REAL TIME CHALLENGES IN ENGINE CONTROL SYSTEMS

RTNS'2019

27TH INTERNATIONAL CONFERENCE ON REAL-TIME NETWORKS AND SYSTEM

ENSEEIHT Toulouse, 06.11.2019
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Public

REAL TIME ENGINE CONTROL CHALLENGES

1 INDUSTRIAL CONSTRAINTS

2 TECHNICAL CONSTRAINTS

3 CONCLUSION

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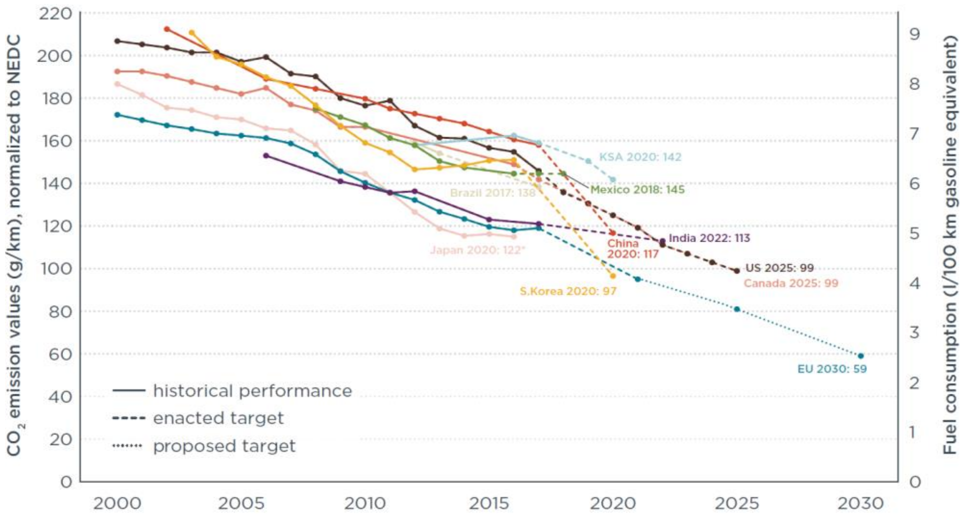
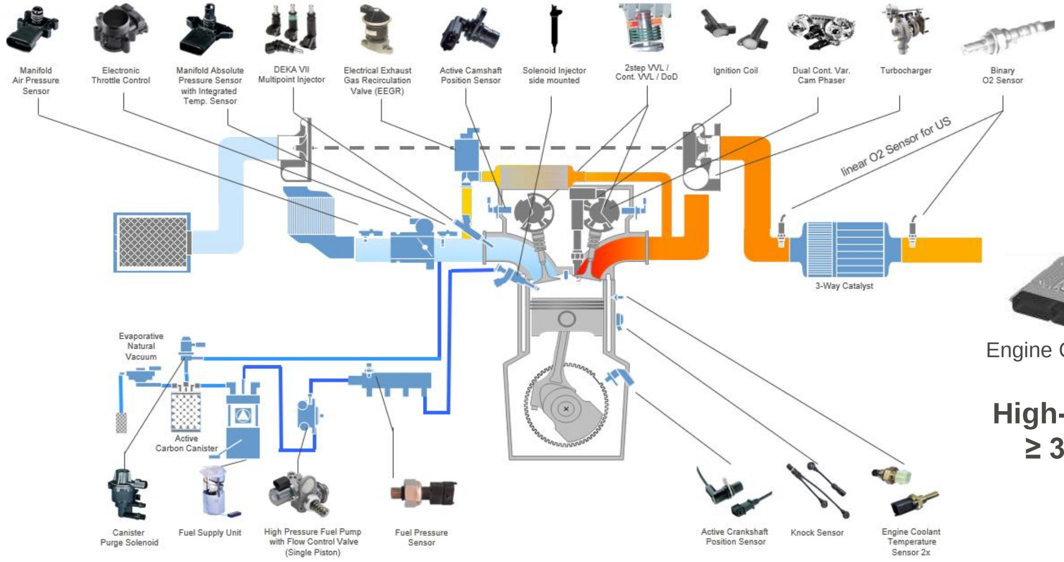
INTERNAL COMBUSTION ENGINE (ICE) SYSTEM OVERVIEW

MAIN MARKET DRIVER IS EMISSION REDUCTION



From: ICCT (International Council on Clean Transportation), CO2 EMISSION STANDARDS FOR PASSENGER CARS AND LIGHT-COMMERCIAL VEHICLES IN THE EUROPEAN UNION, Jan. 2019

