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Argument strength – an engineering perspective

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Adelard

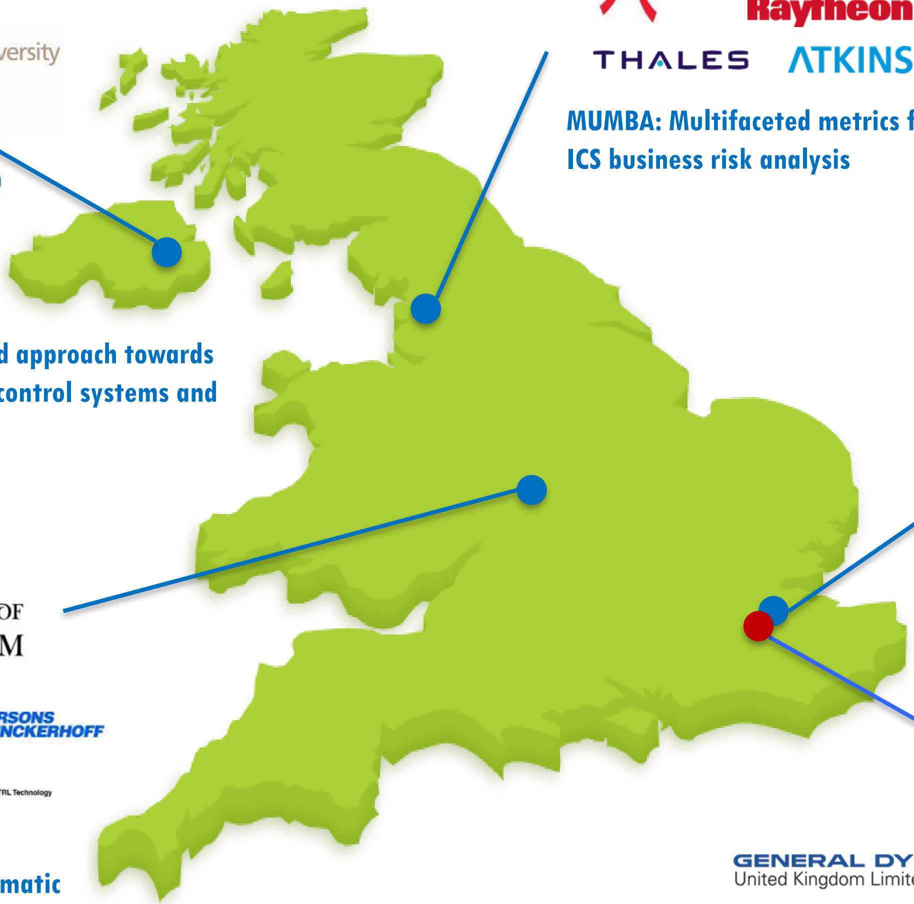
- Adelard is a specialized, influential product and services company working on safety, security and resilience since 1987
- Wide-ranging experience of assessing computer-based systems and components
- Work across a range of different industrial sectors, including defence, nuclear, rail, aviation, financial, medical
  - Policy, methodology, technology
  - Product for managing safety and assurance cases (ASCE)
  - Security-informed safety and dependability
- Consultants PhD level, international team from
  - England, Scotland, Portugal, Italy, Ukraine, Australia, Germany, Greece, Ireland, Hungary, Romania
- Partner in UK Research Institute on Trustworthy ICS (RiTICS)

Safety and security

Research Institute in Trustworthy Industrial Control Systems

EPSRC
Engineering and Physical Sciences Research Council

CPNI
Centre for the Protection of National Infrastructure



LANCASTER UNIVERSITY
AIRBUS
Raytheon
THALES ATKINS

MUMBA: Multifaceted metrics for ICS business risk analysis

£2.4M programme, 5 coordinated projects.

Phase 1 (Directorship) awarded 01/01/14, Chris Hankin, Imperial College London.

Phase 2 awarded 01/10/14.

Queen's University Belfast
Scottish and Southern Energy Power Distribution
THALES
Statnett

CAPRICA: Converged approach towards resilient industrial control systems and cyber assurance

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CEDRICS: Communicating and evaluating cyber risk and dependencies in ICS

Adelard

UNIVERSITY OF BIRMINGHAM
nationalgrid
PARSONS BRINCKERHOFF
RSSB
L3 TRL Technology

SCEPTICS: A systematic evaluation process for threats to ICS (incl. national grid and rail networks)

Imperial College London
GENERAL DYNAMICS United Kingdom Limited
ATKINS
Symantec.

RITICS: Novel, effective and efficient interventions

Health Foundation Review

Health Foundation Report
http://www.health.org.uk/publications/using-safety-cases-in-industry-and-healthcare/

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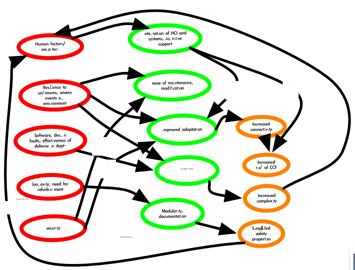
An assurance and decision analysis framework

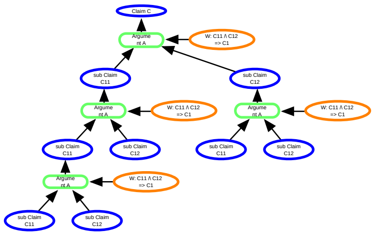
Reasoning and communicating with assurance cases

Developing assurance

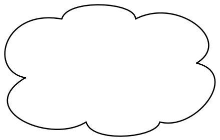
Influence diagram



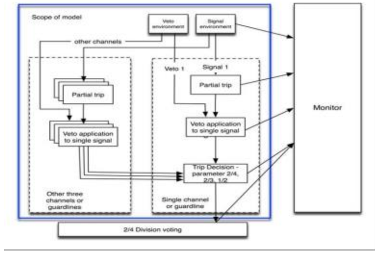
CAE structure



Mental models



Engineeering models



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Assurance principles

Understand the system and environment

- Effective understanding of the hazards and their control should be demonstrated
  - Intended and unintended behaviour of the technology should be understood
  - Multiple and complex interactions between the technical and human systems to create adverse consequences should be recognised.

Assurance process

- Active challenge should be part of decision making throughout the organisation.
- Lessons learned from internal and external sources should be incorporated.

Case itself

- Justification should be logical, coherent , traceable, accessible, repeatable with a rigour commensurate with the degree of trust required of the system.

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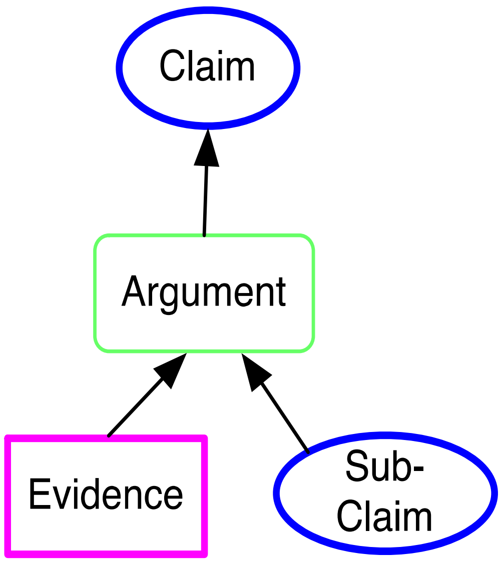
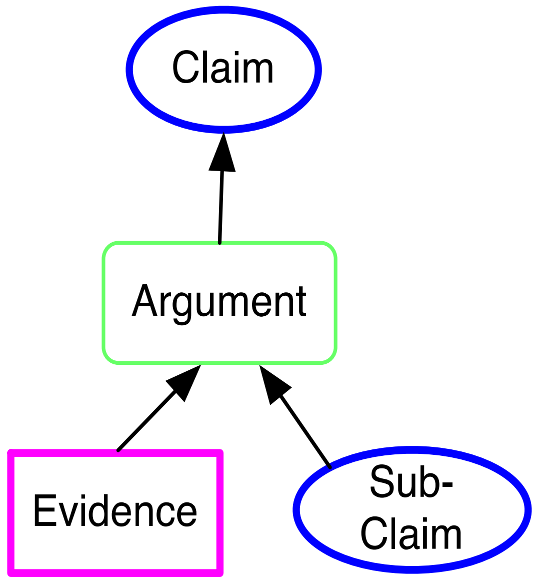
CAE - concepts



