

Human Factors in Design and Preliminary Safety Assessment of Research Reactors

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Impact

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Human Factor in Research Reactors

- The facility cannot be designed in a vacuum
- Will be operated by humans, prone to error.
- Human action: one of the causes of Postulated Initiating Events
- Effect of human actions on the behavior of the facility.

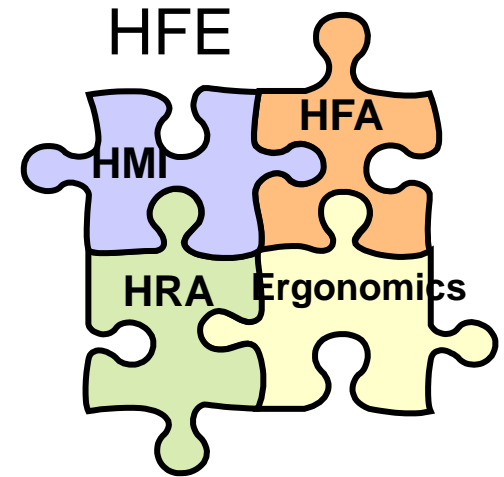
Human Factor

- **“Human Factor”** : design and operation instances of interactions of the operators with the facility
- Addressed by **Human Factor Engineering**
- Two stages:
 - Design
 - Safety Assessment



Human Factor Engineering vs Human Machine Interface

- Broader than Human Machine Interface
- OBJECTIVE: Safe operation of the facility



Application of Human Factor Assessment Techniques

Human Factor Assessment: Evolved from accident management techniques

HFE during Design

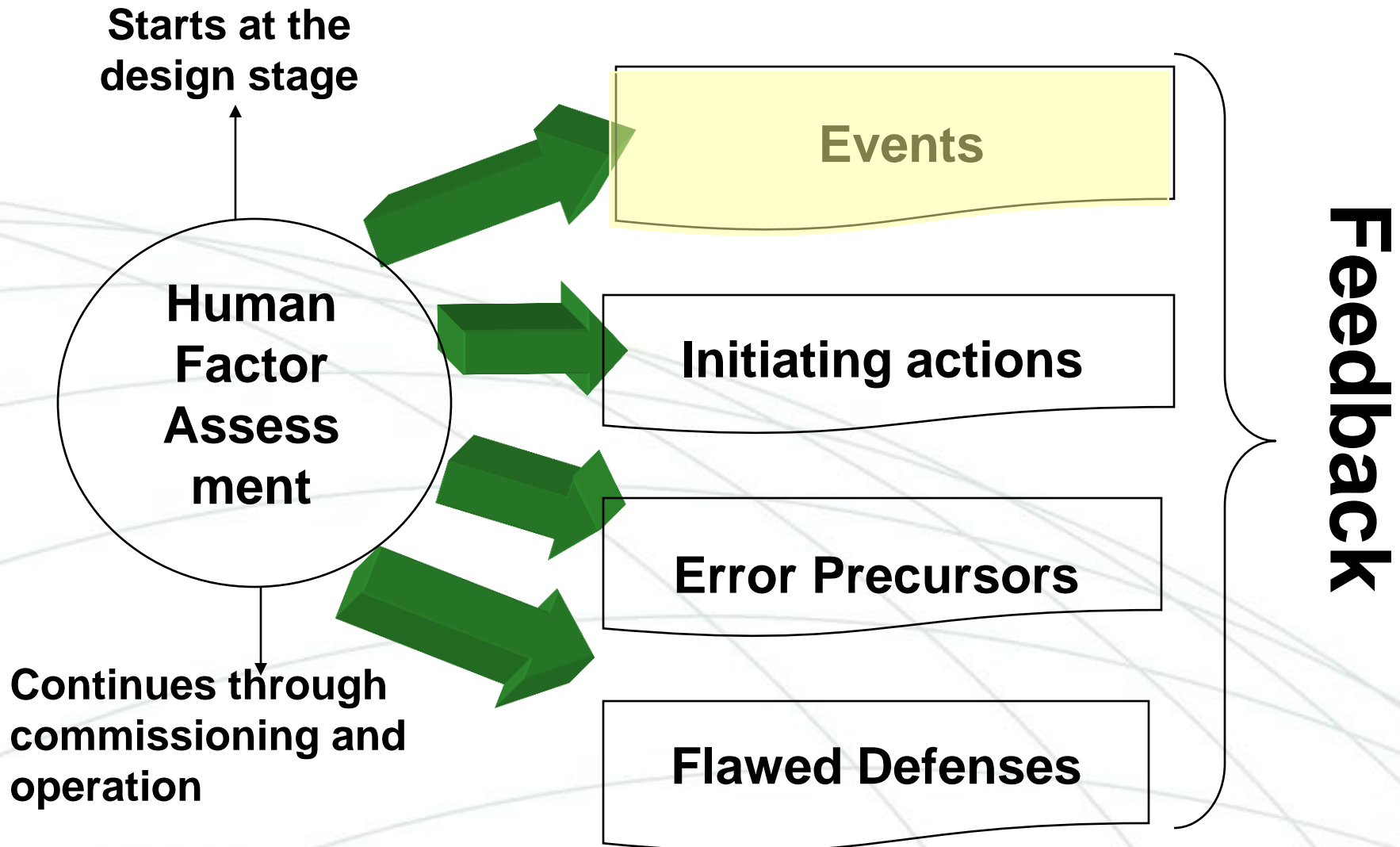
- How do we consider effect of human actions during the design?