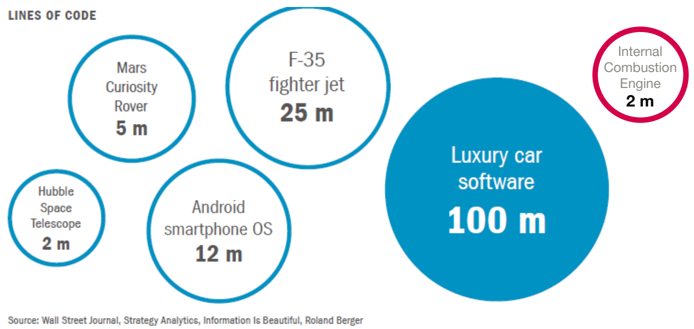
GLOBAL WARMING ⇒ CO2 EMISSION REDUCTION



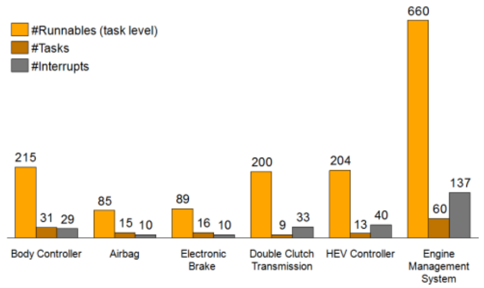
Engine Control Unit

High-end ECU: ≥ 300 pins

⇒ INCREASE COMPLEXITY OF ICE SYSTEM



⇒ INCREASE SW SIZE AND COMPLEXITY



⇒ ICE SW IN AUTOMOTIVE REAL TIME SW

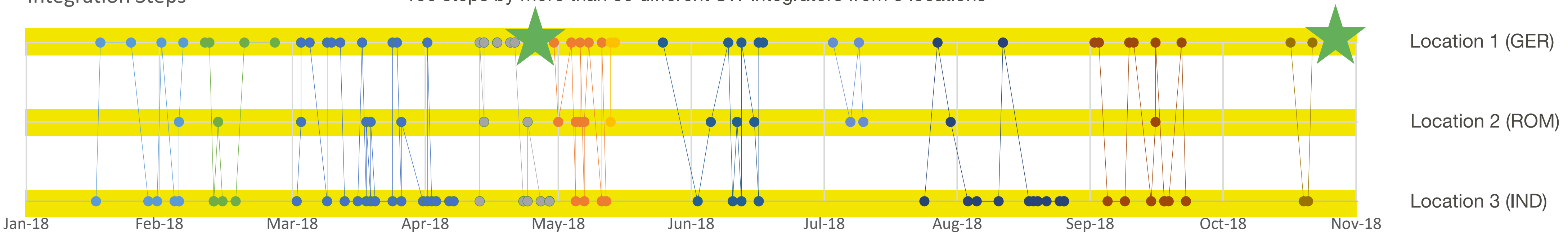
MORE SW NEEDED TO REDUCE FUEL CONSUMPTION !

AFFORDABLE SOLUTIONS

REUSE TO SHORTEN DEVELOPMENT CYCLES, REDUCE DEVELOPMENT COSTS

Integration Steps

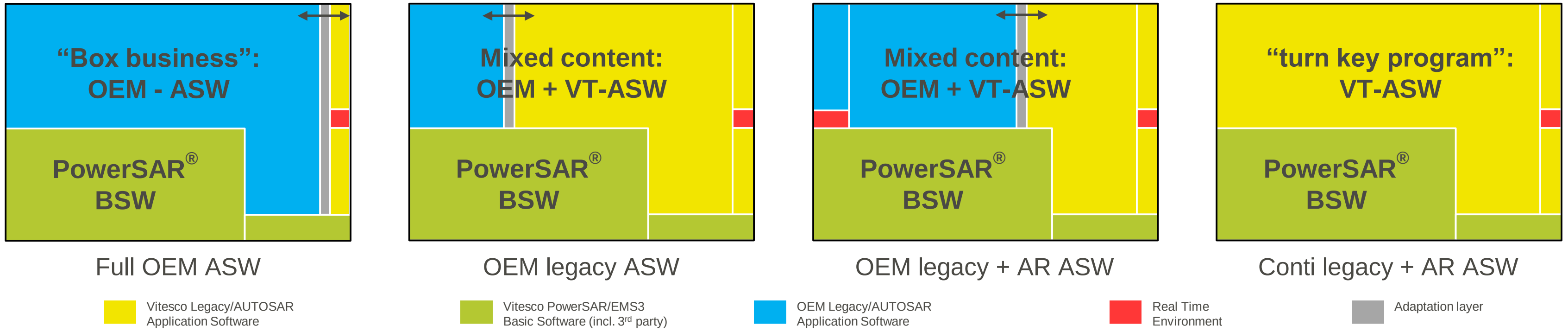
150 steps by more than 80 different SW Integrators from 3 locations



