

Real-Time Systems

1-Introduction

Antonio Camacho Santiago
antonio.camacho.santiago@upc.edu

Motivation of RTS

1-Introduction

Would you pilot an airplane running Windows Vista and Norton antivirus?



Motivation of RTS

1-Introduction

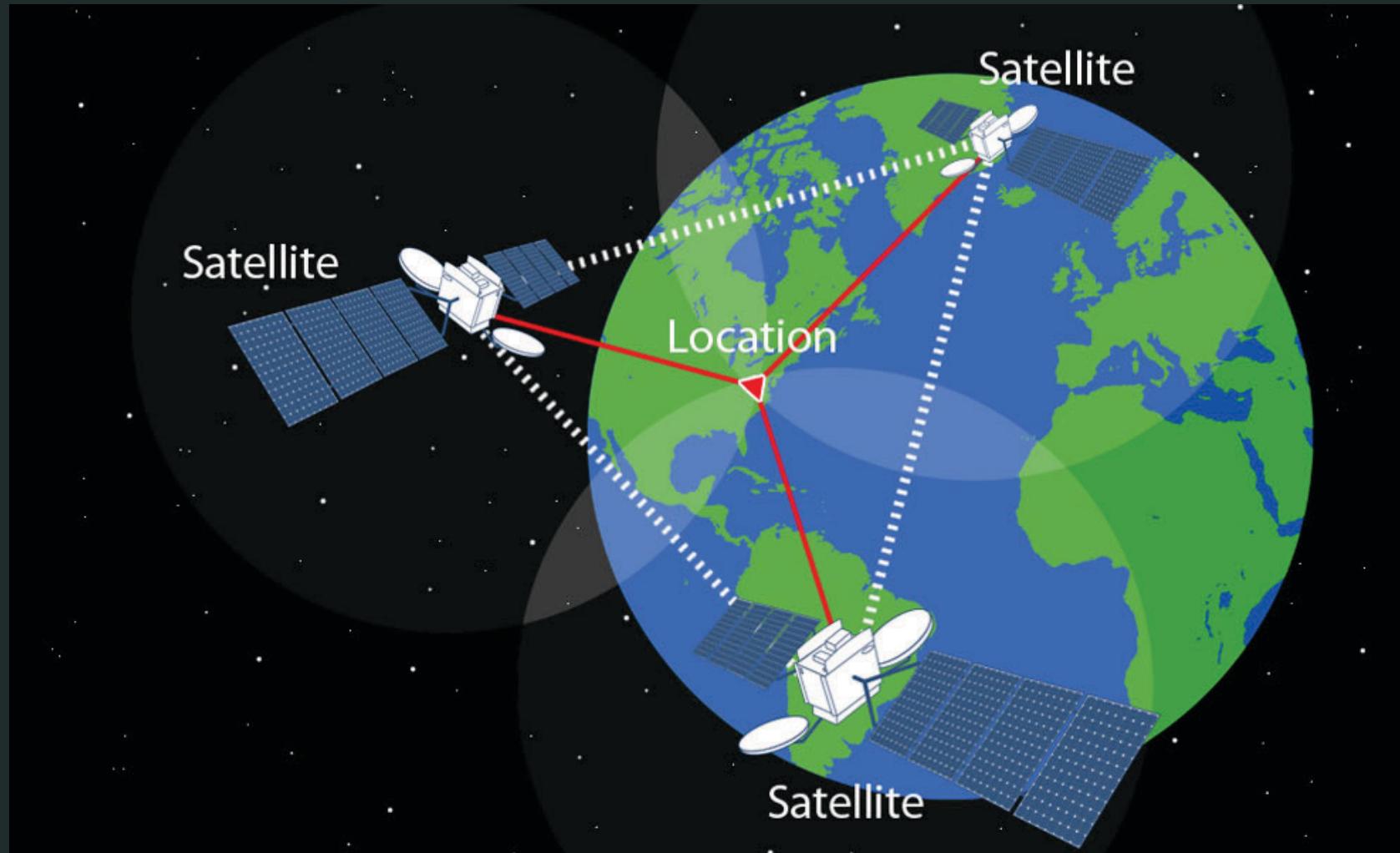
Would you drive a car with unpredictable timing-constraints for the brake?



