Human Reliability Assessment In ATM: the CARA tool

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What I'm going to talk about

CARA: Controller Action Reliability Assessment

HRA

How CARA works
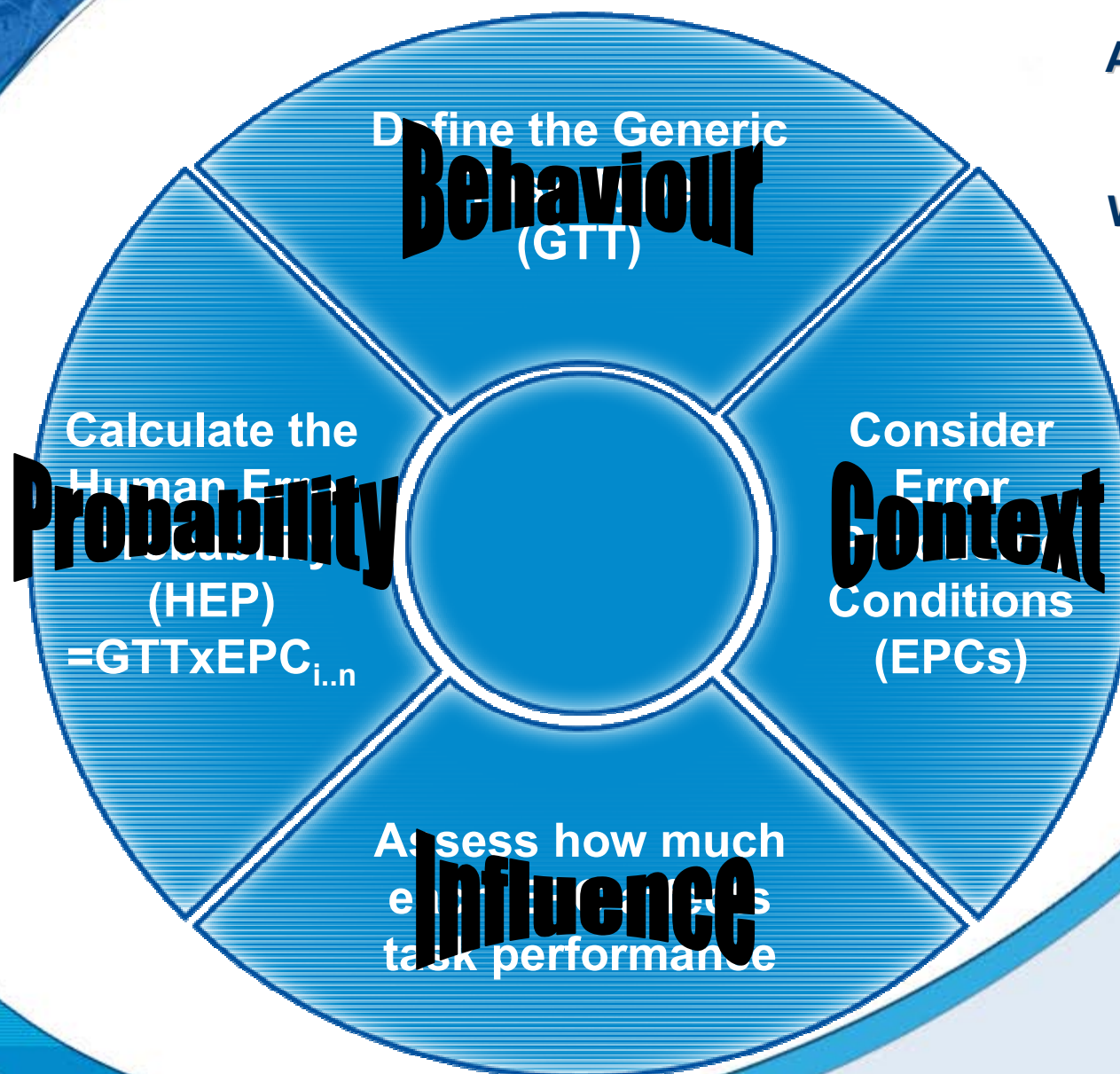
How it was developed

Application Example

Validation check

Where does CARA fit in HRA?

