

Systems Safety

— Human Factors (1) —

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What are Human Factors?

- ◆ Not only the functionality of hardware components but also human or organizational performance affects systems safety.
 - Space Shuttle Challenger (1986)
 - Exxon Valdez oil spill (1989)
 - NY World Trade Center (2001)
- ◆ Issues of human performance related to systems safety are called Human Factors (HFs).
- ◆ Contributions of HFs to systems safety are both positive and negative.



Human Error (HE)

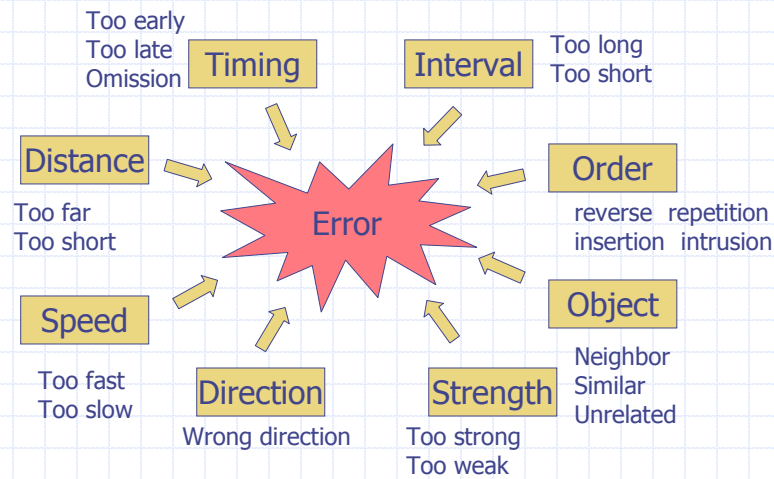
- ◆ Human action that is a primary **cause** or a **contributing factor** in disasters and accidents, or **deviation** from the expected standard action.
- ◆ From a viewpoint of HF researchers
 - Human error is not a cause but a consequence.
 - There are various types of human errors.
 - A serious human error does not occur by chance, misfortune, or laziness, but it occurs inevitably.



Categories of human error

- ◆ Phenotypes
 - Categories judged objectively from the seriousness of consequence or the observed deviation from the standard action.
- ◆ Genotypes
 - Categories presumed from the cognitive mechanism of decision making, conditions and causes surrounding the action.

Error modes (Basic phenotypes)



E.Hollnagel, 1993

Human Reliability Analysis (HRA)

- ◆ Method for qualitative or quantitative assessment of the probability (frequency) and the effects of unsafe human acts
- ◆ 1st generation HRA (-1990)
 - Application of the reliability analysis for mechanical components to human performance
 - Black box approach with no internal mechanism
- ◆ 2nd generation HRA (1990-)
 - Remedies to 1G HRA (Error of commission)
 - Cognitive mechanism of human performance

Procedure of HRA



Technique for Human Error Rate Prediction (THERP)

1. Collection of relevant information
(Documents, field observation, interview)
2. Task analysis (Decomposition to unit actions)
3. Construction of task event trees
4. Assignment of basic error rates
5. Assessment of Performance Shaping Factors
6. Assessment of dependencies
7. Calculation of Human Error Probability (HEP)
8. Adjustment due to recovery factors
9. Sensitivity and uncertainty analysis

THERP error modes

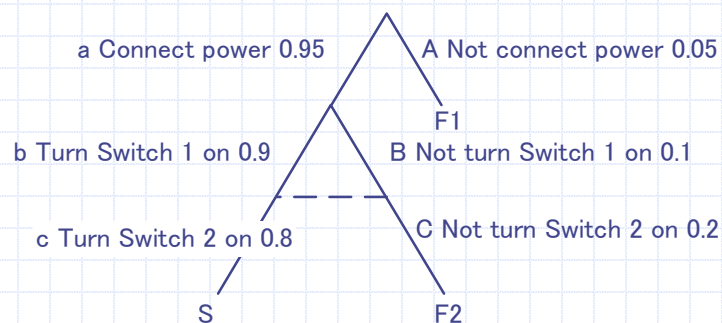


- ◆ **Omission:** Unexecuted action
- ◆ **Commission:** Inappropriate execution
 - Execution of unnecessary actions
 - Execution of actions in a wrong order
 - Wrong execution timing
 - Mischoice of object, direction, etc.
 - Inappropriate strength, duration, etc.



