



HELICOPTERS

Digitalisation of Certification

Regulation Ontology and Inference Engine

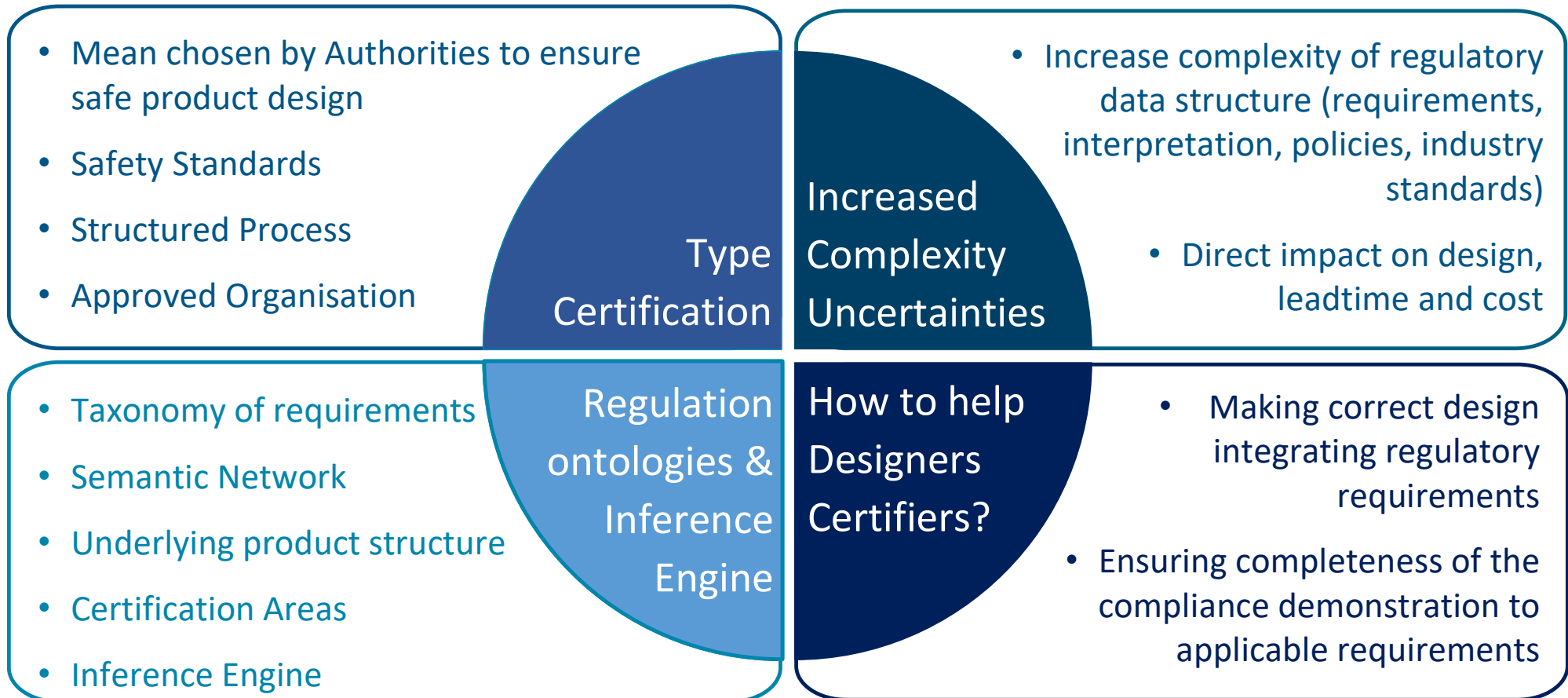
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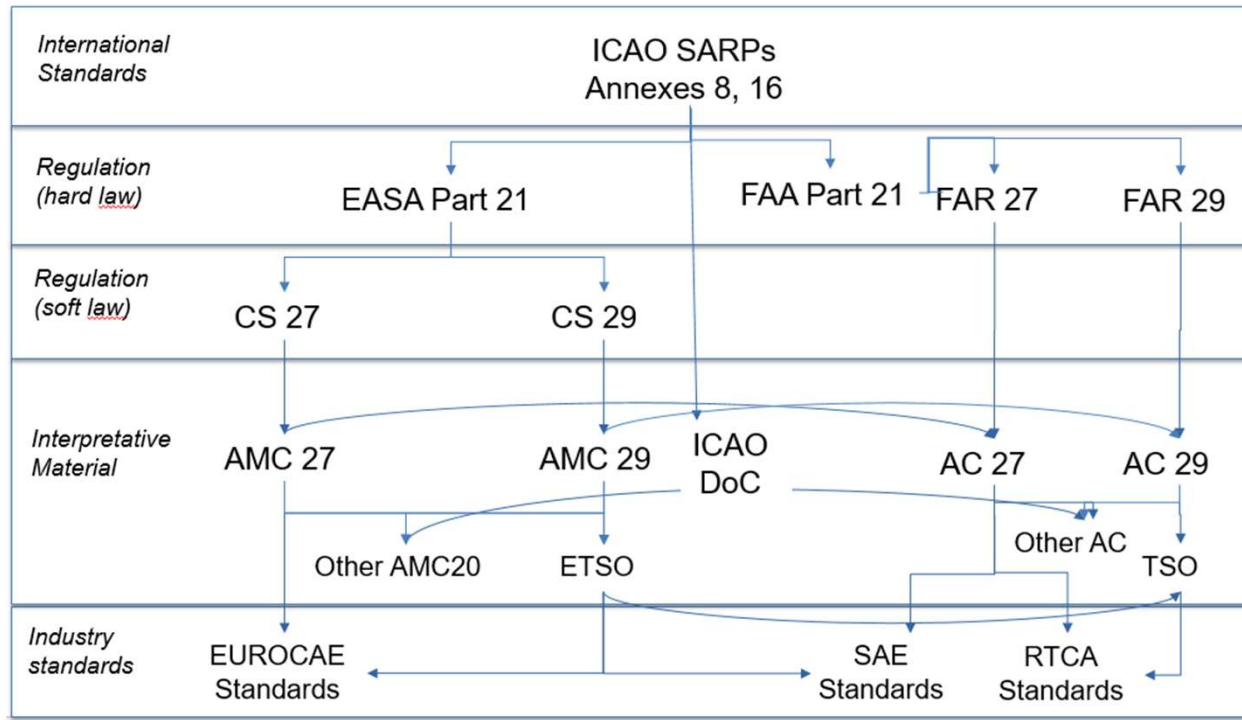
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Statement of Issue