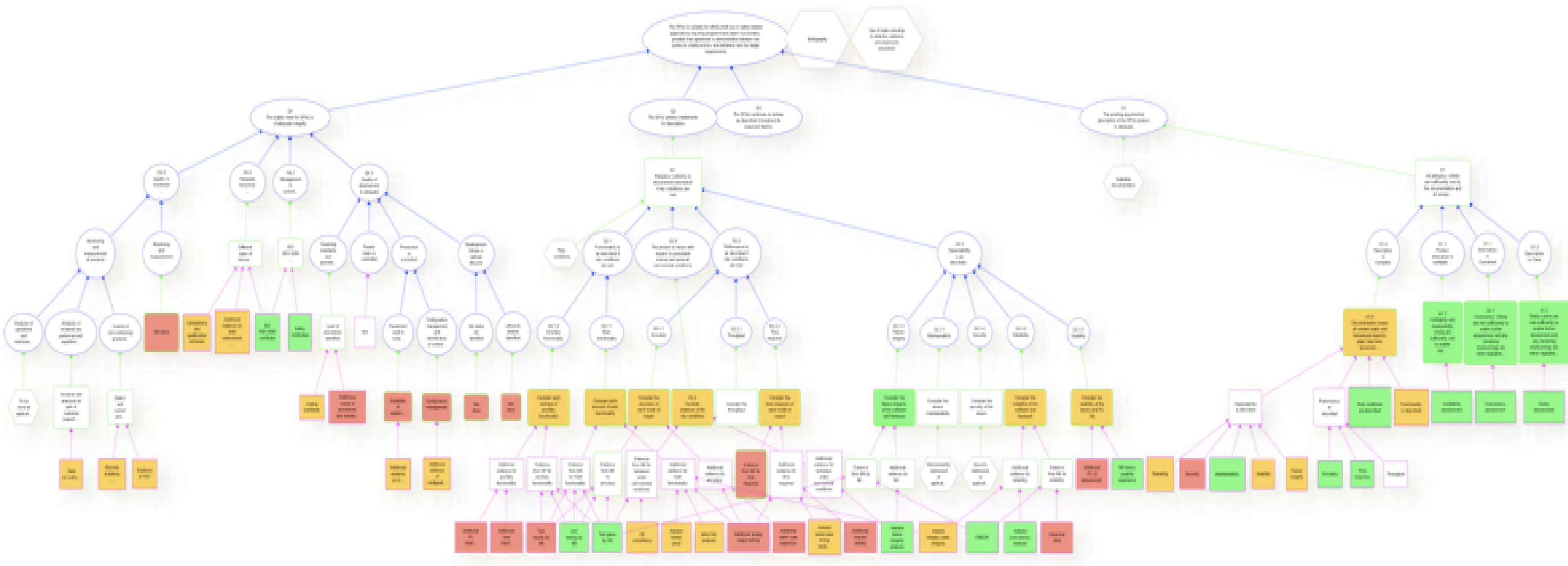
- ***Claims***, which are assertions put forward for general acceptance
  - They are typically statements about a property of the system or some subsystem. Claims that are asserted as true without justification become assumptions and claims supporting an argument are called sub-claims.
- ***Evidence*** that is used as the basis of the justification of the claim
  - Sources of evidence may include the design, the development process, prior field experience, testing (including statistical testing), source code analysis or formal analysis.
- ***Arguments*** link the evidence or sub-claim to the claim
  - They are the "statements indicating the general ways of arguing being applied in a particular case and implicitly relied on and whose trustworthiness is well established", together with the validation for the scientific and engineering laws used.

Concept: Assurance case



Assurance Case "a documented body of evidence that provides a convincing and valid argument that a system is adequately dependable for a given application in a given environment"

In practice … the engineering and the tools



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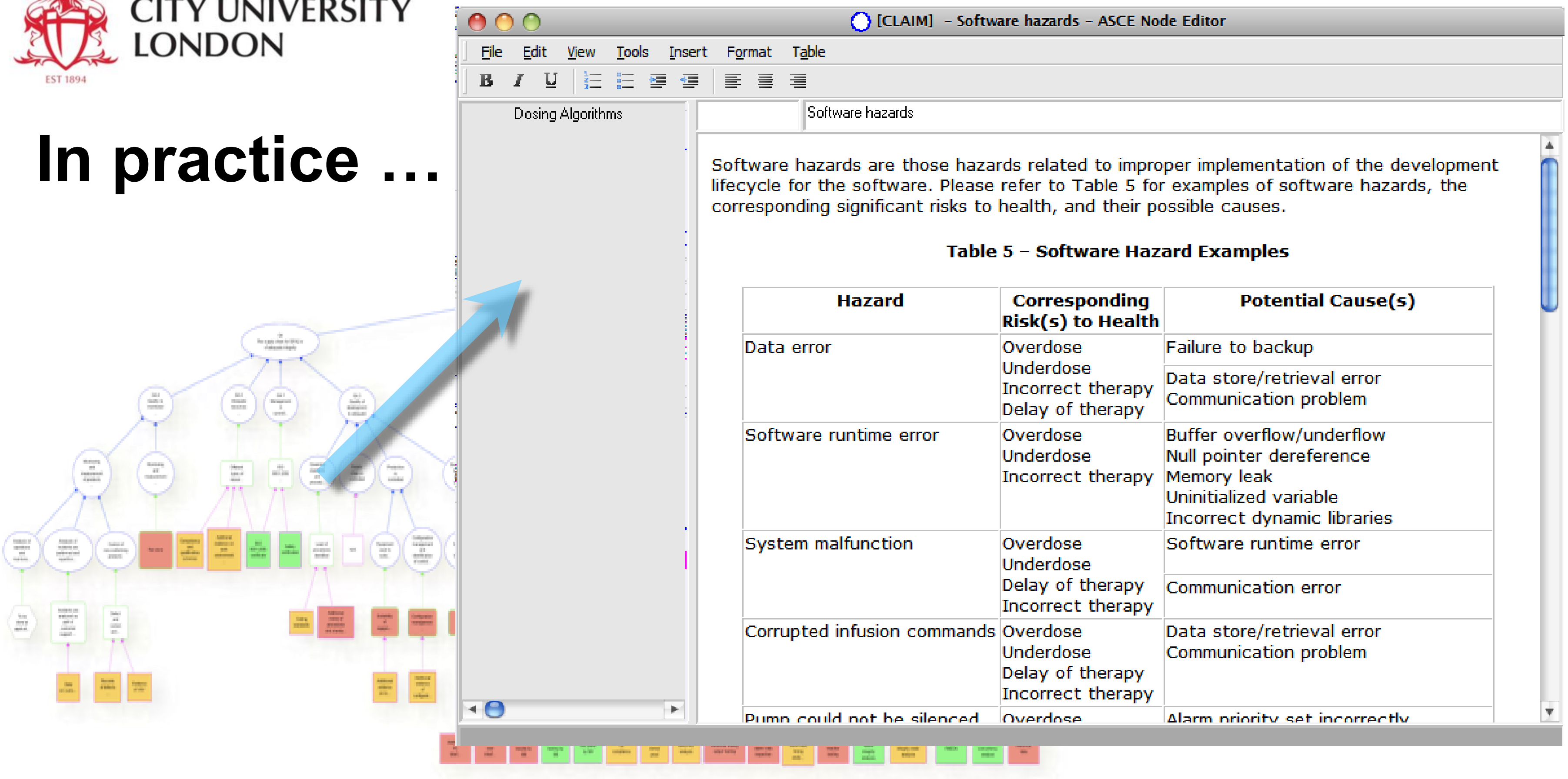
In practice …



Software hazards are those hazards related to improper implementation of the development lifecycle for the software. Please refer to Table 5 for examples of software hazards, the corresponding significant risks to health, and their possible causes.