Task Analysis

Human Error Identification

Model the human in the safety case

Quantify Human Error Probability

Consider Human Dependence

Evaluate the human contribution

Define Error Reduction Measures

Document & Feed forward to Ops

HRA Process

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Elements of Quantification – the HEART template

Human Error Assessment & & Reduction Technique Williams, 1985

Define the Generic **Behaviour** (GTT)
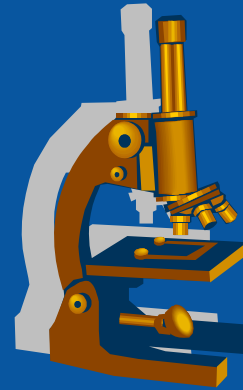
Calculate the Human Error **Probability** (HEP) $=GTTxEPC_{i..n}$

Consider Error **Context** Conditions (EPCs)

Assess how much each influences task performance **Influence**

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Generic Task Types

Deriving the Generic Tasks - the Model Underlying CARA

Attention and Action Hierarchy

Monitoring

Position take-over

A. Offline tasks

B. Checking

C. Monitoring for conflicts

Confirming/ updating mental picture

Sector plan

Workload monitoring

D. Solving conflicts

E. Plan aircraft in/out of sector

F. Manage routine traffic

Managing requests

G. Issuing instructions to ac

Radar
FPS
Info displays
Reminders

Verbal Instruction
Datalink
Non-communication

Quantification Sources

Other HRA techniques

Published HF Studies

Real world Data collection

Simulator Data

Generic Tasks

Task Context	Generic Task Type	HEP	Uncertainty Bounds
A. Offline tasks	A. Offline tasks.	0.03	-
B. Checking	B1. Active search of radar or FPS, assuming some confusable information on display.	0.005	0.002-0.02
	B2. Respond to visual change in display (e.g. aircraft highlighted changes to low-lighted).	0.13	0.05-0.3
	B3. Respond to unique and trusted audible and visual indication.	0.0004	-
C. Monitoring for conflicts or unanticipated changes	C1. Identify routine conflict.	0.01	Holding Value
	C2. Identify unanticipated change in radar display (e.g. change in digital flight level due to aircraft deviation or corruption of datablock).	0.3	0.2-0.5
D. Solving conflicts	D1. Solve conflict which includes some complexity. Note, for very simple conflict resolution consider use of GTT F.	0.01	Holding Value
	D2. Complex and time pressured conflict solution (do not use time pressure EPC).	0.19	0.09-0.39