Task Event Tree (ET)

1. Connect power
 2. Turn Switch 1 on
 3. Turn Switch 2 on
- $$\begin{aligned} \text{HEP} &= A + BC \\ &= 0.05 + 0.1 \times 0.2 \\ &= 0.07 \end{aligned}$$



Performance Shaping Factors (PSFs)

- ◆ Situational factors that affect human reliability. PSFs are used to adjust the basic error rates under nonstandard working conditions.

External PSFs

- Situation characteristics (Architectural features, quality of environment, work hours, etc.)
- Task and equipment characteristics (Perceptual requirements, motor requirements, etc.)
- Job and task instructions (Procedures, communication, etc.)

Internal PSFs

- Organismic factors (Training, state of skill, personality, etc.)

Stressors

- Psychological factors (Suddenness of onset, task speed, etc.)
- Physiological factors (Duration of stress, fatigue, hunger, etc.)

THERP dependency model



Depen- dency	Conditional probability	
	Successive success	Successive failure
ZD	BHSP	BHFP
LD	$(1+19BHSP) / 20$	$(1+19BHFP) / 20$
MD	$(1+6BHSP) / 7$	$(1+6BHFP) / 7$
HD	$(1+BHSP) / 2$	$(1+BHFP) / 2$
CD	1	1

BHSP: Beforehand success BHFP: Beforehand failure

Calculation of total HEP



Task step (Failure)	Basic error rate	High stress (x2)	Depen- dency	Error rate
1 (A)	0.05	0.1	–	0.1
2 (B)	0.1	0.2	ZD	0.2
3 (C)	0.2	0.4	HD	0.7
Total HEP = A + BC				0.24

Operator Action Tree (OAT)



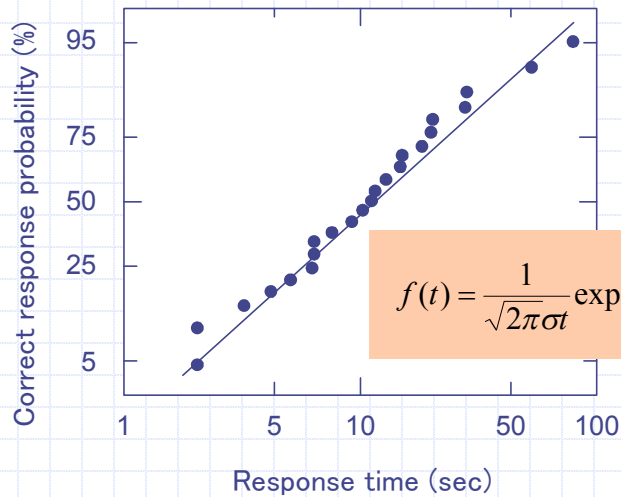
- ◆ THERP is applicable only to tasks for which the standard procedures are given; judgment and diagnosis are out of the scope of THERP.
- ◆ Assumptions of OAT
 - Human performance consists of three steps: information recognition, thinking, and operation.
 - Reliability of judgment is determined by the **time interval available for thinking**.

