Systems Engineering

The Key to Successful Outcomes

What is a Systems Engineer?

- Anyone can print a business card with “Systems Engineer” in the title.
- Lots of schools offer “systems engineering” courses.
- ….But what does it mean to ***be*** a systems engineer?

Maybe some people just have the *SE Knack*?

- See everything as a system
- Strive to understand "context"
- Apply systems engineering principles and practices – without thinking – in all facets of life

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Do successful SE's have a unique talent for "Systems Thinking"?

Systems thinking is a discipline for seeing wholes. It is a framework for seeing interrelationships rather than things, for seeing patterns of change rather than static "snapshots."

Peter Senge

Systems Engineering is more than just process!

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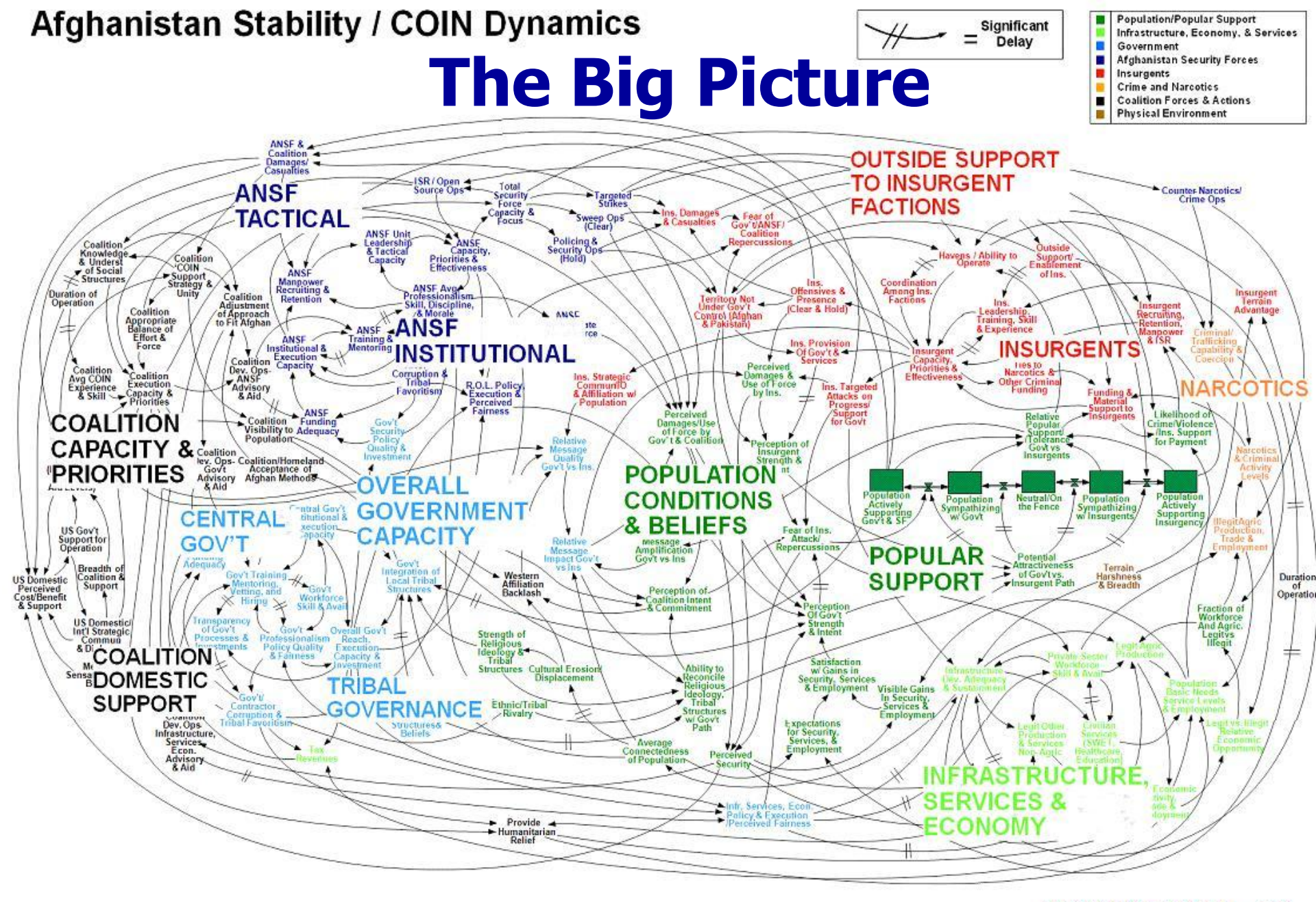
Typical SE Behaviors

