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Performance and safety construction and evaluation for in-car embedded systems

Françoise Simonot-Lion

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Koblenz University

May, 11 2005



**aboratoire Lorrain de Recherche en
Informatique et ses Applications**

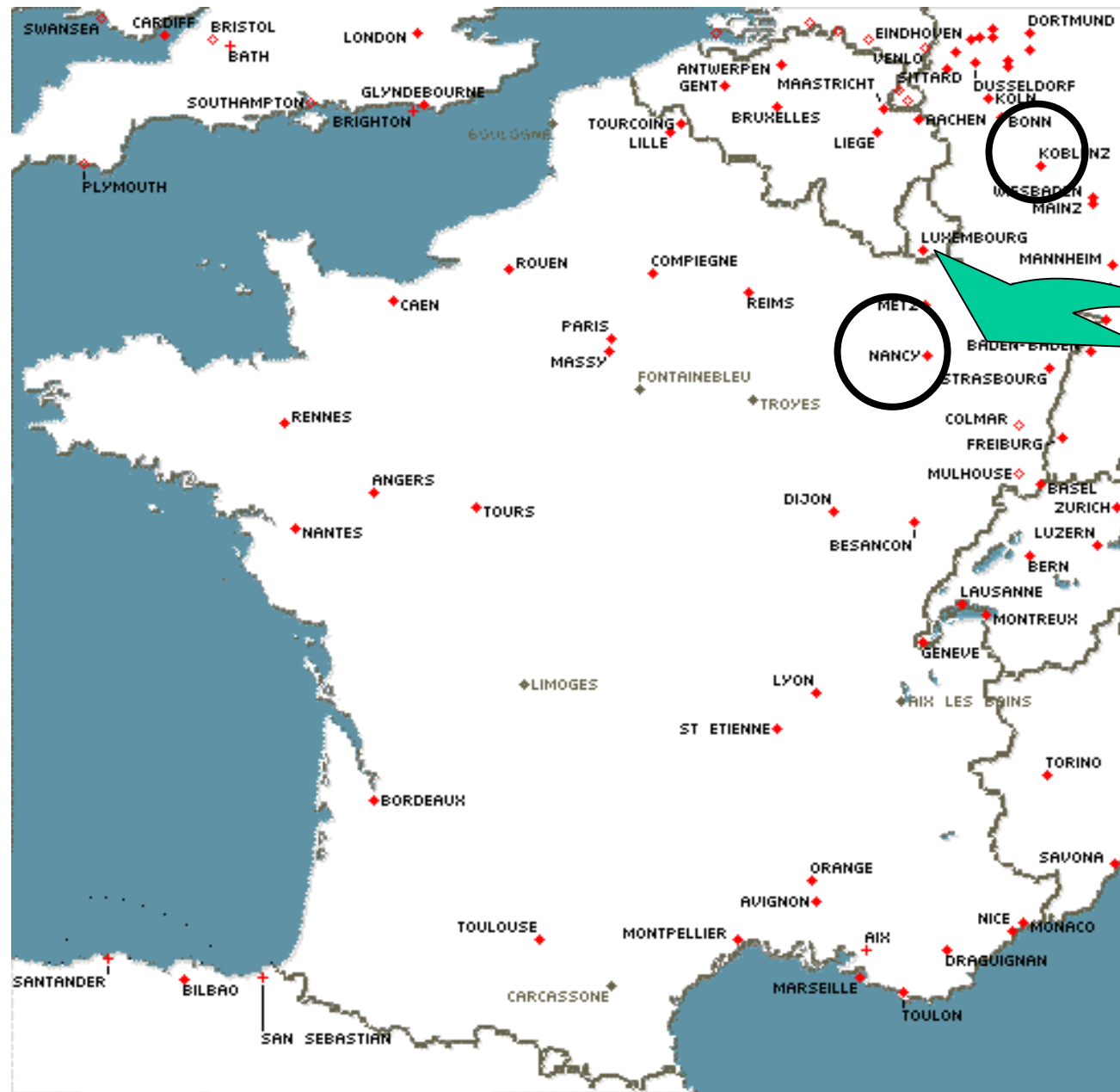
TRIO Team

**Performance and safety construction and
evaluation for in-car embedded systems**

Françoise Simonot – Lion

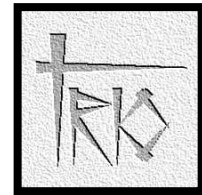
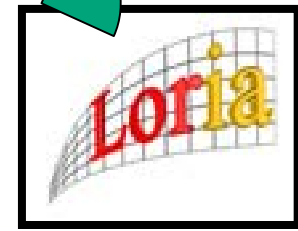
LORIA (UMR 7503)