Motivation of RTS

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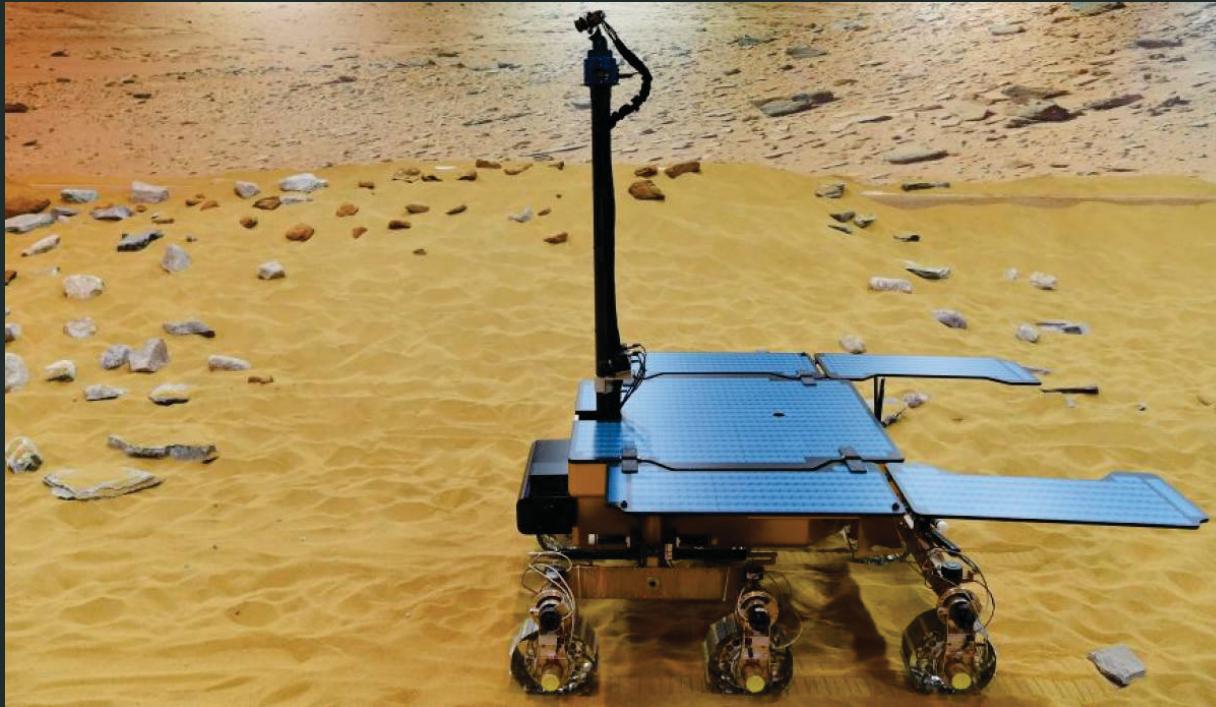
Would you believe in the position of a badly conditioned GPS system?



Motivation of RTS

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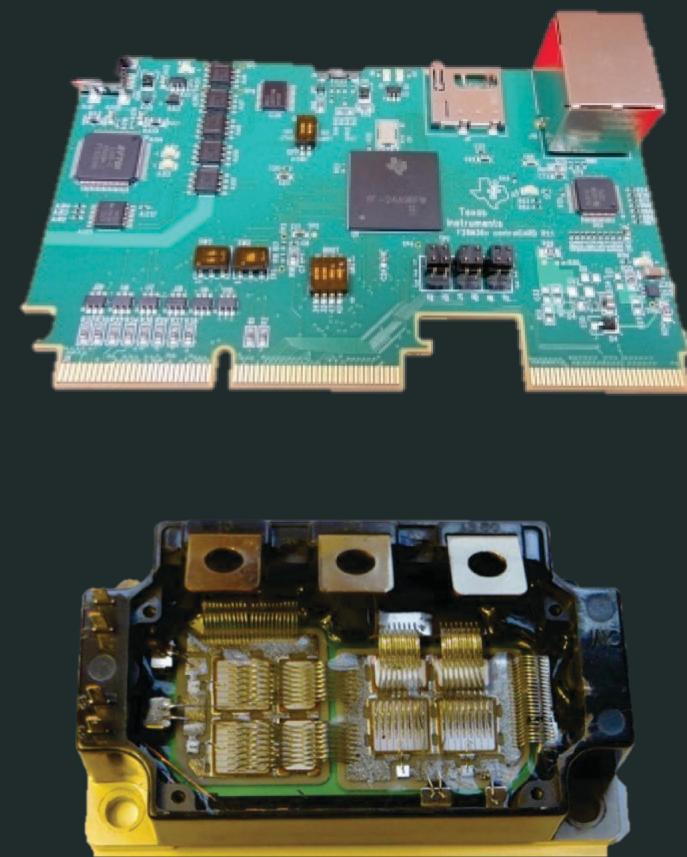
Would it be possible to move a robot without appropriate scheduling?



Motivation of RTS

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How can a 10€ microcontroller drive 6MW of power?



Motivation of RTS

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Can a Segway be controlled without RT guarantees?



How do you feel when video streaming fails?

