BACKBONE MODELS

SUPPORTING A TOTAL SAFETY ASSESSMENT INSIDE THE AIR TRANSPORT SYSTEM

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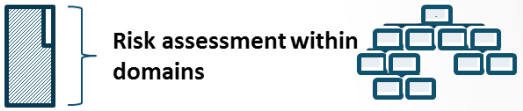
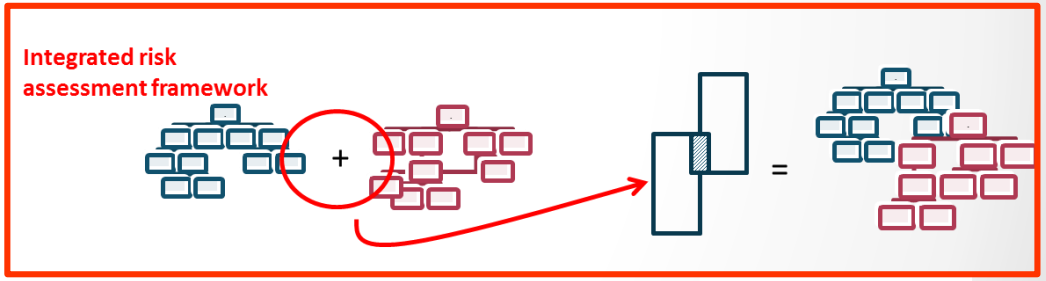
Goals

- Propose means
  - to integrate risk models developed within various domains
  - to perform What-if computation
  - to implement the risk models in the Risk Observatory

Risk observatory requirements



Risk assessment within domains



Prototype Risk Observatory

Total Aviation System Risk Models

- Two-step Modelling Approach
  - 1st step : Backbone model derived from IRP (Eurocontrol) and CATS (NLR) models
  - 2nd step : Risk models developed within domains : ANSP detailed risk model (Eurocontrol), ATM Ground equipment model (Thales), Airborne system models (Thales, Airbus)

- Two risks were selected to validate the modelling approach
  - Runway Excursions (RE), Mid-Air Collisions (MAC),
- Other risks were reviewed, No blocking points were identified
  - Controlled Flight into Terrain (CFIT), Loss of Control in Flight (LOCF), Runway Incursions (RI)
  - *Fire, Smoke & Fumes (FSF)*

