
IDHEAS Suite for Human Reliability Analysis

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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

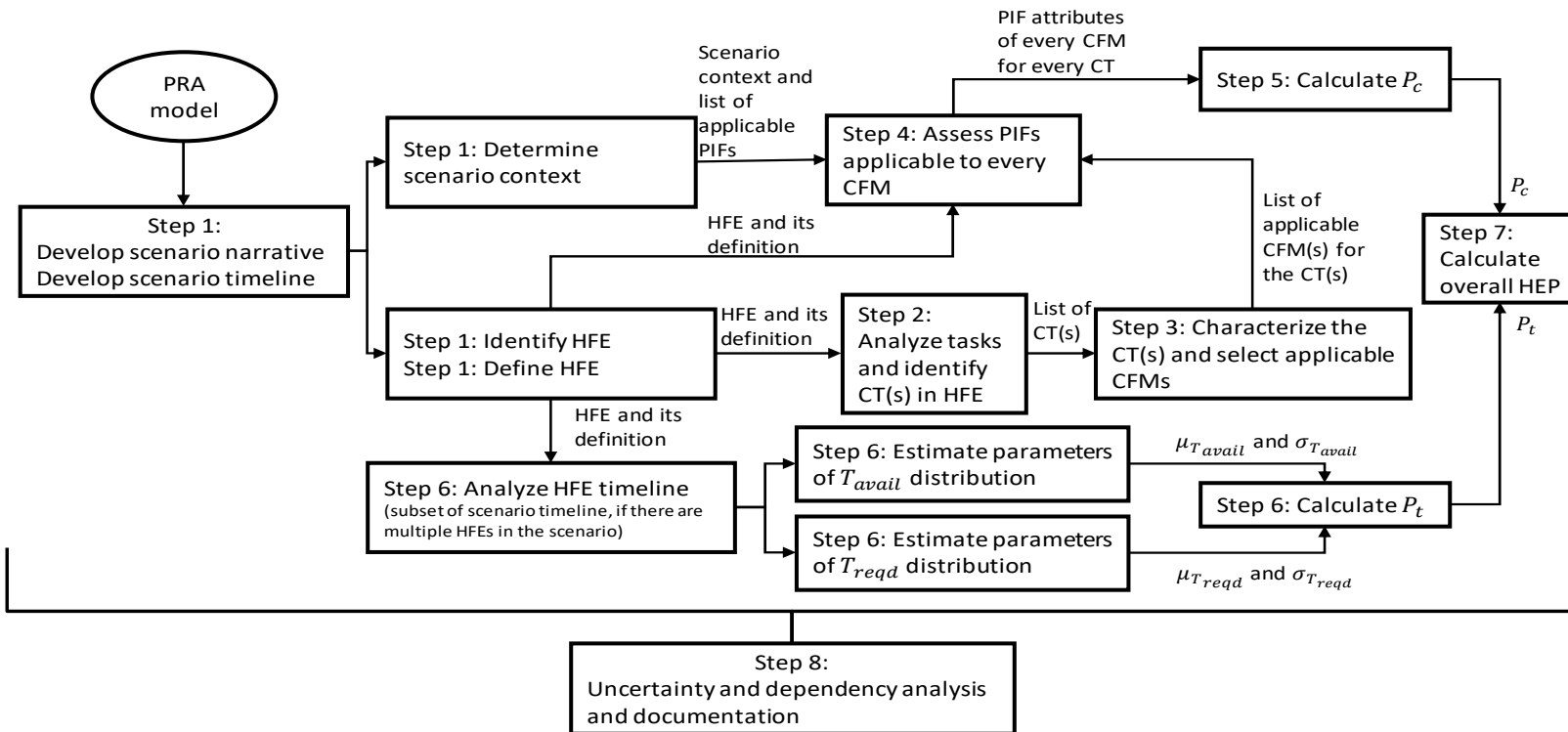
Element	Description	Status
IDHEAS-G	General methodology - the single model	Complete
IDHEAS-AtPower	A HEP calculation method for internal events at-power HRA applications	Complete
IDHEAS-ECA	A HEP calculation method. Originally developed for the event and condition analysis (ECA) but was expanded for 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	3 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)	<ul style="list-style-type: none">• Convolution of the uncertainty distributions of the time-required and time-available
Pc (Cognitive Errors)	<ul style="list-style-type: none">• Critical tasks• Cognitive basis structure<ul style="list-style-type: none">• 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)

NRC IDHEAS-ECA v1.2 172.19.17.129

Load Data Save Data Close

HFE ID: HEP(Ind): Pc's: PI: HEP(Dep):

Loaded Data File:

Documentation Pt (HFE) CT 1 (Pc) CT 2 (Pc) CT 3 (Pc) Dependency

HFE1 ID: HFE2 ID: NOTE: Evaluate the impact of occurrence of HFE1 on HFE2, where HFE1 occurs before HFE2.

