IAEA Technical Meeting EVT2300917 on
Deployment of Artificial Intelligence Solutions for the Nuclear Power Industry:
Considerations and Guidance18-21 March 2024
U.S. Nuclear Regulatory Commission Headquarters, Rockville, MD, USA

Some issues in the Assurability of safety-critical digital systems
Part 1 – Assurance and AI

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The views expressed herein are those of the author and do not represent an official position of the U.S. NRC.

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Assurance

- A claim (about **X**) is supported by sound, valid evidence (under the assumptions and conditions identified in **Y**).
- **X** could be a system design or an O&M process.
- **Y** is a set of conditions and assumptions under which the claim holds.
- Assurance is sometimes referenced to a CAE triplet (claim, arguments, evidence)

Artificial Intelligence

A machine-based system that can go beyond defined results and scenarios and has the **ability to emulate human-like** perception, cognition, planning, learning, communication, or physical action (NRC AI Strategic Plan).

Note: Each human-like capability is referenced to some (domain-specific) application.

AI & Assurance

- How can AI be assured?
- How can AI be used for assurance?

Assuring AI

- What are the bounds of application?
  - In nuclear: safety or non-safety, design or O&M?
- Is assurance comparable between humans and AI?
- How will the CAE needed to assure an application differ for AI?
  - Ex) Can non-interference with a safety function be assured?

AI for Assurance

- Can AI facilitate the CAE needed for assurance?
  - Data collection, processing, and analysis to support Evidence generation
  - System modelling to support Argument construction and validation
  - System and domain analysis to ensure a necessary and sufficient set of Claims to support assurance.

Assuring AI for Nuclear Cybersecurity Applications

- Ongoing NRC research exploring the use of AI to characterize nuclear cybersecurity states.
- Issues encountered relevant to assurance of cybersecurity classification models:
  - Data artifacts & joint IT/OT data
  - Model performance measures & coverage of plant states
- Answers can be very application dependent

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Some issues in the Assurability of safety-critical digital systems Part 2 – Knowledge Engineering is on the back burner