Release to OEM

(complete project: 3-4 years)

DISTRIBUTED DEVELOPMENT & INTEGRATION: SUPPORT BY THE ARCHITECTURE



OEM DEVELOPS HIS PART INDEPENDENTLY AND INTEGRATES / BUILDS AGAIN THE SW

HIGHER INTEGRATION BETWEEN PARTNERS

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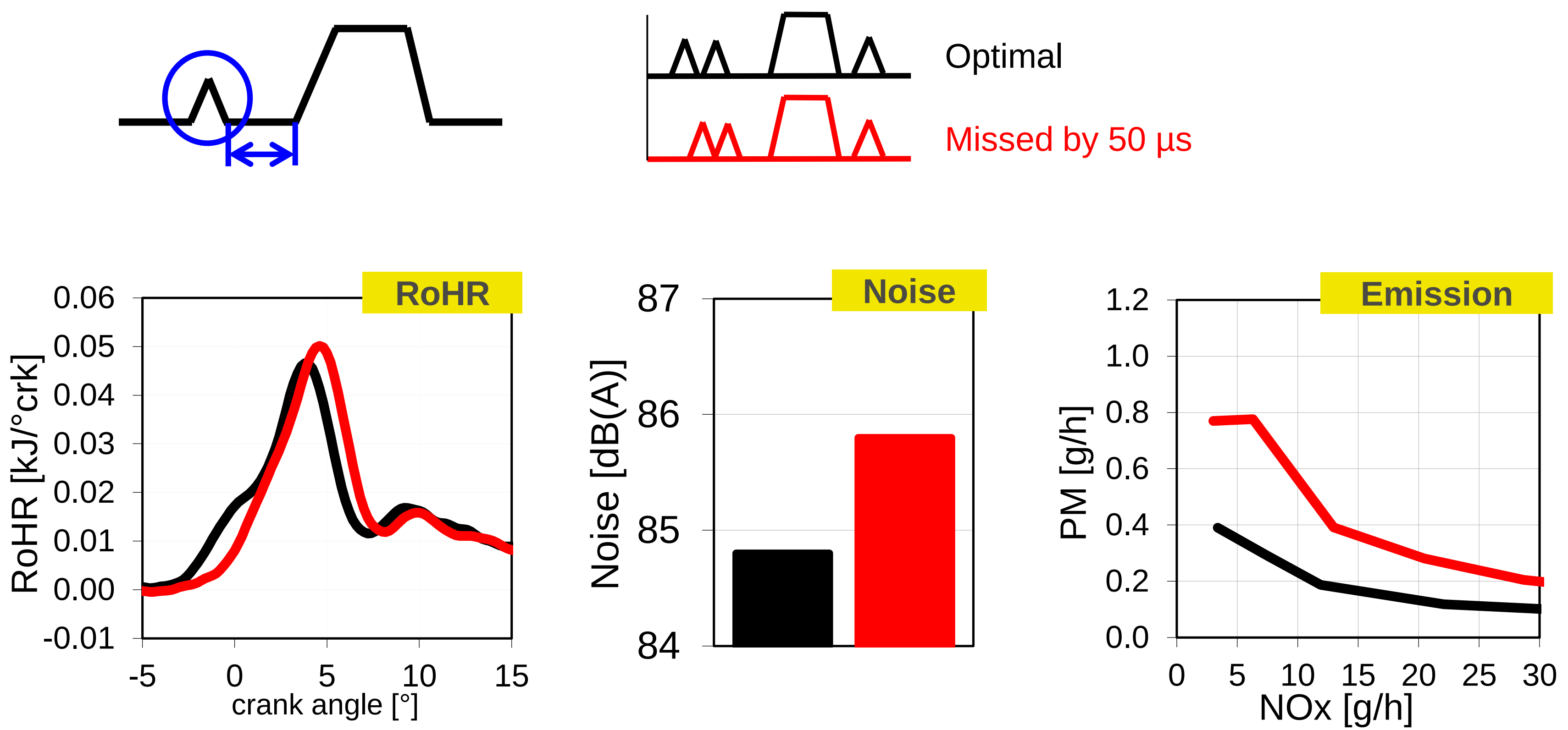
REAL TIME SW

