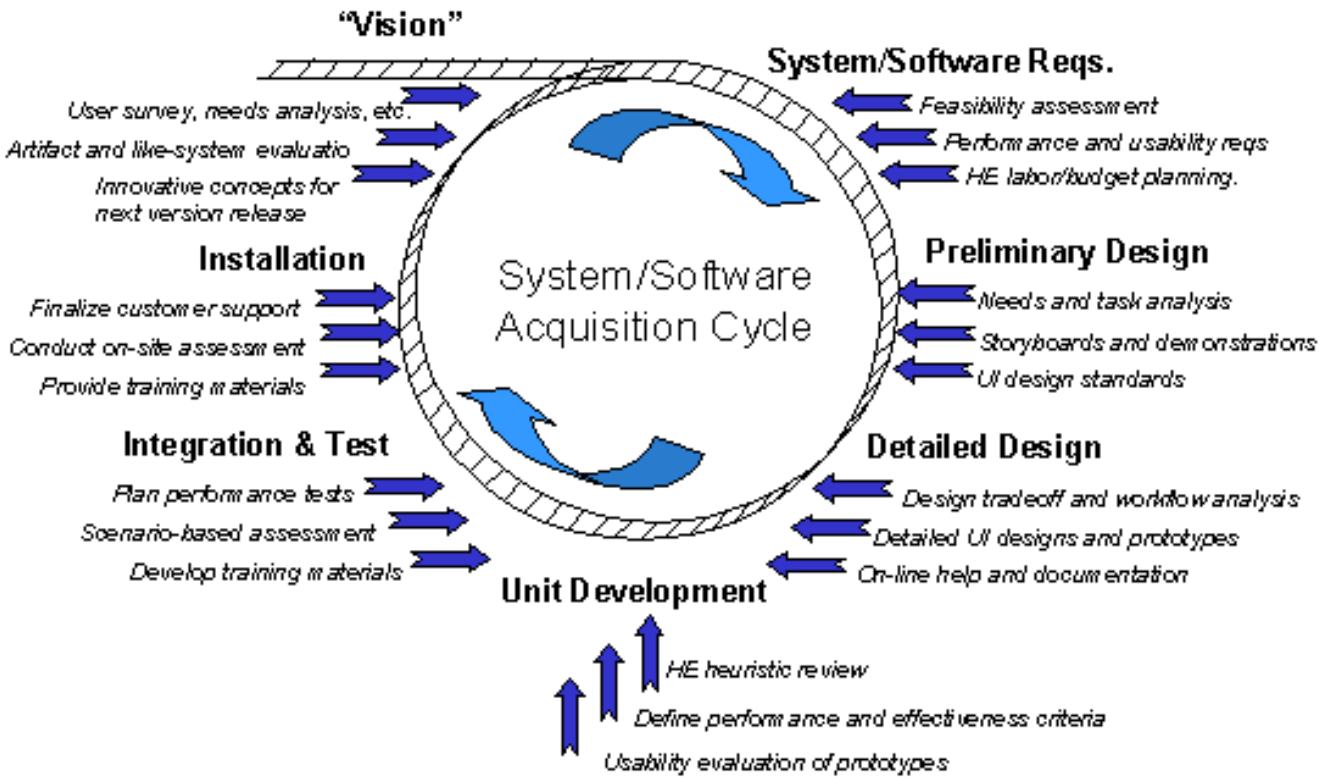
16.422

Human Supervisory Control

Function Allocation and Task Analysis

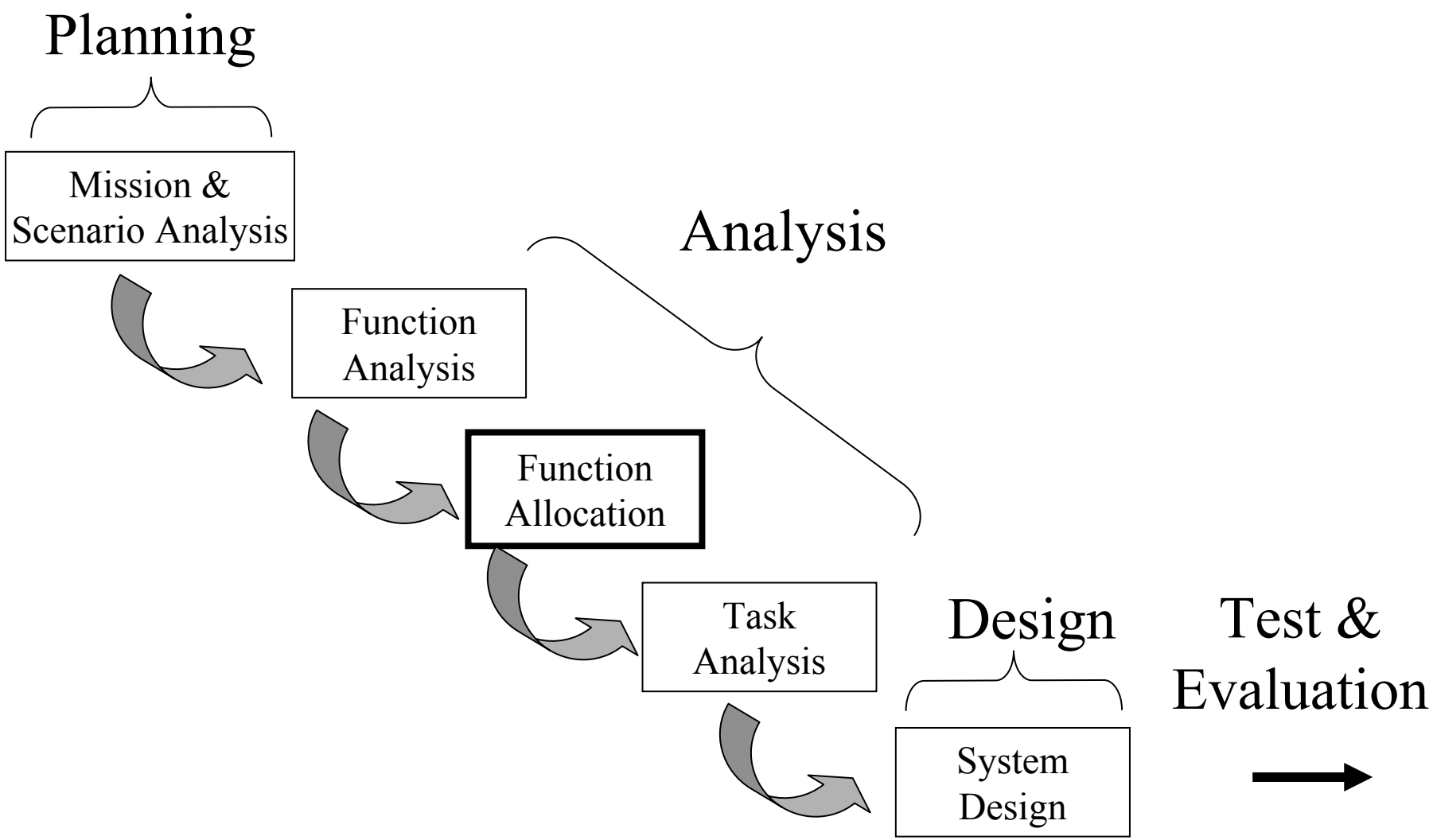
Massachusetts Institute of Technology

Human Systems Engineering



Planning →Analysis→ Detail Design→ Test & Evaluation

Functions & Tasks



Fitts' List

Attribute	Machine	Human
Speed	Superior	Comparatively slow
Power Output	Superior in level in consistency	Comparatively weak
Consistency	Ideal for consistent, repetitive action	Unreliable, learning & fatigue a factor
Information Capacity	Multi-channel	Primarily single channel
Memory	Ideal for literal reproduction, access restricted and formal	Better for principles & strategies, access versatile & innovative
