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Protecting People and the Environment

Human Error Data for the Integrated Human Event Analysis System for Event Conditions Assessment (IDHEAS-ECA)

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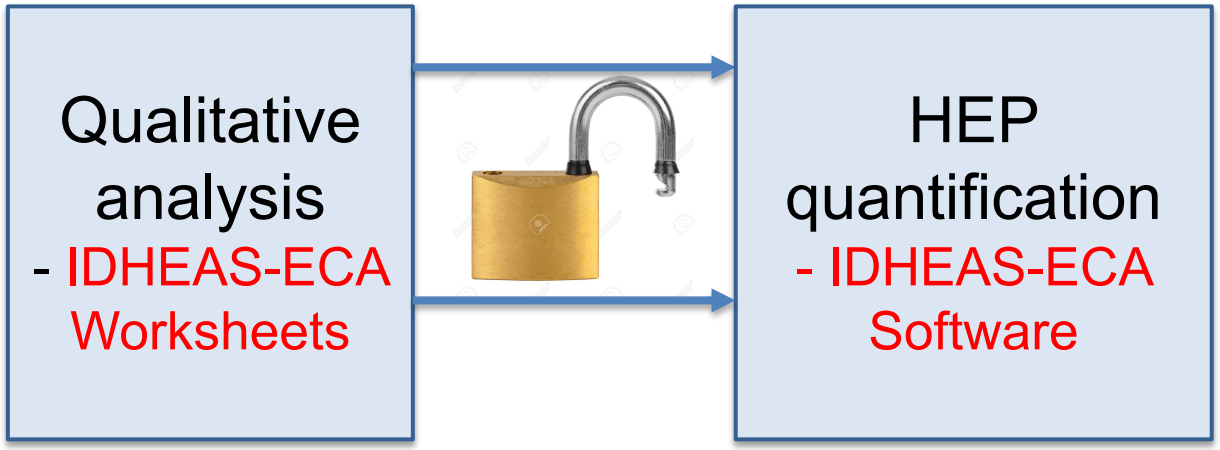
Outline

1. Introduction to IDHEAS-ECA
2. Generalization and integration of human error data for IDEHAS-ECA
3. IDHEAS-ECA Tool

Intended Uses of IDHEAS-ECA

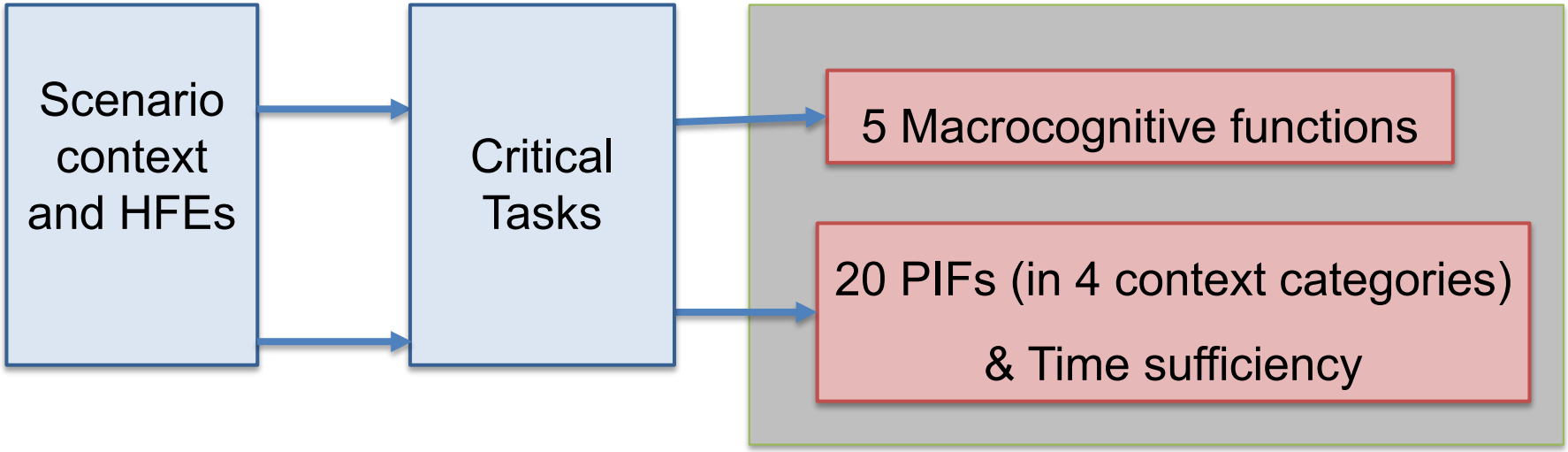
- Perform HRA for all nuclear applications
- It uses five macrocognitive functions and 20 performance influencing factors (PIFs) to model failure of human actions:
  - Main control room (CR) and ex-CR actions
  - At-power and Shutdown
  - Level-1 to Level-2 PRA
  - Human actions with reactors and non-reactors

