EXPERT PANEL Q&A SESSION

INCOSE CROSSROADS OF AMERICA CHAPTER MEETING

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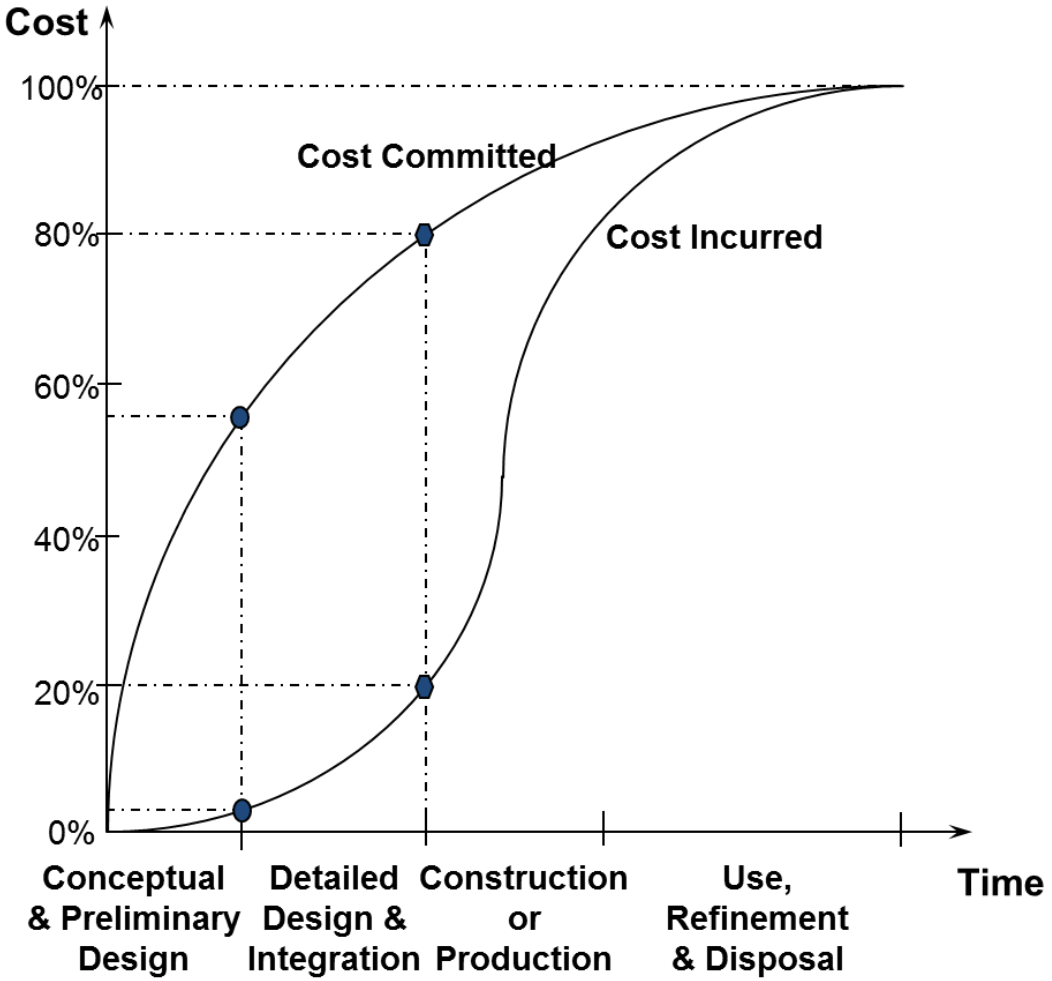
VALUE OF SE

HOW WOULD YOU ARTICULATE THE VALUE OF USING A SYSTEMS ENGINEERING APPROACH?

THE COST IMPLICATIONS OF DECISIONS EARLY IN THE LIFE CYCLE

FIGURE 1.2. BASED ON PRANG, J. (1992). CONTROLLING LIFE-CYCLE COSTS THROUGH CONCURRENT ENGINEERING IN ADDENDUM TO THE ATE & INSTRUMENTATION CONFERENCE PROCEEDINGS, P. 1. MILLER-FREEMAN, ANAHEIM, CA



From D. M. Buede, *The engineering design of systems: models and methods*.

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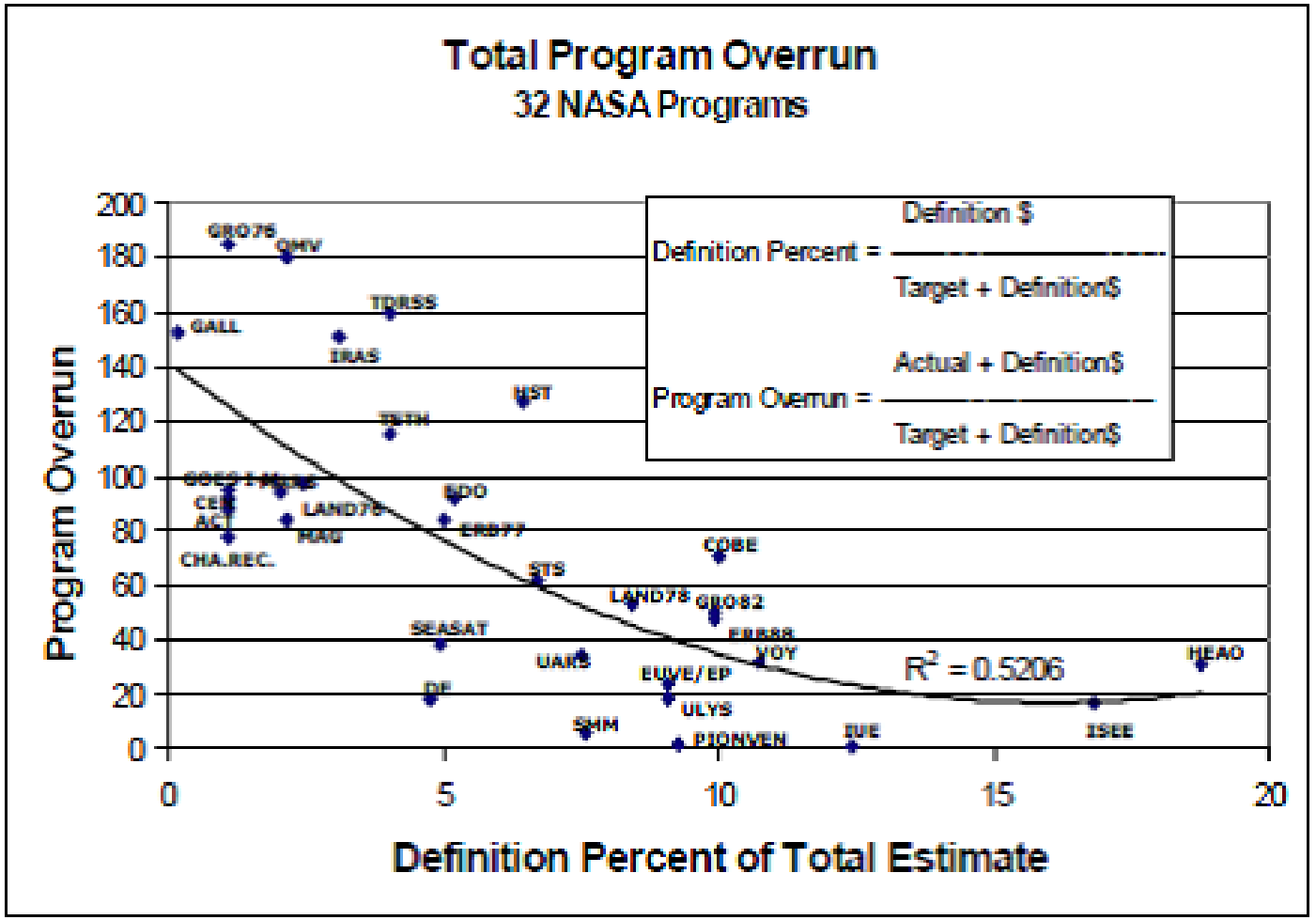
SUMMARY OF ENGINEERING SUCCESS AND FAILURE

