Formal assurance cases as programs for **machine-checking** and checklisting (meta-verification?)

for Panel discussion in ASSURE 2013

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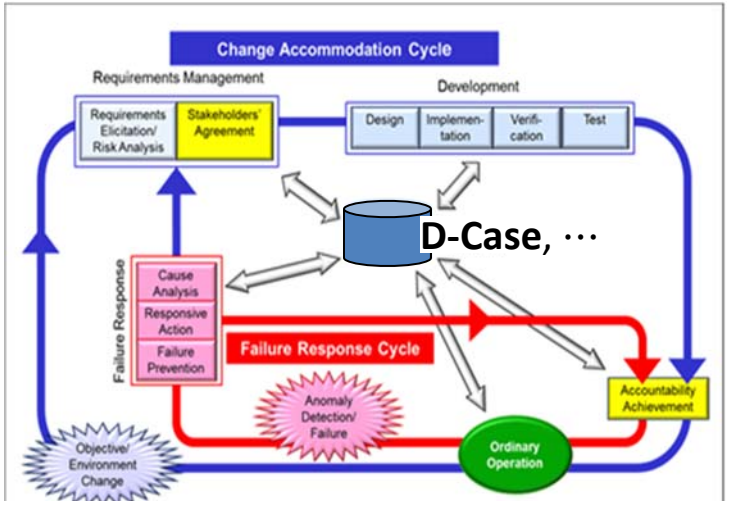
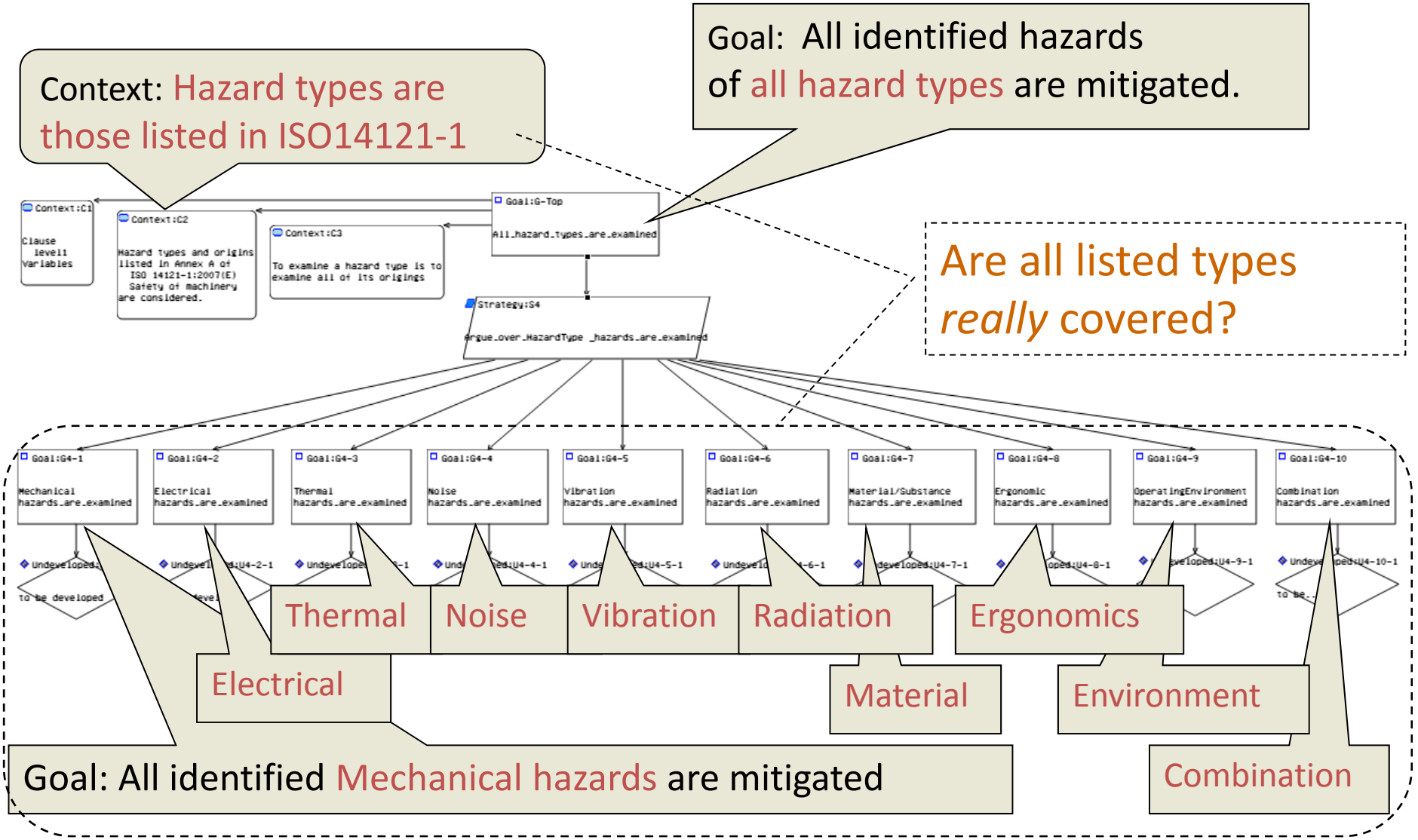
(DEOS project, D-Case)

