Mixed Criticality Systems What is it Really?

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Mixed Criticality Systems (Model) What is it Really?

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A bit of personal history

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2007

The beginning:
Paper of **Vestal**

A bit of personal history

My debut:
I start to work on MCS
using **Vestal's model**

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I start collaborating with **industrial partners** in EU projects

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An opportunity:
My new **PhD student** works for a company called Critical Software and is an **expert in certification**

An attempt:
We **publish** a paper discussing the **dichotomy** around the notion of criticality

The original message

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Criticality of a component:
measure of the severity of that component's failure

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- Defines safety requirements that must be fulfilled
- Drives the development and certification process
  ➔ impacts cost and time

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- Defines safety requirements that must be fulfilled
- Drives the development and certification process
  ➔ impacts cost and time

- Misbehaviour is not limited to the consequence of a deadline miss
  Examples:
  - Wrong output
  - Corruption of blocking of shared resources
  - Buffer overload
  - ...

The original message

- **Criticality** is **not** a measure of **importance**

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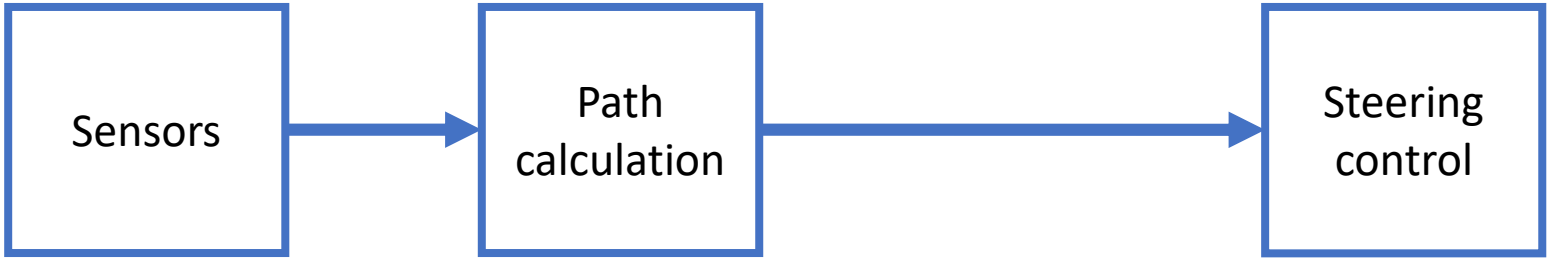
  Example: Auto-pilot



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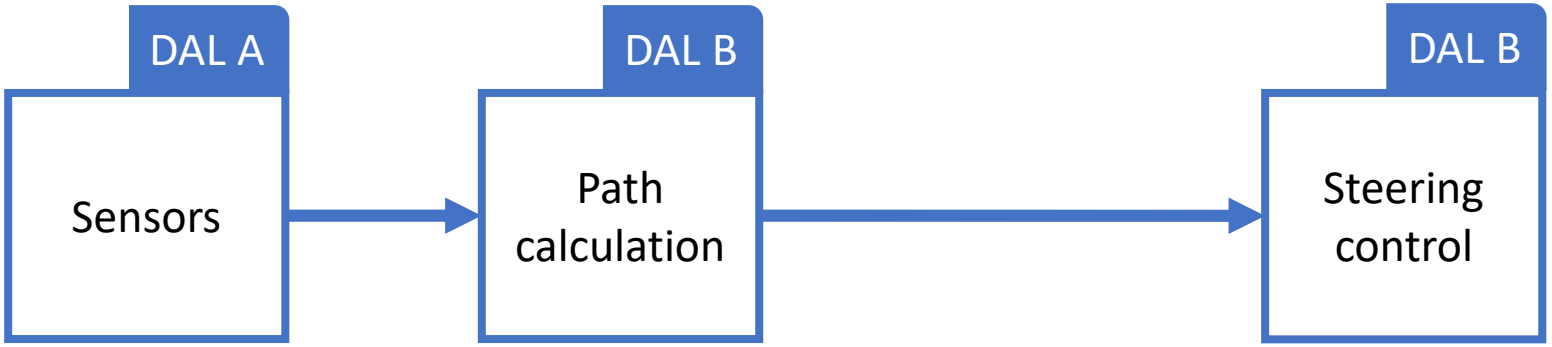

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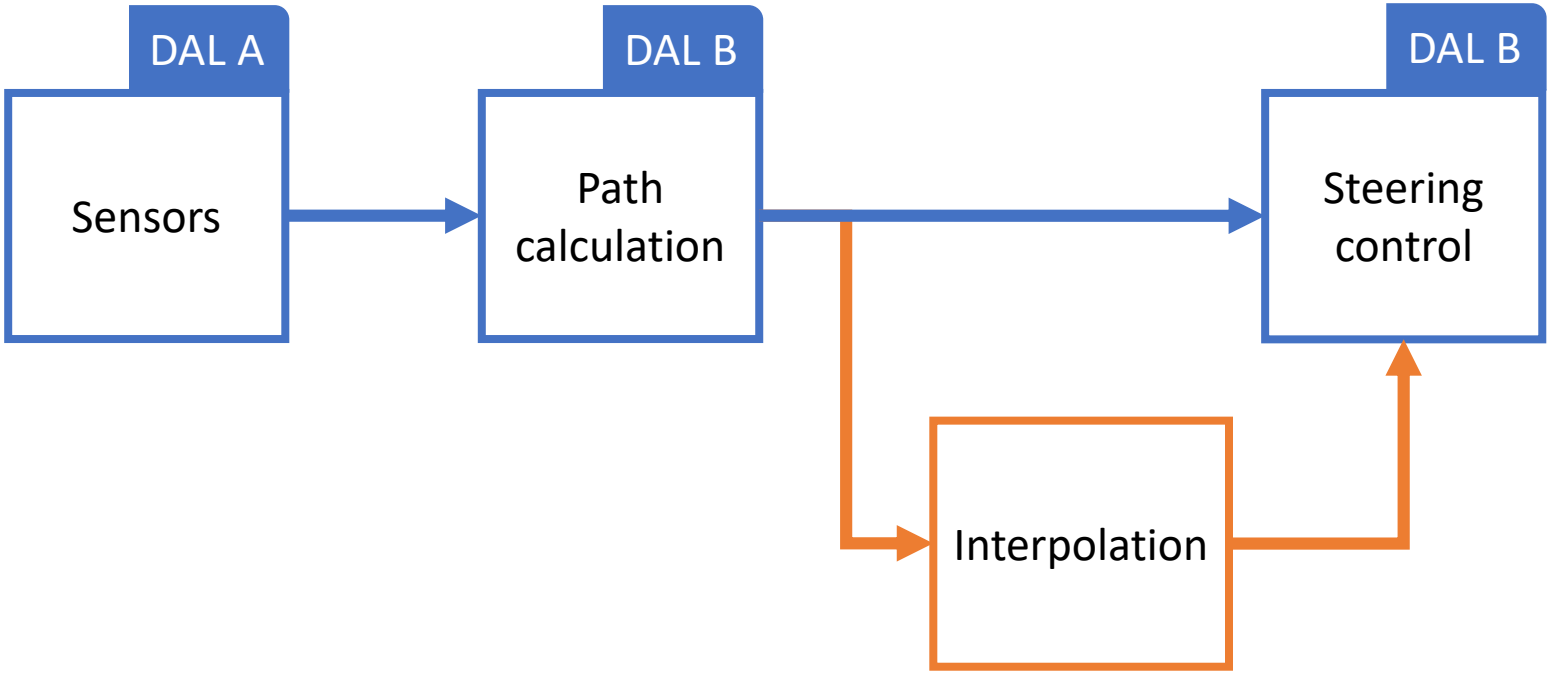