Pre-Determination Analysis Screening Analysis Detailed Analysis

Done with Pre-determination Analysis (Apply the results to the Screening and Detailed Analyses)

Relationship	Assessment Guidelines
Complete Dependency <input type="radio"/> Yes <input type="radio"/> No Yes, if all three items are checked.	<input type="checkbox"/> HFE1 and HFE2 use the same procedure. <input type="checkbox"/> HFE1 is likely to occur because of issues associated with the common procedure (such as having an ambiguous or incorrect procedure). <input type="checkbox"/> There is no opportunity to recover from the issue with the procedure between HFE1 and HFE2.
R1-Function/System <input type="radio"/> Yes <input type="radio"/> No Yes, if either item is checked.	<input checked="" type="checkbox"/> HFE1 and HFE2 have the same functions or systems. <input checked="" type="checkbox"/> HFE1 and HFE2 have coupled systems or processes that are connected due to automatic responses or resources needed.
R2-Time Proximity <input type="radio"/> Yes <input type="radio"/> No Yes, if either item is checked.	<input checked="" type="checkbox"/> HFE1 and HFE2 are performed close in time. <input checked="" type="checkbox"/> The cues for HFE1 and HFE2 are presented close in time.
R3-Personnel <input type="radio"/> Yes <input type="radio"/> No	<input checked="" type="checkbox"/> HFE1 and HFE2 are performed by the same personnel.
R4-Location <input type="radio"/> Yes <input type="radio"/> No Yes, if either item is checked.	<input checked="" type="checkbox"/> HFE1 and HFE2 are performed at the same location. <input checked="" type="checkbox"/> The workplaces for HFE1 and HFE2 are affected by the same condition (such as low visibility, high temperature, low temperature, or high radiation).
R5-Procedure <input type="radio"/> Yes <input type="radio"/> No	<input checked="" type="checkbox"/> HFE1 and HFE2 use the same procedure.

IDHEAS-DEP Screening Analysis

(Draft Graphical User Interface)

NRC IDHEAS-ECA v1.2 | 172.19.17.129

Load Data | Save Data | Close

HFE ID: | HEP(Ind): | Pc's: | Pt: | HEP(Dep):

Loaded Data File:

Documentation | Pt (HFE) | CT 1 (Pc) | CT 2 (Pc) | CT 3 (Pc) | Dependency

HFE1 ID: | HFE2 ID: | NOTE: Evaluate the impact of occurrence of HFE1 on HFE2, where HFE1 occurs before HFE2.

Pre-Determination Analysis | **Screening Analysis** | Detailed Analysis

R1-Functions or Systems | R2-Time Proximity | R3-Personnel | R4-Location | R5-Procedure

Pd(R1): | Pd(R1.1): | Pd(R1.2): | Pd(R1.3):

R1.1 | R1.2 | R1.3

Done with R1.1 Same function or system leads to cognitive dependency

Potential dependency factors and the basis for discounting them

(A) Occurrence of HFE1 leads to the scenario or parts of the scenario being different from what was typically trained, thus, the scenario associated with HFE2 becomes less familiar. (Note: Occurrence of HFE1 alters the scenario for HFE2, thus, HFE1 causes some level of unfamiliarity with HFE2)

(B) Occurrence of HFE1 leads to an incorrect or biased mental model of the situation associated with HFE2.

(A/B) There is no cognitive link (similar thought process) between the two HFEs; thus, occurrence of HFE1 has no impact on scenario familiarity or mental model associated with HFE2.

(A) HFE2 was trained in the scenarios that HFE1 occurs (e.g., Feed & Bleed is the last action after others fail) so there is no unfamiliarity due to HFE1.

(B) HFE2 is well trained on in various scenarios such that personnel are unlikely to develop a wrong mental model due to occurrence of HFE1.

(B) There are opportunities between the HFEs to break the incorrect mental model, such as multiple crews or diverse cues.

(A&B) Click the Justification button below to justify the selection.

Justification

R1.1 Dependency Impact

<input checked="" type="radio"/> High: Pd = 0.3	<input type="radio"/> Medium: Pd = 0.1	<input type="radio"/> Low: Pd = 0.05	<input type="radio"/> Zero: Pd = 0.0
HFE1 creates a mismatched or wrong mental model for HFE2 due to close cognitive links between HFE1 and HFE2 (e.g., thought process).	<ul style="list-style-type: none"> Parts of scenario become unfamiliar (e.g., different from what was trained on), AND HFE1 creates a biased mental model or preference for wrong strategies. 	<ul style="list-style-type: none"> Parts of scenario become unfamiliar (e.g., different from what was trained on), OR HFE1 creates a biased mental model or preference for wrong strategies. 	Both potential dependency factors, (A) and (B), are discounted.

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.