- DEOS project: developing a lifecycle to achieve "Open Systems Dependability"
  ~ "Service continuity under uncertainty and incompleteness" via
  - Consensus building (stakeholders' Agreement)
  - Accountability achievement
  - Failure response
  - Change accommodation
- D-Case: Assurance Case with DEOS extension
  - **Control-doc/data for the DEOS proc.**
  - **Not just for humans; Electronically Integrated with DEOS Runtime Env. (monitoring, action scripting, ...)**

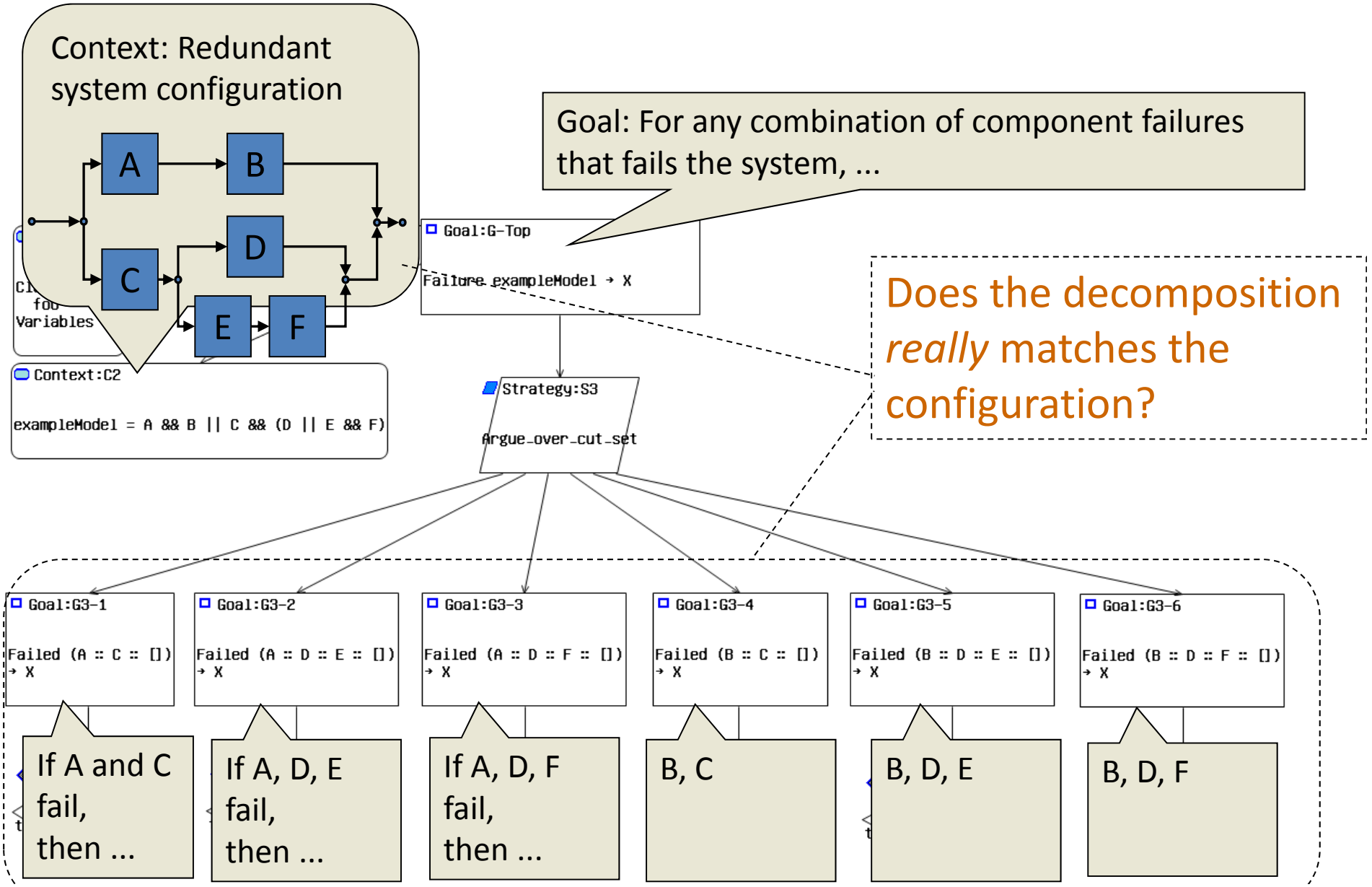


(Tokoro. DEOS project Whitepaper, 2011)

