SOLUTIONS TRANSFER FROM SPACE TO AUTOMOTIVE SYSTEMS

13th May 2016, Stuggart

ANNUAL AUTOMOTIVE EMBEDDED MULTI-CORE SYSTEMS SUMMIT

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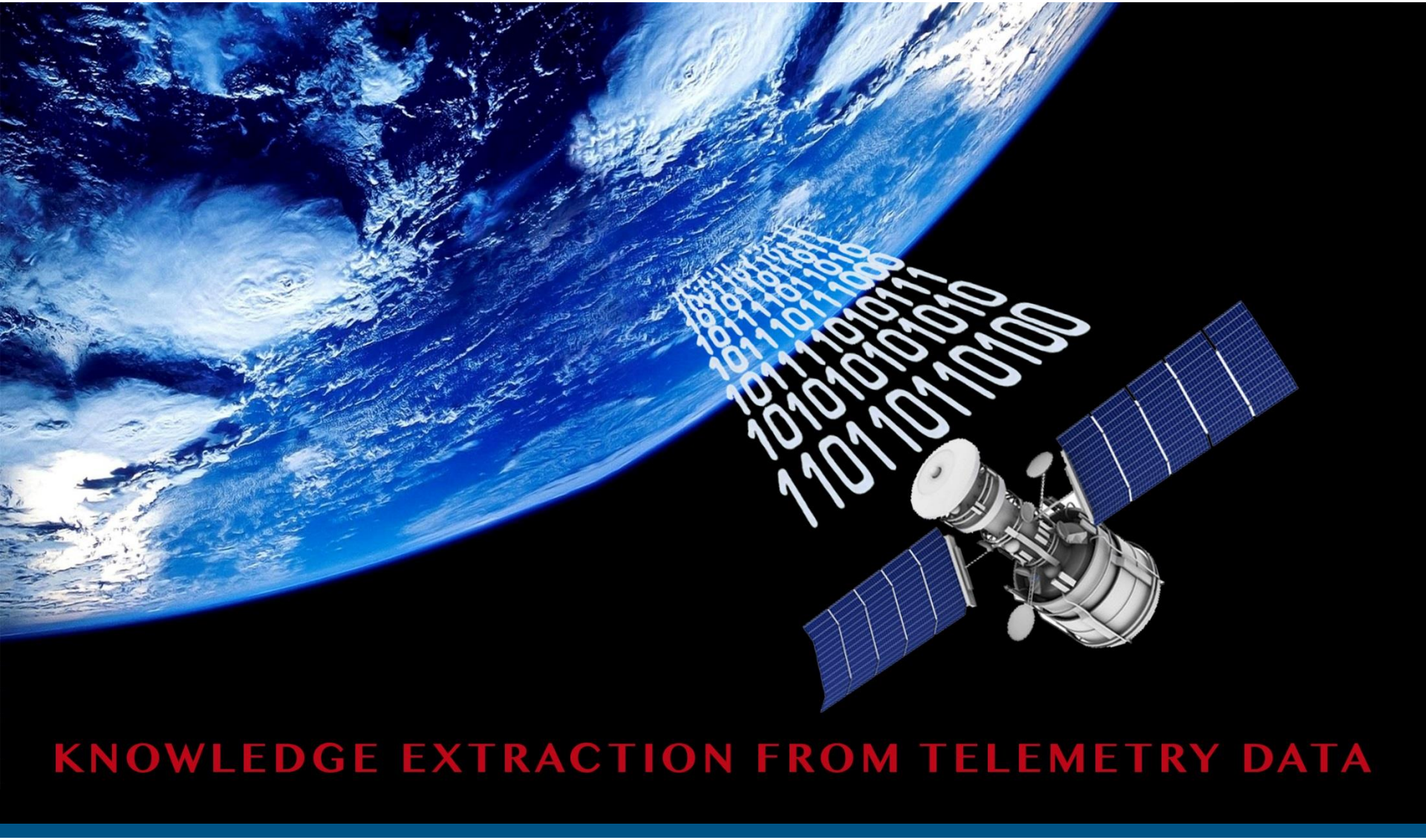
Summary

- **WHERE?**
- **WHAT?**
- **WHY?**
- **EXAMPLES**
- **NEXT?**

From the space sector...



… to the automotive sector

Going through the medical sector

Data deluge

Summary

- WHERE?
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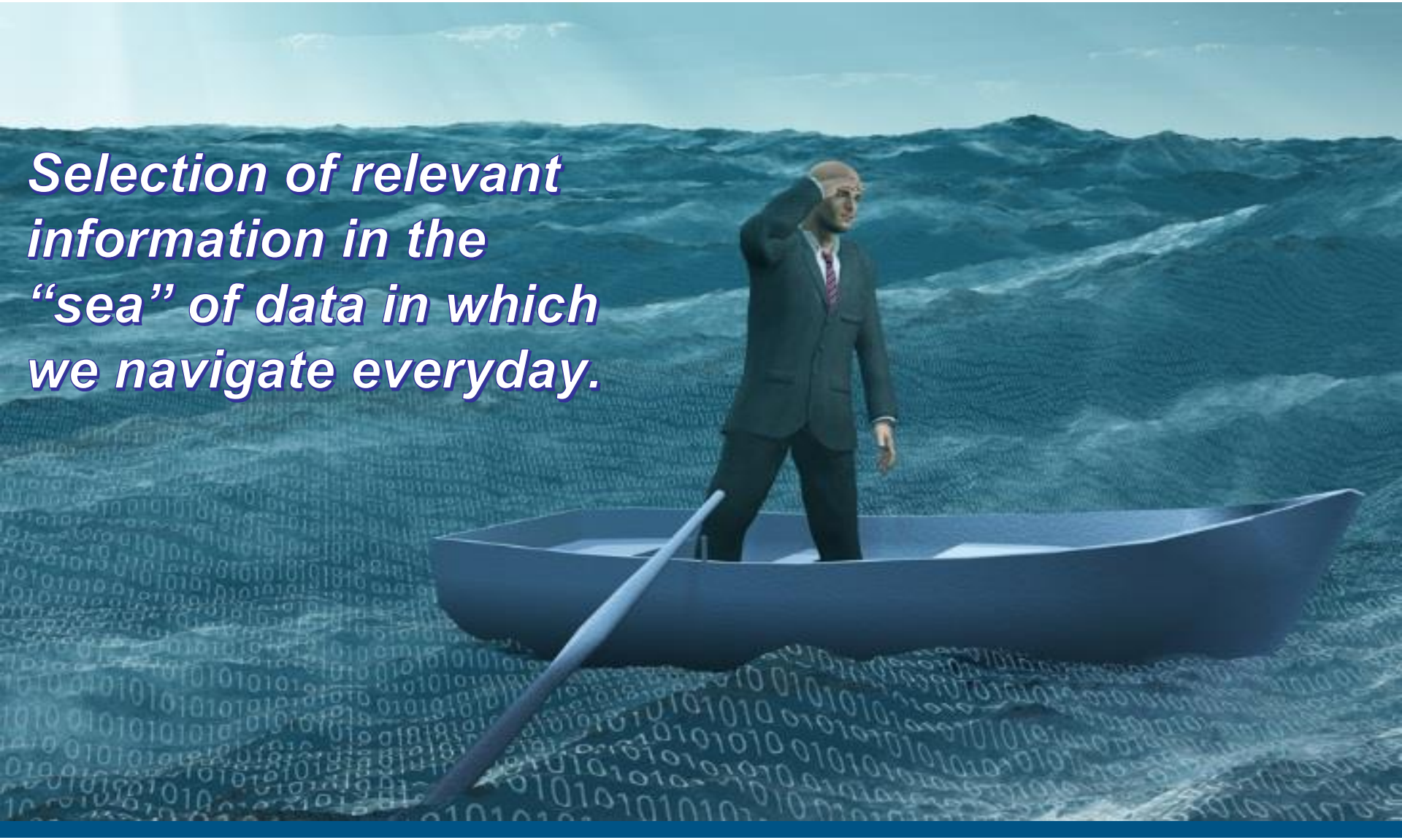
- NEXT?