TABLE 16.1. BASED ON COOK, J. (2000). WHAT THE LESSONS FROM LARGE, COMPLEX TECHNICAL PROJECTS TELL US ABOUT THE ART OF SYSTEMS ENGINEERING. INCOSE SYMPOSIUM

UK Ministry of Defence	UK Civil Information Technology	US Civil Information Technology
Top 25 programs slipped 35-40 mos. on average	10-20% met success criteria	16% project success
10% of projects missed key technical requirements	40-50% late, over-budget, or did not meet technical goals	53% project challenged
	40% failed or were abandoned	31% project cancelled

HOW MUCH TO SPEND ON DEFINING THE SYSTEM

INCREASING RETURNS EVIDENT WHEN EXPENDING UP 10-15% OF THE TOTAL PROGRAM BUDGET DURING THE LATE-CONCEPT AND EARLY-DEVELOPMENT PHASES



From Honour, Eric C. 2013. *Systems engineering return on investment*, School of Electrical and Information Engineering, University of South Australia. Based on Gruhl, W. 1992. Lessons learned, cost/schedule assessment guide. *Internal presentation, NASA Comptroller's Office*.

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SYSTEMS ENGINEERING RETURN ON INVESTMENT

FROM HONOUR, ERIC C. 2013. "SYSTEMS ENGINEERING RETURN ON INVESTMENT." PHD DISS. UNIVERSITY OF SOUTH AUSTRALIA.

- Return on investment for systems engineering effort
  - 7:1 for programs expending little to no systems engineering effort
  - 3.5:1 for programs expending a median level of systems engineering effort
- Correlation was found between systems engineering effort levels and program success measures of cost compliance, schedule compliance, and stakeholder satisfaction
- No correlation was found between systems engineering effort levels and system technical quality

MINIMALIST SE

HOW WOULD YOU DO AN EFFECTIVE BUT MINIMALIST SE APPROACH TO A DESIGN WITH A VERY LIMITED BUDGET?

SOFT SYSTEMS METHODOLOGY

- Developed by INCOSE Pioneer Peter Checkland and colleagues
- Adaptation of “hard” systems engineering
  - Note how steps 1 to 6 form a Vee
- Excellent “how to” resource
  - Burge, Stuart. 2015. “An Overview of Soft Systems Methodology.” http://www.burgehugheswalsh.co.uk/Uploaded/1/Documents/Soft-Systems-Methodology.pdf

