PROPULSION CI

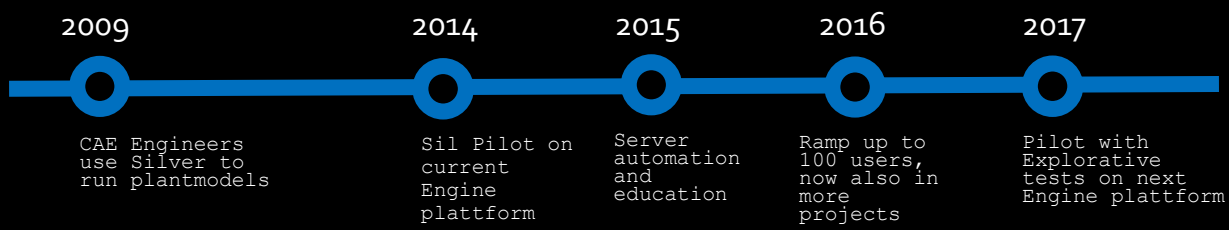
Continuous integration and continuous validation with explorative tests for propulsion controls and calibration

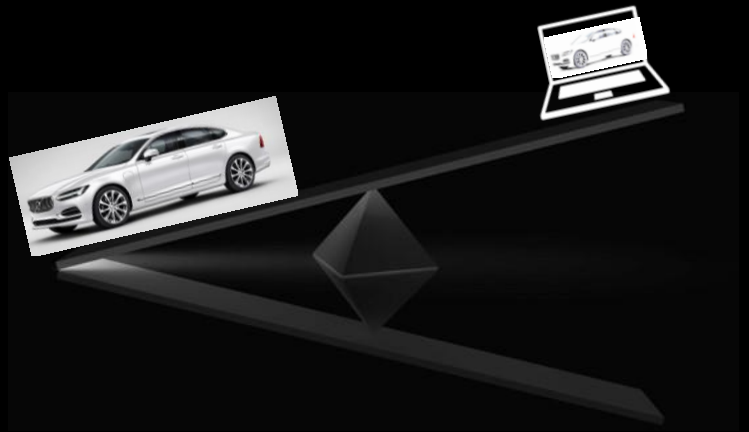
IN THE BEGINNING

- Started 2002
- 10 model developers
- SourceSafe/Vault
  - Used as a network storage
- Manual starting bat files for code gen and building

HISTORY

- Prior to the current engine generation, most tests done in car
- During the development of the current engine generation, automatic unit and system tests were introduced.
  - Aftertreatment SW solely developed in Sil platform.
  - One senior SW developer said: *now I know it will work when we test in the car...*



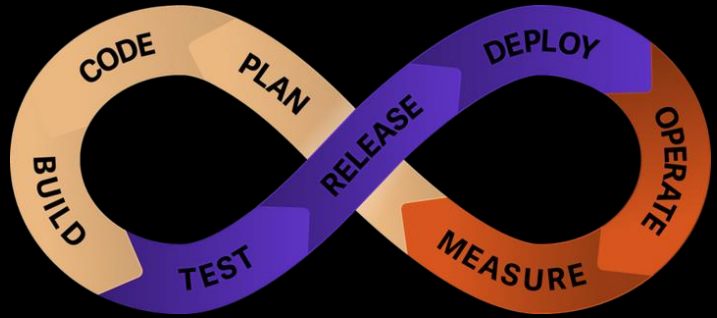


SOFTWARE IN THE ENGINE CONTROL MODULE

- The Software in current generation ECMs is structured into around 400 modules
- A small part of the application code is still made by the HW suppliers