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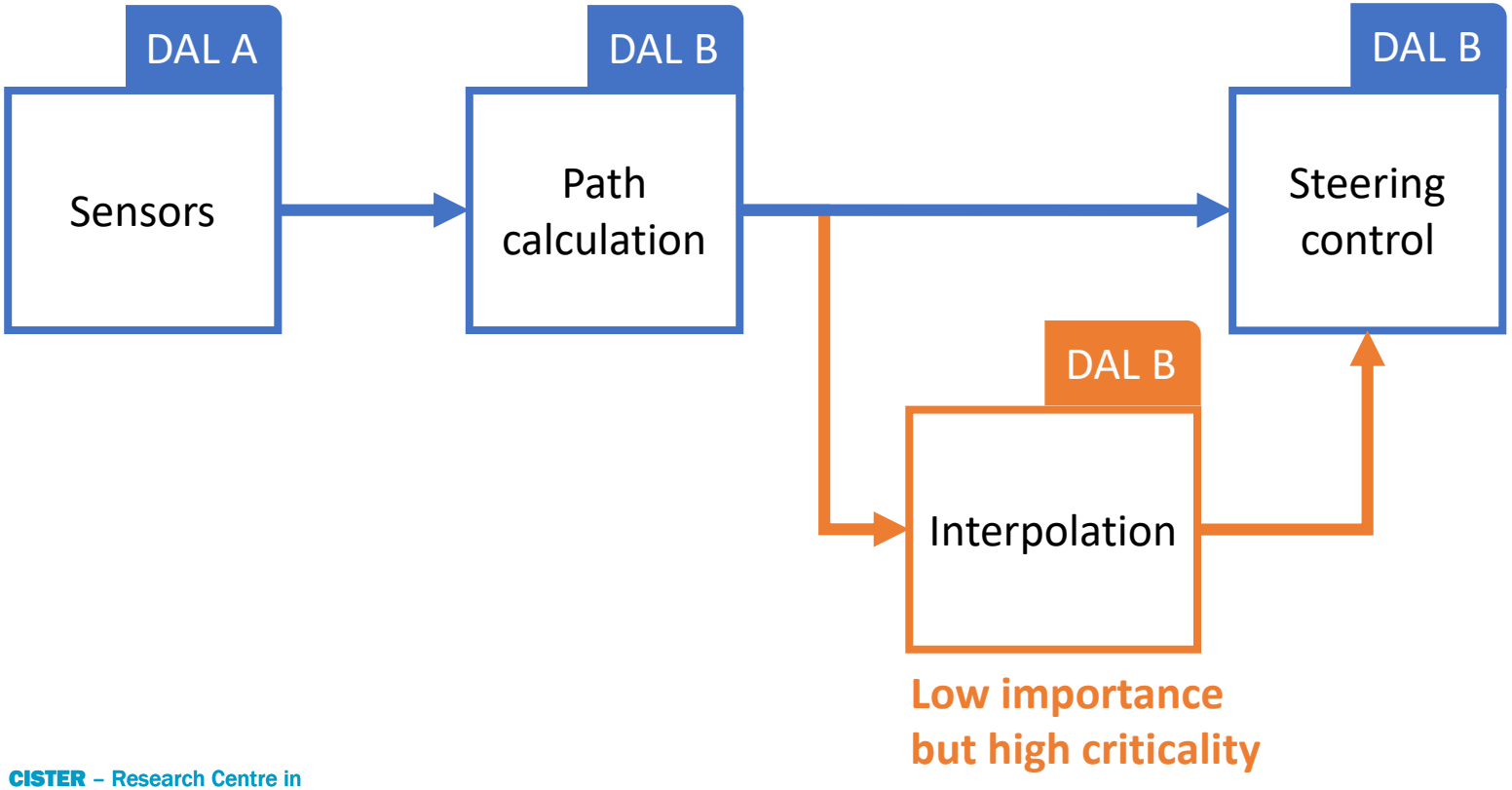

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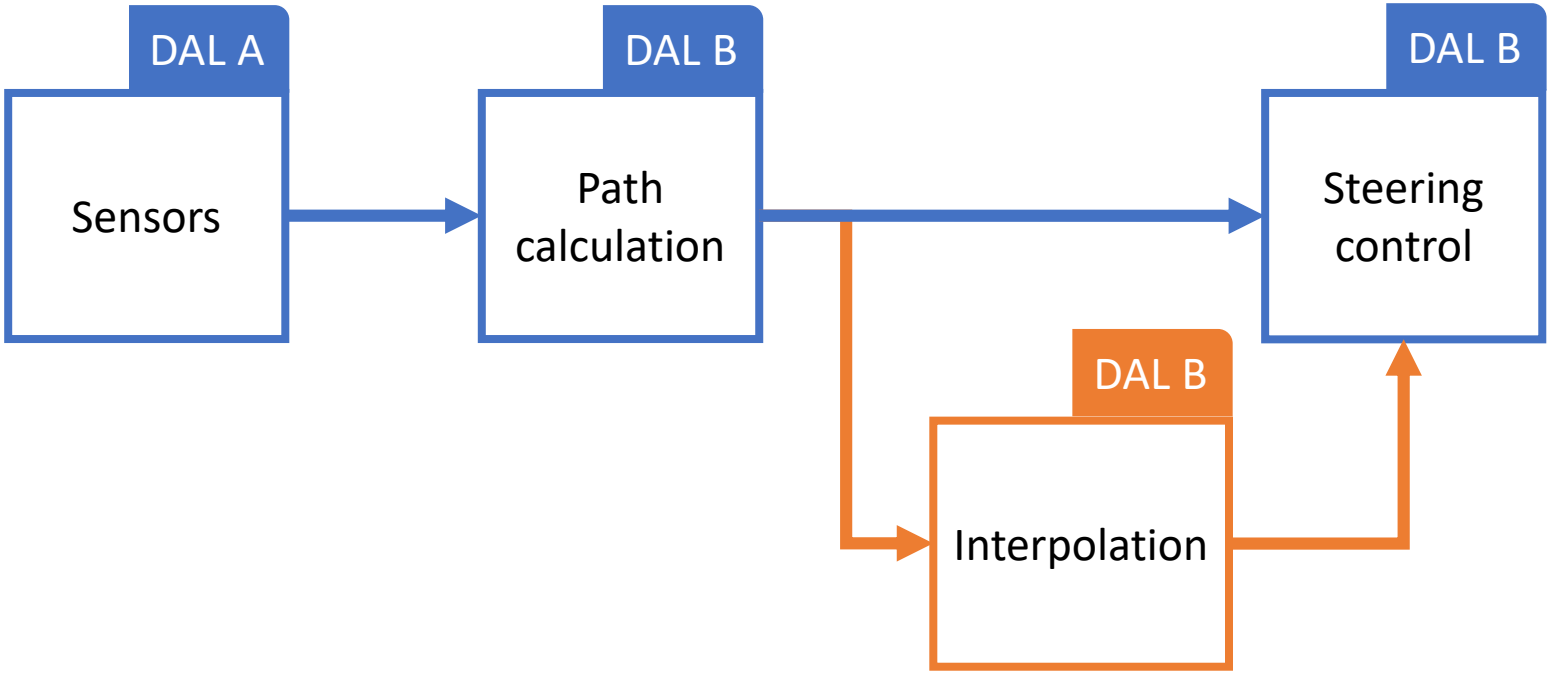

The decision of which function to keep running in case of a fault should not be based on criticality only

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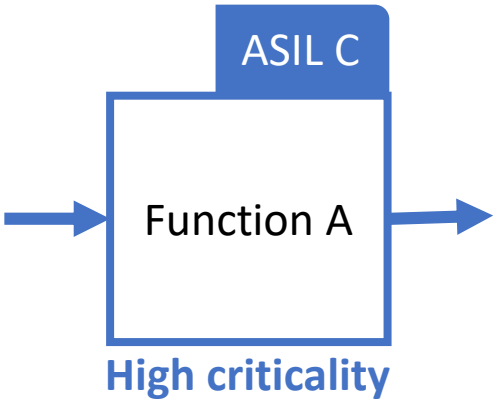

