Human-Centered Systems Engineering Design Approaches
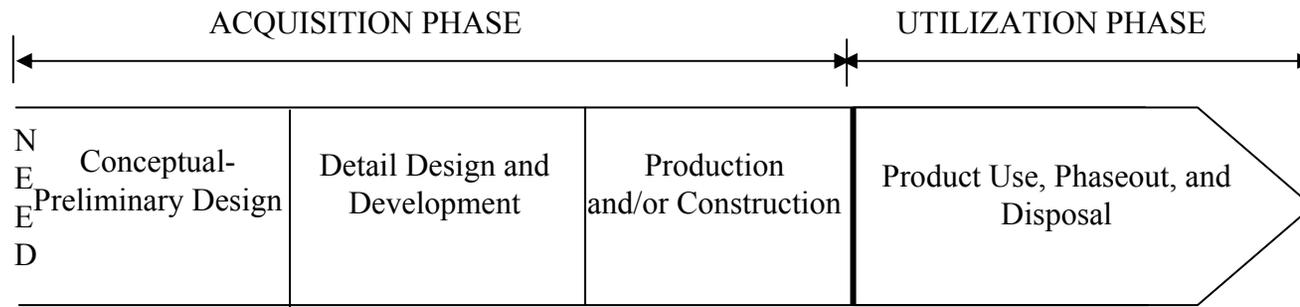
Massachusetts Institute of Technology

Traditional Systems Engineering Process Model*

	ACQUISITION PHASE			UTILIZATION PHASE
N E E D	Conceptual-Preliminary Design	Detail Design and Development	Production and/or Construction	Product Use, Phaseout, and Disposal

- Operational requirements drive technical performance measures which drive human factors requirements…..
  - Human considerations often are low priority

*Blanchard, B. S., & Fabrycky, W. J. (1998). Systems Engineering and Analysis (3rd ed.). Upper Saddle River, NJ: Prentice Hall.

The Spiral Systems Engineering Process Model*

Three Mile Island

- March 28th, 1979
- Main feedwater pump failure, caused reactor to shut down
- Relief valve opened to reduce pressure but became stuck in the open position
  - No indication to controllers
  - Valve failure led to a loss of reactant coolant water
- No instrument showed the coolant level in the reactor
- Operators thought relief valve closed & water level too high
  - High stress
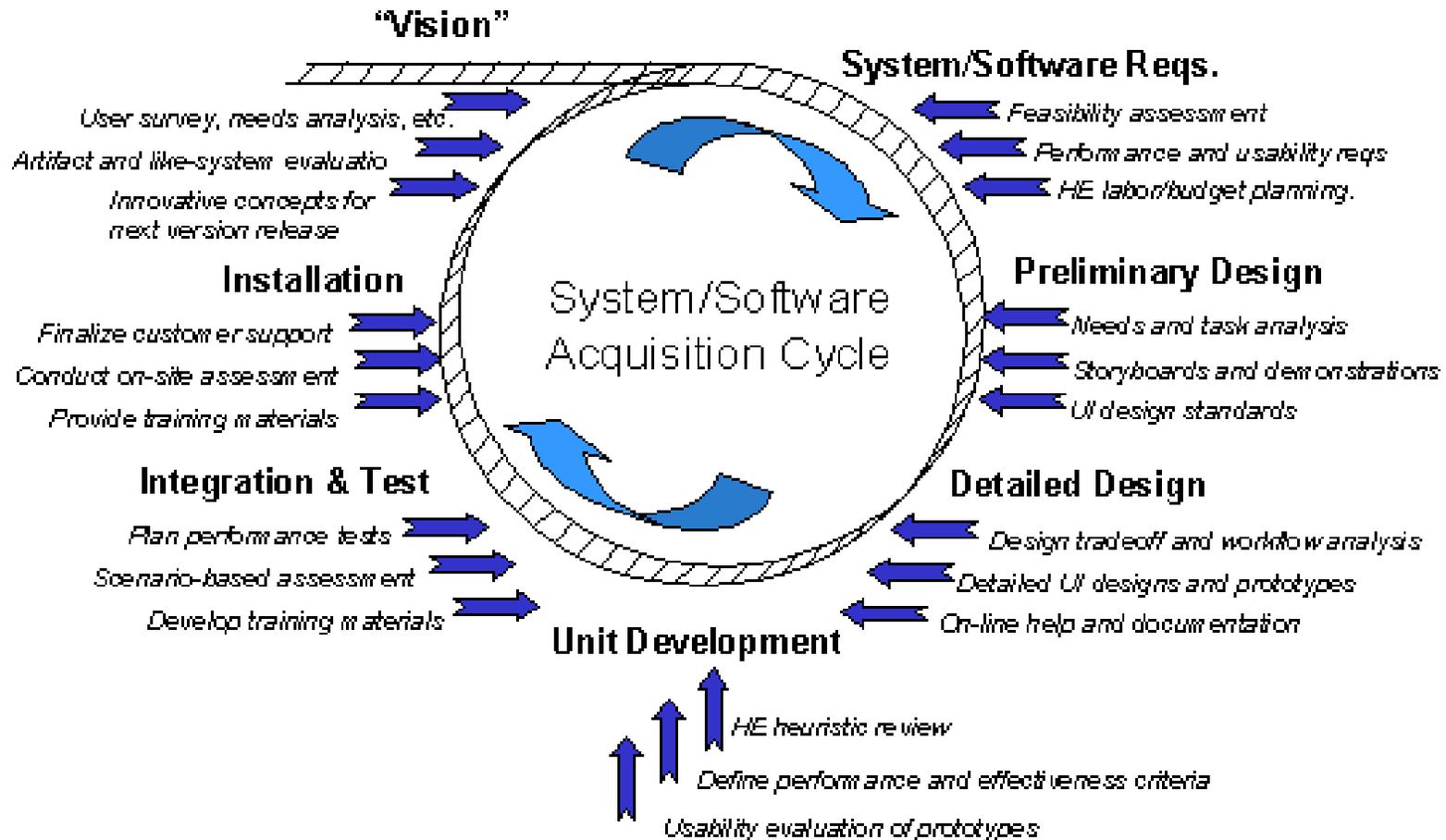 - Overrode emergency relief pump

