# A Short Introduction to Assurance Cases

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# Background

- Paradigm shift in many domains
  - Shift from a prescribed process to a product-oriented assurance
  - Shift from a tick-box to argument-based

- Different drivers:
  - Accidents
    - Piper Alpha, 1988
  - Different business model
    - Rail privatisation, 1992
  - Incidents and recalls
    - FDA, 2010
  - Complexity
    - Automotive, 2011

# Assurance Cases: Definition

- *"A reasoned and compelling **argument**, supported by a body of **evidence**, that a system, service or organisation will operate as intended for a defined application in a defined environment."*

- Often with a particular focus
  - Safety
  - Security
  - Dependability
  - Trust
  - …

[GSN Standard 2011]

# Assurance Cases: Structure

- Primary Claim, e.g.
  - The *contributions* made by the *BSCU software* to *S18 WBS hazards* are acceptable

- Argument, e.g.
  - Hazardous software contributions have been identified
  - Controls have been put in place to manage these contributions
  - Mechanisms are in place to monitor the performance of the controls and the system on an on-going basis

- Evidence, e.g.
  - Tests, analyses, reviews, simulation, expert judgements and compliance with best practice

# Assurance Case Arguments

- *"A connected series of claims intended to establish an overall claim"*

- Deductive argument: overall claim follows with necessity

  *All men are mortal.*
  *Aristotle is a man.*
  *----------------*
  *Therefore, Aristotle is mortal.*

- Inductive argument: overall claim follows with probability

  *System detects most faults via sensors.*
  *Collected sensor data shows lack of faults.*
  *--------------------------------------------------------------*
  *Therefore, System is very likely to be fault-free.*

- Unfortunately, assurance case arguments are predominantly inductive rather than deductive
  - and are often implicit!

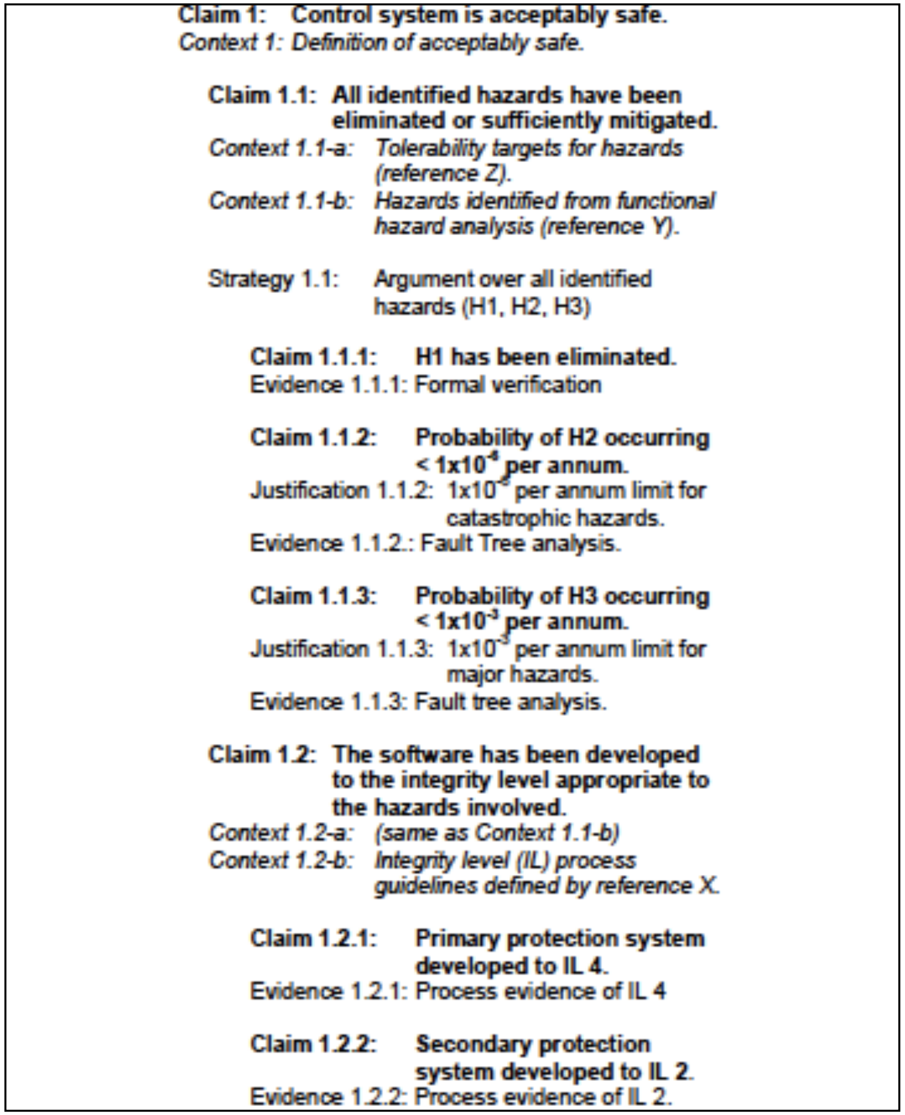
# Assurance Case Notations

- Clear representation is necessary
  - Comprehensible to all assurance-case stakeholders
  - Enable effective review and maintenance
- Main notations are:
  - Textual
  - Tabular
  - Graphical
- With increased interest in formalism
- Assurance cases for large scale and complex system will include most of the above notations