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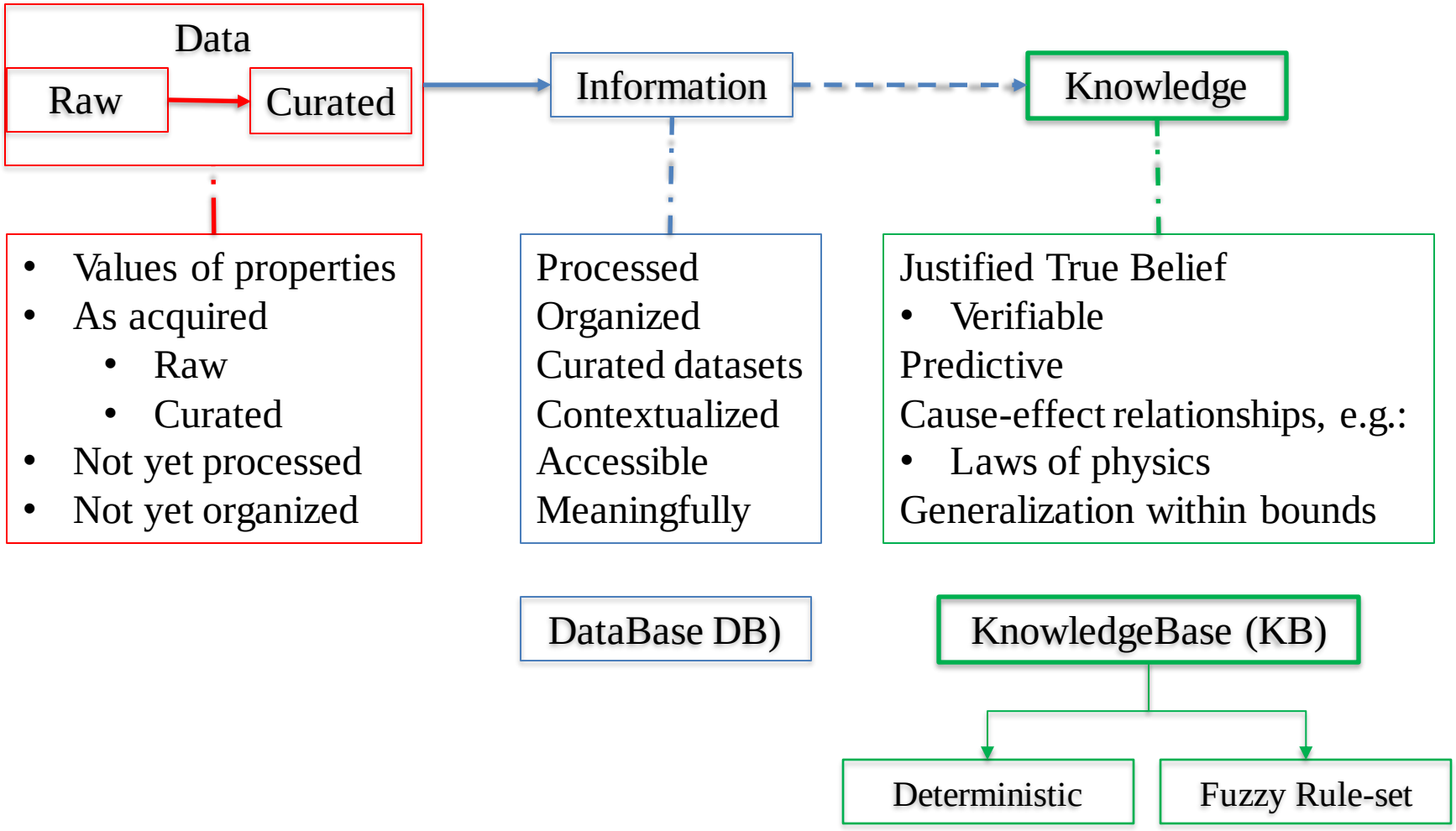