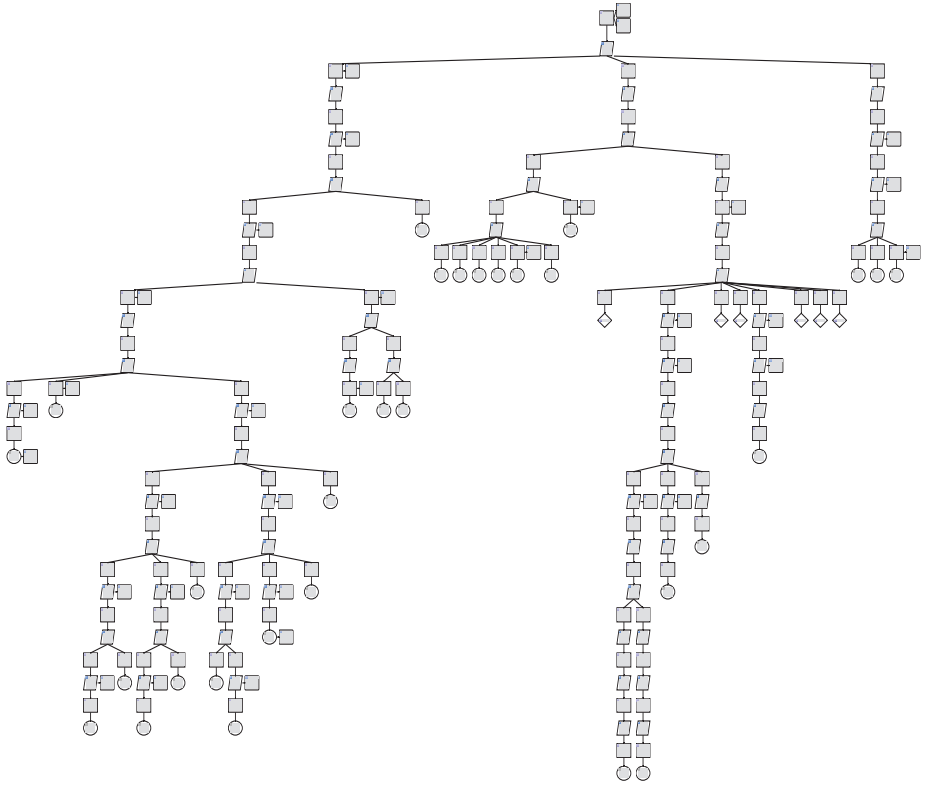
A very mundane checking



a not-so-mundane but mechanical checking



Problem



- Reviewer must do mundane checking by reading informal contents of argument elements
  (beside exercising judgment).
- Points to check are interspersed across 100s of these, each of which is frequently updated.

- Let machines check what they can check

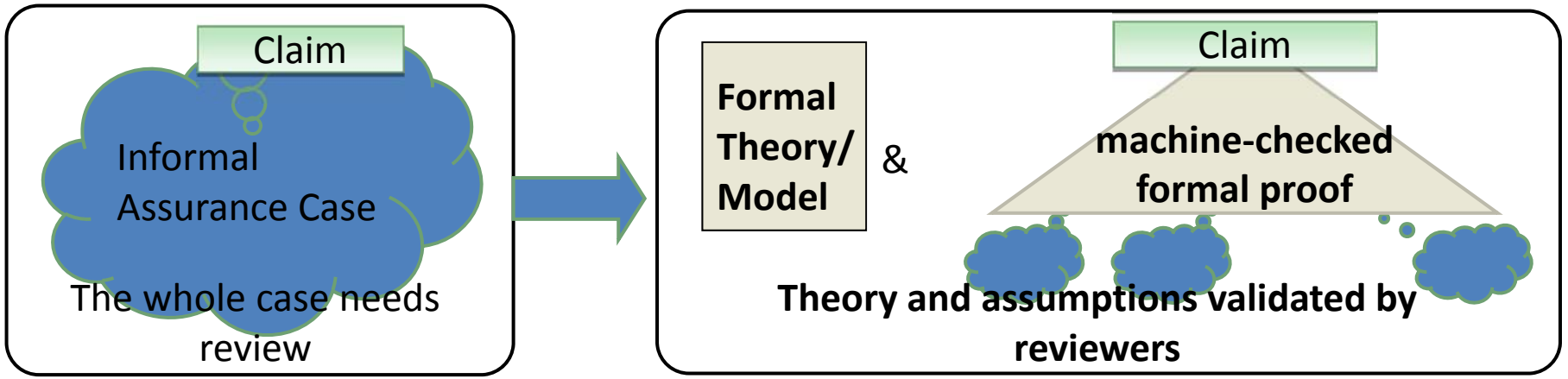
  to let reviewers concentrate on exercising expert judgment.

Formal AC as ⟨*Theory* , Proof⟩

- Checking can only be w.r.t. the basis of argument.