Reasoning Computation	Deductive, tedious to program, fast & accurate, poor error correction	Inductive, easier to program, slow, accurate, good error correction
Sensing	Good at quantitative assessment, poor at pattern recognition	Wide ranges, multi-function, judgment
Perceiving	Copes with variation poorly, susceptible to noise	Copes with variation better, susceptible to noise

Hollnagel, 2000

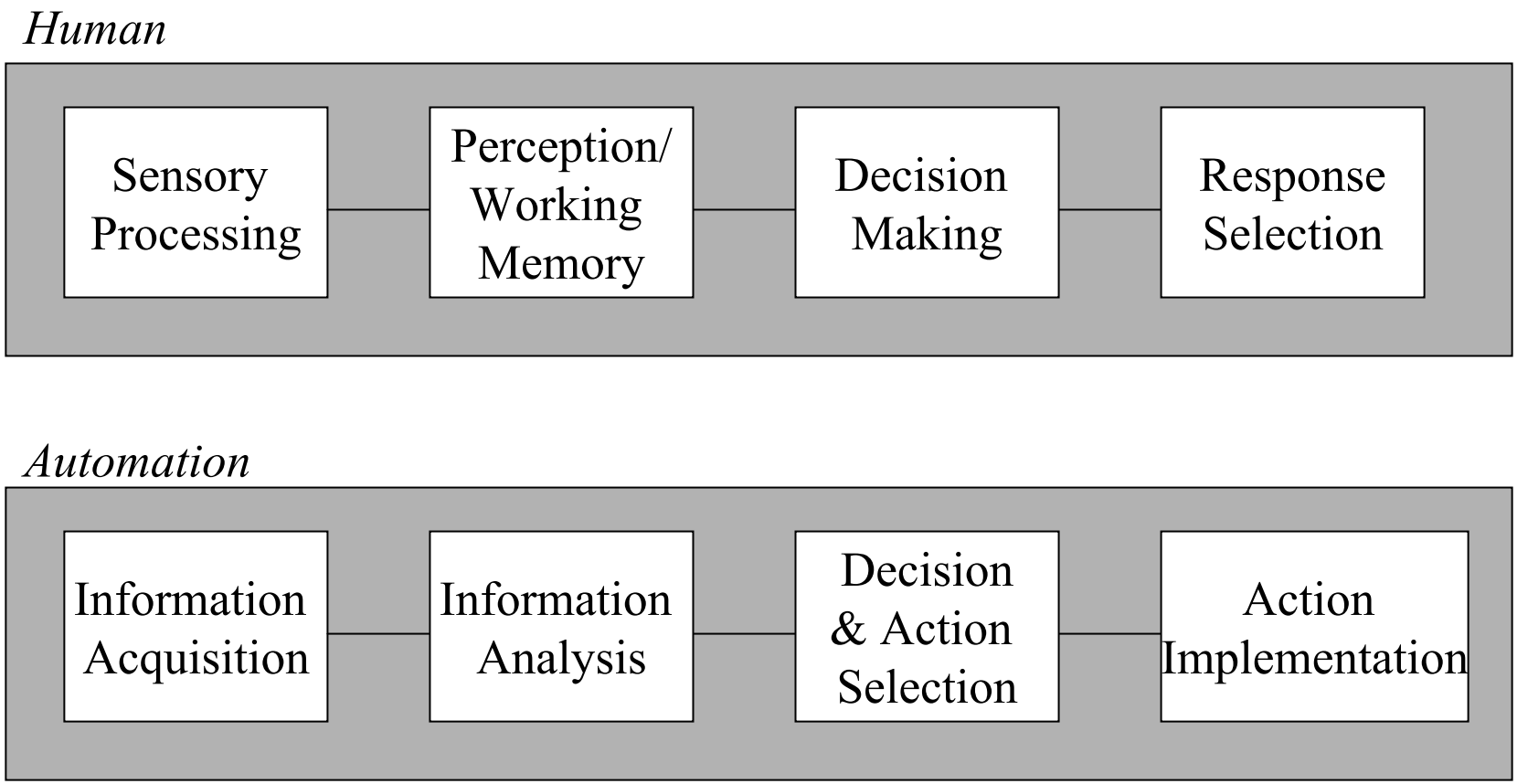
inductive and **deductive**. Induction is usually described as moving from the specific to the general, while deduction begins with the general and ends with the specific; arguments based on experience or observation are best expressed inductively, while arguments based on laws, rules, or other widely accepted principles are best expressed deductively.

