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Certification of Safety Critical Software

Alan Wassyng, Ph.D., P.Eng.
McMaster Centre for Software Certification
wassyng@mcmaster.com
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Personal History

- Building safety-critical software applications since 1989
- Senior member of the team that developed methodology for safety-critical software at Ontario Hydro
- Senior member of team that built and verified Darlington Shutdown System One
- With colleagues in McSCert, mainly Tom Maibaum and Mark Lawford, working on software certification in nuclear power, medical devices, automotive, financial legacy systems
- One of the founders of the Software Certification Consortium

wassyng@mcmaster.ca

Certification of Software

- Systems are certified, not usually just the software
- We need to pay special attention to the software in safety-critical systems, since software fails differently from manufactured physical systems
- Software engineering is still a relatively young discipline, so we suggest that, to be effective, we need to look at two interrelated topics
  - How to *build* safety-critical systems that contain software, so that they can be certified effectively
  - How to effectively *certify* safety-critical systems that contain software

Our Goals

- "Prove" that
  - If built according to spec, the application will be safe and effective (validation)
  - The application is built to spec (verification)
  - We have high confidence that the application will deliver "safe" behaviour in the face of hardware malfunction (fault tolerant)
  - The application will continue to be correct and safe over its lifetime (maintainable and evolvable!)

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Major Principles

- Separate safety systems from control systems
  - Not just for independence, reduction in complexity is crucial to managing (software) safety
- Defense-in-depth
  - This obviously applies to the design/implementation
    - Diversity
    - Avoidance of single points of failure
  - It also applies to methods for building and certifying the software
    - In the face of uncertainties, we can bolster our confidence by using more than one way to show compliance of any step – review/inspection as well as mathematical analysis/verification, ***and*** testing of models and code. With better understanding (in future) we will be able to target coverage better

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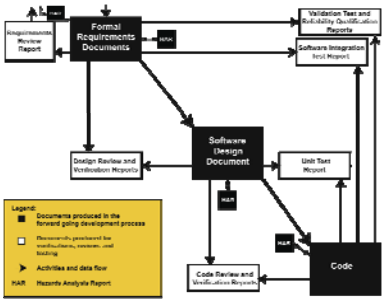
One Way to Build It



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Facilitate Verification

- An obvious interaction between building and certifying the software
  - How can we facilitate verification and certification while building it?
    - Get/Process/Set
    - Provide explicit refinements and verify them in sequence
    - Integrated methods and high-degree of traceability
    - Provide explicit requirements for fault tolerance
    - Record rationale and document defense-in-depth strategies
    - Mathematics and rigour
    - Qualified tools

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Certification Methods

- An important tripod: *People/Process/Product*
- Certifying that the *people* involved have the necessary knowledge
  - Acknowledged to be a problem. Need further research to do this effectively, but minimal standards should be enforced now
- Certifying the software development *process*
  - Check compliance to existing and relevant standards
- Certifying the *product*
  - We generally do not do this well at all – testing is not enough

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Certify the Product

- This must be the main focus of any certification effort
- Audits of validation and verification
- Assurance/safety cases

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Audits

- If the certifying agent (CA) has trust in the manufacturer and confidence that an approved process was followed during development
- and If the process produces suitable audit points, e.g. inspection/design reviews, verification reports, and so on
  - The CA can audit slices through the system
  - Different slices can be audited effectively by different people

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Assurance Cases

- The certifying authority may mandate that the manufacturer present an assurance/safety case that documents, in a structured way
  - The claims that are made (often, safety claims)
  - Arguments that support the validity of those claims
  - Backed up by evidence – drawn primarily from the product and process
- Opinion: These assurance cases need to be structured in compliance with some consensus standard or they will be too difficult to review effectively

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What We Don't Have Yet

- Identified attributes of software related to certification requirements and associated metrics
- How various analyses and verification techniques contribute to overall confidence in safety and efficacy
- Appropriate templates for assurance cases
- How arguments in assurance cases can be objectively and repeatably evaluated
- Effective and dependable integrated tool sets that support integrated methods of development (including model driven engineering) and certification
- Safe and effective forensic tools

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