CI/CD SYSTEM

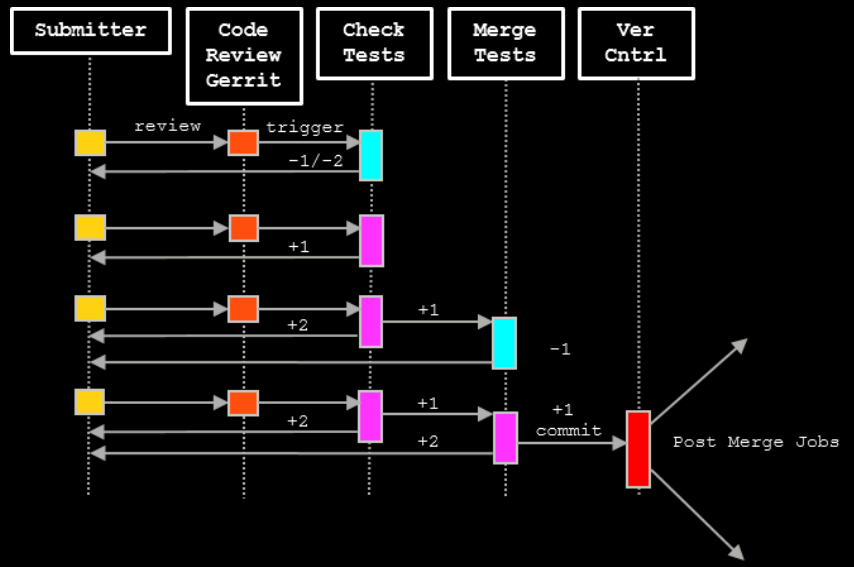
- **Ensuring the integrity is not dependent on a single individual making the right call. It is ensured by the system.**
- **Fast Feedback**, small changes often, automatic testing
- **Transparency**, Follow your commit
- **CI/CD system as code**, using Python plugin Jenkins job builder and YAML files as pipeline configuration