- **Always trying to understand the "Big Picture"**
  - Context and CONOPS
- **Analyzing "expectations" to separate "needs" from "wants"**
  - Requirements
- **Obsessive about determining root causes**
  - Root cause analysis
- **Frequently making check lists**
  - Verification

Afghanistan Stability / COIN Dynamics

The Big Picture



WORKING DRAFT – V3

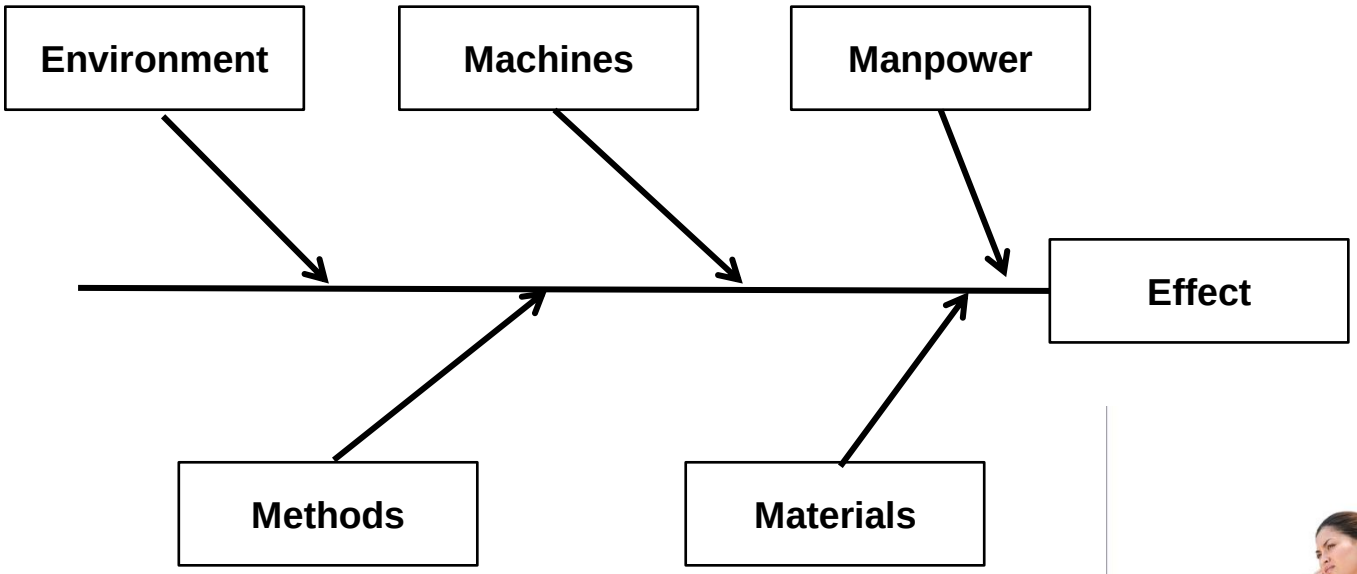
Fig. 6

Separating Needs and Wants

- **Wants**

- **Needs**

Obsessive About Root Causes



Frequently Making Check Lists

Level	Rev	ID	Name	Make or Buy	Requirement		Predecessor	Verification		Auditor	Date
0	0	0.0	Bicycle System	M	0.0.1	"Light Wt" - <105% of Competitor	"User Need" Doc ¶ 1	0.0.1	Assess Competition		
0	0	0.0	Bicycle System	M	0.0.2	"Fast" - Faster than any other bik	"User Need" Doc ¶ 2	0.0.2	Win Tour de France		
1	0	1.1	Bicycle	M	1.1.1	8.0 KG max weight	0.0.1, Marketing	1.1.1	Test (Weigh bike)		
1	0	1.1	Bicycle	M	1.1.2	85 cm high at seat	Racing rules ¶ 3.1	1.1.2	Test (Measure bike)		
1	0	1.1	Bicycle	M	1.1.3	66 cm wheel dia	Racing rules ¶ 4.2	--	*Verif at ass'y level*		
1	0	1.1	Bicycle	M	1.1.4	Carry one 90 KG rider	Racing rules ¶ 2.2	1.1.4	Demonstration		
1	0	1.1	Bicycle	M	1.1.5	Use advanced materials	Corporate strategy ¶ 6a	--	*Verif at ass'y level*		
1	0	1.1	Bicycle	M	1.1.6	Survive FIVE seasons	Corporate strategy ¶ 6b	1.1.6	Accelerated life test		
1	0	1.1	Bicycle	M	1.1.7	Go VERY fast (>130 kpm)	0.0.2	1.1.7	Test against benchmark		
