IDHEAS Suite for Human Reliability Analysis

Y. James Chang, Jing Xing, Jonathan DeJesus Segarra
U.S. Nuclear Regulatory Commission

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Background

- The Integrated Human Event Analysis System (IDHEAS) was developed under an NRC Commission's direction in 2006 "to evaluate the different human reliability models to propose either a single model for the NRC to use or guidance on which model(s) should be used in specific circumstances."
  - The NRC staff chose the "a single model" path – IDHEAS model
- Today, IDHEAS is a model with many application components (collectively, IDHEAS Suite) for performing human reliability analysis (HRA)

IDHEAS Suite

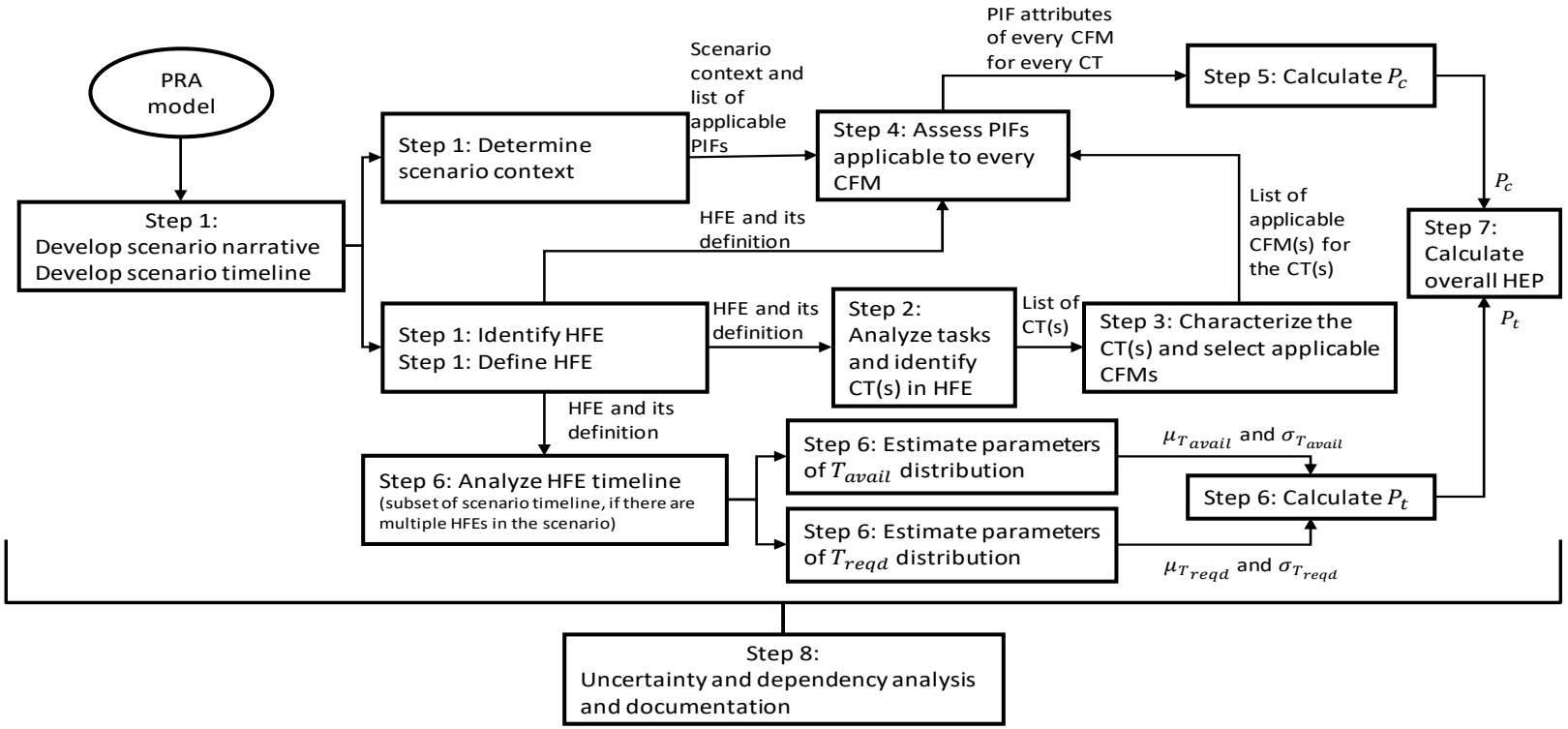
Element	Description	Status
IDHEAS-G	General methodology - the single model	Complete
IDHEAS-AtPower	A HEP calculation method for internal events at-power HRA applications	Complete
IDHEAS-ECA	A HEP calculation method. Originally developed for the event and condition analysis (ECA) but was expanded for all HRA applications.	Complete
IDHEAS-DATA	Data basis	Draft complete
IDHEAS-DEP	Dependency analysis	Draft complete
IDHEAS-TIME	Estimate the uncertainty distribution of the time-required	In-process
IDHEAS-REC	Error recovery	TBD
IDHEAS-ECA software tool	Facilitate the implementation of IDHEAS-ECA	V1.2 In progress

