THINKING OUTSIDE THE BOX – in SYSTEMS ENGINEERING & INTEGRATION

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INCOSE TUTORIAL (1/2 DAY)

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PRIMARY SOURCE

- MUCH OF THE MATERIAL IN THIS TUTORIAL IS FROM DR. EISNER'S BOOK:

- "**MANAGING COMPLEX SYSTEMS - THINKING OUTSIDE THE BOX**", JOHN WILEY, 2005

BRIEF BIO – Dr. Eisner

- Served since 1989 as Distinguished Research Professor and Professor, Engineering Management & Systems Engineering Department, The George Washington University
- Prior 30 years in industry, including President of two systems and software engineering companies
- Life Fellow of IEEE; Fellow of INCOSE and the NYAS
- Member: Tau Beta Pi, Eta Kappa Nu, Sigma Xi, Omega Rho
- Written four books:
- -- Computer-Aided Systems Engineering, Prentice-Hall, 1988
- -- Essentials of Project and Systems Engineering Management, John Wiley, 1997, 2002, 2008
- -- Reengineering Yourself and Your Company, Artech House, 2000
- -- Managing Complex Systems – Thinking Outside the Box, John Wiley, 2005
- BEE – CCNY; MS – Columbia; Doctor of Science - GWU

WHY IS THIS AN ISSUE?

- WE CONTINUE TO HAVE MAJOR PROBLEMS BUILDING AND MANAGING COMPLEX SYSTEMS
- FOR THIS TUTORIAL, OUR EMPHASIS WILL BE ON:
- -- THINKING OUTSIDE THE BOX
- -- THE DOMAINS OF SYSTEMS ENG'G AND SYSTEMS INTEGRATION

TYPICAL COMPLEX SYSTEMS

- -- NORAD AIR DEFENSE
- -- AIR TRAFFIC CONTROL SYSTEM
- -- NATIONAL TELEPHONE SYSTEM
- -- HIGHWAY SYSTEM
- -- NATIONAL AVIATION SYSTEM
- -- SPACE SYSTEMS
- -- NATIONAL MISSILE DEFENSE

COMPLEX SYSTEMS - 1

- FACTORS HIGHLY CORRELATED WITH COMPLEXITY:
- -- SIZE
- -- FUNCTIONALITY
- -- PARALLEL vs SERIAL OPERATION
- -- NUMBER MODES OF OPERATION
- -- DUTY CYCLE

COMPLEX SYSTEMS - 2

- FACTORS (CONTINUED)
- -- REAL-TIME OPERATIONS
- -- VERY HIGH PERFORMANCE
- -- NUMBER/TYPES OF INTERFACES
- -- DEGREE OF INTEGRATION
- -- NON-LINEAR BEHAVIOR
- -- HUMAN-MACHINE INTERACTION

SYSTEMS OF SYSTEMS

- ALMOST ALWAYS ARE ALSO COMPLEX SYSTEMS
- GROWING AS A SEPARATE AREA OF INVESTIGATION AND DISCIPLINE
- EXAMPLE: NATIONAL AVIATION SYSTEM
- LEADING TO “SYSTEM OF SYSTEMS ENGINEERING”

PROBLEM AREAS

- SERIOUS PROBLEMS ARISE IN AT LEAST FOUR KEY AREAS:
- -- SYSTEMS
- -- PEOPLE
- -- SOFTWARE
- -- MANAGEMENT

TOP 5 SYSTEMS ENG'G ISSUES IN DEFENSE INDUSTRY (*)

- 1. LACK OF AWARENESS OF SE
- 2. INADEQUATE RESOURCES
- 3. INSUFFICIENT TOOLS AND ENVIRONMENTS
- 4. POOR REQUIREMENTS ENG'G
- 5. POOR INITIAL PROGRAM FORMULATION
- (*) NDIA Report, January 2003

SYSTEMS ENGINEERING

- DEFINITION:
- **SYSTEMS ENGINEERING IS AN ITERATIVE PROCESS OF TOP-DOWN SYNTHESIS OF A REAL-WORLD SYSTEM THAT SATISFIES, IN A NEAR OPTIMAL MANNER, THE FULL RANGE OF REQUIREMENTS FOR THE SYSTEM**

COMMENTARY - INTEGRATION

- AS AN ELEMENT OF SYS. ENG'G (SE)
- AS PER "SYSTEMS INTEGRATION" AND "SI" COMPANIES & AGENCIES
- SYNTHESIS OF SE AND PM SKILLS
- WHAT IS THE "OPTIMAL" APPROACH TO INTEGRATION OF STOVEPIPES?
- IS IT "STRAIGHTFORWARD" OR "DIFFICULT"?