# Assurance Case Notations: Text

- Normal prose
  - Primary medium of expression in law and philosophy
- Structured prose
  - Explicitly denoting the critical parts of the argument
- Argument outline
  - Indentation, numbering and font changes

[Holloway 08]



**Claim 1: Control system is acceptably safe.**
*Context 1: Definition of acceptably safe.*

**Claim 1.1: All identified hazards have been eliminated or sufficiently mitigated.**
*Context 1.1-a: Tolerability targets for hazards (reference Z).*
*Context 1.1-b: Hazards identified from functional hazard analysis (reference Y).*

Strategy 1.1: Argument over all identified hazards (H1, H2, H3)

**Claim 1.1.1: H1 has been eliminated.**
Evidence 1.1.1: Formal verification

**Claim 1.1.2: Probability of H2 occurring < $1x10^{-6}$ per annum.**
Justification 1.1.2: $1x10^{-6}$ per annum limit for catastrophic hazards.
Evidence 1.1.2.: Fault Tree analysis.

**Claim 1.1.3: Probability of H3 occurring < $1x10^{-3}$ per annum.**
Justification 1.1.3: $1x10^{-3}$ per annum limit for major hazards.
Evidence 1.1.3: Fault tree analysis.

**Claim 1.2: The software has been developed to the integrity level appropriate to the hazards involved.**
*Context 1.2-a: (same as Context 1.1-b)*
*Context 1.2-b: Integrity level (IL) process guidelines defined by reference X.*

**Claim 1.2.1: Primary protection system developed to IL 4.**
Evidence 1.2.1: Process evidence of IL 4

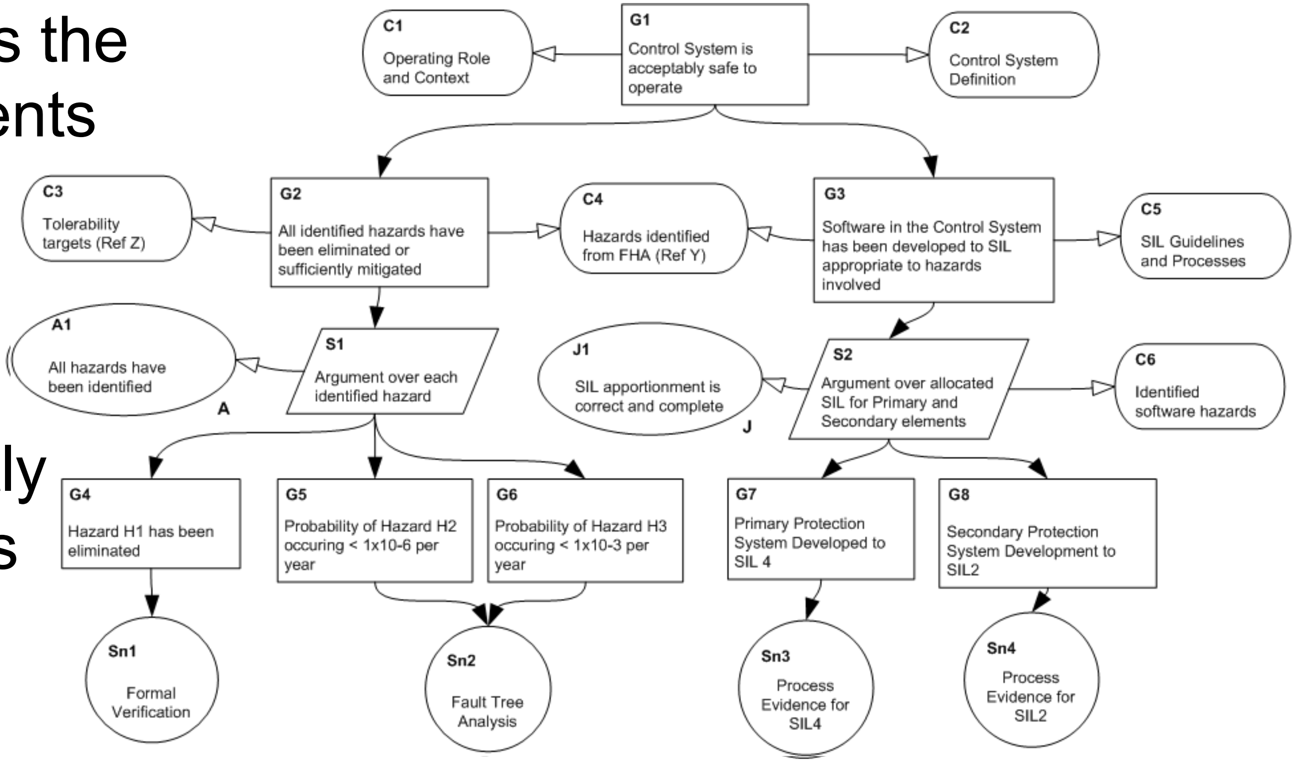
**Claim 1.2.2: Secondary protection system developed to IL 2.**
Evidence 1.2.2: Process evidence of IL 2.

