

The Application of HRA data in IDHEAS-ECA

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Improvement of Current HRA Methodology

The HEP of Manually Tripping Reactor in 90 seconds during ATWAS:

- HEP_1 : All Instruments work correctly, but Rx breakers not automatically tripped.
- HEP_2 : S/G Low-Low Level signal generated, but Reactor Trip signal failed.
- HEP_3 : S/G Low-Low Level signal failed.

Improvement of Current HRA Methodology

During Loss of Main Feed Accident:

- HEP_1 : Operators failed to manually initiate AFW.
- HEP_2 : Operators failed to perform Feed & Bleed.

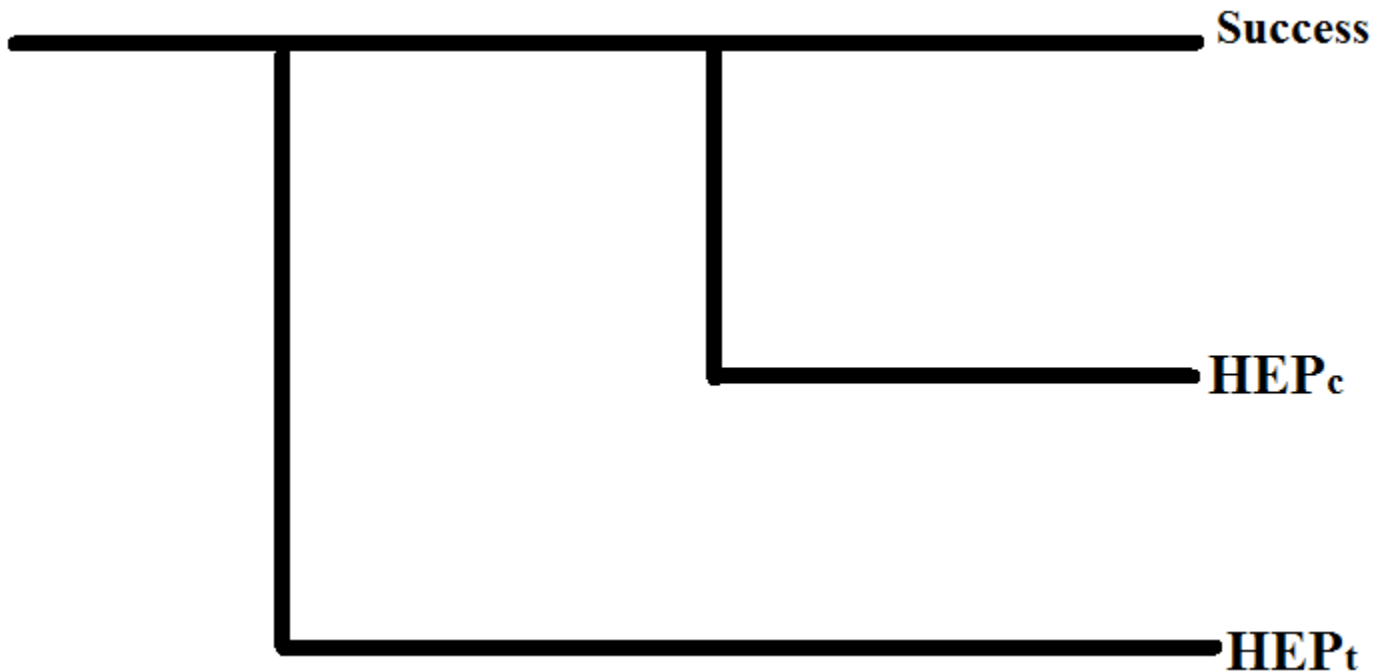
IDHEAS-ECA

HEP includes HEP_t and HEP_c

- HEP_t is the error probability due to time uncertainty for a human failure event.
- HEP_c is the error probability due to failures of macro-cognitive functions given the time for performing the required action is sufficient.

