A REFINED RISK ASSESSMENT FRAMEWORK FOR AUTOMOTIVE

AUTOMOTIVE SPIN ITALIA

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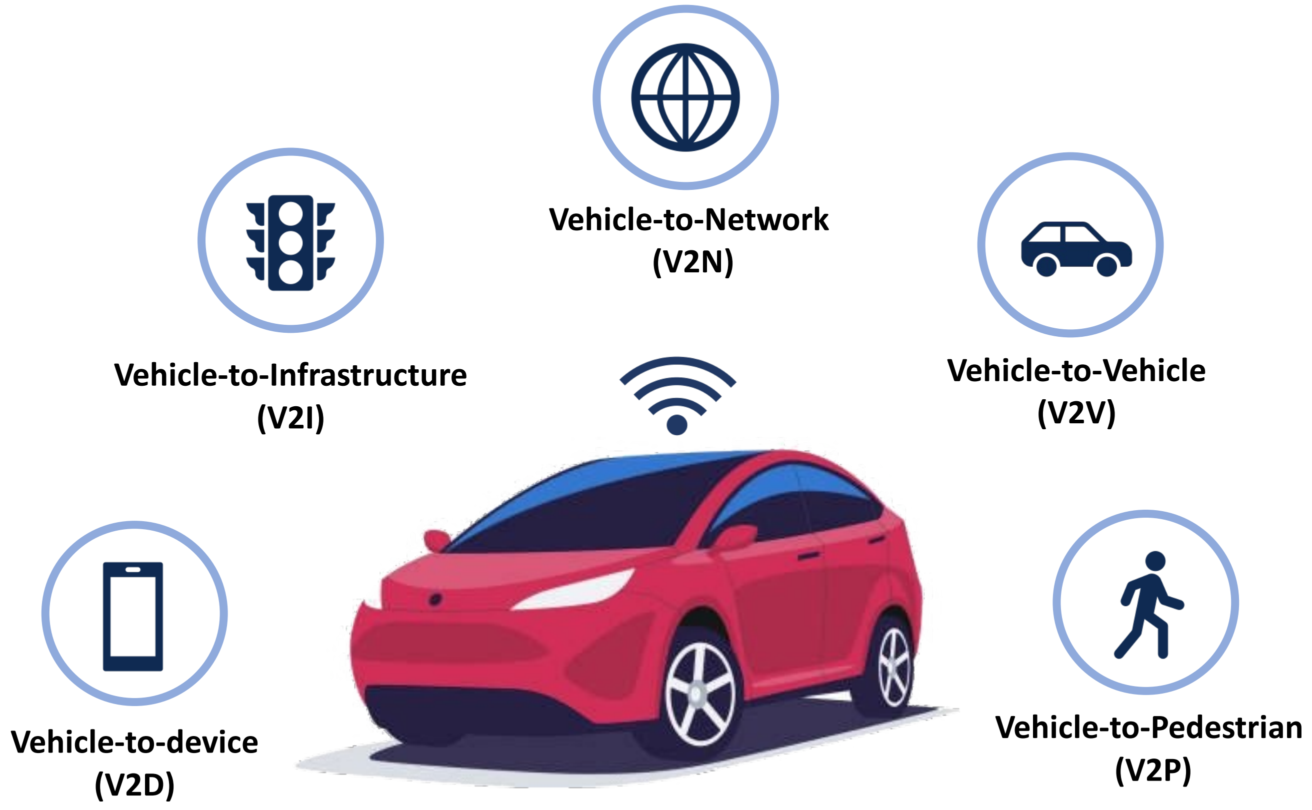
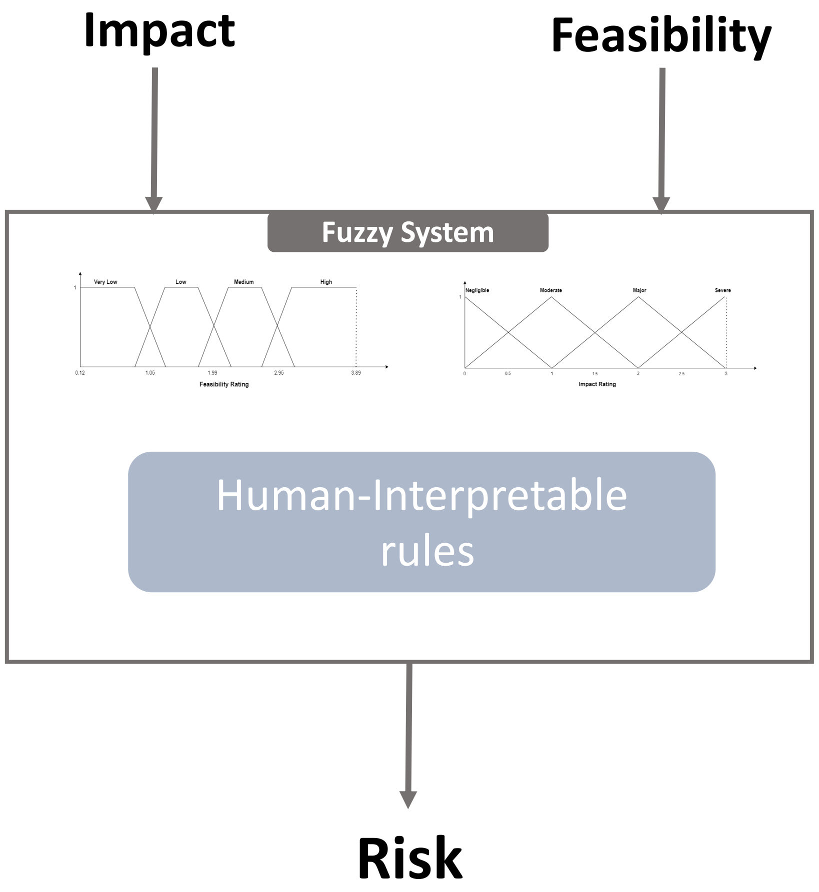
Introduction