# Notations: Graphical

- Two main notations:
  - Claims-Arguments-Evidence (CAE)
  - Goal Structuring Notation (GSN)

- GSN documents the individual elements of arguments

- More significantly the relationships between these elements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G8
Secondary Protection System Development to SIL2
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Process Evidence for SIL4
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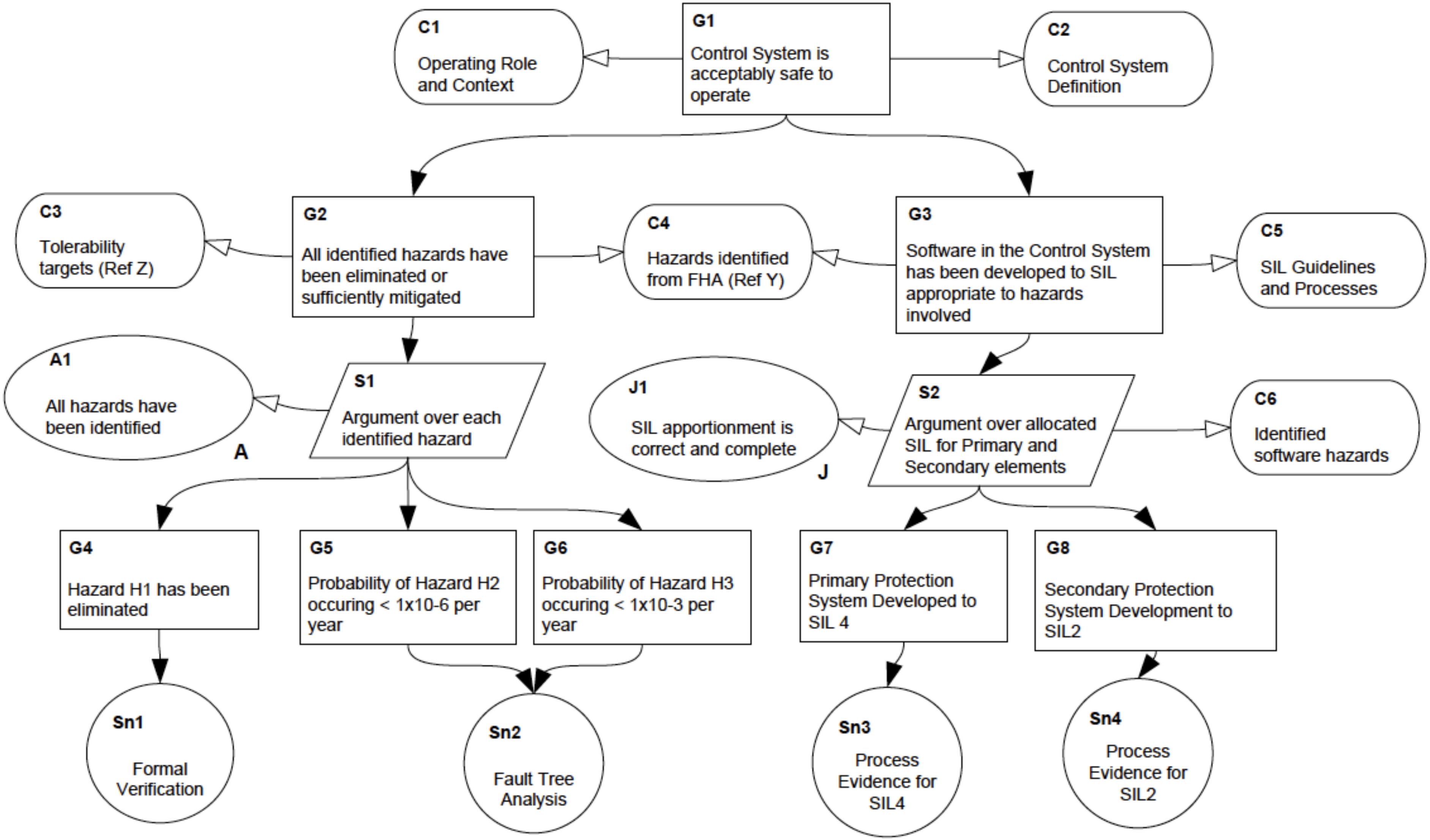
Process Evidence for SIL2

[GSN Standard 2011]