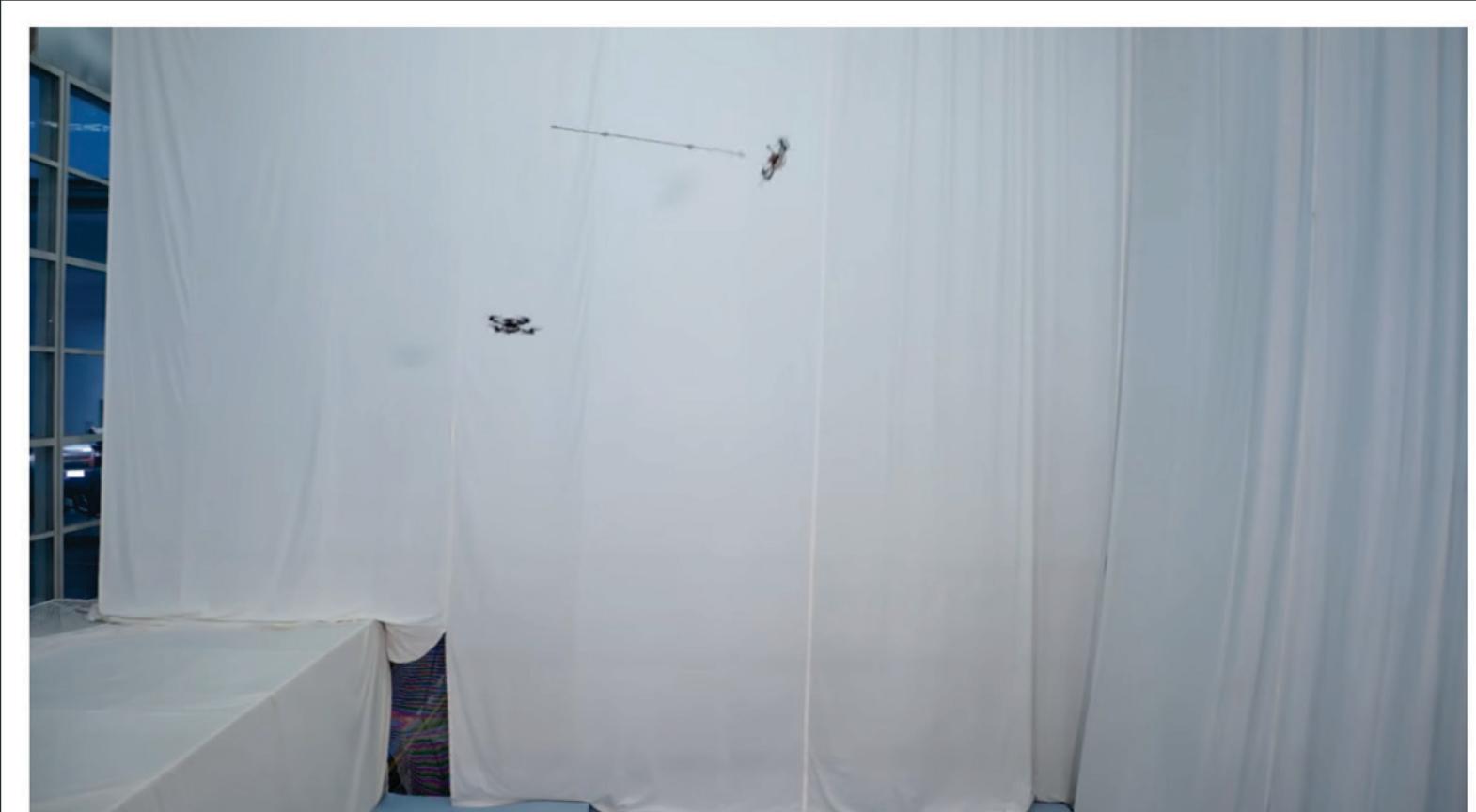
THE
TWILIGHT
ZONE



Motivation of RTS

1-Introduction

How is this possible?



Quadrocopter Pole Acrobatics

Time requirements:

- Time elapsed from CAN_high_beams=TRUE until OUTPUT_high_beams=TRUE should be less than 20ms
- Time elapsed from no power to full power for the onboard charger should be less than 5 seconds
- From CAN_WakeUp message to acceptance of the CAN state and its confirmation, less than 100ms must elapse
- CAN confirmed absent state should be realized after 5 messages being lost

What's a Real-time system?

“Any system in which the time at which output is produced is significant”

A Dictionary of Computer Science (7 ed.)

What's a Real-time system?

The time elapsed to generate an output is bounded.

The performance depends not only in the solution but in the time it occurs.

What's **NOT** a Real-time system?

A fast system.

A system with high resources (μ -processors, RAM, ...) available.

Sometimes the difference between RT and non-RT systems is clear.

