Certification Opportunities for IMA

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Imagine. . .

- Maybe 10 years from now
- New guidelines: DO-297B and DO-178D
- What might we hope for?
- And what might we have to deal with?

What Might We Have To Deal With?

- A lot of code for health monitoring
- And a lot of (possibly adaptive) code for recovery
  - Take a pretty safe airplane, add a lot of complex, seldom-executed code to make it safer
- Aircraft-to-aircraft negotiation
  - NextGen: distributed airspace management
- Some of the pilots may be remote, on the ground
- Frequent updates, product families, customization
- Complex, outsourced, development and supply chain

What Might We Hope For (From DO-178x)?

- Justifiable confidence in its effectiveness
  - In the face of the new challenges on previous slide
    - ⋆ e.g., it's not productive to view a learning system, say, as merely a different means for implementing software
    - ⋆ And then to try to apply DO-178B to it
    - ⋆ It's a more radical change than that
- Manageable cost
- Credible and inexpensive recertification for product evolution
  - Incremental cost for incremental changes

What Might We Hope For (From DO-297x)?

- Truly compositional certification
  - Components are qualified (certified standalone)
  - The certification of the system considers its (IMA) architecture
  - And the component qualifications
  - But need not go inside the component or architecture implementations
- Credible and inexpensive recertification with changed/new components
- IMA concept extends beyond individual aircraft:
  - Distributed, cooperating, elements
    (remote piloting, NextGen)

Credibility: A Recent Incident

- Fuel emergency on Airbus A340-642, G-VATL, on 8 February 2005 (AAIB SPECIAL Bulletin S1/2005)
- Toward the end of a flight from Hong Kong to London: two engines flamed out, crew found certain tanks were critically low on fuel, declared an emergency, landed at Amsterdam
- Two Fuel Control Monitoring Computers (FCMCs) on this type of airplane; they cross-compare and the "healthiest" one drives the outputs to the data bus
- Both FCMCs had fault indications, and one of them was unable to drive the data bus
- Unfortunately, this one was judged the healthiest and was given control of the bus even though it could not exercise it
- Further backup systems were not invoked because the FCMCs indicated they were not both failed

Standards-Based Software Certification

- E.g., airborne s/w (DO-178B), security (Common Criteria)
- Applicant follows a prescribed method (or processes)
  - Delivers prescribed outputs
    - ⋆ e.g., documented requirements, designs, analyses, tests and outcomes; traceability among these
  - Certification examines the outputs
- Works well in fields that are stable or change slowly
  - Can institutionalize lessons learned, best practice
    - ⋆ e.g. evolution of DO-178 from A to B to C
- But less suitable with novel problems, solutions, methods
  - Might work only because of implicit factors
    - ⋆ Conservative practices, safety culture
  - Can become a barrier to innovation

Standards and Goal-Based Assurance

- All assurance is based on **arguments** that purport to justify certain **claims**, based on documented **evidence**
- Standards usually define only the evidence to be produced
- The claims and arguments are implicit
- Hence, hard to tell whether given evidence meets the intent
- E.g., does MC/DC coverage provide evidence for good testing, or good requirements, or absence of unintended function?
- Recently, goal-based assurance methods have been gaining favor: these make the elements explicit