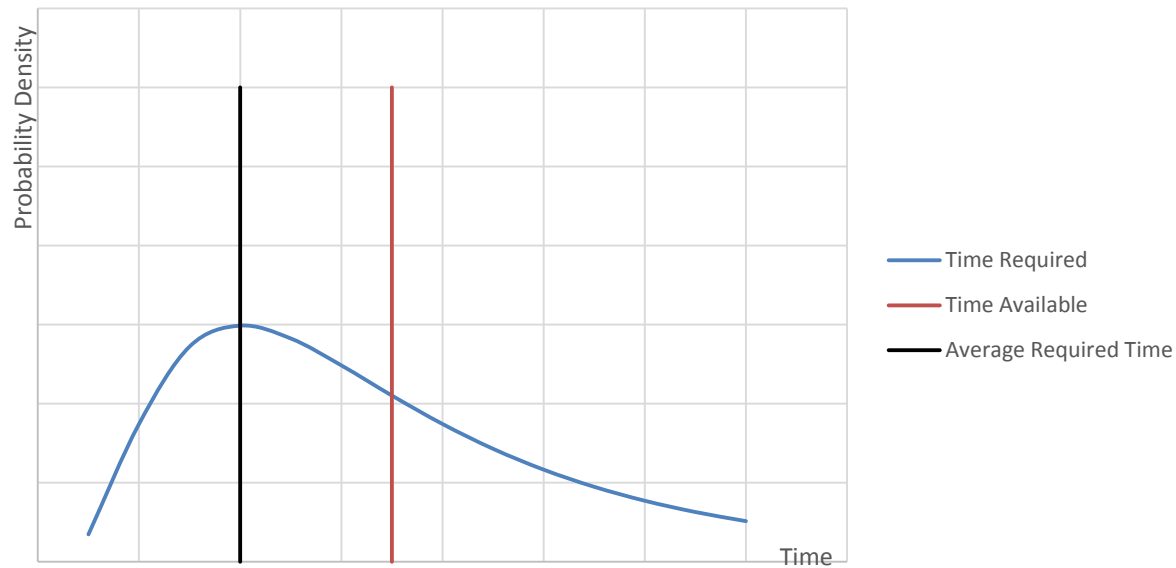
IDHEAS-ECA

$$HEP = HEP_t + (1 - HEP_t) * HEP_c$$

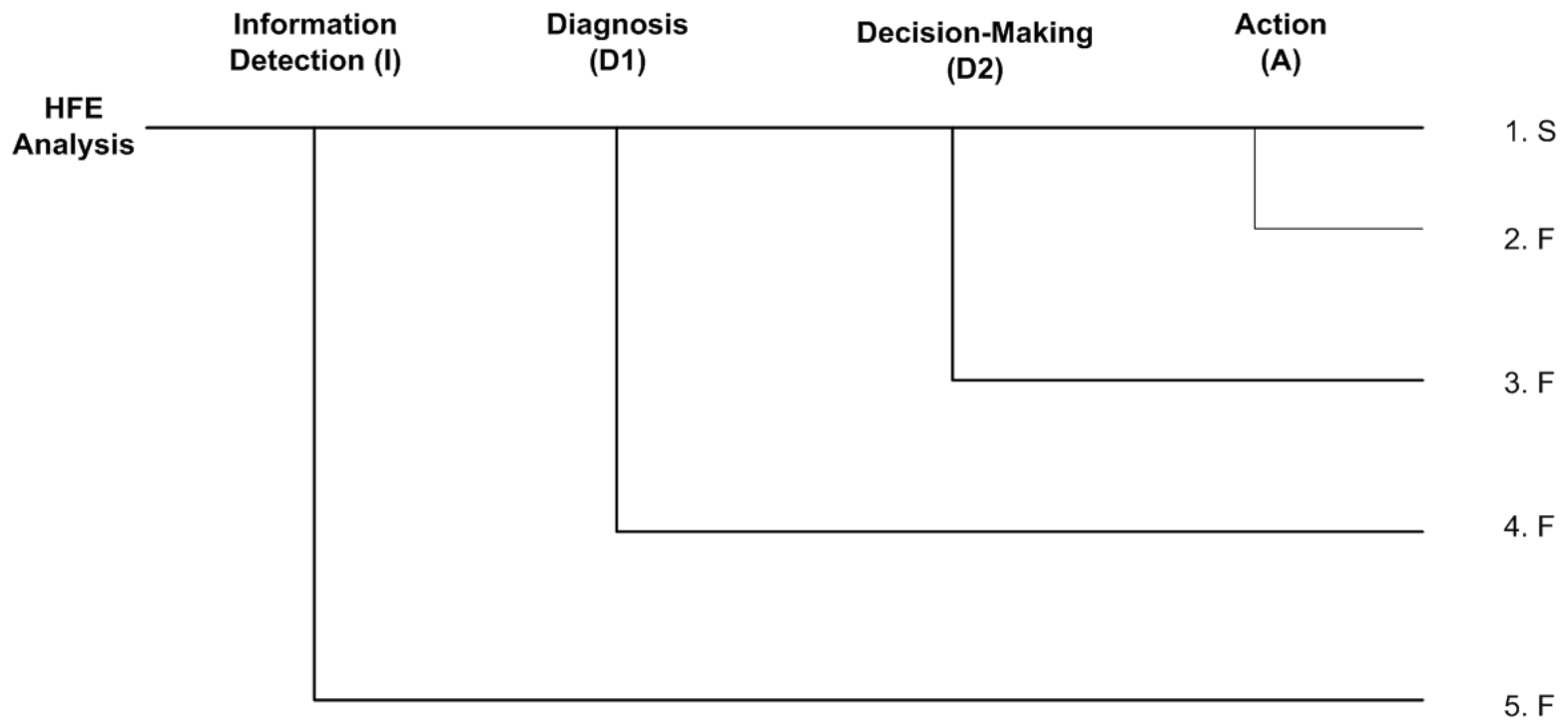


HEP_t

$$HEP_t = 1 - \varphi\left(\frac{\ln(x) - \mu}{\sigma}\right)$$



HEP_C



**Psychological
Factors**

Context Factors

Performance Influence Factors (PIFs)

Human Error Probability (HEP)



PIF

- PIFs Classified: Task Nature Factors and Multipliers
- PIFs developed according to SPAR-H and PRA Standard.
- Global PIFs applied to HFE: Available Time, Fitness for Duty, and Work Processes.
- Local PIFs applied to CFMs: Complexity, HMI, Procedures, ...

Task Nature Factors

Information Detection	Detection Mechanism	Information Locations	Information Quality
Diagnosis	Diagnosis Mode	Diagnosis Type	
Decision	Decision Mode	Decision Type	Consequence
Action	Action Type	Action Location	

Detection mechanism	Locations	Quality	BHEP
Passive detection	MCR	Complete	1.00E-06
		Incomplete	1.00E-03
		Indirectly	1.00E-02
	Local	Complete	5.00E-06
		Incomplete	5.00E-03
		Indirectly	5.00E-02
	Protected Area	Complete	1.00E-04
		Incomplete	1.00E-02
		Indirectly	1.00E-01

Decision Mode	Decision Type	Consequence	BHEP
Single Choice			0
Multiple Choices	Skill-Based	Low Consequence	1.00E-05
		High Consequence	1.00E-03
	Rule-Based	Low Consequence	1.00E-05