Connected and autonomous vehicles:

- Use of **Artifical Intelligence (AI)** based autonomous functionalities
- Increased connectivity beyond vehicle boundaries
- Significant increase in **risks related to cyber-security**
- Risk assessment is a pivotal and increasingly complex activity

Introduction



Fuzzy logic based risk assessment

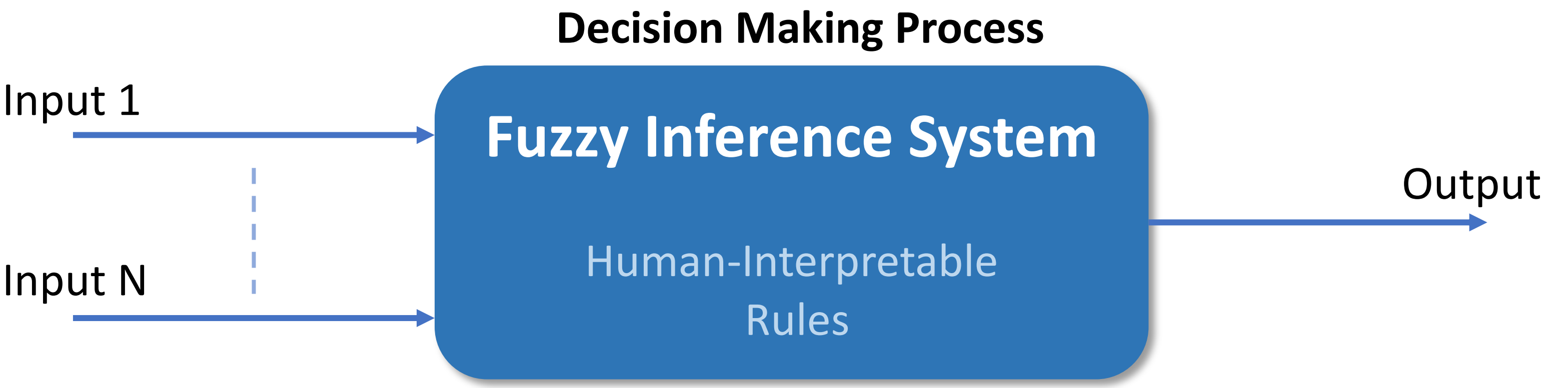
- In line with the ISO/SAE 21434
- Provides output on a continuous scale, favouring risk prioritization and classification
- Explicitly models incomplete or imprecise input data
- Preserves the explainability of the process

Agenda

- Introduction
- **Fuzzy Logic Basics**
- Risk Assessment Framework
- Application Example
- Conclusions

What is fuzzy logic

- **Fuzzy logic** is a way to model logical reasoning where the truth of a statement is not binary



Fuzzy Inference System

Input variables are «fuzzified» through the use of membership functions, in order to obtain a set of **input fuzzy variables**

The rule base is applied to the fuzzy input in order to obtain a set of **output fuzzy variables**

The output is defuzzified, i.e. its exact value is estimated based on its fuzzy form