A common problem



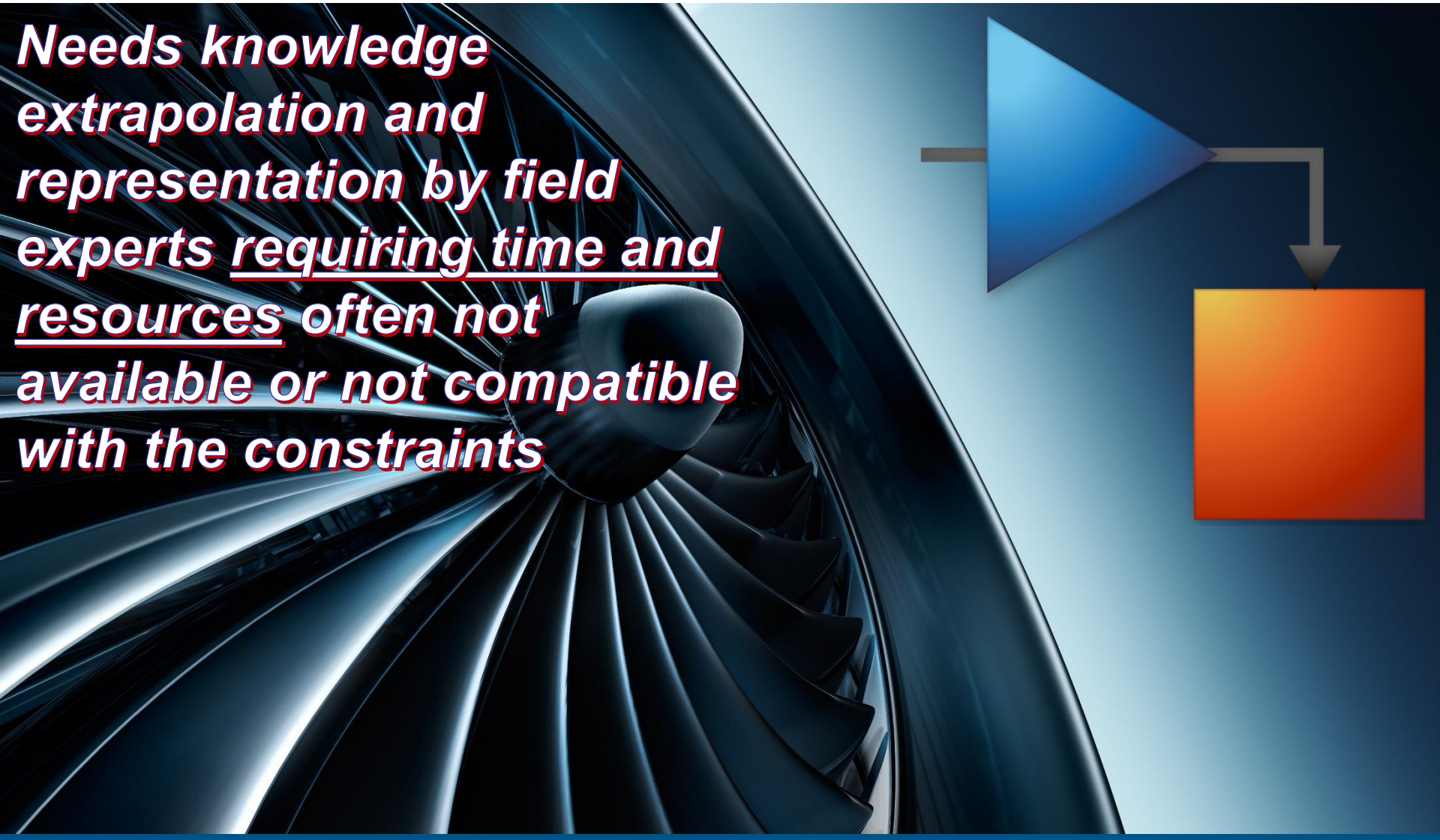
Knowledge extraction & diagnostics

Nominal behavior

This nominal behaviour may be used as reference to automatically identify normal observations and any "new" phenomena

NOVELTY DETECTION OR BROADLY SPEAKING DIAGNOSTICS

Model based approach



Model based approach

Data-based approach

Knowledge extraction

Knowledge extraction is based on the ***comparison*** between data acquired in two different time periods, in order to detect novelties in the behaviour of the parameters.

Reference dataset

Comparison dataset

2013

2014

2015

2016

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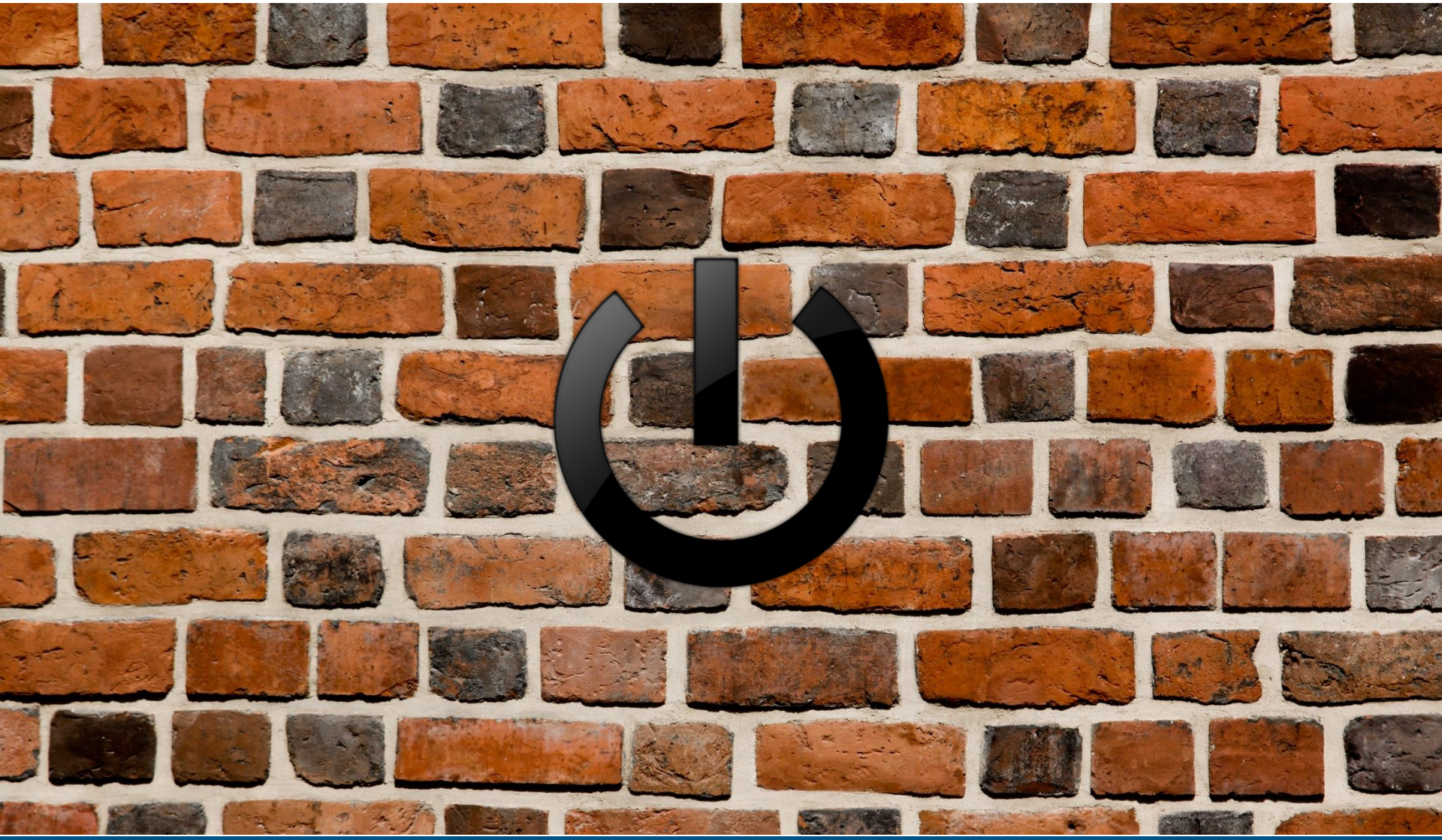
Power wall...



Real parallelism

Parallelism applied to multi-core

TASK PARALLELISM

TASKS CARRY OUT **DIFFERENT WORKS** AMONG EACH OTHER.

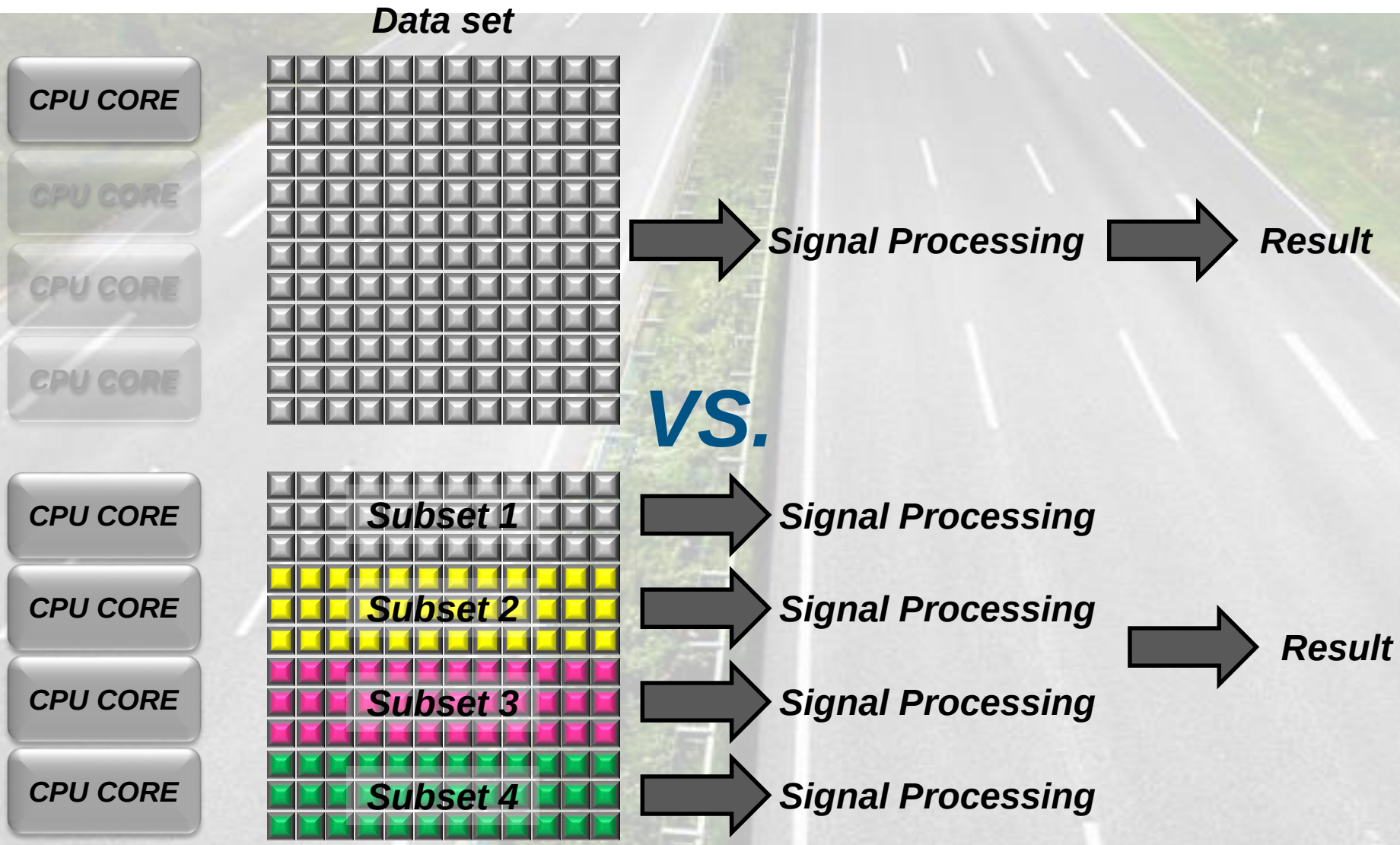
IF TASKS ARE INDEPENDENT THEY MAY BE CARRIED OUT **CONCURRENTLY**.