Backbone model – 1/4

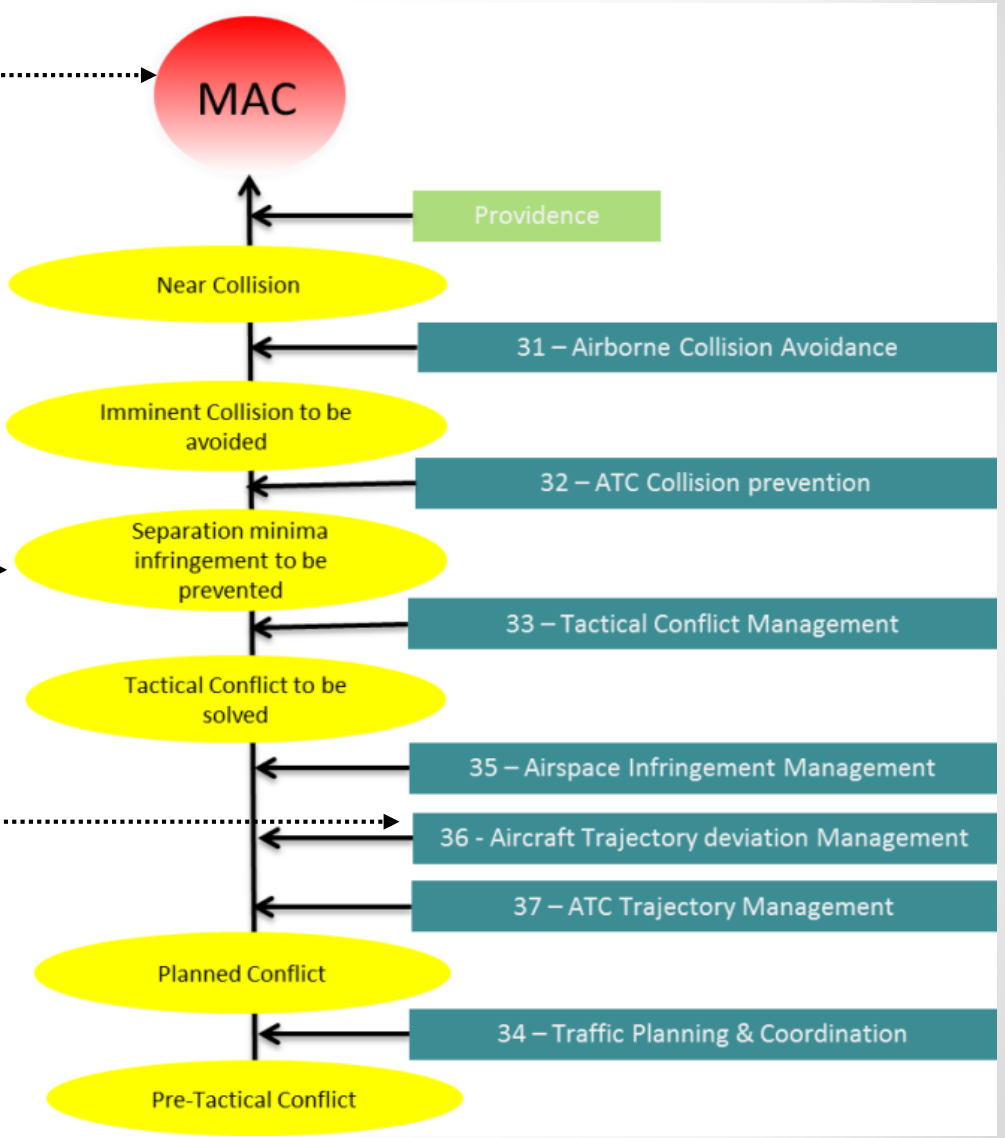
Backbone model - Principle

The backbone model manages in a consistent way **contributors** and **influencing factors** leading to a