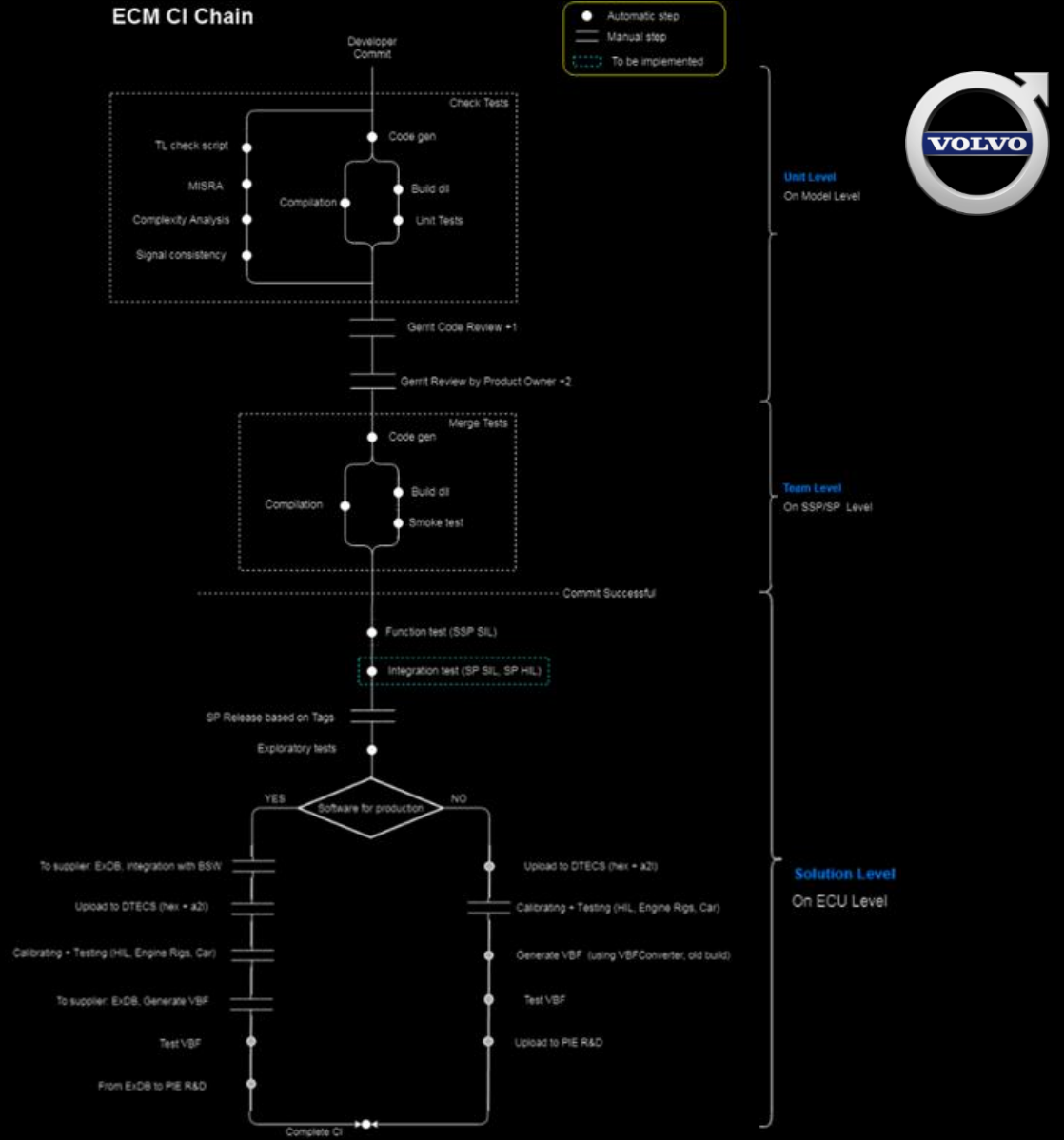


CI/CD SYSTEM

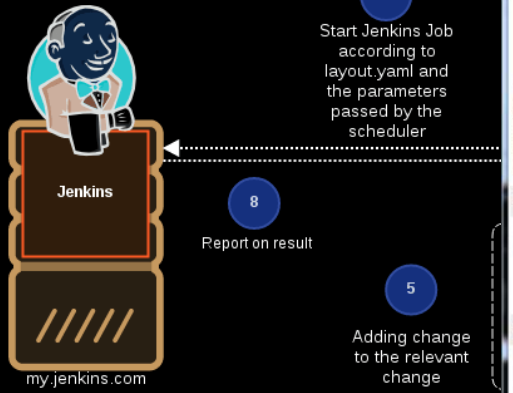
CI system structure

Build dll, unit tests, Merge tests and Exploratory tests executed by Silver and TestWeaver





CI/CD SYSTEM



7
Start Jenkins Job according to layout.yaml and the parameters passed by the scheduler

8
Report on result

5
Adding change to the relevant change

Legend
- zuul service
- conf file
- zuul internal

Zuul Status

Real-time status monitor of Zuul, the pipeline manager between Gerrit and Workers.

Queue lengths: 0 events, 0 results.

Filters Expand by default:

check (1)

Newly uploaded patchsets enter this pipeline to receive an initial +/-1 Verified vote from Jenkins. You can retrigger this check by commenting "recheck" in gerrit

pt_pcc 2066,3 — 0 min / 6 min

VED4_GEN3-010_Generate_Code	success
VED4_GEN3-012_CPP_Check	
VED4_GEN3-013_Checkscript	success
VED4_GEN3-022_Compile	
VED4_GEN3-030_UnitBuild_UnitTests	success
VEP4_GEN3-010_Generate_Code	
VEP4_GEN3-012_CPP_Check	queued
VEP4_GEN3-013_Checkscript	queued
VEP4_GEN3-022_Compile	queued
VEP4_GEN3-030_UnitBuild_UnitTests	queued
GEP3_ Generate_Code	success
SIMDIFF	success
MXRAY_Report	success

gate (1)

Changes that have been approved by core developers are enqueued in order in this pipeline.