# GSN: Goal Structure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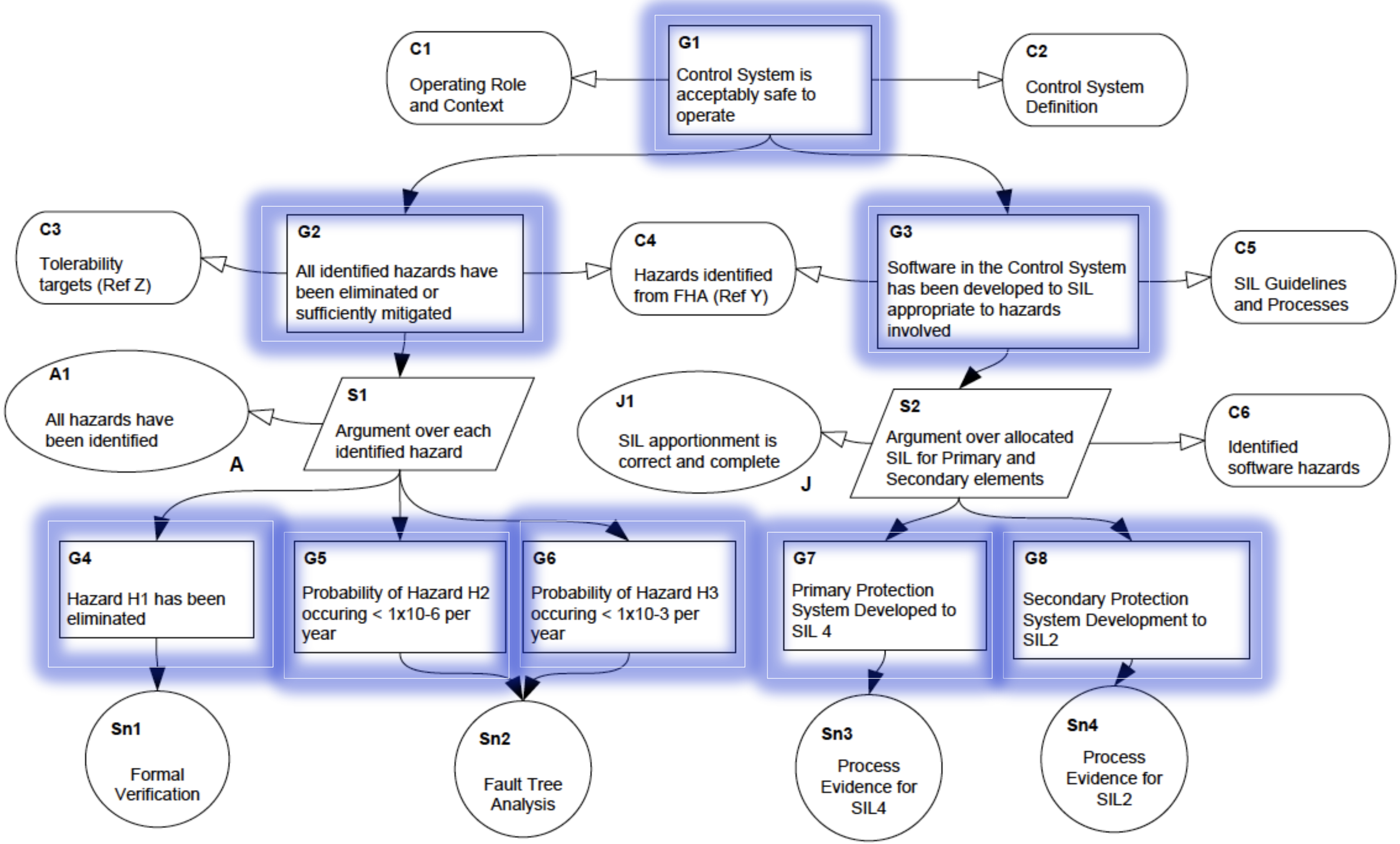
# GSN: Goals