Three Mile Island

- Automation worked correctly

- Confirmation bias: people seek out information to confirm a prior belief and discount information that does not support this belief
    - At TMI, operators selectively filtered out data from other gauges to support their hypothesis that coolant level was too high

Human Systems Engineering*

(Courtesy of Aptima, Inc. Used with permission.)

General Principles for Design of Human-Centered Automation*

- The human operator must be in command.
- The operator must be in involved.
- Human operator must be informed.
- Automated systems must be predictable.
- Automated systems should monitor the human.
- System agents should have intentional knowledge of other agents
- Training, learning and operation of automation should be simple
- Only automate functionalities if there is a need.

Alert systems integration?

*Billings, 1997

Specific Design Requirements for Human-Centered Automation*

- Automation systems should be comprehensible.
- Automation should ensure operators are not removed from command role.
- Automation should support situation awareness.
- Automation should never perform or fail silently.
- Management automation should improve system management
- Designers must assume that operators will become reliant on reliable automation.
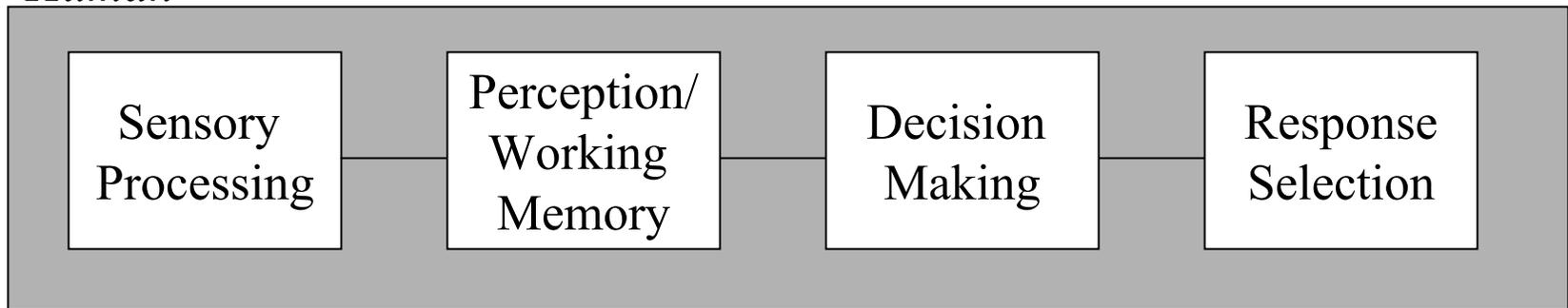
*Billings, 1997