DATA PARALLELISM

IDENTICAL TASKS APPLIED TO **DIFFERENT DATA**.

DATA PARALLEL TASKS CAN BE PROCESSED IN A COMPLETE **SYNCHRONOUS** WAY.

Data parallelism



Example of Data parallelism

Benchmark for execution time of ***matrix multiplication*** using as input ***1000x1000 matrixes***.

	Single core	Dual core
	[s]	[s]
without Data Parallelism	1.195	1.159
with Data Parallelism	1.224	0.629

Ref. Programming strategies for Multicore Processing: Data Parallelism, National Instruments, http://www.ni.com/white-paper/6421/en

Mitigating main issue

"*Software is slowing faster than hardware is accelerating*" since software engineers do not have the luxury of optimizing the code.

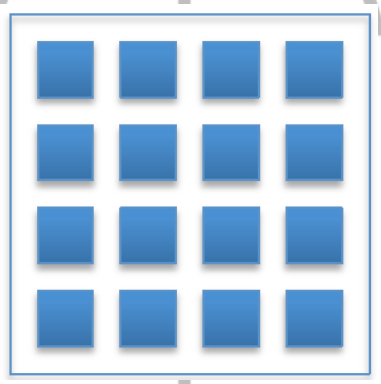
Therefore it is common that ***applications are not optimized*** for the hardware on which they are run.

However the exploitation of ***data parallelism***, which is possible thanks to multicore processing, ***do not require a high level of customization*** of the original *serial* code, since it is quite easy to ensure that the system's functionality is still correct after spreading the functionality across several cores all executing simultaneously.

The main issues associated to parallel code execution such as ***software locks*** and ***data dependencies*** do not apply when exploiting data parallelism because the ***processing on the several cores are independent among each other***.

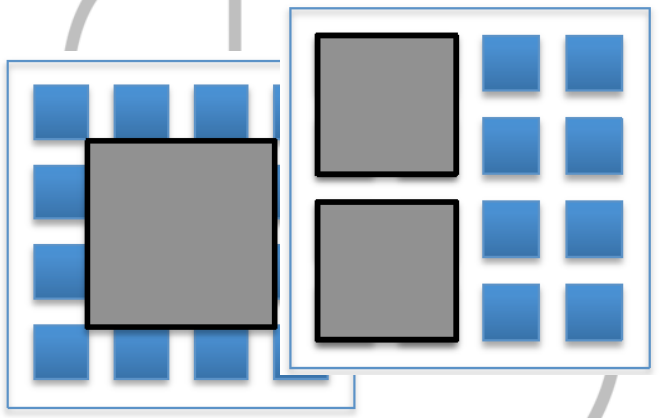
Symmetric vs. Asymmetric

SYMMETRIC



CONNECTING TWO OR MORE SIMILAR CORES INTO ONE DIE

ASYMMETRIC



COMBINATION OF HETEROGENOUS CORES

MAXIMUM PERFORMANCE IS ACHIEVED WHEN

EXECUTION TIME OF PARALLEL AND SERIAL PHASES ARE EQUAL

- SERIAL PHASES EXECUTED ON THE HIGHEST PERFORMANCE SINGLE PROCESSOR
- PARALLEL PHASES EXECUTED ON THE MANY SIMPLE PROCESSORS

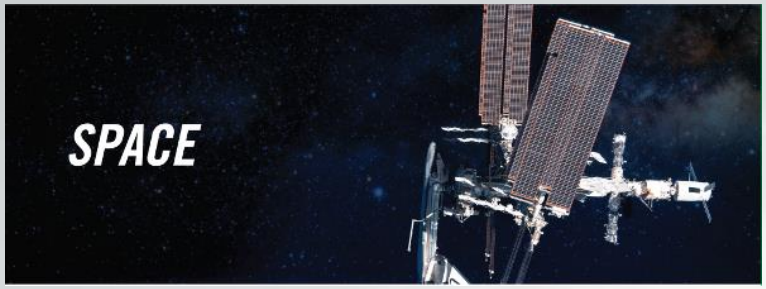
Possibilities...

- The advances in multi-core processors design make feasible applications of knowledge extraction from large data flows also for ***online*** novelty detection and diagnostics;

- In particular by exploiting ***data parallelism*** and ***symmetric architectures*** it is possible to implement in embedded platforms solutions that have been for the moment limited to desktop PCs;

- Therefore all the examples that will be shown in this presentation are suitable also for online functioning in embedded multicore platforms.

General applicability



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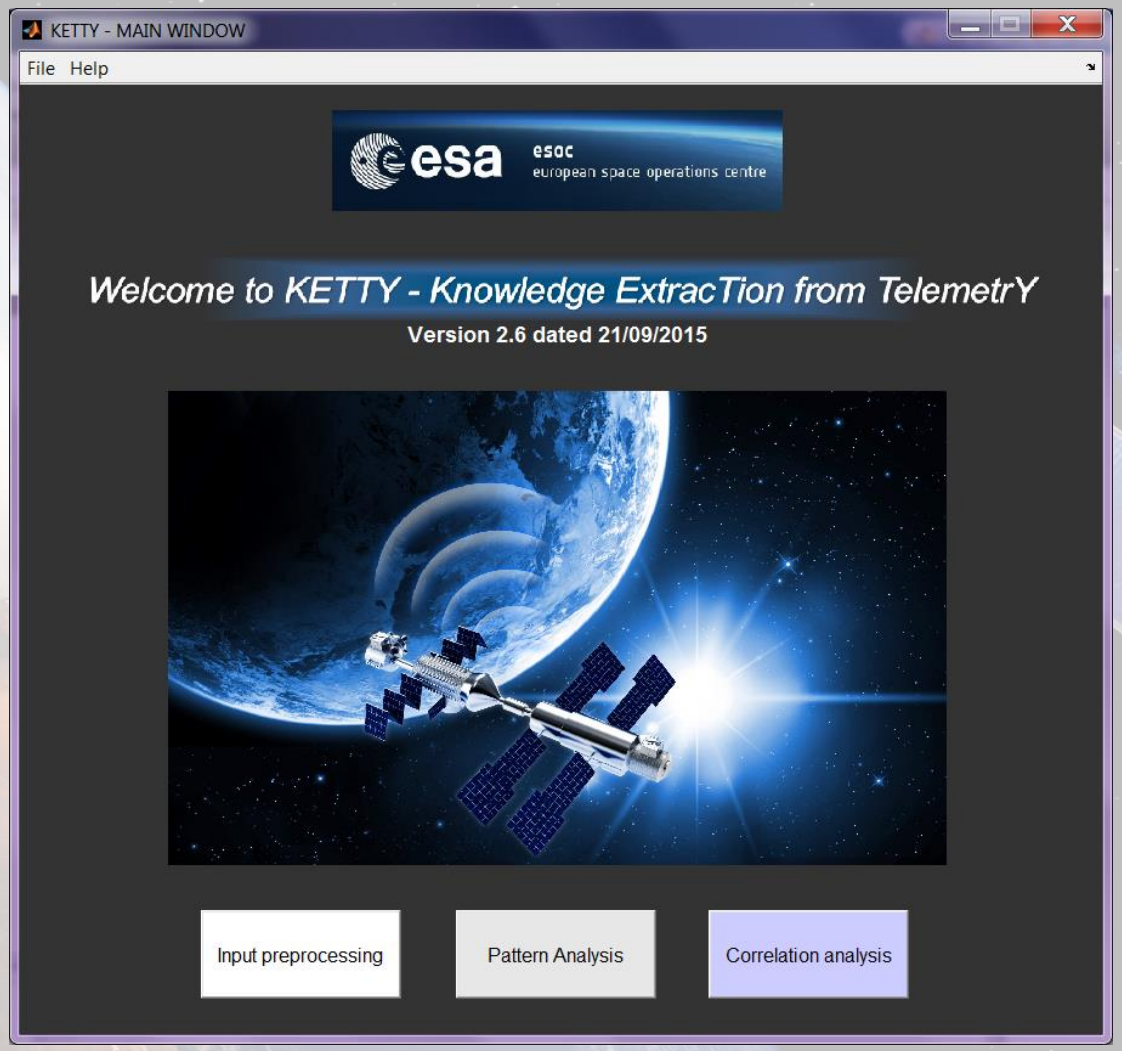
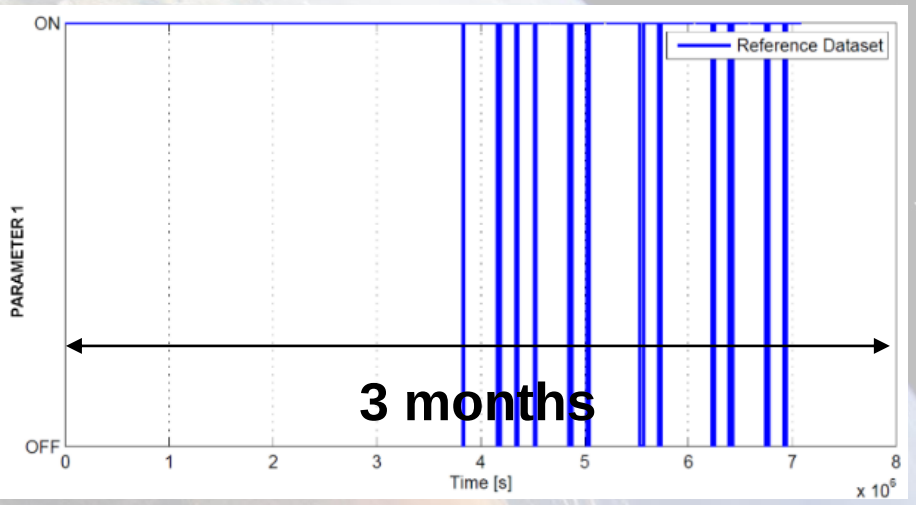
General applicability