Global risk

Precursors Hazardous situations

Barriers Means to **prevent error** and **failure propagation**

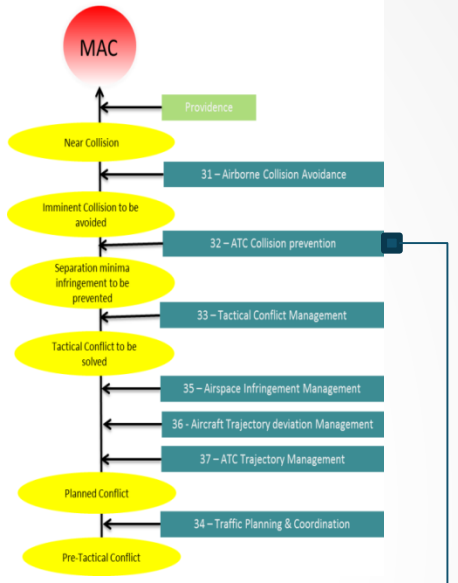


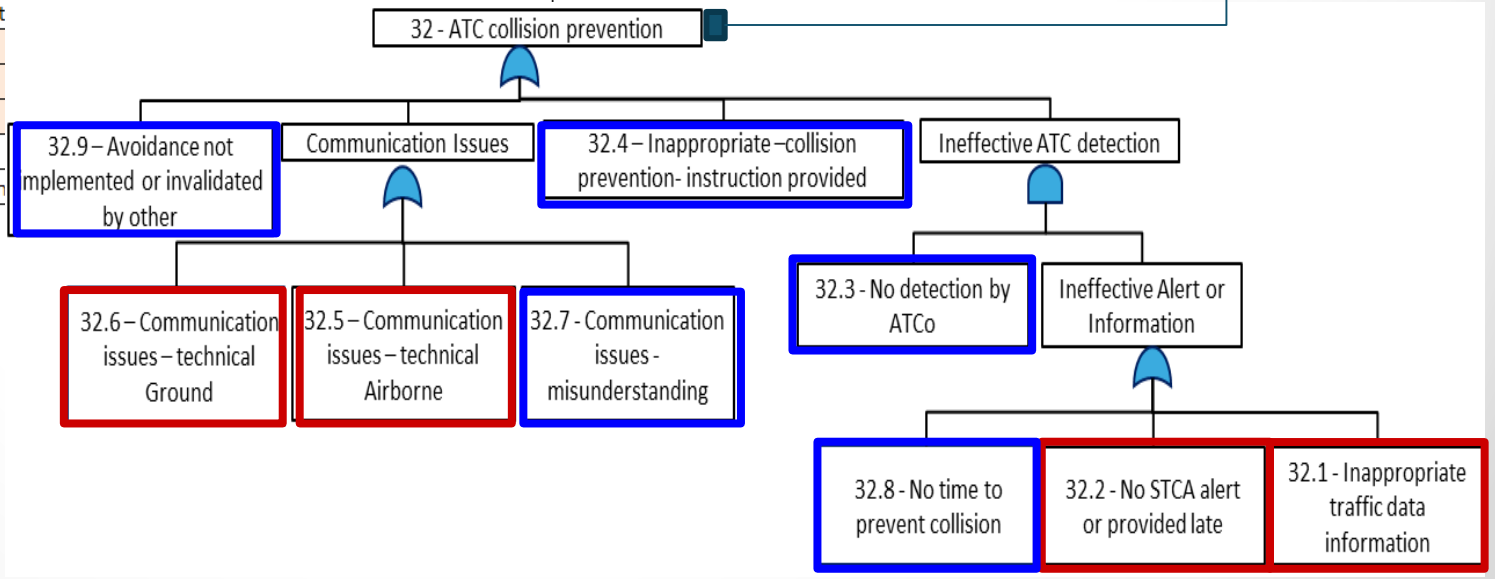
Backbone model – 2/4

Generic Contributing Factors - Elements that contribute to the occurrence of a precursor or a barrier failure

- **Technical factor** (airborne, ground system failure)
- **Human factor** (flight crew, ATCO, ground operator error)

32	ATC collision prevention
32,1	Inappropriate traffic data information
32,2	No STCA alert or provided late
32,3	No detection by ATCo
32,4	Inappropriate (collision prevention) instruct
32,5	Communication issues - technical airborne
32,6	Communication issues - technical ground
32,7	Communication issues - misunderstanding
32,8	No time to prevent collision
32,9	Avoidance invalidated by other aircraft man