1	0	1.1	Bicycle	M	1.1.8	Frame is to be Red, shade 123	Marketing	1.1.8	Inspection		
1	0	1.2	Packaging	B	1.2.1	Packaged for Shipment	0.0.4, Marketing				
1	1	1.2	Packaging	B	1.2.1	Photo of "Hi Tech" Wheel on Box	0.0.4, Marketing				
1	0	1.2	Packaging	B	1.2.2	Survive 2 m drop	Industry std				
1	1	1.3	Documentation	M	1.3.1	Assembly Instructions	0.0.4				
1	1	1.3	Documentation	M	1.3.2	Owner's Manual	0.0.4				
2	0	2.1	Frame Assembly	B	2.1.1	Welded Titanium Tubing	1.1.5, 1.1.6				
2	0	2.1	Frame Assembly	B	2.1.2	Maximum weight 2.5 KG	1.1.1, allocation				
2	0	2.1	Frame Assembly	B	2.1.3	Demo 100 K cycle fatigue life	1.1.6				
2	0	2.1	Frame Assembly	B	2.1.4	Support 2 x 90 KG	1.1.4, 1.1.6				
2	0	2.1	Frame Assembly	B	2.1.5	Powder-coat frame Red, shade 12	1.1.8				
			•			•					
			•			•					

Applying SE to Every Day Life

- Clearly defining objectives (requirements), while staying focused on outcomes
- Decomposing problems and issues into component pieces
- Structured decision-making (trade studies)
- Focusing on accuracy (verification) and appropriateness (validation) of outcomes
- Being sensitive to risk
- Taking the long view (supportability)

Clearly defining objectives - focused on the outcomes

- **MOE (outcome): score**
- **New clubs may be a "want" but probably won't impact MOE**
- **Considers enabling systems**
  - System for maintenance of greens will impact MOE