KETTY
Knowledge ExtracTion from TelemetrY

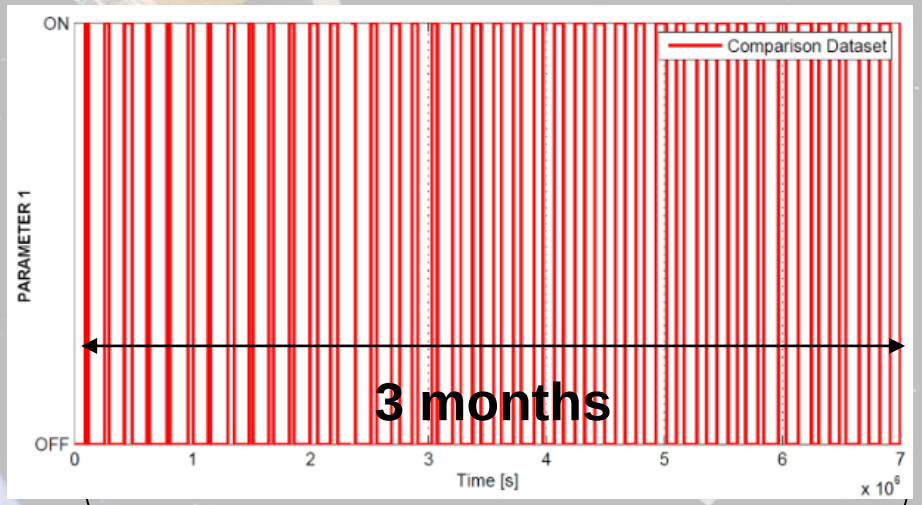


Example 1 - Long-term novelty detection

Reference dataset



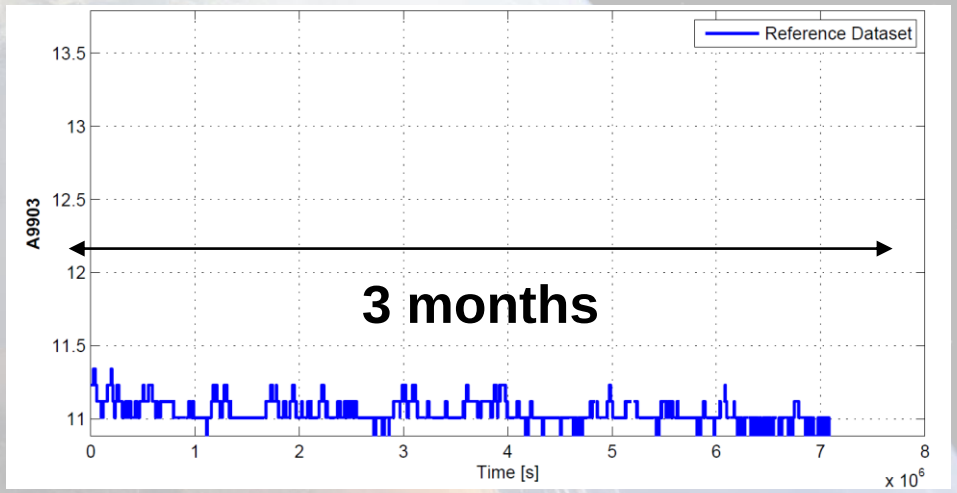
Comparison dataset



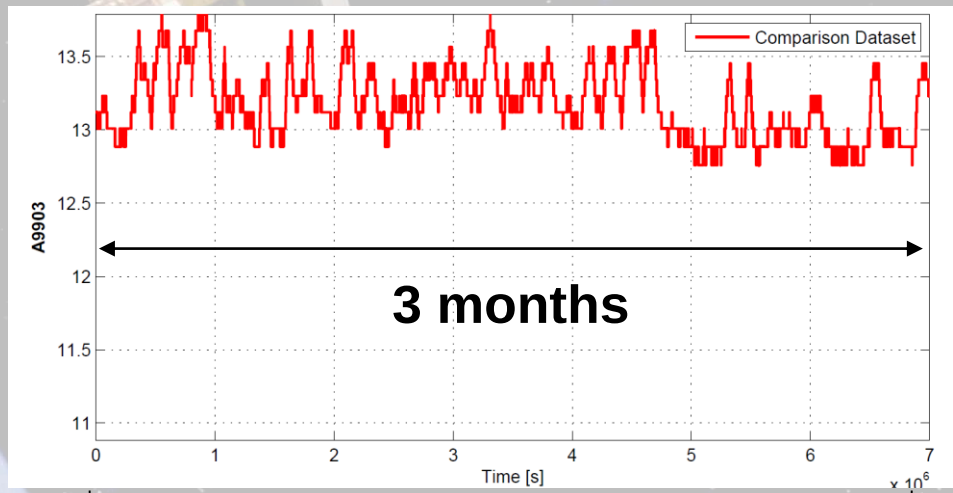
Novelty detection

Example 2 - Long-term novelty detection

Reference dataset



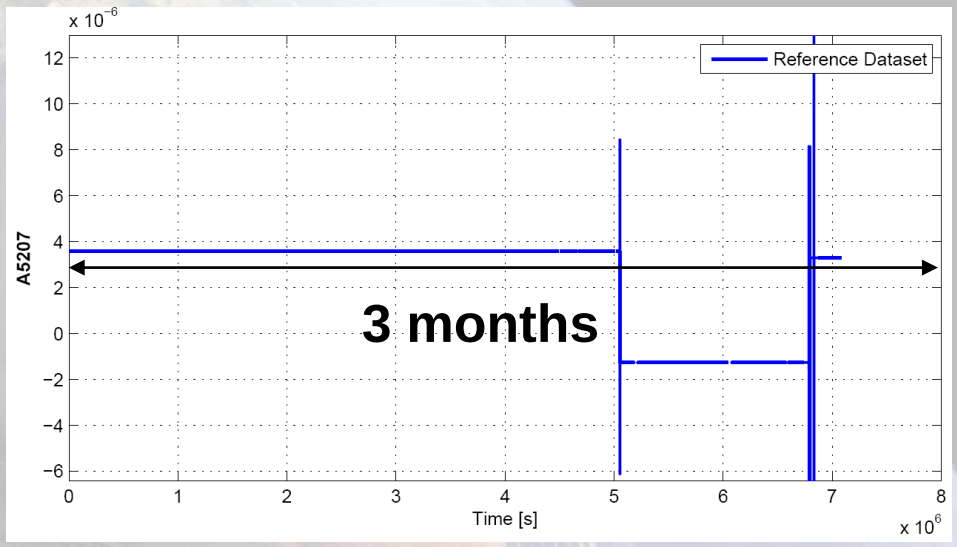
Comparison dataset



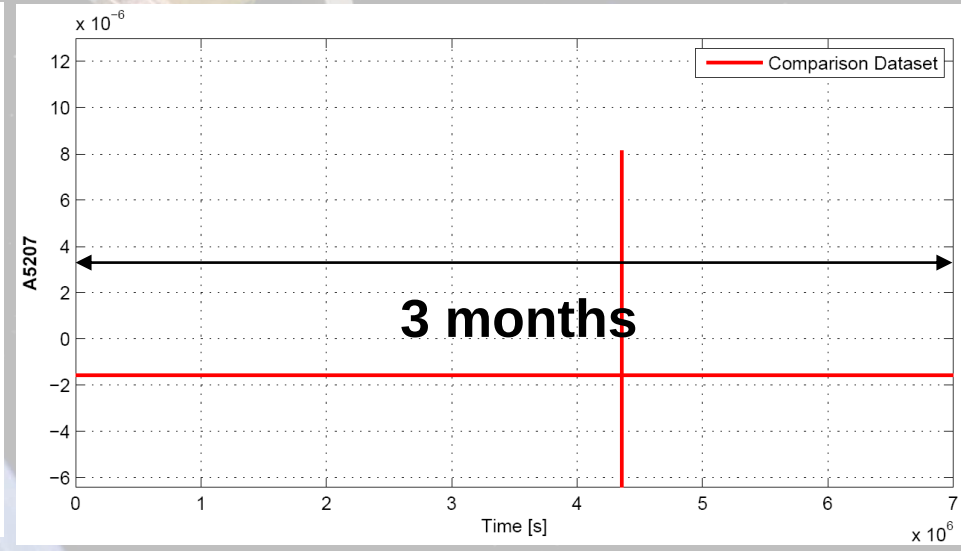
Novelty detection

Example 3 - Long-term novelty detection

Reference dataset



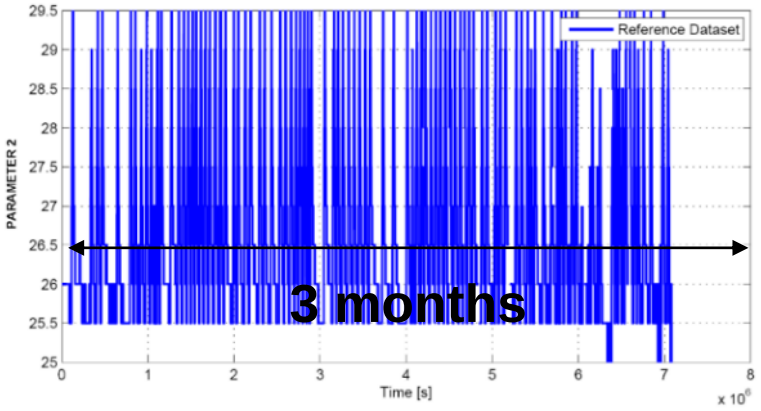
Comparison dataset



Novelty detection

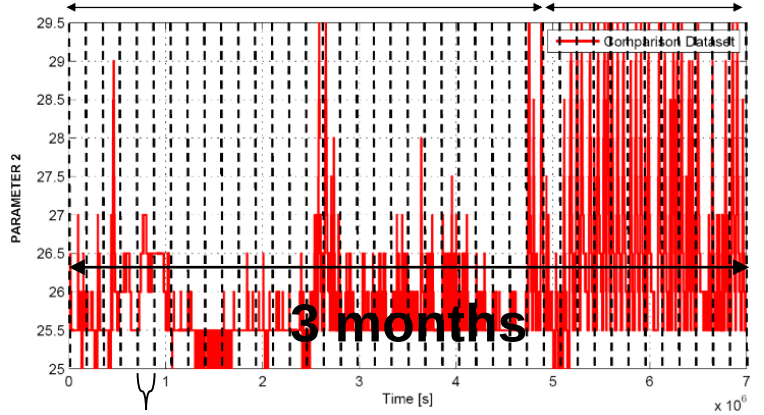
Example 4 - Short-term novelty detection

Reference dataset



Comparison dataset

From 1st to 28th period *From 29th to 40th*

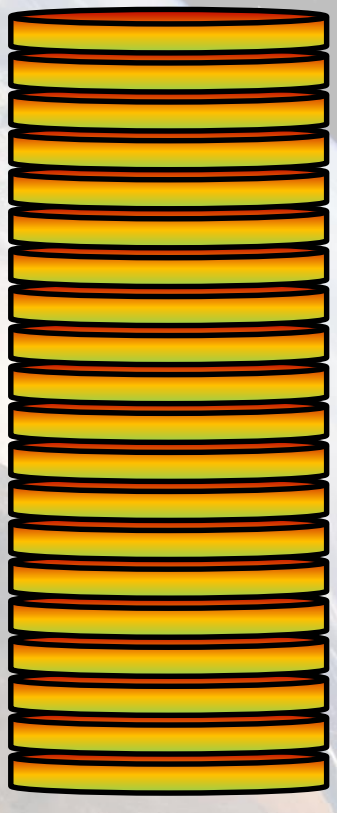


Novelty detection

Period N°	Period starting date and time	Period ending date and time	Sympt. variable
9	2009-05-01,00:00:00	2009-05-02,23:59:48	0.329
8	2009-04-29,00:00:00	2009-04-30,23:59:48	0.271