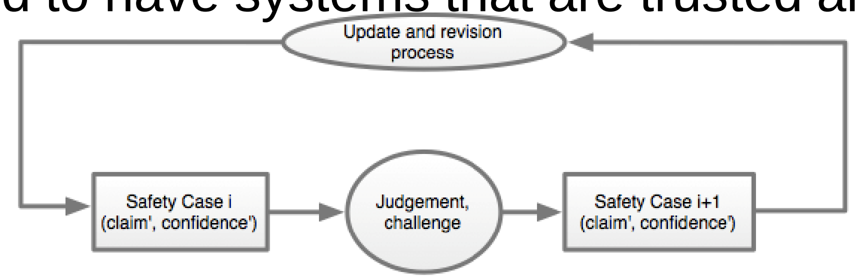
Table 5 – Software Hazard Examples

Hazard	Corresponding Risk(s) to Health	Potential Cause(s)
Data error	Overdose Underdose Incorrect therapy Delay of therapy	Failure to backup Data store/retrieval error Communication problem
Software runtime error	Overdose Underdose Incorrect therapy	Buffer overflow/underflow Null pointer dereference Memory leak Uninitialized variable Incorrect dynamic libraries
System malfunction	Overdose Underdose Delay of therapy Incorrect therapy	Software runtime error Communication error
Corrupted infusion commands	Overdose Underdose Delay of therapy Incorrect therapy	Data store/retrieval error Communication problem
Pump could not be silenced	Overdose	Alarm priority set incorrectly

The importance of narrative
Reaching back – avoiding ppt of ppt dilution

Communication and reasoning

- Structured justification has two roles:
  - Communication is essential, from this we can build confidence and consensus
    - boundary objects that record the shared understanding between the different stakeholders
  - A method for recording our understanding and reasoning about dependability
- Both are required to have systems that are trusted and trustworthy



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Standards and guidelines

- IEC/ISO
  - ISO/IEC 15026-2:2011 IS Systems and software assurance - assurance cases
  - IEC 62741 Ed. 1.0 (WD) Reliability of systems, equipment and components, guide to the demonstration of dependability requirements. The dependability case
  - IEC 62853/Ed1: Open Systems Dependability
- OMG Object Management Group
  - Structured Assurance Case Meta-Model (SACM)
  - RFI on Machine-checkable Assurance Case Language (MACL)
- Opengroup
  - Real-Time and Embedded Systems: Dependability through Assuredness Framework

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Strength or confidence in an "argument"

- How do we describe how confident we are or need to be?
  - Linguistic, probabilistic, implicit
- How do we aggregate doubts/confidence into the overall judgment in a way that is conservative but useful?
  - Bayesian frameworks (BBNs) not feasible, look for conservative, rigorous yet useful approaches. Chain of confidence.
- Can we build confidence by addressing inherent sources of doubt in the informal notations?
  - Development of CAE Blocks
  - Interplay of deductive and inductive

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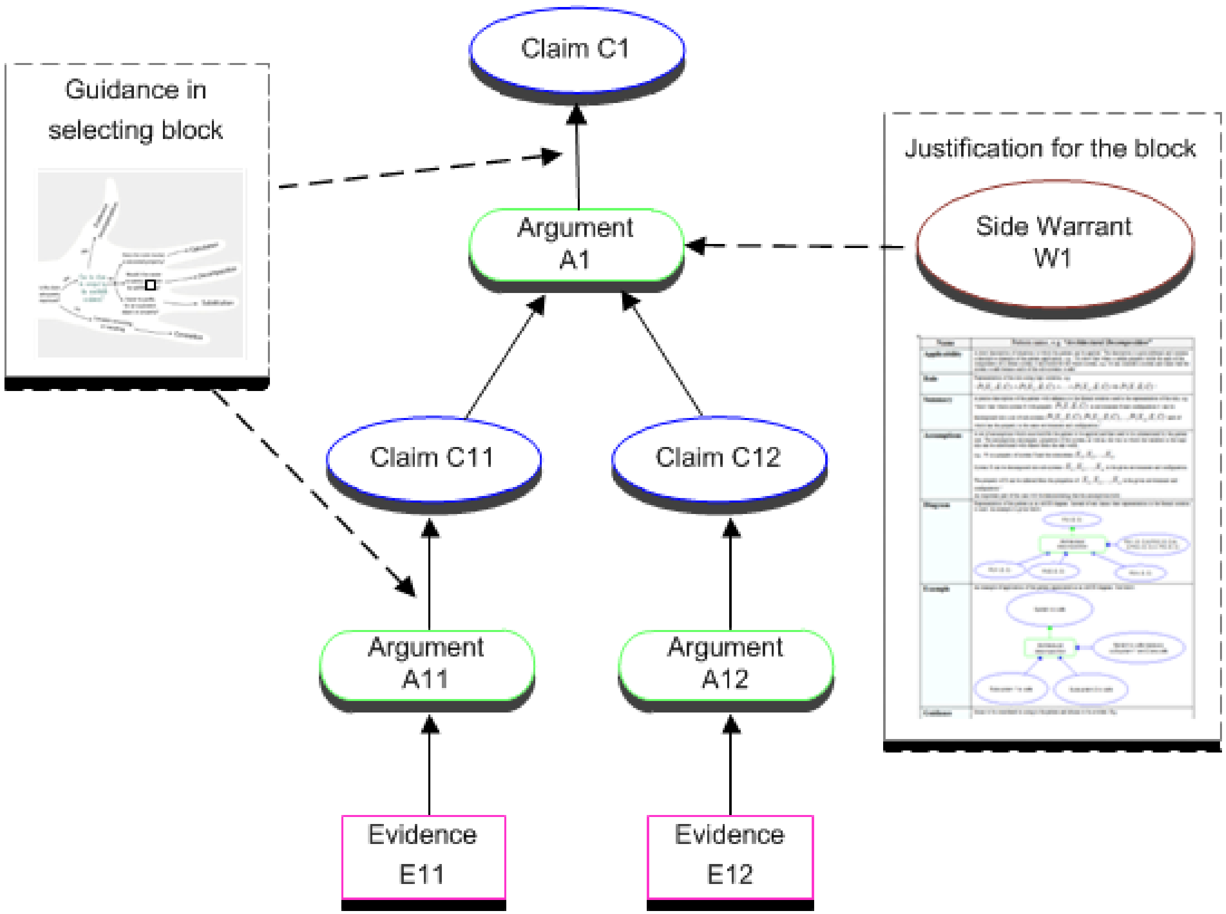
Development of the Blocks approach



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5 Building Blocks

- **Decomposition**
  Partition some aspect of the claim
- **Substitution**
  Refine a claim about an object into claim about an equivalent object
- **Evidence incorporation**
  Evidence supports the claim
- **Concretion**
  Some aspect of the claim is given a more precise definition
- **Calculation or proof**
  Some value of the claim can be computed or proved