Overview of IDHEAS-ECA



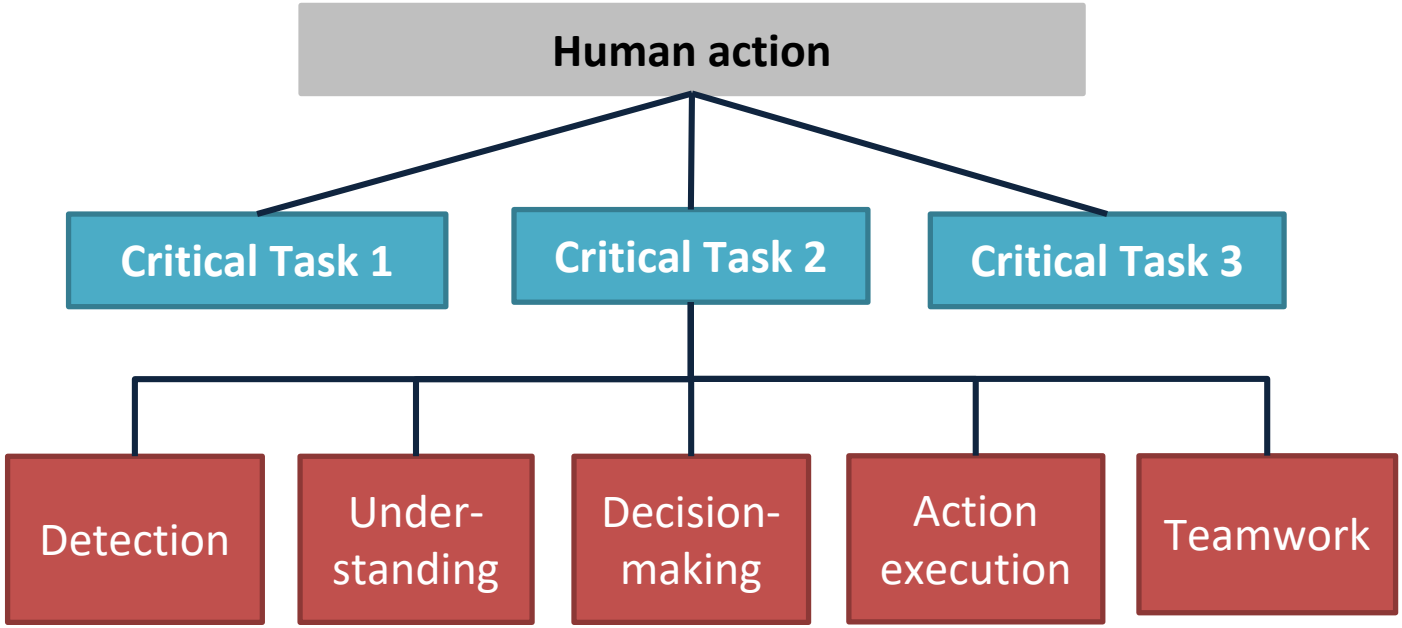
- Extensive qualitative analysis has to be performed using IDHEAS-ECA Worksheets
- HEP quantification can be done with IDHEAS-ECA Software.