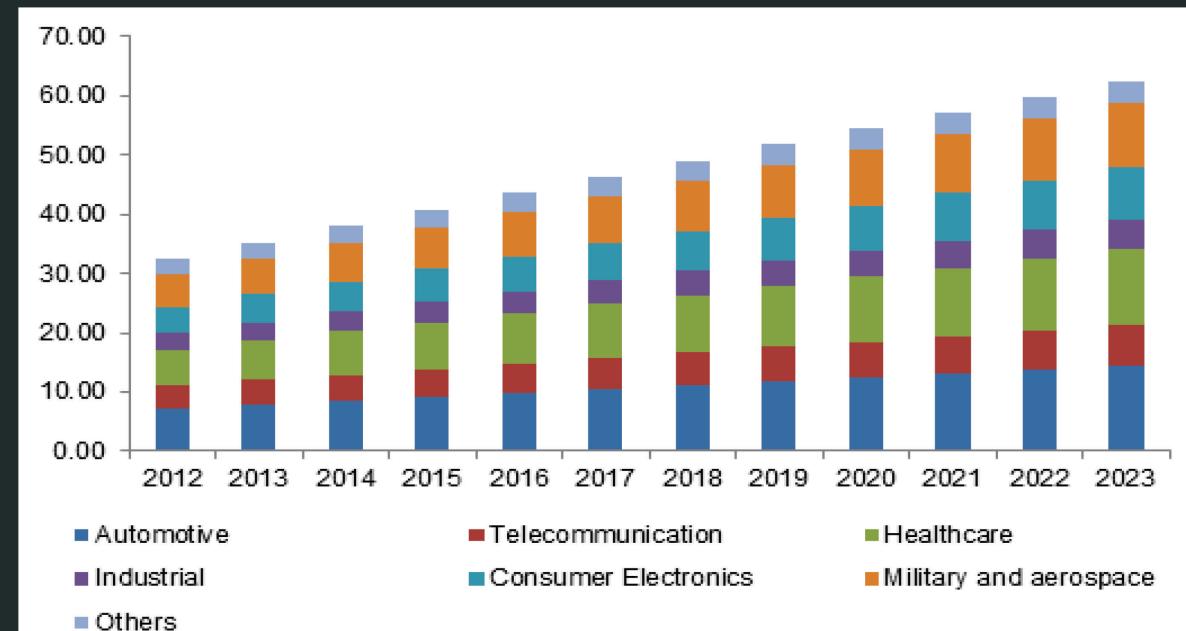
However, sometimes it is not.