10	2009-05-03,00:00:00	2009-05-04,23:59:48	0.255
7	2009-04-27,00:00:00	2009-04-28,23:59:48	0.252
11	2009-05-05,00:00:00	2009-05-06,23:59:48	0.232
12	2009-05-07,00:00:00	2009-05-08,23:59:48	0.232
26	2009-06-04,00:00:00	2009-06-05,23:59:48	0.206
⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮
36	2009-06-24,00:00:00	2009-06-25,23:59:48	0
37	2009-06-26,00:00:00	2009-06-27,23:59:48	0
38	2009-06-28,00:00:00	2009-06-29,23:59:48	0
40	2009-07-02,00:00:00	2009-07-03,23:59:48	0
29	2009-06-10,00:00:00	2009-06-11,23:59:48	0

Problem complexity reduction

S/C telemetry data
(monitored by FCE)



~10.000
params / day

The FCE has to focus only on the priority parameters among the ~ 10 new novelties per day (a part for those days in which major mission changes occur).

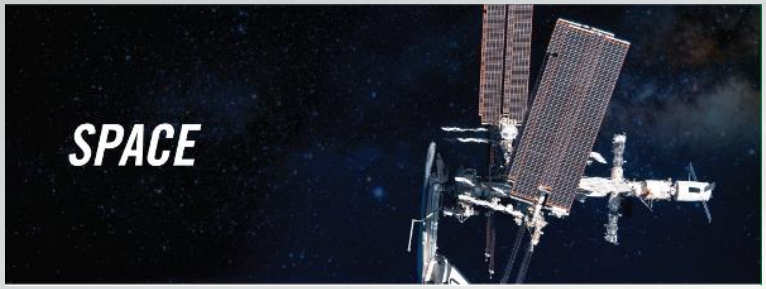
Novelties
(sorted by priority)

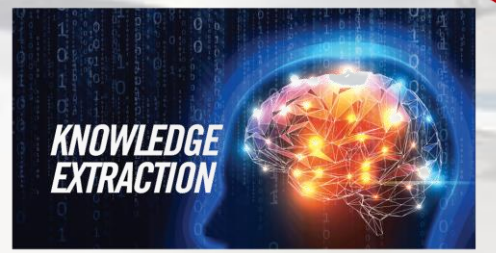
< 1.000 params / day
(upon relevant events)

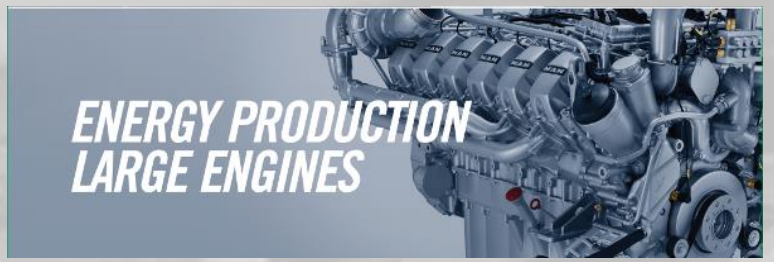
New novelties
(sorted by priority)

~ 10 params / day
(when no special events occur)