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Generic Tasks

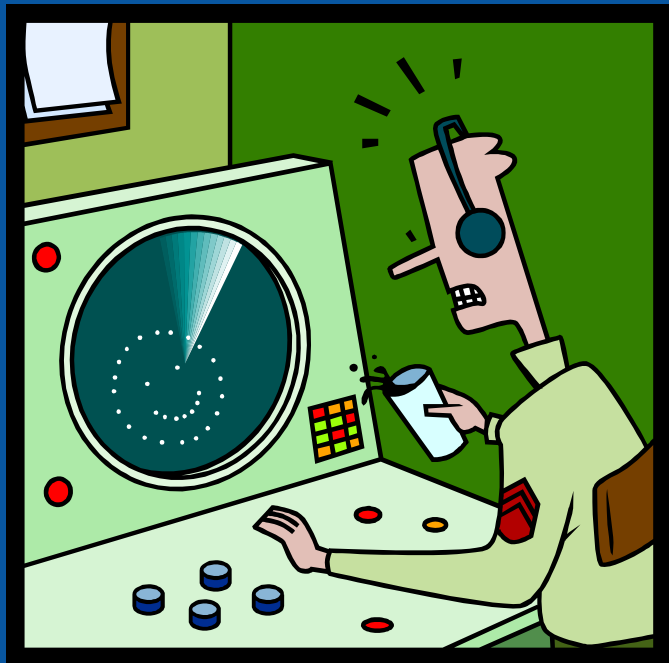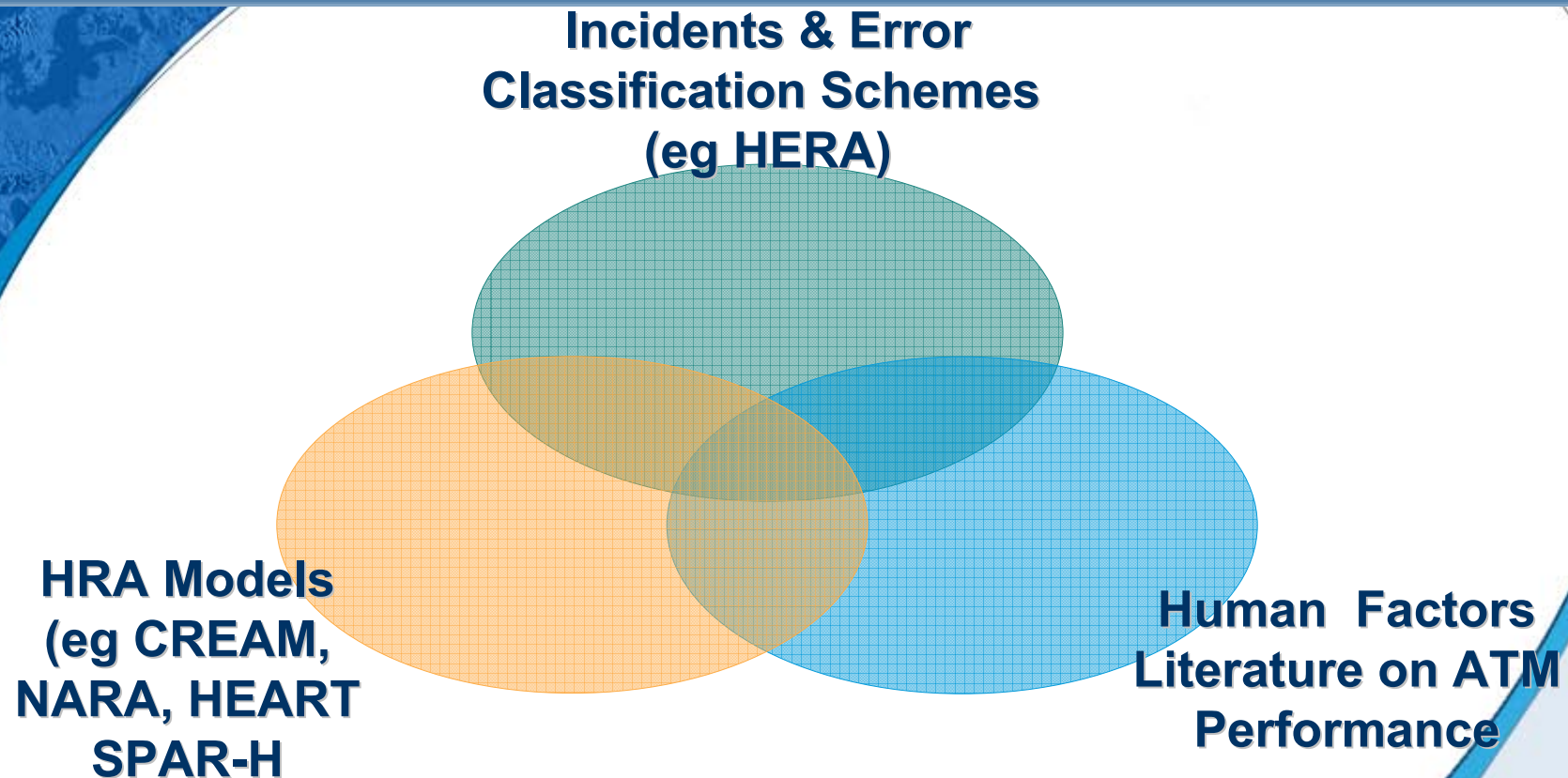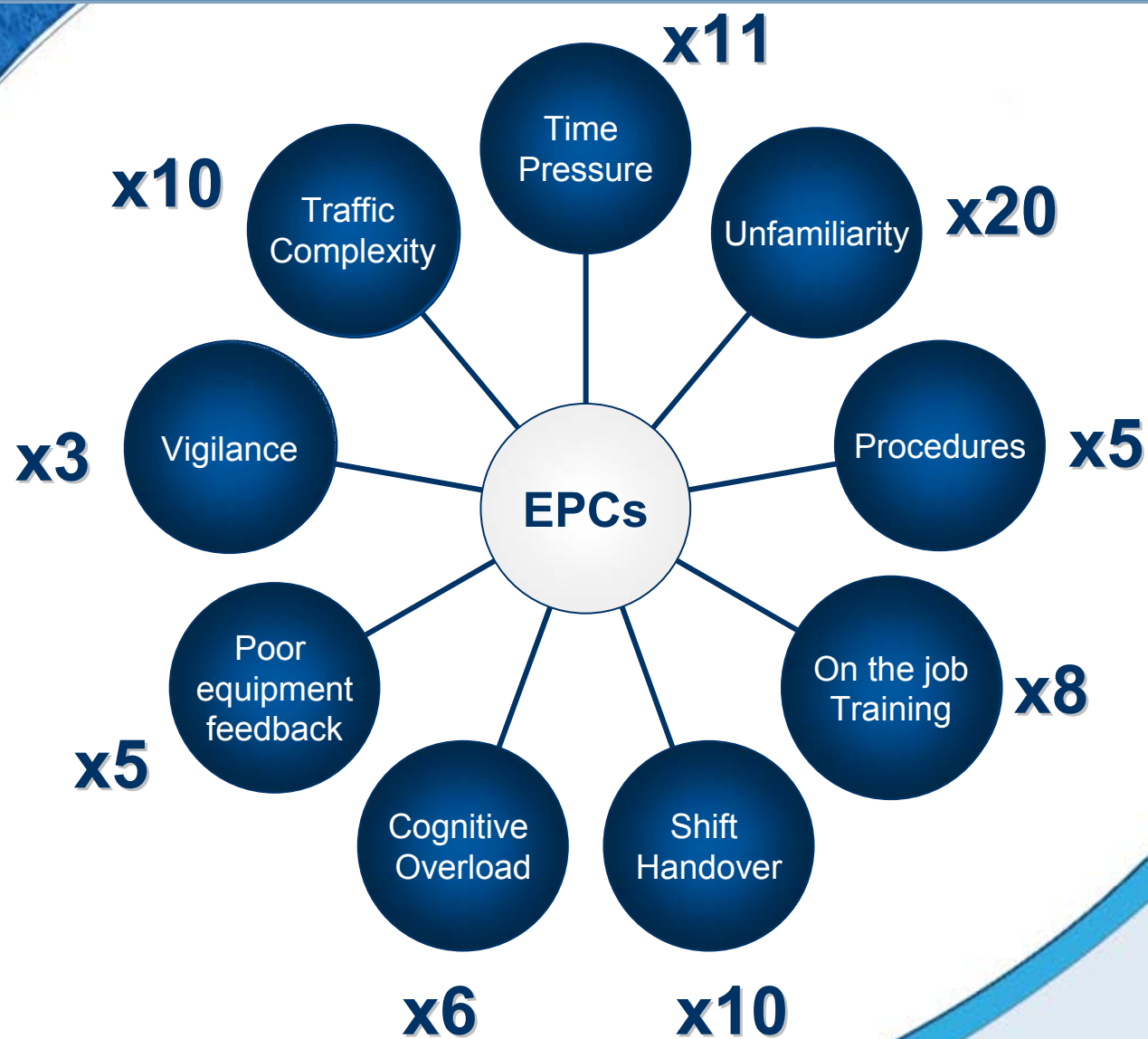| E. Plan aircraft in/out of sector	E. Plan aircraft in/out of sector.	0.01
F. Manage routine traffic	F. Routine element of sector management (e.g. rule-based selection of routine plan for an aircraft or omission of clearance).	0.003
G. Issuing instructions	G1. Verbal slips.	0.002
	G2. Physical slips (two simple choices).	0.002
M. Technical and support tasks	M3. Routine maintenance task.	0.004