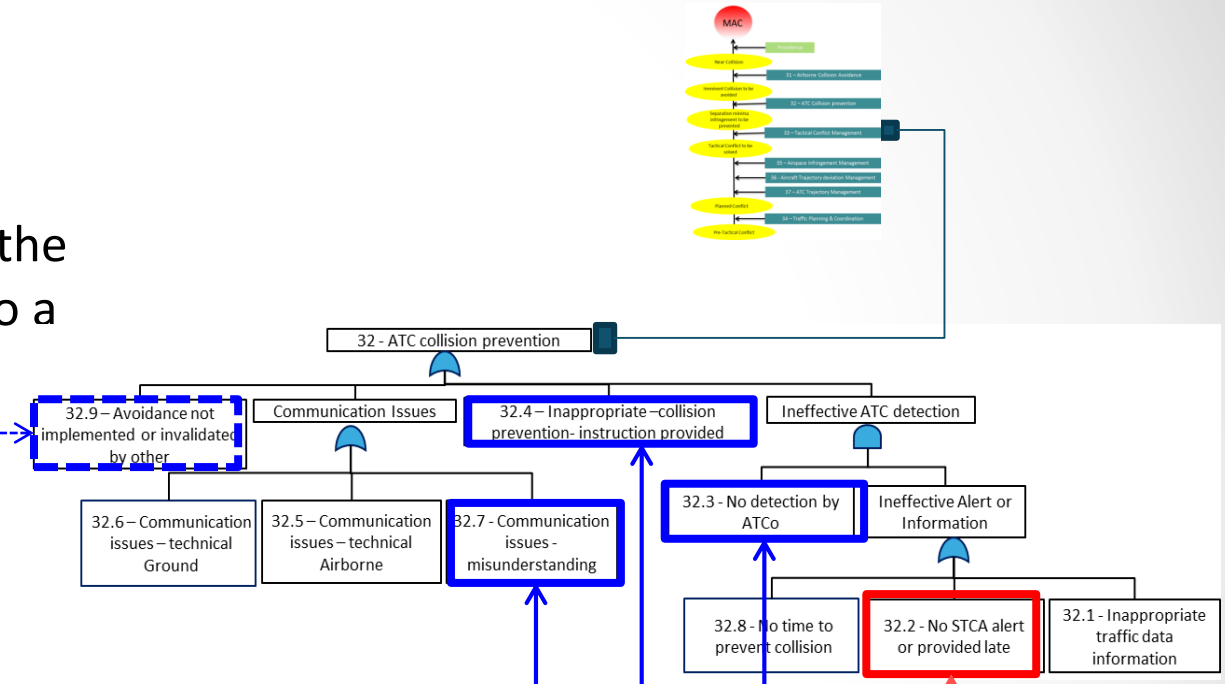




Backbone model – 3/4

Influencing Factors IF

adverse conditions that may increase the frequency of precursors contributing to a risk



Flight Crew Fatigue increases the frequency of **Flight crew errors**

Low ATC experience increases the frequency of **ATC human errors**

Low Surveillance coverage increases the frequency of **STCA detection failure**

Backbone model – 4/4

- **Influencing Factors** are defined by **Attributes, Weight** and **Occurrence Rate**
  - Attributes and weights are generic
  - Occurrence rates are specific to an organization (e.g. Airline, ANSP, …)

ATC Experience level

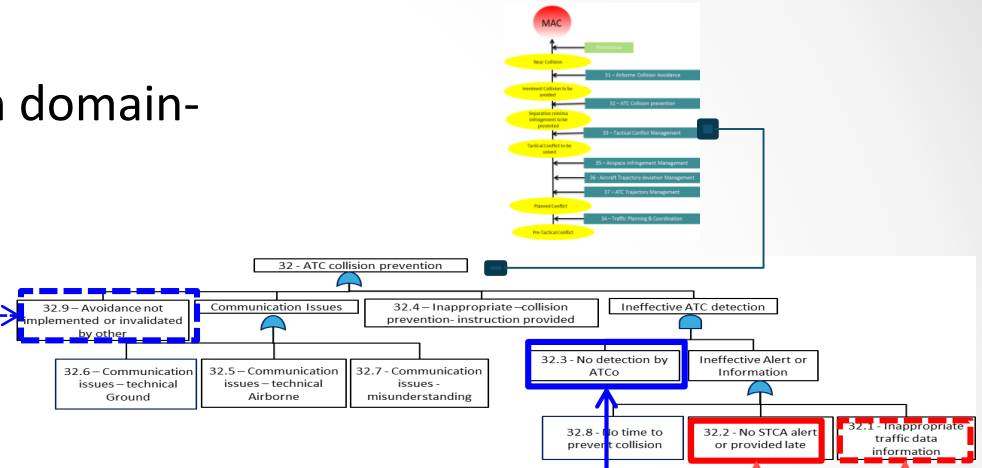
Attribute	Weight	Rate
High	1	5%
Medium	1.2	90%
Low	2	5%

Rectified weight = $\text{Sum}_{i:\text{attributes}}$ (Rate $_i$ * Weight $_i$)

- Rectified weight for "ATC Experience level"= 1.23
  - Probabilities of influenced contributors are multiplied by the Rectified weight

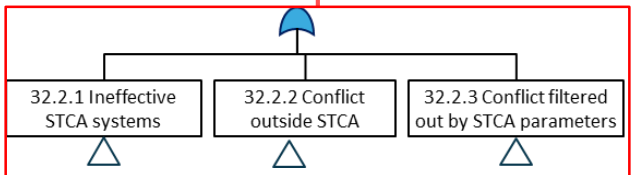
Domain Specific Models

→ The Backbone manages the **interface** with domain-specific safety models.