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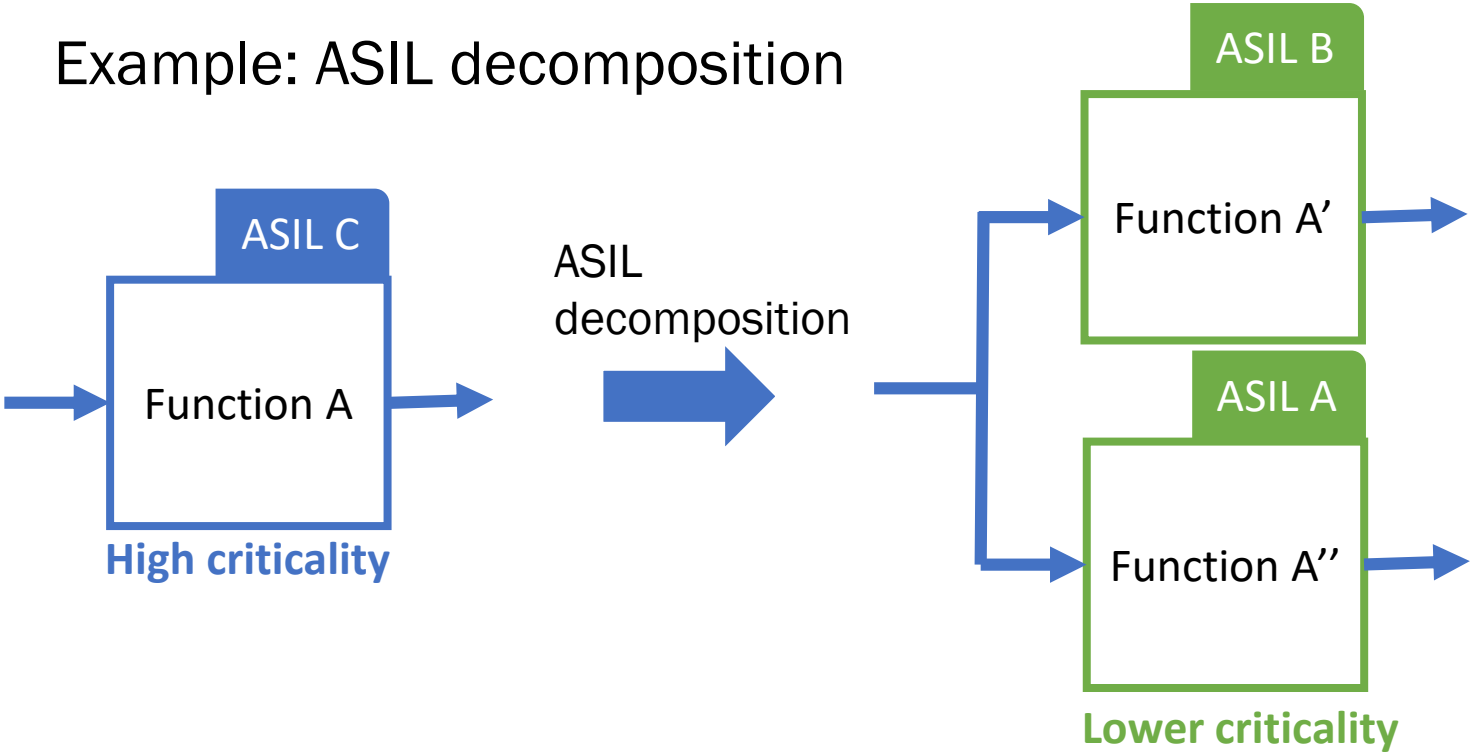

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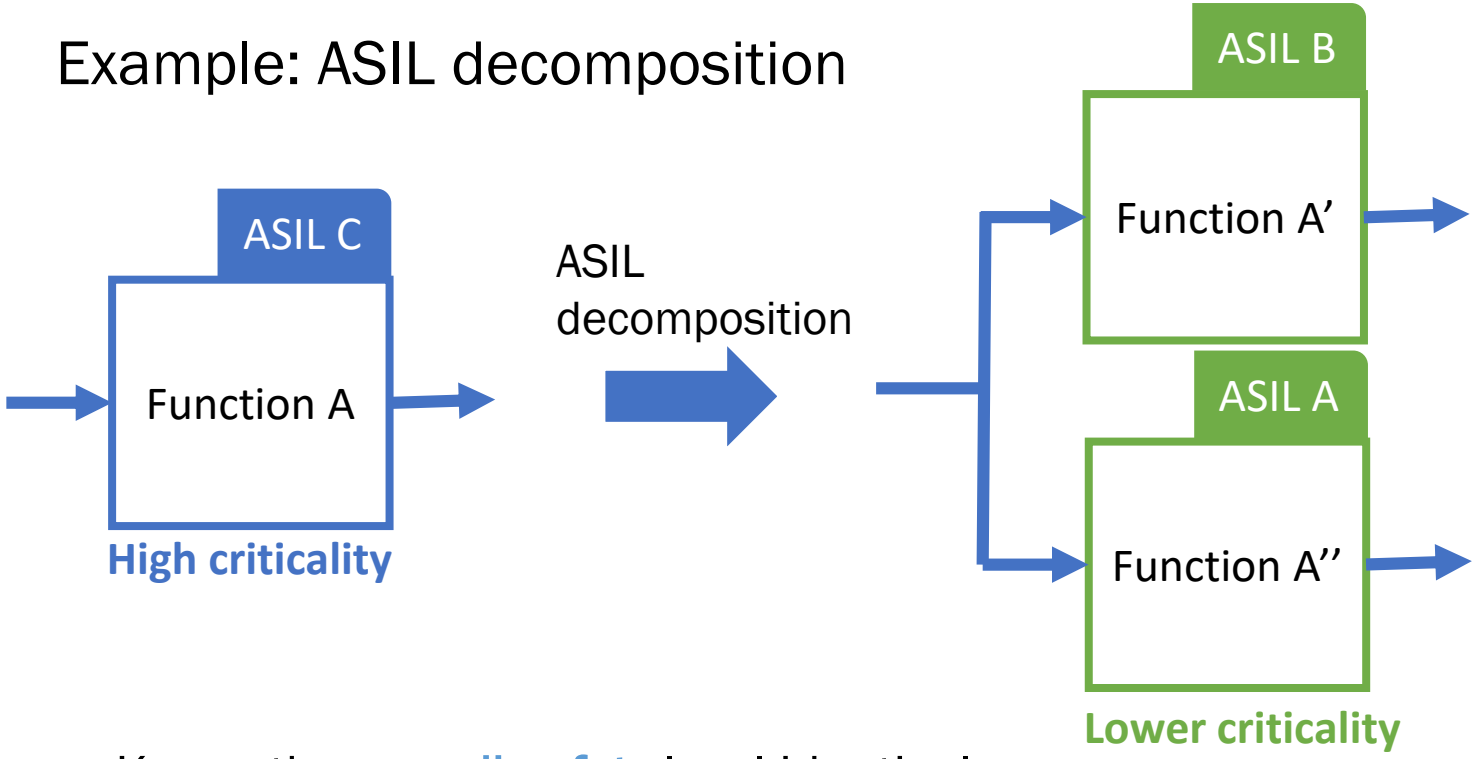

- Keeps the overall safety level identical
- Reduces cost and development effort

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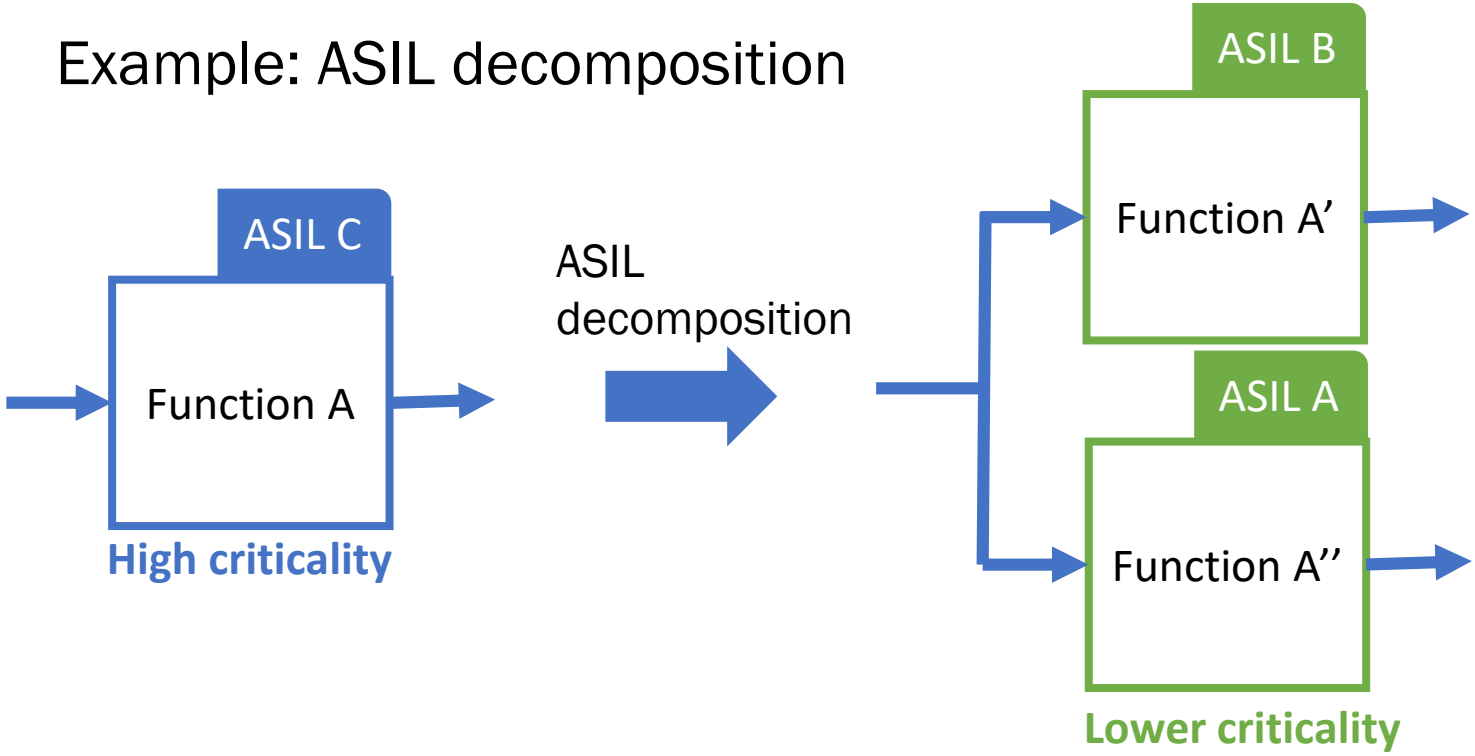