THE RIGHT VALUE AT THE RIGHT TIME

Impact of accuracy control for „dwell“ and “minimum fuel mass” to emissions

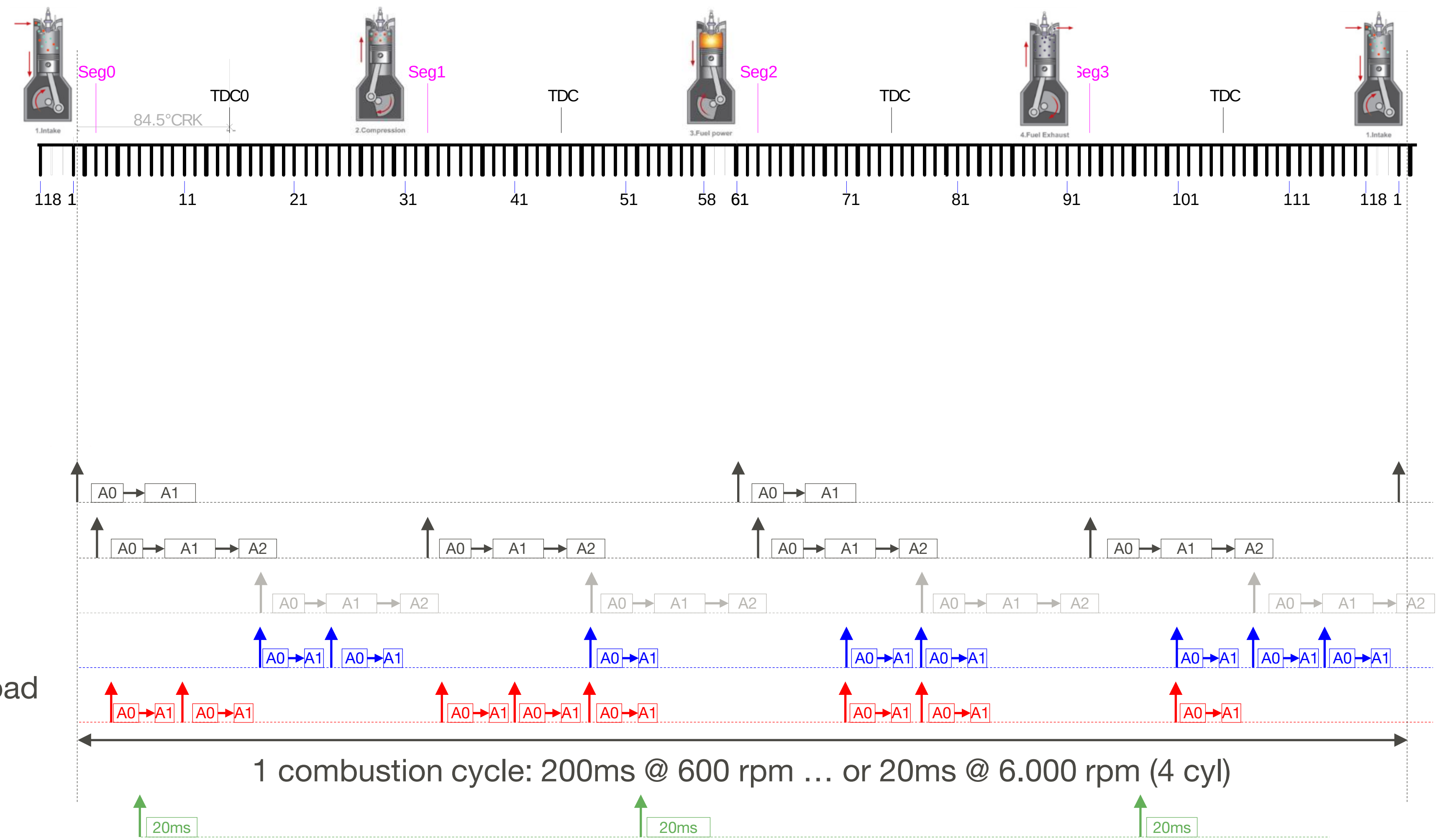


at n= 1500 min^{-1}, p_{mi}= 4,2 bar, HR50= 8°KW, EGR=35%

THE RIGHT TIMING IS IMPORTANT !