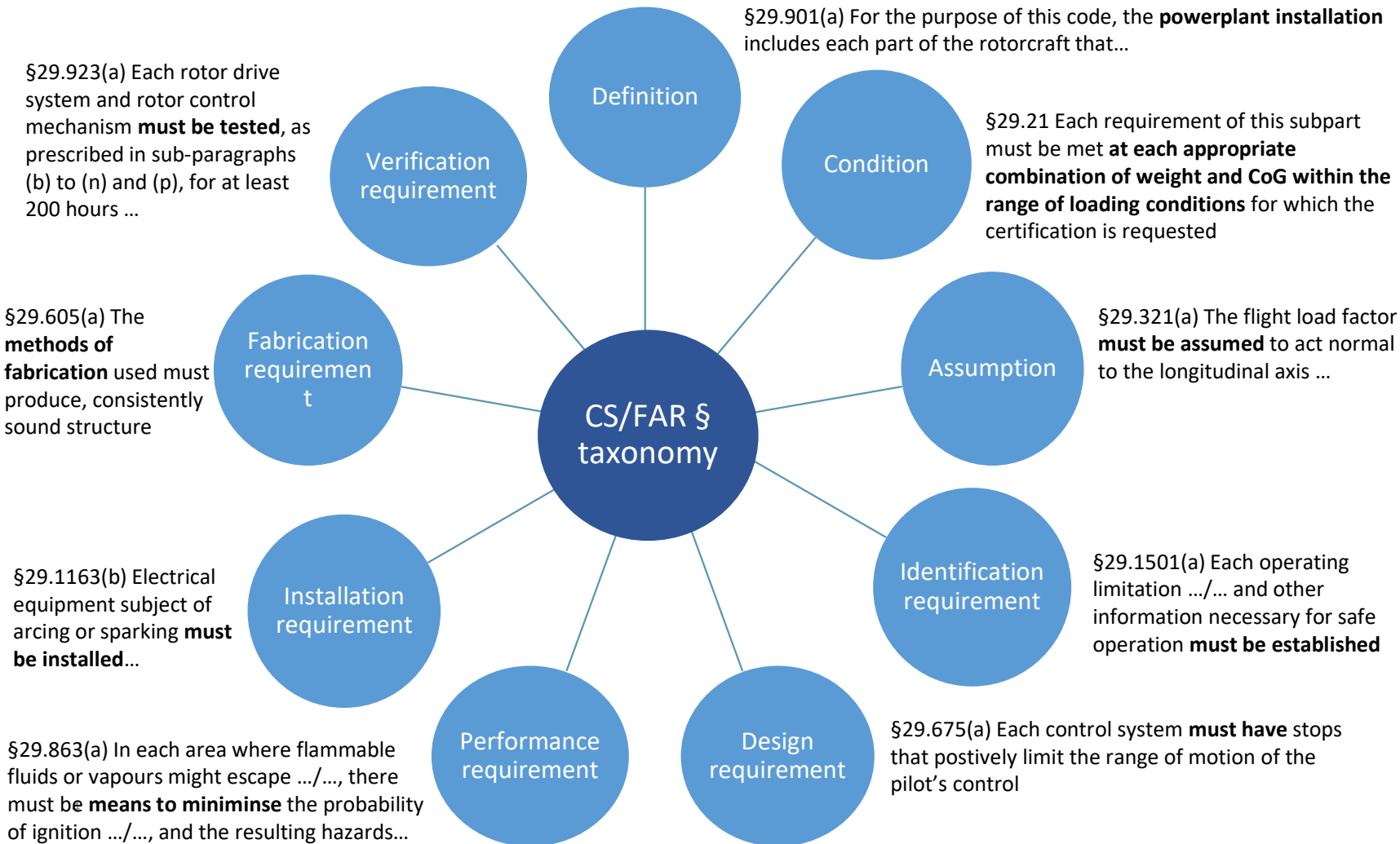
Opening Routes in the Regulatory Jungle



Increasing Complexity

- Long lasting history with contradictory objectives
- Stability of the framework
- Ability to cover innovations while ensuring safety

Opening Routes in the Regulatory Jungle



Wide variety of purpose

- From prescriptive to performance based requirements
- From rotorcraft to part level
- From design to manufacture, operation and maintenance