If a **safety mechanism** was to stop/penalize all lower criticality tasks whenever **one** of them **fails** ➔ ASIL decomposition would never be acceptable

The original message

- Presented a more industrially-oriented view of mixed criticality
- Raised awareness about the potential misunderstanding

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- Presented a more industrially-oriented view of mixed criticality
- Raised awareness about the potential misunderstanding

- Focused on what the MCS model is not ➔ It was perceived as dimishing the impact of a large body of work
- Did not discuss how to improve the state of things

The goal of this talk

- Analyse the so-called Vestal MCS model
- Understand its key properties
- Discuss its use and applicability

- Objective:
  - Extand/generalize the MCS model
  - Expand its reach to other problems than mixed-criticality systems

Vestal's model

Vestal's model

Tasks	Execution budget		Period	Deadline
	Model 1	Model 2		
Tsk1	C1	C1'	T1	D1
Tsk2	C2	C2'	T2	D2
Tsk3	C3	C3'	T3	D3
Tsk5	C4	0	T4	D4
…				
Tskn	Cn	0	Tn	Dn

Vestal's model

	Tasks	Execution budget		Period	Deadline
		Model 1	Model 2		
Subset 1	Tsk1	C1	C1'	T1	D1
	Tsk2	C2	C2'	T2	D2
	Tsk3	C3	C3'	T3	D3
Subset 2	Tsk5	C4	0	T4	D4
	…				
	Tskn	Cn	0	Tn	Dn

Two different models for each task to provide different guarantees

Vestal's model
Multi-mode version

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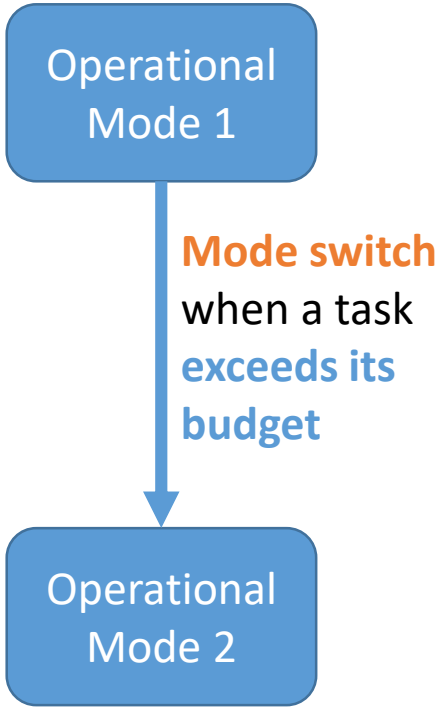

Vestal's model
Multi-mode version

Tasks	Execution budget		Period	Deadline
	System config. 1	System config. 2		
Tsk1	C1	C1'	T1	D1
Tsk2	C2	C2'	T2	D2
Tsk3	C3	C3'	T3	D3
Tsk5	C4	0	T4	D4
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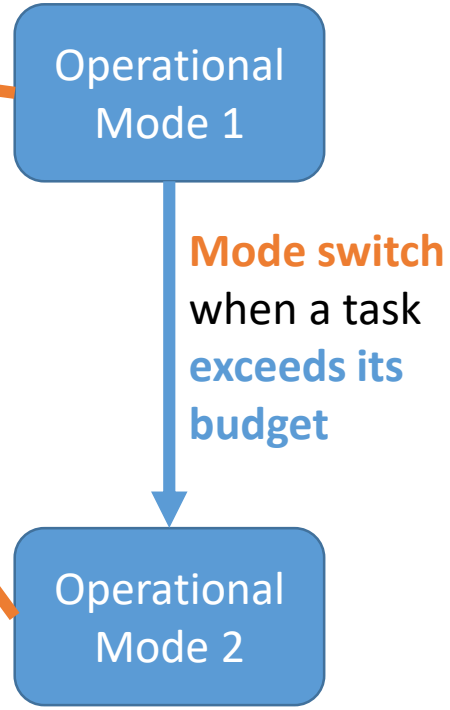
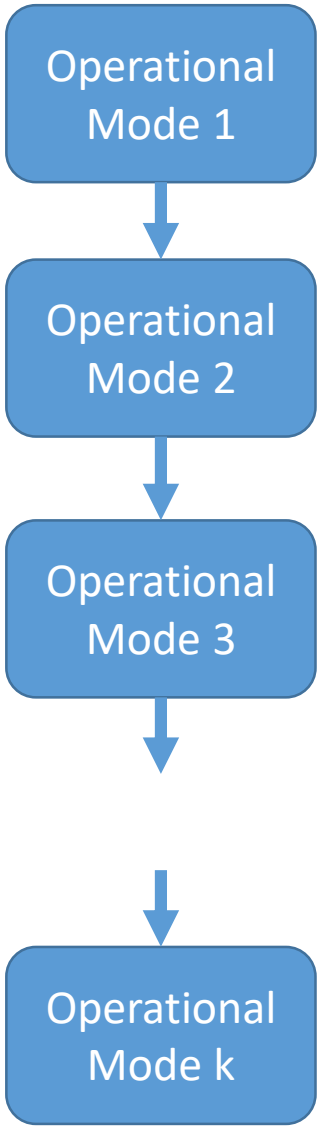


Vestal's model
Multi-mode version - Extensions

Tasks	Execution budget			Period	Deadline
	System config 1	System config 2	System config 3		
Tsk1	C1	C1'	C1''	T1	D1
Tsk2	C2	C2'	C2''	T2	D2
Tsk3	C3	C3'	0	T3	D3
Tsk5	C4	C4'	0	T4	D4
...					
Tskn	Cn	0	0	Tn	Dn



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Tasks	Execution budget			Period	Deadline
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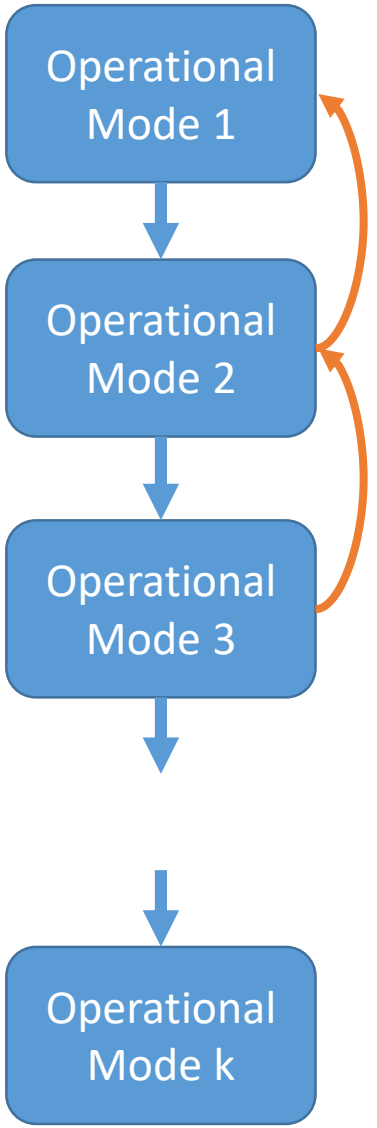