		High Consequence	1.00E-03
	Knowledge-Based	Low Consequence	1.00E-04
		High Consequence	1.00E-02

Values and Multipliers for Information Detection

PIFs	Multipliers
Experience/Training	1 - 10
Communication	1 - 10
Environment	1 - 10
HMI	1 - 10
Complexity	1 - 5
Stress	1 - 5
Work Load	1 - 10

Data Applied for IDHEAS-ECA

- **Update the BHEPs from data**
- **Update the multipliers from data**
- **Add more PIFs if they are important and not in current IDHEAS-ECA model.**

BHEP Update

Data Without Any Negative PIFs

Macro Cognitive	Unsat.	Demands
Detection (Alarm)	0	2
Detection (Meter)	0	0
Diagnosis	0	46
Decision	0	194
Action	0	143

Results from Data

Alarm – Detection Mode

Detection Mode	UnSat	Demand	HEP	Ratio
Procedure Directed Check	3	1290	2.71E-03	1.0
KB-Driven Monitoring	0	37	1.35E-02	5.0
Procedure Directed Monitoring	0	0	NA	NA
Awareness/Inspection	5	148	3.72E-02	13.7

Meter - Type				
Type	UnSat	Demand	HEP	Ratio
Meter	7	378	1.98E-02	1.0
Indication Light	2	312	8.01E-03	0.4
Computer	3	747	4.69E-03	0.2
Other	1	148	1.01E-02	0.5

Meter – Detection Mode

Detection Mode	UnSat	Demand	HEP	Ratio
Procedure Directed Check	3	607	5.77E-03	1.0
KB-Driven Monitoring	10	966	1.09E-02	1.9
Procedure Directed Monitoring	1	90	1.67E-02	2.9
Awareness/Inspection	3	573	6.11E-03	1.1