An embedded system is a computer system aimed to perform dedicated tasks

98% of all processors in the planet are embedded in other objects

Many daily applications are embedded

Typically, embedded systems must fulfill RT requirements

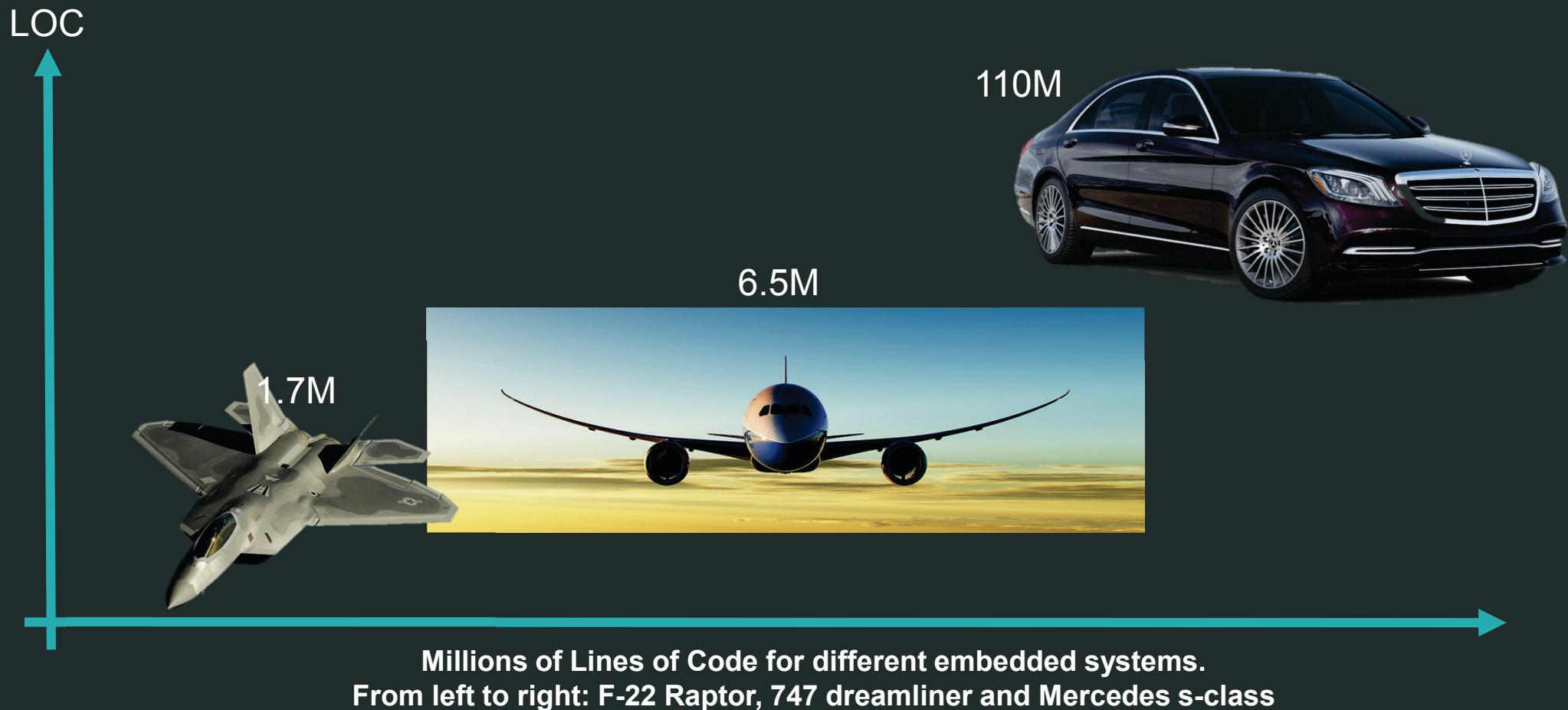


Europe embedded system market size, by application, 2012-2023 (USD Billion)

Embedded systems

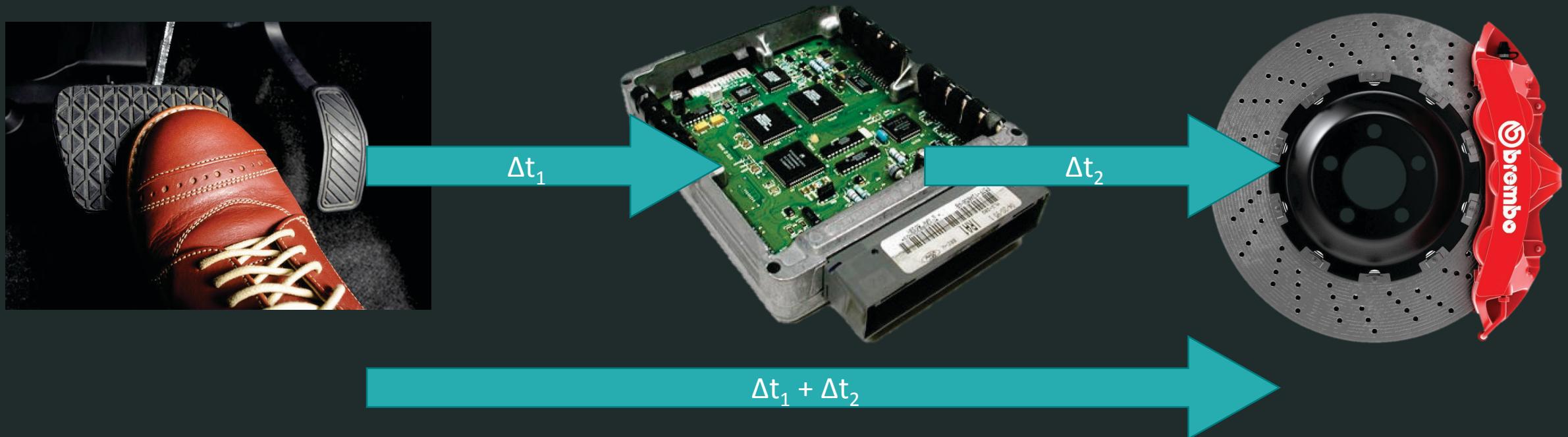
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Lines of code of embedded systems



Embedded control systems are a special RT case of embedded systems.

Ex.: Anti-lock Brake System.