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Pilot actions

Error Producing Conditions

Sources of Error Producing Conditions

**Incidents & Error
Classification Schemes
(eg HERA)**

**HRA Models
(eg CREAM,
NARA, HEART
SPAR-H**

**Human Factors
Literature on ATM
Performance**

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Error Producing Conditions (examples)

x11 — Time Pressure

x10 — Traffic Complexity

x20 — Unfamiliarity

x3 — Vigilance

EPCs

x5 — Procedures

x5 — Poor equipment feedback

x8 — On the job Training

x6 — Cognitive Overload

x10 — Shift Handover

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CARA in practice: airport example

**Need to speed up airport throughput
Aircraft 1 vacates runway early
Aircraft 2 anticipates this, lands sooner**

a/c2

a/c1

Air Traffic
Services

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CARA in practice

Task: Identify AC1 stopped: Audible and visual warning: Controller identifies AC 1 is stationary within the OFZ

Generic Task Type: B3. Respond to unique and trusted audible and visual indication

Human Error Probability: 0.0004

Error Producing Conditions: None identified

Assumptions/ HF Requirements: Well designed alarm with unique compelling audible signal (non-startling); directional from radar display; visual alarm flashing until acknowledged (flash rates as per standards); attention-gaining; trials must verify HF acceptability

CARA in practice

Task: Warn AC2 in time: - Audible and visual warning: Controller identifies AC 1 is stationary within the OFZ