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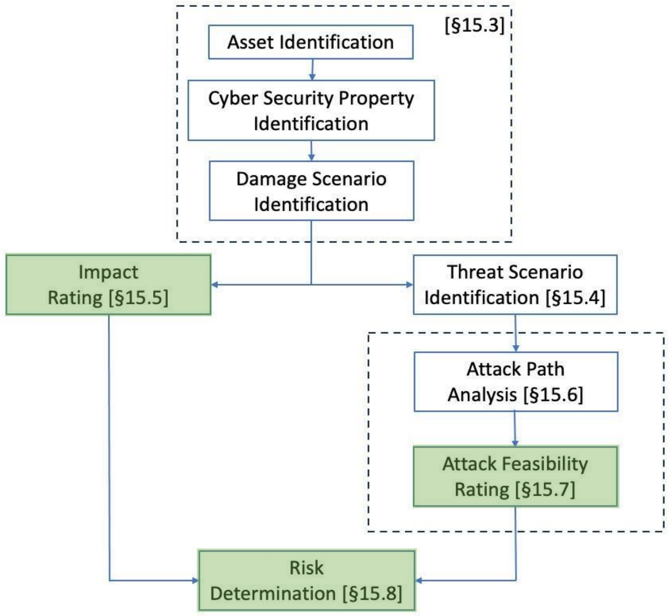
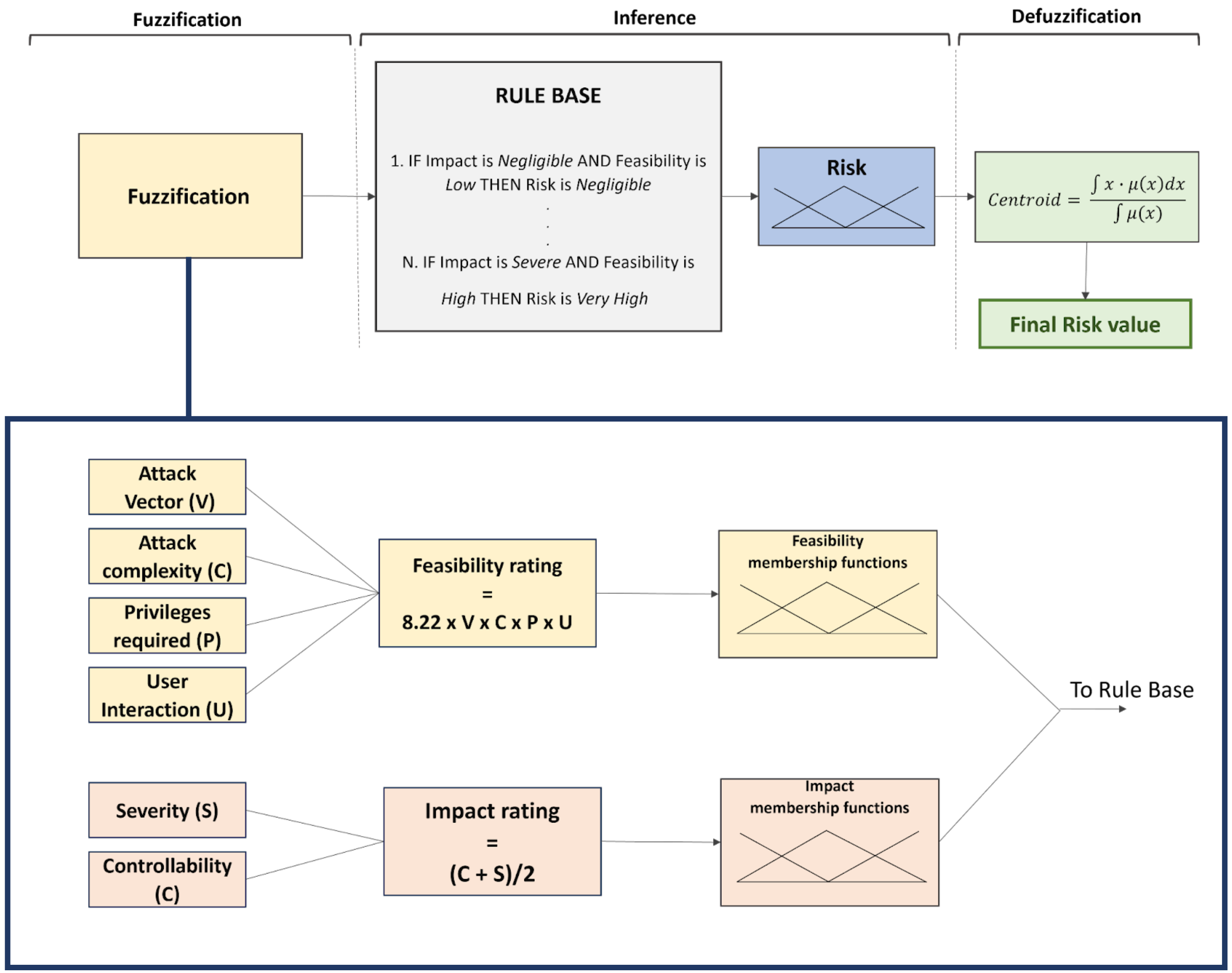
Framework Overview