Decision - Outcome

Outcome	UnSat	Demand	HEP	Ratio
Simple and Distinct	23	4113	5.71E-03	1.0
Order	1	41	3.66E-02	6.4
Maintaining	0	109	4.59E-03	0.8

Decision - Basis

Basis	UnSat	Demand	HEP	Ratio
Standard	15	2757	5.62E-03	1.0
Adaptation Required	0	88	5.68E-03	1.0
Anomaly	9	1546	6.14E-03	1.1

Decision - Uncertainty

Uncertainty	UnSat	Demand	HEP	Ratio
Procedure-Based Activity	7	2394	3.13E-03	1.0
Skill-Based Behavior	9	1089	8.72E-03	2.8
Knowledge-Based Behavior	8	732	1.16E-02	3.7

Diagnosis - Basis

Basis	UnSat	Demand	HEP	Ratio
Procedure	22	1277	1.76E-02	1.0
Skill	1	79	1.90E-02	1.1
Knowledge	3	662	5.29E-03	0.3

Diagnosis - Familiarity

Familiarity	UnSat	Demand	HEP	Ratio
Standard	12	1357	9.21E-03	1.0
Novel	6	579	1.12E-02	1.2
Anomaly	8	69	1.23E-01	13.4

Action - Recoverability

Recoverability	UnSat	Demand	HEP	Ratio
Immediately Recoverable	24	1708	1.43E-02	1.0
Recoverable With Significant Efforts	11	1383	8.32E-03	0.6
Unrecoverable	18	840	2.20E-02	1.5

Action - Type

Type	UnSat	Demand	HEP	Ratio
Simple and Distinct	19	1617	1.21E-02	1.0
Order	20	1484	1.38E-02	1.1
Maintaining	10	597	1.76E-02	1.5

Action - Location

Location	UnSat	Demand	HEP	Ratio
Main or Auxiliary Control Board	48	3849	1.26E-02	1.0
Back Control Panels	5	97	5.67E-02	4.5

Time Criticality

		Expansive Time	Nominal Time	Barely Adequate Time
Alarm	HEP	5.21E-03	7.51E-03	4.46E-03
	Ratio	1.0	1.4	0.9
Meter	HEP	3.39E-03	8.37E-03	3.52E-02
	Ratio	1.0	2.5	10.4
Diagnosis	HEP	7.13E-03	1.69E-02	8.88E-03
	Ratio	1.0	2.4	1.2
Decision	HEP	5.08E-03	6.53E-03	1.47E-03
	Ratio	1.0	1.3	0.3
Action	HEP	9.60E-03	1.44E-02	1.84E-02
	Ratio	1.0	1.5	1.9

Workload				
		Normal	Concurrent Demands	Multiple Concurrent
Alarm	HEP	2.58E-03	8.82E-03	1.72E-02
	Ratio	1.0	3.4	6.7
Meter	HEP	4.76E-03	7.33E-03	3.44E-02
	Ratio	1.0	1.5	7.2
Diagnosis	HEP	1.52E-02	1.12E-02	3.78E-02
	Ratio	1.0	0.7	2.5
Decision	HEP	3.25E-03	6.56E-03	7.25E-03
	Ratio	1.0	2.0	2.2
Action	HEP	1.23E-02	1.05E-02	2.50E-02
	Ratio	1.0	0.9	2.0

Conclusions

- **Time Criticality has a strong impact for Meter Data Collection, but not for others.**
- **Workload may impact all Cognitive Mechanisms.**
- **Location is important for Action.**
- **Alarm Detection is sensitive to the Modes**
- **Skill-, Rule-, Knowledge-Behaviors may impact Decision.**

Questions and Discussions

Additional Slides

Action		
PIFs	# of Demands	
	Status 1	Status 2
UnintuitivePlantResponse	3917	29
UnintuitiveControls	3922	24
AdditionalMentalEffortRequired	3812	134
InadequateFeedback	3934	12
SimilarControls	3946	0
NonStandard	3590	356
NoisyBackground	3946	0
Coordination	3946	0
CommunicatorUnavailable	3933	13
MultipleDemand	3437	509
MemoryDemand	3798	148

Action – Extend of Communication

Extend of Communication	UnSat	Demand	HEP	Ratio
Nominal Communication	47	3437	1.38E-02	1.0
Extensive Onsite Communication	6	509	1.28E-02	0.9