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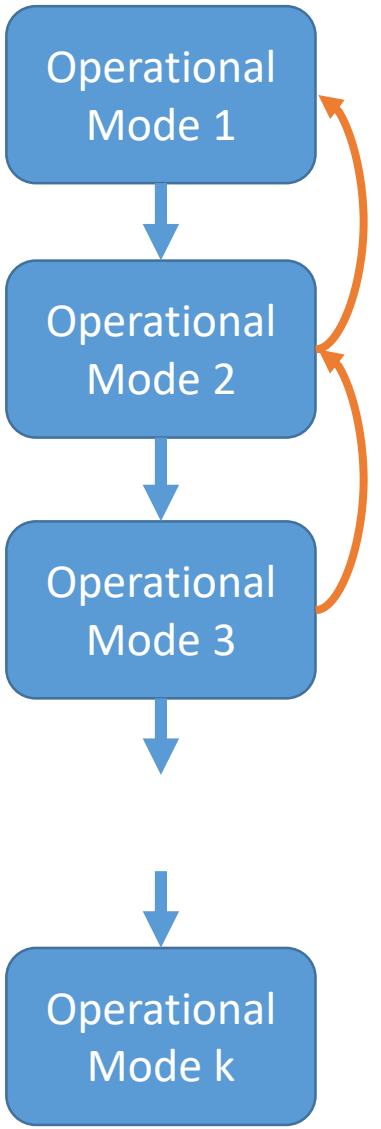

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	System config 1	System config 2	System config 1	System config 2	Sys. conf 1	Sys. conf 2
Tsk1	C1	C1'	T1	T1'	D1	D1'
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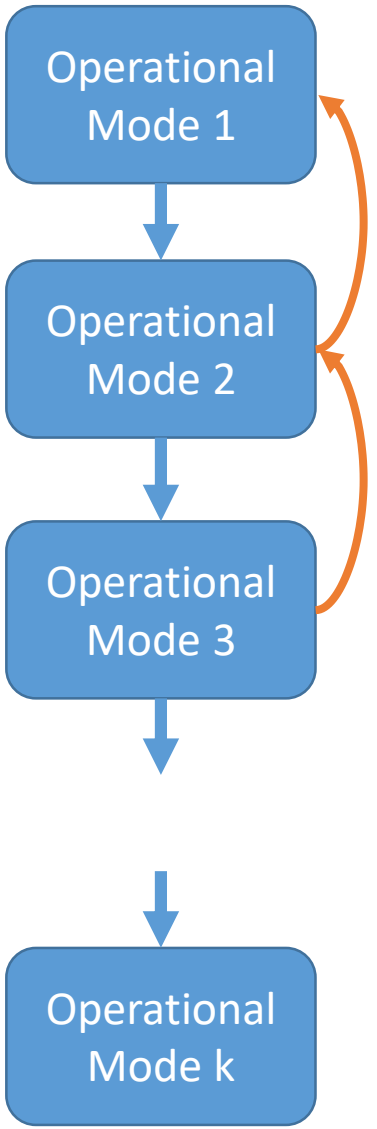

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- Each task has a different configuration (execution budget, period, deadline, ...) in each mode

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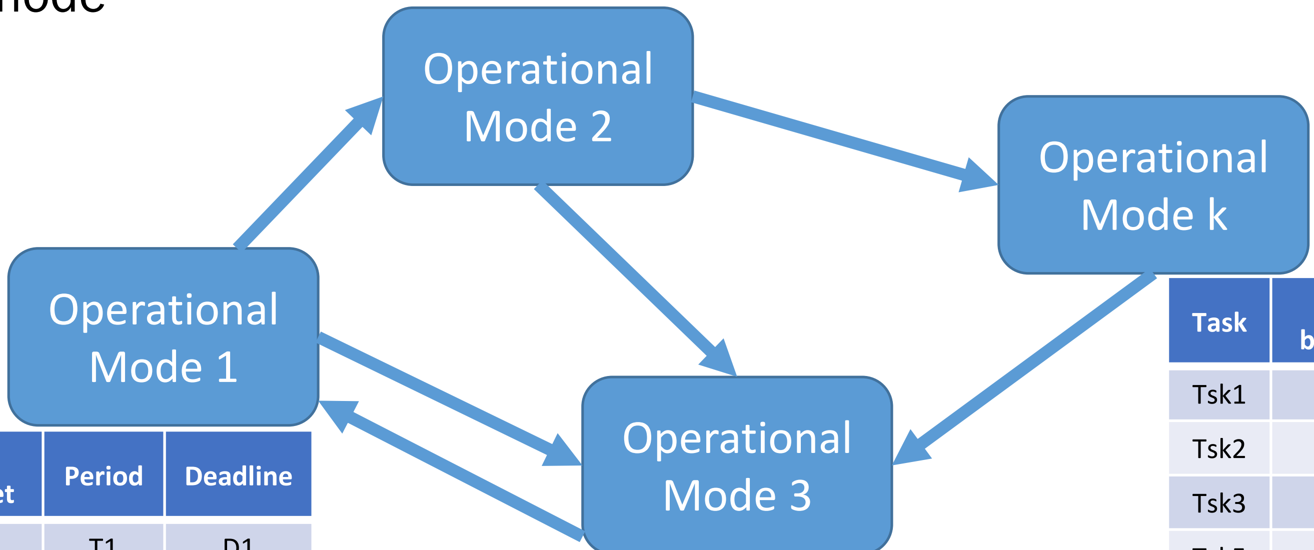

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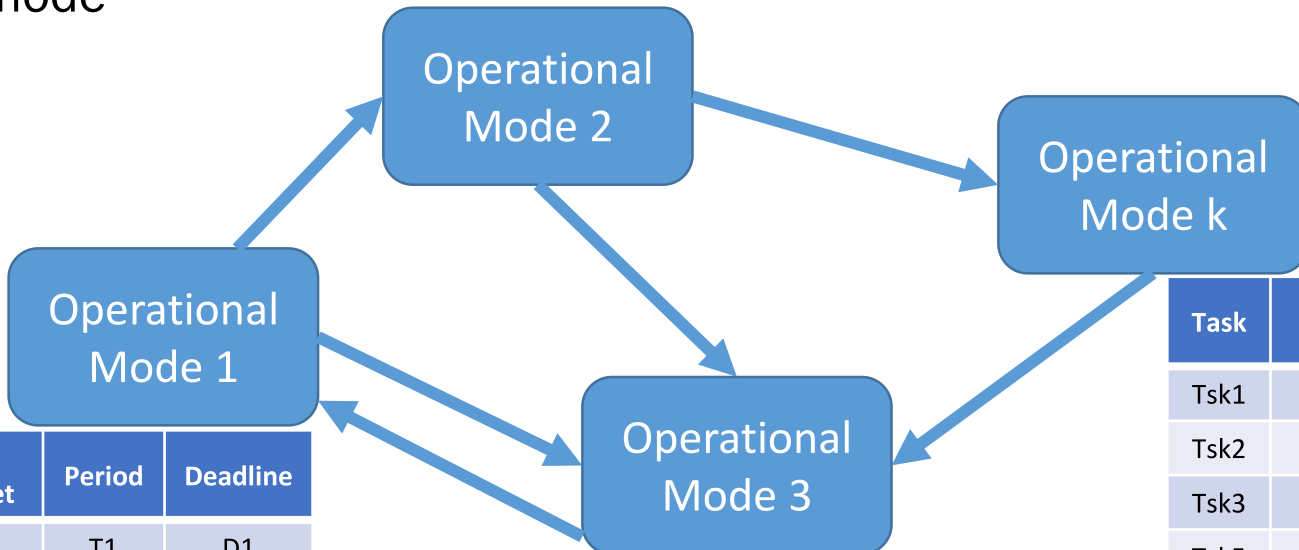

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Similar to Ekberg and Yi 2014