IDHEAS-G

(General Methodology, NUREG-2198)

- Recommended for NRC use by NRC's Advisory Committee on Reactor Safeguards
- Developed on the foundation of a large psychological literature review (NUREG-2114)
- Include an HRA process and a toolbox to perform all process elements
  - Provide technical basis, models, and guidance to perform all process elements (13 appendixes)
  - An element could be modeled with different levels of detail and different approaches, e.g.,
    - Failure modes: macrocognitive functions, cognitive processes, and cognitive mechanisms
    - HEP quantification approaches: expert elicitation, data based, and model-based
- Provide equations and parameters but not the values of parameters

HRA Process



CFM = cognitive failure mode
CT = critical task
HEP = human error probability
HFE = human failure event
PIF = performance-influencing factor
PRA = probabilistic risk assessment

P_c = error probability due to CFMs
P_t = error probability due to uncertainty in T_{avail} and T_{reqd}
T_{avail} = time available
T_{reqd} = time required
$\mu_{T_{avail}}$ and $\sigma_{T_{avail}}$ = mean and standard deviation of T_{avail}
$\mu_{T_{reqd}}$ and $\sigma_{T_{reqd}}$ = mean and standard deviation of T_{reqd}

IDHEAS HEP Quantification Model
(Calculate HEP of a Human Failure Event)

Main Element	Sub-Elements Highlights
Pt (Time Insufficiency)	• Convolution of the uncertainty distributions of the time-required and time-available

Pc (Cognitive Errors)	• Critical tasks
	• Cognitive basis structure
	  • 5 Macrocognitive functions (Detection, Understanding, Decisionmaking, Action Execution, and Interteam)
	  • 20 PIFs, each PIF has a set of attributes
	• Two types of PIFs (base PIFs and modifier PIFs) based on their effects on HEPs
	• The accumulated PIFs effects on a CFM is [probabilistic sum of the base PIFs' effects] × [sum of the modifier PIFs' effects] ÷ Error Recovery

IDHEAS-DATA

- Provide extensive data-basis for IDHEAS-model based HEP estimations
- Pacific Northwest National Laboratory (PNNL) is reviewing the IDHEAS-DATA draft report
  - Ensure literature information is used correctly (status: PNNL completed the review)
  - Determine whether the equation calculating multiple PIFs combined effects on HEP is appropriate (by 6/2022)

IDHEAS-TIME

- PNNL analyzes simulator data to recommend distribution for the time-required
- Data sources include EPRI, Halden HAMMLAB, KAERI, and ÚJV Řež, a. s.
- Draft report available by Dec. 2021
- Only includes control room actions