How IDHEAS-ECA models human failure

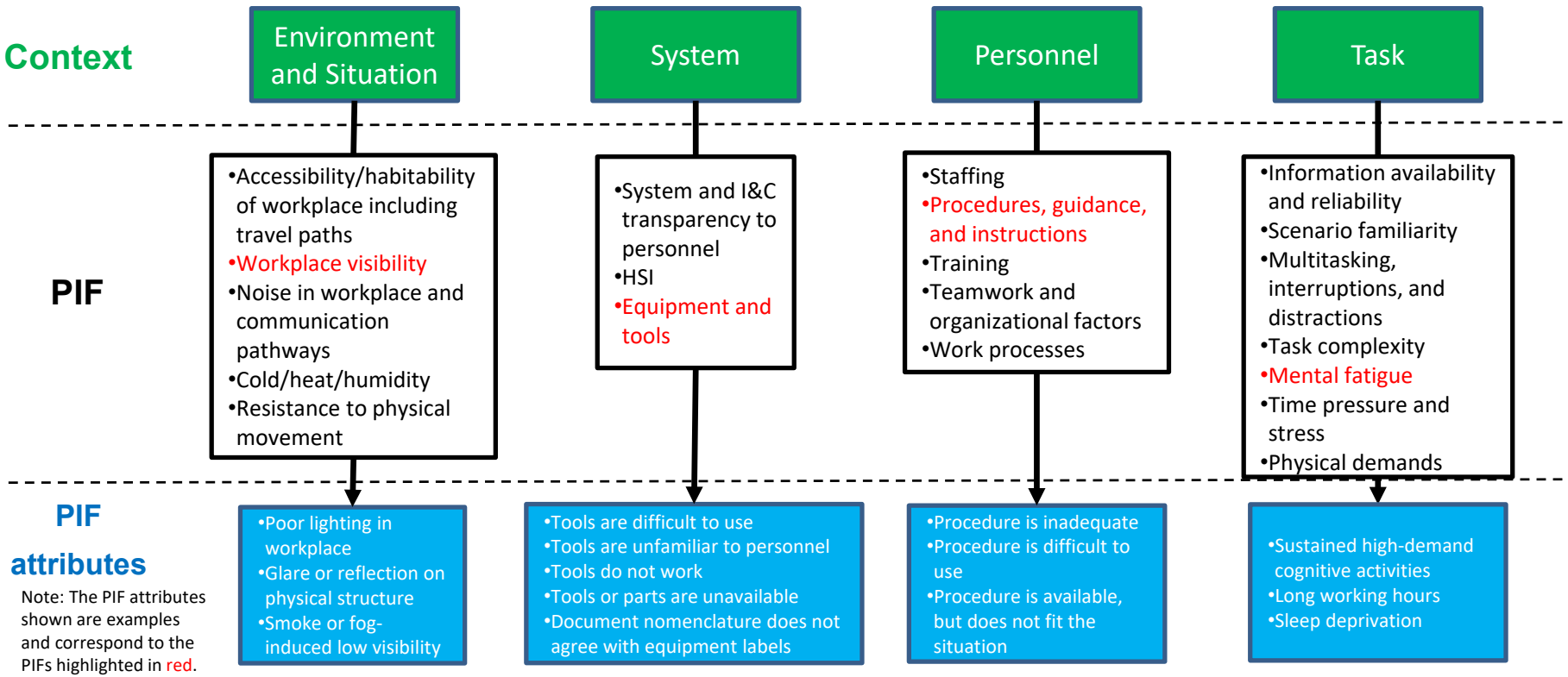


- Context are the conditions that affect human performance of an action.
- PIFs are used to model the context.