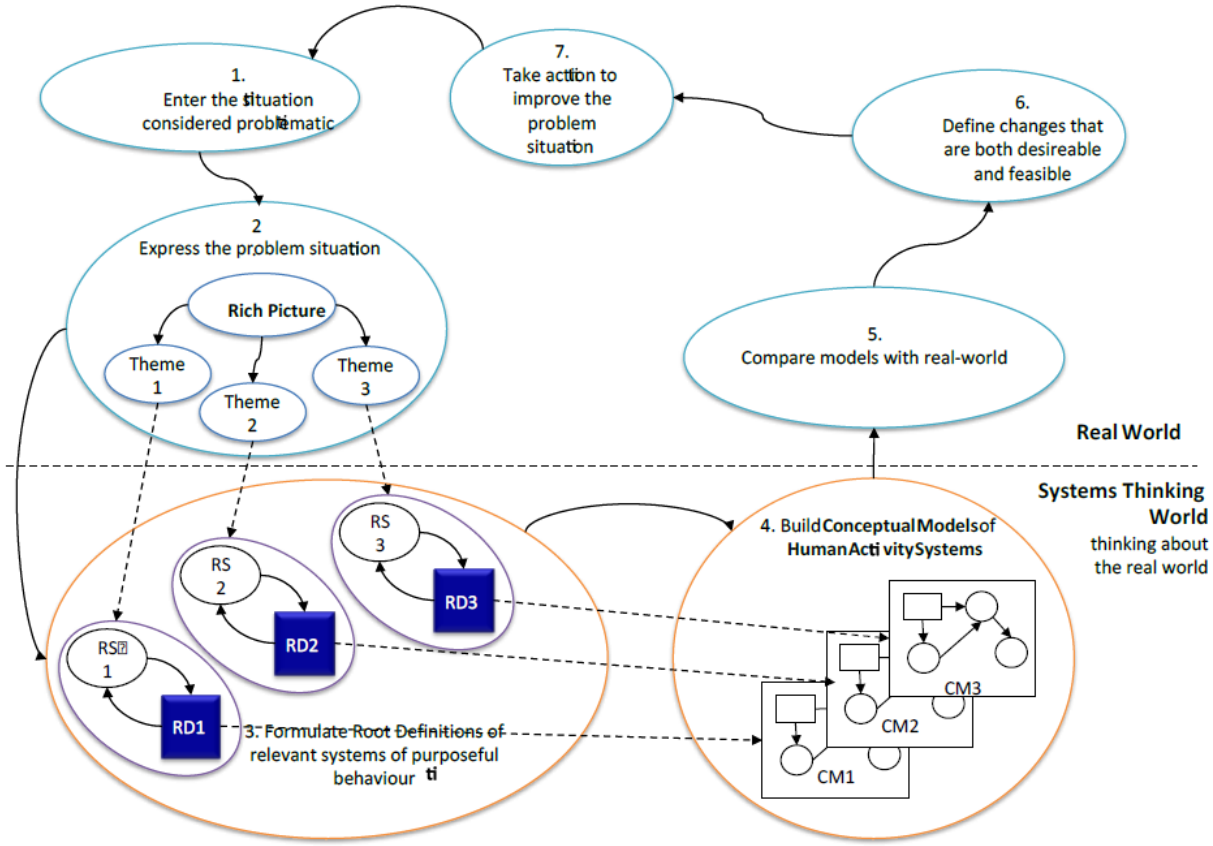

Figure 1: The 7 Step Soft Systems Methodology

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SOFT SYSTEMS METHODOLOGY

SSM Step	Topic	Sponsor Participation
1	Description of the Situation Considered Problematical	Required
2	Expression of the Situation as a Rich Picture	Optional
3a	Identification of the Relevant Purposeful Activity Systems	Optional
3b	Root Definitions of the Relevant Purposeful Activity Systems	Optional, but an opportunity to add value
4	Conceptual Models of the Relevant Systems (Holons) Named in the Root Definitions	Optional
5	Comparison of Models and the Real World	Optional, but an opportunity to add value
6	Identification of Changes	Required

SOME QUESTIONS FOR THE PROJECT SPONSOR

SSM STEP 1

- What are the things that you need to solved or improved?
- Who are some of the stakeholders in these categories?
  - Direct beneficiaries
  - Bosses
  - Colleagues
  - Employees
  - General public
- Are there other stakeholders who do not fit in these categories?
- How do the stakeholders get along? Do they have conflicting values or desires?
- What are some issues or roadblocks that you are facing?
- Is there some past history that indicates certain approaches are doomed to failure?

EXPRESSION OF THE SITUATION AS A RICH PICTURE

SSM STEP 2

- Group activity to develop rich pictures
  - Ask the group to note all physical entities involved, for example, the critical people, organizations, or aspects of the landscape
  - Develop the rich picture by describing the key elements and key linkages between them
  - Check that these things have been captured in the picture
    - Structures
    - Processes
    - Climate
    - People
    - Issues expressed by people
    - Conflicts

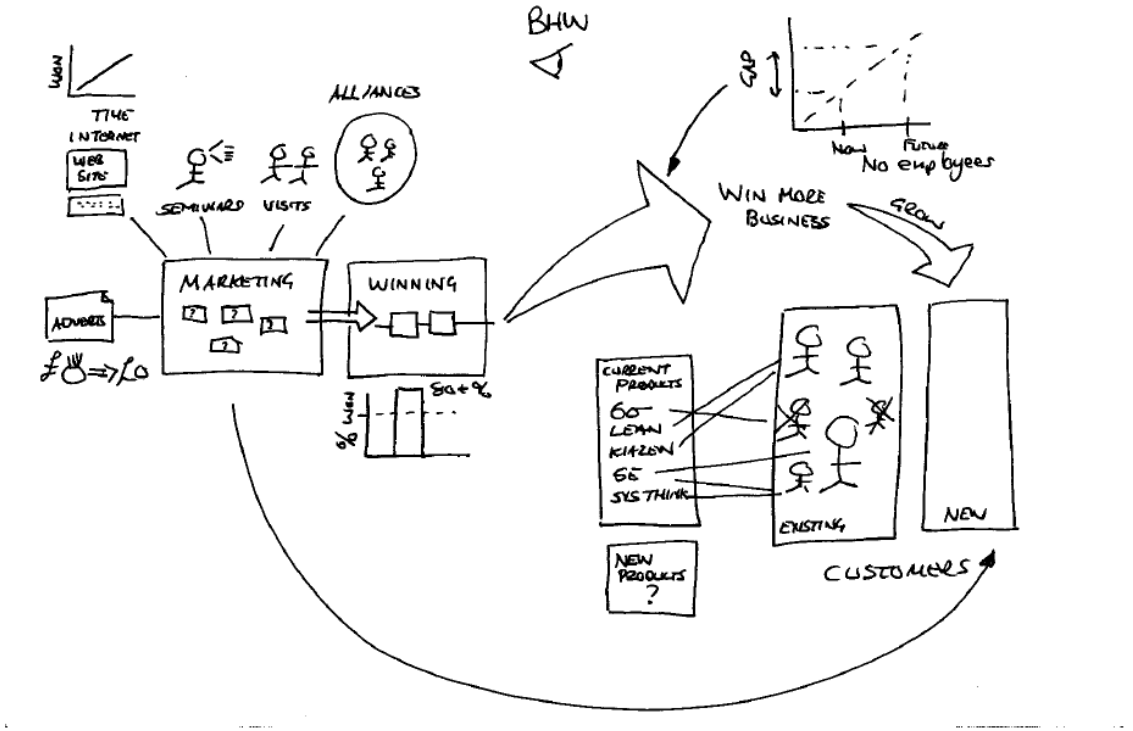

Figure 2: Win More Business Rich Picture.