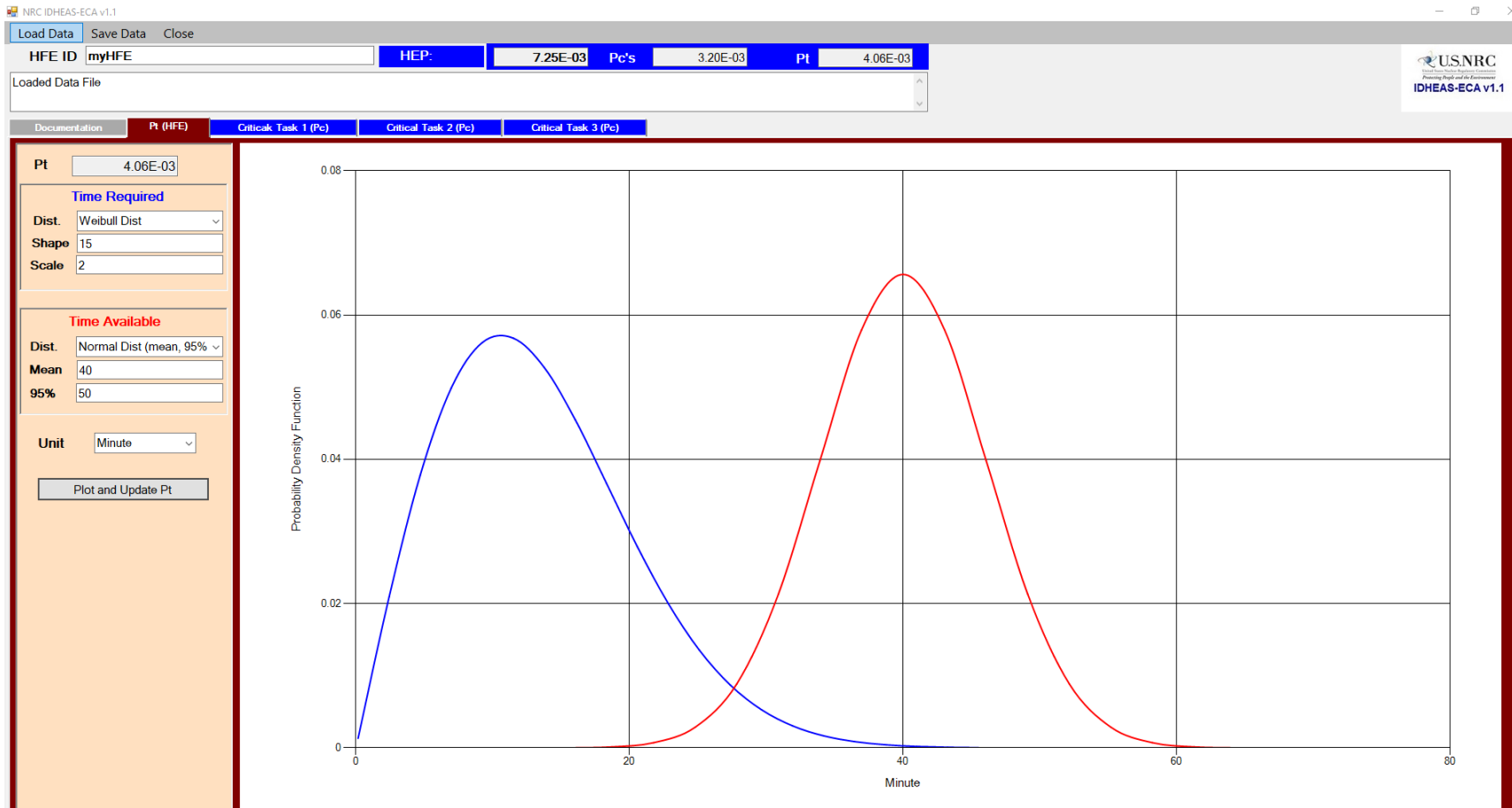
IDHEAS-ECA Software Tool

(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)



Calculate Pc

(IDHEAS-ECA v1.1 Screenshot)

NRC IDHEAS-ECA v1.1

Load Data Save Data Close

HFE ID: myHFE HEP: 5.96E-02 Pc's: 5.58E-02 PI: 4.06E-03

Loaded Data File

Documentation H (HFE) Critical Task 1 (Pc) Critical Task 2 (Pc) Critical Task 3 (Pc)

Accounted for HEP(HFE) ID: Critical Task 1 Pc: 5.58E-02

<input checked="" type="checkbox"/> Detection	Recovery	<input checked="" type="checkbox"/> Understanding	Recovery	<input checked="" type="checkbox"/> Deciding	Recovery	<input checked="" type="checkbox"/> Action	Recovery	<input type="checkbox"/> InterTeam	Recovery
5.00E-03	1	5.00E-02	1	1.00E-03	1	1.00E-04	1	1.00E-03	1

SF2: Unfamiliar elements in the scenario

SF2: Unfamiliar elements in the scenario

CFM Selection

- Detection
- Understanding
- Decisionmaking
- Action
- InterTeam

Collapse All

Expand All

Uncheck All

Check All

- Scenario Familiarity
 - SF0: No impact
 - SF1: Unpredictable dynamics in known scenarios
 - SF2: Unfamiliar elements in the scenario
 - SF3: Infrequently performed scenarios
 - SF4: Bias or preference for wrong strategies exists, mismatched mental models
- Information Completeness and Reliability
- Task Complexity
- Environmental Factors
- System and IC Transparency
- Human-System Interface
- Staffing
- Procedures and Guidance
- Training and Experience
- Team Factors
- Work Practices
- Multitasking, Interruption, and Distraction
- Mental Fatigue, Stress, and Time Pressure

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