Modeling human actions with macrocognitive functions

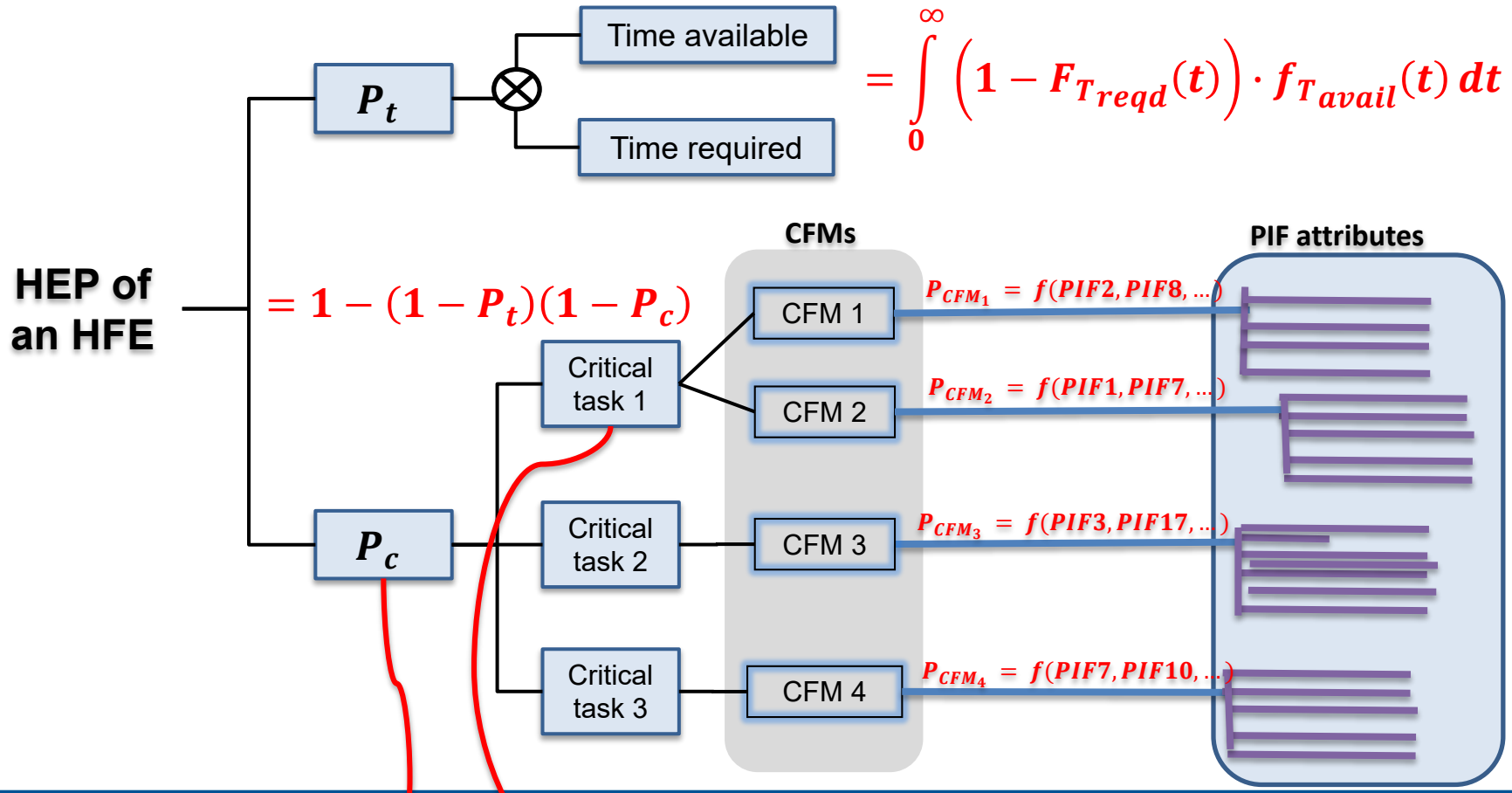


PIF Structure



Note: The PIF attributes shown are examples and correspond to the PIFs highlighted in red.