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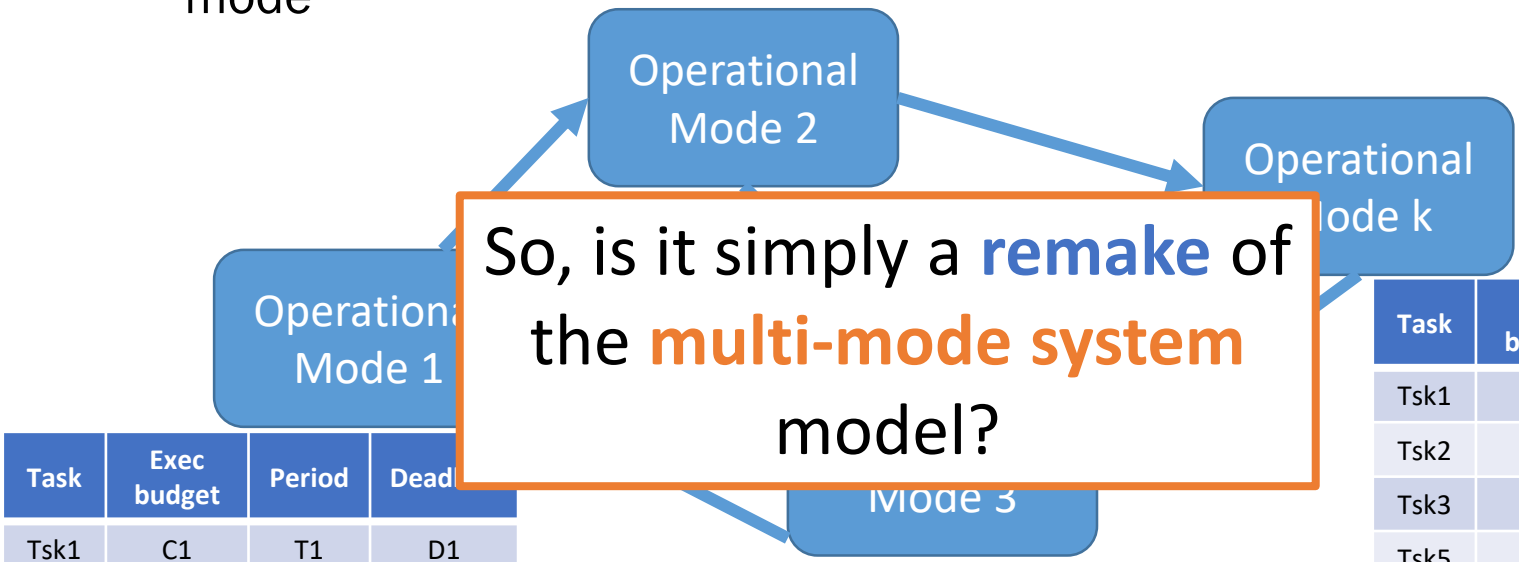

So, is it simply a **remake** of the **multi-mode system** model?

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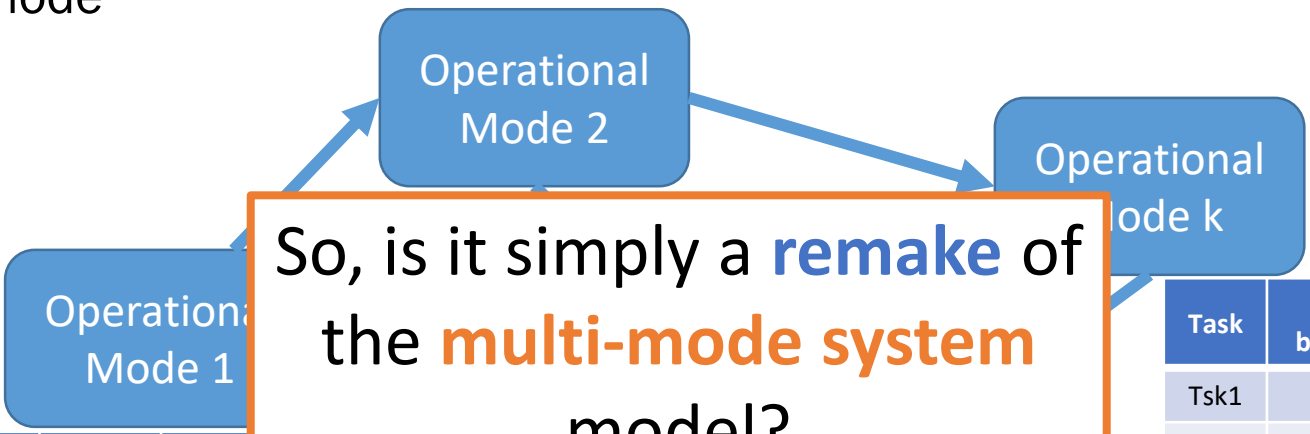

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Difference with multi-mode

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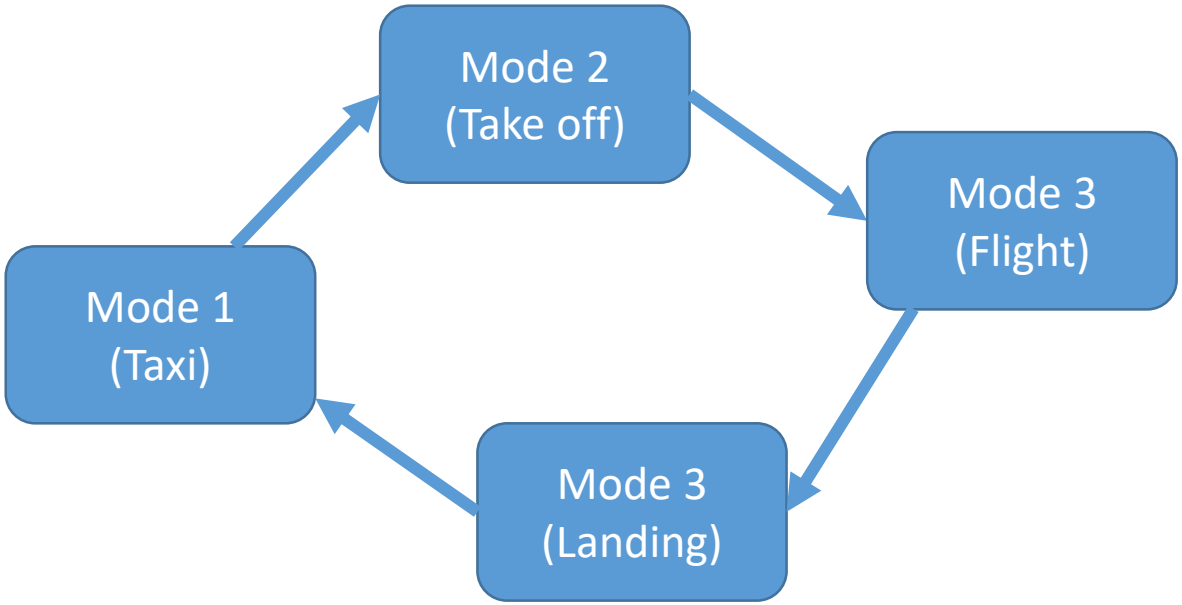
- Multi-mode system model
  - Mode changes are triggered by external requests
  - The system must adapt with a bouded delay



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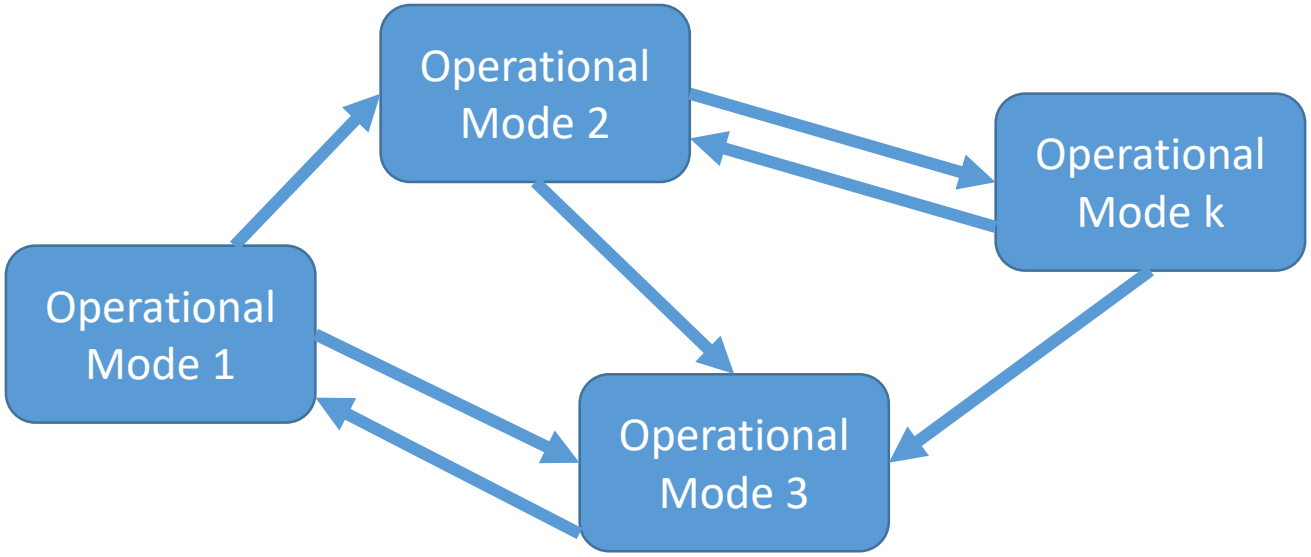