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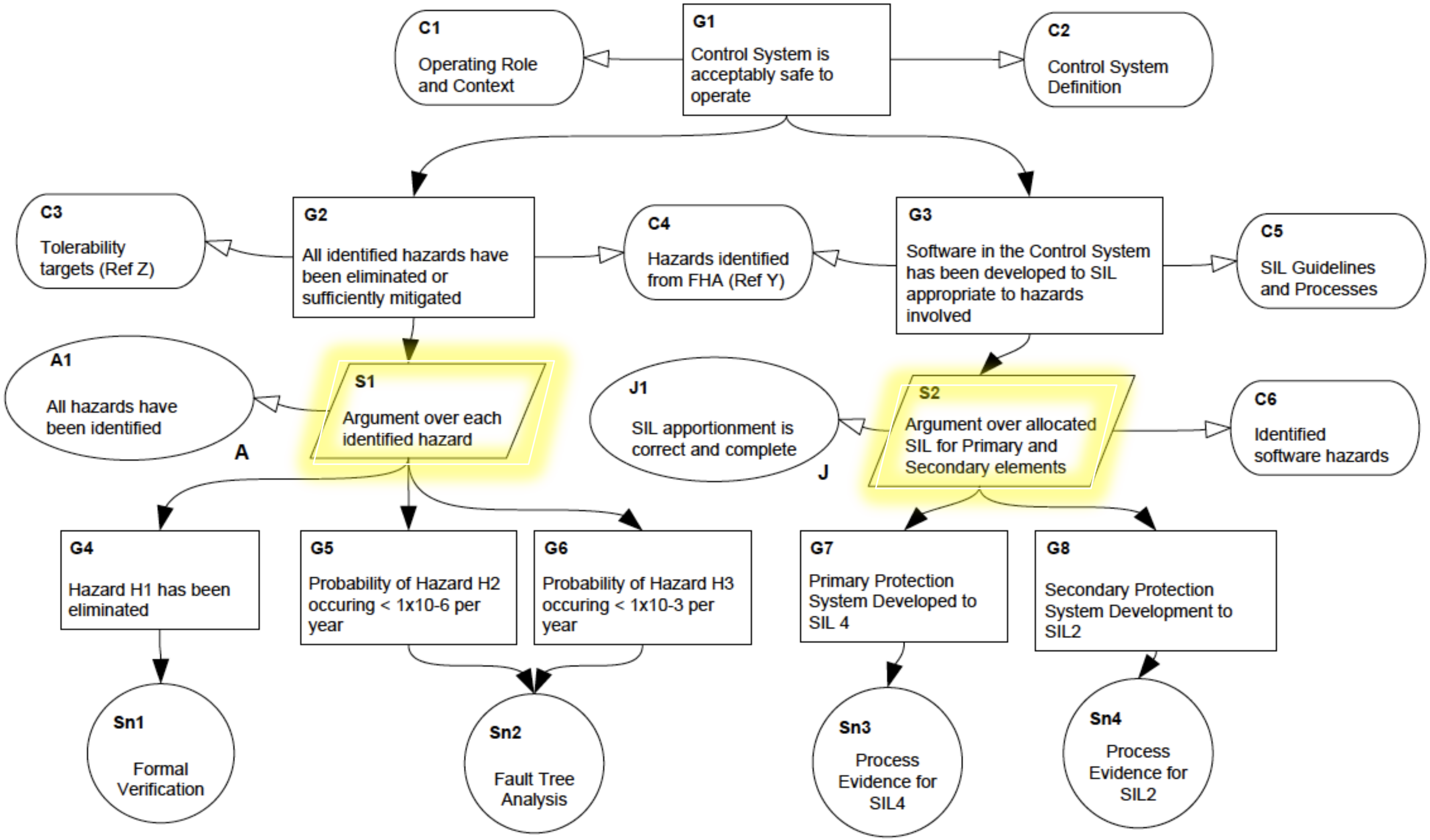
# GSN: Strategies



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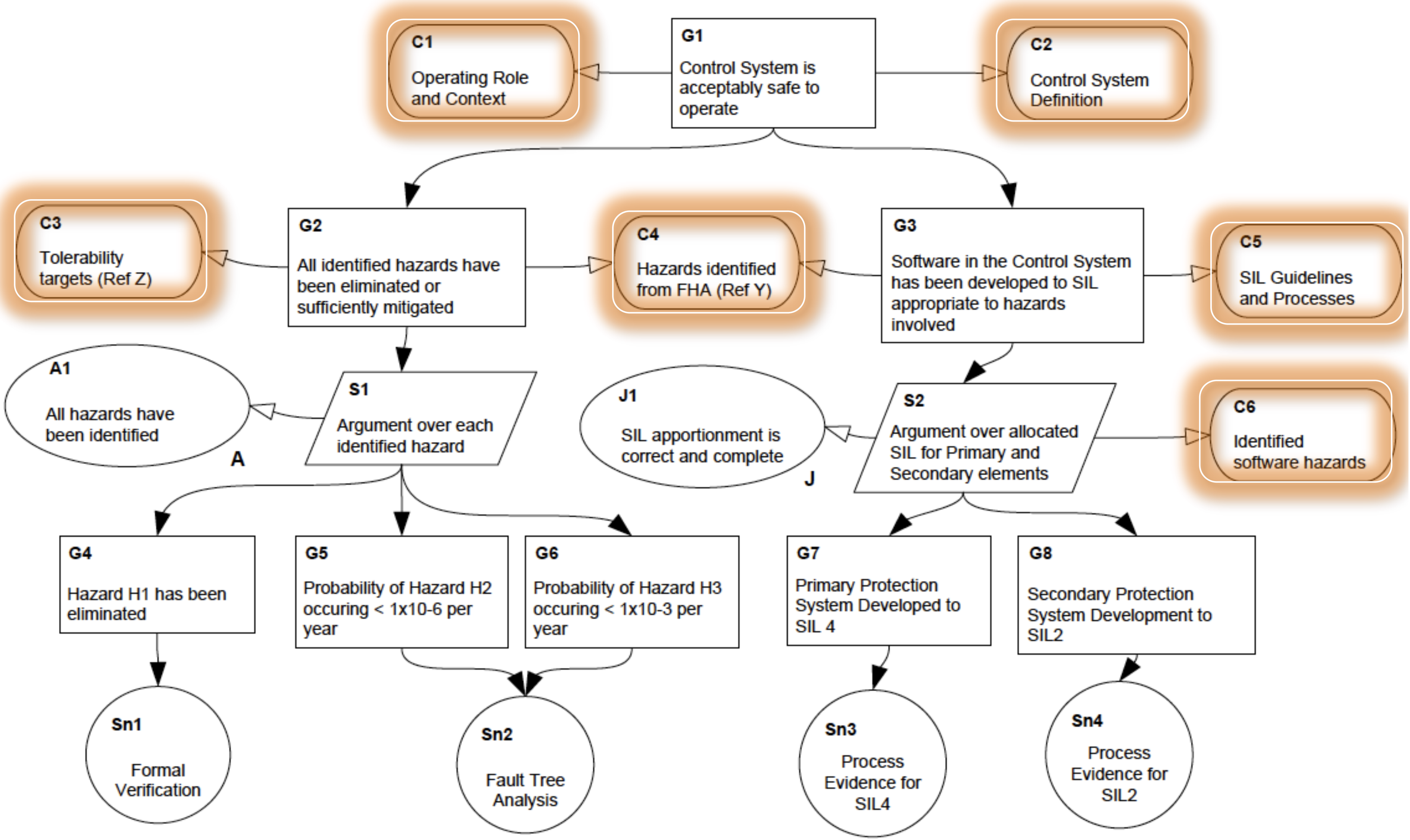

