



Role of Expert Judgement in Assurance

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Project Goals & Approach

Expert judgement comes up a lot, so:

- ❑ Investigate the roles of expert judgement in assessment, especially in safety assessment
- ❑ Determine the associated requirements
- ❑ Review the literature, determine useful techniques
- ❑ Develop comprehensive approach to support assessment as needed in safety and software engineering

Ongoing project

Disclaimer

As will become
painfully evident, I
am not an **expert**
on **expert**
judgement so
please do not
judge me too
harshly

Qualitative vs. Quantitative

- ❑ Credible numbers (mostly probabilities) usually preferred
- ❑ Assurance decisions take the form:
$$metric < delta$$
- ❑ Many items of interest cannot be quantified with significant credibility, e.g.:
 - Software dependability
 - Human error rates
- ❑ So we end up with qualitative assessment
- ❑ Informally, we turn to expert judgement

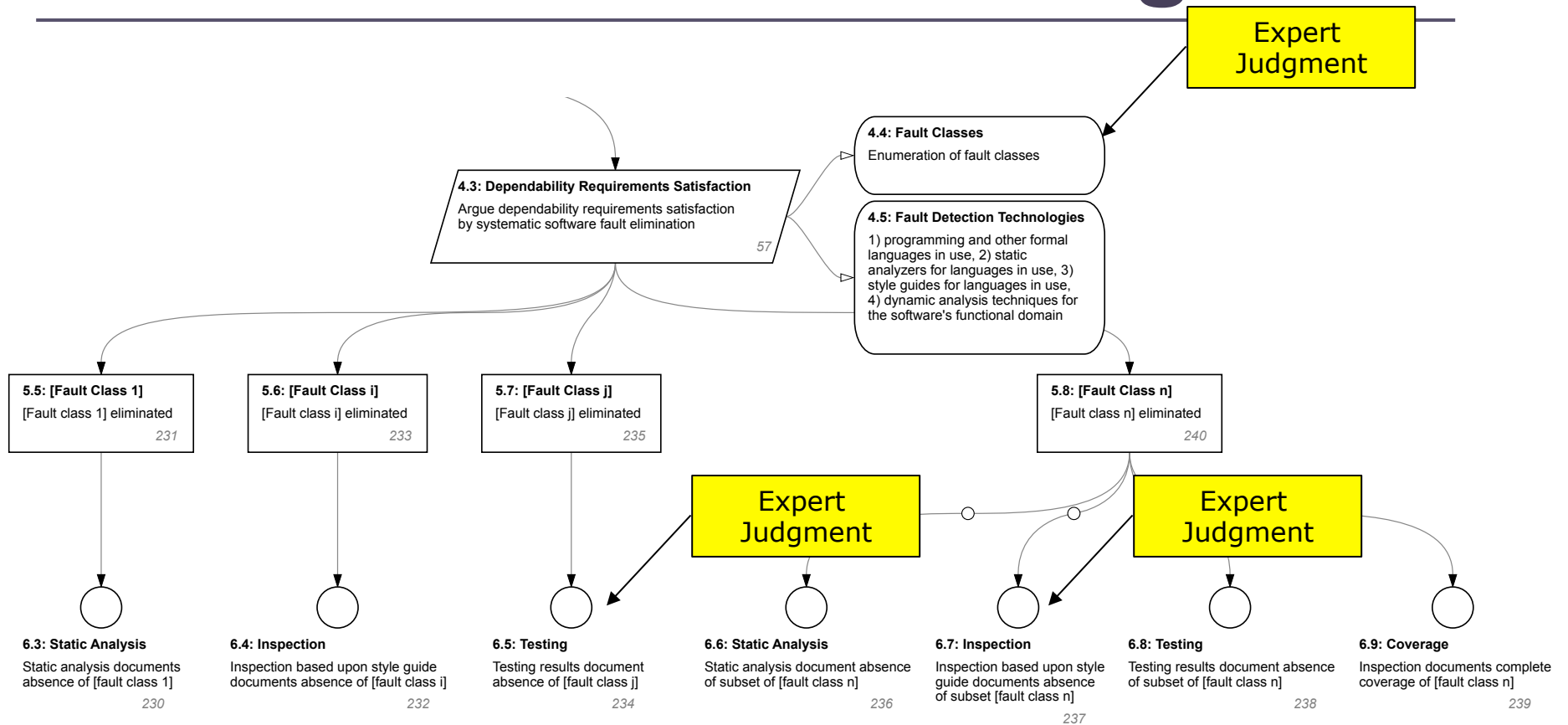
Typical Questions

- Experts:
 - “How accurate are assessments made by experts?”
 - “What if the expert is wrong?”
 - “How is the term ‘expert’ defined in any particular assessment situation?”

- Judgement examples:
 - “Is the system adequately safe?”
 - “Is the argument compelling?”
 - “Are the requirements complete?”
 - “Has hazard analysis been conducted thoroughly?”
 - “Is the software process in use adequate?”
 - “Has software been tested sufficiently?”

Macro vs. micro is an important distinction

Software Assurance Argument



Expert judgment is everywhere

Expert Judgement

- ❑ Very broad topic
- ❑ Great deal of material in the literature
- ❑ Does not seem to be a credible, comprehensive theory

Some of the Literature...

- ❑ A Structured Expert Judgment Study for a Model of Campylobacter Transmission During ***Broiler-Chicken Processing***
- ❑ Expert judgment based multi-criteria decision model to address uncertainties in risk assessment of ***nanotechnology-enabled food product***