OAT procedure



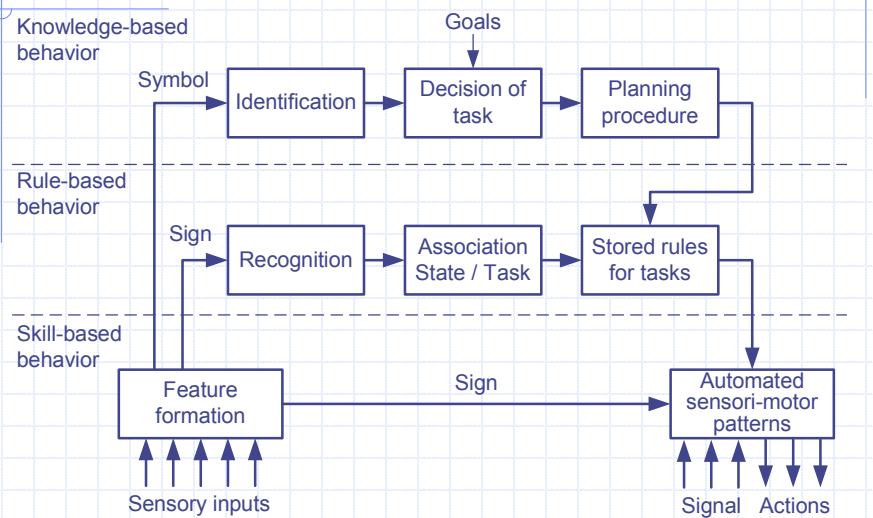
1. Identify human actions to be taken for maintaining safety, and then collect relevant information on the decision for the actions.
2. Evaluate the time margin available for thinking.
$$t_T = T_0 - t_I - t_A$$
3. Evaluate error rate from Time Reliability Correlation.
4. Evaluate system reliability using the obtained error rate in ETA or FTA.

Time Reliability Correlation (TRC)



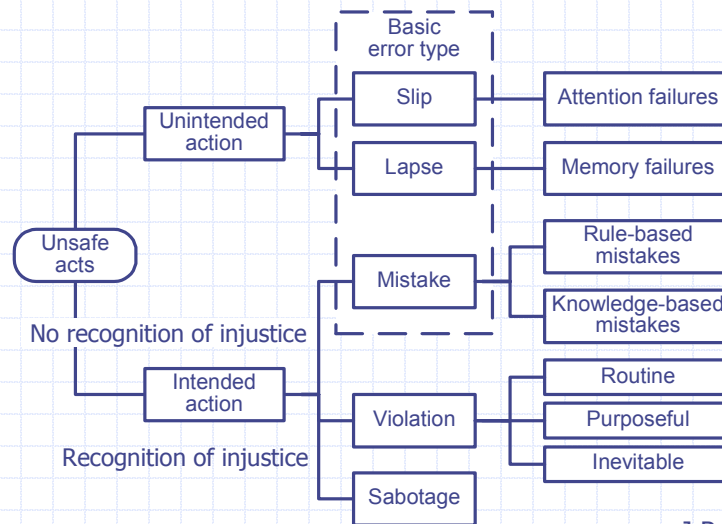
$$f(t) = \frac{1}{\sqrt{2\pi\sigma t}} \exp\left[-\frac{(\ln t - \mu)^2}{2\sigma^2}\right]$$

SRK model



J.Rasmussen, 1983

Taxonomy of unsafe acts

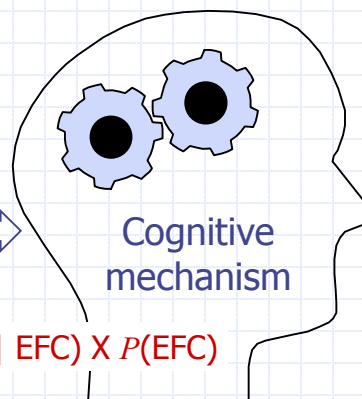


J.Reason, 1990

New concept of human errors



Personal factors
Environmental factors
Social factors



$$HEP = P(\text{Unsafe acts} \mid \text{EFC}) \times P(\text{EFC})$$

◆ Error Forcing Context (EFC)

Context where humans inevitably commit errors



Common Performance Condition (CPC)

- ◆ CPCs are factors that influence human performance in common. If most of the CPCs are inappropriate, EFC will be formed.
 - Adequacy of organization
 - Working conditions
 - Adequacy of human-machine interface and operational support
 - Availability of procedures or plans
 - Number of simultaneous goals
 - Available time
 - Time of day
 - Adequacy of training and preparation
 - Crew collaboration quality



Violation Promoting Context (VPC)

- ◆ Context that promotes people to commit violation
 - Time pressure and insufficient human resource
 - Insufficient knowledge and experience
 - System that is hard to use
 - Routinized violation or past success by violation
 - Recognition of responsibility or creativeness
 - Insufficient check system
- ◆ The cause of violation resides in the surrounding context rather than personal characters, if one is not ill-willed.