Queue: pt_pcc

pt_pcc 1932,14 — 0 min / 8 min

VED4_GEN3-010_Generate_Code	success
VED4_GEN3-022_Compile	
VED4_GEN3-032_CompleteBuild_DLL	
VED4_GEN3-033_Run_MergeTests	queued
VEP4_GEN3-010_Generate_Code	success
VEP4_GEN3-022_Compile	success
VEP4_GEN3-032_CompleteBuild_DLL	success
VEP4_GEN3-033_Run_MergeTests	

build_gep3_ (0)

Build GEP3_ start this by commenting "build gep3_pfi_hev" in gerrit

build_vep4_gen3 (0)

Build VEP4_GEN3, start this by commenting "build vep4_gen3" in gerrit.

build_gep3_ (0)

build_gep3_ (0)

build_gep3_ (0)

Build , start this by commenting "build gep3_ " in gerrit

build_gep3_ (0)

Build GEP3, start this by commenting "build gep3_ in gerrit

build_ved4_gen3 (0)

Build VED4_GEN3, start this by commenting "build ved4_gen3" in gerrit.

release (0)

When a commit is tagged as a release, this pipeline runs jobs that publish archives and documentation.

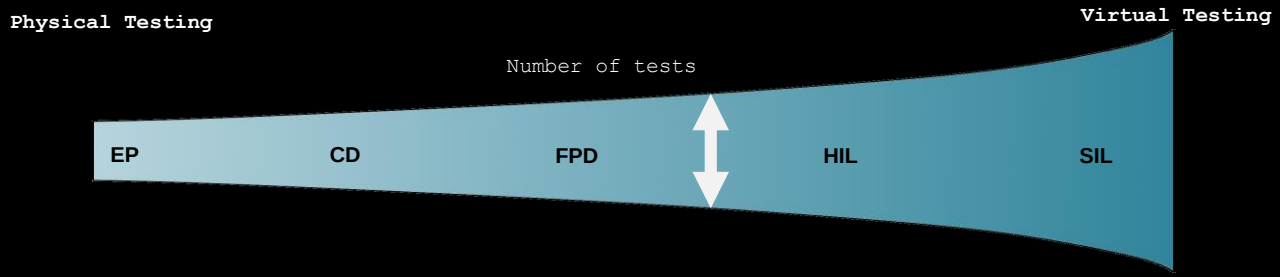
weekly (0)

Jobs that are run on master every week.

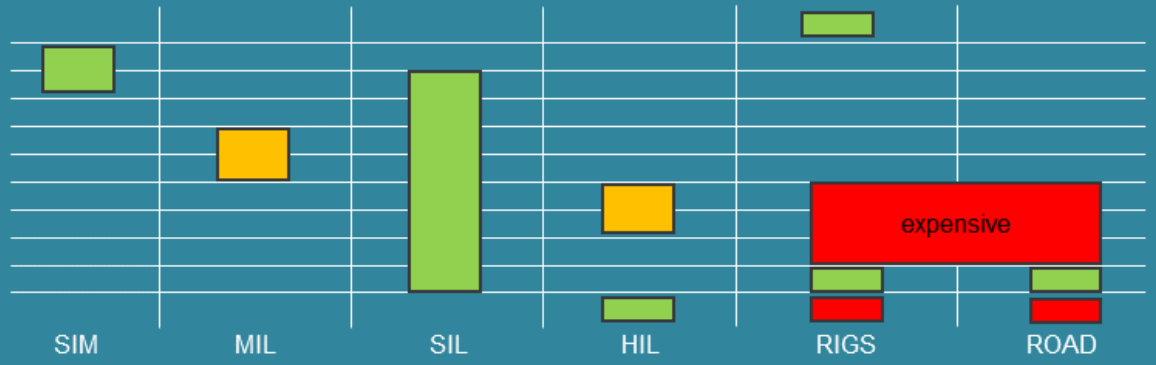
Zuul version: 2.6.0

Last reconfigured: Wed Aug 22 2018 07:55:18 GMT+0200 (centraleuropeisk sommartid)

SIL, THE CORE OF THE CI SYSTEM



- Standardized Data Collection
- Plant Modelling
- Model Calibration
- Conceptual SW design
- Integrated SW design
- Diagnosis development
- SW Validation
- SW Calibration
- Attribute Validation
- HW and diagnostic validation



WHY EXPLORATIVE TESTING?

