ?y)
Adhesive bonding	$xJ_{ab}y :=$ ∃g(gStj ∧ gTx ∧ gTy)	•individual(?x) ∧ individual(?y) ∧ individual(?g) ∧ is_joiningEntity(?j) ∧ straddle(?g, ?j) ∧ tangent(?g, ?x) ∧ tangent(?g, ?y) → adhesiveBonding(?x, ?y)
Mechanical fastening with treaded fasteners	$xJ_{tf}y :=$ ∃u,v {(uXx ∧ uXy) ∧ (vTx ∨ vTy) ∧ (uPfs ∧ vPfs)} ∧ fsXj	•individual(?x) ∧ individual(?y) ∧ individual(?u) ∧ individual(?v) ∧ individual(?fs) ∧ individual (?j) ∧ cross(?u, ?x) ∧ cross(?u, ?y) ∧ tangent(?v, ?x) ∧ is_part_of(?u, ?fs) ∧ is_part_of(?v, ?fs) ∧ cross (?fs, ?j) → threadedMechanicalFastening(?x, ?y) •individual(?x) ∧ individual(?y) ∧ individual(?u) ∧ individual(?v) ∧ individual(?fs) ∧ individual (?j) ∧ cross(?u, ?x) ∧ cross(?u, ?y) ∧ tangent(?v, ?y) ∧ is_part_of(?u, ?fs) ∧ is_part_of(?v, ?fs) ∧ cross (?fs, ?j) → threadedMechanicalFastening(?x, ?y)
Mechanical fastening with rivets	$xJ_{rf}y :=$ ∃u,v {(uXx ∧ uXy) ∧ (vTx ∧ vTy) ∧ (uPfs ∧ vPfs)} ∧ fsXj	•individual(?x) ∧ individual(?y) ∧ individual(?u) ∧ individual(?v) ∧ individual(?fs) ∧ cross(?u, ?x) ∧ cross(?u, ?y) ∧ tangent(?v, ?x) ∧ tangent(?v, ?y) ∧ is_part_of(?u, ?fs) ∧ is_part_of(?v, ?fs) ∧ cross (?fs, ?j) → rivetedMechanicalFastening(?x, ?zy)

- Minimal design rule selection



Rule	If	Then
1	(f_2=31)	d=1
3	(f_4=0)	d=1
5	(f_6=1)	d=1
7	(f_9=0)	d=1

Rule	If	Then
2	(f_3=1)	d=1
4	(f_5=1)	d=1
6	(f_7=1) ∧ (f_8=1)	d=1

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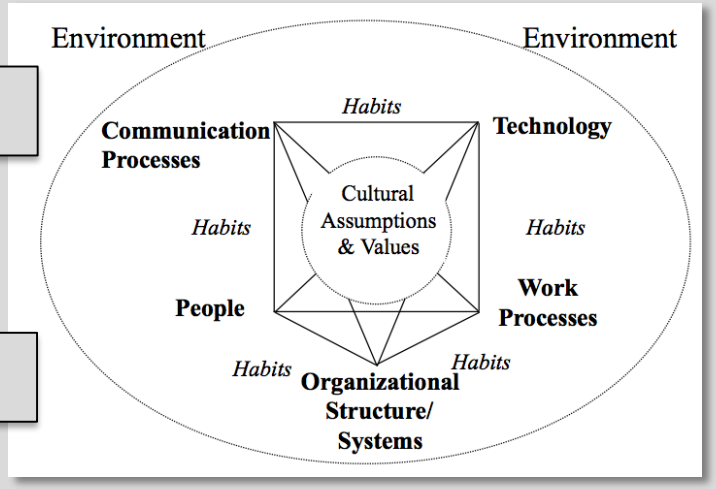
Socio-Cultural Technical Systems Roadmap for Implementing IPD Teams

(Gluesing)



SE Workforce Development: Key Issues for WSU

- SE is growing in MI
  - Government (DoD, NASA)
  - Contractors (GDLS, BAE, SAIC)
- Customer-focused approach
  - Tight integration with stakeholders
  - Need options for offerings (Grad Certificate leading to MS)
  - Need "SE" brand, not just "engineering management"
- Build on successes
  - Engineering Management onsite program at Ford
  - Use existing coursework where possible
  - Enrich with case studies from local partners (TACOM/TARDEC, GDLS)

Graduate Certificate

- SE/IME 6840
  Project Management
- SE/IME 7995
  Systems Engineering
- SE/IME 7720
  Engineering Risk and Decision Analysis
- SE/IME *7998*
  Engineering Management and Leadership

End

Questions?