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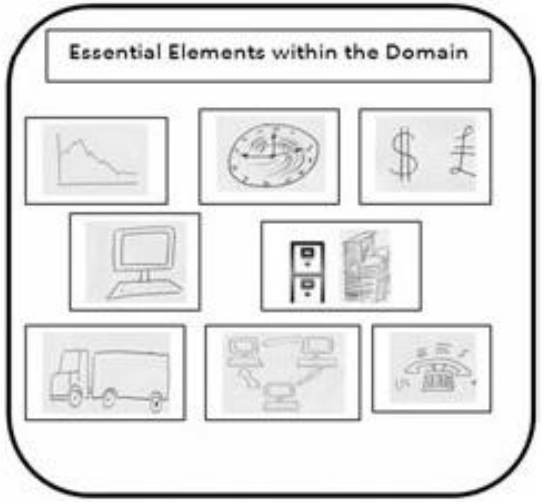
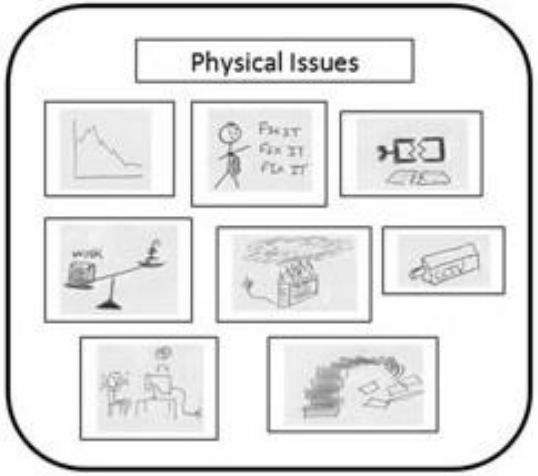
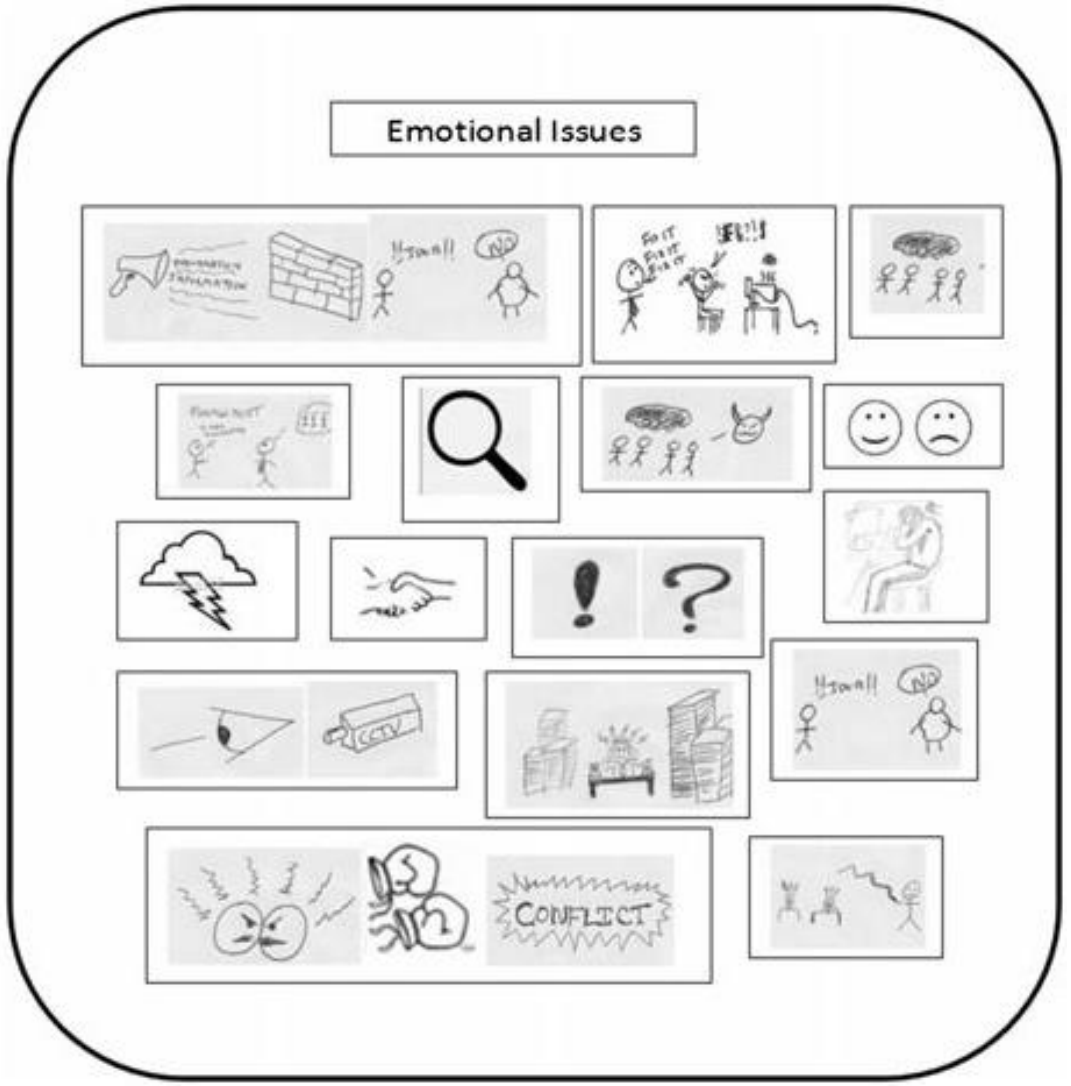
ICONOGRAPHY FOR RICH PICTURES

BERG, TESSA, AND ROB POOLEY. 2013. "CONTEMPORARY ICONOGRAPHY FOR RICH PICTURE CONSTRUCTION." *SYSTEMS RESEARCH AND BEHAVIORAL SCIENCE* NO. 30 (1):31-42.







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GENERIC ACTIVITES

SSM STEPS 3A TO 6

Prepare in advance for group work

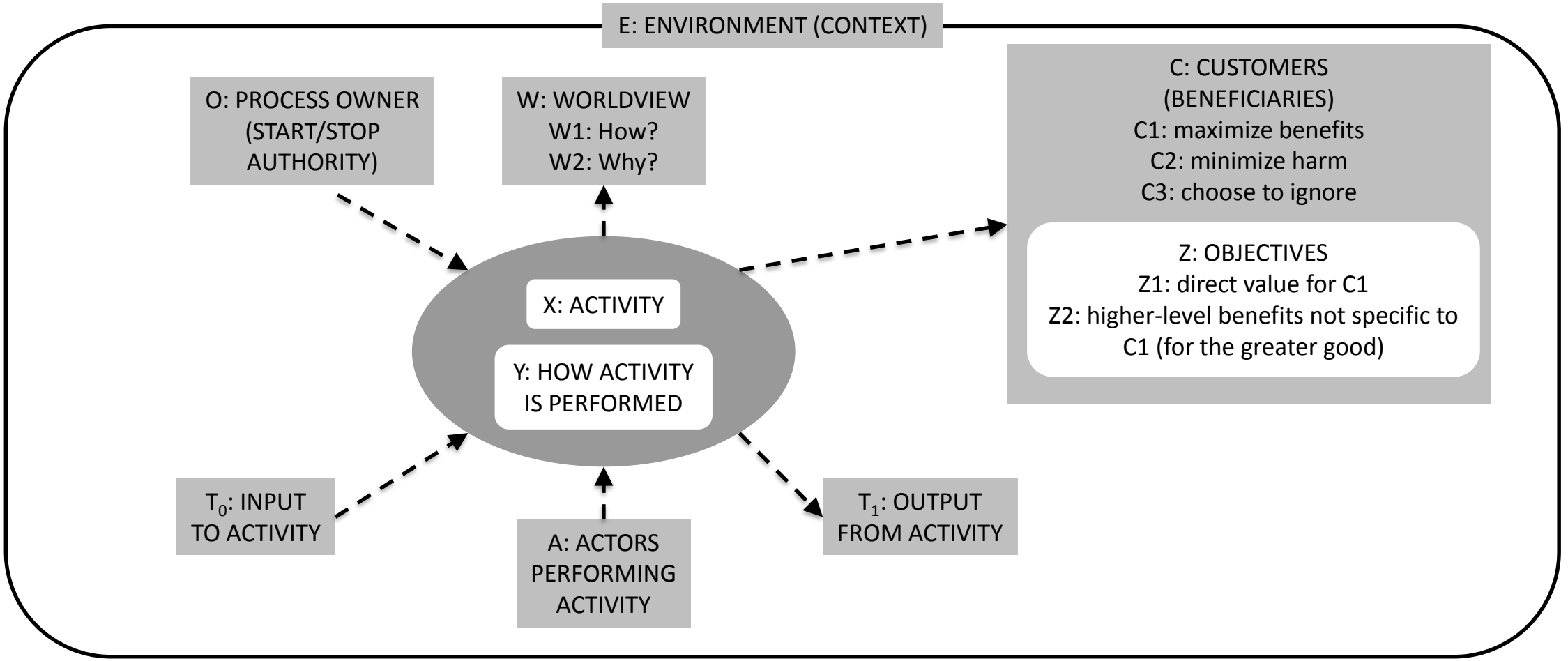
- Before plenary session, everyone needs to spend some time on generating data and concepts based on templates
- Research shows that creative ideas are best developed as individuals rather than in a group
- Bring your laptops with your filled-in templates to plenary session