Some problems with Fitts…

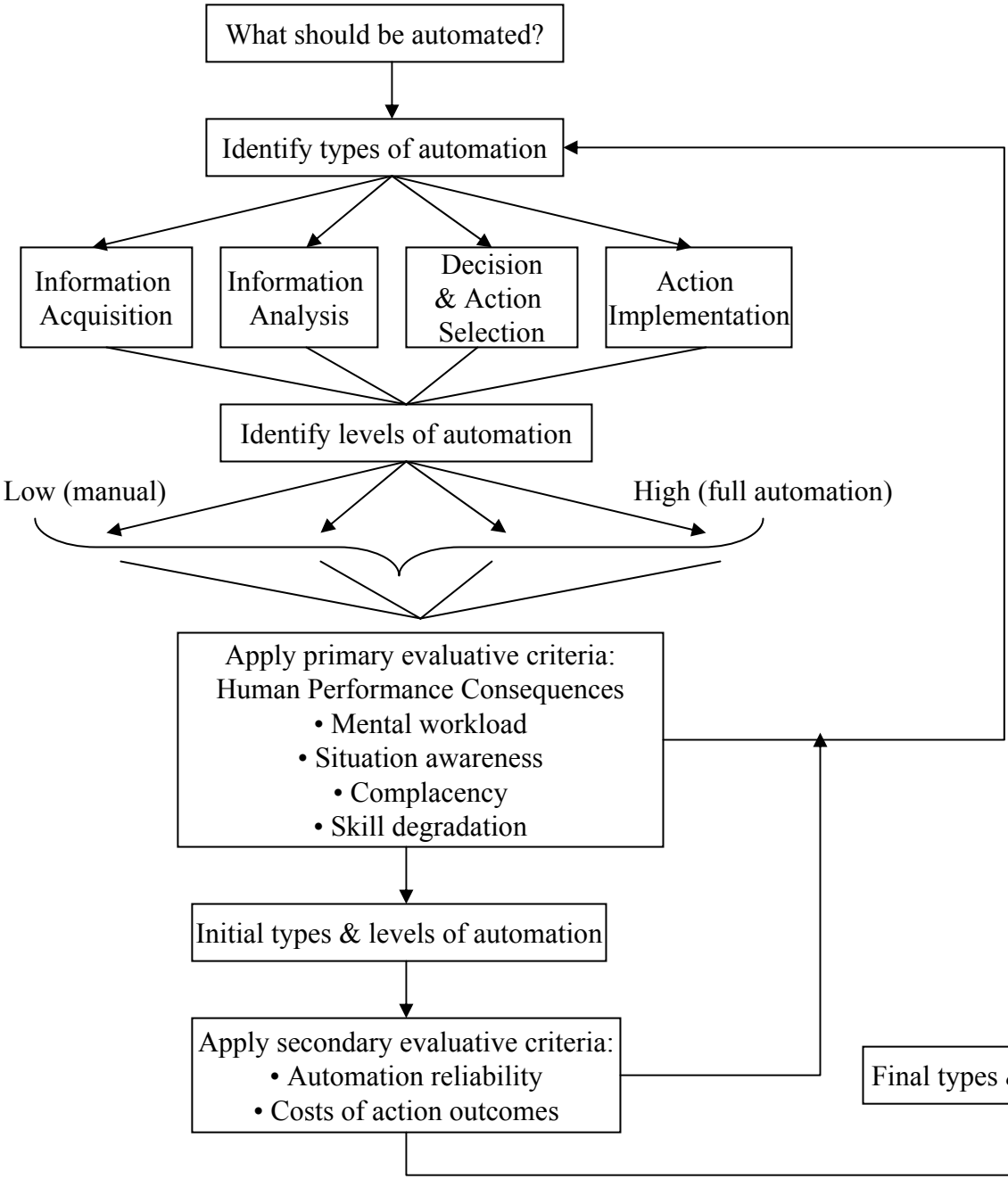
- Tasks/functions defined in machine terms, not human-oriented
  - Introduces a bias
  - "Laws of human behavior"
- Environmental/ecologic context
- Learning, fatigue, stress, anxiety generally not incorporated into design picture
- Task division vs. task complement
- Static vs. dynamic allocation
  - Adaptive allocation/automation
  - Function allocation is not binary