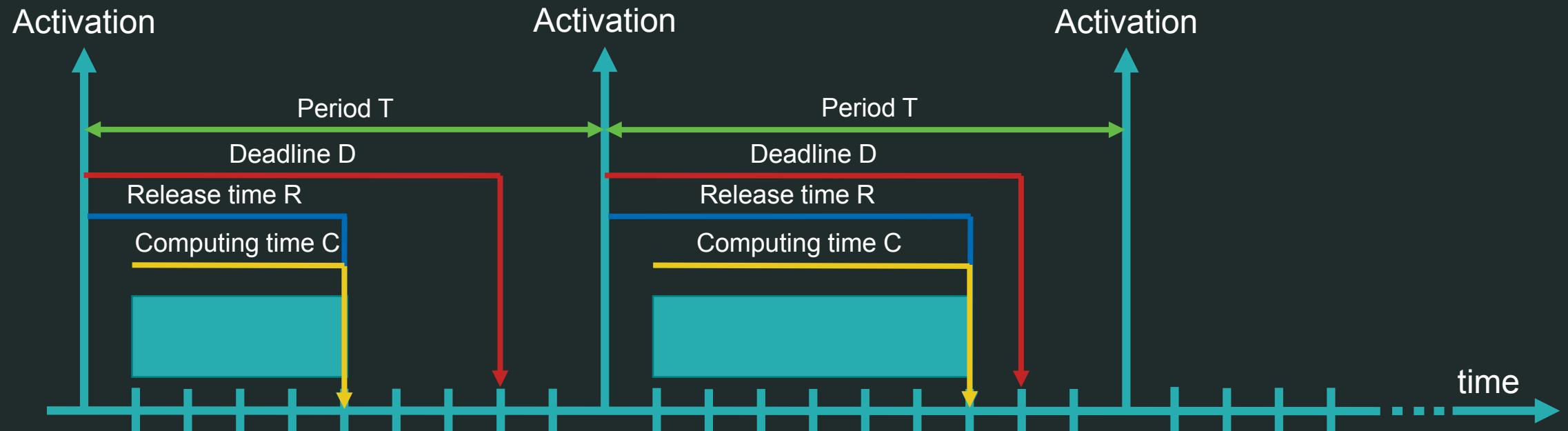
A correct action executed too late can be useless or even dangerous.

This will be the main topic addressed during the course, focusing on RT methodologies.