ANGULAR TIME

SW DYNAMICS DRIVEN BY ACTUATOR CONTROL DYNAMICS



1. Frequency = f(rpm)
2. Different periods
3. Different phases
4. Periodic and aperiodic
5. 1 to 4 CAMs
6. Chaining cross cores to balance cpu load
7. …

ANGULAR TASKS AND TIME BASED TASKS RUNNING ON THE SAME CPU

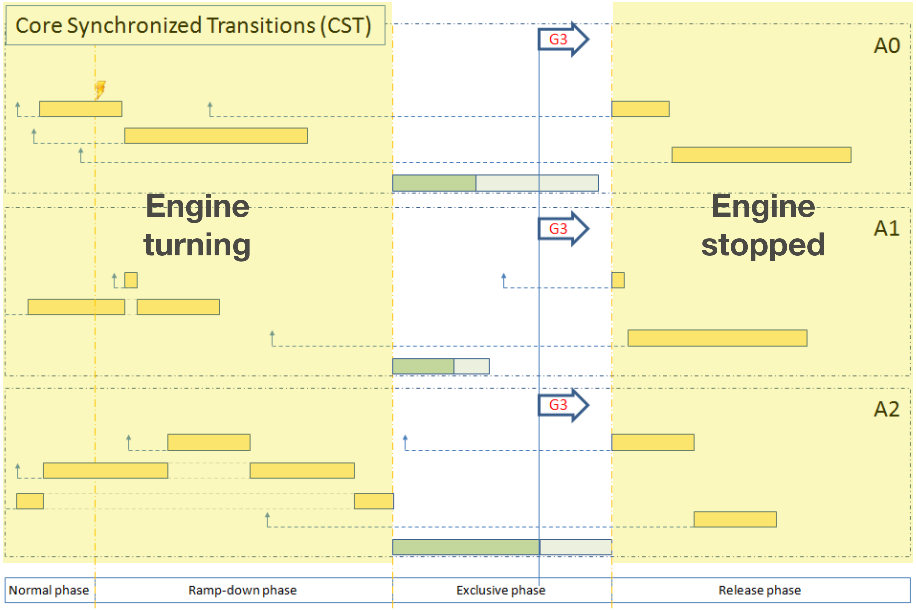
SPORADIC TIME

NEED OF COHERENT SYSTEM STATE CROSS ALL TASKS ON ALL CORES

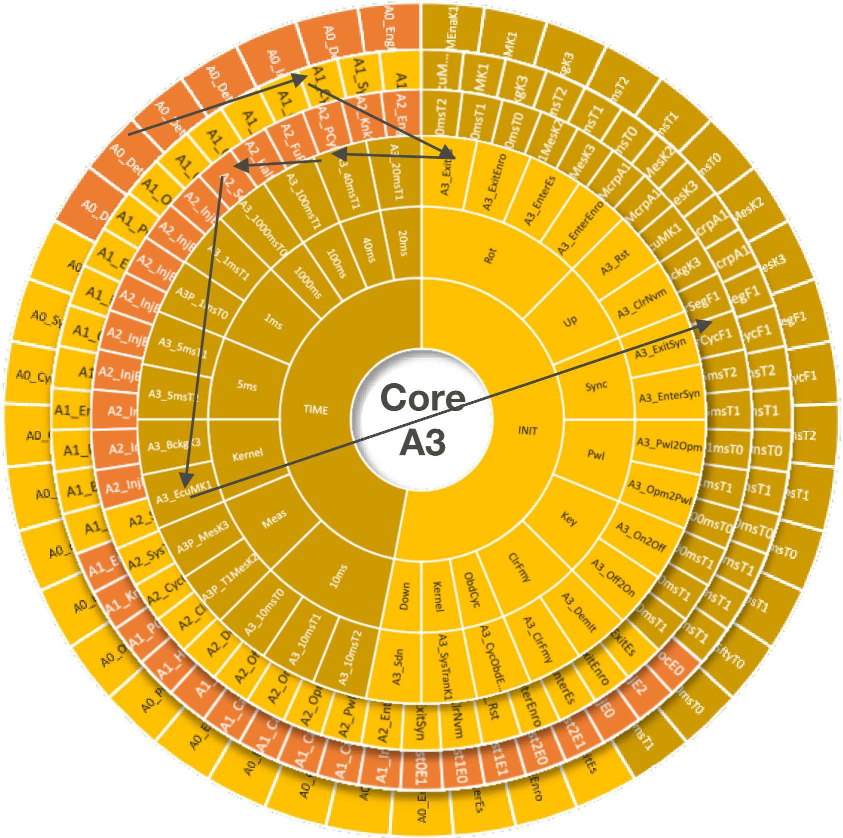
30mn trip: 120.000 x TDC Task* — Nominal computation
180.000 x 10ms Task
… but only 1 x Starting, 1 Stalling — Strategy initialisation
1 x key off, …
0 x Clear Fmy, …