FAA Human Factors Design Standard

- Basic design elements
  - Durability, proper function allocation, user testing, reliability
- Simplicity
- Consistency
  - Be consistent with user mental model.
- Standardization
  - Maintain identical interfaces for identical functions.
- Safety
  - Provide a fail-safe design and make it error tolerant
- User-centered perspective
  - Maximize human performance but minimize training requirements
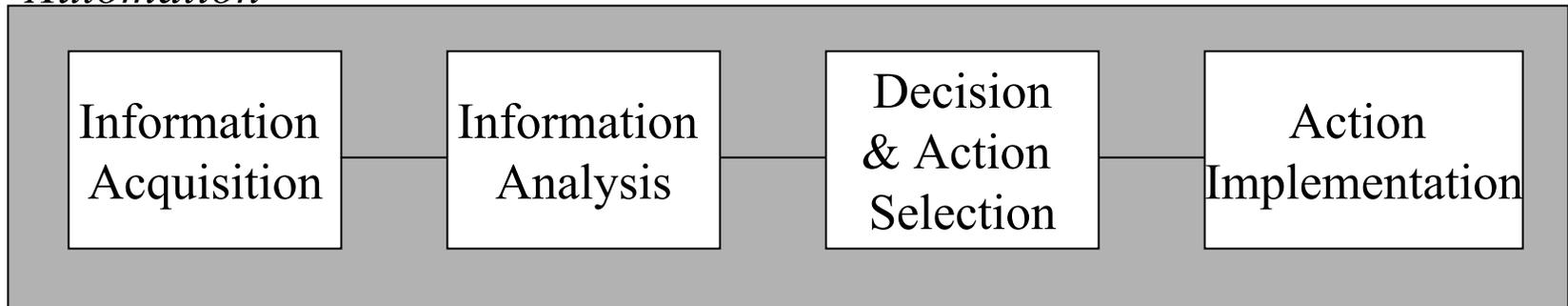- Support
- Maintenance

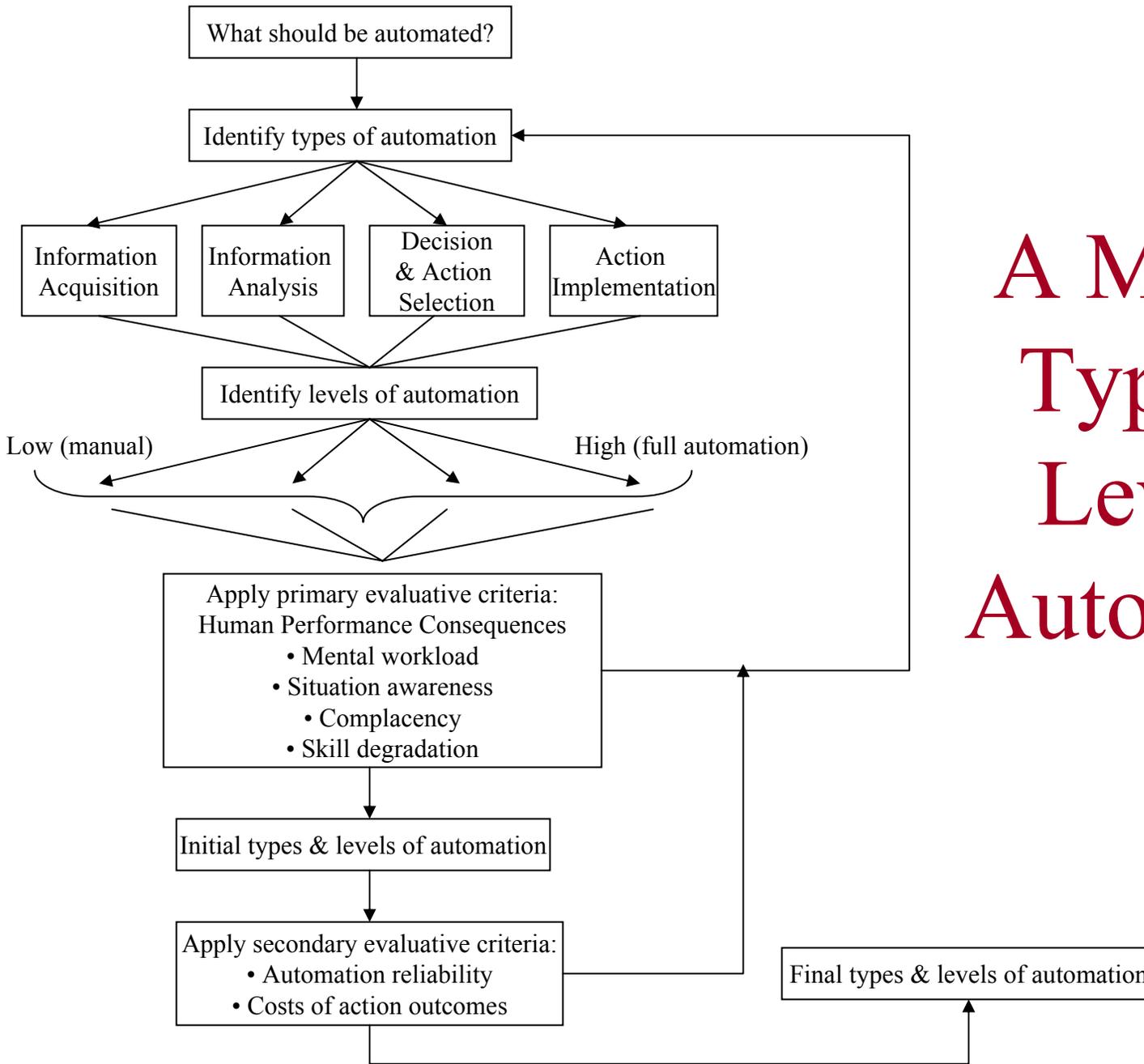# Designing automation to support information processing