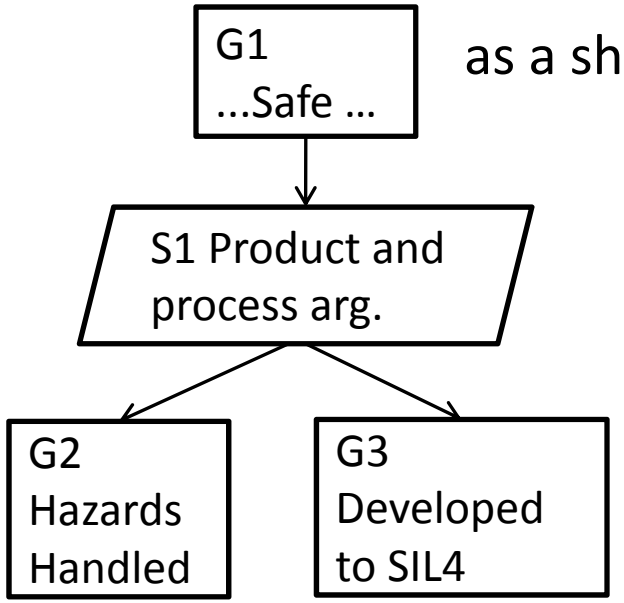
  Vocabulary / ontology of concepts and things;
  models of system/environment;
  reasoning principles both inductive and deductive, ...

- Let each AC be ⟨ decl./def. of the basis , arg. on that basis ⟩
  formulated as ⟨ formal theory (model) , formal proof in it ⟩
- All mundane checks are turned into
  "Is this a formal proof in this theory?"
- Expert reviewer exercises judgment on
  "Is this theorising valid in Real World ?"

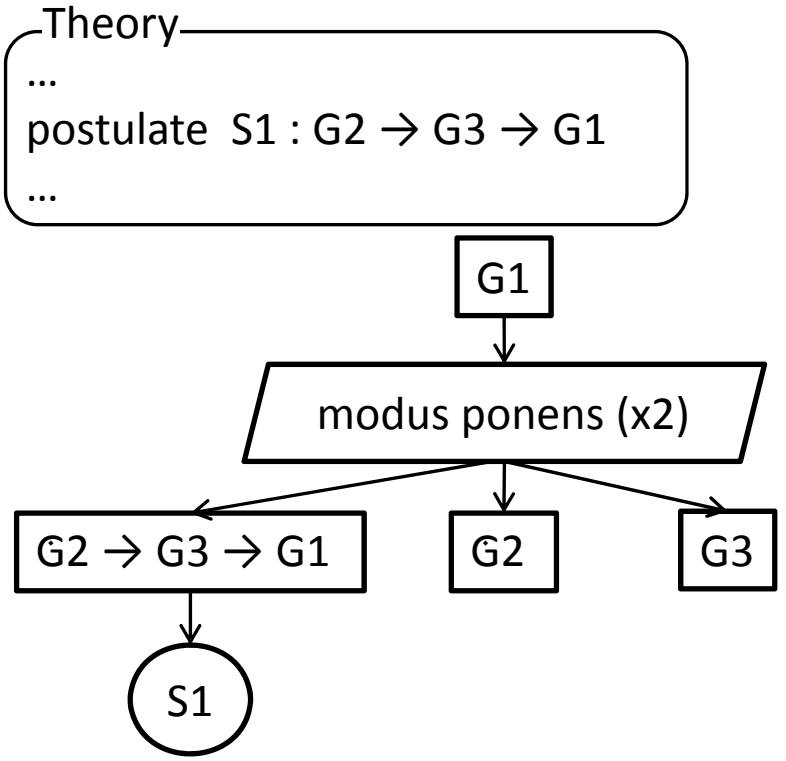


“Arguments are not proofs” ?