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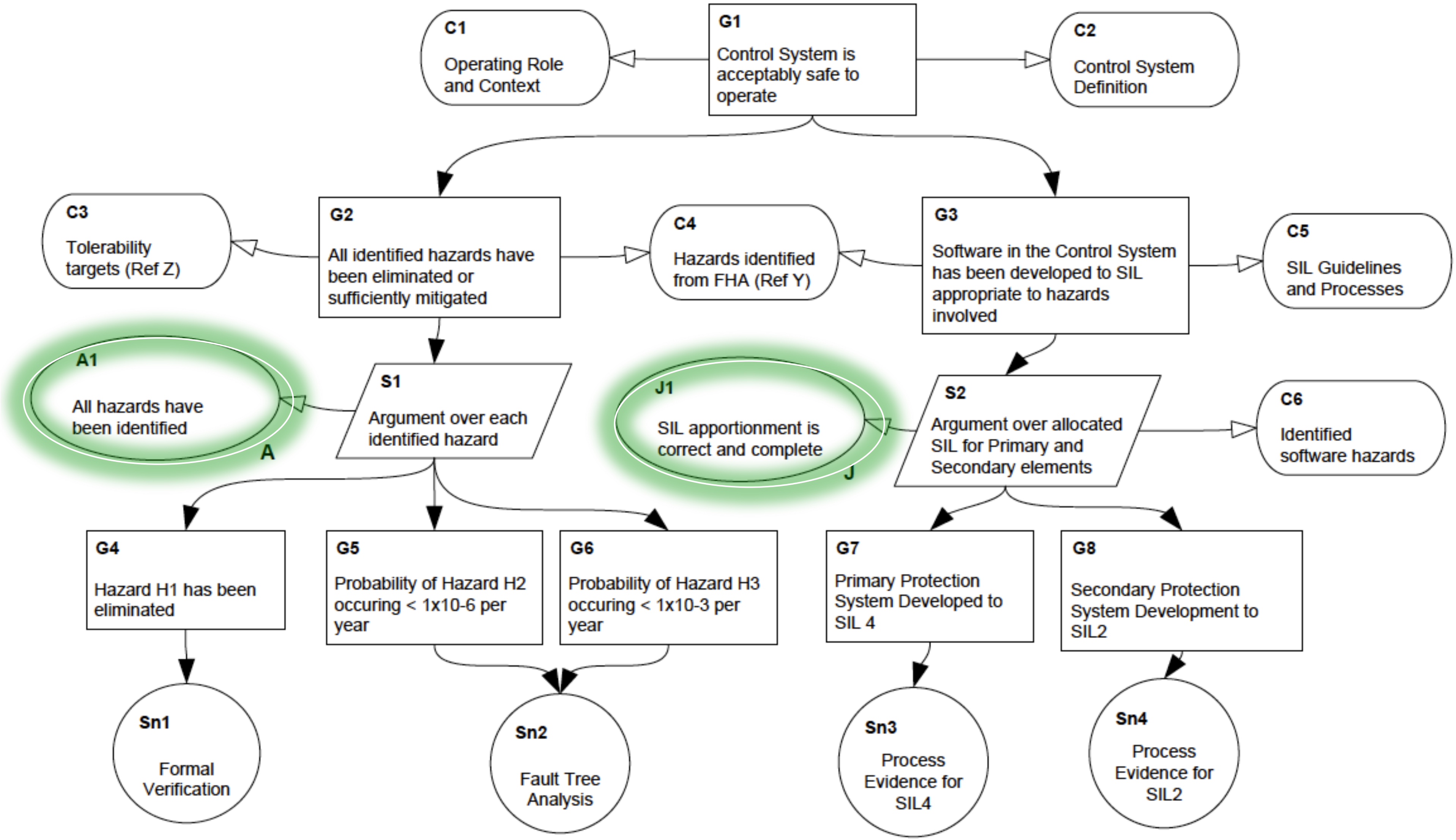
# GSN: Assumptions/Justifications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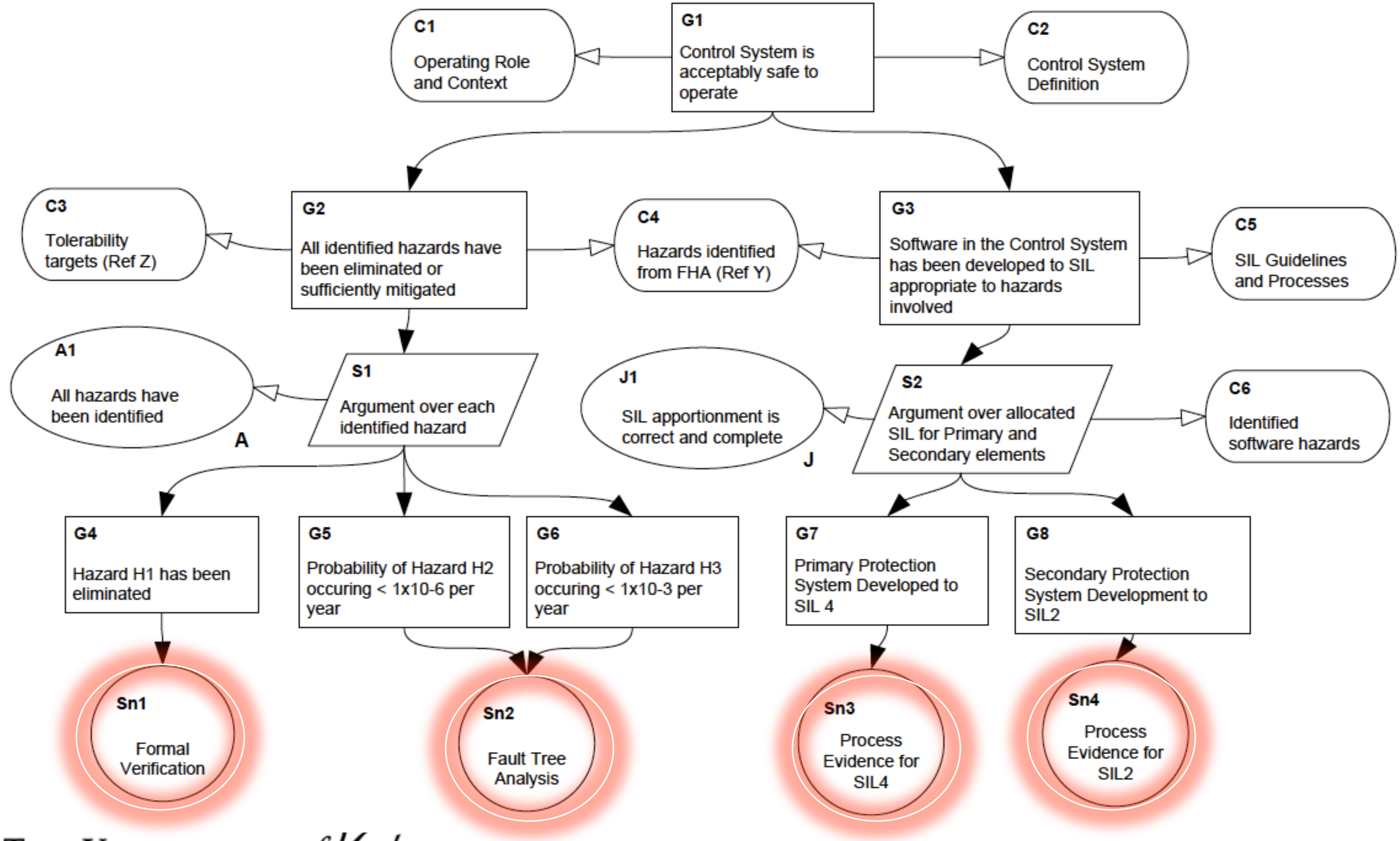
THE UNIVERSITY of York