Airline Operation model details **Flight crew errors**

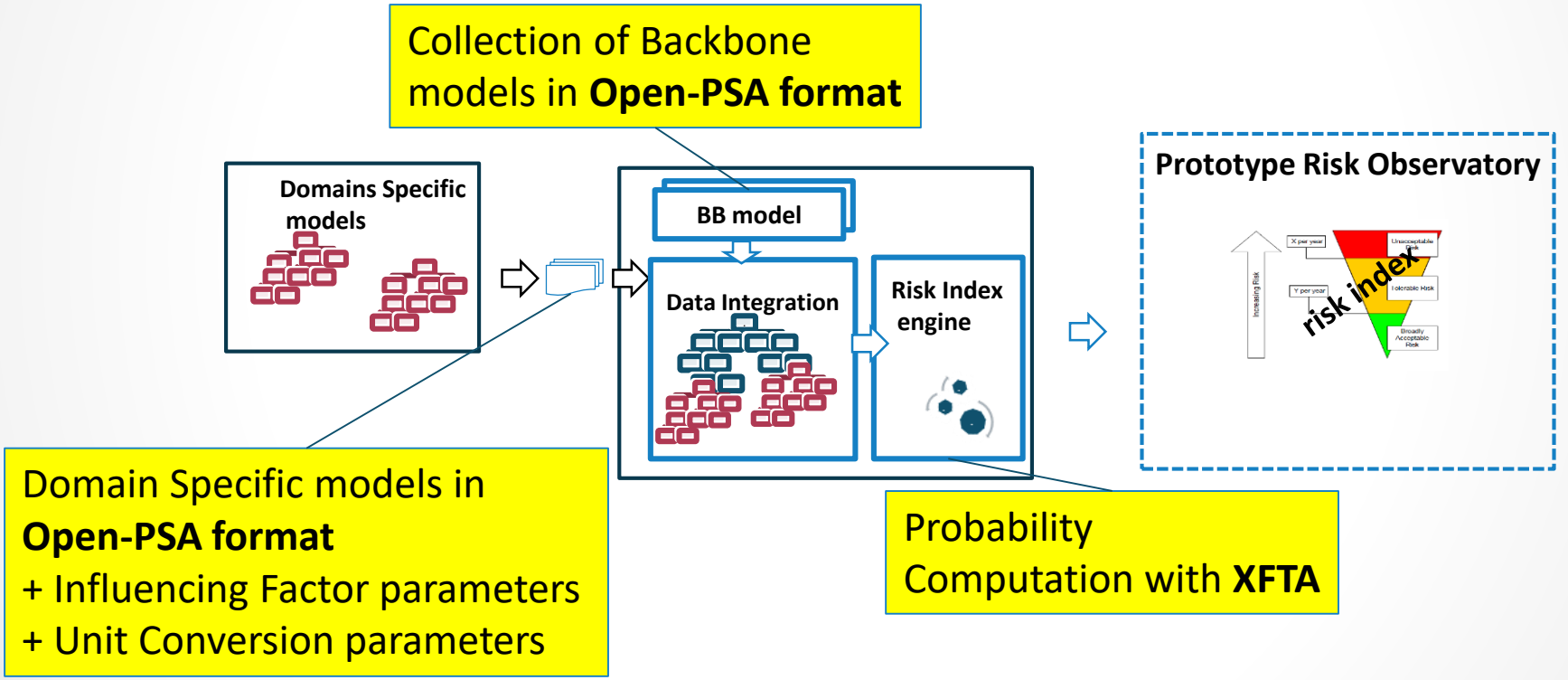
ATC Operation model details **ATC human errors**



Ground Equipment Manufacturer Model details **Ground Technical failures** (qualitative and quantitative aspects)

Aircraft Manufacturer Model details **Airborne Technical failures**

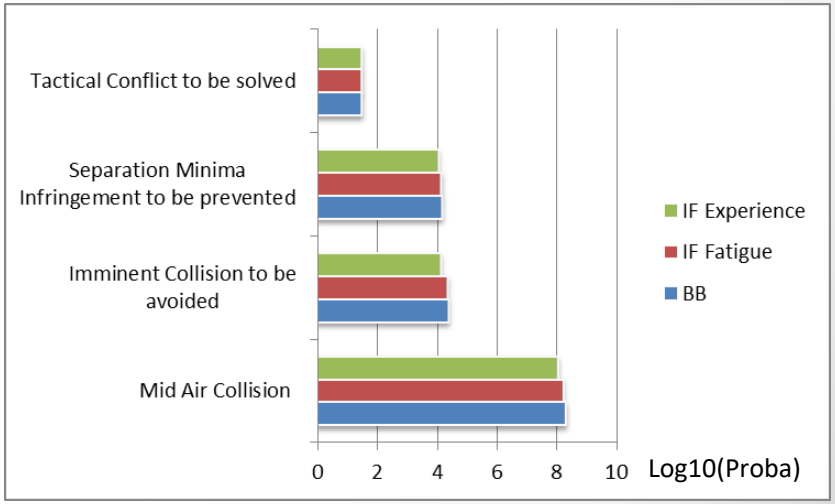
Implementation in the Risk Observatory



What-if Computations – 1/2

- Compute the probability of safety indicators (MAC, Imminent collision, …) with variations of the Backbone model
  - Backbone standalone provides the baseline figures
  - Study the Impact of Influencing Factors :
    - Select active IFs
      - Crew Fatigue, ATC Experience Level
    - Change occurrence rates of IFs
    - Compute the probability of safety indicators and compare with baseline figures