Opening Routes in the Regulatory Jungle

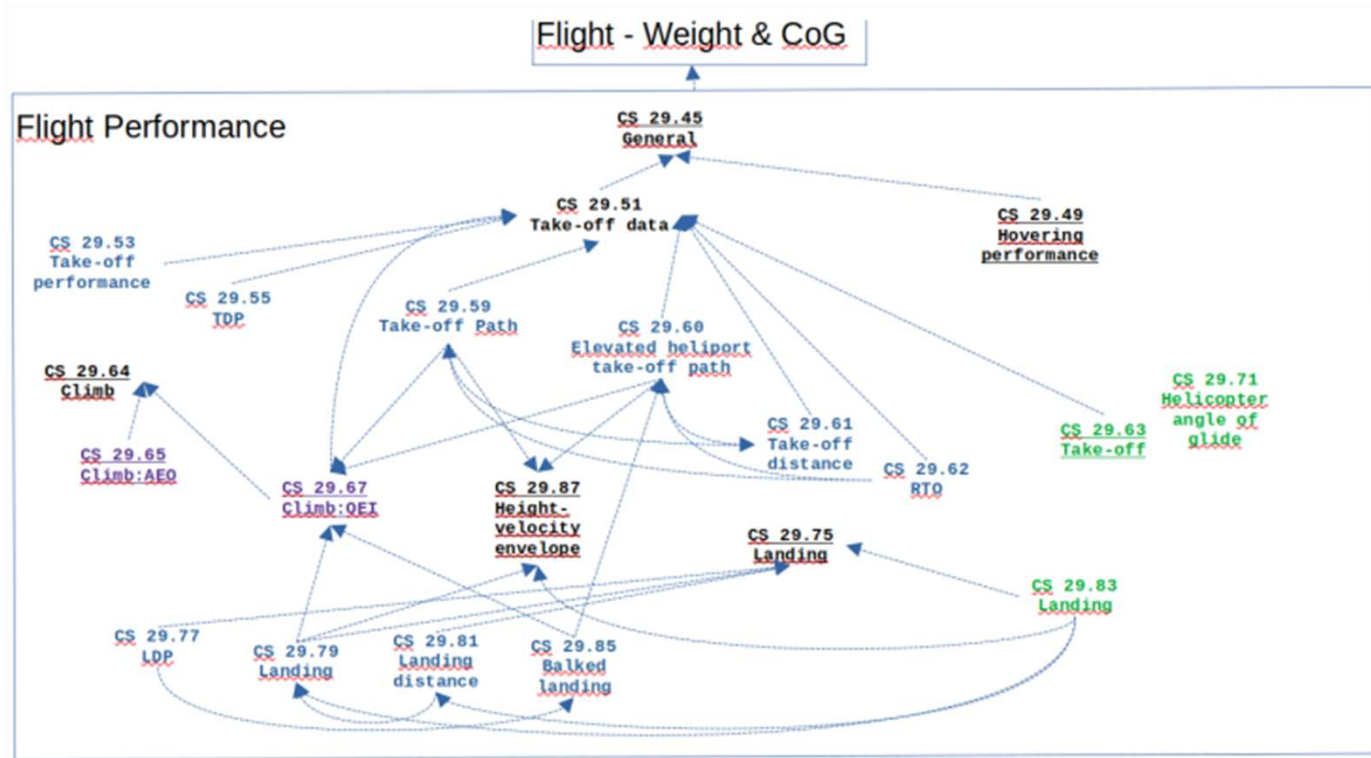


Fig. 3. Flight Performance Requirement Network

A complex semantic

Many requirements linked together with associated:

- definitions (e.g. TDP, T/O distance),
- assumptions (e.g. normal piloting skills),
- conditions (e.g. WAT)
- discriminants (e.g. Category, Weight, Pax)

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Regulation Ontologies and Inference Engine

Rotorcraft

Structure

- Fuselage Structure
- Rotor Pylon Structure
- Auxiliary Lifting Surfaces
- Rotors and Blades
- Control Systems
- Landing Gear
- Floats & Hulls
- Personnel and Cargo
- Accommodations
- Fire Protection
- External Loads
- Miscellaneous

Powerplant

- Engine(s)
- Rotor Drive System(s)
- Fuel System
- Oil System
- Cooling
- Induction System
- Exhaust System
- Controls & Accessories
- Powerplant Fire Protection

Equipment

- Flight and Navigation Instruments
- Powerplant Instruments
- Radio-communication and navigation
- Autopilot
- Flight Director System
- Electrical System
- Lights
- Safety equipment
- Vacuum System
- Hydraulic System
- Protective Breathing Equipment
- Cockpit Voice Recorder
- Flight Data Recorder
- Data link Recorder
- Vibration Health Monitoring System
- Emergency Locator Transmitter
- Ice Protection System

Enabling product

- Operating limitations & Instructions
- Instructions for Continued
- Airworthiness

The underlying generic product

- CS/FAR requirements applicable to an implicit conceptual product