- ❑ Bene-Eia: A Bayesian Approach to Expert Judgment Elicitation with Case Studies on ***Climate Change Impacts on Surface Waters***
- ❑ ***Health risk assessment for nanoparticles***: A case for using expert judgment
- ❑ Expert Judgment Versus Public Opinion – ***Evidence from the Eurovision Song Contest***
- ❑ Expert Judgment on Inadvertent ***Human Intrusion into the Waste Isolation Pilot Plant***

Copi and Cohen

“An expert’s judgment constitutes no conclusive proof; experts disagree, and even when they are in agreement they may be wrong. However, reference to an authority in an area of competence may carry some weight, but it doesn’t prove a conclusion. Ultimately, even experts need to rely upon empirical evidence and rational inference.”

“Appeal to inappropriate authority: A fallacy in which a conclusion is accepted as true simply because an expert has said that it is true. This is a fallacy whether or not the expert's area of expertise is relevant to the conclusion.”

- Copi and Cohen *Introduction to Logic* (14th ed.)

Mizrahi

- Distinguishes between appeals to authority and cognitive authority
- Claims arguments from expert opinion are weak arguments:
 - “However, research on expertise shows that expert opinions are only slightly more accurate than chance and much less accurate than decision procedures.”*
- Provides examples from:
 - Medical research and diagnosis, economics
- Mizrahi, M. (2013). Why Arguments from Expert Opinion are Weak Arguments. *Informal Logic*, 33(1), 57-79.

Wagemans

- Defines expert as: “someone who is epistemically responsible for a particular domain of knowledge”
- Separates the proposition of interest from the assertion made by an expert about the proposition
- Introduces an argument fragment that documents this separation:
 - 1 Opinion O (X) is true or acceptable (Y).
 - 1.1 Opinion O (X) is asserted by expert E (Z).
 - 1.1' Being asserted by expert E (=Z) is an indication of being true or acceptable (=Y).
- Wagemans, J. (2011). The Assessment of Argumentation from Expert Opinion. *Argumentation*, 25(3), 329-339.