(*) TDC: 4 cylinders, average 2.000 rpm

2 TYPES OF COMPUTATIONS



SYSTEM TRANSITION IN A PROTECTED MODE



BALANCE BETWEEN 3 "TIME DOMAINS" … ON ALL CORES

DATA COMMUNICATION BETWEEN TASKS & DOMAINS TO BE CONTROLLED

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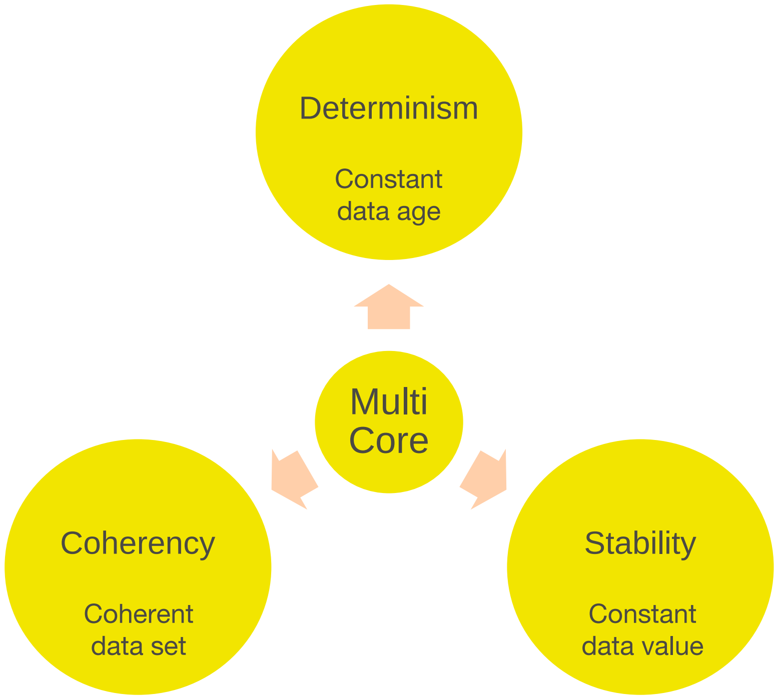
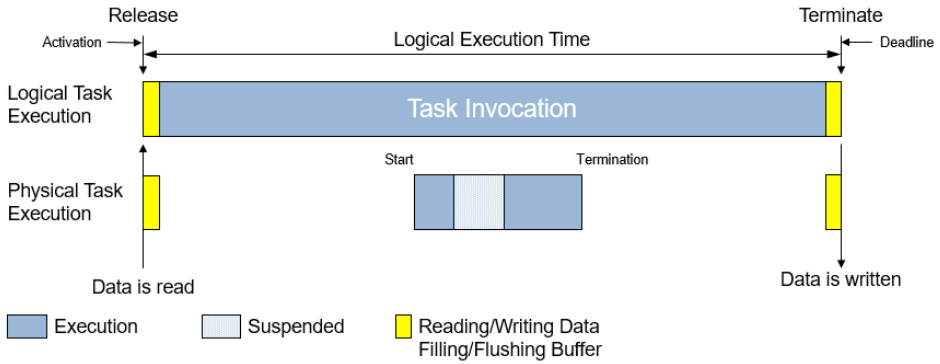
INTER-TASK COMMUNICATION

DIFFERENT TYPES OF INTEGRITY



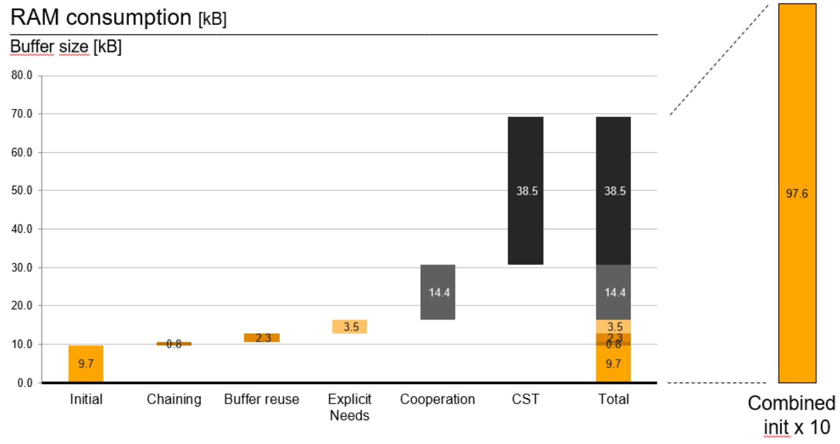
3 TYPES OF INTEGRITY



LOGICAL EXECUTION TIME TO ENSURE DETERMINISM

Typical Project

3.500 modules	120 Tasks
30.000 data	1500 Runnables
16.000 c-functions	100.000 access points