IDHEAS-ECA Process - Step 5: HEP Quantification

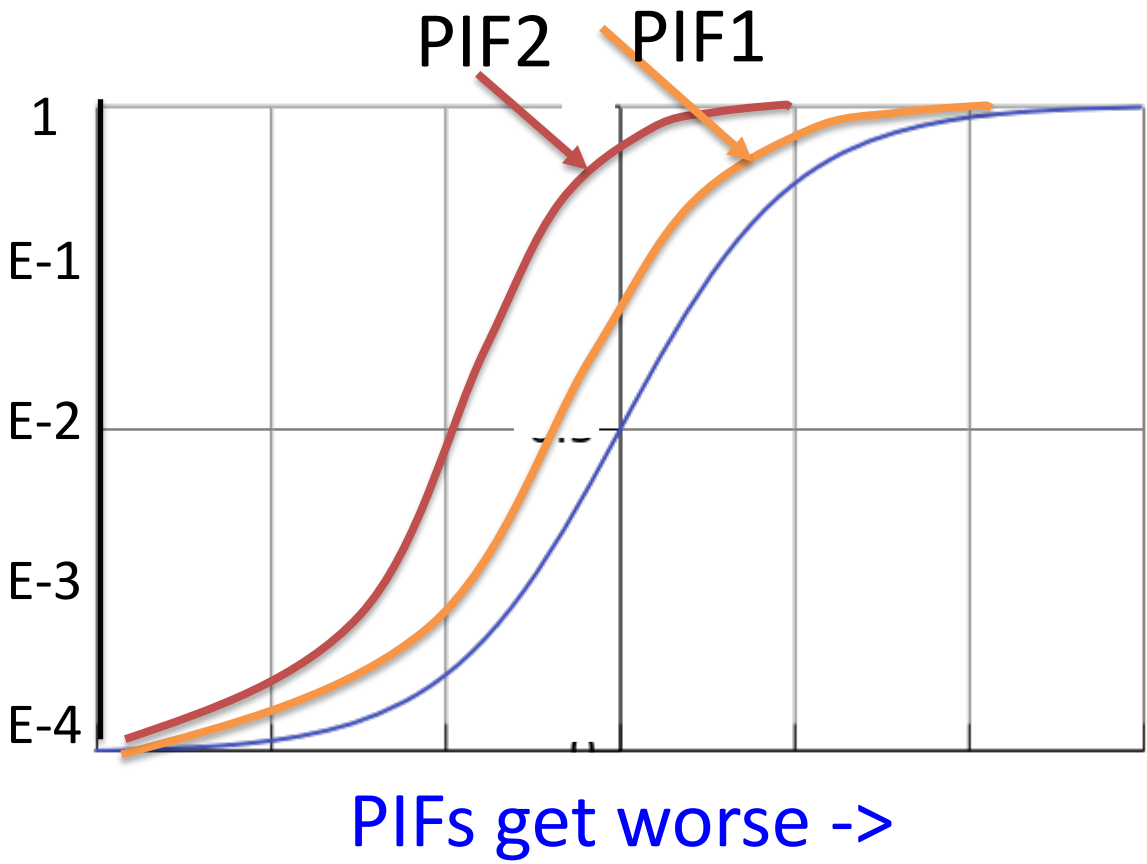


$$1 - \prod_{i=1}^{3}\left(1 - P_{CT_i}\right) = \quad = 1 - \prod_{i=1}^{2}\left(1 - P_{CFM_i}\right)$$

Step 5
HEP Quantification Model for P_c

Base PIFs and Base HEPs

- A Base PIFs can change HEP from a minimum value to 1 (blue curve)
  - Information availability and reliability,
  - task complexity
  - scenario familiarity
- Modification PIFs
  - Remaining 17 PIFs (orange and red curves)



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Step 5
HEP Quantification model for P_c

2. Linear combination of PIF effects

$$P_{CFM} = P_{CFM_{Base}} \cdot \left(1 + \sum_{i=1}^{n} (w_i - 1)\right) \cdot C \cdot \frac{1}{Re}$$

Base HEP from Base PIFs

PIF weights from Modification PIFs

PIF interaction factor; set to 1 with linear combination

Recovery factor; set to 1 unless data suggest otherwise

$$\boldsymbol{w_i} = \frac{ER_{PIF}}{ER_{PIF_{Base}}}$$

ER_{PIF} ≡ error rate at a given PIF attribute

$ER_{PIF_{Base}}$ ≡ error rate when the PIF attribute has no or low impact

IDHEAS-ECA provides the base HEP Values and PIF Weights for every CFM at a given PIF attribute (Appendix B)