simonot@loria.fr



**CNRS /
INRIA /
Universities of
Nancy**

450 members

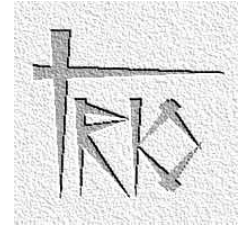




UMR 7503

TRIO

Temps Réel et InterOpérabilité Real Time and InterOperability



INRIA Project Team since January 2002

General objective

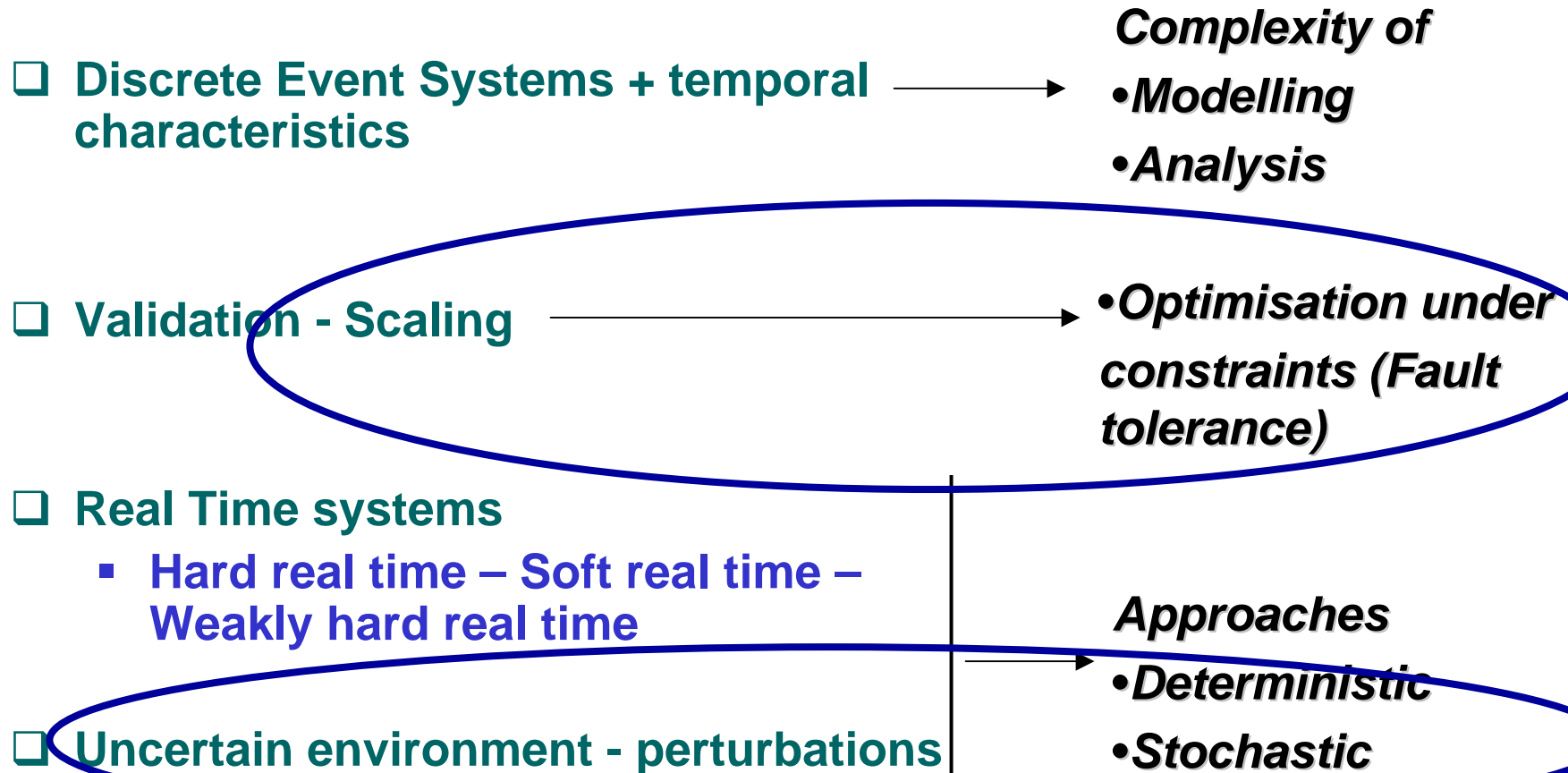
**To provide techniques and methods for
design, validation and scaling
real time distributed systems**

Keywords:

- Physical time (Event Driven Timed Systems)
- Hardware – Software architectures – OS and protocols – Distribution
- Partially known environment - Perturbations