- A generic product breakdown structure over several levels

Regulation Ontologies and Inference Engine

Certification Areas

- Weight & CoG
- Flight Aspects (Performance, Handling Qualities)
- Operation
- Safety Aspects
- Noise
- Fire Protection
- Ice Protection
- Flight Loads / Aerodynamic
- Strength (Static and Fatigue)
- Function & Design
- Materials & Fabrication Methods
- Human Factors Aspects
- Vibration and Dynamic
- **Environmental Conditions**
- Airborne Electronic Hardware Aspects
- Security Protection
- Software Aspects
- Aircrew Information
- Operating Limitations
- Instruction for Continued Airworthiness
- Placards & Markings

Environmental Conditions

- Temperature & Altitude
- Temperature Variations
- Humidity
- Operational Shocks and Crash Safety
- Vibrations
- Explosive Atmosphere
- Waterproofness
- Fluids Susceptibility
- Sand and Dust
- Magnetic Effects
- Power Input
- Voltage Spike
- Audio Frequency Conducted Susceptibility
- Induced Signal Susceptibility
- Radio Frequency Susceptibility (Radiated and Conducted)
- Emission of Radio Frequency Energy
- Lightning Induced Transient Susceptibility
- Lightning Direct Effects
- Icing
- Electrostatic Discharge
- Fire, Flammability

Configuration Parameters

- Certification Basis
- Certification Scope
- Certification Assumptions
- Certification limitations
- Category (Weight / Seats)
- Kinds of Operations
- Flight Crew Composition
- Environmental Conditions
- Engine Type
- Engine Configuration
- External Power Provisions
- Landing Gear Type
- External Loads
- Vibration Health Monitoring