# GSN: Solutions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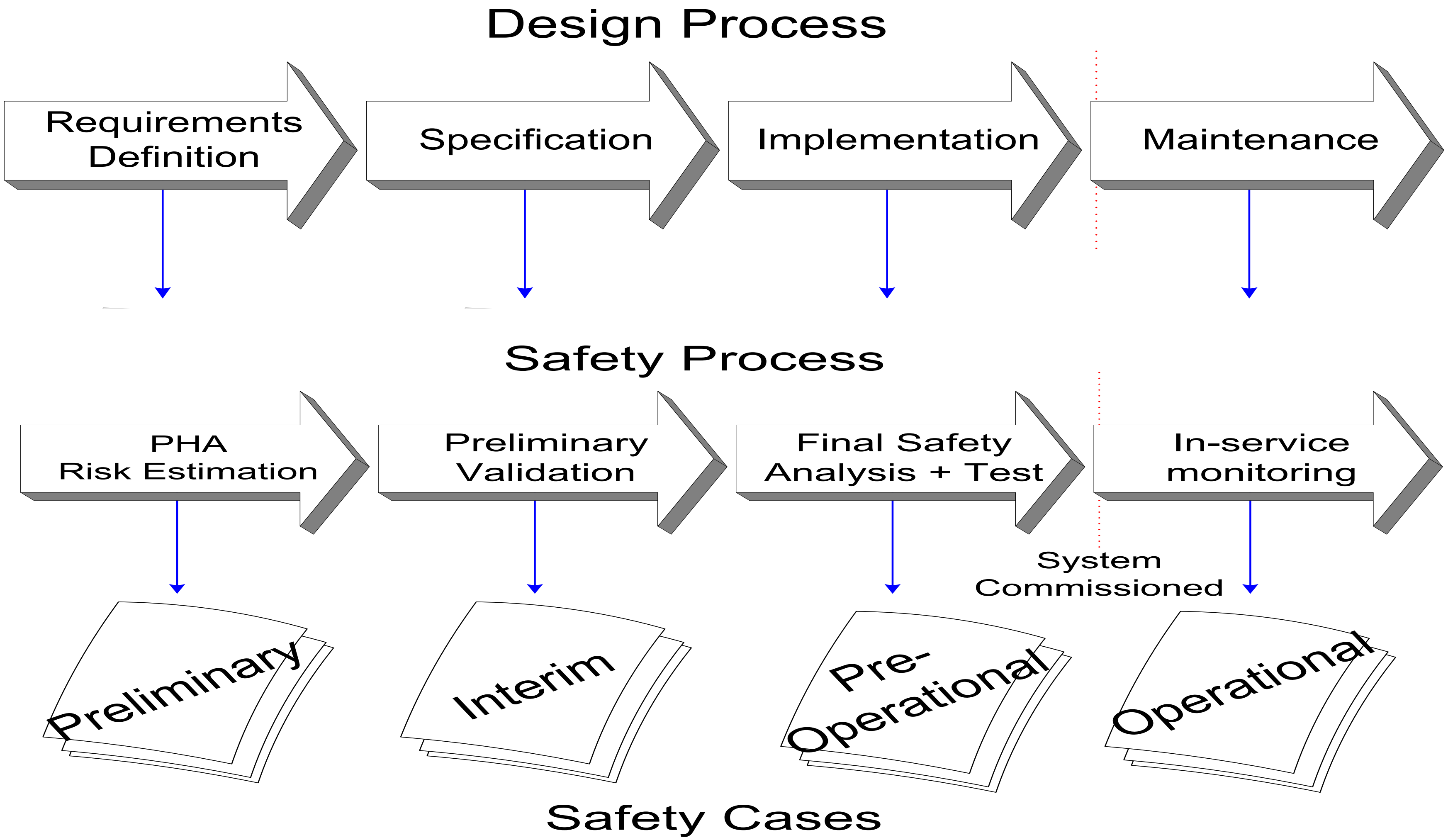
# Assurance Case Review