“INSIDE THE BOX” - 1 WHAT’S OUTSIDE?

- 1. APPROACH 100% INTEGRATION OF ALL STOVEPIPES
- 2. ”BEST OF” BEST OF BREED IS THE OPTIMAL APPROACH
- 3. MEASURE AS MUCH AS YOU CAN THINK OF

“INSIDE THE BOX” - 2 WHAT’S OUTSIDE?

- 4. ADD MORE PEOPLE TO GET BACK ON SCHEDULE
- 5. ACCEPT REQUIREMENTS FROM CUSTOMER AS FIXED AND INVIOLATE
- 6. PROMISE WHATEVER THE CUSTOMER APPEARS TO WANT

"INSIDE THE BOX" - 3 WHAT'S OUTSIDE?

- 7. ALL LEVELS OF MANAGEMENT NEED DOLLAR RESERVES
- 8. DO IT RIGHT THE FIRST TIME (CROSBY - DIRFT)
- 9. GET THE PROCESS RIGHT AND THE PRODUCT WILL ALWAYS BE RIGHT
- 10. DON'T DO WORK UNLESS YOU SEE IMMEDIATE PROFIT FROM IT

"INSIDE THE BOX" – 4 WHAT'S OUTSIDE?

- 11. ALL SYSTEMS SHOULD BE ARCHITECTED USING THE DoDAF APPROACH
- 12. THERE IS NO OVERALL APPROACH (NO SILVER BULLET) THAT WILL 'SOLVE' THE SYSTEM ACQUISITION PROBLEM

THINKING PERSPECTIVES (5 of 9 WAYS TO TOTB)

- 1. BROADEN AND GENERALIZE
- 2. CROSSOVER
- 3. QUESTION CONVENTIONAL WISDOM
- 4. BACK OF THE ENVELOPE
- 5. EXPAND THE DIMENSIONS

THINKING PERSPECTIVES (4 OF 9 WAYS TO TOTB)

- 6. “OBVERSITY”
- 7. REMOVE CONSTRAINTS
- 8. THINKING WITH PICTURES
- 9. THE SYSTEMS APPROACH
- WE WILL LOOK AT EACH OF THESE NINE; RECOMMENDED TOTB

1. BROADEN & GENERALIZE

- THE RAILROADS (Strategic Planning)
- SYSTEM of SYSTEMS ENGINEERING (SoSE)
- SOME EXAMPLES (THEY ALWAYS HELP)
- -- IBM -- MICROSOFT
- -- WANG LABS -- HALOID

1. BROADEN & GENERALIZE (CONTINUED)

- FUNCTIONAL DECOMPOSITION – LOOK SIDEWAYS, UP AND DOWN
- USING FORMAL ALTERNATIVES AS WAY OF ARCHITECTING
- EXAMPLE: FDM OR TDM
- SIMPLY ADD FUNCTIONS – WHAT HAPPENED TO THE PDA/PHONE?

2. CROSSOVER

- BUILD SYSTEM(S) IN ONE DOMAIN; APPLY IN SEVERAL (NOTE EXAMPLES)
- CREATES ENORMOUS "LEVERAGE"
- REUSE - SOFTWARE & SYSTEMS
- DEVELOPER OFF-THE-SHELF
- MODELS & SIMULATIONS
- ACCOUNTING FIRMS

3. QUESTION CONVENTIONAL WISDOM - 1

- HALOID, AGAIN
- NATIONAL MISSILE DEFENSE (Hit a Bullet With a Bullet)
- NORMAN AUGUSTINE
- ROSS PEROT
- DR. DEMING
- (see also next page)