Human

Sensory Processing	Perception/ Working Memory	Decision Making	Response Selection

Automation

Information Acquisition	Information Analysis	Decision & Action Selection	Action Implementation

*Parasuraman, Sheridan, Wickens, 2000

A Model of Types and Levels of Automation*
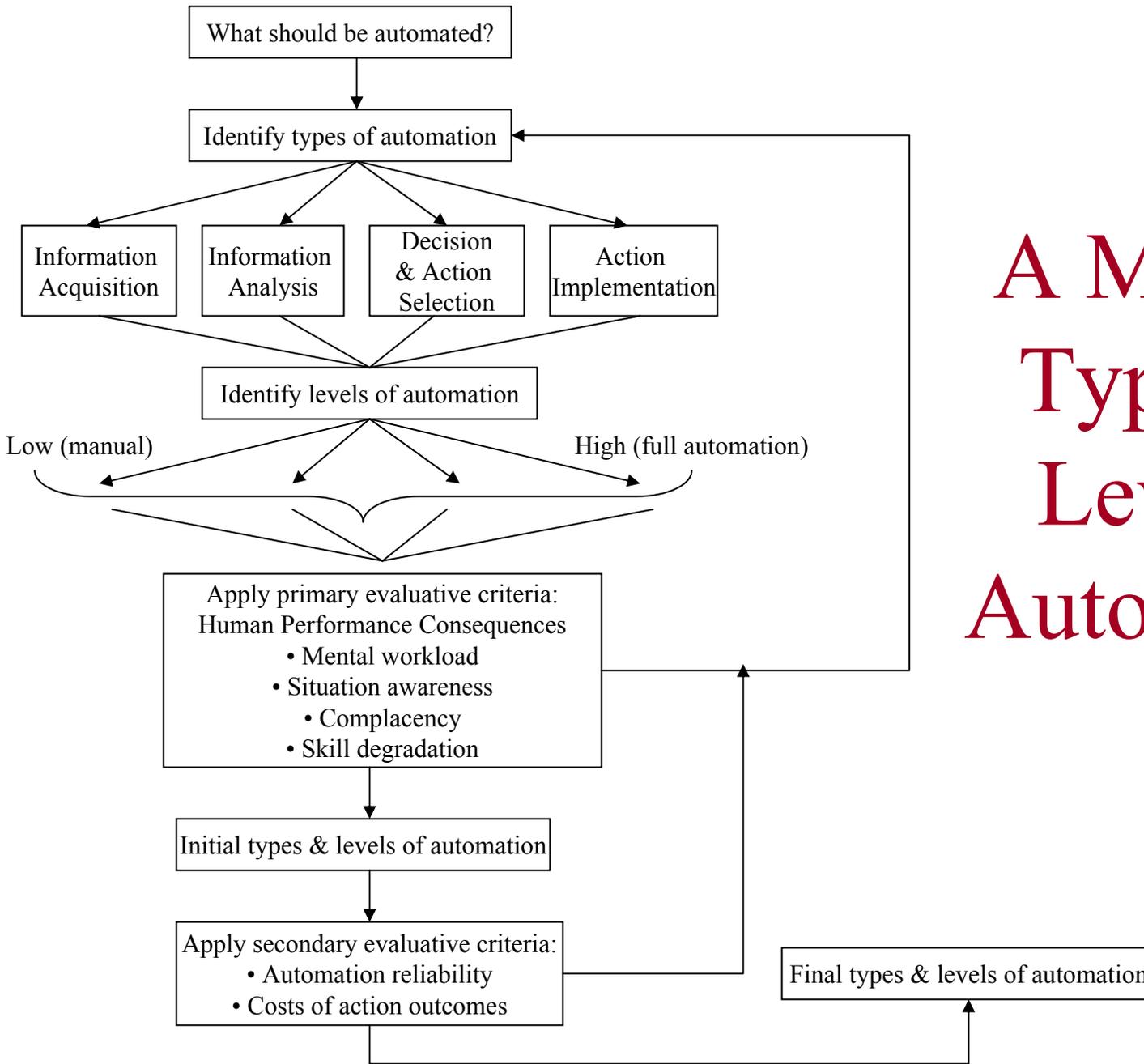
*Parasuraman, Sheridan, Wickens, 2000

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.

A Model of Types and Levels of Automation*

*Parasuraman, Sheridan, Wickens, 2000