Research issues

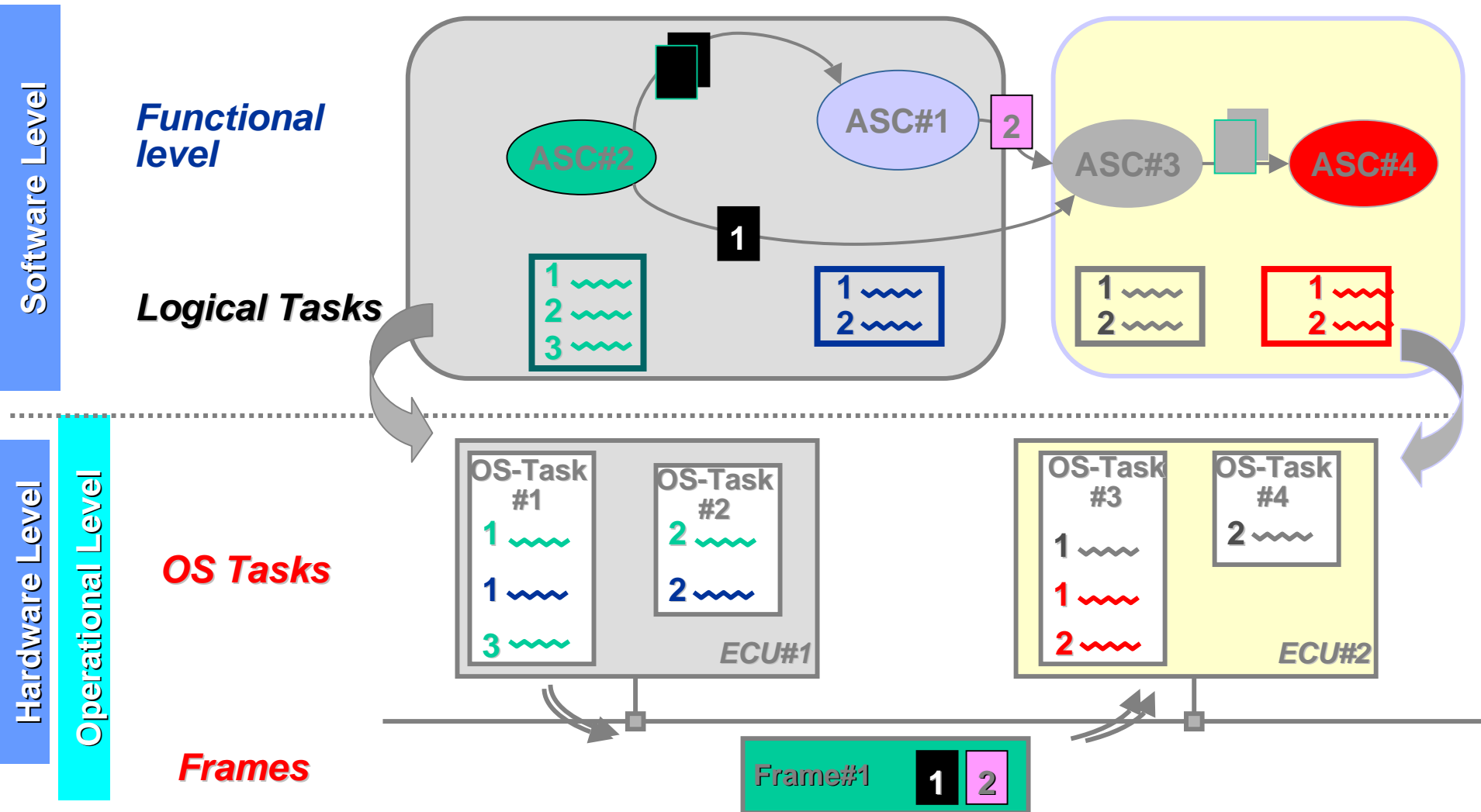
In-Vehicle embedded Systems



In-vehicle embedded systems

Design and scaling