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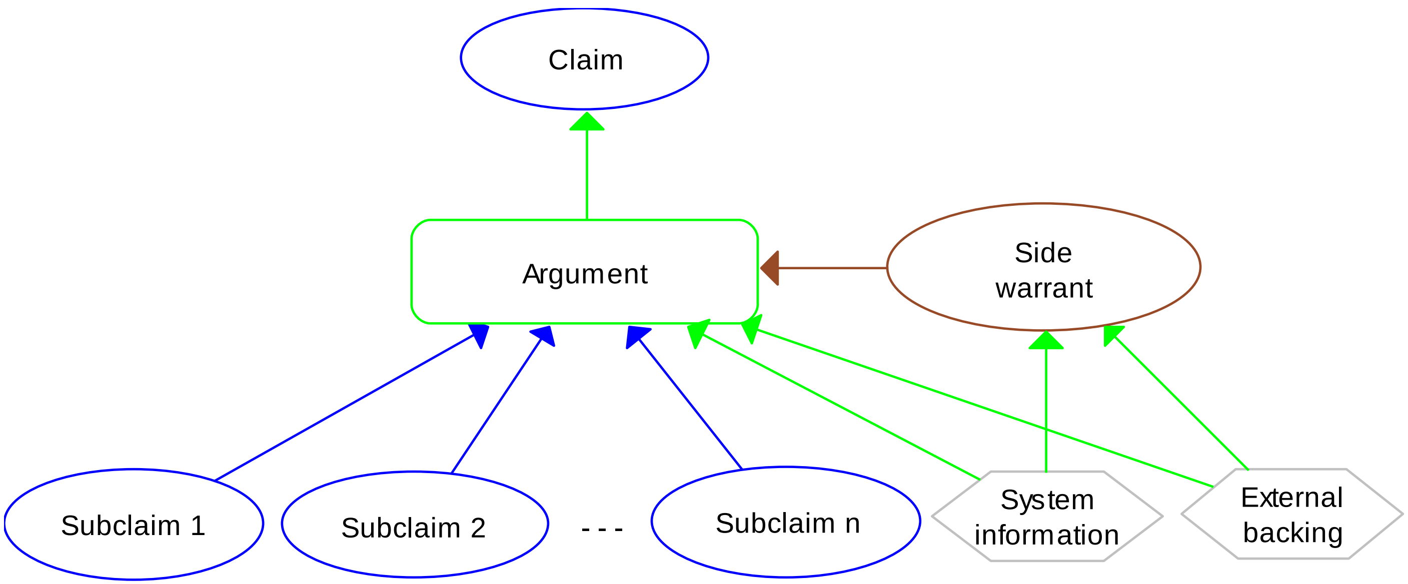
General structure of the block

CAE blocks are a series of archetypal argument fragments. They are based on the CAE normal form with further simplification and enhancements.

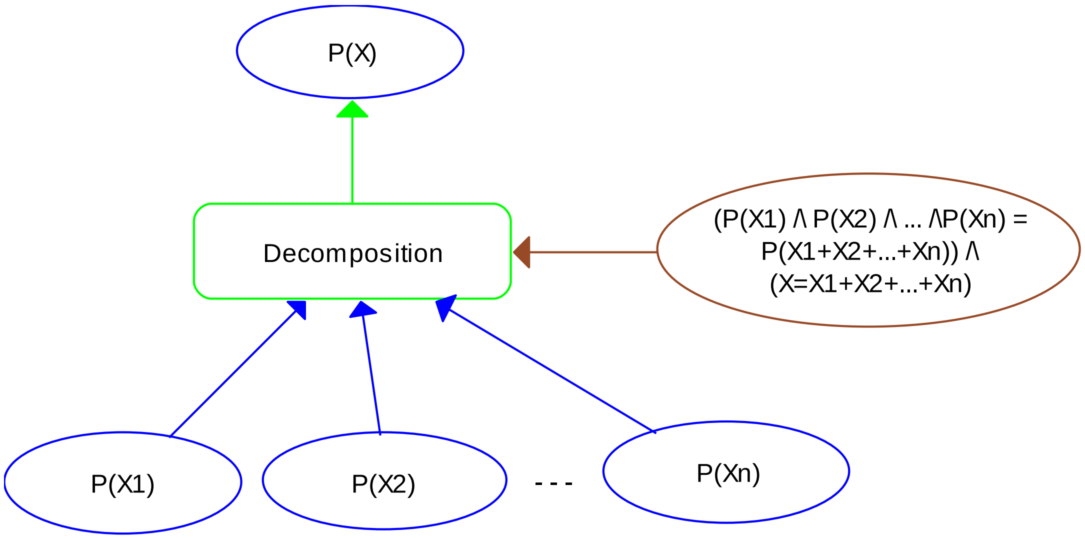


General block structure

Decomposition block

This block is used to claim that a conclusion about the whole object, process, property or function can be deduced from the claims or facts about constituent parts.

$$P_1(X_1)\wedge P_2(X_2)\wedge \ldots \wedge P_i(X_n) \Rightarrow P(X)$$



Example of a single object decomposition

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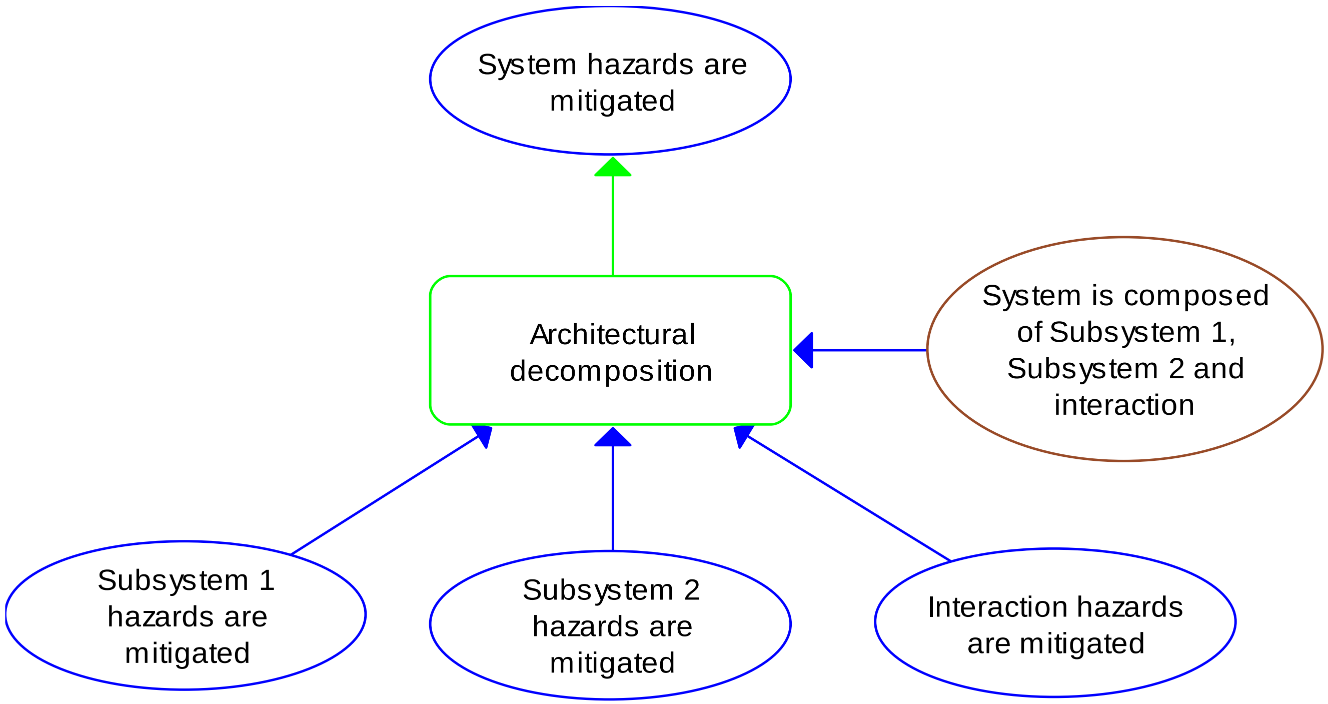
Examples of single decomposition