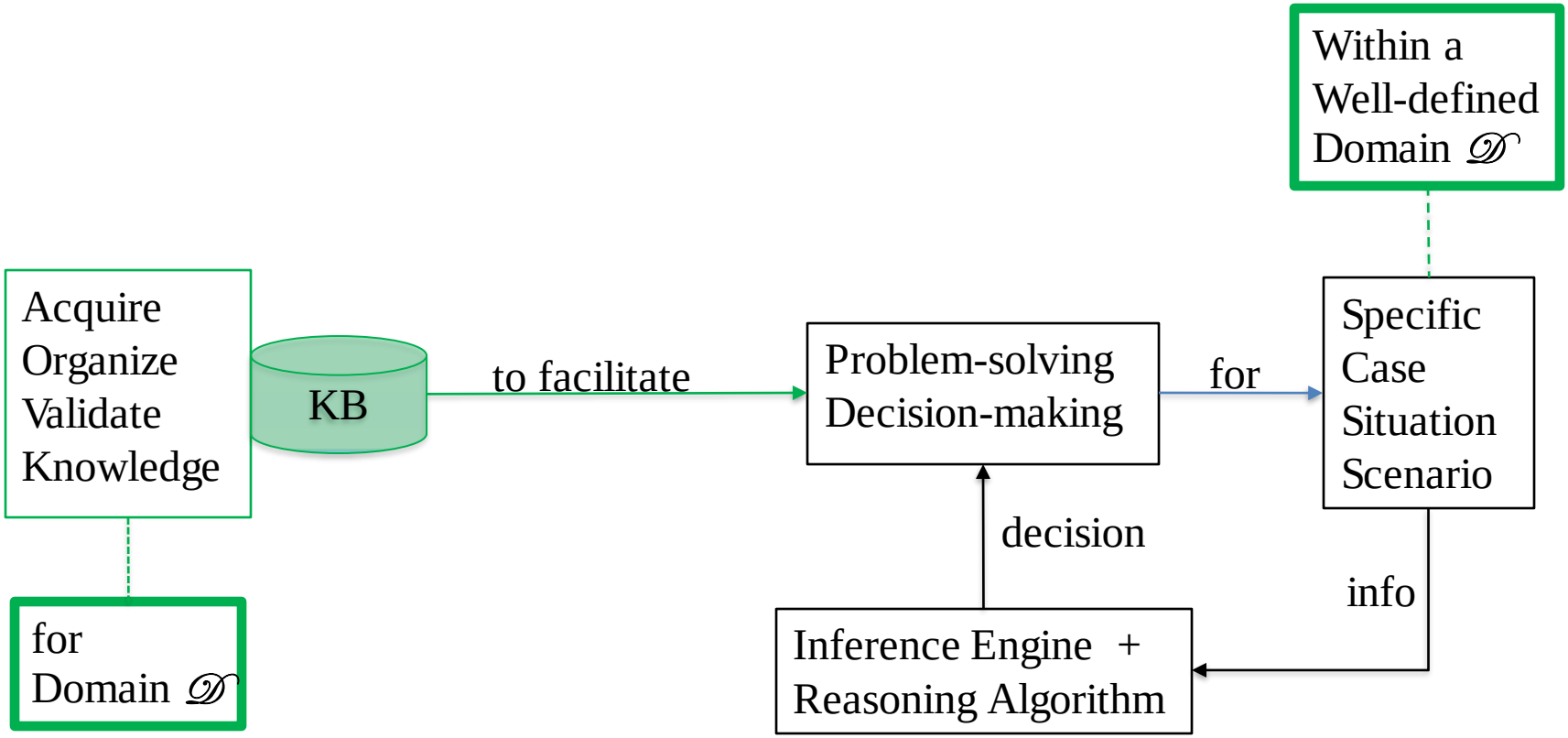
Distinguish between data, information & knowledge