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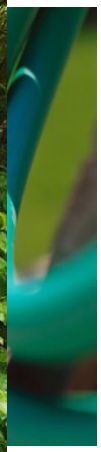
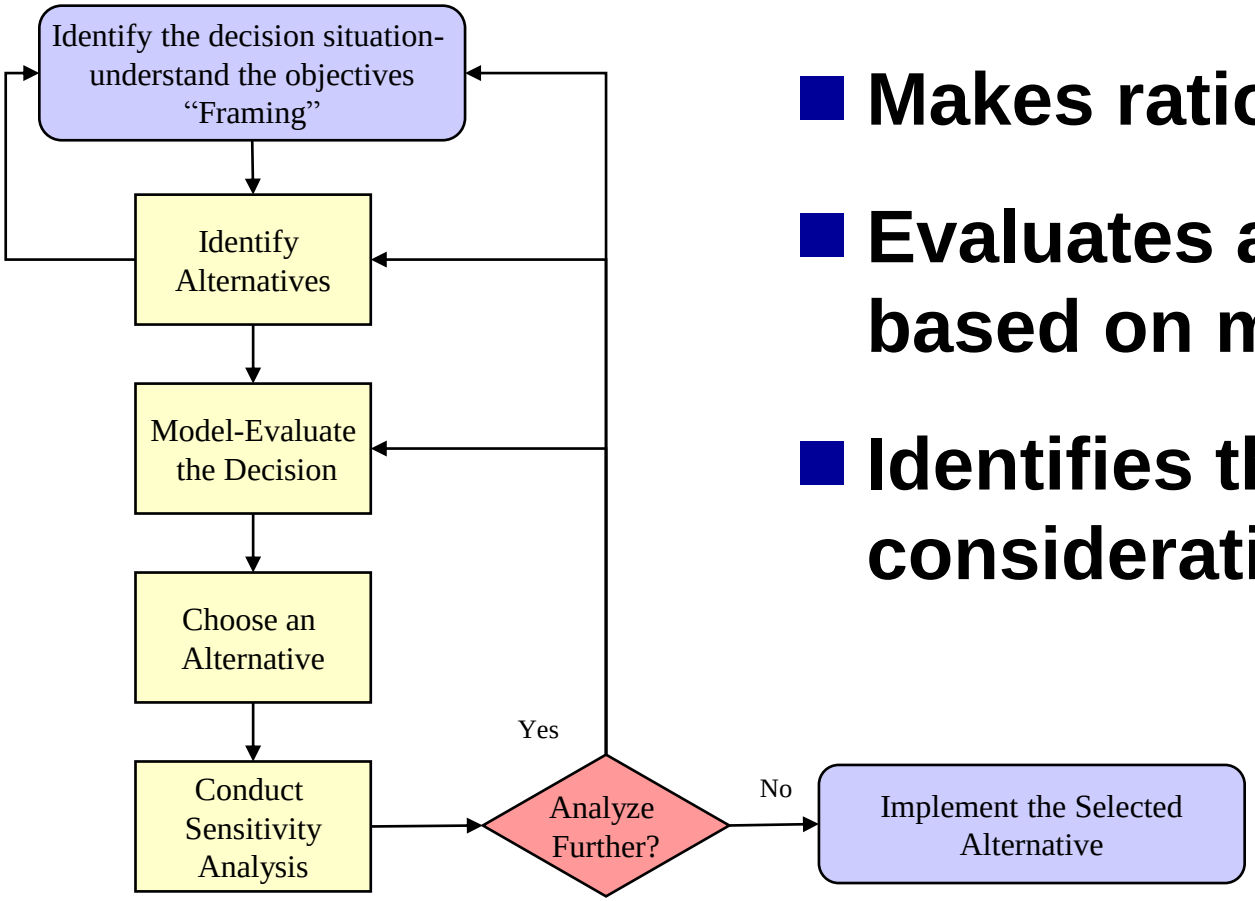
Decomposing Problems and Issues

- How would you approach the project for installing a new flower garden?



Do you see everything as a WBS?

Structured Decision Making



- Makes rational decisions
- Evaluates alternatives based on merit
- Identifies the important considerations

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Accuracy versus Appropriateness

- **Accurate (Verification)**
  - Verification: relates back to the approved requirements set and can be performed at different stages in the life cycle

- **Appropriate (Validation)**
  - Validation: relates back to the Concept of Operations