Generic Task Type: **F**: Routine instruction or clearance

Human Error Probability: 0.003

Error Producing Conditions: Time Pressure
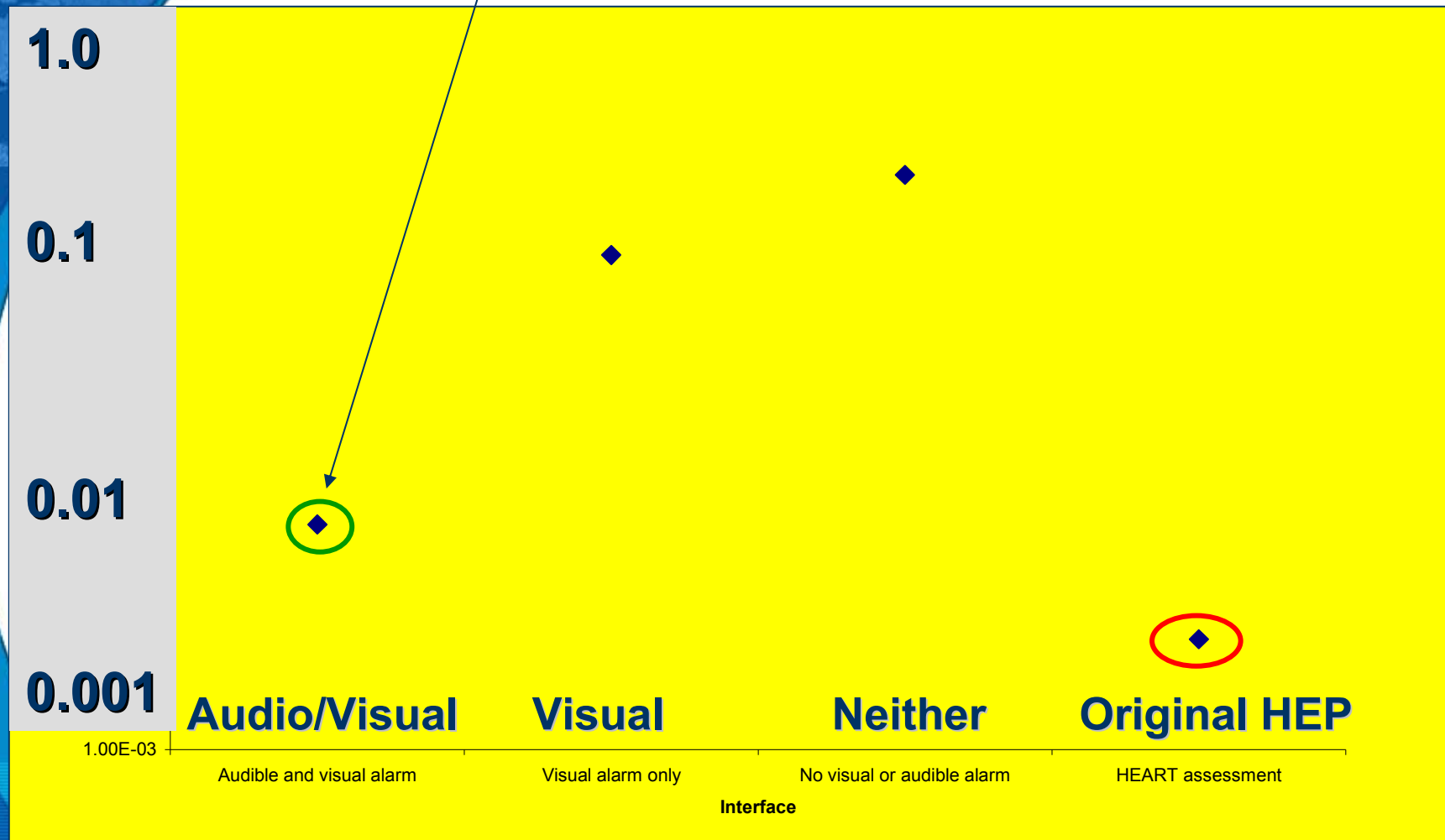**Maximum Affect** x11
Assessed Proportion of Affect: 0.2

Human Error Probability: 0.009

Assumptions/ HF Requirements: Assume controllers trained to warn AC2 rather than talk to AC1 to identify the problem – procedures need to be developed/assessed and trained