Knowledge Engineering (KE)



Knowledge Representation (KR)

KR: the field of artificial intelligence (AI)
dedicated to representing knowledge about the world
in a form that can be mechanized to solve complex tasks.

Means of KR — example: Ontology

a set of concepts and categories in a subject area or domain that shows their properties and the relations between them

KR formalisms – characteristics of interest:

- Expressivity
- Tractability
- Comprehensiblity
- Usability; Learnability

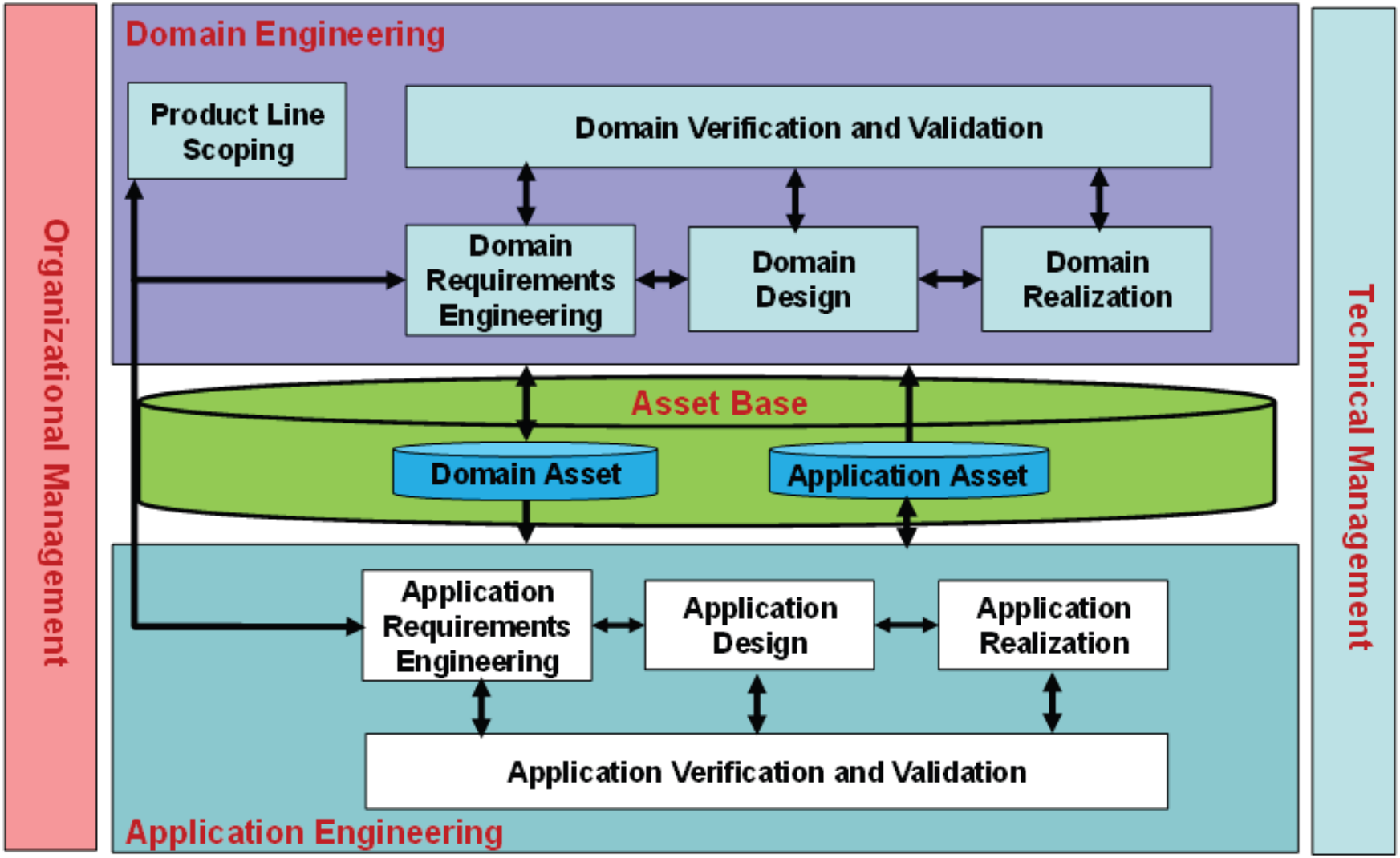
Domain Engineering

Development, evolution, and sustenance of domain specific knowledge and artifacts to support the development and evolution of particular systems in the domain.

Includes engineering of:

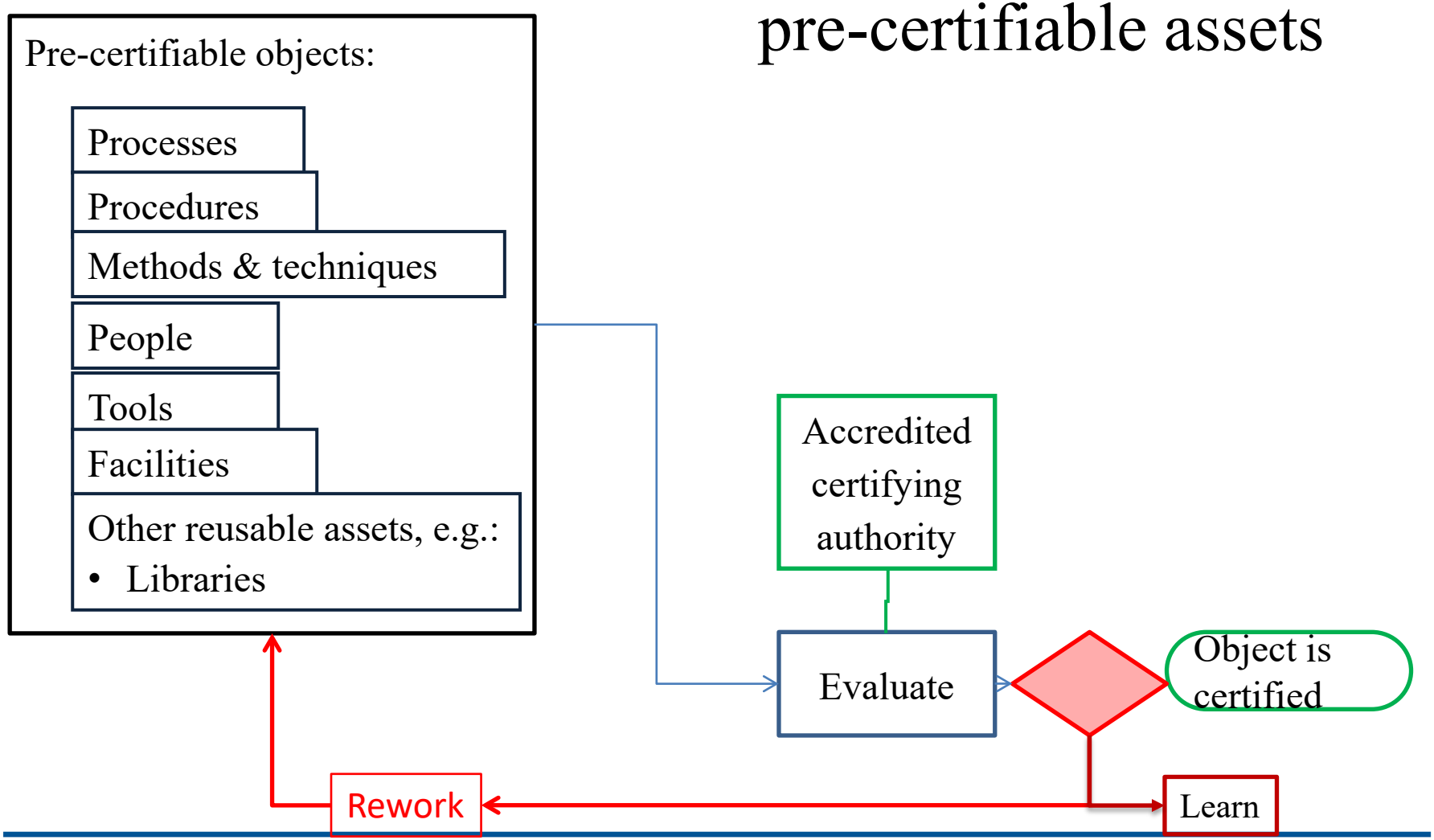
- Domain models
- Components
- Methods
- Tools
- Asset management (possibly)