3. QUESTION CONVENTIONAL WISDOM - 2

- STICK TO WHAT YOU KNOW HOW TO DO
- ACCEPT WHAT YOU ARE TOLD, LITERALLY AND PRECISELY
- SMART FOLKS CARE ONLY ABOUT DOING GOOD WORK
- MAXIMIZE INTEGRATION-STOVEPIPES

3. QUESTION CONVENTIONAL WISDOM - 3

- HAS LED TO NEW BUSINESS PARADIGMS, FOR EXAMPLE:
- -- DRUCKER'S MBO
- -- PETERS & WATERMAN
- -- KAPLAN & NORTON (SCORECARD)
- -- GOLEMAN (EMOT. INTELLIGENCE)
- "JAPANESE" STYLE OF MANAGEMENT
- -- SENGE'S FIVE DISCIPLINES

4. BACK OF THE ENVELOPE - 1

- THE CONCEPT: THE SHORT FORM PENETRATING SOLUTION
- USE EXPERIENCE AND INTUITION TO GO QUICKLY TO 1st SOLUTION
- GREAT IDEAS IN PHYSICS
- A SHORT FIVE STEP PROCESS (SEE NEXT PAGE)

4. BACK OF THE ENVELOPE - 2

- A SHORT FIVE STEP PROCESS:
- 1. WHAT IS THE PROBLEM?
- 2. WHAT ARE THE KEY FACTORS, VARIABLES, AND OBSERVABLES?
- 3. WHAT INFERENCES FROM (2)?
- 4. ALTERNATIVE SOLUTIONS?
- 5. BEST SOLUTION?

4. BACK OF THE ENVELOPE (BOTE) - 3

- GREAT IDEAS THAT FIT ON BOTE:
- The earth is not the center of our solar system
- The earth is round rather than flat
- Maxwell's equations
- $E = mc^2$
- Newton's gravitational law
- Information theoretic entropy
- Man can fly, but not like a bumblebee

5. EXPANDING THE DIMENSIONS

- THE 3D SPREADSHEET
- COCOMO 1 ---> COCOMO 2
- A WELL-KNOWN MULTIFUNCTIONAL DEVICE, i.e., THE PDA
- WHERE TO PUT ELEVATORS?
- WHERE TO FLY OUR JETS?
- THE “GRAND UNIFIED THEORY”

6. “OBVERSITY” - 1

- FOCUS ON THE OBVERSE, THE NEGATIVE
- 36 WAYS TO FAIL; 10 SHOWN HERE
- 1. Do Most Everything Ad Hoc
- 2. No Learning From Mistakes
- 3. Always Overpromise & Underdeliver
- 4. Reinvent the Wheel Whenever You Can

6. "OBVERSITY" - 2

- CONTINUING LIST: HOW TO FAIL
- 5. Make Sure to Avoid Focusing

  6. Planning & Action Antithetical; So Stop the Infernal Planning
- 7. Always Make Unrealistic Schedules
- 8. Assume Decomposition Is Correct
- 9. Assume Requirements Are Correct
- 10. No Risk Assessments; No Payoff

7. REMOVE CONSTRAINTS - 1

- NO, IT CAN'T BE DONE (!)
- TYPICAL CONSTRAINTS
- 1. NOT ENOUGH FUNDING
- 2. NOT ENOUGH TIME
- 3. POOR DRIVING REQUIREMENTS
- 4. LACK OF TECHNICAL EXPERTISE
- 5. POOR FACILITIES