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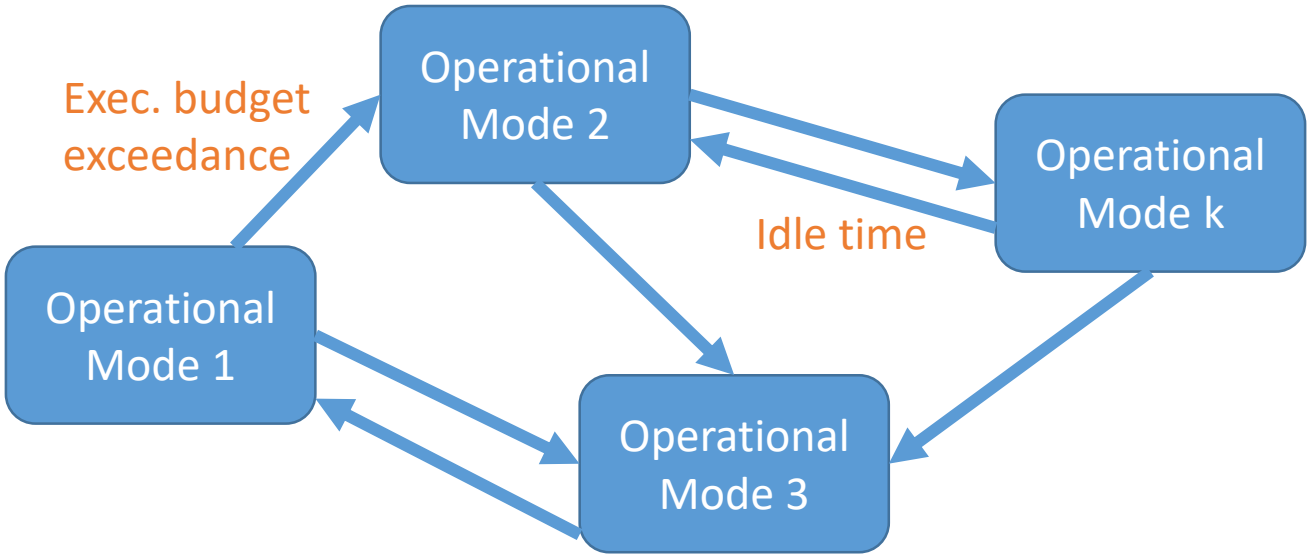

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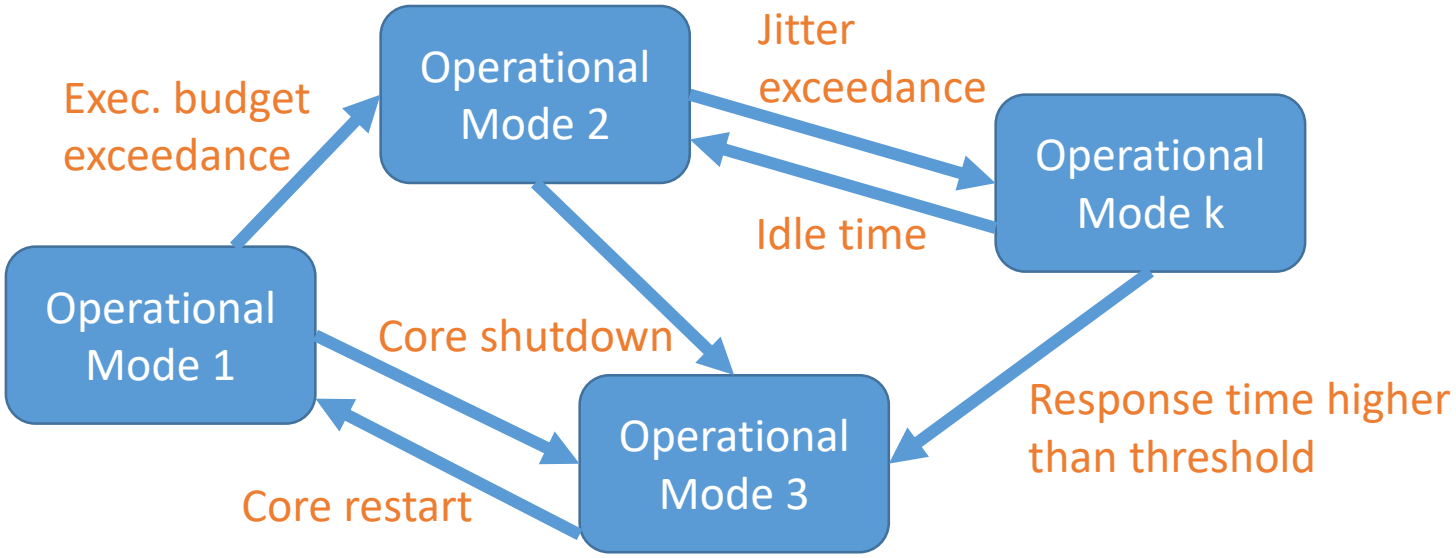

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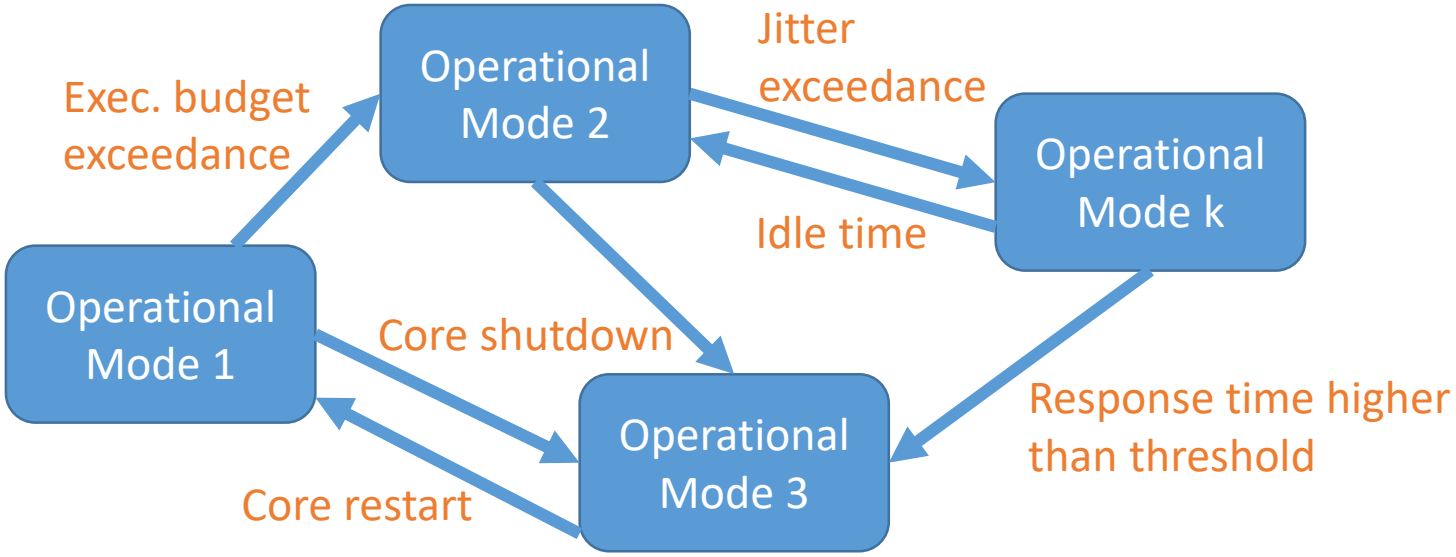