Implement Human Factors Assessment as early as possible during the design process

Human Factor Assessment

- Two parts:
 - Deterministic Assessment
 - Human Reliability Analysis (HRA)
- HRA is developed as part of the PSA
- Deterministic assessment follows the design process

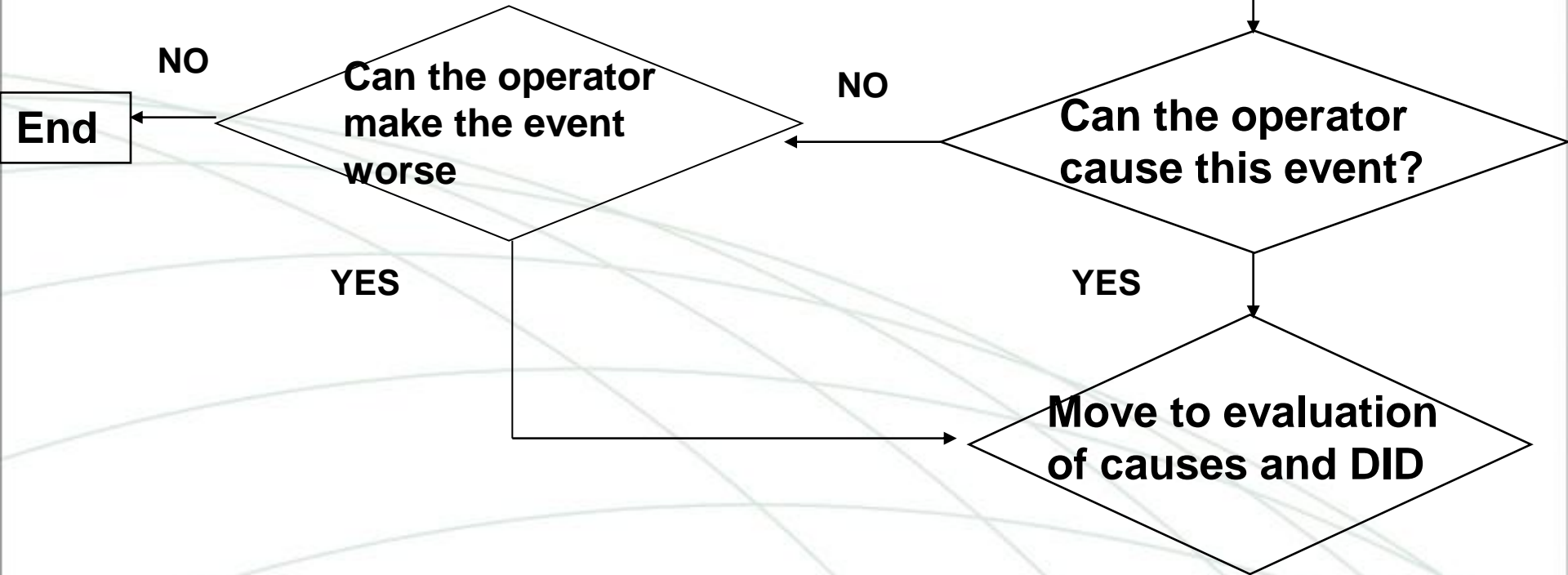
Human Factor Assessment



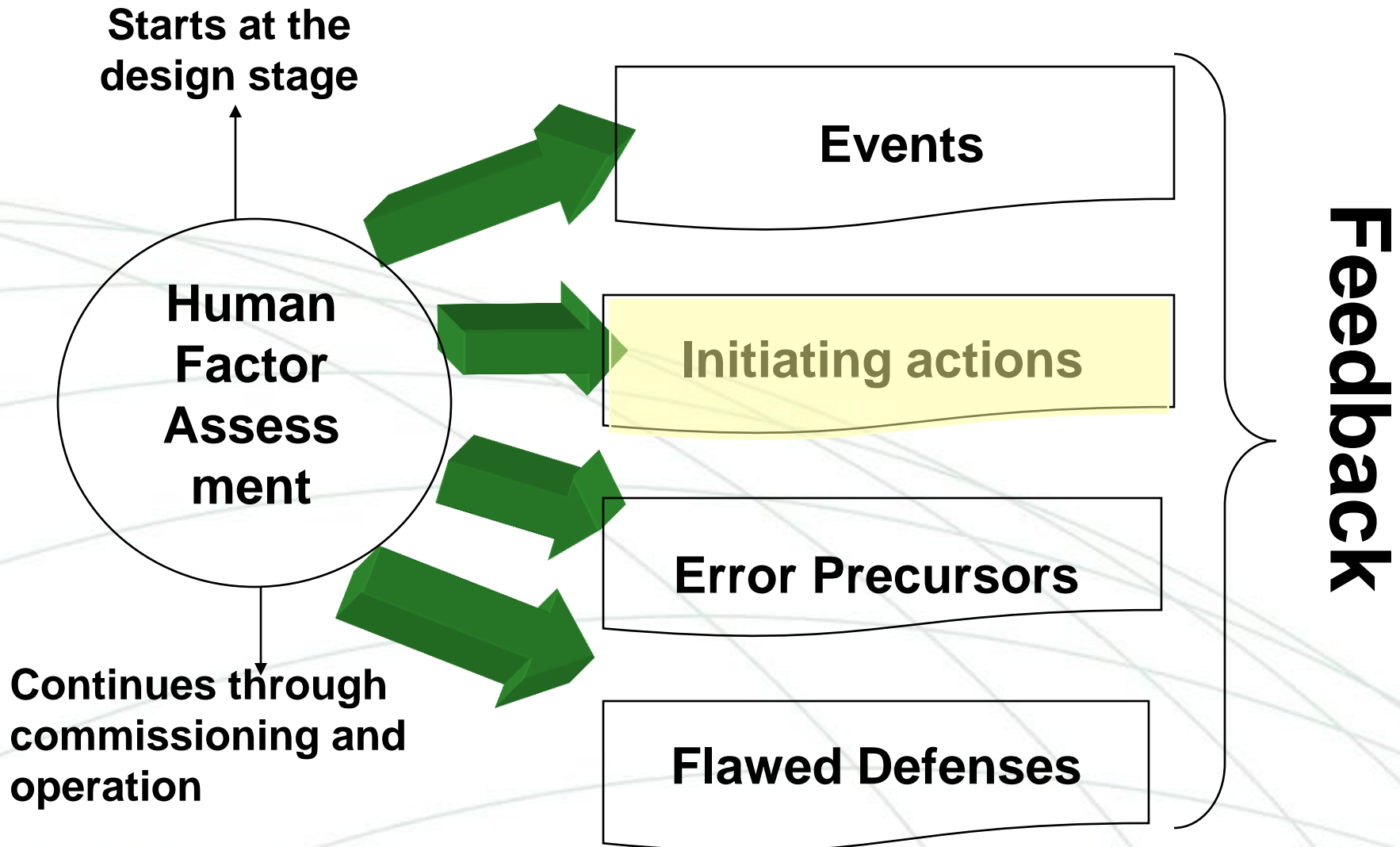
HFA: Initiating Events

MLD, barrier analysis,