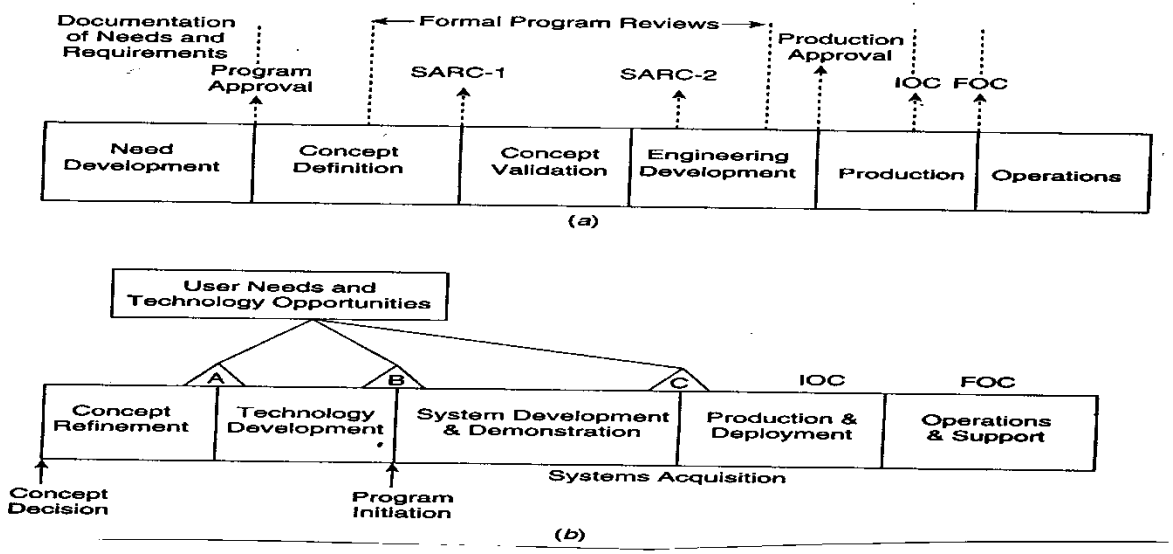
7. REMOVE CONSTRAINTS - 2

- CONTINUE - TYPICAL ISSUES
- 6. PEOPLE NOT TEAM PLAYERS
- 7. INSUFFICIENT FINANCIAL INFORMATION
- 8. NO SUPPORTING TOOLS
- 9. NEGATIVE ATTITUDES
- 10. WRONG-HEADED CUSTOMERS

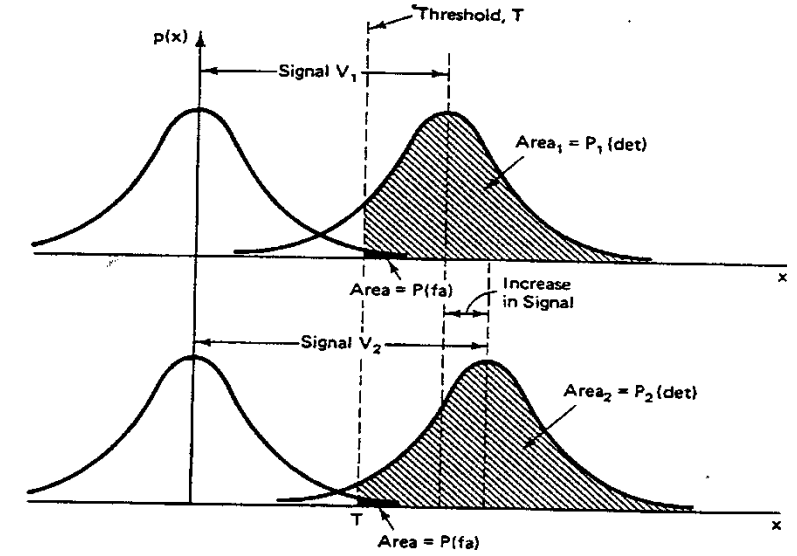
8. THINKING WITH PICTURES

- ARNHEIM (1969)
- “Visual Perception Is a Cognitive Activity”
- DATA FLOW/FLOWCHARTS
- NUMEROUS DIAGRAMMING METHODS
- SE MODELING
- DEFENSE ACQUISITION (next slide)

ACQUISITION "PICTURES"



"VIEWS" - DETECTION AND FALSE ALARMS



Detection and false-alarm probability examples.

9. THE SYSTEMS APPROACH - 1

- 1. A SYSTEMATIC & REPEATABLE PROCESS
- 2. CONFIRMS INTEROPERABILITY
- 3. A COST-EFFECTIVE SOLUTION TO CUSTOMER'S PROBLEM
- 4. FULL CONSIDERATION OF ALTERNATIVES
- 5. USES ITERATION TO CONVERGE AND REFINE
- 6. LEADS TO SATISFACTION OF ALL FINAL REQUIREMENTS
- 7. LEADS TO A ROBUST SYSTEM

9. THE SYSTEMS APPROACH - 1

- SOME EXAMPLES:
- 1. BOEHM, Response Time Trades
- 2. EISNER, Clock Time Problem
- 3. EISNER, Architecting Alternatives
- 4. LOOKING AT A COMPLETELY DIFFERENT SYSTEM ACQUISITION PROCESS (2500% GAIN!?)