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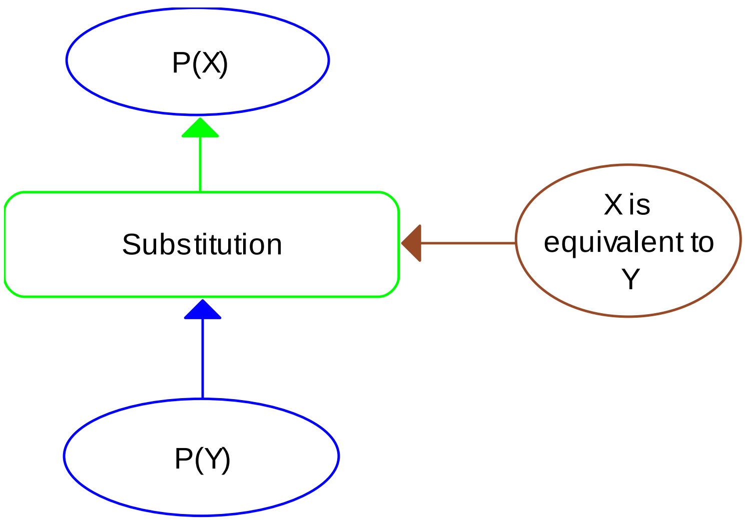
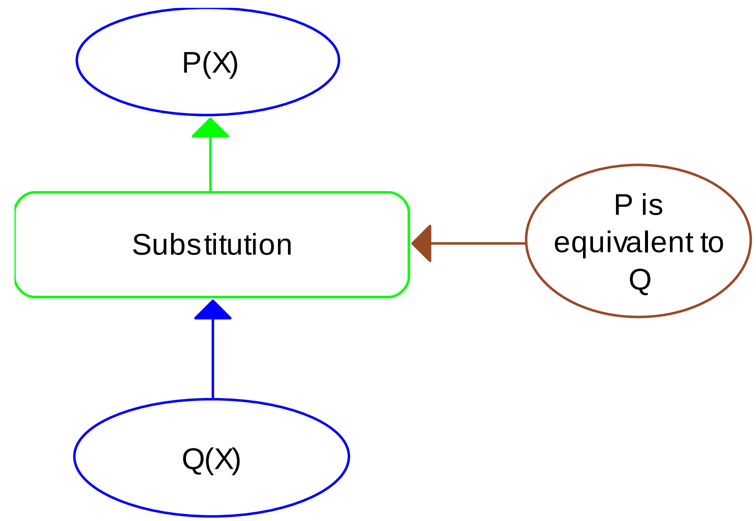
Substitution block

This block is used to claim that if a property holds for one object, then it holds for an equivalent object. The nature of this ‘equivalence’ will vary with the object and property and will need to be defined.



Object substitution



Property substitution

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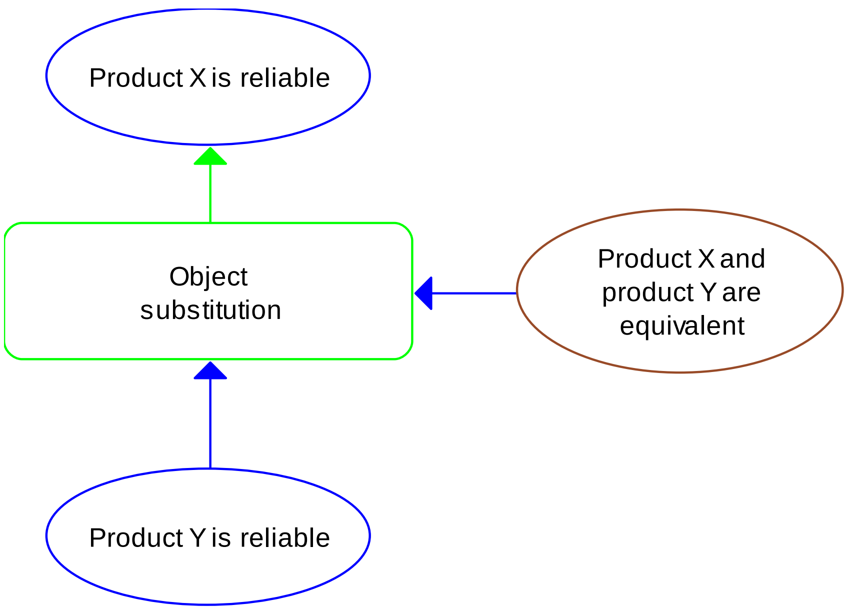
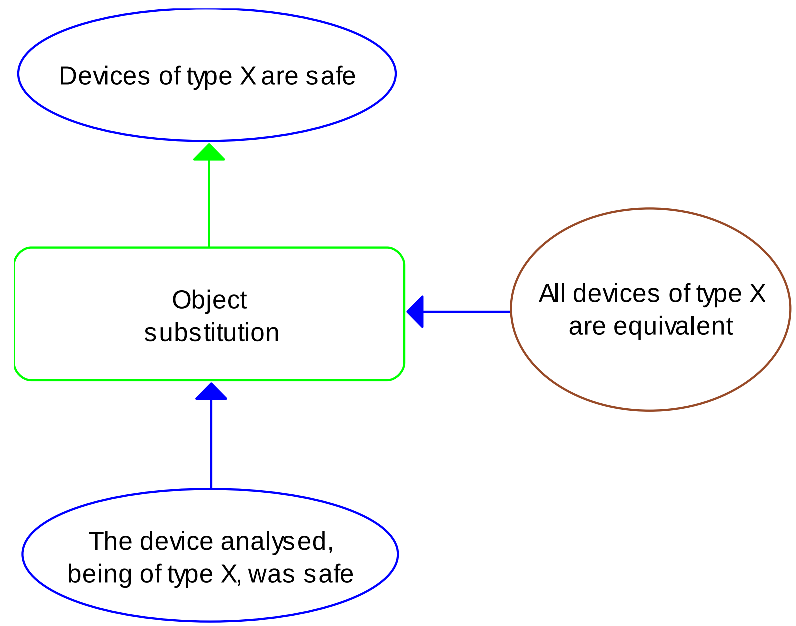
Examples of substitution