IAEA list, HAZOP, etc

Identification of
events



Human Factor Assessment



HFA: Causes

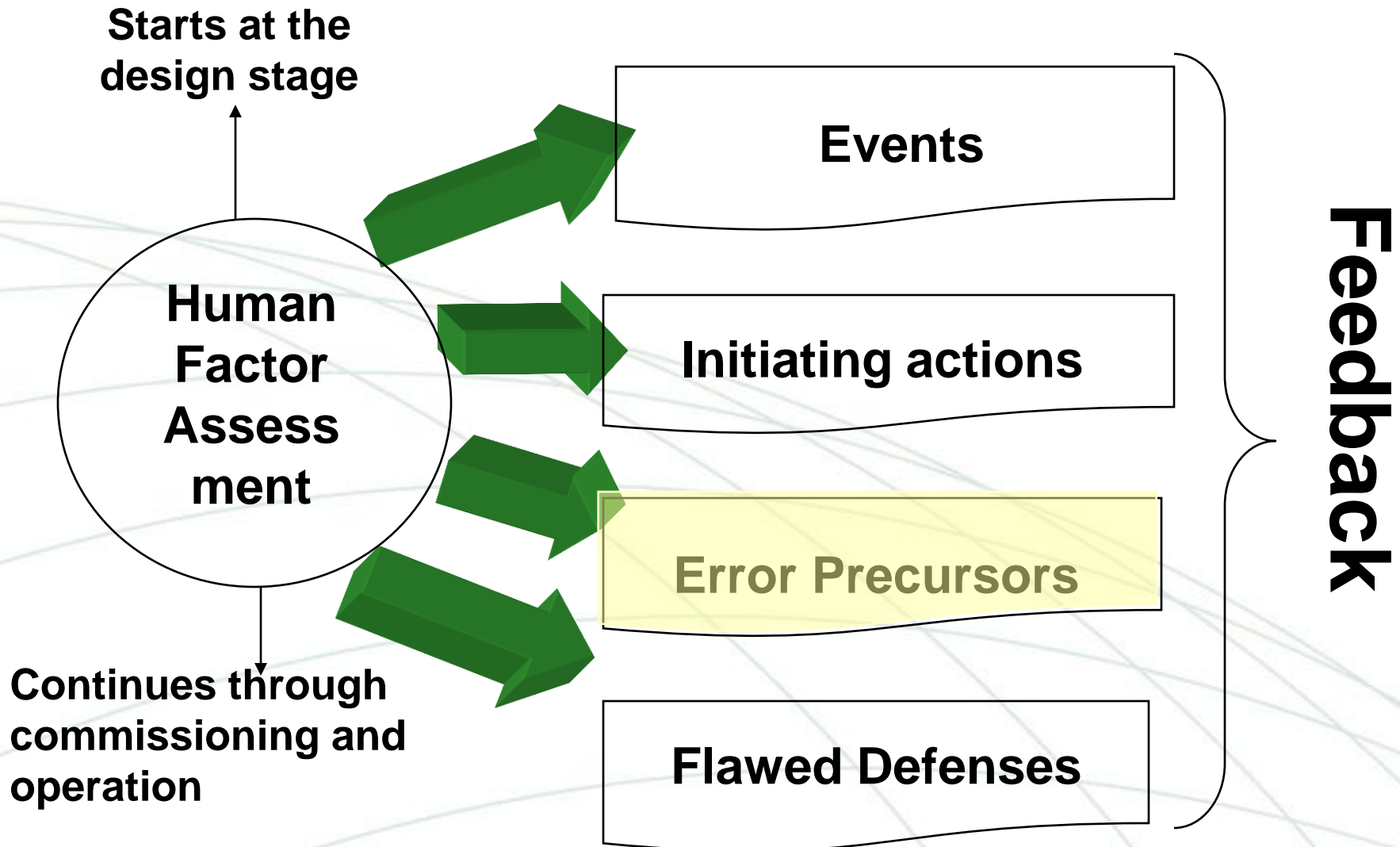
First Step: Identify actions with largest potential impact on the safety of the facility