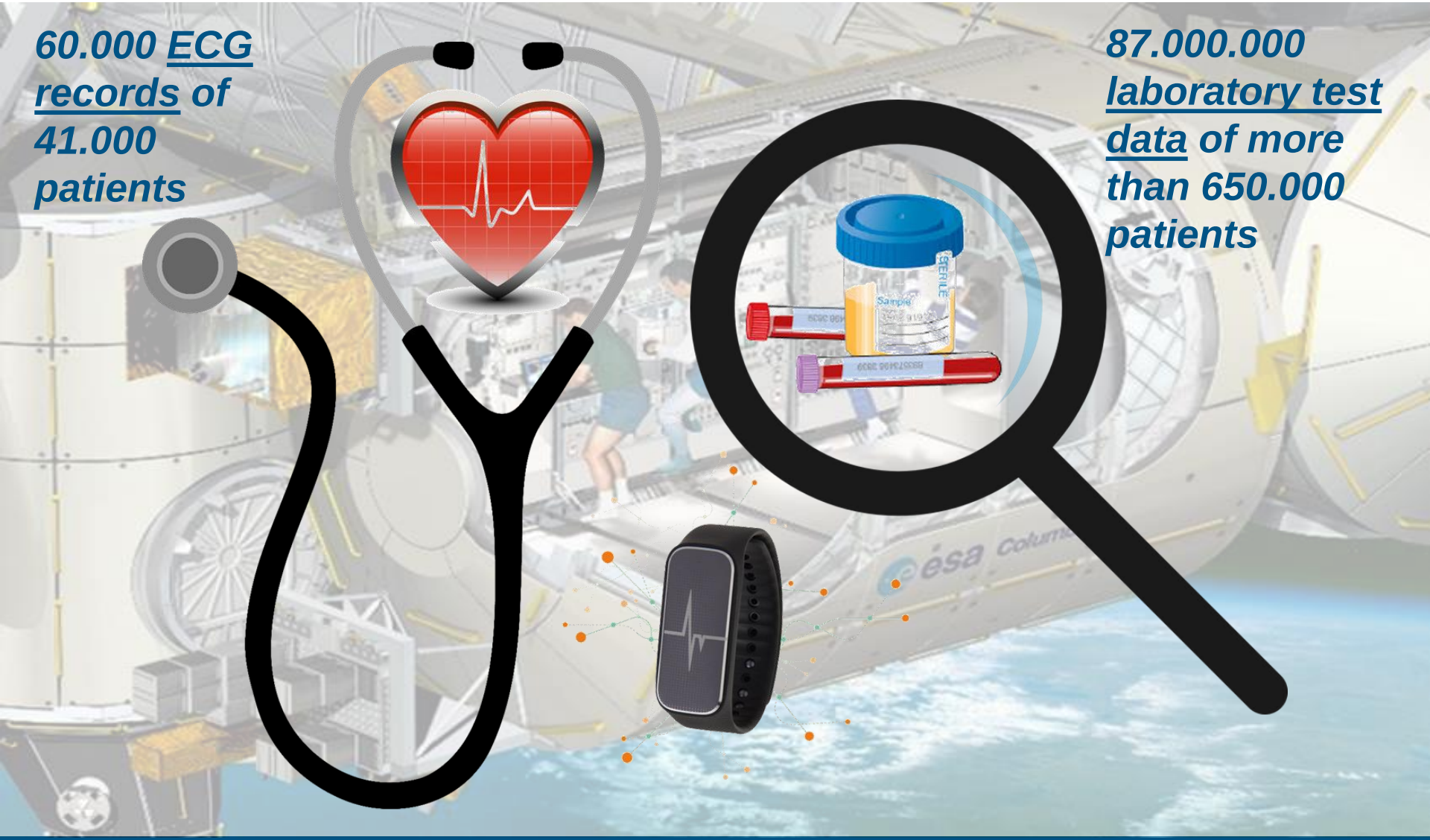
General applicability



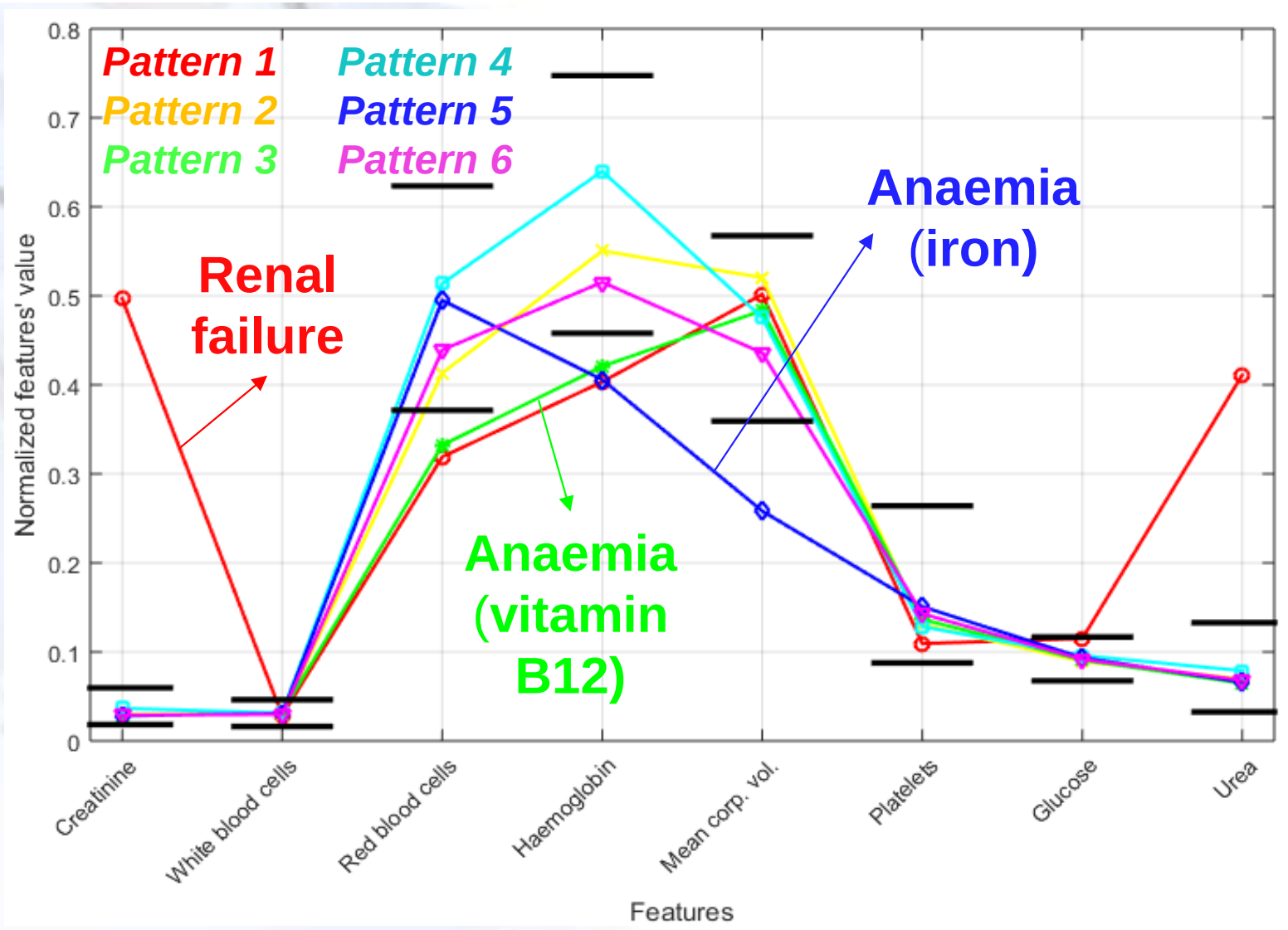




Knowledge extraction for medicine



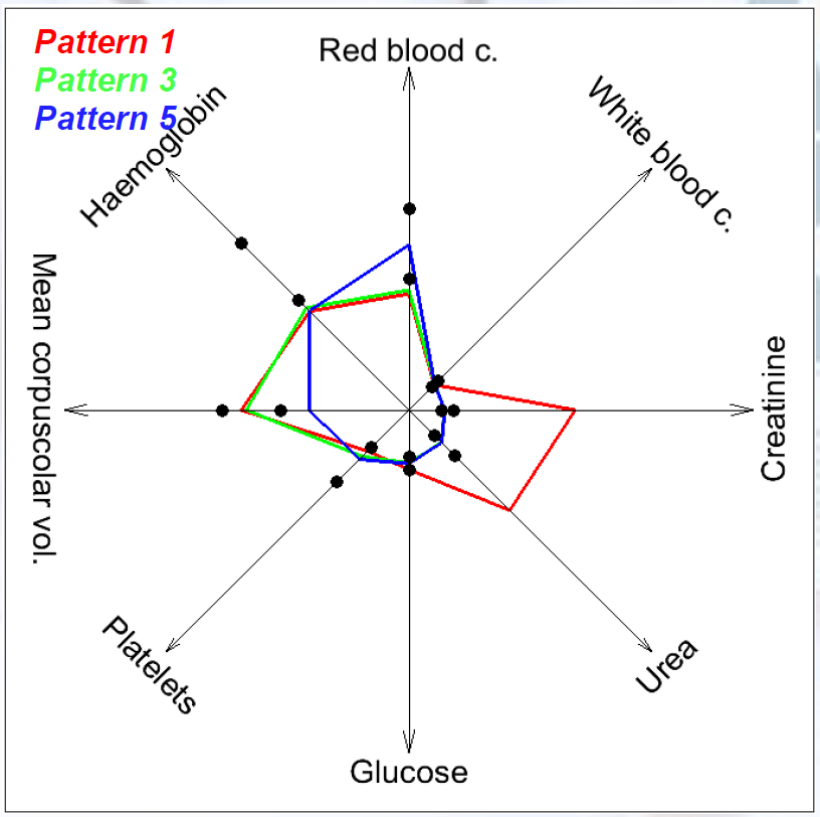
Laboratory data - Investigation results



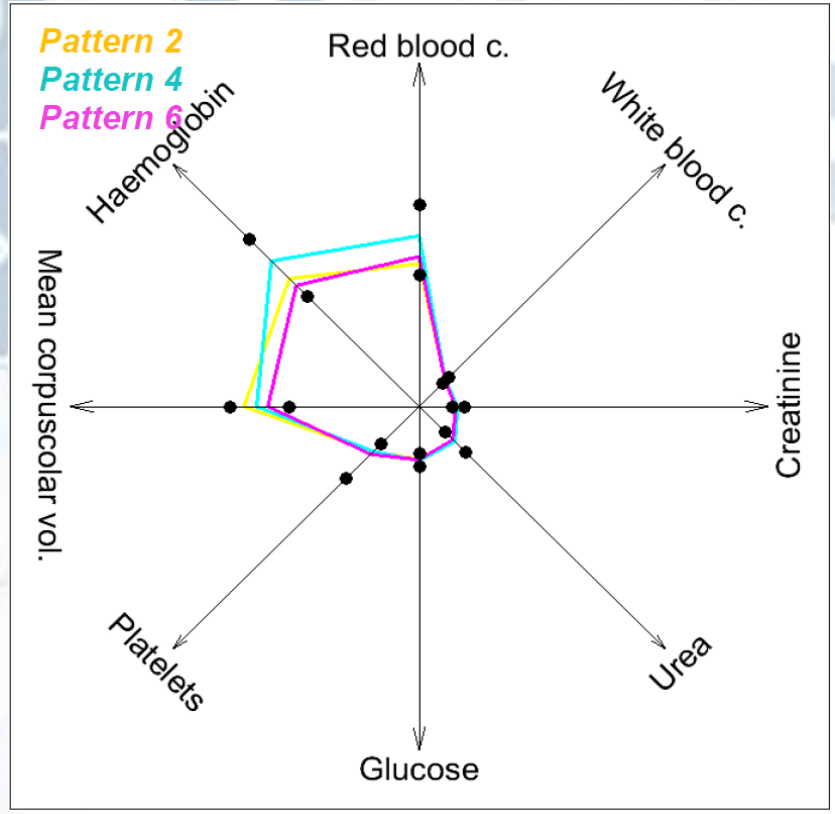
Clustering results - Investigation

Radar chart visualization of the patterns:

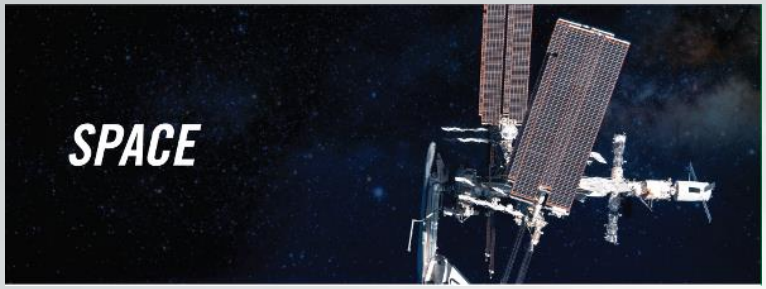
PATHOLOGICAL PATTERNS

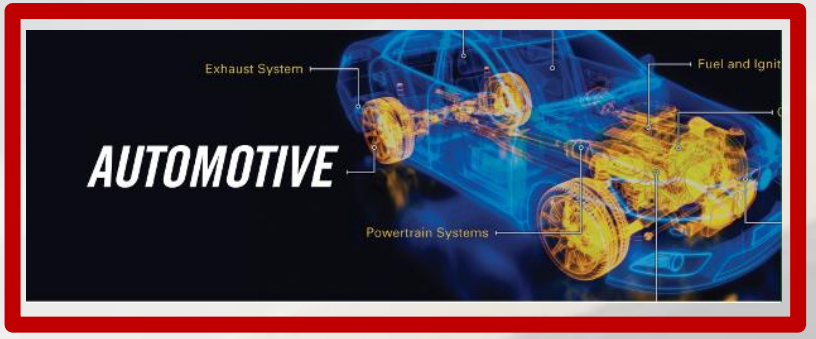


HEALTHY PATTERNS

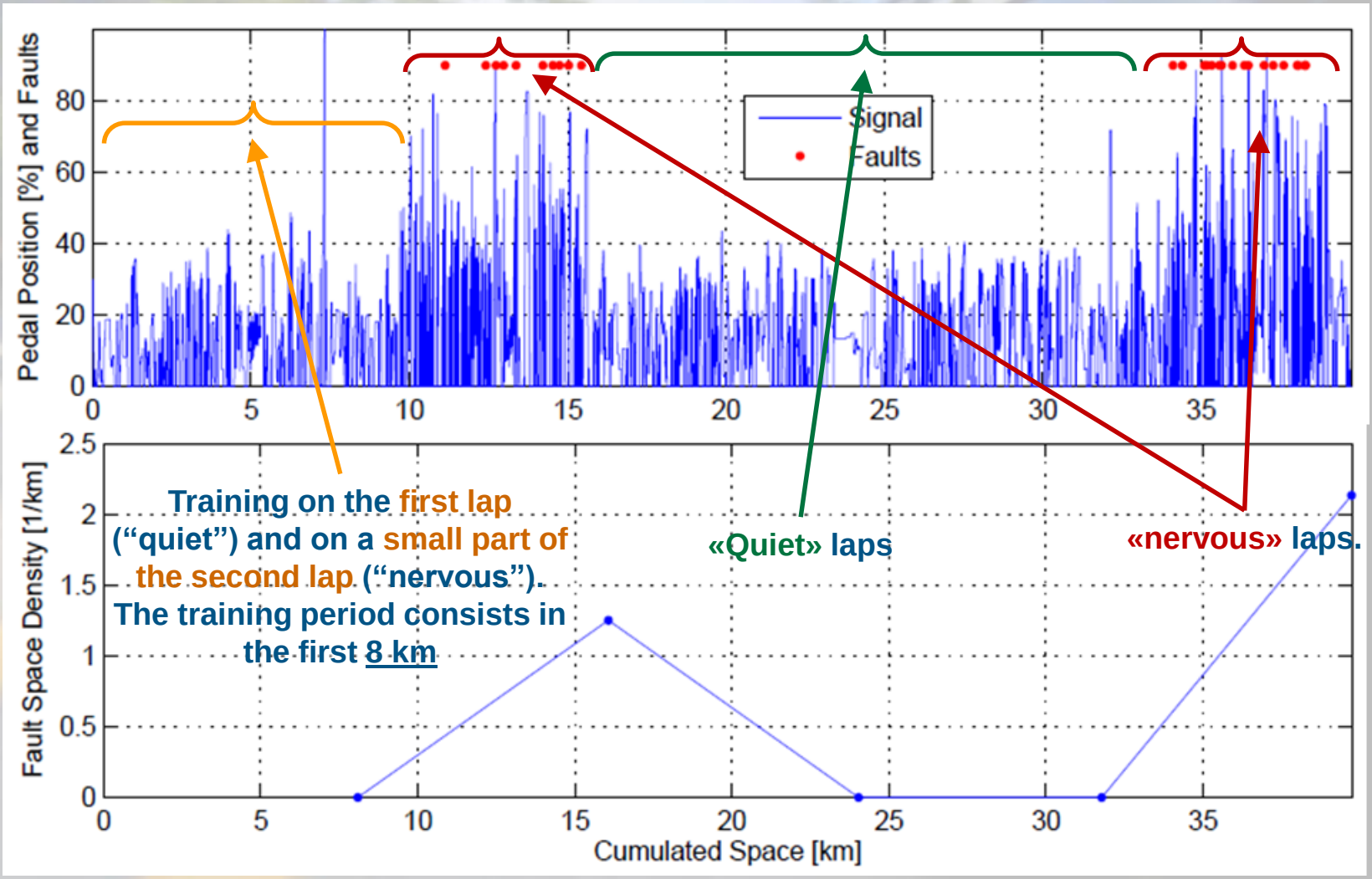


General applicability

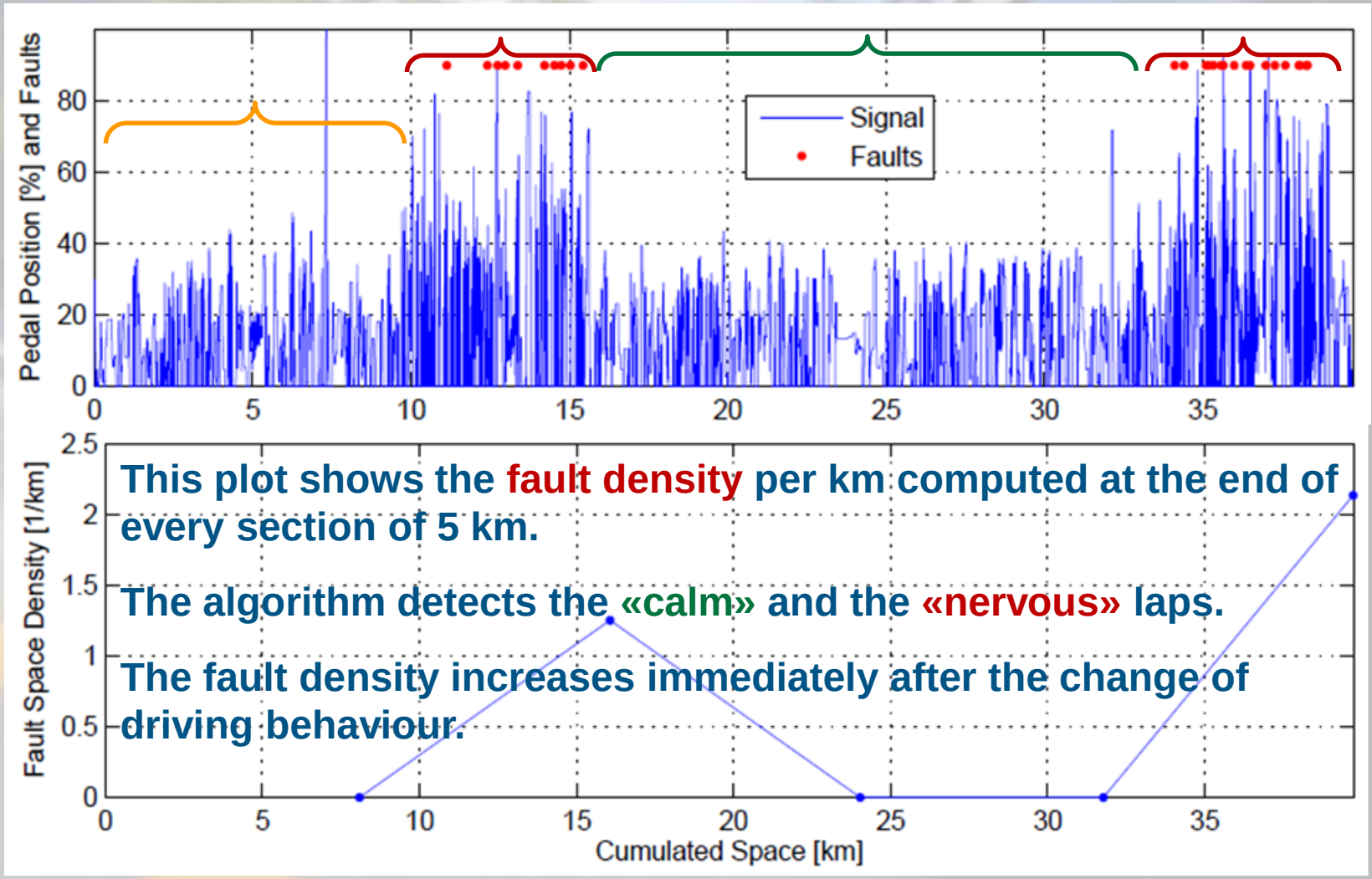




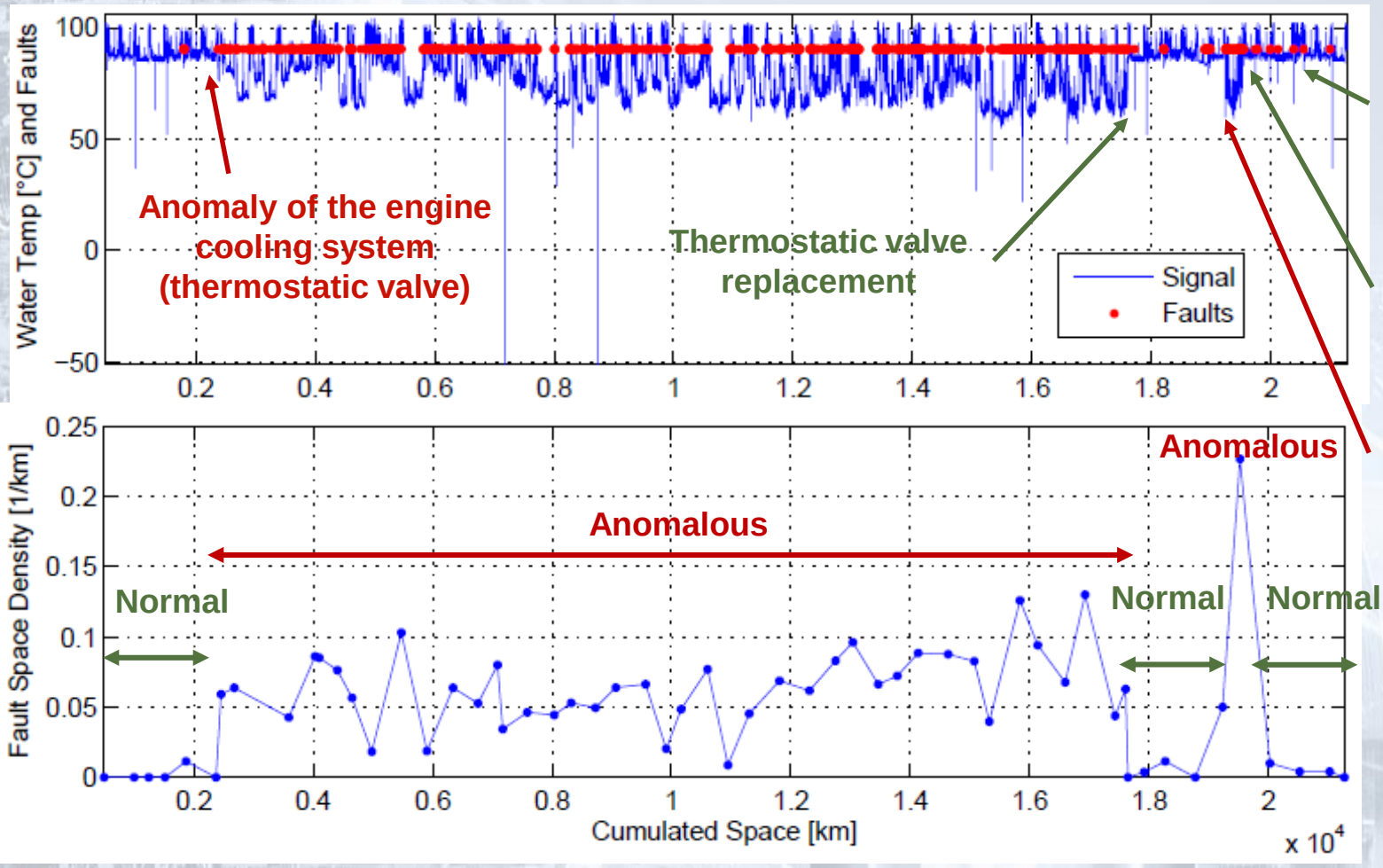