Reference model

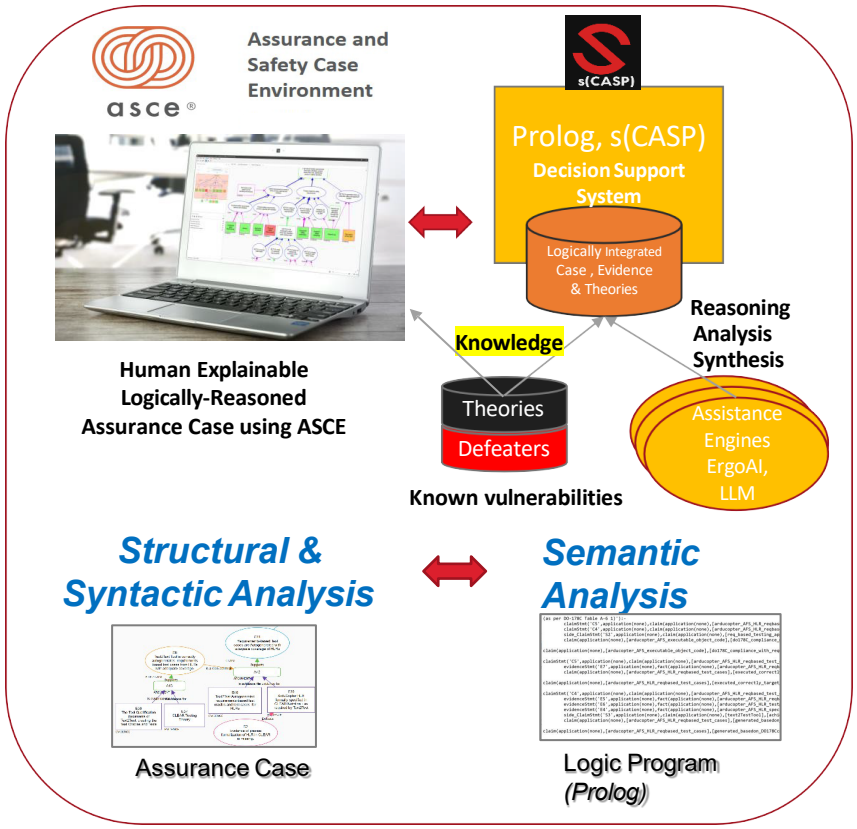


Source: **ISO/IEC 26550:2015(E)**

Domain engineered pre-certifiable assets

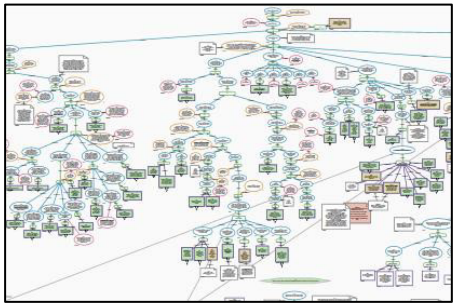


CLARISSA TOOLS



Step 1

Assurance Case to Logic Program



ASCE

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claimStmt('C28',application('C28'),claim(application('C28'),
    evidenceStmt('E36',application('C28'),fact(application('
    evidenceStmt('E33',application('C28'),fact(application('
    evidenceStmt('E35',application('C28'),fact(application('
    evidenceStmt('E37',application('C28'),fact(application('
    evidenceStmt('E34',application('C28'),fact(application('
    evidenceStmt('E38',application('C28'),fact(application('
    claim(application('C28'),[tim,tim_driver_license,tim_car
    theory('C14',application('C28'),claim(application('C28'),

claim(application('C28'),[tim,tim_driver_license,tim_car,saf

evidenceStmt('E36',application('C28'),fact(application('C28'
    fact(application('C28'),[tim_driver_license],[valid],[us

fact(application('C28'),[tim_driver_license],[valid],[us]).