- Takes place during TARA, after damage and threat scenarios have been identified
- The input variables that determine the risk are *Feasibility Rating* and *Impact Rating*





Membership functions

Membership functions are used to map the input space to a degree of truth between 0 and 1 for a set of human interpretable labels

Feasibility Rating

Calculated with CVSS → input range [0.12, 3.89]

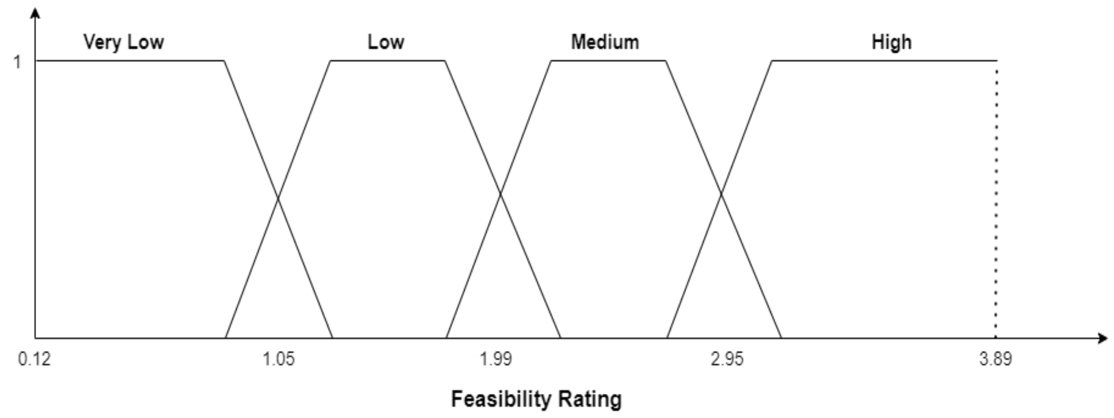
Discrete Mapping

Classic reasoning

Input Interval	Label
2.96 – 3.89	*High*
2.00 – 2.95	*Medium*
1.06 – 1.99	*Low*
0.12 – 1.05	*Very Low*

Membership functions

Fuzzy reasoning



Rule base

Risk Matrix

		Feasibility rating			
		Very Low	Low	Medium	High
Impact rating	Severe	2	3	4	5
	Major	1	2	3	4
	Moderate	1	2	2	3
	Negligible	1	1	1	1

Rule Base

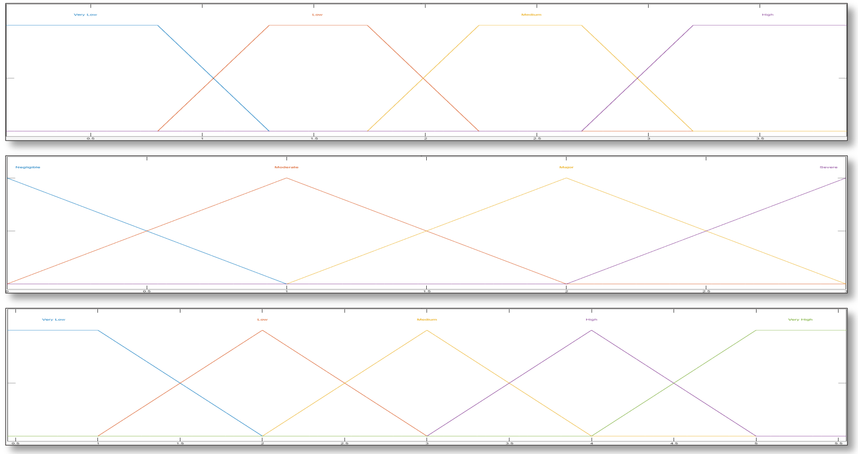
		Feasibility rating			
		Very Low	Low	Medium	High
Impact rating	Severe	*Low*	*Medium*	*High*	*Very High*
	Major	*Very Low*	*Low*	*Medium*	*High*
	Moderate	*Very Low*	*Low*	*Low*	*Medium*
	Negligible	*Very Low*	*Very Low*	*Very Low*	*Very Low*

IF **Impact Rating** is *Severe* AND **Feasibility Rating** is *Very Low* THEN **Risk** is *Low*

IF **Impact Rating** is *Severe* AND **Feasibility Rating** is *Very Low* THEN **Risk** is *Medium*