- Bandwidth
- Trust
- Machine/computer metaphors

Designing automation to support information processing



*Parasuraman, Sheridan, Wickens, 2000

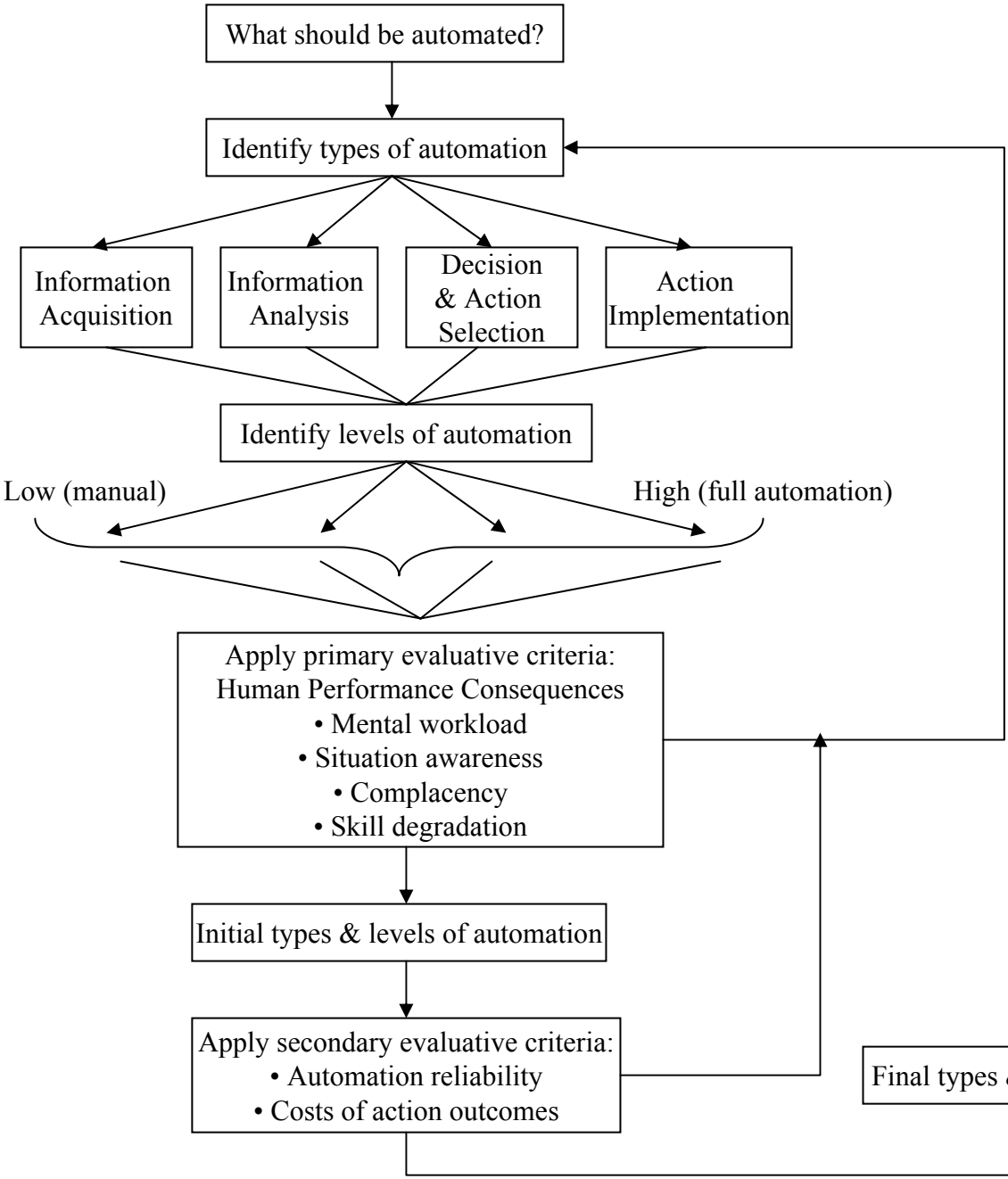


A Model of Types and Levels of Automation*

*Parasuraman, Sheridan, Wickens, 2000

Sheridan and Verplank's 10 Levels of Automation of Decision and Action Selection

Automation Level	Automation Description
1	The computer offers no assistance: human must take all decision and actions.
2	The computer offers a complete set of decision/action alternatives, or
3	narrows the selection down to a few, or
4	suggests one alternative, and
5	executes that suggestion if the human approves, or
6	allows the human a restricted time to veto before automatic execution, or
7	executes automatically, then necessarily informs humans, and
8	informs the human only if asked, or
9	informs the human only if it, the computer, decides to.
10	The computer decides everything and acts autonomously, ignoring the human.