Burgman et al

- ❑ Systematic analysis of expert judgment motivated by risk assessment in the field of ***biological security***
- ❑ Generally applicable in assurance context
- ❑ ***Extremely*** thorough and detailed literature survey (> 70 pages)
- ❑ Comprehensive bibliography
- ❑ Evaluation measures:
 - Reliability, accuracy, coherence,

An Exemplar

Experts judging
the work of
others

- Software inspections:
 - Initially no systematic inspections in software dev.
 - Fagan inspections introduced, but:
 - Process weaknesses
 - Revealed necessity of experts rather than generalists
 - Active reviews built on Fagan's work:
 - Tailored to weakly identified experts
 - Introduced simple *dialectic* model
 - Phased Inspections – brilliant solution to all problems

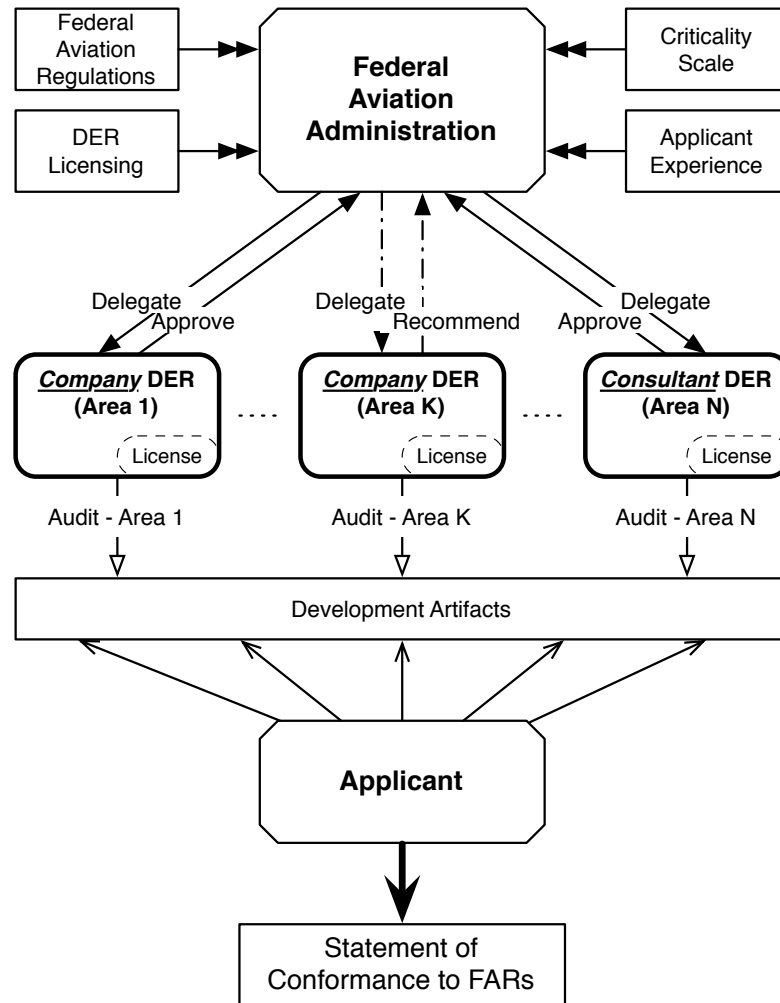
Challenge the
work of the
expert

Important Exemplar

□ FAA Approval:

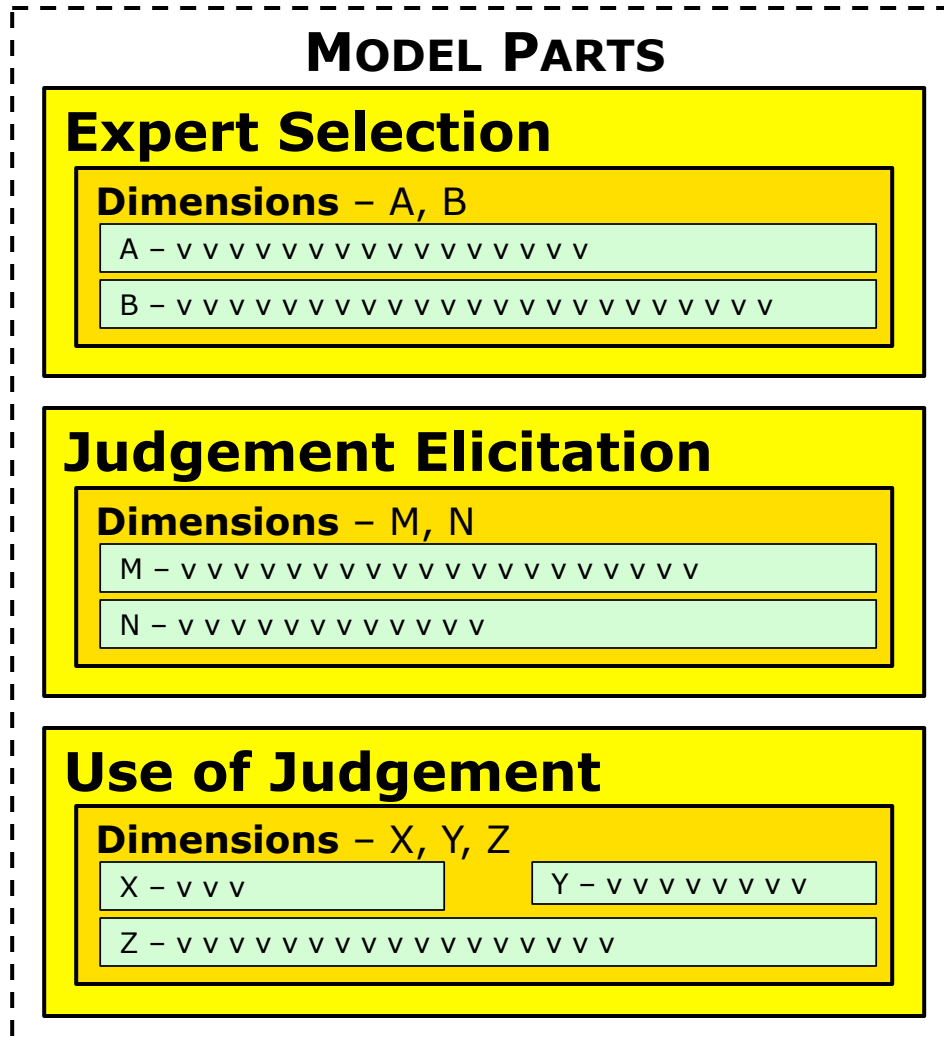
- FAA has a system of approval that depends on expert judgement
- Systematic, comprehensive
- Community has extensive experience with the system
- Seems to work well
- Maybe we could learn from the FAA
- (To the best of my knowledge, no other regulating agency has anything comparable)

FAA DER Expert Judgment



- Experts:
 - Designated Engineering Representatives (DER)
- Licensing
- DER technical areas
- Company vs. consultant
- Audit process
- Approve vs. recommend
- FARs & conformance
- Lifecycle judgment

A Simple Model



- Three parts:
 - Expert selection
 - Judgement elicitation
 - Use of judgement
- Each part defined as a set of dimensions
- Each dimension elaborated as a set of possible values

- Taxonomy of space
- Details selected for specific application

Dimensions of Expert Selection

- ❑ Formal training
- ❑ Relevant experience including positions held
- ❑ Previous judgment experience
- ❑ Assessment of previous judgments such as subsequent approval by a regulating authority
- ❑ Licenses held
- ❑ Publications
- ❑ References
- ❑ Awards and honours

Values For Specific Dimensions

- Formal training:
 - Academic degree(s)
 - Professional course(s)
 - Industrial training course(s)
- Relevant experience:
 - Years active in subdomain A, in subdomain B, etc.
 - Project management in domain C