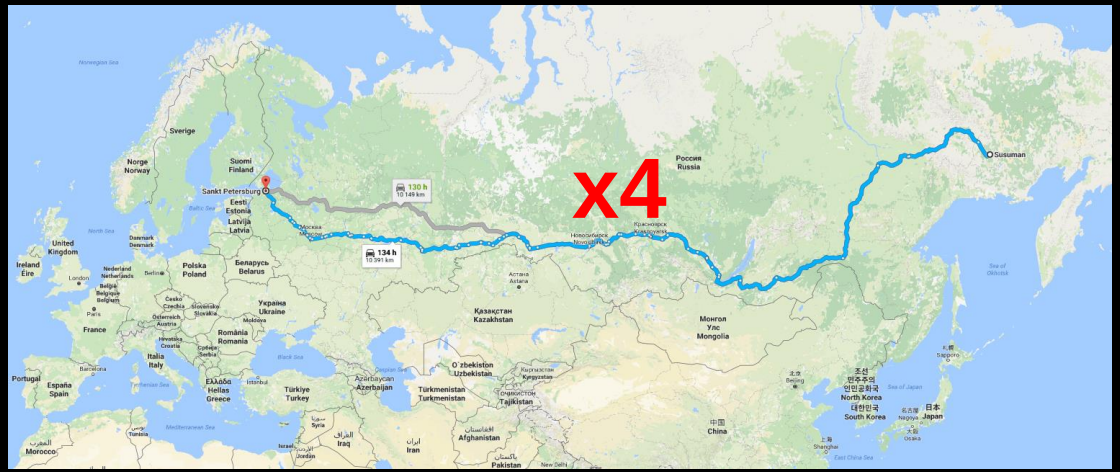
Background

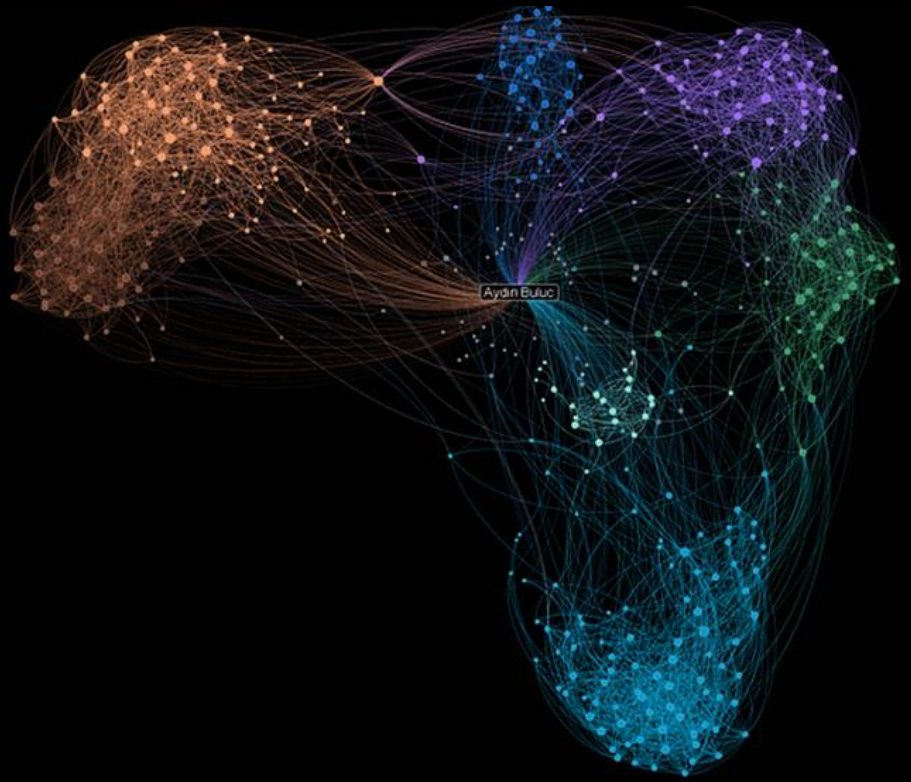
Foufas asked seniour calibration engineer:

> JF: *-what are the biggest problems with the air charge control system?*
>
> *ANSWER: -Oscilations of the actuators during normal quite steady state conditions...*

WHY EXPLORATIVE TESTING?