Work as a group after preparing

- Decide if one participant should act as moderator
  - What is the moderator's role?
  - Can the moderator contribute ideas or just facilitate?
- Appoint someone to act as the "secretary" to capture the group's consensus root definitions
  - Ideally, the secretary should will be able to start with their template on their laptop and modify
- Each group member shares with team that they developed before the session
  - Be sure everyone shares their data or concepts at least once
  - As teammates are sharing their material, the moderator helps the group decide on the consensus for the group and the secretary records the result on their laptop
  - 30-40 minutes for a group of 6-8 it not unreasonable
- Be honest about how much advanced preparation you did before the plenary session

STEP 3B TEMPLATE: RELEVANT PURPOSEFUL ACTIVITY THAT PROVIDES VALUE

ADAPTED FROM EMES, M. R., P. A. BRYANT, M. K. WILKINSON, P. KING, A. M. JAMES, AND S. ARNOLD. 2012. "INTERPRETING "SYSTEMS ARCHITECTING"." SYSTEMS ENGINEERING 15 (4): 369-395.



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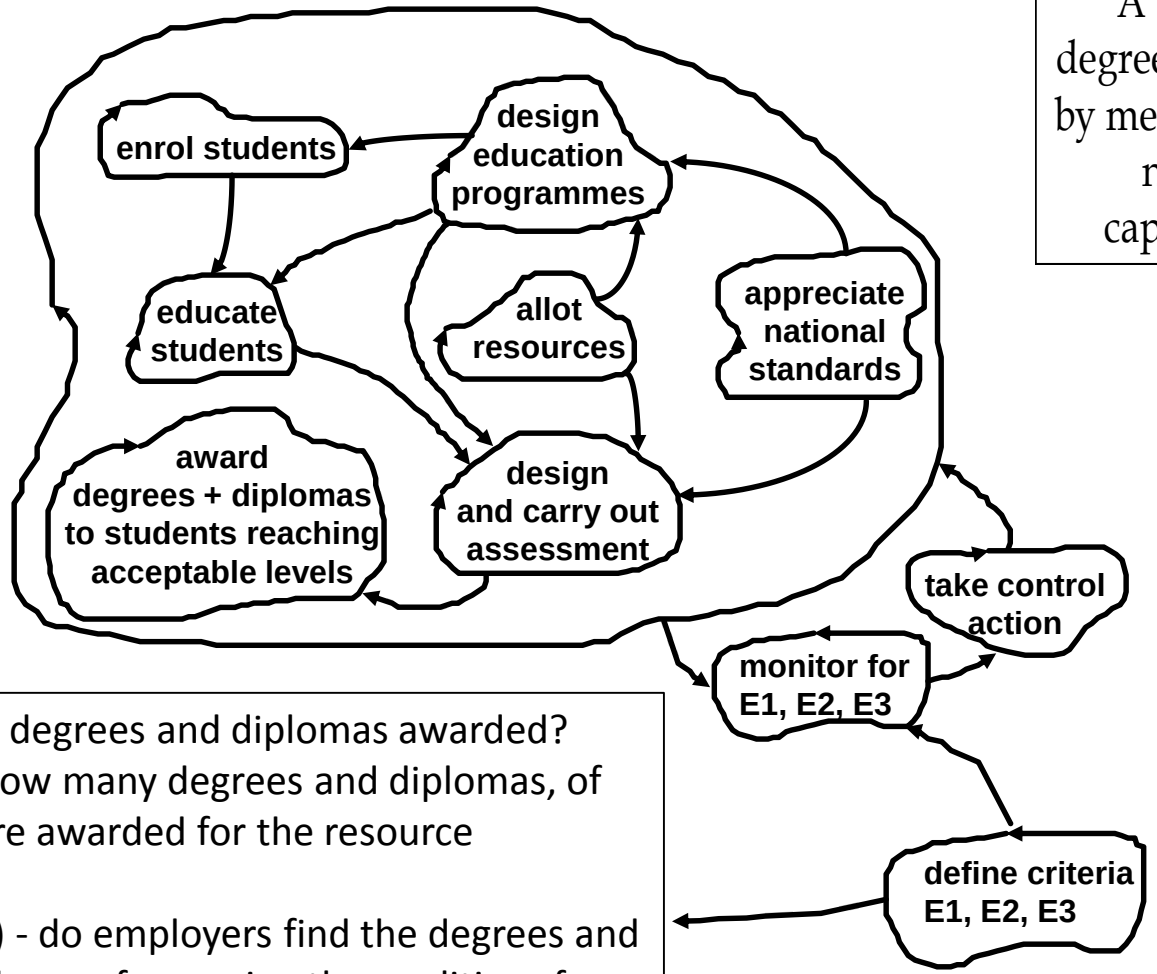
STEP 3B TEMPLATE TERMINOLOGY

- C: Customers (Beneficiaries) = C1 U C2 U C3
  - C1: we want to maximize benefits relative to detriments for them
  - C2: we want to minimize the harm to them
  - C3: we choose simply to ignore them
- A: The doer of the activity
- T: Transformation
  - X: the doing activity (one of the 8 agreed purposeful activities)
  - T_0: input to doing activity
  - T_1: output of doing activity
  - Y: means by which transformation is achieved
- W = Worldview = W1 U W2
  - W1— How? Belief that A doing X by Y under the authority of O in context E will enable T_0 to be transformed to T_1.
  - W2—Why? Belief that transforming T_0 to T_1 in context E will enable higher-level objectives Z to be achieved benefiting customers C
  - Z = Z1 U Z2
  - Z1: direct value for beneficiaries C1
  - Z2: additional higher-level benefits Z2 not specific to C1 (for the greater good)
- O: authority that makes go / no-go decisions
- E: Environment — ethical limits, regulations, financial constraints, resource limitations

STEP 4: CONCEPTUAL MODEL EXAMPLE 1

IMRAN. "WHAT IS SYSTEMS ANALYSIS?" BCS, THE CHARTERED INSTITUTE FOR IT. HTTP://BCSNOTES.WEEBLY.COM/UPLOADS/3/9/2/6/3926851/SSM.PPT



A university owned and operated system to award degrees and diplomas to suitably qualified candidates (X), by means of suitable assessment (Y), (in conformance with national standards), in order to demonstrate the capabilities of candidates to potential employers (Z).