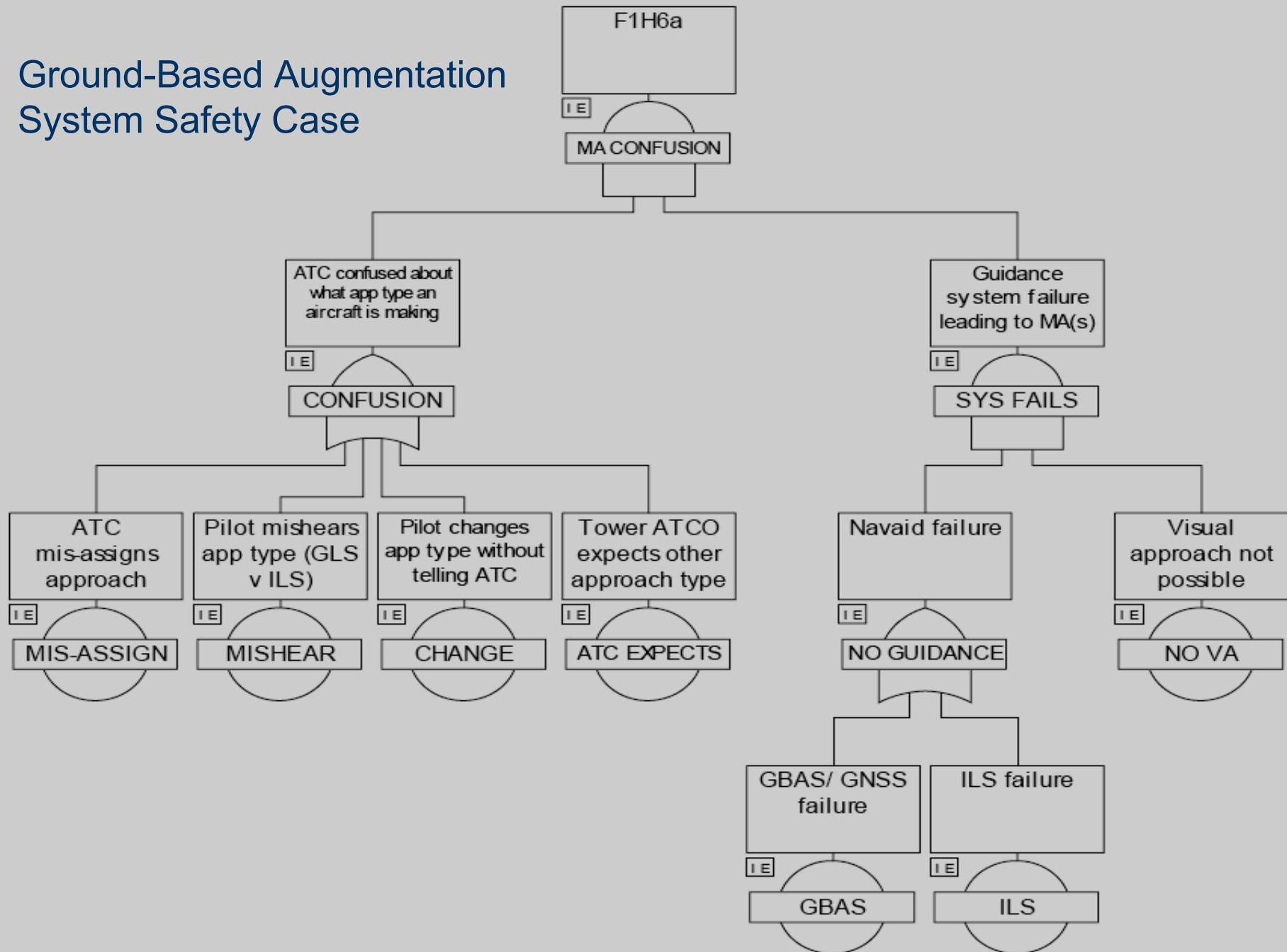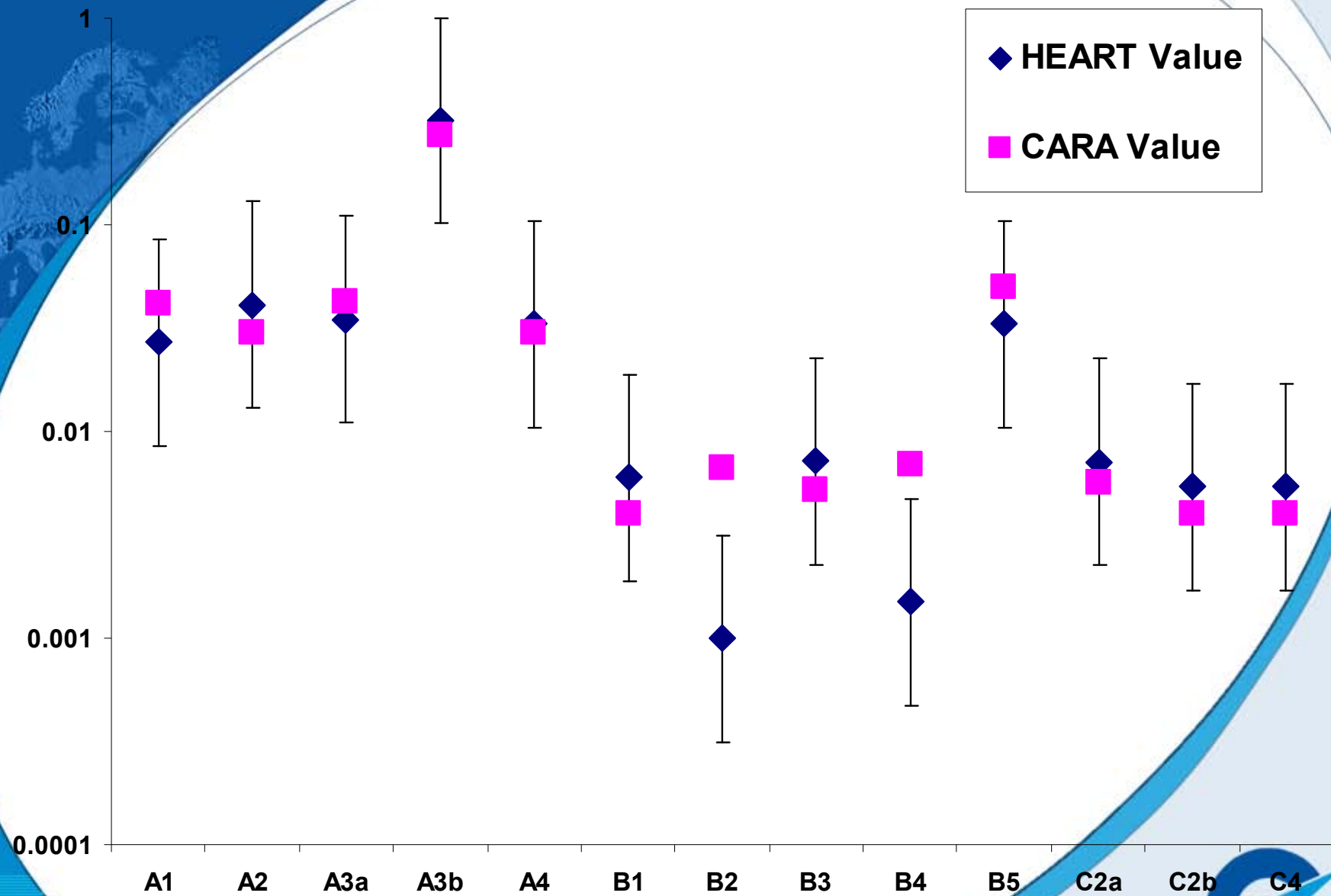# An example of CARA in action