Product substitution

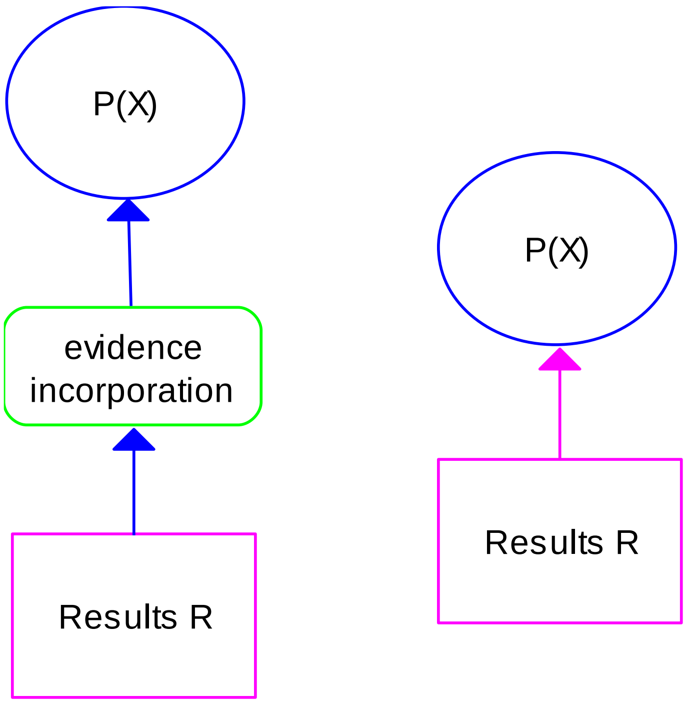


Generalised: product type substitution

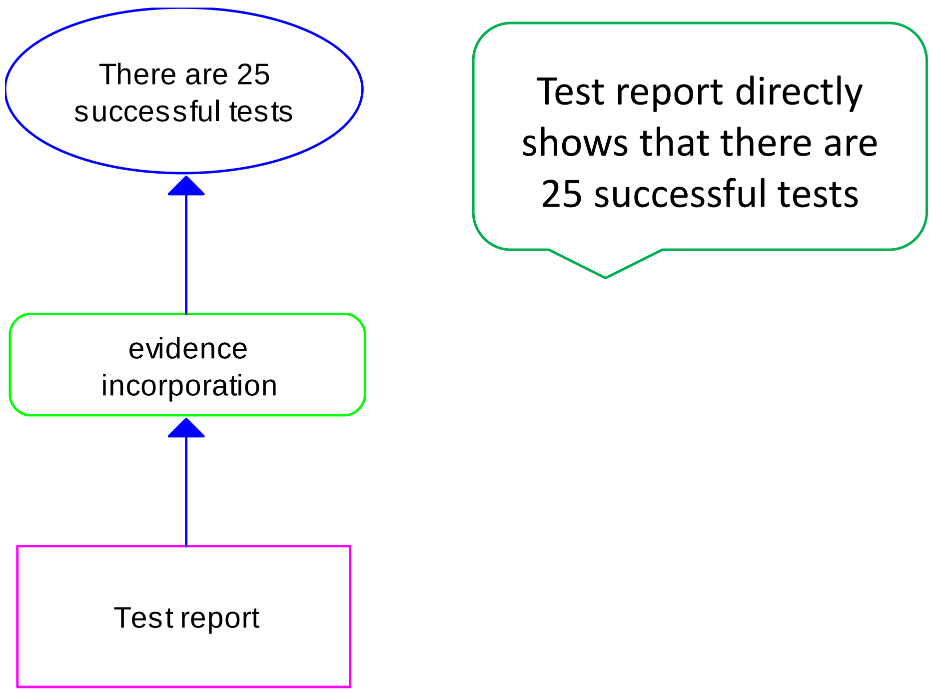
Evidence incorporation

This block is used to incorporate evidence elements into the case.

A typical application of this block is at the edge of a case tree where a claim is shown to be directly satisfied by its supporting evidence.

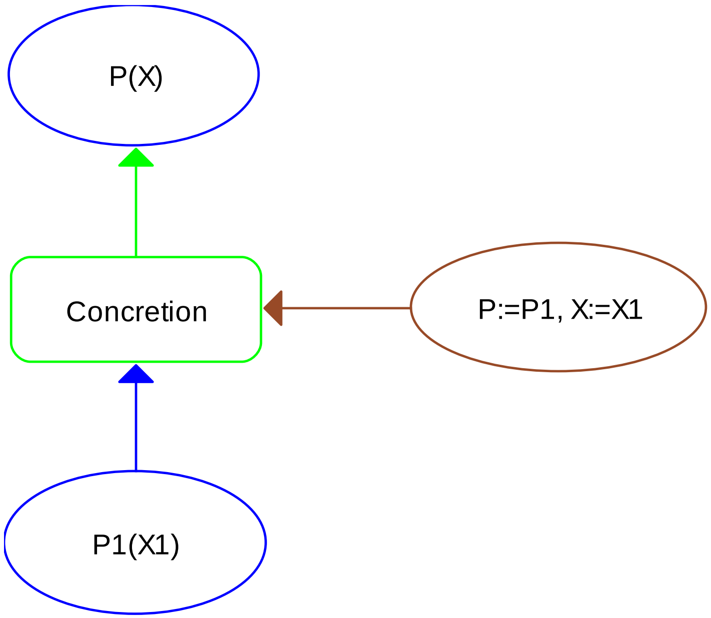


Example of evidence incorporation

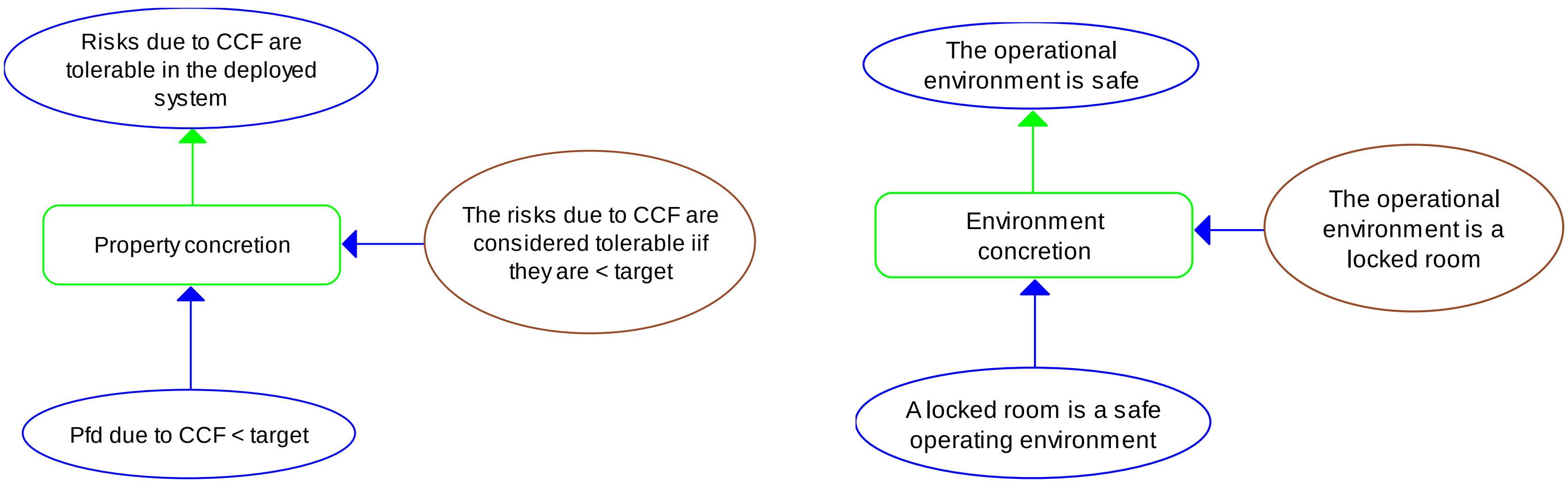


Concretion

This block is used when a claim needs to be given a more precise definition or interpretation. The top claim *P(X, Cn, En)* can be replaced with a more precise or defined claim *P1(X1, Cn, En)*