Concepts and Definitions

1-Introduction

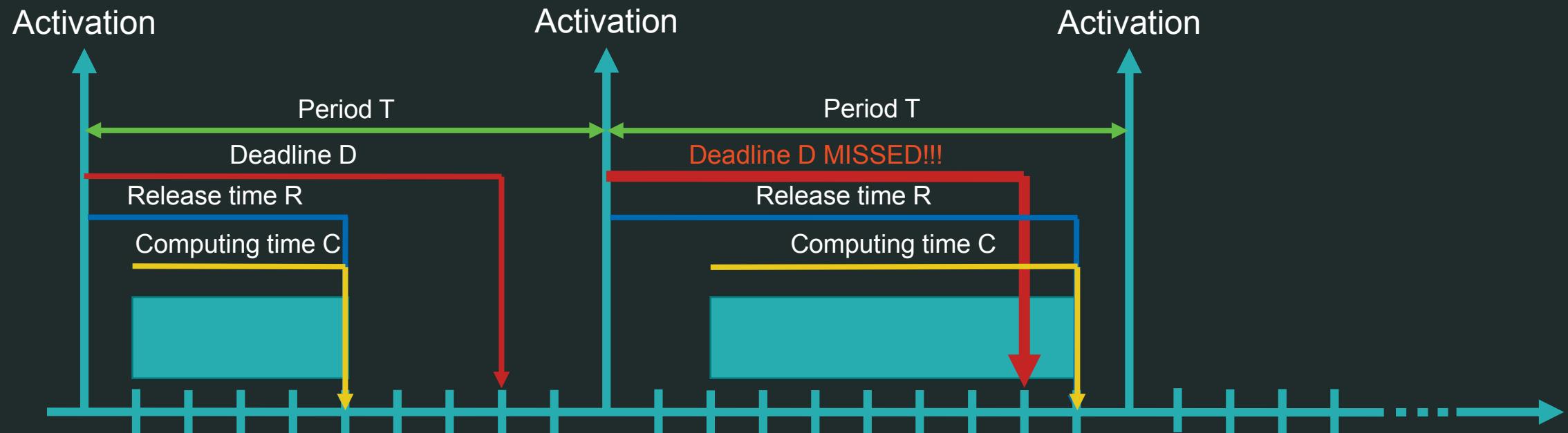
Time requirements of a task



Concepts and Definitions

1-Introduction

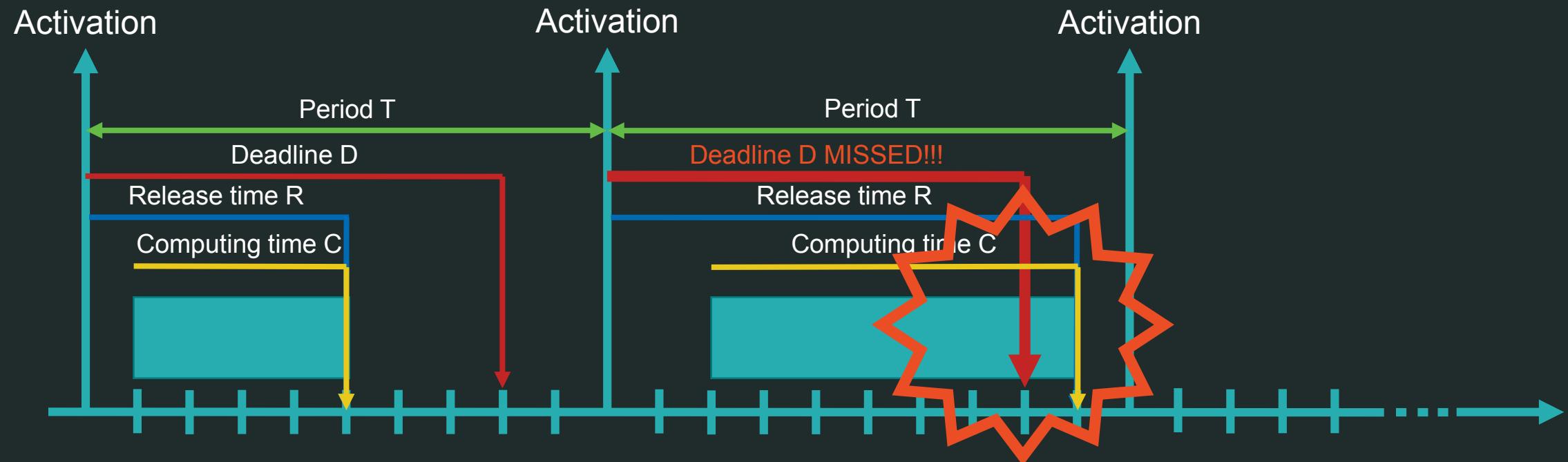
The problem: missing a deadline!!!