Example: Base HEPs for *Information availability and reliability*

PIF Attribute		D	U	DM	E	T
Inf1	Information is temporarily incomplete or not readily available	NA	5E-3	5E-3	NA	NA
	Information is moderately incomplete – a small portion of key information is missing	NA	5E-2	5E-2	NA	NA
	Information is largely incomplete - Key information is masked or indications are missing	NA	2E-1	2E-1	NA	NA
Inf2	Unreliable or uncertain - Personnel is aware that source of information could be temporally unreliable - pieces of Information change over time thus they become uncertain by the time personnel use them	NA	E-2	E-2	NA	NA
	Moderately unreliable or uncertain - Personnel recognize information unreliable - Conflicts in key information	NA	5E-2	5E-2	NA	NA
	Key information is highly uncertain	NA	E-1	E-1	NA	NA
	Extremely unreliable - Key information is misleading	NA	E-3	E-3	NA	NA

IDHEAS-ECA provides the base HEP Values and PIF Weights for every CFM at a given PIF attribute (Appendix B)

Example: PIF Weights for Multitasking/Interruption/Distraction

PIF Attribute		D	U	DM	E	T
MT0	No impact	1	1	1	1	1
MT1	Distraction by other on-going activities that demand attention	1.2 – 2.8	1.1	1.1	1.2 – 2.8	1.2 – 2.8
MT2	interruption taking away from the main task	1.1 - 4	1.1 – 1.7	1.1 – 1.7	1.1 - 4	1.1 - 4
MT3	Concurrent visual detection and other tasks	2 - 10	NA	NA	NA	NA
MT4	Concurrent auditory detection and other tasks	10 -20	NA	NA	NA	NA
MT5	Concurrent diagnosis and other tasks	NA	3-30	NA	NA	NA
MT6	Concurrent Go/No-go decision-making	NA	NA	2	NA	NA
MT7	Concurrently making Intermingled, complex decisions / plans	NA	NA	5	NA	NA
MT8	Concurrently executing action sequence and performing another attention/working memory task	NA	NA	NA	2.3	NA
MT9	Concurrently executing intermingled or inter-dependent action plans	NA	NA	NA	5	NA
MT10	Concurrently communicating or coordinating multiple distributed individuals or teams	NA	NA	NA	NA	5

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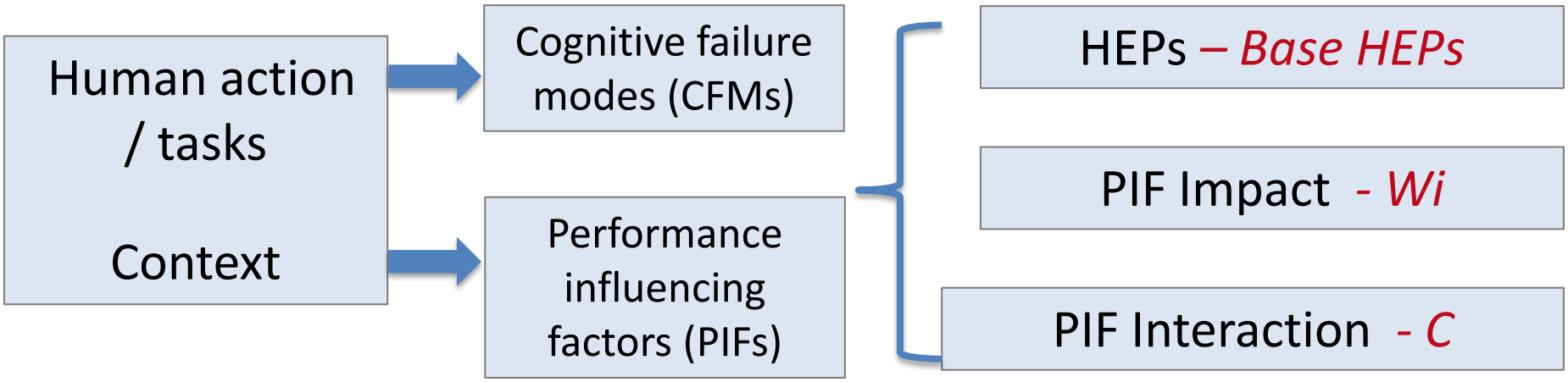
Use of Human Error Data to inform HEPs

1. Documentation - Evaluate data source

2. Generalization - Interpret and represent data in IDEHAS-DATA

3. Integration - Consolidate the data in IDEHAS-DATA for IDHEAS-ECA



Example 1: Data documentation

REF: Message Complexity on Pilot Readback Performance (Prinzo et a., 2006)