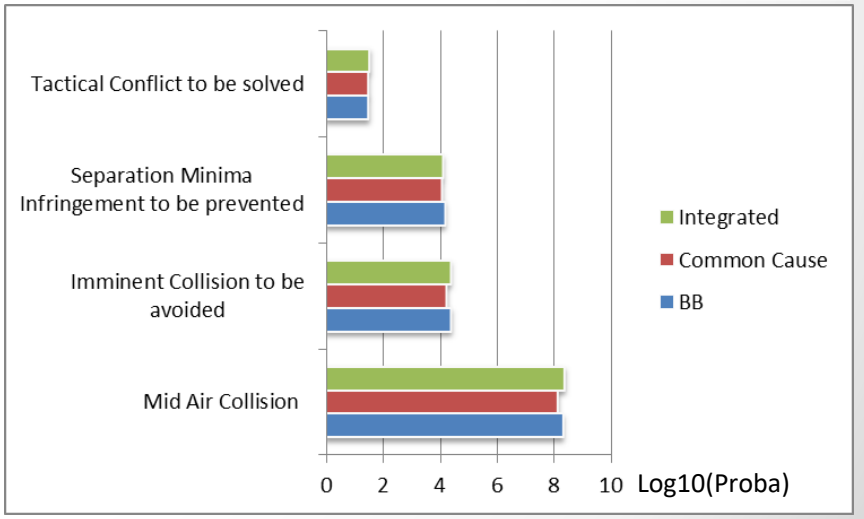
Precursor	BB	IF Fatigue	IF Experience
Mid Air Collision	5,0E-9	6,2E-9	9,2E-9
Imminent Collision to be avoided	4,2E-5	4,5E-5	7,7E-5
Separation Minima Infringement to be prevented	6,9E-5	7,2E-5	9,1E-5
Tactical Conflict to be solved	3,3E-2	3,3E-2	3,4E-2



What-if Computations – 2/2

- Compare the probability computed with variations of the Backbone model
  - Study the Impact of Domain Specific models
    - Integrate Backbone + Domain specific risk models
      - ATM Ground equipment, Airborne equipment
      - Airline Contributing Factor Probabilities
    - Compare probability of safety indicators with baseline figures
  - Study the Impact of Common Causes
    - Add Common Causes Groups to the Risk models
      - Airborne Communication Failures
    - Compare probability of safety indicators with baseline figures

Precursor	BB	Common Cause	Integrated
Mid Air Collision	5,0E-9	7.5e-9	4.3e-9
Imminent Collision to be avoided	4,2E-5	6.0e-5	4.4e-5
Separation Minima Infringement to be prevented	6,9E-5	8.8e-5	8.2e-5
Tactical Conflict to be solved	3,3E-2	3,4E-2	3.0e-2



Conclusion

→ Lessons Learnt

The Backbone Model helps to compute safety indicators using domain specific contributors

... this requires some Modelling Effort

- → Define Generic Contributors for a given risk
- → Link Generic and Domain Specific Contributors
- → Use Conversion rules for quantification (various units : per flight, per flight-hour, per operational-hour, ….)

→ Way forward

Use collected data to quantify Generic and Domain Specific Contributors

Reuse existing Backbone models to study new concepts of operations (for instance RPAS insertion in Traffic)

Propose Backbone models for other Risks

FUTURE SKY SAFETY

Consortium

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Centro para a Excelência e Inovação na Indústria Automóvel
Centro Italiano Ricerche Aerospaziali
Centre Suisse d'Electronique et Microtechnique SA
Institutul National de Cercetari Aerospatiale "Elie Carafoli"
Instituto Nacional de Técnica Aeroespacial
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http://www.futuresky.eu/projects/safety

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