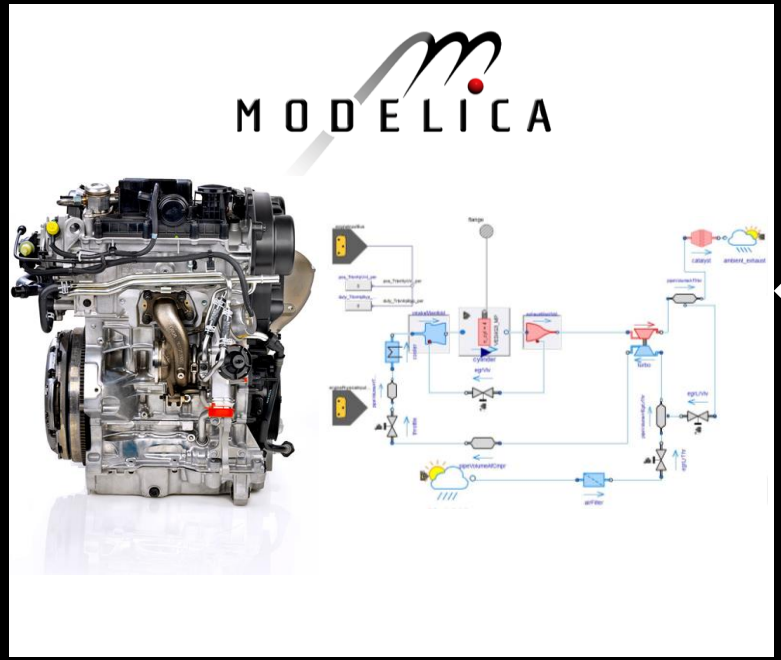
- **45360 km** driven 9 days and 6 hours of continuous driving all in **5 days and 8 hours** of simulation time
- Current max is 30000kh each 24h
- Maximize state coverage of Engine speed, Engine torque, Car speed, code coverage and choosen problem areas
- **Active intelligent search** for system flaws and errors, ie breach of requirements. There will be more nodes in these problematic areas.