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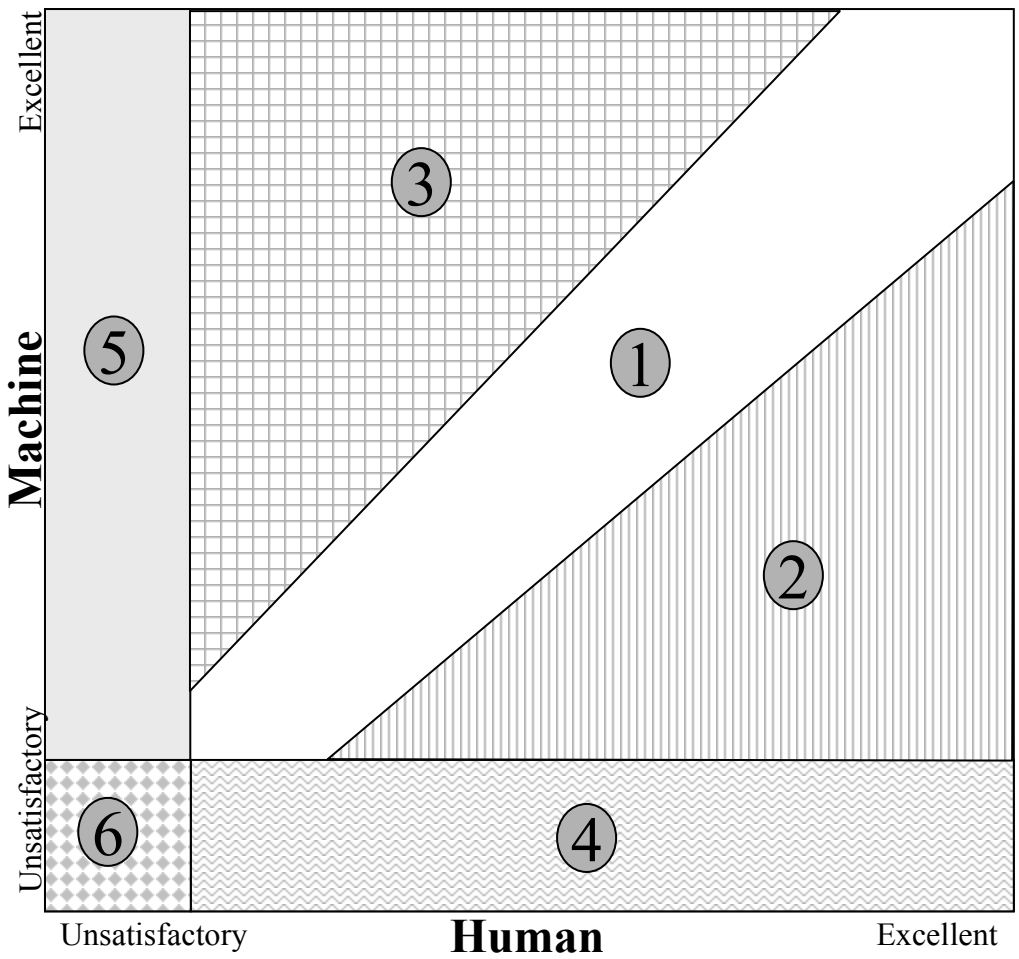
Function Allocation Criteria



1: No difference in the relative capabilities of human & machine.

2: Human performance > machine performance.

3: Machine performance > human.

4: Machine performance is so poor that the functions should be allocated to humans.

5: Human performance is so poor that the functions should be allocated to machine.