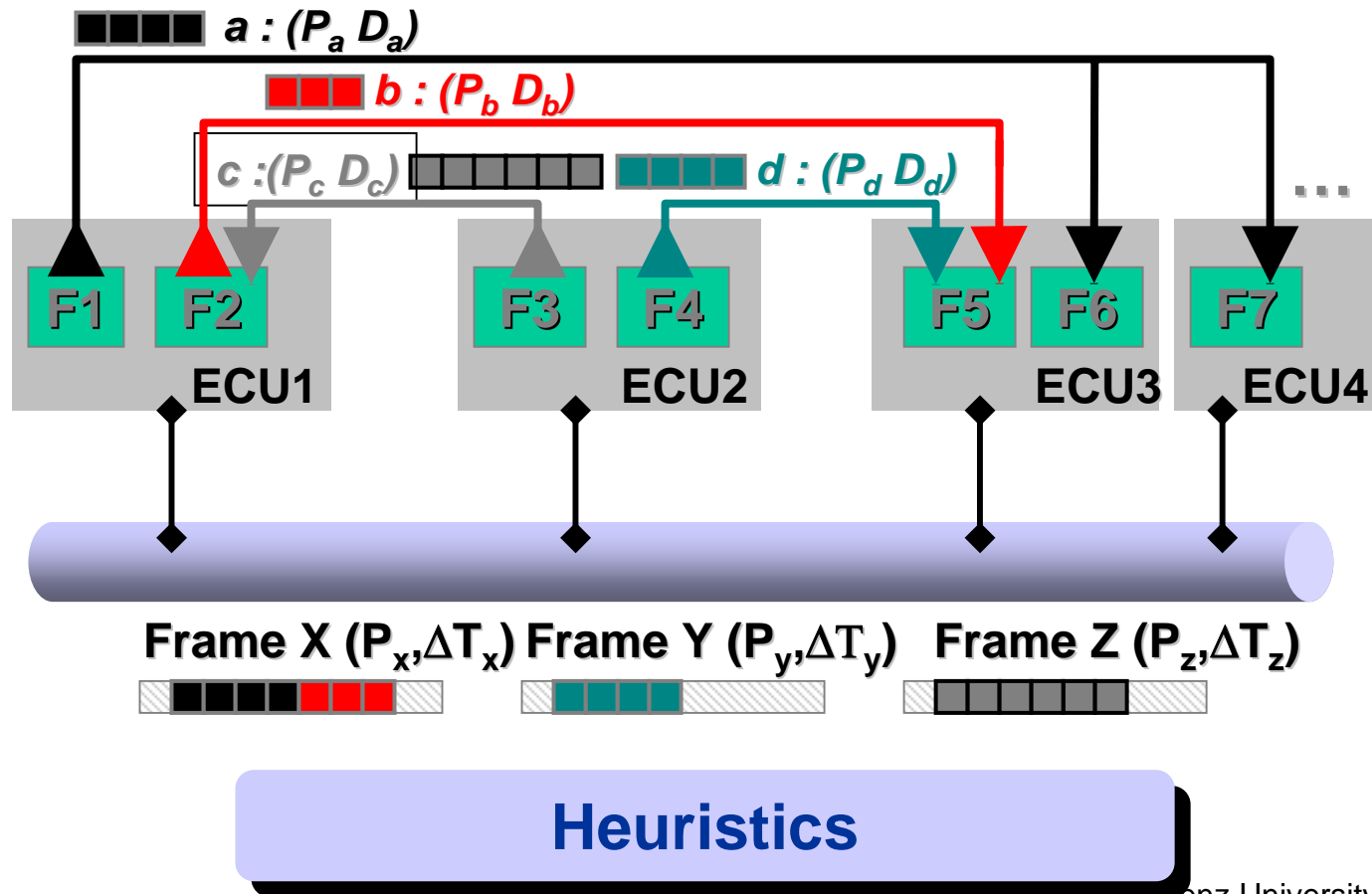
Modeling the distribution of logical tasks onto ECU (OS Task) software flows between distant tasks onto network (Frame)