- They should be, *in an explicitly declared theory.*



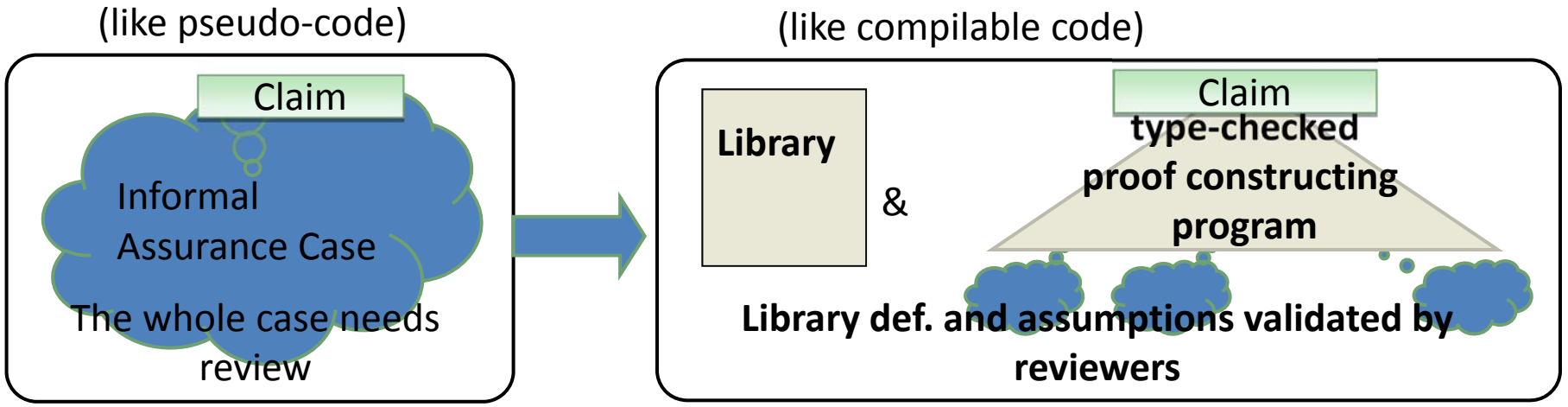
as a shorthand for



- Declare inductive and other extra-logical aspects explicitly in the theory.
  - arguments need not be “from the first principles” to be a formal proof.
- Separate
  - declarations and definitions to be agreed on / validated and
  - their usage in arguments to be checked / verified.

Formal AC as Programs

- Conventional formulation of formal proofs lacks mechanism for large-scale development (no definitional mech., no structuring, …)
- Write an AC as ⟨ library defn., program ⟩ using a prog. lang. supporting "Proofs as Programs" with rigorous semantics, e.g., Agda.
- Checking an argument = type-checking a program
  Checking 100 connected args = doing a build on a project
- For constructing understandable, maintainable, large arguments, all the programming / sw-eng. techniques can be imported wholesale. (*abstraction, recursive defn, modularisation, change-management, …*)



Formal AC as Programs

- Proposition = Type of data that counts as direct evidence
- Proof = Program that produces the direct-evidence data when run

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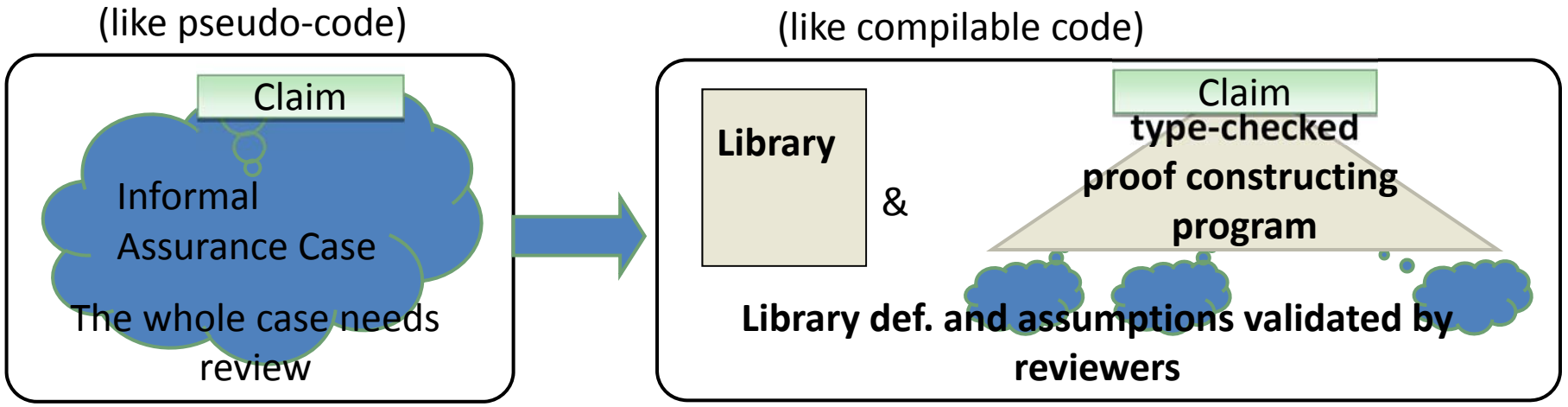