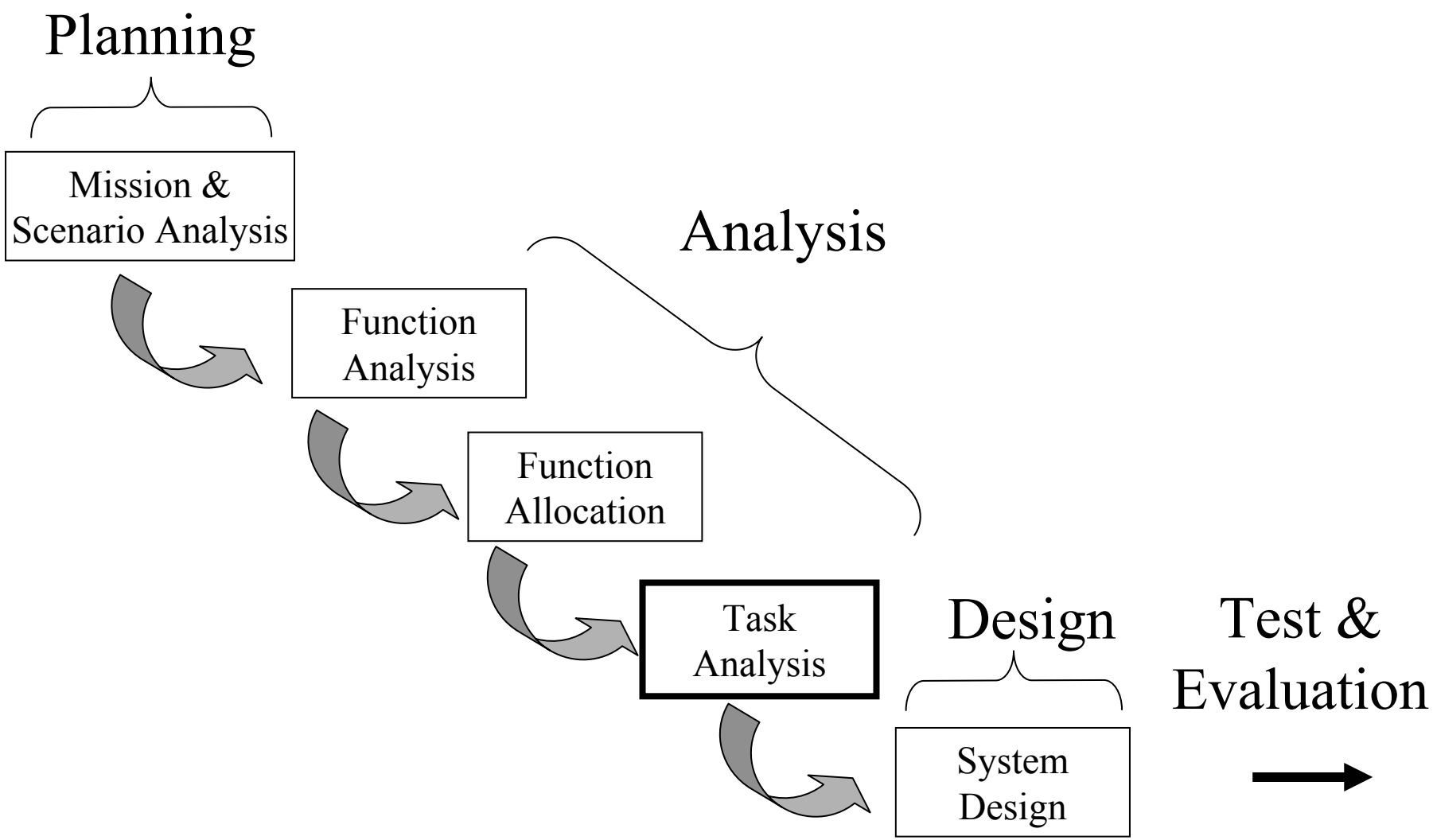
6: Unacceptable performance by both human and machine.

Three function allocation criteria:

- Balance of value
- Utilitarian & cost-based allocation
- Allocation for affective or cognitive support.

Price, 1985

Functions & Tasks



Task Analysis

- Determining what an operator must accomplish to meet a mission goal
  - Interactions both on a local and system level are critical
  - Will contain actions and/or cognitive processes
- Flow process charts, operational sequence diagrams, critical task analysis
  - Attempt to understand how a particular task could exceed human limitations, both physical and cognitive
- Cognitive task analysis
  - Not the only system analytic method but a critical one
  - Shift away from system control to systems management.

Supervisory control becoming more about cognitive tasking than manual tasking, especially with increasing automation

Cognitive Task Analysis (CTA)