Design and optimal scaling

Priority-based protocol

- Frame packing under real time constraints : *Priority, size, emission rule*

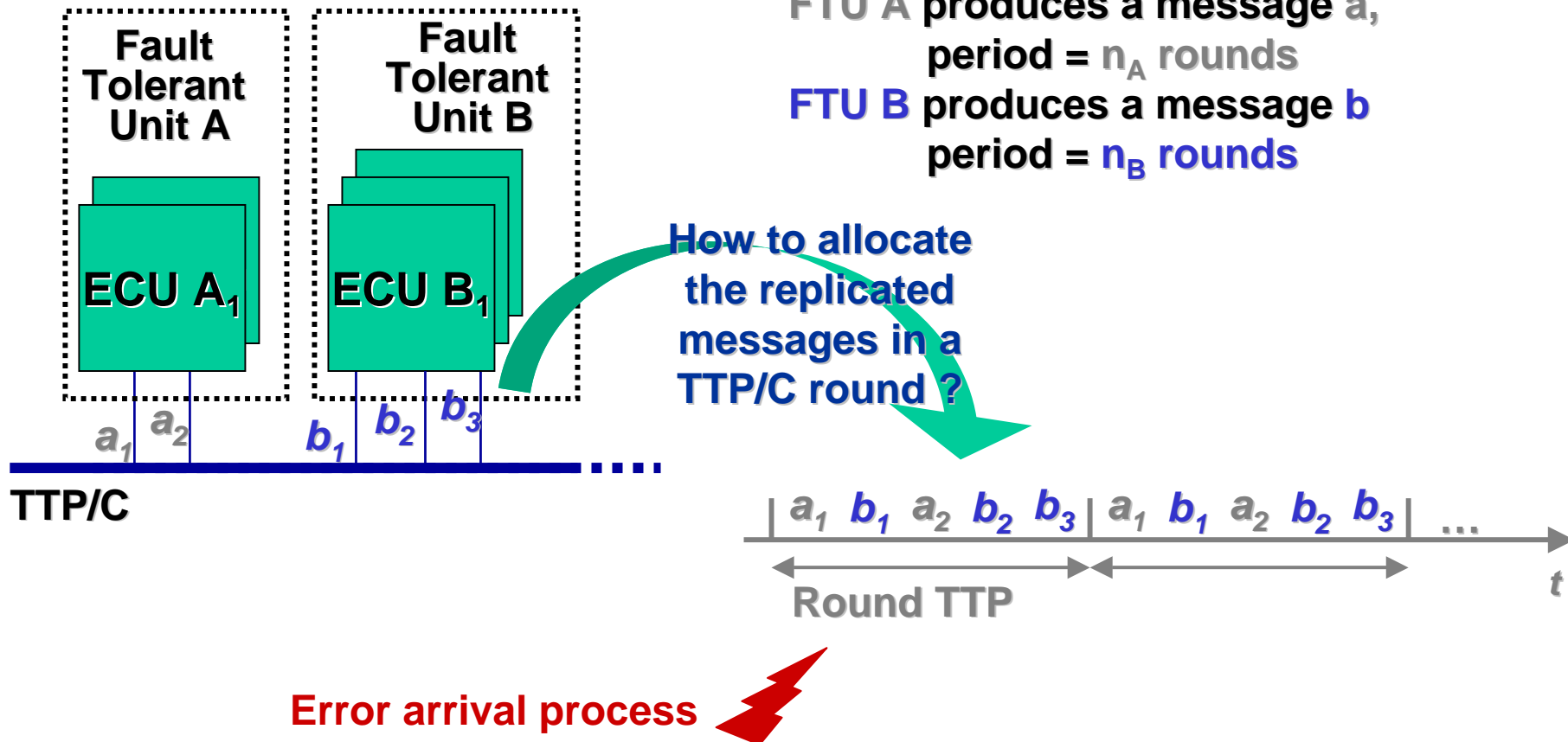


Minimisation of bandwidth consumption

NP-complete

Design and optimal scaling Time-Triggered protocol

Redundant nodes – TTP / C protocol – Fault Tolerant Unit



Design and optimal scaling Time-Triggered protocol

□ How to place the replicated messages in a TTP/C round ?

▪ Fail silent nodes

To minimize the probability of loss of all the replicated values during a producing period

▪ Non Fail silent nodes

To minimize the probability of loss of at least one replicated values during a producing period

→ Optimal allocation (under assumptions on FTUs)

→ Sub-optimal allocation (heuristics)