- Various issues to consider, including:
  - **Argument Comprehension**
    - Can the argument be fully understood by the reader?
  - **Sufficiency of argument**
    - Are the premises of the argument, taken together, strong enough to support the conclusion(s) being drawn?
  - **Integrity of evidence**
    - Has the evidence been developed and thoroughly reviewed by suitably competent and experienced personnel?

- Sadly, uncovering and understanding the arguments and evidence remain a key challenge for reviewers!

# Incremental Development



# Tool Support

- Improved presentation
  - e.g. through argument views
- Support for argument construction
  - e.g. structured expression and controlled vocabulary
- Support for review
  - e.g. syntactic checks of argument structure
- Support for reuse
  - e.g. argument patterns and modularisation
- Maintenance
  - e.g. change management and traceability

# Benefits

- **Making the implicit explicit**
  - Easier to review the arguments, question the evidence and challenge the adequacy of the reasoning presented
  - Creating greater transparency in the overall assurance process

- Aiding communication among stakeholders
- Integrating and assessing evidence sources
- Aiding safety management and governance
- …

[Health Foundation 2012]

# Challenges

- Removed from reality
- Approximation of truth
- Lack Empirical evidence
- Subjectivity
- Training needs
- Apologetic arguments
- Lack Scientific Assessment
- Paper exercise
- Capability of Tools
- Prescriptive arguments
- Lack of Examples
- Imbalance of skills
- Illusion of pictures
- Cost-effectiveness
- Wrong people

**and many more…**

Many potential benefits and challenges

Hence this workshop