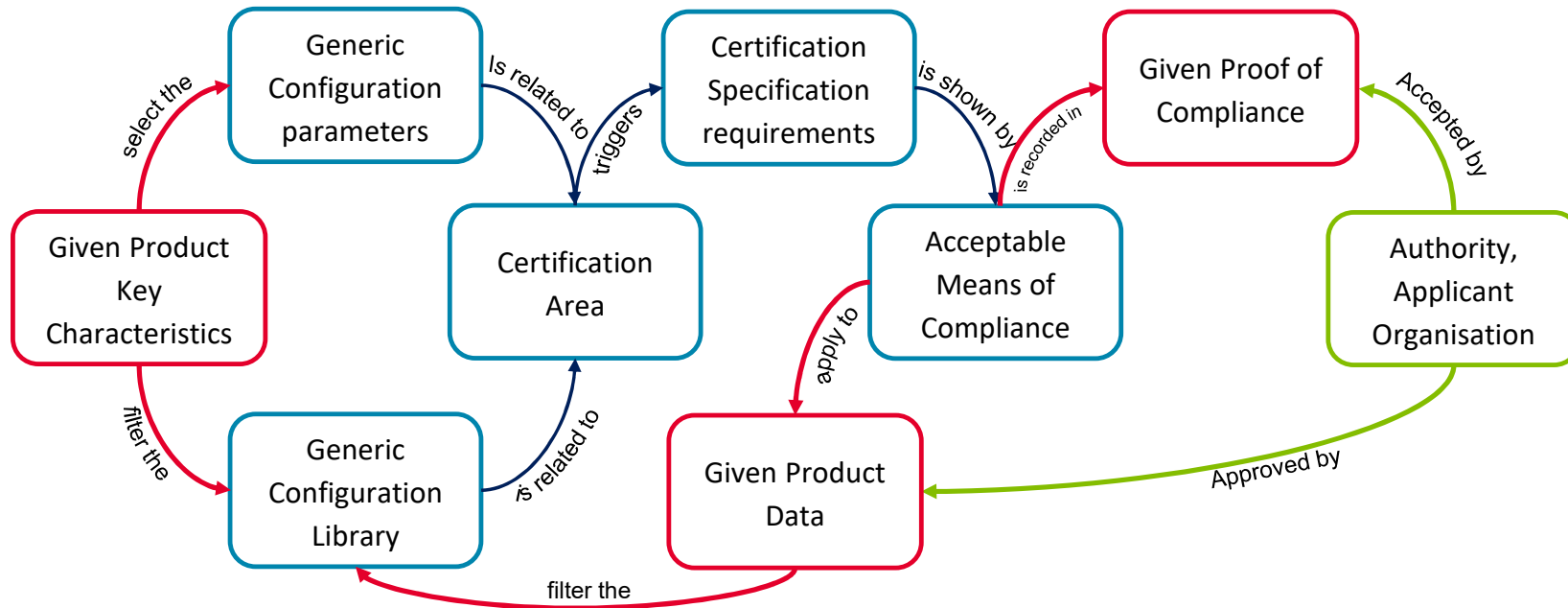
Generic Conditions, Parameters and Areas

Certification Areas:

- Linked to given certification requirements
- Associate to a field of knowledge

Configuration Key Characteristics

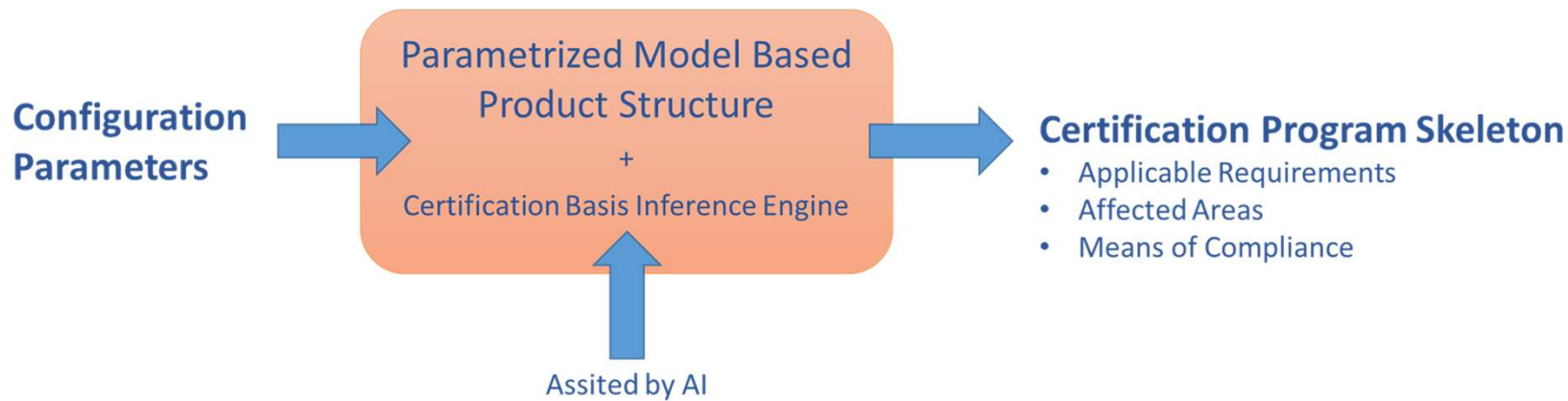
Regulation Ontologies and Inference Engine



Link between concepts

- A close link between **Generic Concept**, **Given Product** and **Organisation**

Regulation Ontologies and Inference Engine

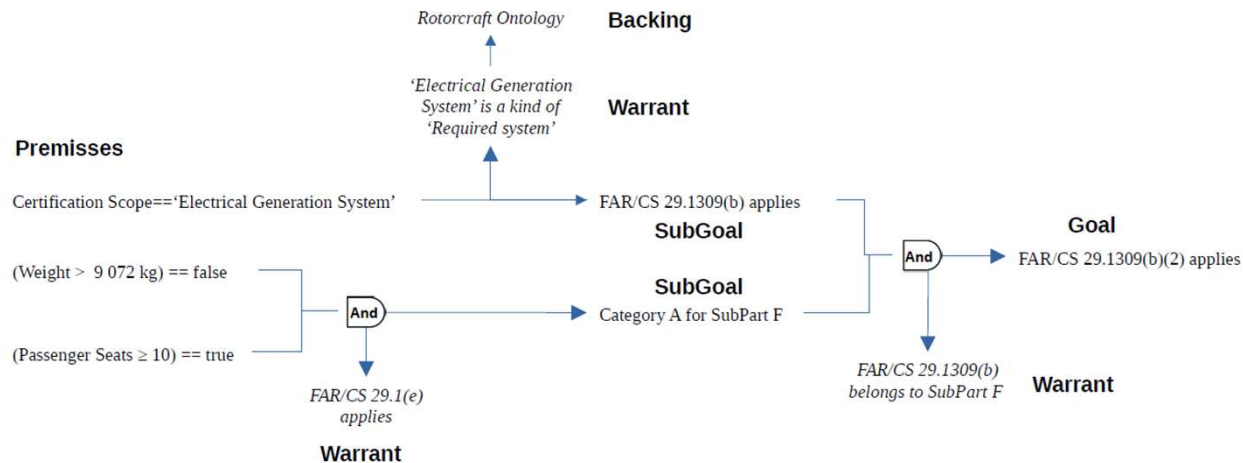


Machine Learning or Logic Knowledge ?

- Needs: Prediction, Traceability
- ML based on statistical model feeded by past data
- Logic Knowledge Inference Engine solving request by unification of rules and knowledge

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Use Case reasoning



```

/* fact base 1: Configuration Parameters */
isConfigurationParameter('Certification Basis', 'CS 29').
isConfigurationParameter('Weight >= 9 072 kg', 'FALSE').
isConfigurationParameter('Passenger Seats >= 10', 'TRUE').
isConfigurationParameter('Certification Scope', 'Electrical Generation System').

/* fact base 2: System Architecture Entities */
/* contains relationships: */
isRotorcraftPart('Electrical Generation System',
  ['Normal Generation', 'Emergency Generation', 'Provisions for External Power']).
/* is-kind-of relationships */
isRotorcraftPartKind('Normal Generation', 'Generating System').
isRotorcraftPartKind('Generating System', 'Required equipment')....

/* rule CS 29.1(e) */
( Weight = 'FALSE', Seats = 'TRUE' ) -> ( CatA = ['C', 'D', 'E', 'F'], CatB = ['B', 'G'] )

/* fact base 3: Certification Specification Items */
isCS29FReq('CS 29', 'F: Equipment', 'CS 29.1309(b) (1)', 'Required equipment', 'B').
isCS29FReq('CS 29', 'F: Equipment', 'CS 29.1309(b) (2)', 'Required equipment', 'A').
  