- Operation: MCR, pool top operations.
- Maintenance: contributes with latent errors.

Includes refueling.

- Accident Management and Mitigation: for BDBA. Impact on design of DID level 4 systems.

Human Factor Assessment



HFA: Error Precursors

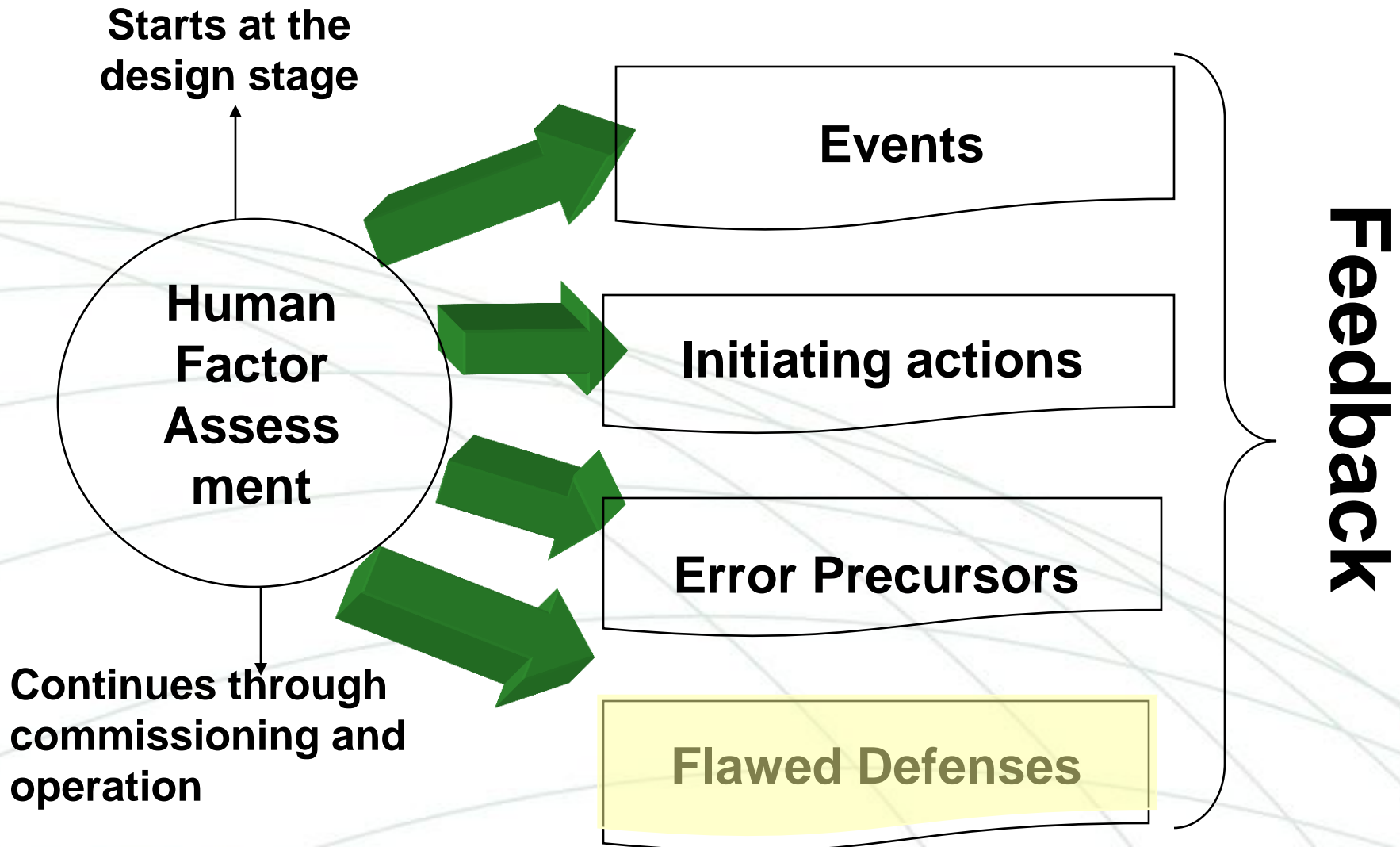
Error Precursors are related to

- task demands,
- work environment,
- individual characteristics
- human nature.

HFA: Error Precursors

- Task demands:
 - Characteristics of the task and the system
 - Ergonomics
 - Time
 - Feedback of success
- Work Environment:
 - Design of the system and work space
 - Environmental conditions: temperature, light, humidity, radiation field
- Personal Characteristics:
 - Physical and psychological aptitude
 - Training
 - Work satisfaction, personal situation, etc
- Human Nature:
 - “Friday afternoon effect”, “End of shift effect”, overconfidence, “nothing happens”, etc.

Human Factor Assessment



HFA: Flawed Defenses

- The HFA process can identify flawed defenses.
- Feedback is provided to the design.
- Two possible scenarios
 - The defense can be redesigned or barriers can be added
 - Only administrative barriers are possible

Human Factor Engineering Tools

- Prototypes:
 - evaluate “operability” of systems.
 - Identify operation actions.
- Task Analysis
 - Systematic tool to evaluate operation
- Commissioning:
 - Verify operability.
 - Final evaluation of procedures and manuals
- Training:
 - Evaluate procedures.

Examples of HFE issues in Research Reactor Design

Design:

- Identification of latent design errors (FMEA, HRA)
- Establish HF design basis (ergonomics, ease of operation, interference, RPS).
- Pool top operation (tool design, minimization of simultaneous operation, task requirements)
- Maintenance (space, ease of handling)
- Accident management (evaluation of accident sequence, verification that the operator cannot interfere)

Examples of HFE issues in Research Reactor Design

Main Human Machine Interface

Main Control Room:

- >Evaluation of design in parallel with the design process
- >Review of Displays and Controls against standards and by focus groups (operations, safety, process, etc) – Checklists.
- >Task analysis.

Examples of HFE issues in Research Reactor Design

Main Human Machine Interface

Reactor Pool Top Operations

Task analysis, Identification of error forcing context, ergonomics of tools, time requirements, feedback on success.

Design of tools:

- Consultation with experienced operators
- Ergonomics
- Custom design according to task
- Hazard identification
- Assessment of risks to operator and facility
- Minimization of risks

Feedback to design

Summary and Conclusions

- HFE can be addressed early in the design process
- Feedback to the design must be provided as soon as possible.
- Prototypes, training and commissioning can be valuable tools.
- In the RRR, HFE comprises several aspects. Emphasis is made identification of latent errors and design of the interfaces (MCR and pool top).