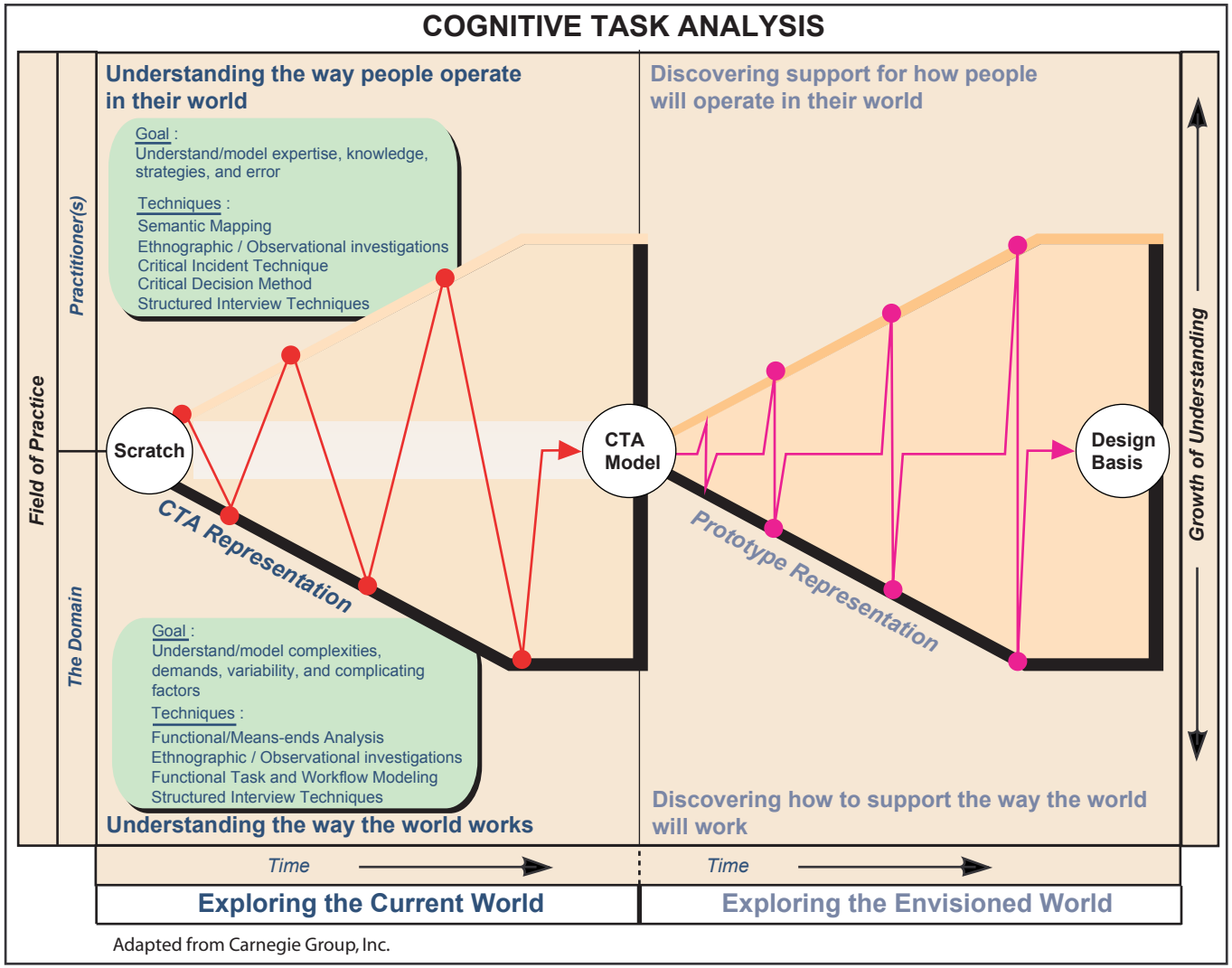
- Goal: To analyze and represent the knowledge and cognitive activities needed in complex work domains
- CTA is generally a descriptive modeling technique of workers' knowledge and cognition
  - As opposed to Computational Cognitive Models (CCM)
  - Knowledge Elicitation techniques provide input to CTA and CCM
    - Experts vs. Novices
- Evolutionary systems vs. revolutionary systems
- Background Research
  - Standards, procedures, manuals, organizational charts
- Field Studies
  - In both real environments and high fidelity simulations
- Questionnaires/Surveys

http://www.ul.ie/~infopolis/methods/incident.html

CTA, Cont.

- Interviews
  - Individuals vs. focus groups
  - Critical Incident Technique/Critical Decision Method
- Observations
  - PARI Method (Precursor (reason for action), Action, Result, Interpretation (of result))
  - Verbal protocols
- Design Reviews
  - Usability, Expert, Heuristic
- Problems with CTA
  - Labor intensive
  - Generate much data that is difficult to analyze
  - Gap between CTA and design
  - Opportunistic

CTA: A Bootstrapping Process



• critical decision method in which participants are asked to describe a specific decision-making incident in detail and then to respond to probes seeking elaboration of important aspects of the decision sequences.

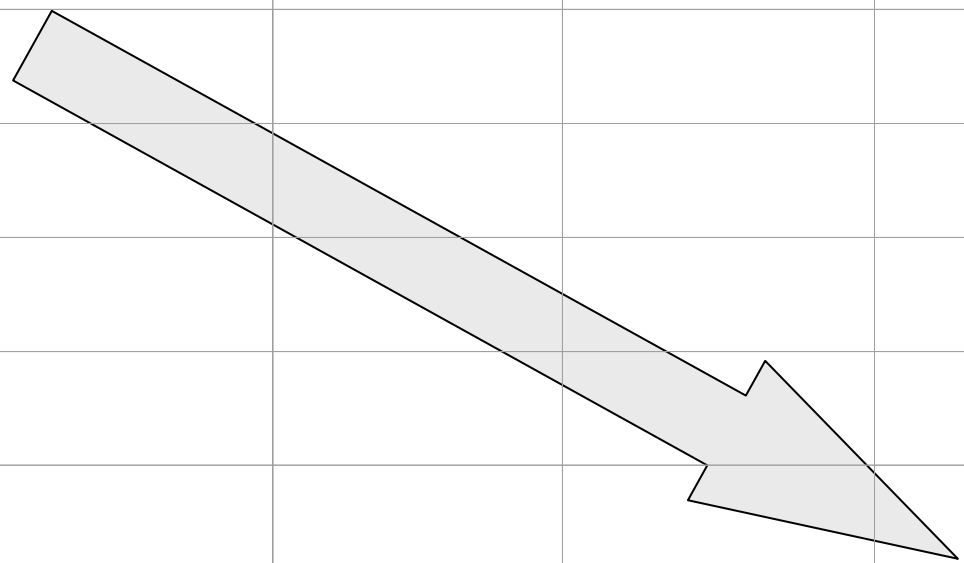
• Semantic mapping (a.k.a., mind-mapping, idea mapping, word webbing, etc.) is a term which describes a variety of strategies designed to show how key words or concepts are related to one another through graphic representations. Mapping is an *effective* technique for teaching vocabulary and textual patterns of organization; and it is also *effective* for improving note taking and creative thinking skills.