CRITICAL: EFFICIENCY OF BUFFERING ALGORITHM

INEFFICIENT STRATEGY MAY LEAD TO … NON-DISTRIBUTABLE SW

CORE ABSTRACTION FOR EASIER SW DISTRIBUTION

3 LEVELS OF ABSTRACTION

PROBLEM: CORE ALLOCATION IS A MULTI-CRITERIA CHOICE

Event availability
- A function has a required Rate: 1st criteria for integration

Link to Safety Core / Active Lockstep
- Safety relevant functions have to be processed on Core with Active Lockstep

Core affinity
- Vs. HW feature (e.g. dbl fpu, …) , other function

OEM/Other parties constraints
- OEM-SW fix some distribution

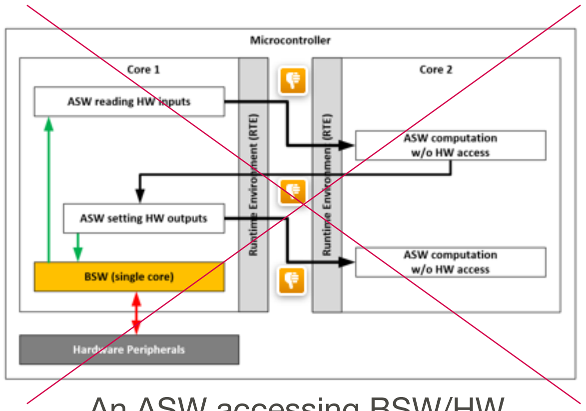
Last Writer Wins (Lww) situations
- Limit risk for data written at different rate

Sequencing constraint
- Order of Runnables matters !

Distributivity of the function
- Some functions are risky to distribute (complex real time, not multi-core ready)

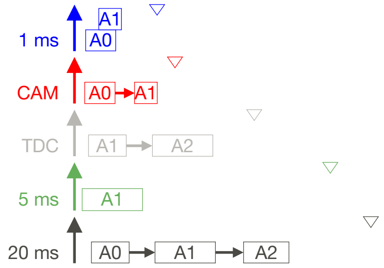
CPU load balancing
- Higher freedom for introduction of more functions in a late step

BSW SERVICES AVAILABLE ON EACH CORE



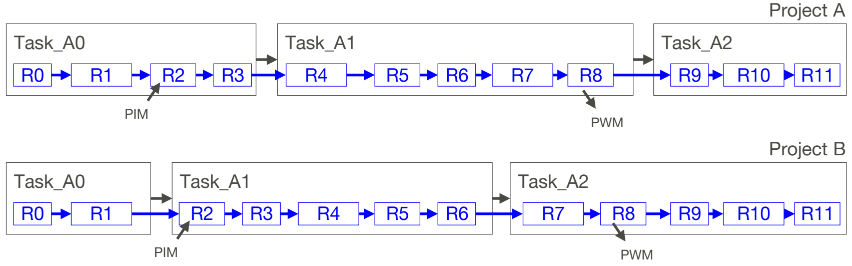
An ASW accessing BSW/HW NOT bound to a Core

SW ARCHITECTURE INDEPENDENT OF HW FEATURES



Standard task setup for all projects despite different HW configurations (µC)