C	candidate students
A	university staff
T	candidate students → degree holders and diplomates
W	the belief that awarding degrees and diplomas is a good way of demonstrating the qualities of candidates to potential employers
O	the University governing body
E	national educational and assessment standards

E1 (efficacy) - are degrees and diplomas awarded?
E2 (efficiency) - how many degrees and diplomas, of what standard, are awarded for the resource consumed?
E3 (effectiveness) - do employers find the degrees and diplomas a useful way of assessing the qualities of potential employees?

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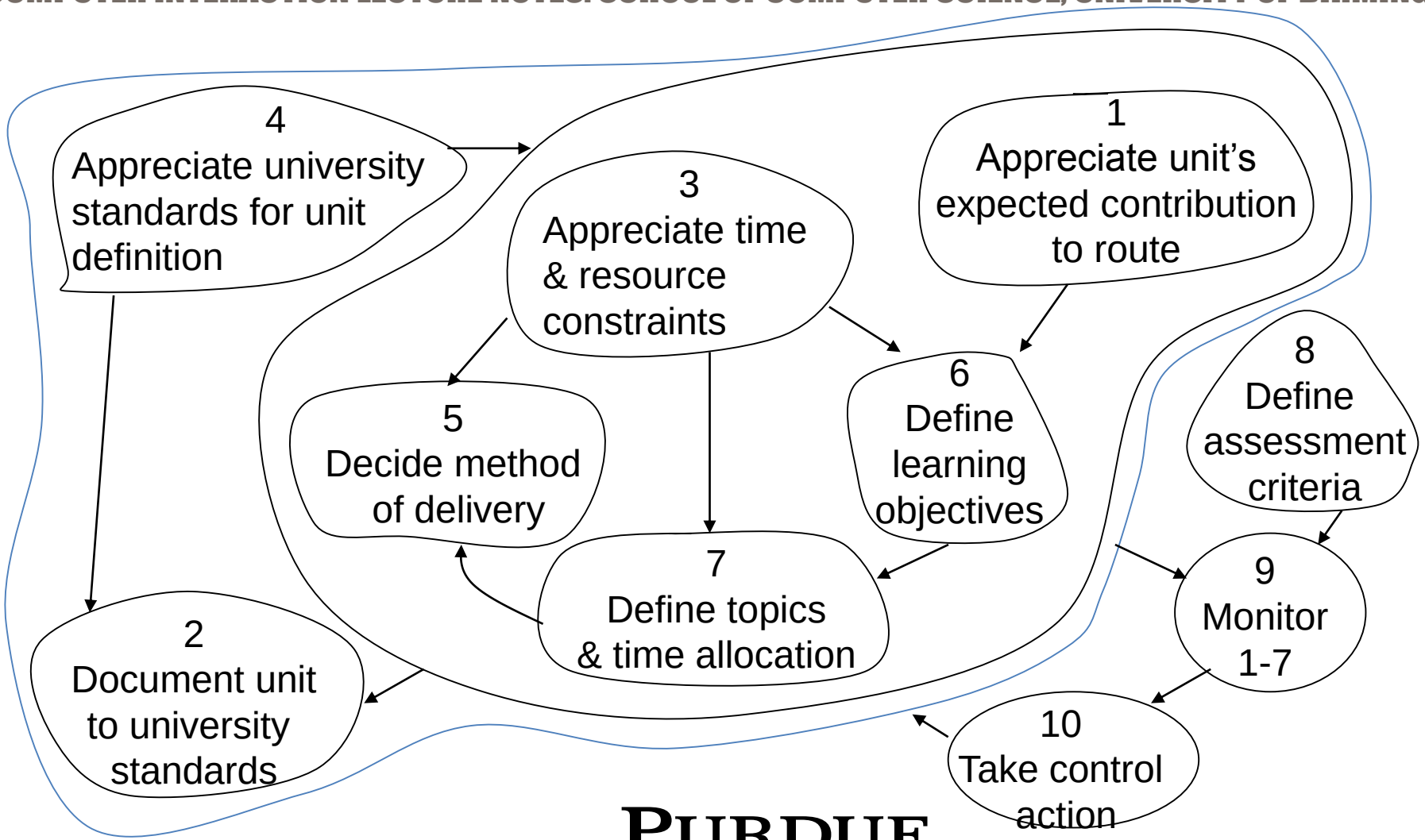
STEP 4: CONCEPTUAL MODEL EXAMPLE 2

FROM DIX, ALAN. "LECTURE 19: SOCIO-ORGANIZATIONAL ISSUES AND STAKEHOLDER REQUIREMENTS –PART 2." CSC 252 HUMAN-COMPUTER INTERACTION LECTURE NOTES. SCHOOL OF COMPUTER SCIENCE, UNIVERSITY OF BIRMINGHAM, UK