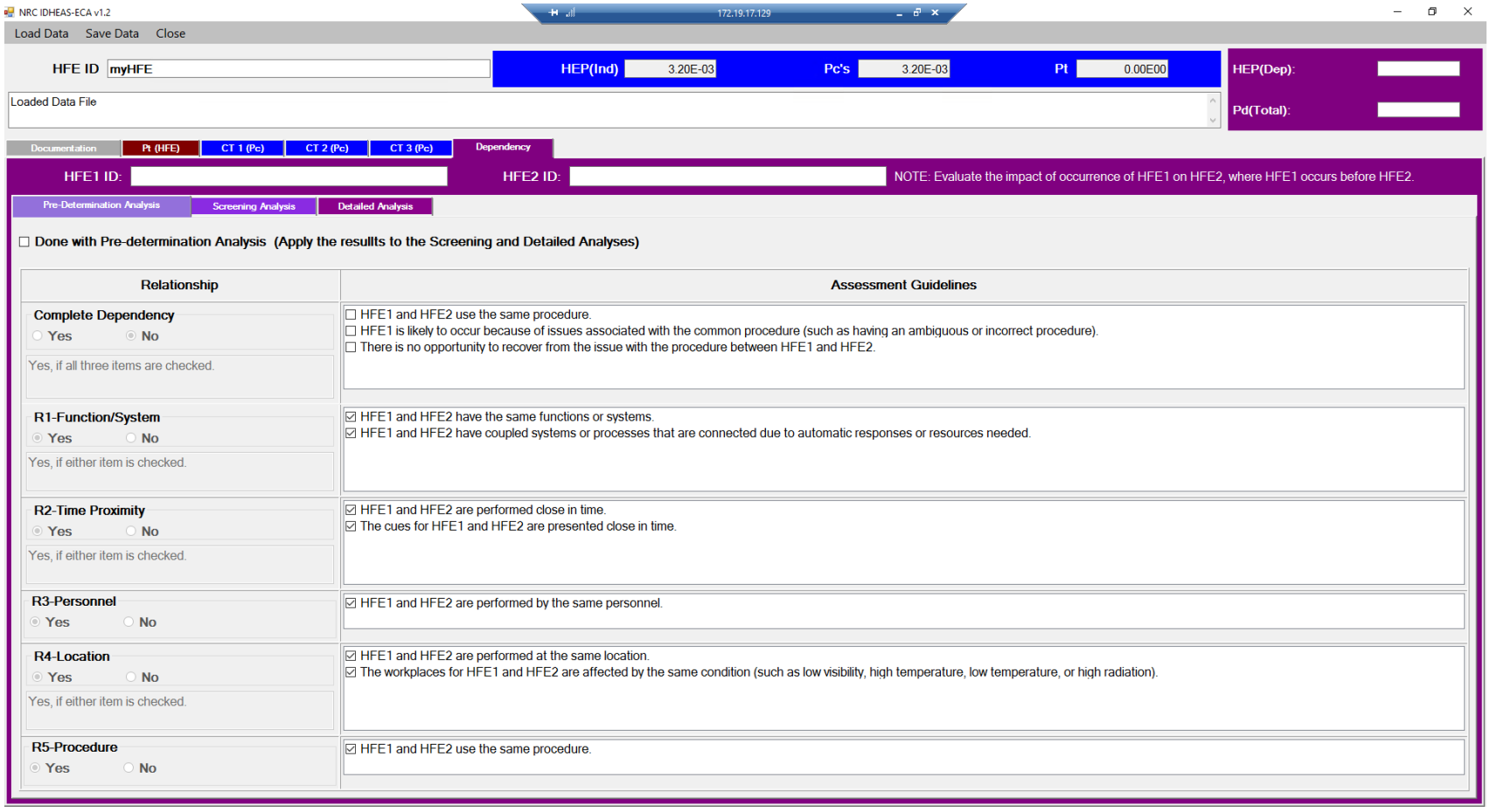
IDHEAS-DEP

(RIL-2021-14)

- Assess the dependency effects of the occurrence of HFE1 on HFE2. HFE1 occurs earlier than HFE2
- Model 3 types of dependency
  - Consequential dependency, Resource-sharing dependency, and Cognitive dependency
- Include 5 relationships to assess dependency effects
  - Function/system, time proximity, personnel, location, and procedure
- Three levels of analysis
  - Predetermination, Screening, and Detailed
- Quantification based on IDHEAS. Does not use THERP's five-level dependency

IDHEAS-DEP Predetermination Analysis

(Draft Graphical User Interface)