Task: Pilots listen to and read back messages from air traffic controllers

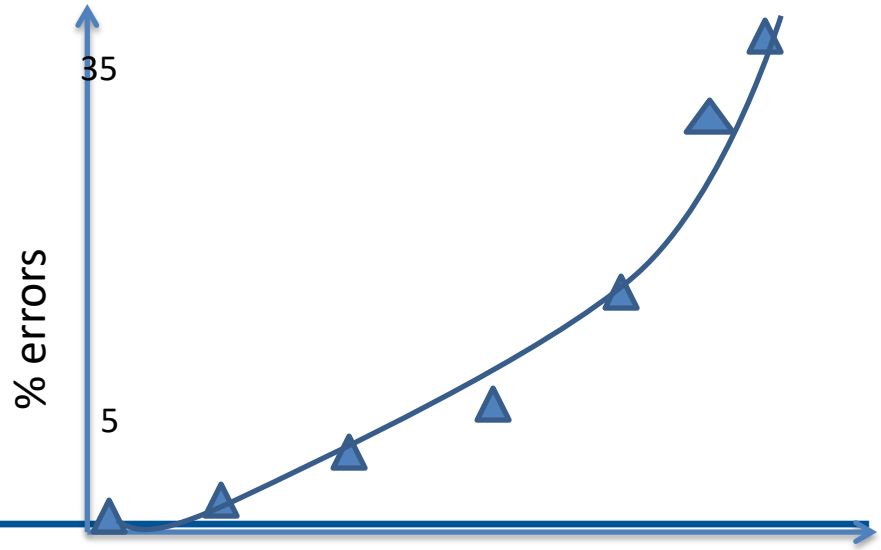
CFMs: Information misperceived; Information not retained or miscommunicated

PIF: Detection complexity – Message complexity indicated by the number of information items that pilots have to retain in their working memory

Results: Readback errors increase with message complexity

Data:

Complexity	% errors
1	< 1
5	3.6
10	6.1
11	10.8
12	12
13	19
16	37



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Example 1: Data generalization in IDHEAS-DATA

	CFMs	Attributes in the original data		HEP	Other PIFs	Ref ID
		PIF attribute	Attribute states			
D	Failure to respond to alarms	Number of compelling signals	Few Several Many	3E-3 1E-2 1E-1	None	02
	Error in responding to compelling signals	number of annunciators	1 to 10 11 to 40 larger than 40	0.0001 to 0.05 0.10 to 0.20 0.25	No peer-checking?	
	Failure of getting information	Number of messages communicated	1, 5, 8, 11, 15, 17, >20	0.005 0.036 0.05 0.11 0.23 0.32 >0.5	Mixed levels of stress Low distraction No peer-checking	31
U		comprehension and skill	high level	0.15	Unknown	21
		cognitive complexity	Typical Moderate High	3E-3 0.03 0.05	Unknown Unknown Unknown	
	U4 and U5	# of aviation topics in one communication	1 2	0.038 0.060	No peer checking	31

Example 1: Data integration for IDHEAS-ECA

Multiple data points in IDHEAS-DATA for CFM Failure of Detection and PIF attribute "Detection overload with multiple competing signals."

Data integration:

- Anchor to operational data first
- Infer the base HEP by detaching the effects of other PIFs (e.g., the HEP is the reported error rate divided by a factor of 10 for no-peer-checking)
- Adjust the base HEP toward the median of all the data points

PIF Attribute		Detection
C0	No impact on HEP	0
C1	Detection overload with multiple competing signals - track the states of multiple systems, - monitor many parameters, - memorize many pieces of information detected - Many types or categories of information to be detected	Few (<7) 3E-3 Multiple (7~11) 1E-2 Many (11~20) 1E-1 Excessive amount (>20) 3E-1