Example of concretion

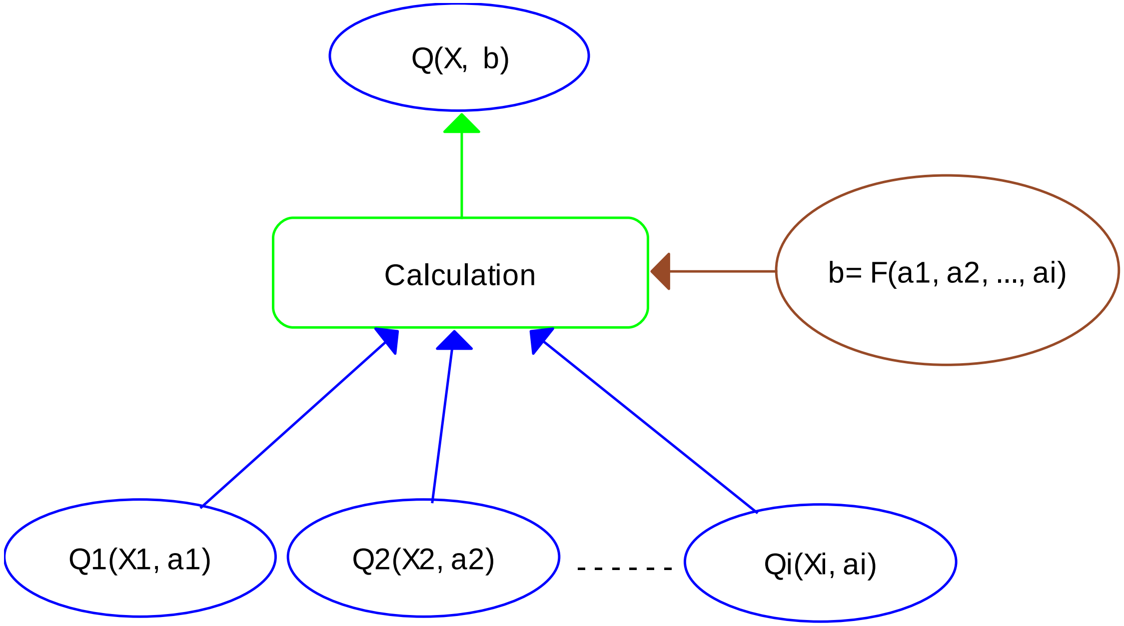


Property concretion

Environment concretion

Calculation

This block is used to claim that the value of a property of a system can be computed from the values of related properties of other objects. Show that the value *b* of property *P(X, b, E, C)* of system *X* in env *E* and conf *C* can be calculated from values $Q_1(X_1, a_1, E, C), Q_2(X_2, a_2, E, C), \ldots, Q_n(X_n, a_n, E, C)$



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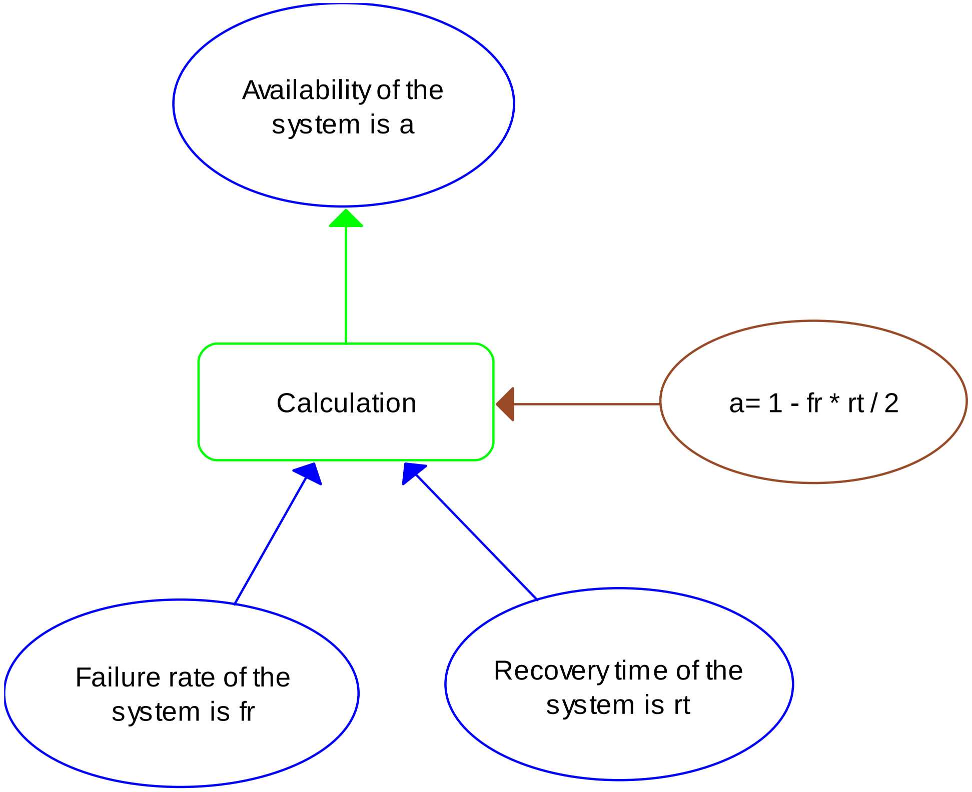
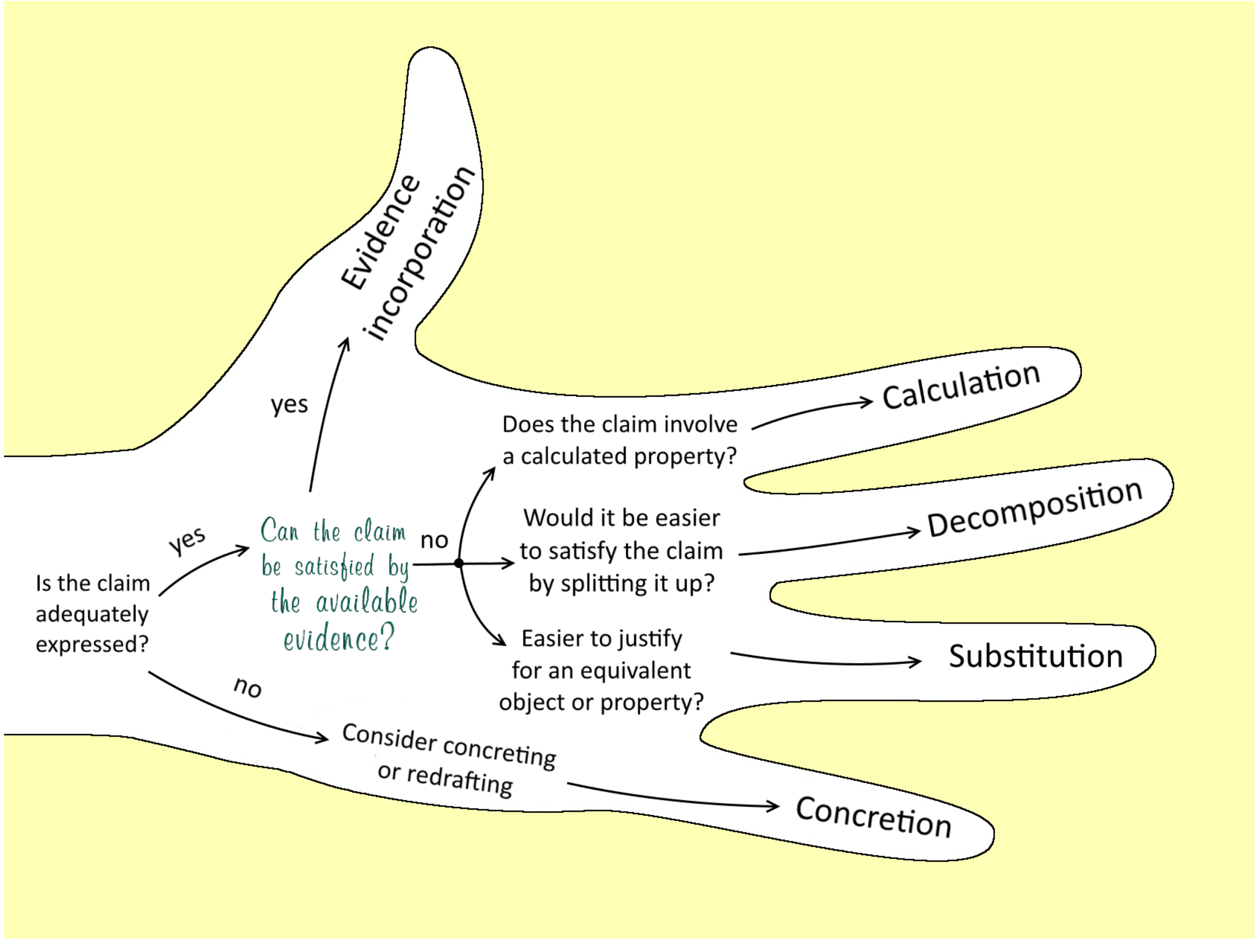
Example of calculation