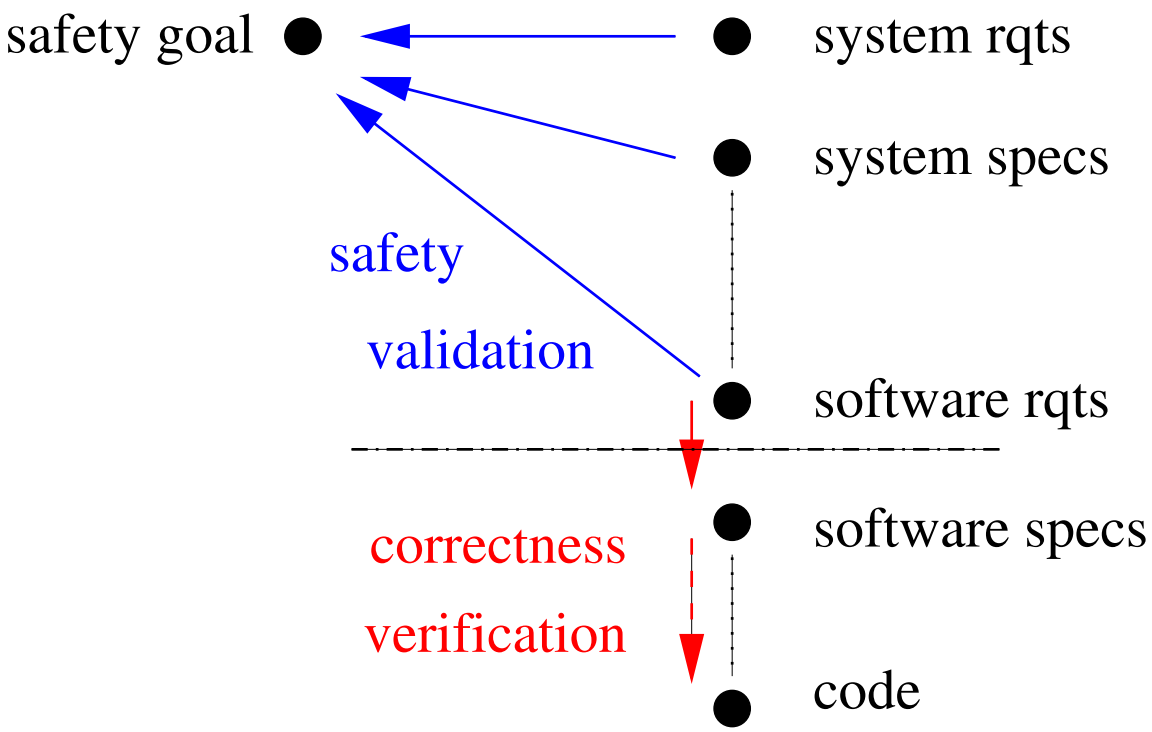
The Goal-Based Approach to Software Certification

- E.g., UK air traffic management (CAP670 SW01), UK defence (DefStan 00-56), growing interest elsewhere
  - Recommendation of NRC report: Sufficient Evidence?
- Applicant develops a safety case
  - Whose outline form may be specified by standards or regulation (e.g., 00-56)
  - Makes an explicit set of goals or claims
  - Provides supporting evidence for the claims
  - And arguments that link the evidence to the claims
    - ⋆ Make clear the underlying assumptions and judgments
    - ⋆ Should allow different viewpoints and levels of detail
- Generalized to security, dependability, assurance cases
- The whole case is evaluated by independent assessors
  - Explicit claims, evidence, argument

Relation to Current Practice

- Fairly consistent with top-level certification practice
- Applicants propose means of compliance
  - cf. ARP4754, ARP4761
  - Apply safety analysis methods (HA, FTA, FMEA etc.) to an informal system description
- And a Plan for Software Aspects of Certification
  - Typically DO-178B
  - To be sure implementation does not introduce new hazards, require it exactly matches analyzed description
    - ⋆ Hence, DO-178B is about correctness, not safety
- It's the latter that we propose to change
  - Analyze the implementation for preservation of safety, not correctness
  - This may be a way to deal with adaptive systems

Software Hazards:
Standards Focus on Correctness Rather than Safety



- Premature focus on correctness inappropriate for adaptive systems, goal-based methods could reduce this

Safety Cases and Monitoring

- Health monitoring implies online checking
- We know how to do this (runtime verification)
- But what (source of) properties to monitor?
- Low Level SW requirements unlikely to be useful
  - DO-178B ensures these are implemented correctly
- Similarly with High Level SW requirements
- Most likely it's the requirements that are in error
- We need an independent source of properties to monitor
- Aha: the safety case
  - Monitor against the claims of the safety case

IMA and Compositional Certification

- Profound insight (Ibrahim Habli & Tim Kelly)
  - The safety case may not decompose along architectural lines
- So what is an architecture?
- A good one supports and enforces the safety case
- Cf. MILS approach to security: yesterday afternoon
  - Explicitly compositional
  - Relates to IMA
- Intuitively, it's what partitioning is all about
- But I think the idea of a MILS Policy Architecture provides a useful interface between policy and mechanism

Closing Thoughts And Questions

- Is it time to rethink the approach to software certification?
- And are safety cases the way to go?
- What other approaches could cope with the challenges we face?
- Do we want to move toward explicitly compositional certification?
- Are we doing it anyway, but implicitly?
- Can the safety and security worlds benefit from a common foundation?
- What did I leave out?