MATLAB Fuzzy Logic Designer

Membership functions



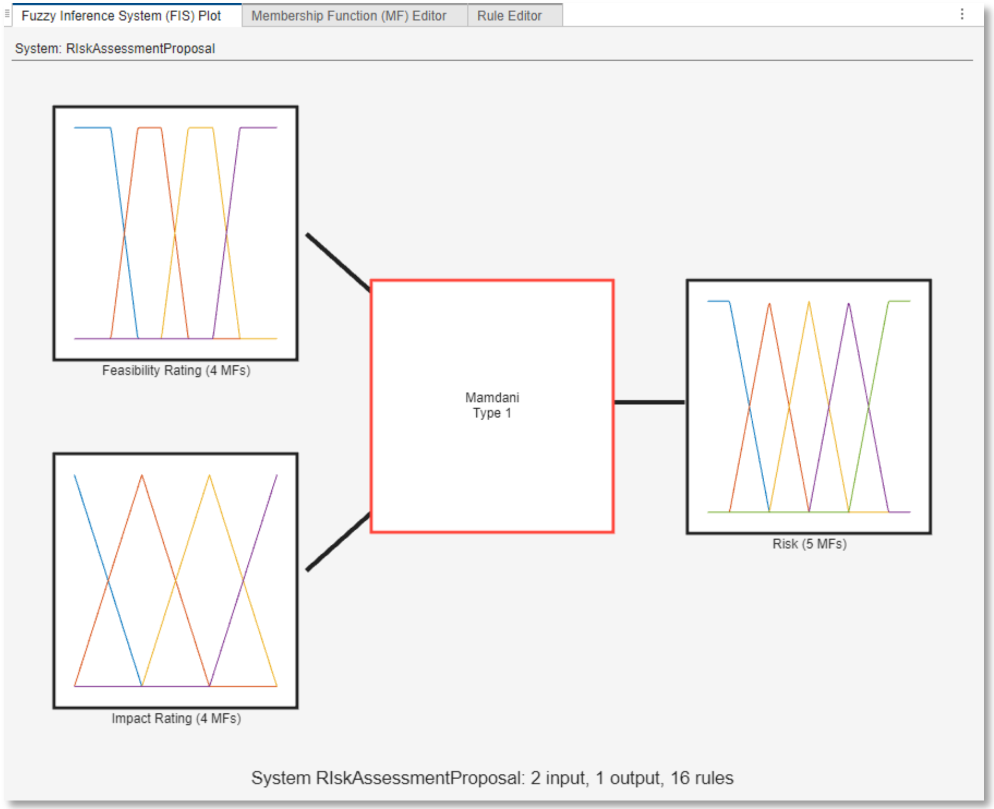
Rule base

System: RIskAssessmentProposal

Add All Possible Rules | Clear All Rules

	Rule	Weight	Name
1	If Feasibility Rating is Very Low and Impact Rating is Negligible then Risk is Very Low	1	rule1
2	If Feasibility Rating is Low and Impact Rating is Negligible then Risk is Very Low	1	rule2
3	If Feasibility Rating is Medium and Impact Rating is Negligible then Risk is Very Low	1	rule3
4	If Feasibility Rating is Very Low and Impact Rating is Moderate then Risk is Very Low	1	rule4
5	If Feasibility Rating is Low and Impact Rating is Moderate then Risk is Low	1	rule5
6	If Feasibility Rating is Medium and Impact Rating is Moderate then Risk is Low	1	rule6
7	If Feasibility Rating is Very Low and Impact Rating is Major then Risk is Very Low	1	rule7
8	If Feasibility Rating is Low and Impact Rating is Major then Risk is Low	1	rule8
9	If Feasibility Rating is Medium and Impact Rating is Major then Risk is Medium	1	rule9
10	If Feasibility Rating is Very Low and Impact Rating is Severe then Risk is Low	1	rule10
11	If Feasibility Rating is Low and Impact Rating is Severe then Risk is Medium	1	rule11
12	If Feasibility Rating is Medium and Impact Rating is Severe then Risk is High	1	rule12
13	If Feasibility Rating is High and Impact Rating is Negligible then Risk is Very Low	1	rule13
14	If Feasibility Rating is High and Impact Rating is Moderate then Risk is Medium	1	rule14
15	If Feasibility Rating is High and Impact Rating is Major then Risk is High	1	rule15
16	If Feasibility Rating is High and Impact Rating is Severe then Risk is Very High	1	rule16