ASW INTEGRATION INDEPENDENT OF ABSTRACT CORE



CORE ABSTRACTION FOR HIGHER SYNERGY BETWEEN PROJECTS, EASIER INTEGRATION

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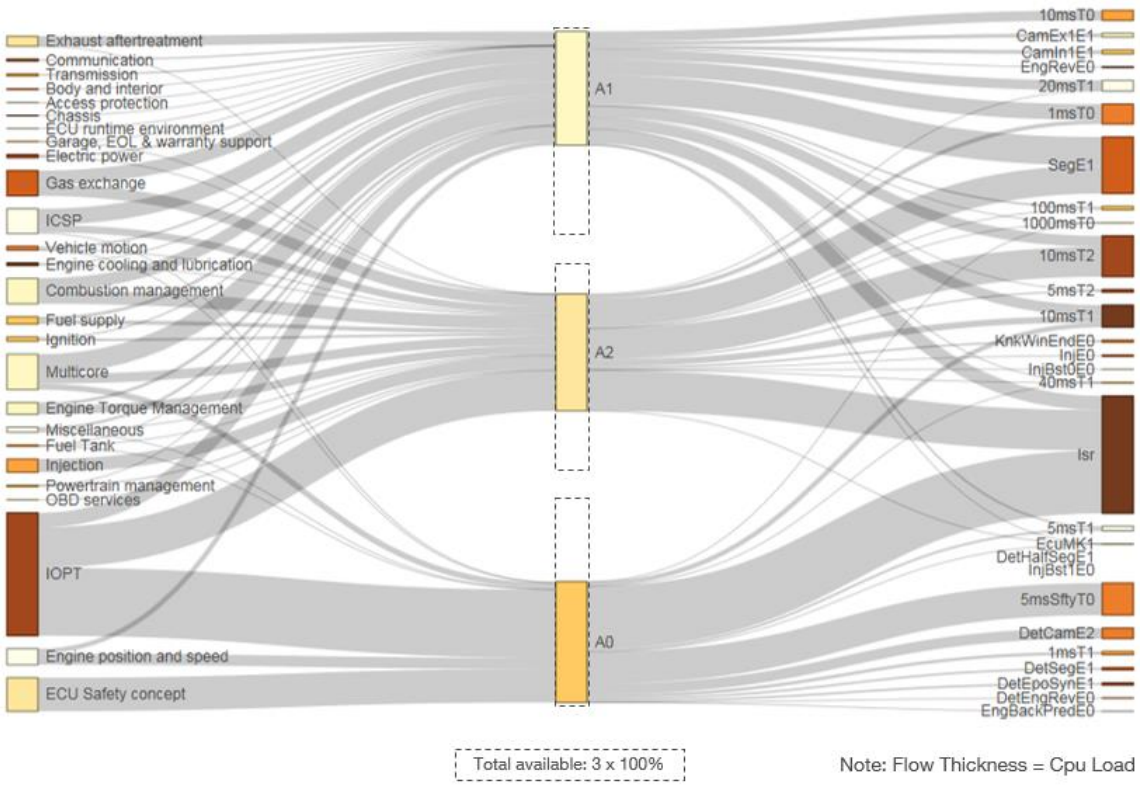
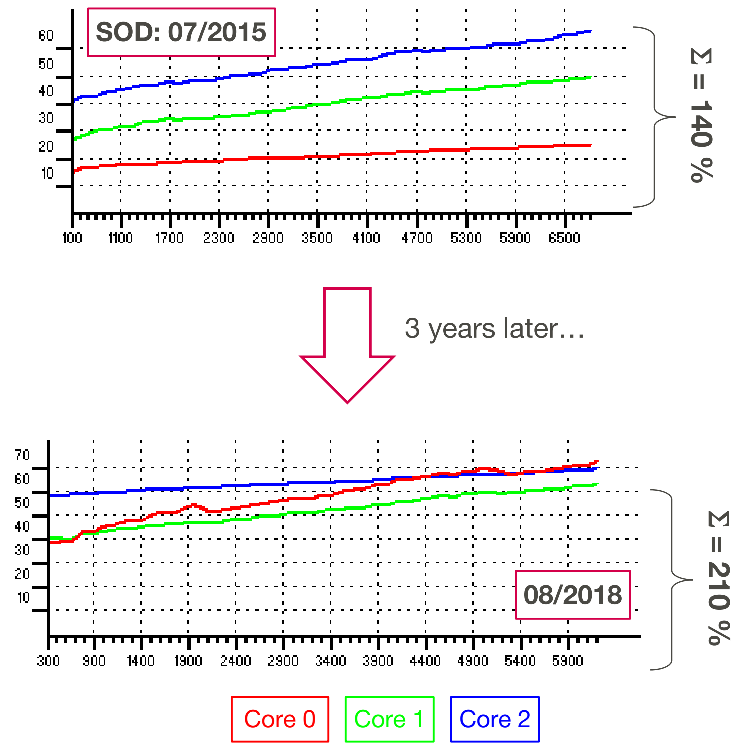
CORE DISTRIBUTION

ENSURING SYSTEM HEALTH DESPITE FUNCTIONAL CONTENT INCREASE



BALANCED FUNCTIONS AND RATES

CPU LOAD



LOAD BALANCING PREPARES THE SYSTEM FOR FUTURE EVOLUTIONS

(EVENT) RESPONSE TIME MONITORING IS A BETTER INDICATOR OF THE SYSTEM HEALTH

THANK YOU
FOR YOUR ATTENTION