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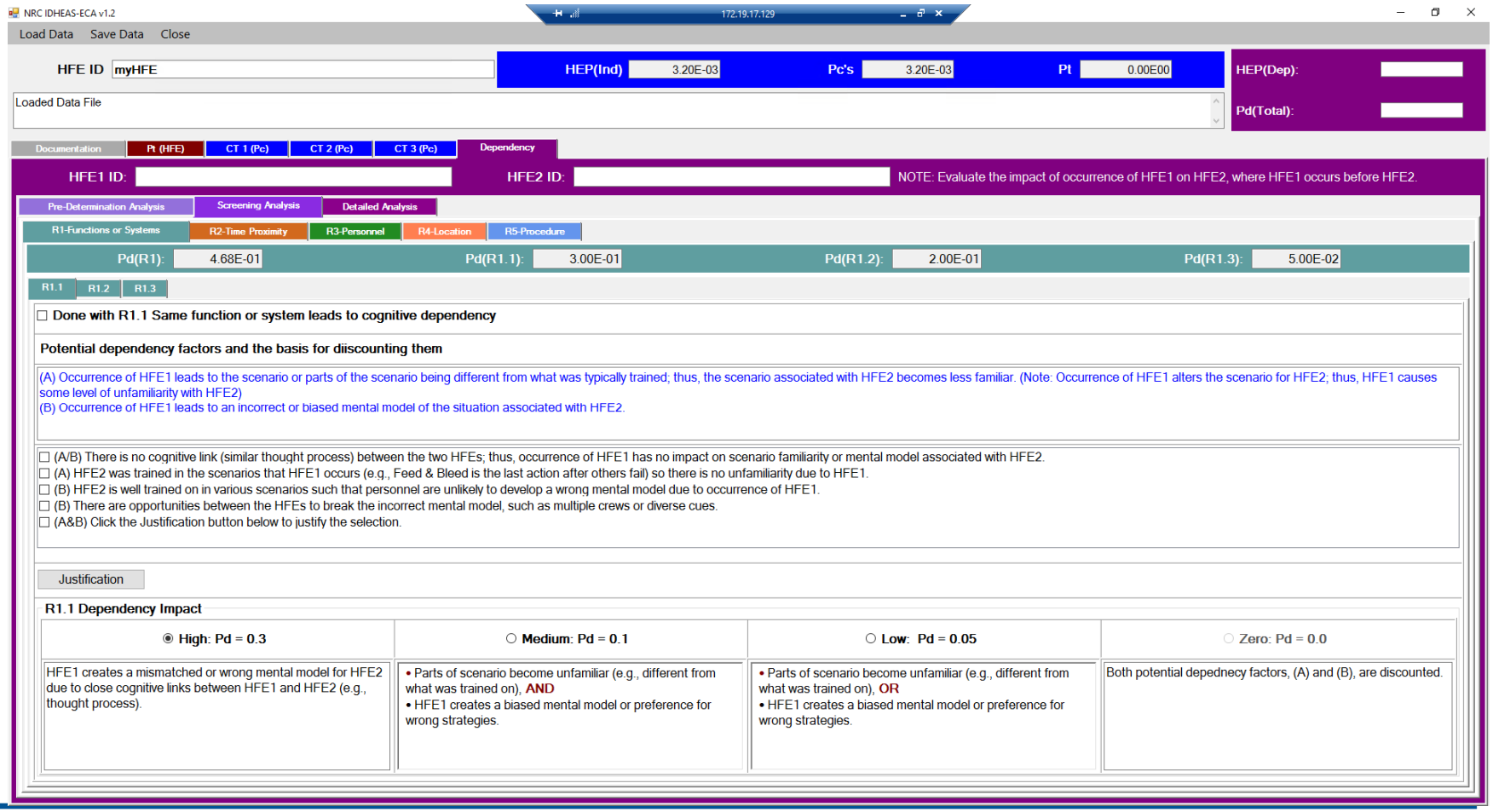
IDHEAS-DEP Screening Analysis

(Draft Graphical User Interface)



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IDHEAS-DEP Screening Analysis

- Calculate the total dependency effects (Pd)
  - Pd is the probabilistic sum of all applicable dependency effects
- The dependent HEP is the probabilistic sum of the individual HEP and Pd

More About IDHEAS-DEP

- IDHEAS-DEP Detailed Analysis
  - Requires using IDHEAS-ECA method
  - The dependency effects are represented by the corresponding PIF attributes
  - IDHEAS-DEP suggests the corresponding PIF Attributes for the analysts' consideration
- IDHEAS-DEP status
  - Report (Research Information Letter) should be available to the public in Dec. 2021 (RIL-2021-14)
  - To be included in IDHEAS-ECA software tool v1.2.