WHAT MIGHT BE YOUR TENDENCIES?

- TEND TO THINK OUT OF THE BOX NOW?
- DON'T LIKE TO STICK YOUR NECK OUT?
- PERSISTENCE?
- A QUESTIONNAIRE (27 PAIRS)

THINKING IN GROUPS - 1

- WHY IS THIS IMPORTANT?
- THE DELPHI PROCESS
- GROUPTHINK - The Abilene Paradox
- KENNEDY'S 5 CHANGES (Bay of Pigs):
- 1. Participants are Skeptical Generalists
- 2. Bobby/Sorenson as Intellectual Watchdogs
- 3. Task Forces Give Up Formalities
- 4. Subgroups Explore Additional Alternatives
- 5. He Avoided Early Meetings and Debates

THINKING IN GROUPS - 2

- De BONO'S 6 THINKING HATS
- ADVOCACY vs INQUIRY
- SYNTEGRITY (Stafford Beer)
- FACILITATION
- SYNECTICS
- ARE YOU PART OF A FUNCTIONAL OR DYSFUNCTIONAL GROUP?

WIDENING THE CIRCLE

- LATERAL THINKING - de BONO
- TRIZ
- ACKOFF'S FABLES
- HBR - BREAKTHROUGH THINKING
- WHAT WERE SOME OF THE LEGENDS TELLING US? (e.g., Einstein, Descartes, Edison…)

THOUGHTS OF INTEREST

- **EINSTEIN**
- "Things should be made as simple as possible, but no simpler"
- Use a minimum number of primary concepts and relationships
- Comfortable with "breaking the rules"
- **DESCARTES**
- Divide "difficulties" into parts; examine each part
- Absolute belief in the power of thinking
- **EDISON**
- It's all about 1% inspiration and 99% perspiration…

THE INVENTIVE MIND - 1

- CONSISTENTLY USE APPROACHES THAT ARE “OUTSIDE THE BOX”
- ARE EXCELLENT AT “SYNTHESIS”
- CAN SEE DIRECTIONS FOR A SOLUTION THAT OTHERS CAN’T SEE
- CONTINUOUSLY ASK “WHAT IF”
- ARE OPEN TO CHANGE

THE INVENTIVE MIND

- MANAGEMENT
- -- DRUCKER
-
- -- XEROX MANAGEMENT
- -- DEMING
- -- WELCH
- -- DRUCKER

- SCIENTIFIC
- -- EDISON
- -- EINSTEIN
- -- NEWTON
- -- GALILEO
- -- MAXWELL
- -- WRIGHT BROS.

SUMMARY - 1

- SUGGESTED CORE COMPETENCIES FOR "MANAGING COMPLEX SYSTEMS":

"MANAGING COMPLEX SYSTEMS":

- 1. SYSTEMS ENGINEERING
- 2. PROJECT MANAGEMENT
- 3. THINKING OUTSIDE THE BOX

BASE IN SYSTEM TECHNOLOGY AREAS

PLUS

BASE IN SYSTEM TECHNOLOGY AREAS COMPETENCY AND KNOWLEDGE

SUMMARY - 2

- 6 AREAS -IMMEDIATE APPLICATION:
-
- 2. REQUIREMENTS ANALYSIS
- 1. INTEGRATION OF STOVEPIPES
- 2. REQUIREMENTS ANALYSIS
- 3. SYSTEMS ARCHITECTING
- 4. SYSTEM MEASUREMENT
  - 5. CONSIDERATION OF ALTERNATIVES

SUMMARY - 3

- NEW WAYS OF THINKING CAN BE ENERGIZING
- NEW WAYS OF THINKING WILL
  - NEW WAYS OF THINKING CAN BE
- COMMITMENTS TO MAKE CHANGES (BUT IN SPECIFIC WAYS)
- NEW WAYS OF THINKING WILL