Complete System



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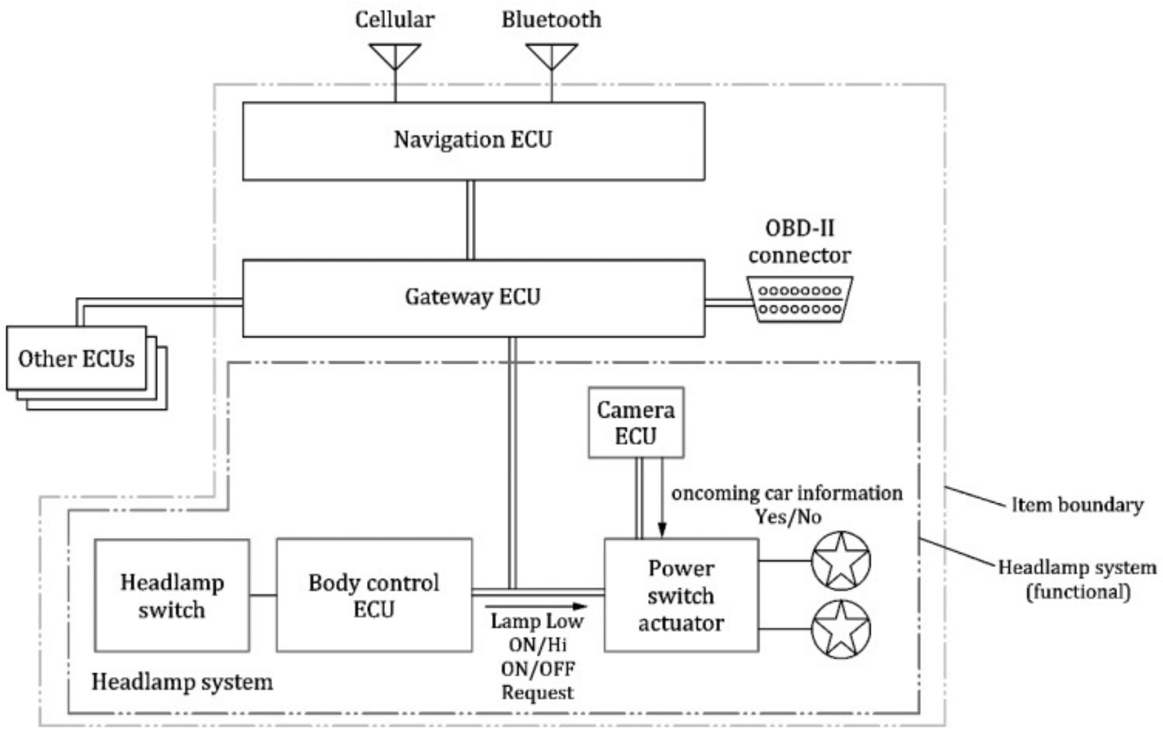
Application example

Headlamp System



Damage Scenario:

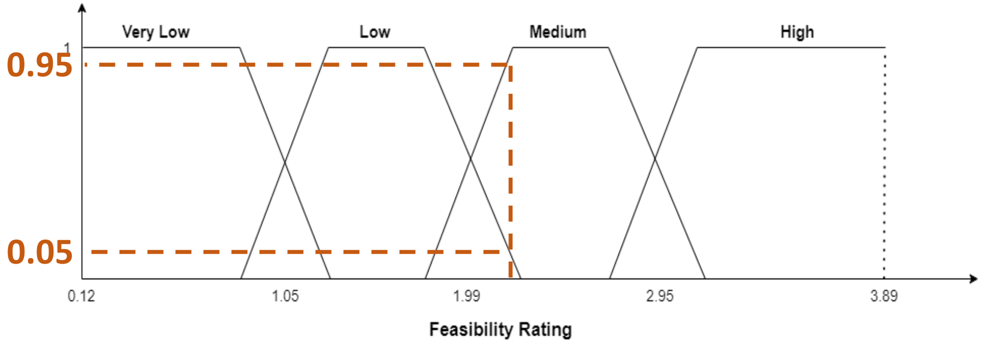
Front collision with a narrow stationary object (e.g. a tree) caused by unintended turning-off of headlamp during night driving at *low speed* (<30 km/h) and *icy road surface.*

Threat Scenario:

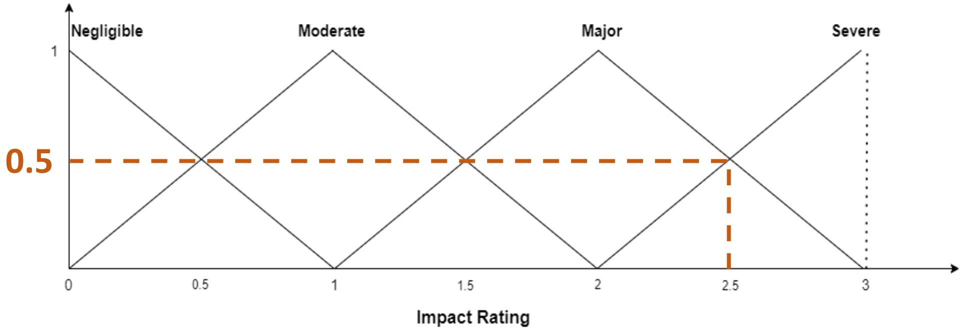
Tampering with a signal sent by body control ECU leads to loss of integrity of the data communication of the “Lamp Request” signal to the power switch actuator ECU, potentially causing the headlamp to turn off unintentionally.