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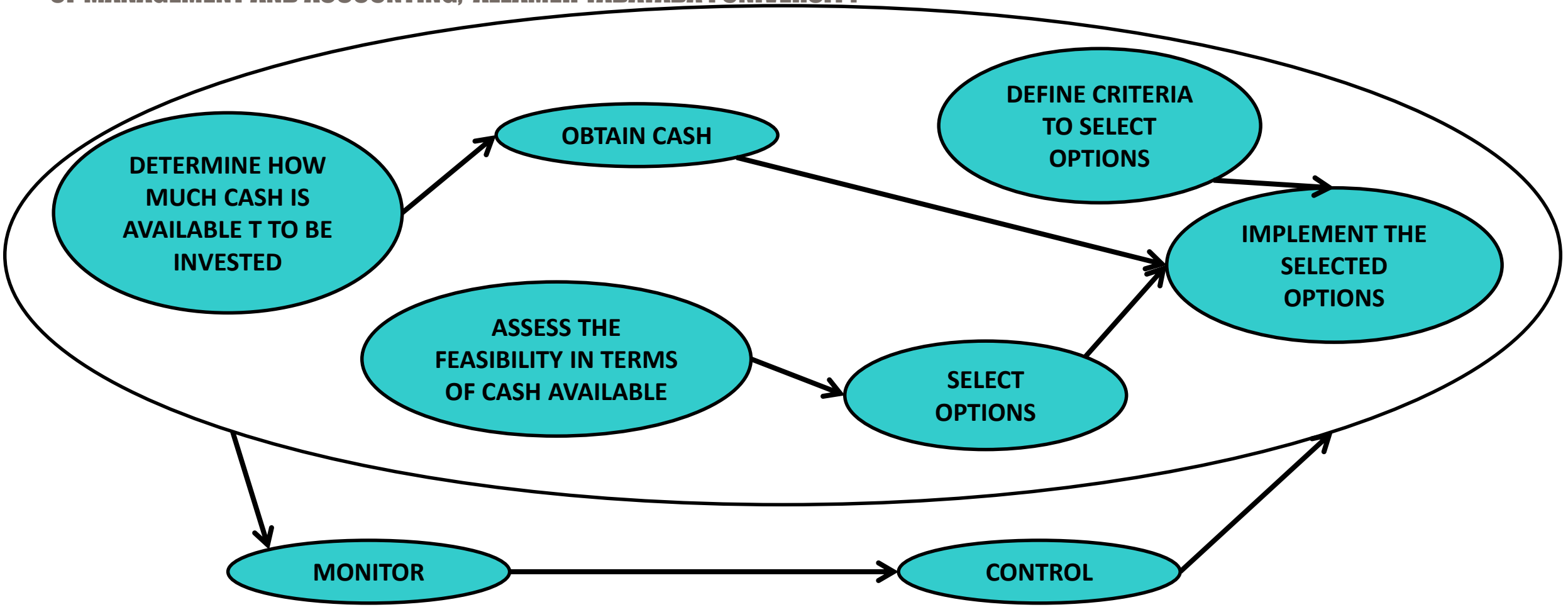
STEP 4: CONCEPTUAL MODEL EXAMPLE 3

HANAFIZADEH , PAYAM FROM " APPLICATION OF SOFT SYSTEMS METHODOLOGY IN SOLVING REAL WORLD PROBLEMS" FACULTY OF MANAGEMENT AND ACCOUNTING, ALLAMEH TABATABA'I UNIVERSITY



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STEP 5: BURGE COMPARISON MATRIX EXAMPLE

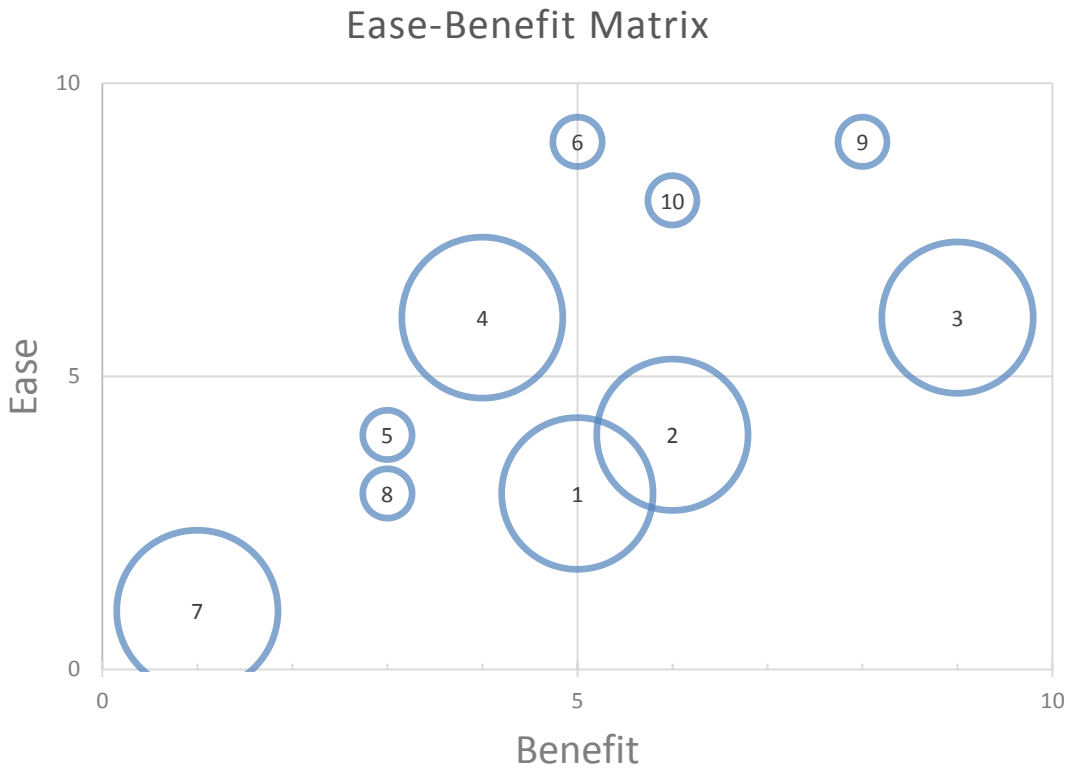
Conceptual Model Activities	Real World	What could we do
Identify potential/ current customers & understand their needs	Performed on an ad hoc basis by the partners. No real systematic approach to identifying potential customers and elicitation of needs	1. Design develop and implement a more systematic approach
Review current product/service portfolio	Portfolio developed on an as requested basis. No overarching strategy for product or service offerings	2. Establish a formal review process with in each business area and across the company as a whole
Create marketing material of products and services	Created on an as required basis. No consistent format, approach or message.	3. Agree a standard format for marketing material and develop materials for all current products and services
Develop new products and services	Performed on an as required basis for prospective customers	4. Establish business area planning for new products and services
Define unique competitive advantage for Company	Endless debates about what is unique about the company. It clearly is unique as our client base comprises mainly large multi-national companies or government organizations	5. Seek advice and guidance on how to define and agree our unique competitive advantage
Assess Competition	No systematic analysis performed	6. Don't bother – if our products and services are okay clients will come OR 7. Undertake a detail competition assessment exercise
Identify routes to market for each customer (strategy)	To date a rather random approach	8. Perhaps need guidance on what is possible
Performing marketing activity to strategy	Not done – marketing passive	Do it!
Monitor Operational activities	Established quarterly marketing meetings	9. Make this element a formal item on the Meeting Agenda
Take Control Action	Nothing	10. Use the Marketing meeting actions to drive the control action

STEP 5: BURGE EASE-BENEFIT MATRIX EXAMPLE

The Matrix

Change	Benefit	Ease	Resources
1	5	3	8
2	6	4	8
3	9	6	8
4	4	6	9
5	3	4	1
6	5	9	1
7	1	1	9
8	3	3	1
9	8	9	1
10	6	8	1