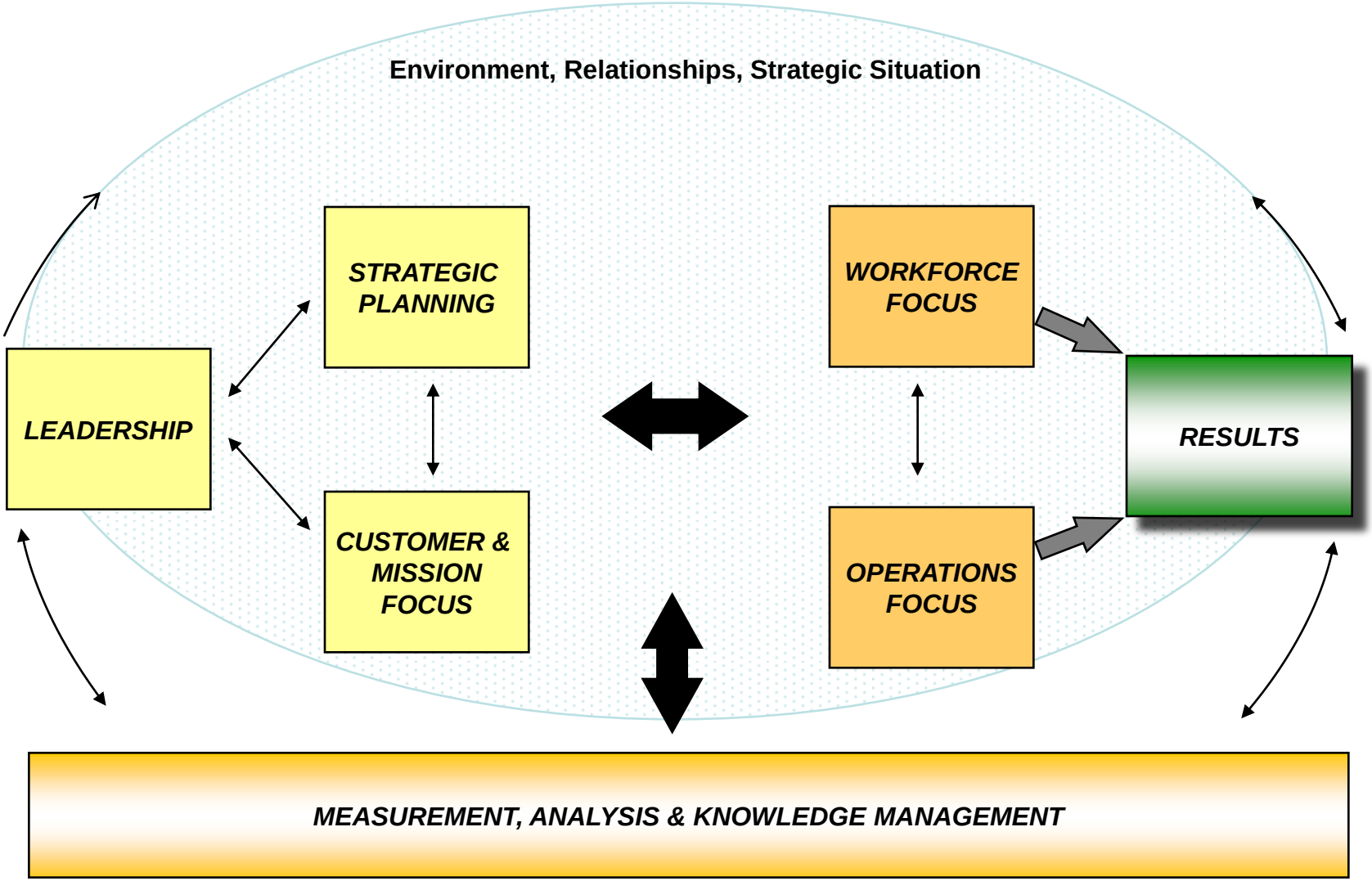
Sensitivity to Risk

- Understands the risk philosophy appropriate to the project
- Adjusts rigors of the process to the need
- Considers the effort to make it work (cost and schedule)

Taking the Long View

- Sees things that that might go wrong in the future
- Avoids, prevents, and prepares to be successful
- Considers Reliability, Maintainability, and Supportability aspects of all decisions.

Case: Applying SE to Organizations



Reference: *Criteria for Performance Excellence*, 2011-2012

Summary

A Way of Thinking

- Recognize the need
- Understand the problem
- Think about potential solutions
- Define the problem
- Make rational decisions
- Implement and prove the solution
- Usability

A Formal Process

- Requirements definition
- Concept of Operations
- Concept and Architecture Development
- Functional Analysis
- Trade-off Analysis
- Integration, Verification, and Validation
- RAM and ILS

So What?

- Great processes do not replace great insight (talent versus dedication)
- Knowing when (and what) to compromise is the part of the ***art*** in Systems Engineering
- People with “the knack” are valuable assets to any project