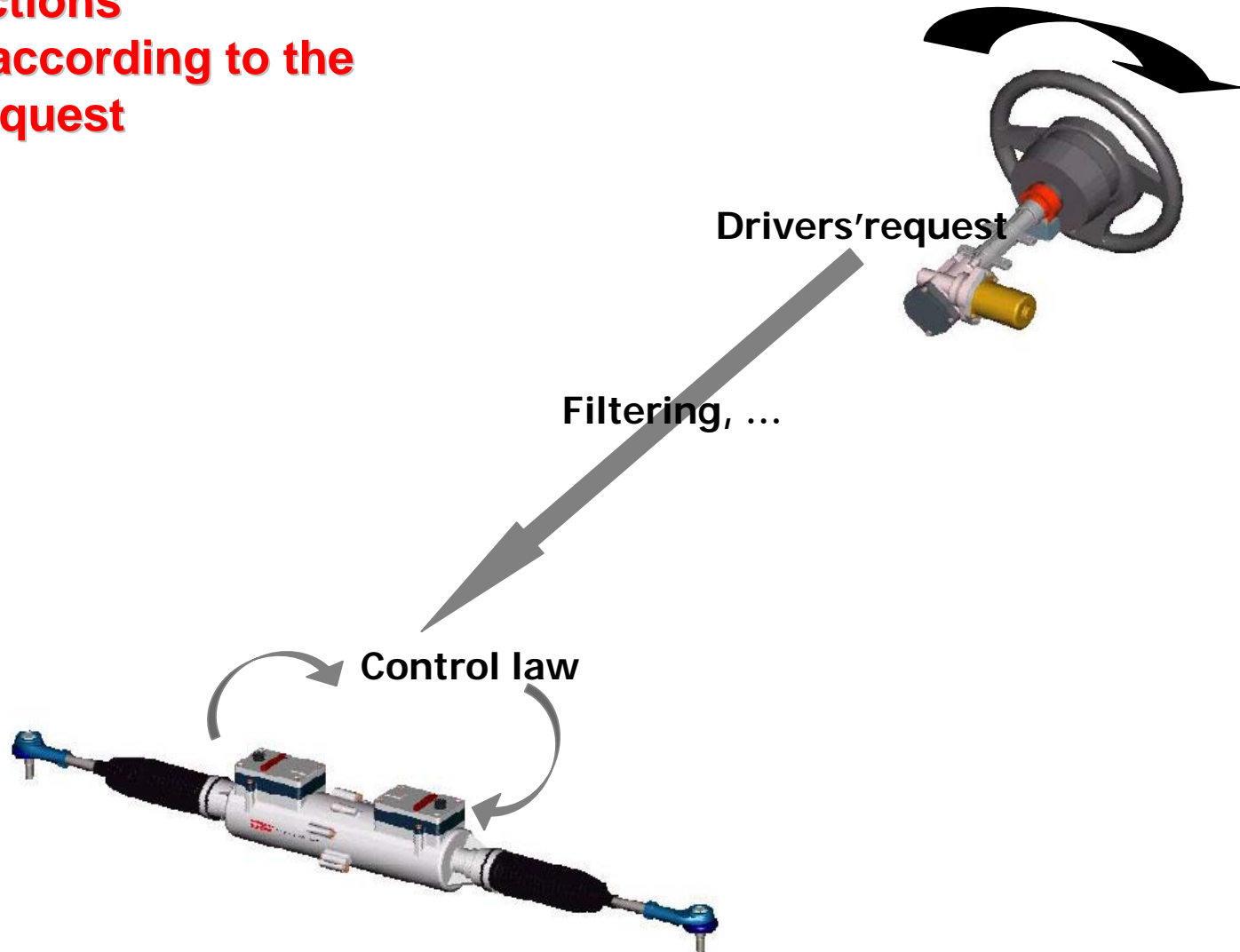
In-vehicle embedded systems

Safety assessment - certification

Steer by Wire systems

Critical functions

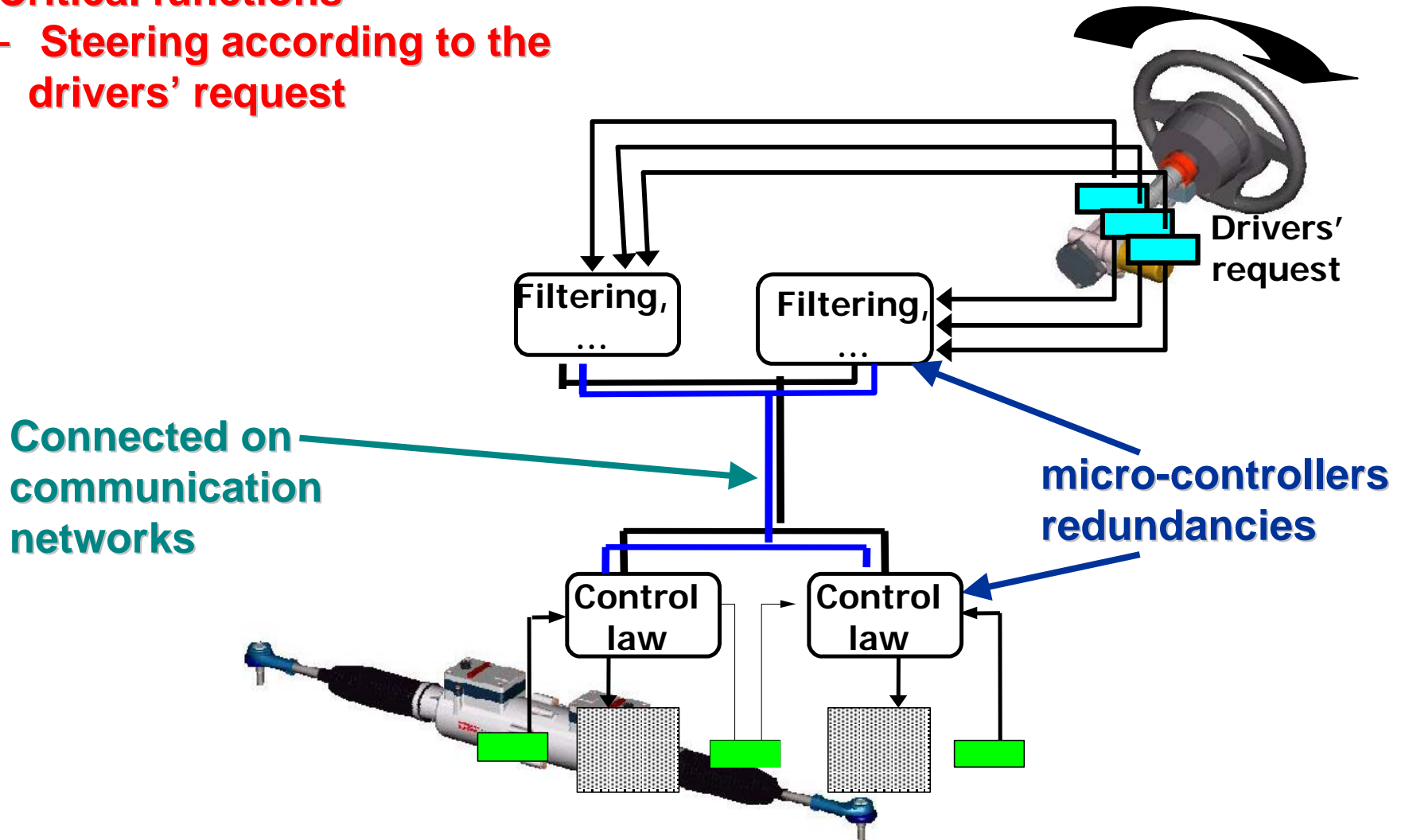
- Steering according to the drivers' request