Functional Means/Ends Analysis

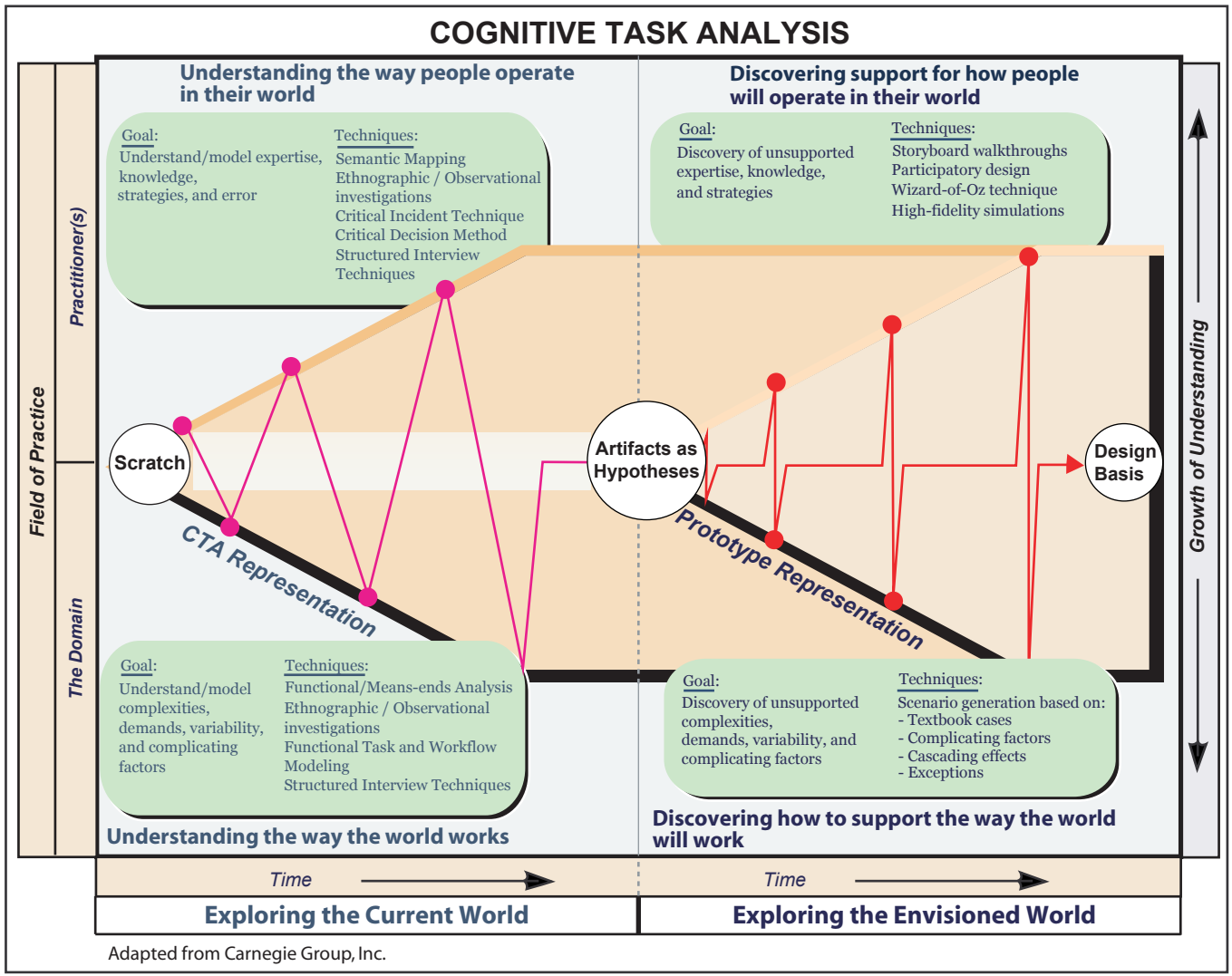
Abstraction (Means/ends)

Decomposition (Whole/Part) →

	Total System	Subsystems	Subassembly	Component
Functional Purpose				
Abstract Function				
Generalized Function				
Physical Function				
Physical Form				



CTA: A Bootstrapping Process



WoZ: http://www.dcs.napier.ac.uk/marble/Usability/WizardOfOz.html

Work Analysis v. Task Analysis

- Descriptive v. Normative v. Prescriptive
- Ecological focus
  - Constraints v. instructions
  - Map v. directions
- Not a mutually exclusive set

Criterion	Task Analysis	Work Domain Analysis
Mental Economy	Efficient	Effortful
Unforeseen Circumstances	Brittle	Flexible
Scope of Applicability	Narrow	Broad

normative analysis focuses on "how decision makers should ideally perform" an activity. Bell et al. (1988) have claimed that "normative theory has something to do with how idealized, rational, super-intelligent people should think and should act." Normative analysis is often contrasted with prescriptive analysis, which is usually said to be geared toward examining what real people ought to do given their real-world constraints and cognitive limitations (or how decision aids might aid real decision makers).

Resources

- A Survey of Cognitive Engineering Methods and Uses
  - http://mentalmodels.mitre.org/cog_eng/index.htm
- ONR/Aptima Cognitive Task Analysis website
  - http://www.ctaresource.com/