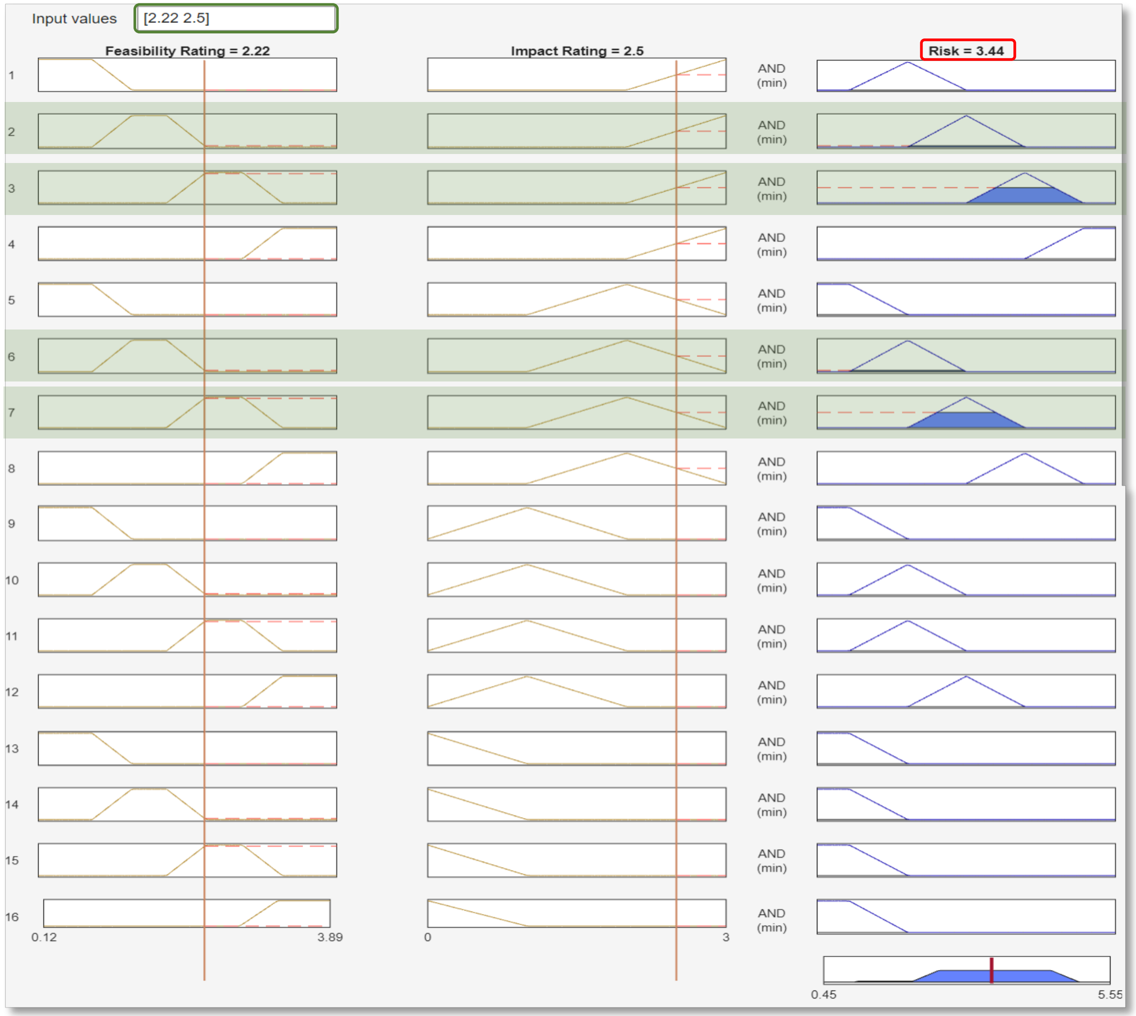
Example Risk Calculation

Attack Path Analysis with CVSS Score → **2.22** → ***0.95 Medium, 0.05 Low***



Severity: 2/3
Controllability: 3/3 → **2.5** → ***0.5 Major, 0.5 Severe***





Some results

Threat scenario	Damage Scenario	FIS Result	ISO/SAE 21434 Result
1	1	5.00	5
	2	4.00	4
	3	4.41	4
	4	4.41	4
	5	3.50	4
2	1	3.94	4
	2	2.94	3
	3	3.44	3
	4	3.44	3
	5	2.50	3

- Results are generally in line with the standard proposed method
- Output is on a continuous scale instead of a discrete one
- Allows to capture differences in risks that would have the same value according to the traidional method

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	2	2.94	3
	3	3.44	3
	4	3.44	3
	5	2.50	3