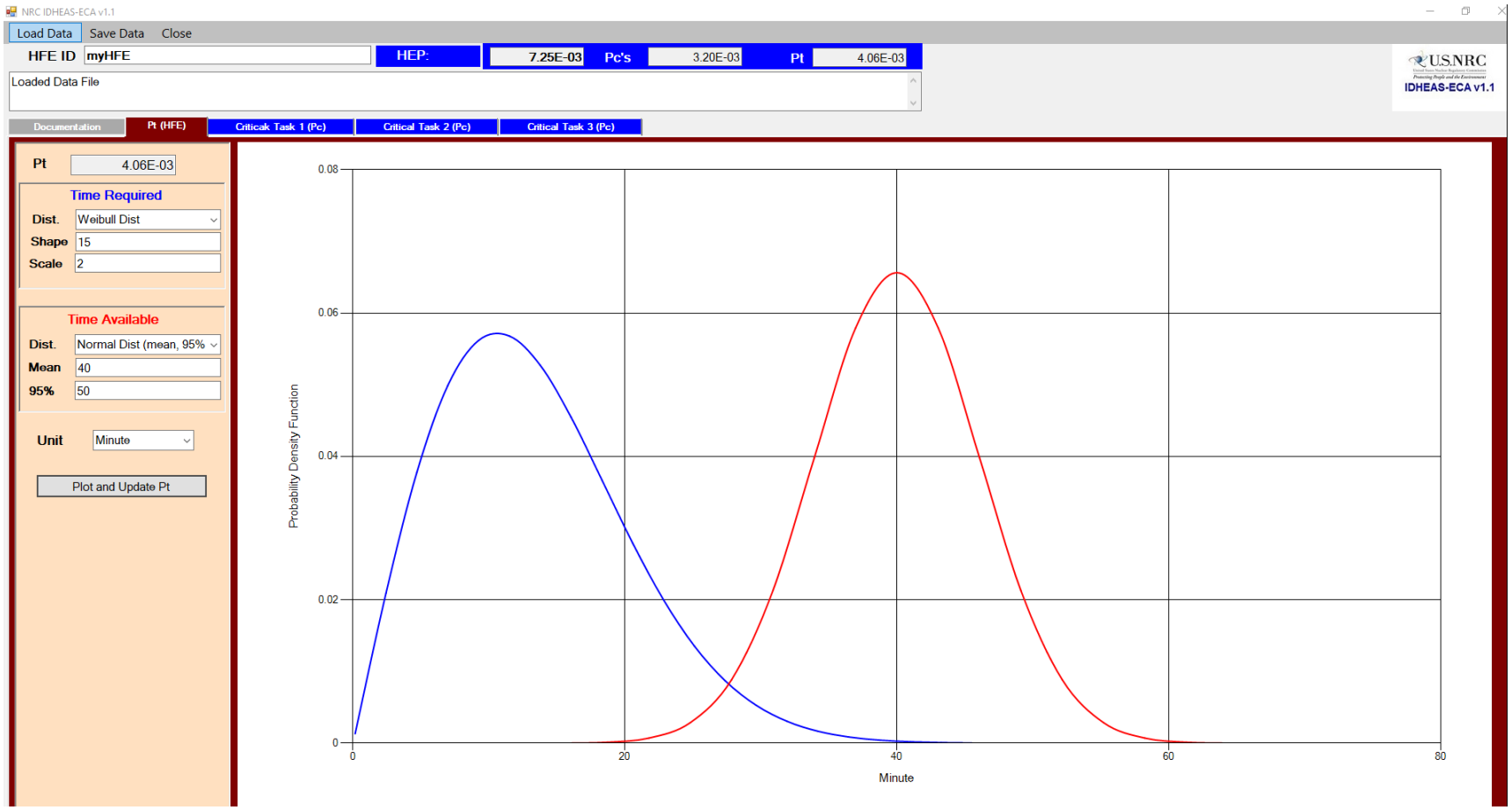
IDHEAS-ECA Software Tool

(IDHEAS-ECA RIL-2020-02)

- V1.1 is available to calculate individual HEPs
- V1.2 is scheduled to be available in Jan. 2022.
  - Include IDHEAS-DEP to calculate dependent HEPs
  - Fixed the found issues
  - Add lognormal distributions to calculate Pt

Calculate Pt

(IDHEAS-ECA v1.1 Screenshot)