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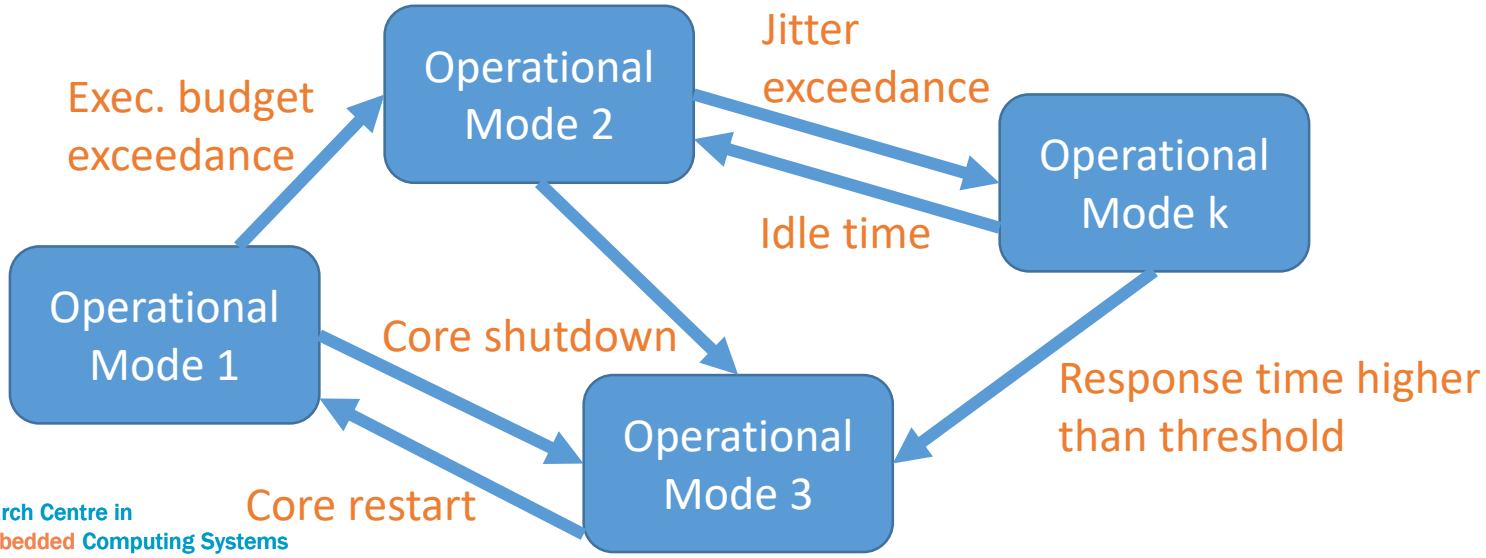
    ➔ we know which system state(s) may trigger a mode switch
    ➔ more efficient analysis/scheduling strategies are possible



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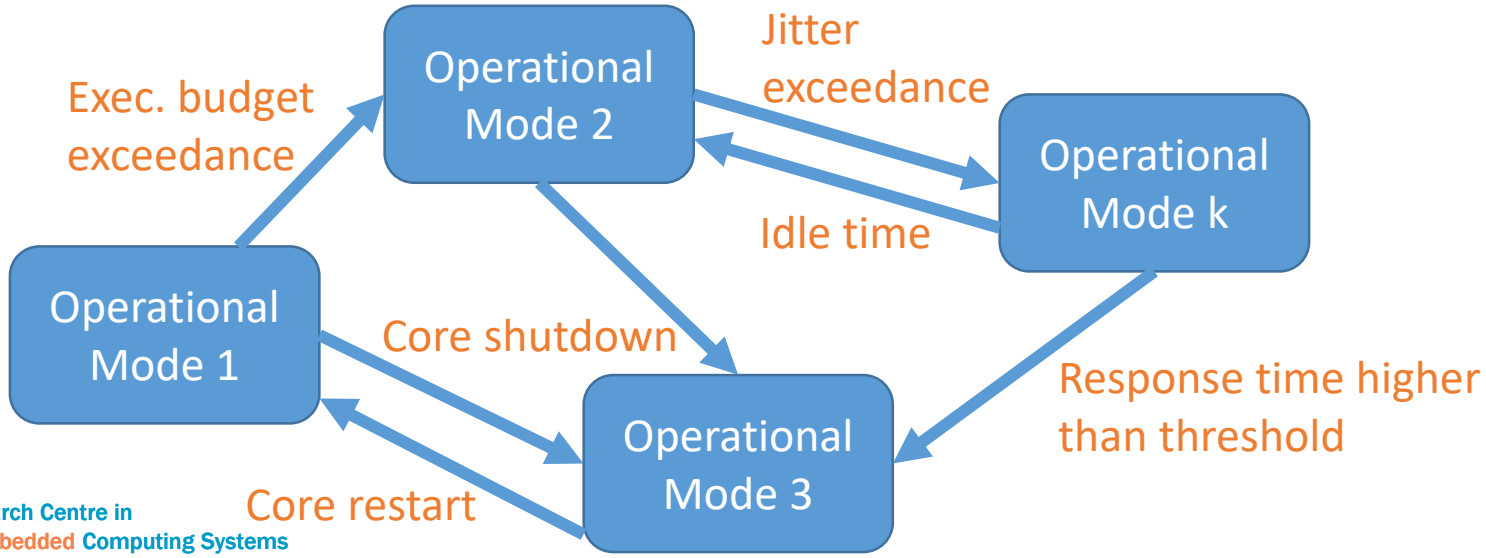

A new name?

- Self-adaptive system model
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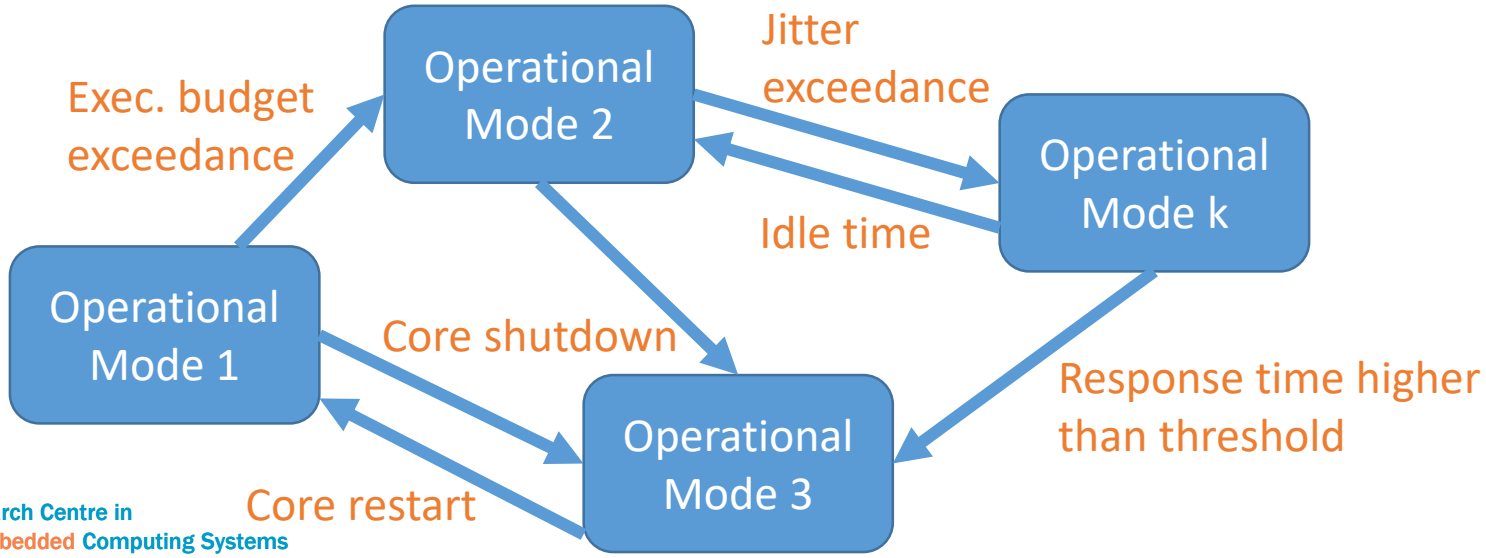

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- Soft or firm real-time systems
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- Self-optimising systems
  - System optimises its behaviour based on observable parameters (e.g., response time, execution time, inter-arrival time or jitter)

Conclusion

- Yes, Vestal's model may be useful for certification of safety critical systems but …
- … the viewpoint should change
  - The notion of criticality should probably not be the key aspect
  - Emphasis should be made on operational modes, system configurations in those modes and observable properties that trigger mode changes
- The applicability of Vestal's model generalization is not restricted to safety critical systems

Future work and open problems

- Define a generic terminology for the generalized model discussed here
  - No ambiguity
  - No double meanings
- Migrate and extend the existing theory to actual existing problems out there
- Mix the self-adaptive system model with the multi-mode system model
  - i.e., react to both internal observables and external requests

Questions?