Steer by Wire systems

Critical functions

- Steering according to the drivers' request



Steer by Wire systems

Steer-by-Wire is a Safety Critical System

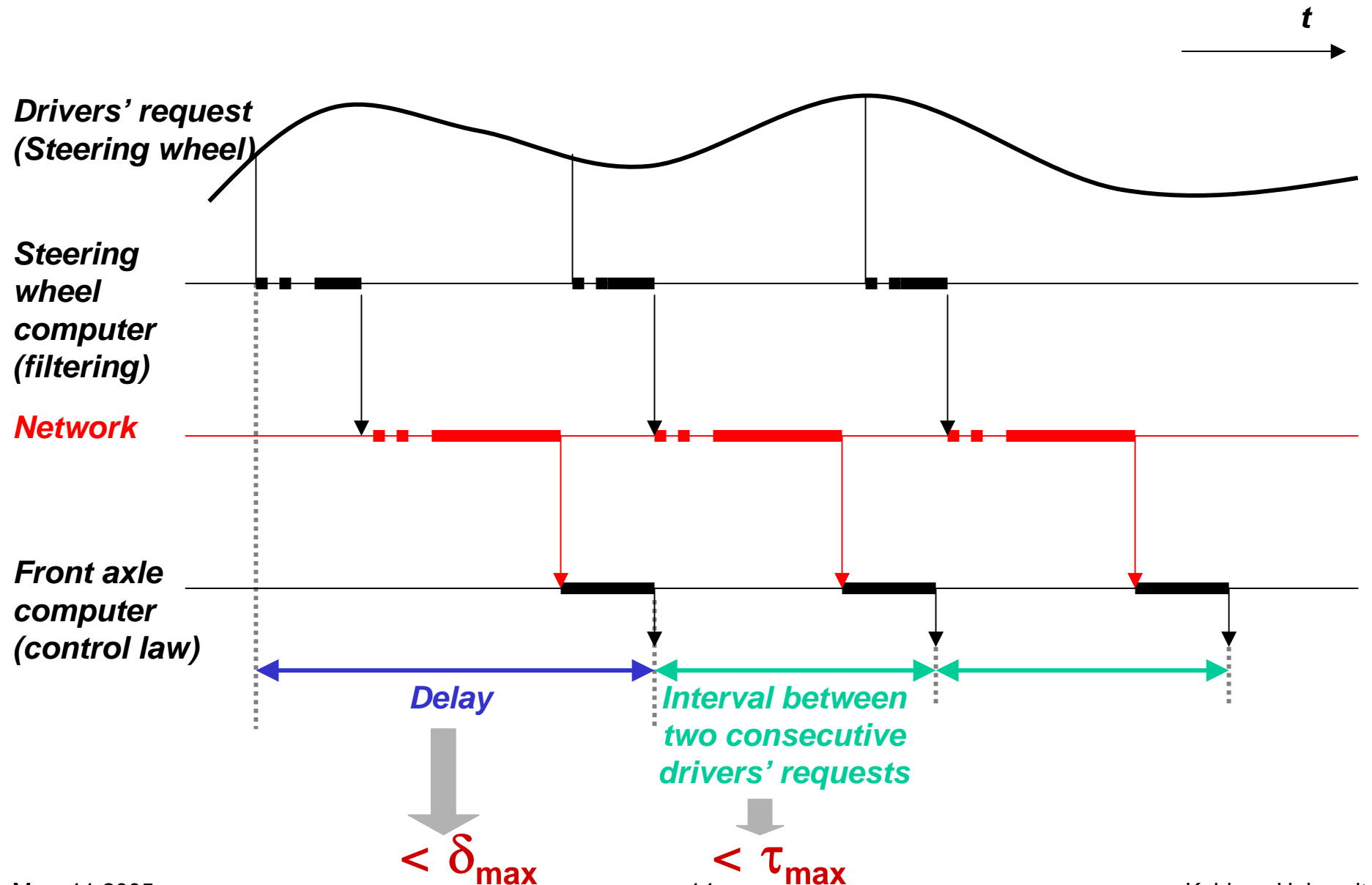
Certification ? Standard ?