Concepts and Definitions

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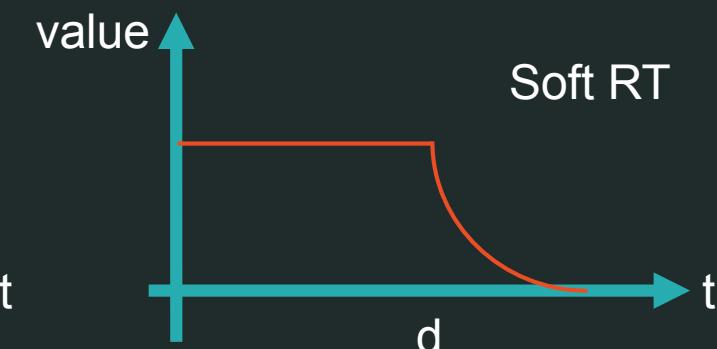
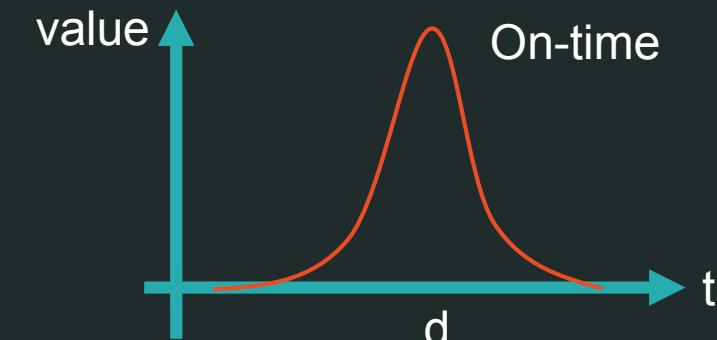
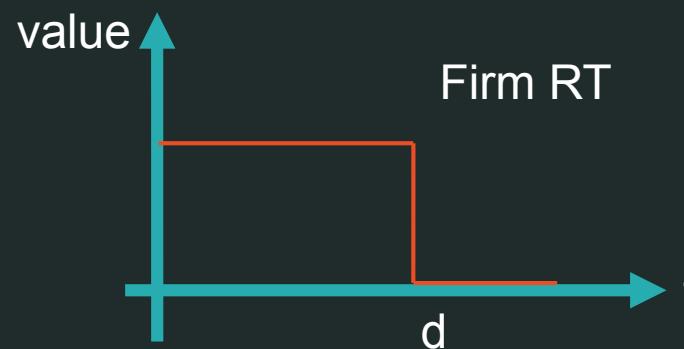
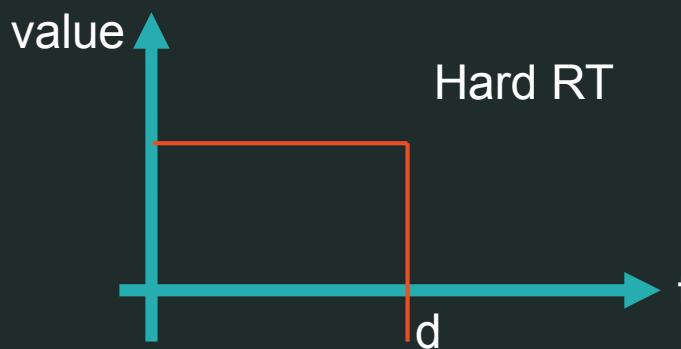
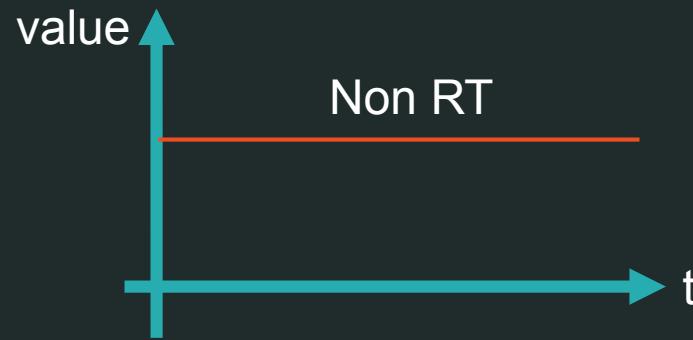
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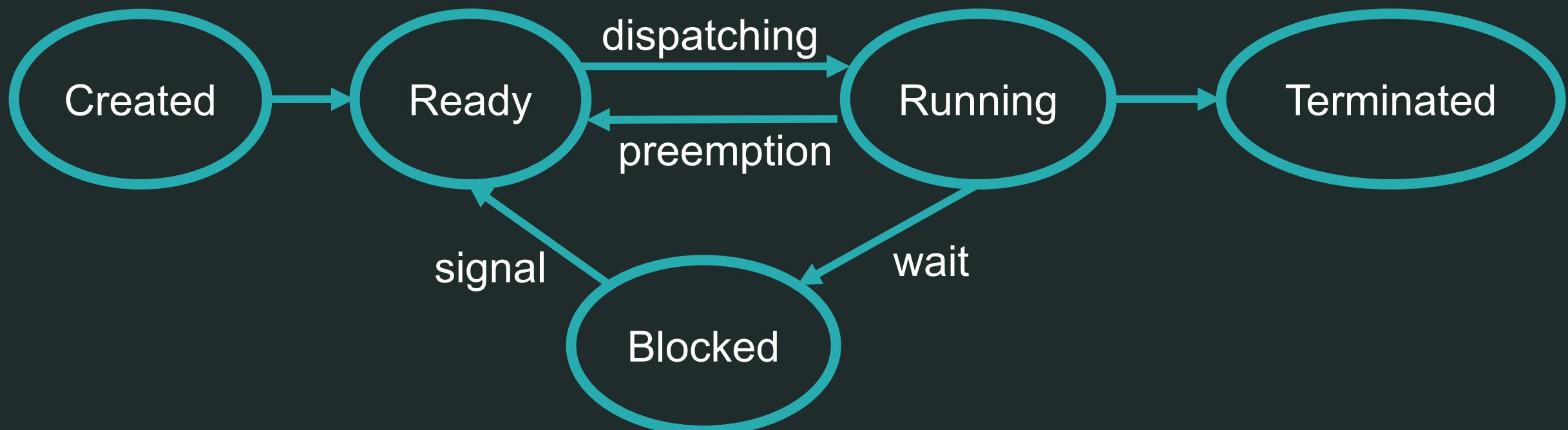
Concepts and Definitions

1-Introduction

RT-model depending on the effects of missing a deadline



A typical structure of the state of a task. Task life-cycle:



Infinite variations may exist

Schedulers:

Cyclic

Rate monotonic, Deadline monotonic

Earliest Deadline First, Earliest Due Date

...

Worst Case Execution Time (WCET)

RT Operation System (RTOS)

Latency, jitter, granularity, ...

Fixed/Dynamic Priorities, Priority inversion, ...

Critical section, resource allocation, ...

...

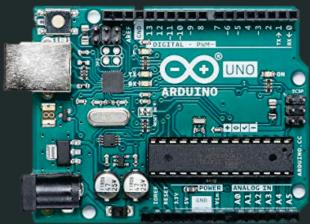
Parallel computing

Communications (IoT, industry 4.0, ...)

Resource constrained embedded systems

Event driven, self-triggered, send on delta, ...

Trends in micro-controllers architecture (for embedded control systems)



Single microcontroller
Low cost



Digital Signal Processor (DSP)
Advanced processing



DSP (dual-core)
RTControl+Communications



Hardware/Software PID
(Micro + 3 PID Peripherals)



FPGA (Field Programmable
Gate Array)