evidenceStmt('E33',application('C28'),fact(application('C28'
    fact(application('C28'),[tim,tim],[testimonials_of_good_
```

s(CASP)

Query:

?- claimStmt(C28,application(C28),claim(application(
[tim,tim_driver_license,tim_car,safe_driving_factor_list],[
theory. Tim is a safe driver in the US).

Answer:

yes

Model:

{ claimStmt(C28,application(C28),claim(application(C28)
[tim,tim_driver_license,tim_car,safe_driving_factor_list],[
theory. Tim is a safe driver in the US),

Semantic Reasoning

Step 2

Source: CLARISSA team presentation at ARCOS meeting, Niskayuna NY March 12, 2024

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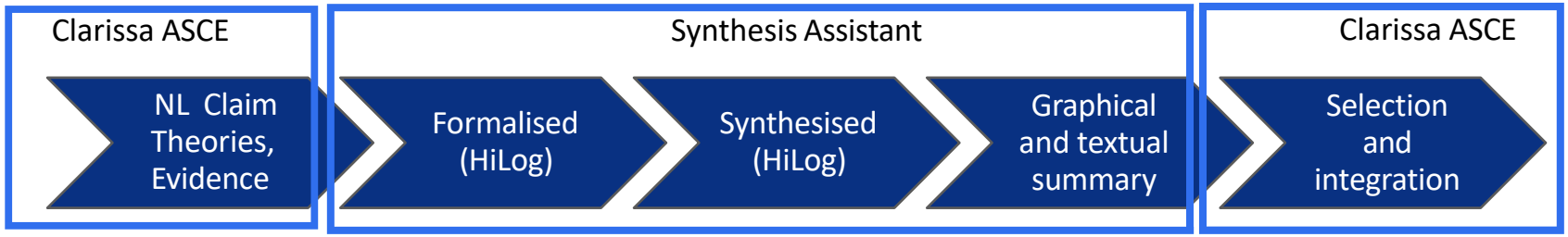
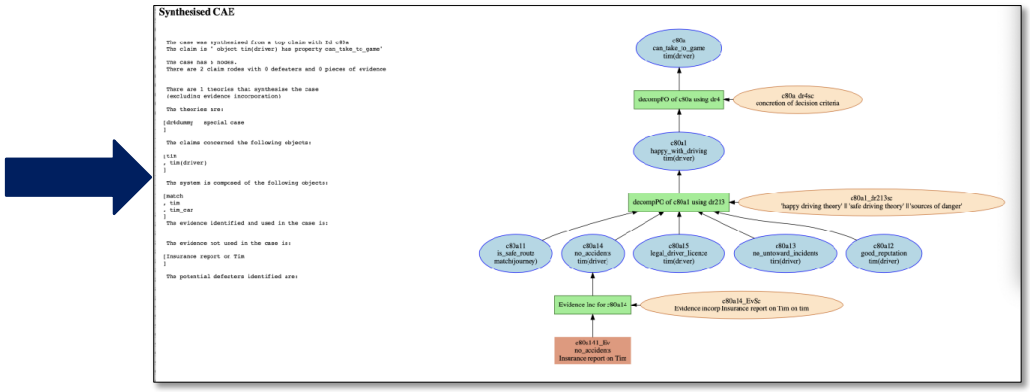
ASSURANCE CASE SYNTHESIS

Synthesis Assistant is a research tool designed to synthesize claims, arguments and evidence structures from a root or top-level claim.



- Given:
  - Top-level claim (defined in ErgoAI or node imported from an ASCE file)
  - Definition of the system structure
  - Possible defeaters
  - Theories used to develop the case
  - Evidences for the case



Source: CLARISSA team presentation at ARCOS meeting, Niskayuna NY March 12, 2024

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Supporting information

ISO/IEC 26550 family of standards

ISO/IEC 26550:2015(E)
Software and systems engineering — Reference model for product line engineering and management

ISO/IEC 26551:2016(E)
Tools and methods for product line requirements engineering

ISO/IEC 26552:2019(E)
Tools and methods for product line architecture design

ISO/IEC 26553:2018(E)
Processes and capabilities of methods and tools for domain realization and application realization

ISO/IEC 26554:2018(E)
Methods and tools for domain testing and application testing

ISO/IEC 26555:2015
Tools and methods for technical management

ISO/IEC 26556:2018(E)
Tools and methods for organizational management

ISO/IEC 26550 family of standards

ISO/IEC 26557:2016(E)
Methods and tools for variability mechanisms

ISO/IEC 26558:2017(E)
Methods and tools for variability modeling

ISO/IEC 26559:2017(E)
Methods and tools for variability traceability

ISO/IEC 26560:2019(E)
Methods and tools for product management

ISO/IEC 26561:2019(E)
Methods and tools for technical probe

ISO/IEC 26562:2019(E)
Processes and capabilities of methods and tools for transition management

ISO/IEC 26563:2022(E)
Processes and capabilities of methods and tools for configuration management of assets

ISO/IEC 26564: 2022(E)
Methods and tools for product line measurement

ISO/IEC 26550 family of standards

ISO/IEC 26850:2021(E)
Methods and tools for the feature-based approach to software and systems product line engineering

ISO/IEC 26565 to ISO/IEC 26599: To be developed