CEI 61508 → System Integrity Level (SIL) 4

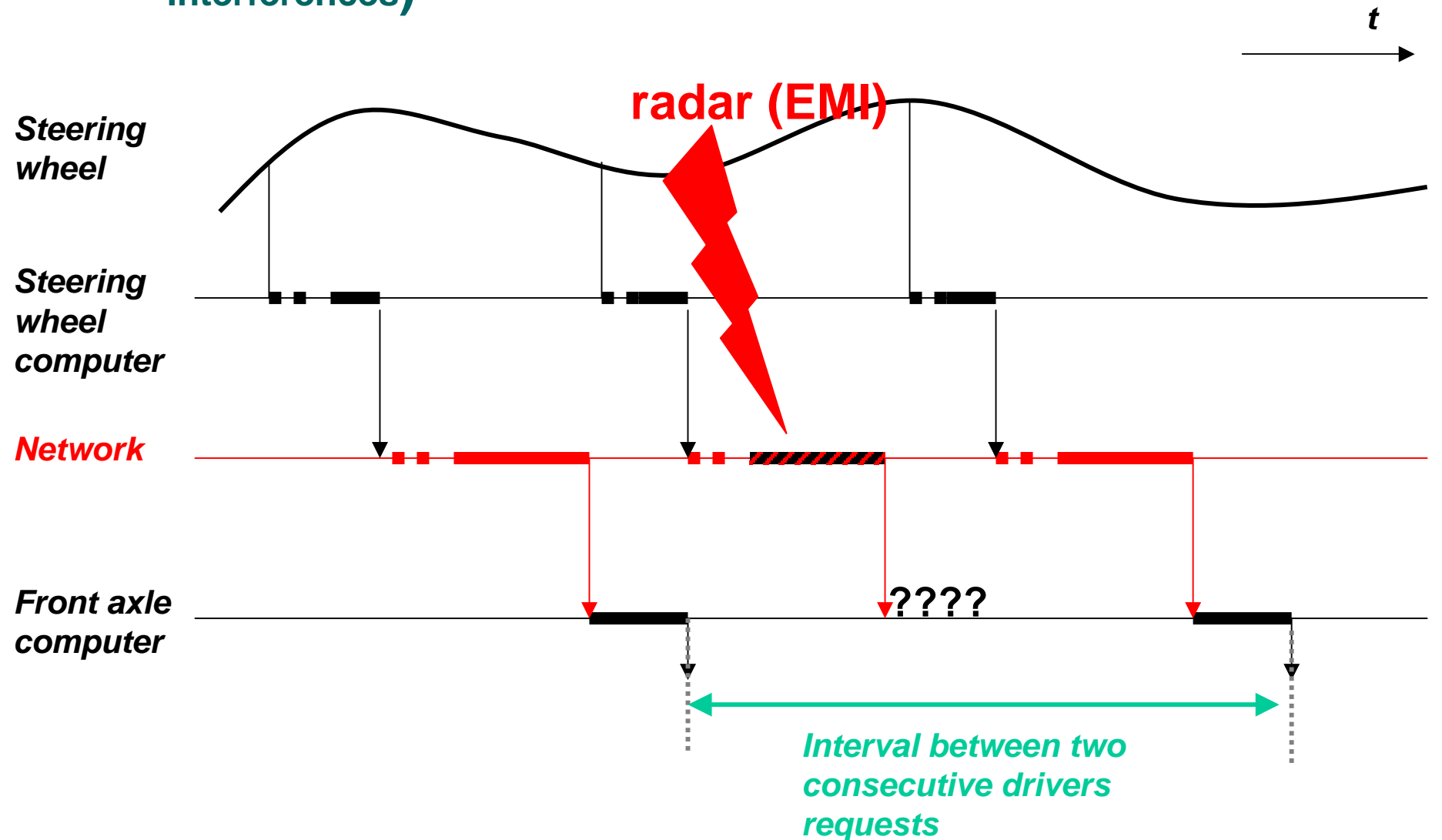
Probability to have a *critical* failure in one hour $< 10^{-9}$

**How to ensure / verify this property
on an
Operational Architecture?**

Electronic / software delays - properties



❑ Electronic / software delays under EMI (Electro Magnetic Interferences)



□ Electronic / software delays under EMI (Electro Magnetic Interferences)

Let us consider:

- a traject followed by the vehicle (constant vehicle speed),
- Z a part of this traject subject to EMI
 - L is the length of Z (seconds)
- the network is TTP/C
 - η_{wc} is the number of TTP rounds in L
- η_{max} is τ_{max} /round size (Matlab / Simulink)
- P_{err} is the probability that each round in Z is corrupted

$$P_{fail}(Z, P_{err}) = 1 - \underbrace{R(\eta_{max}, \eta_{WC}; P_{err})}$$

Probability to have less than
 η_{max} consecutive corrupted
rounds in η_{wc} rounds

❑ Electronic / software delays under EMI (Electro Magnetic Interferences)

		T D M A cycle length (ϵ_n)									
		1	2	3	4	5	6	7	8	9	10
P _{err}	0,5	X	X	X	X	X	X	X	X	X	X
	0,4	X	X	X	X	X	X	X	X	X	X
	0,3	X	X	X	X	X	X	X	X	X	X
	0,2		X	X	X	X	X	X	X	X	X
	0,1			X	X	X	X	X	X	X	X
	0,09			X	X	X	X	X	X	X	X
	0,08				X	X	X	X	X	X	X
	0,07				X	X	X	X	X	X	X
	0,06				X	X	X	X	X	X	X
	0,05				X	X	X	X	X	X	X
	0,04					X	X	X	X	X	X
	0,03						X	X	X	X	X
	0,02						X	X	X	X	X
	0,01							X	X	X	X
	0,009							X	X	X	X
	0,008									X	X
	0,007									X	X
	0,006									X	X
	0,005									X	X
	0,004									X	X
0,003									X	X	
0,002											
0,001											

X → $< 10^{-9}$

□ → $< 10^{-7}$
 $\geq 10^{-9}$

■ → $\geq 10^{-7}$

For more informations

<http://www.loria.fr>

<http://www.loria.fr/equipes/TRIO/>