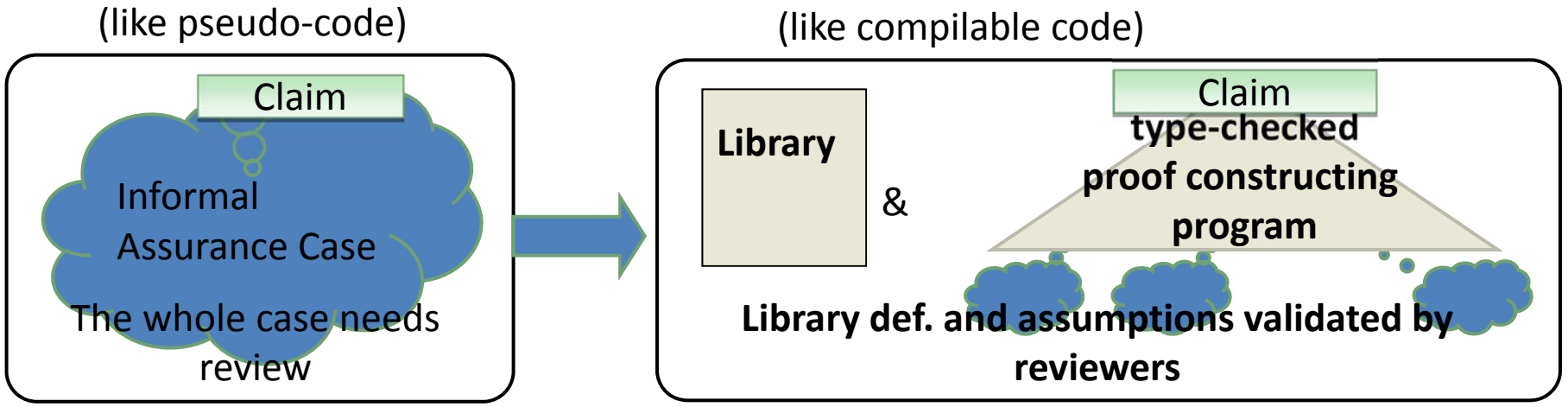
Formal AC as Programs

- Proposition = Type of data that counts as direct evidence
- Proof = Program that produces the direct-evidence data when run

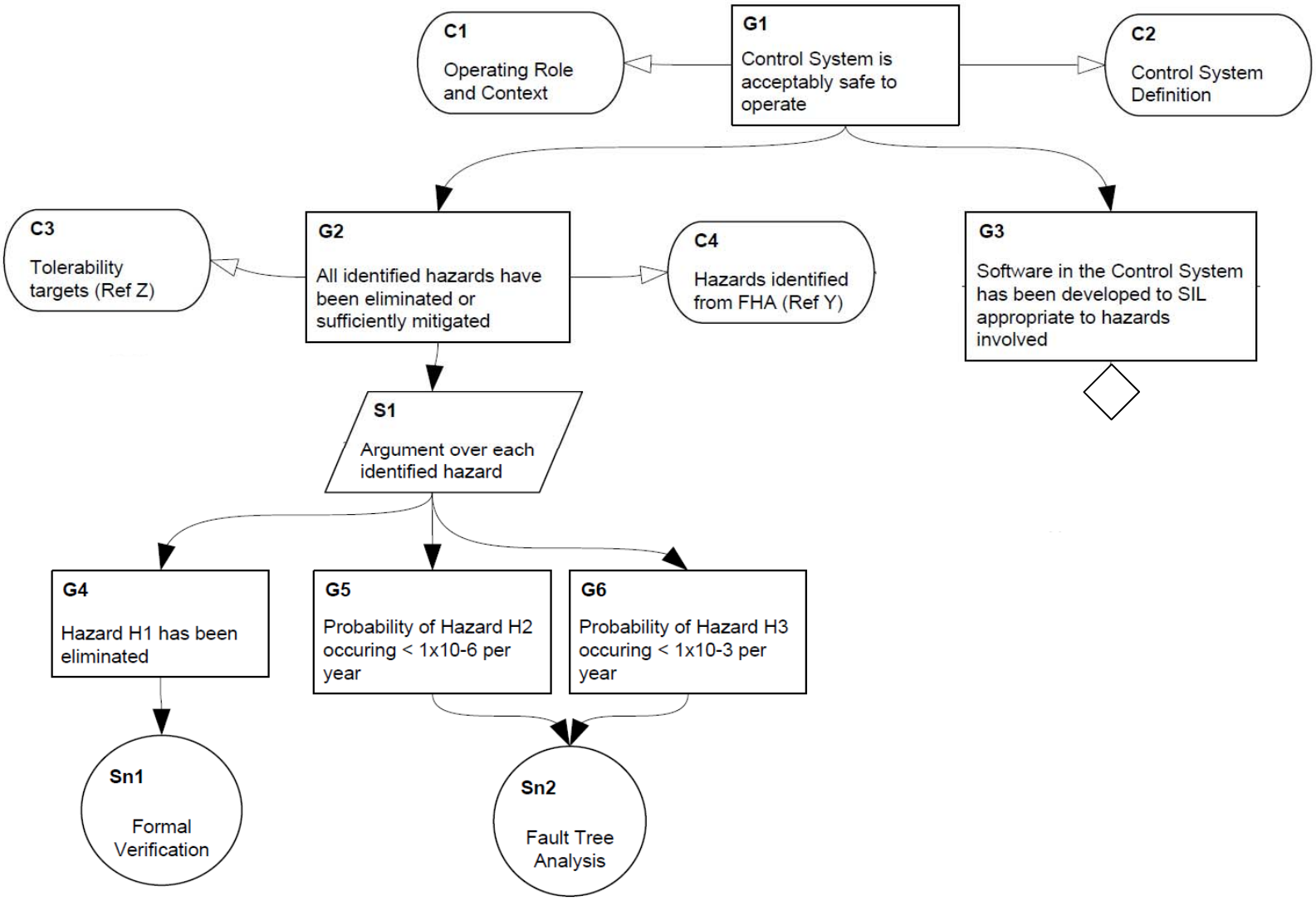
- Write an AC as ⟨ library defn., program ⟩ using a prog. lang.