```

CS 29.1309(b) (2)

Electrical Generation Certification

Success criteria:

- Find §1309(b)(2)
- H160 = Cat A&B Large Rotorcraft
- Electrical Generation System = required equipment

Conclusion, Expected Benefits and Future Work

▪ Conclusion

- *Feasibility to support Certifier/Designer thanks to the creation of a CS/FAR ontology and rules*
- *Selected of the AI-LKB Inference Engine technology adapted to the need (trustworthy prediction of applicable requirements and Means of Compliance)*

▪ Expected Benefits

- *More robust certification inputs to development and reduction of likelihood for unidentified non compliance (and therefore EASA Level of Involvement),*
- *Better efficiency, Time and cost saving, Competence and knowledge capitalization*

▪ Future Work

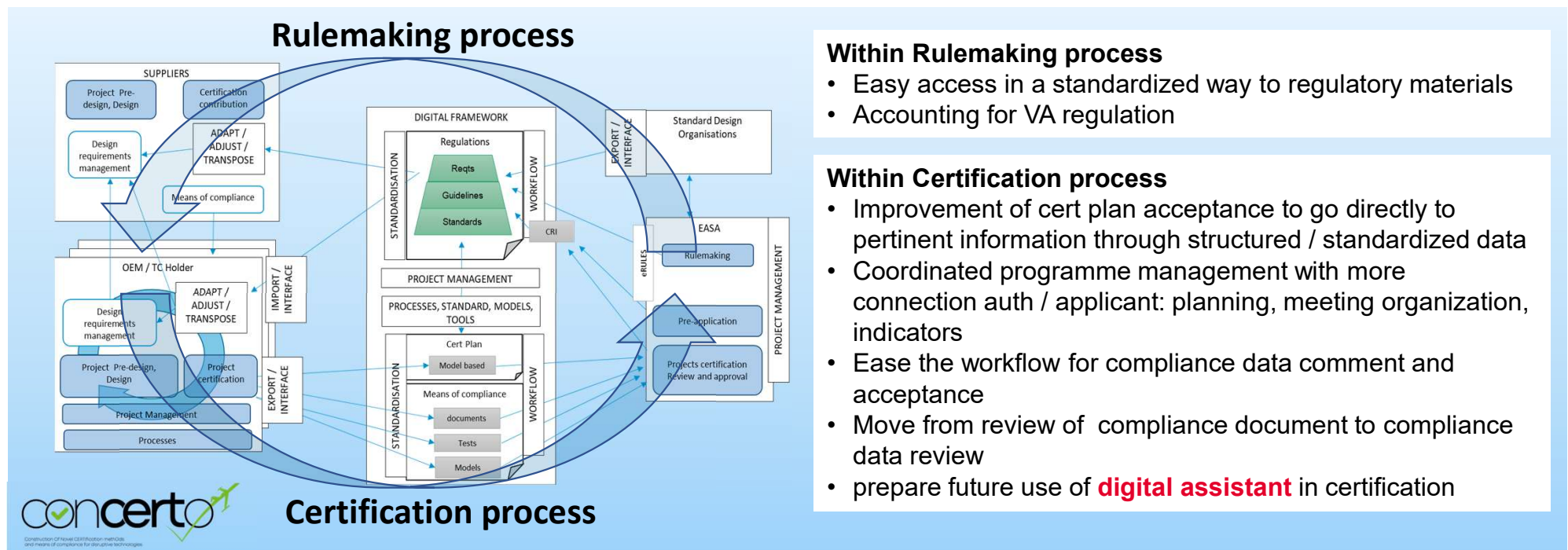
- *Continue developing the ontology classes and inference rules to the complete regulatory material scope (CS, AC/AMC/Standards)*
- *Use Machine Learning to populate and infer ontology instances*
- *Develop a verification strategy to ensure a high level of trustworthy*

Conclusion, Expected Benefits and Future Work

Future Work (cont')

- Integration in tools used for development or certification

➔ **EASA/Industry digital framework project co-financed by EU/Clean Aviation** and involving through the **SAB AG.002** more than 60 participants from 35 companies representing all sectors



Thank you for attention
Questions?