Bubbles Sizes Proportional to Resources



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VERIFICATION AND VALIDATION

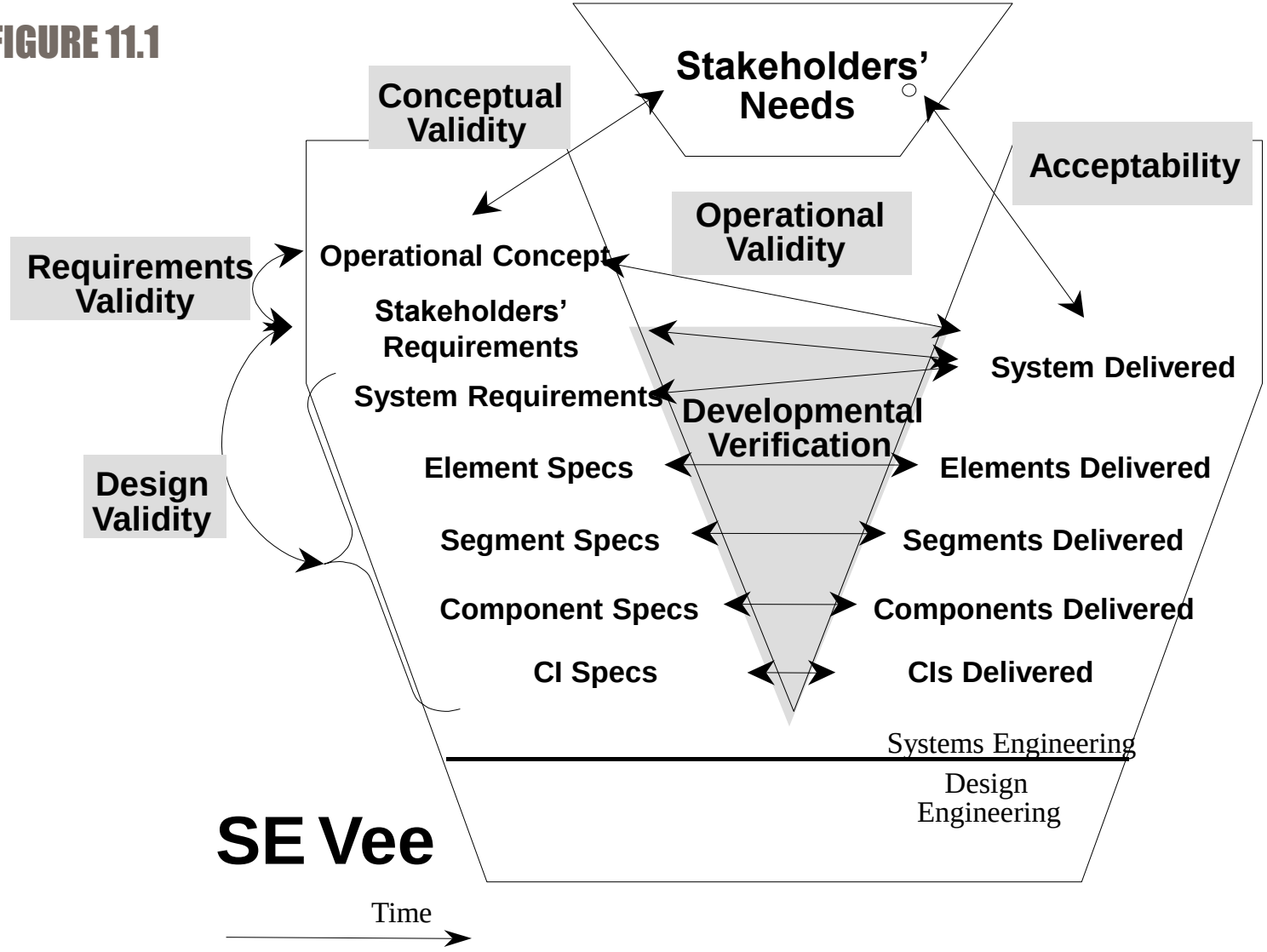
WHAT'S THE DIFFERENCE AND DOES IT MATTER?

DEFINITIONS

- *Integration*
  - Process of assembling system from its components
- *Qualification*
  - Process of verifying and validating system design and then obtaining the stakeholders' acceptance of the design
    - Verification determines that the system was built right
    - Validation determines that the right system was built
    - Acceptance determines that the system is acceptable to be operated by the end users

VERIFICATION, VALIDATION AND ACCEPTANCE

FIGURE 11.1



From D. M. Buede, *The engineering design of systems: models and methods*. © 2016 John Wiley & Sons, Inc.

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BOTTOM-UP INTEGRATION

ADVANTAGES AND DISADVANTAGES

Advantages

- Easier to detect flaws in tiniest pieces of system
- Test conditions easier to create
- Observation of test results easier

Disadvantages

- “Scaffold” systems must be produced to support pieces as they are integrated
- System’s control structure cannot be tested until the end
- Major errors in system design typically not caught until the end
- System does not exist until last integration test is completed
- Requires a hierarchical system architecture

TOP-DOWN INTEGRATION

Approach

- Integration begins with a major or top-level module that invokes “stubs” (shell or model replica) that simulate lower level modules.
- Once top-level module is qualified, actual modules replace stubs until entire system is qualified.

Advantages

- Early demonstration of the system allowed
- Representation of test cases easier
- More productive if major flaws occur toward the top of system
- Most useful for systems using large amounts of pre-existing commercial-off-the-shelf software

Disadvantages

- Stubs have to be developed
- Representation of test cases in the stubs may be difficult
- Observation of test output may be artificial and difficult
- Requires a hierarchical system architecture
- Difficult to accomplish for systems with hardware, people, and facilities

BIG-BANG INTEGRATION

Approach

- Untested CIs are assembled when available and combination is tested

Advantage

- Immediate feedback on status of system elements is provided
- Little or no pretest planning required
- Little or no training required

Disadvantage

- Source of errors difficult to trace
- Many errors never detected

QUALIFICATION METHODS

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QUALIFICATION REQUIREMENTS

FOUR ELEMENTS OF QUALIFICATION REQUIREMENTS

- *Observance methods*: how qualification data for each input/output and system-wide suitability requirement will be obtained. There are four methods for obtaining qualification data:
  1. Analysis (includes simulation)
  2. Demonstration
  3. Inspection
  4. Test
- *Verification plan*: how the qualification data will be used to determine that the real system conforms to the design that was developed
- V*alidation plan*: how the qualification data will be used to determine that the real system complies with the stakeholders' requirements
- A*cceptance plan*: how the qualification data will be used to determine that the real system is acceptable to the stakeholders

QUALIFICATION REQUIREMENTS

CONSEQUENCES OF QUALIFICATION PLANNING

- Discovery that different stakeholders may have different concepts of what is an acceptable qualification method
- The tradeoffs between the costs of using different qualification methods are illuminated
- Deeper understanding of the intent of the requirements
  - Requirements may need revision
  - Operational scenarios and system function may need revision