Driving style analysis



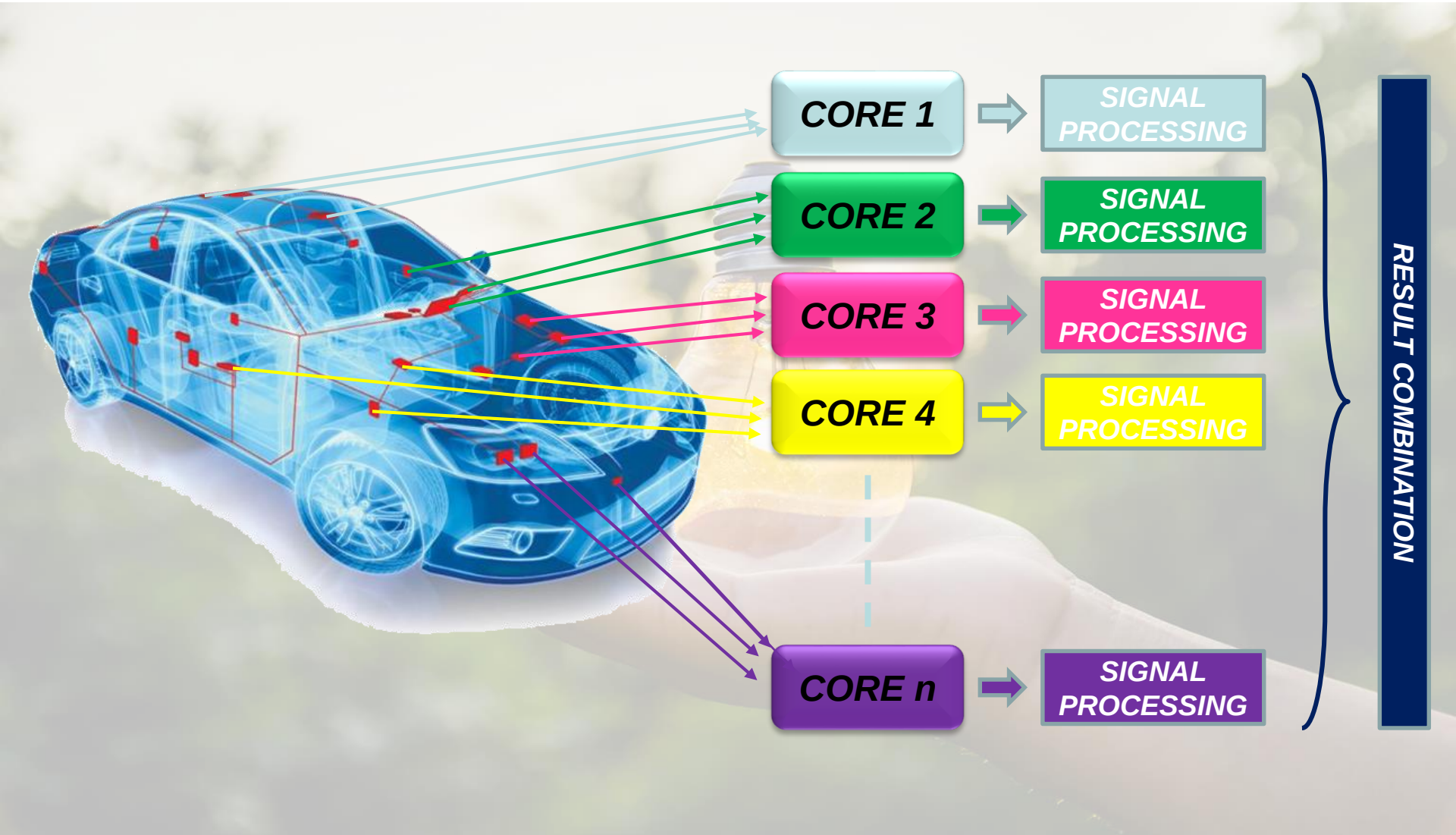
Driving style analysis



Engine cooling system



Next?


CORE 1
CORE 2
CORE 3
CORE 4
CORE n
SIGNAL PROCESSING
SIGNAL PROCESSING
SIGNAL PROCESSING
SIGNAL PROCESSING
SIGNAL PROCESSING
RESULT COMBINATION


THANK YOU!
QUESTIONS?