- **Issues ALL SORTED OUT:** free-/bound-variables, scoping, safe-looping,…
- Type checked patterns / templates guarantee that any legal instantiation results in "correct" argument.

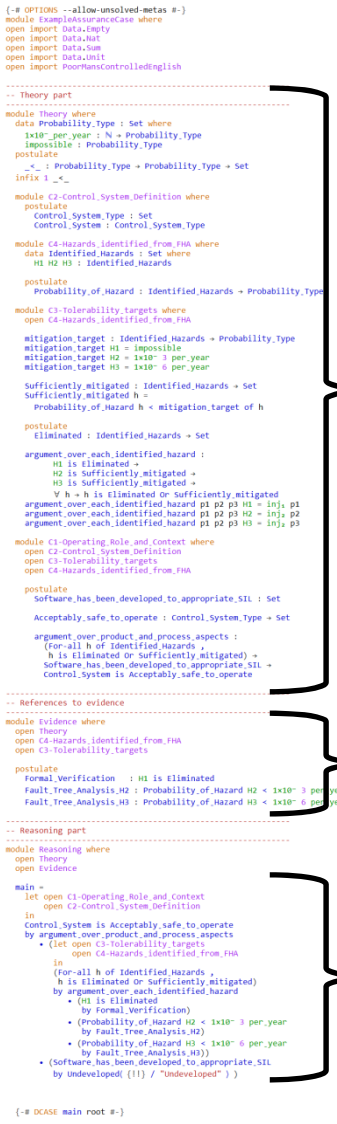
- For constructing understandable, maintainable, large arguments, all the programming / sw-eng. techniques can be imported wholesale. (*abstraction, recursive defn, modularisation, change-management, …*)



(From GSN Standard Figure 6, simplified)



(Fig 6 in arguments-as-programs form)



“Theory” part:

- Declares and defines the basis of the argument:
  Primitive terms for primitive things and concepts,
  Defined terms for defined things and concepts,
  Presumptive relationship among legal terms.
- Gives definite meaning to any legal combination of terms.
- Must be agreed / approved through supporting process.
- Organized into modules corresponding to contexts.

“Evidence” part

- Declares presumptive existence of evidence to some claim-terms
- Must be agreed / approved through supporting process

“Reasoning” part

- Exhibits a combined term as a proof for the top claim-term
  Whether it is a legal proof or not is machine-checkable.
- The top claim-term must be agreed / approved.

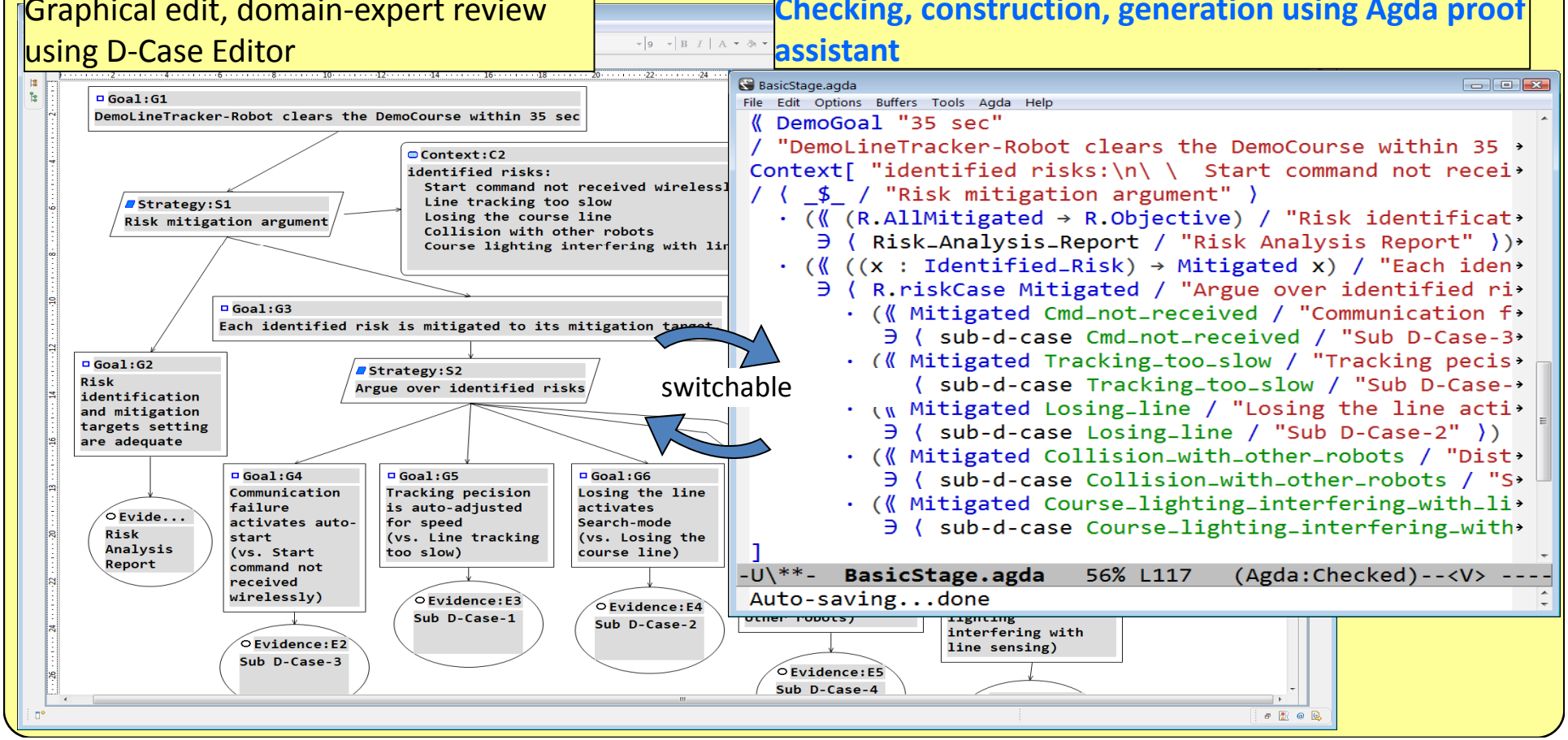
D-Case/Agda (“D-Case in Agda” Verification Tool)