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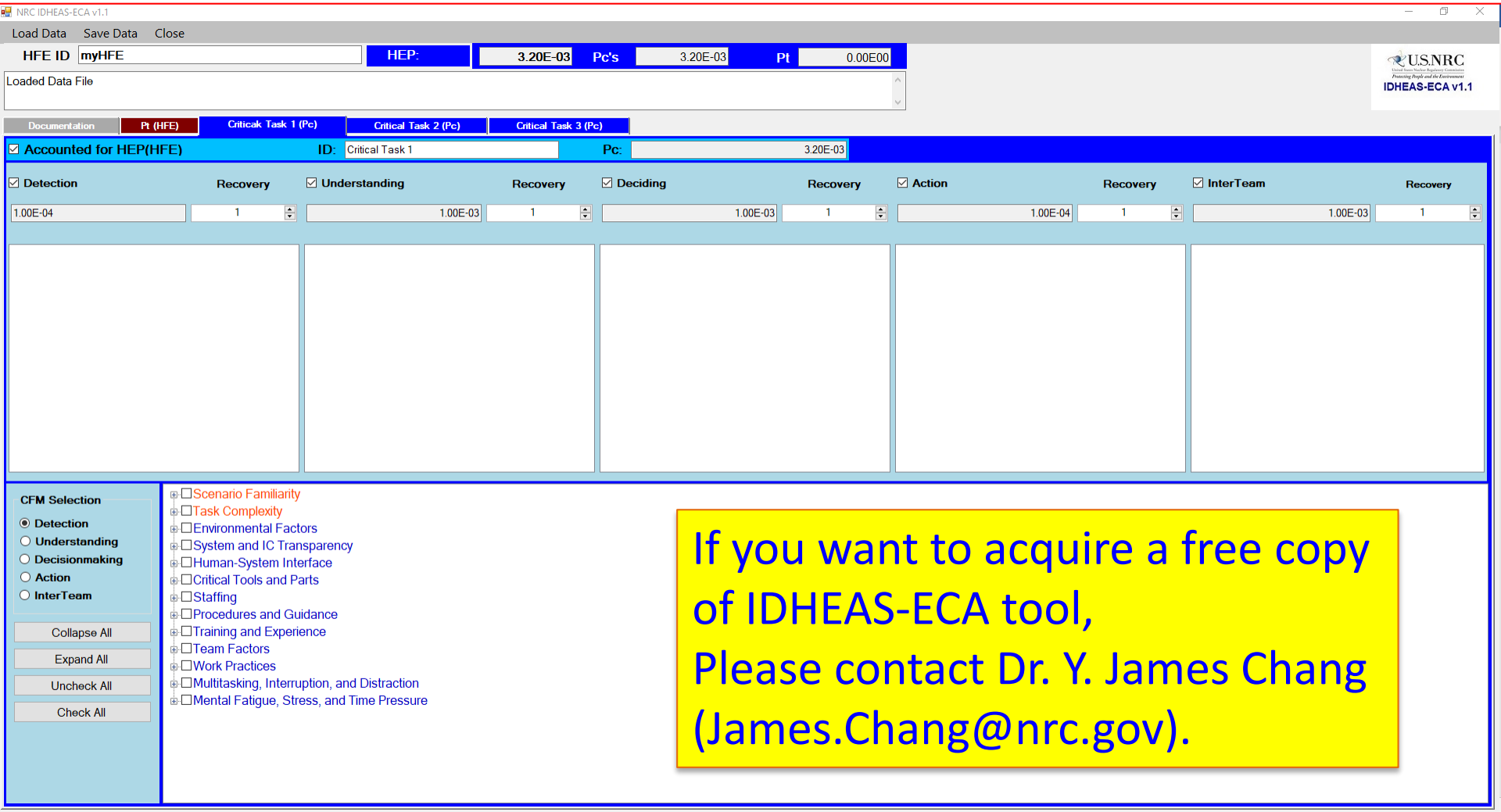
The NRC's IDHEAS-ECA Software



If you want to acquire a free copy of IDHEAS-ECA tool,
Please contact Dr. Y. James Chang (James.Chang@nrc.gov).

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Summary

- Human error data of various sources are generalized into IDHEAS-DATA for IDHEAS cognitive failure modes (CFMs) and PIF attributes
- The NRC staff integrated the generalized human error data in IDHEAS-DATA to infer the numbers of base HEPs and PIF weights for IDHEAS-ECA
- Data generalization is generic for IDHEAS CFMs and PIF attributes; Data integration is specific for the HRA method.
- Data generalization is an on-going, continuous effort; Data integration should be periodically updated.