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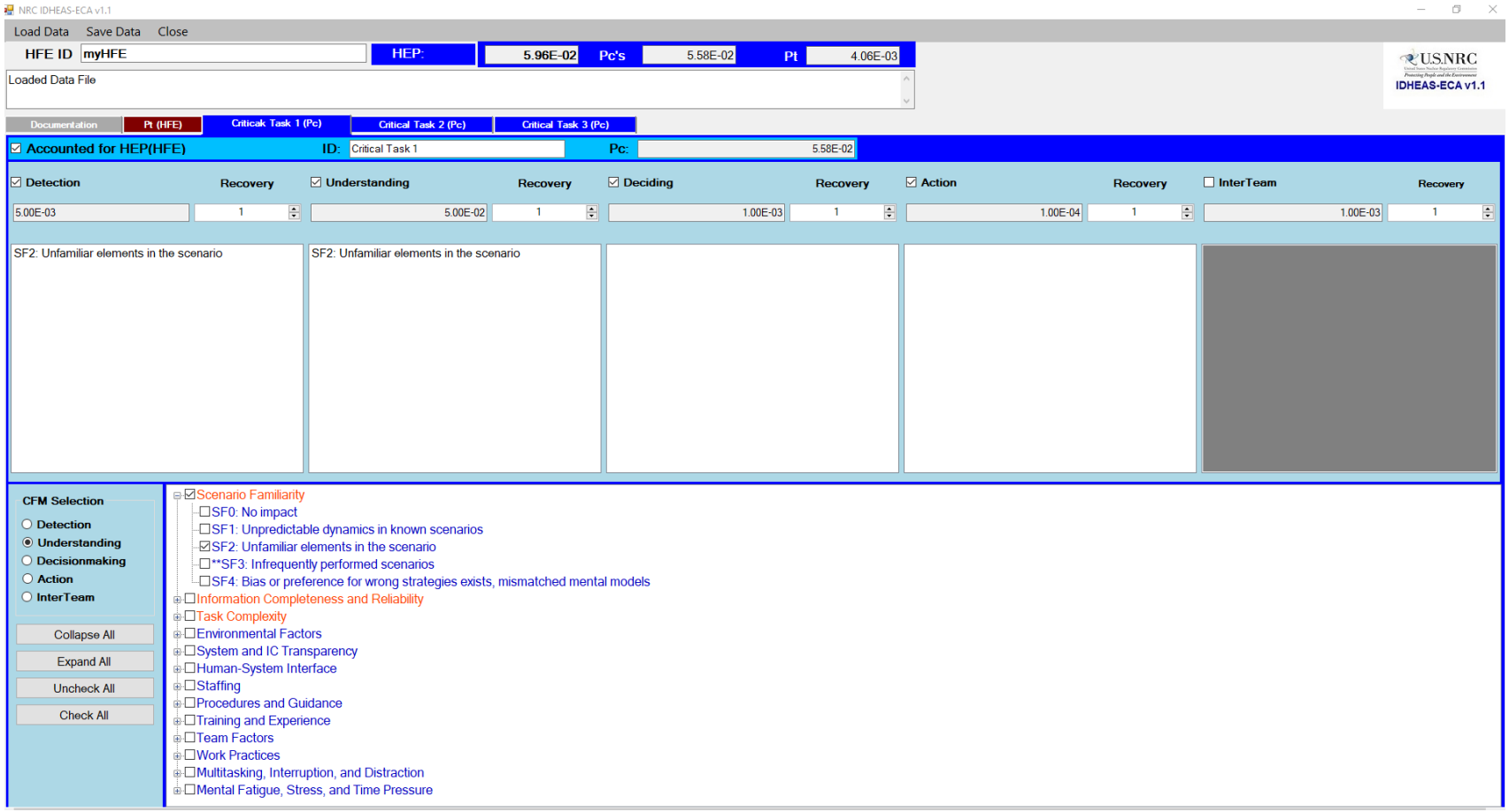
Calculate Pc

(IDHEAS-ECA v1.1 Screenshot)



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Conclusion

- IDHEAS advances the cognitive basis and data basis for HRA and tie to the current cognitive and behavior science literature.
- Recommended for the NRC use by NRC's Advisory Committee on Reactor Safeguards
- NRC plans to gradually replace SPAR-H with IDHEAS-ECA
- Methods and tools will be available to the public