Judgement Elicitation

- ❑ One expert or many, Delphi iteration?
- ❑ Feedback and training?
- ❑ For quantities:
 - Intervals or language-based description?
 - Probabilities or ratios/fractions?
- ❑ Uncertainty:
 - Expert assessment of bounds
 - Overconfidence – intervals exclude the truth
 - Language based, e.g., highly unlikely
- ❑ Questionnaire or report?
- ❑ No candidate structure in model (see Burgman et al)

Process

MODEL PARTS

Expert Selection

Dimensions - A, B

A - vvvvvvvvvvvvvvvvvvv
B - vvvvvvvvvvvvvvvvvvv

Judgement Elicitation

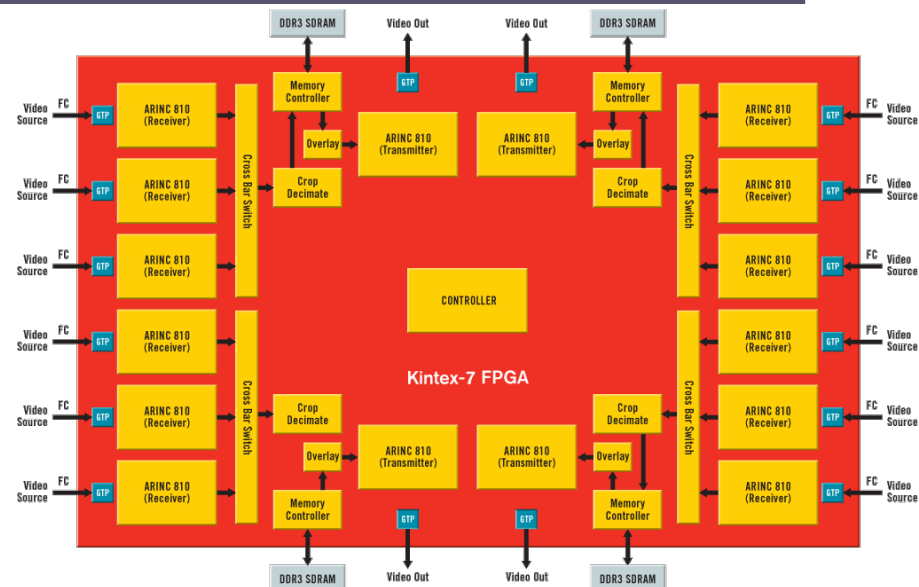
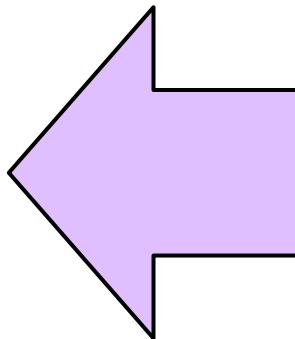
Dimensions - M, N

M - vvvvvvvvvvvvvvvvvvv
N - vvvvvvvvvvvvvvvvvvv

Use of Judgement

Dimensions - X, Y, Z

X - vvv Y - vvvvvvvvv
Z - vvvvvvvvvvvvvvvvvvv



Goal to be judged
(From argument)

- ❑ Characteristics
 - FPGA
 - Heterogenous logic
 - Real time
 - Avionics, level A

Project Plans

- Develop preliminary elaboration of the model
- Apply the model to a variety of circumstances:
 - Macro, e.g. safety assessment, software system assessment
 - Micro, e.g., specific software process elements
- Merge more literature concepts into model
- Analyze DER process in depth
- Modify DER process by merging assurance argument fragments to inject rigor into audits

Summary

- ❑ Expert judgement is a critical component of assurance
- ❑ Judgements are evidence
- ❑ Surprisingly complex topic, surprisingly comprehensive literature – far more is known than one would expect
- ❑ Considerable empirical evidence of many elements of the problem
- ❑ Critical challenge for assurance/safety cases