‘Helping hand’ - guidance on selecting Blocks



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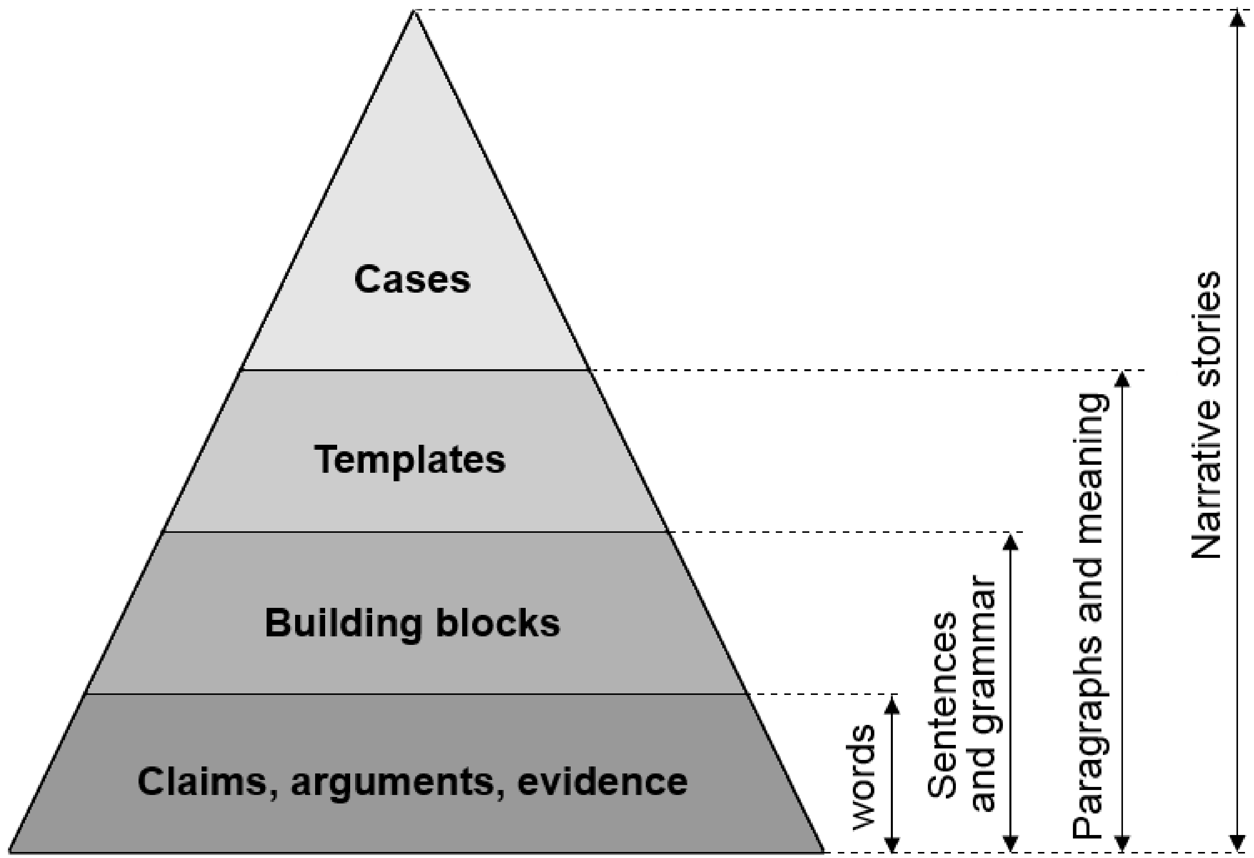
Schematic of the CAE stack



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Fragments

Nordic 32 example

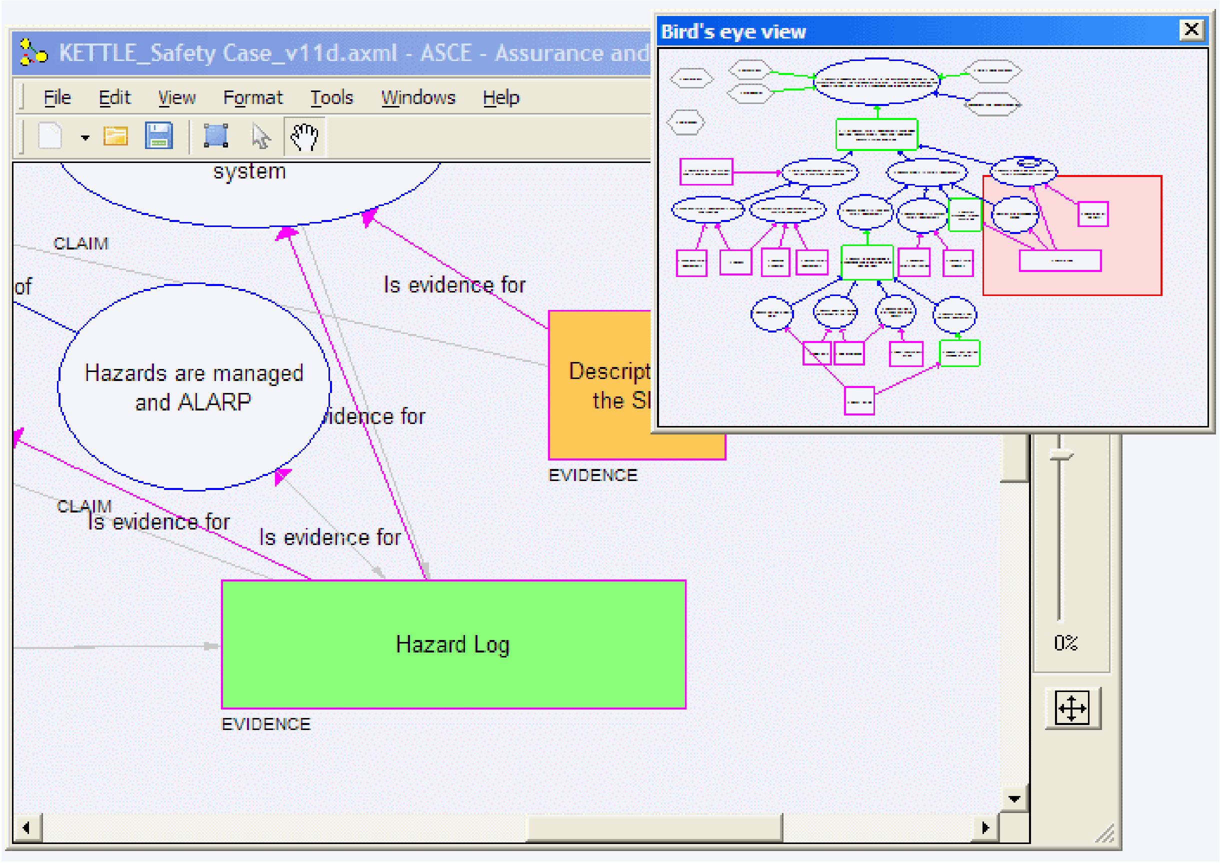
Use of blocks:

1. Concretion
2. Substitution
   - Decompositions
   - Evidence incorporations
3. Decomposition
   - Evidence incorporations

Tool support – ASCE

http://www.adelard.com/asce/choosing-asce/index.html

(free for non-commercial educational use)



Summary

- Claims Argument Evidence
  - Use of terminology
  - Trusted evidence required
- Key roles for Case
  - Communication and reasoning
- Importance of both narrative and graphical structure
- Mature tools, methodology, guidance
- Illustrated some aspects of how deal with confidence
- Keen to learn from this community
  - Methodology and theoretical basis
  - Experience from other application areas
  - Comments and suggestions welcome