- Provides translation between arg. in graphical form and in Agda program form.
- AC as an Agda program is checked in Agda dev. environment, which also is a proof-assistant for constructing args as programs.
- Google “D-Case/Agda” for download.

dcase-en dcase-agda code-agda

Graphical edit, domain-expert review using D-Case Editor

Checking, construction, generation using Agda proof assistant



Checklisting and meta-verification (speculative)

- Proving is primarily about

  Verification : “Are we building the system right?”

  (w.r.t. given, specified criteria : sys. spec, operational conditions, …)

  and not about

  Validation : “Are we building the right system?”

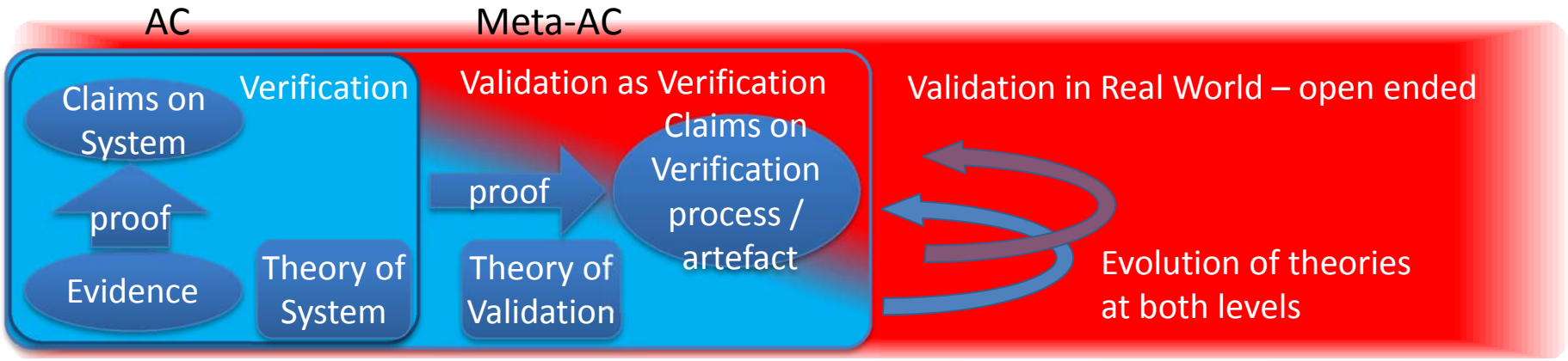
  (w.r.t. “Real World” : user needs, actual environment, …)

  No definitions for “right claims to make”, “right structure to argue”, …
- But checklists / requirements for AC in guides and standards are there to help.
- Template libraries can be prepared to enforce required forms and contents of AC.

  (But no explanation of why it’s good. Little room for adaptation.)

Checklisting and meta-verification (speculative)

- Part of validation can be verification about system-verif.:
  Meta-verification: “Are we verifying the system right?”,
  (w.r.t. checklists / requirements for AC in guides and standards)
- **Formal AC as data with rigorous semantics can be a target for such verification.**
- The rationale for checklists for AC could be codified in a “theory of validation” about properties of AC, and Meta-AC about AC could argue for the ‘goodness’ of AC.
- AC ~ Traceability matrix on steroids (R. Chapman, ‘08)
  Meta-AC ~ Checklists on steroids



Recommendations?

- Explicitly declare / define the basis of the argument.
  AC is not just an argument.
- Make the argument machine-checkable w.r.t. that basis via “arguments as proofs.”
- Apply programming and software engineering techniques for constructing and maintaining large AC,
  directly via “arguments as programs.”
- Develop libraries of verified patterns / frameworks
  - to ease construction of formal AC,
  - to enforce recommended forms and contents of AC.
- Formulate the rationale behind requirements for AC in standards as a theory of meta-verification about verification