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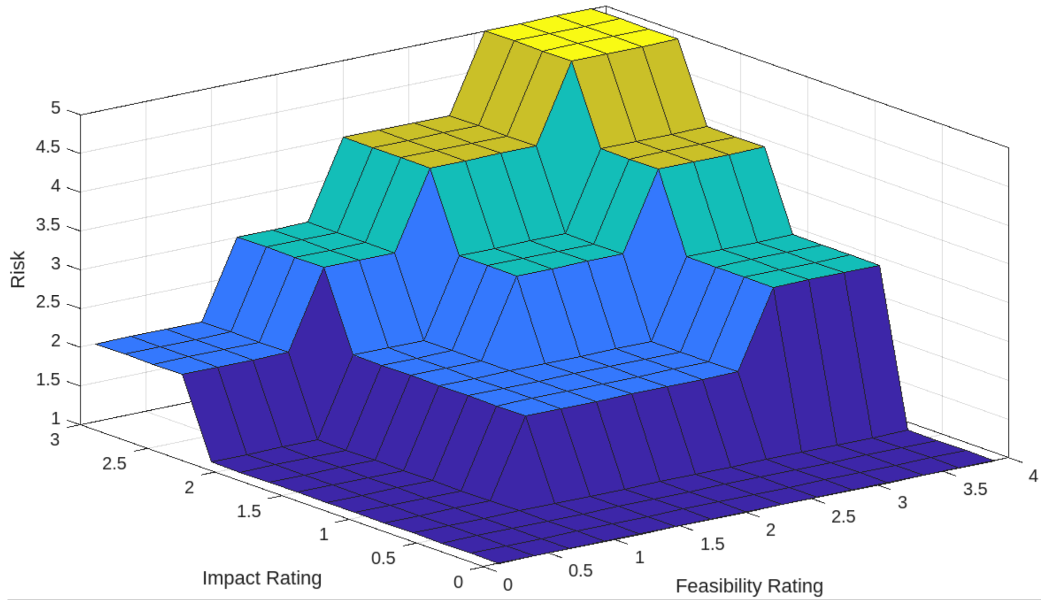
Advantages

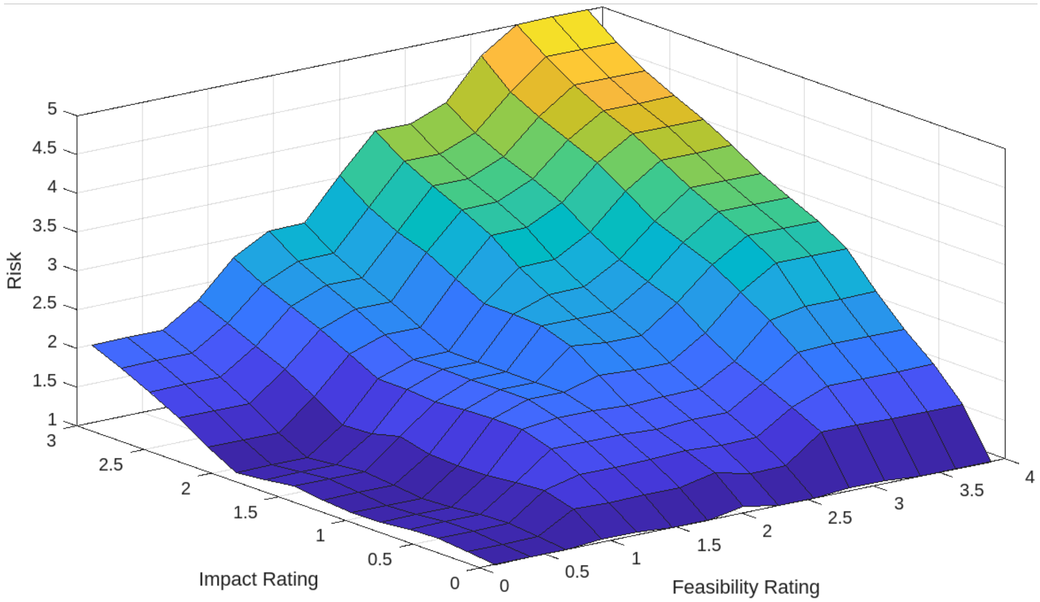
- The risk surface is smoother, which indicates a finer level of detail in terms of risk calculation

- The methodology preserves the linear ordering among the risks calculated with it

Traditional Methodology



Fuzzy Logic-Based Methodology



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Conclusions

The proposed **fuzzy-logic-based framework** aims to bring some advantages to the risk assessment procedure while remaining within the scope of the TARA process. Its key features are:

- **Increased granularity** in the risk output (continuous scale)
- **Allows to differentiate between risks** that would have the same value otherwise
- Capability of handling a certain **degree of uncertainty**
- **Flexibility & minimal overhead** thanks to tools support