Task HEP = 0.0004 + 0.009 = 0.0094

1.0			
0.1			
0.01			
0.001	**Audio/Visual**	**Visual**	**Neither**	**Original HEP**

1.00E-03

Audible and visual alarm	Visual alarm only	No visual or audible alarm	HEART assessment

Interface

Ground-Based Augmentation System Safety Case

Key Findings from GBAS study for CARA

GTT application
more straightforward

Fewer EPCs
Required - better
match at GTT level

Similar error
probabilities

Identified
improvements
to CARA

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Future work
Data collected on alarm response
Internal Review 08
Manual Production (08)
Application in Macro Safety Case (SESAR)

Questions?

Do the Generic Tasks Match Safety Case Needs?

ASAS (Airborne Separation Assurance System)	
Instruct wrong aircraft	F
Give ASAS instruction to non-ASAS equipped aircraft	F/G1
Fail to detect ASAS aircraft deviation	C2
Send incorrect spacing	F
Link wrong aircraft on screen	G2
Fail to detect deceleration of aircraft	C2
Pilot exceeds spacing	P
Pilot targets wrong aircraft	P
Pilot turns early	P

RVSM (Reduced Vertical Separation Monitoring)	
Fail to detect level bust	C2
Issue wrong flight level clearance	F
Fail to react in time to short term conflict alert	B3
Fail to provide collision avoidance advice	D2
Fail to use correct emergency terminology	G1
Fail to detect non-RVSM aircraft	C1
Fail to coordinate aircraft into sector with conflict-free trajectory	E