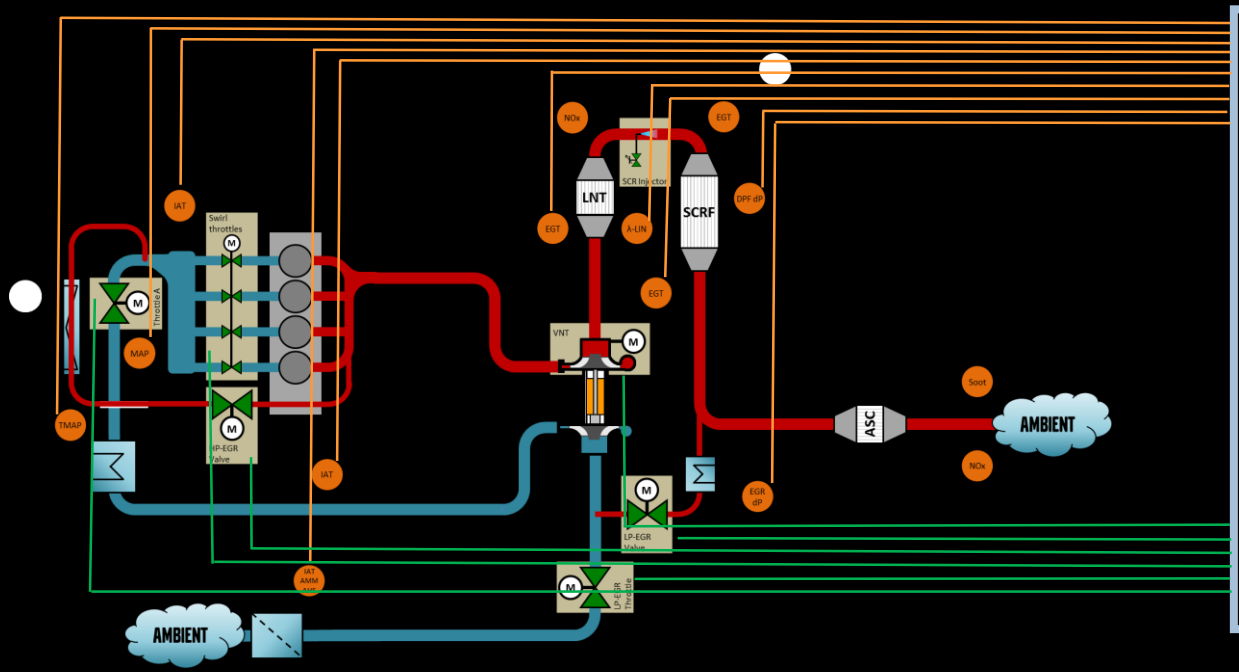


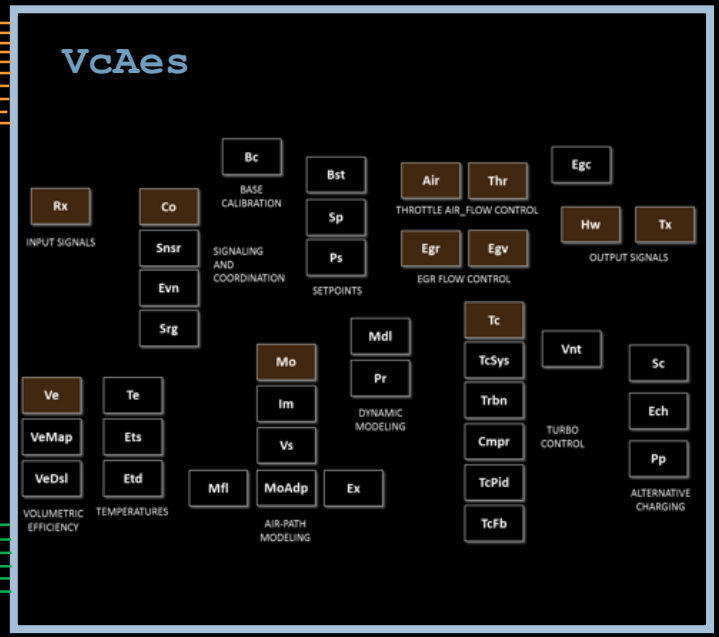
EXPLORATIVE TESTS

Test setup



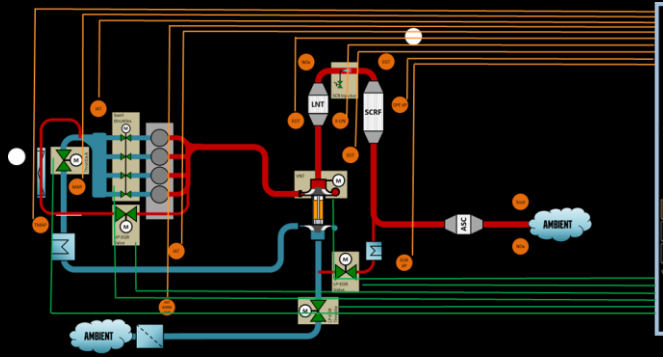
EXPLORATIVE TESTS

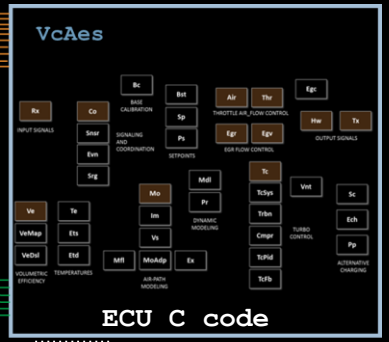




EXPLORATIVE TESTS

Test setup



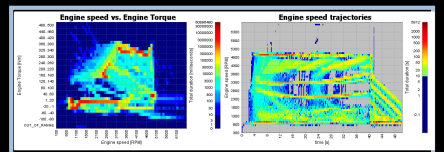


ECU C code

Silver

Vehicle Model

Test Weaver



Test Report

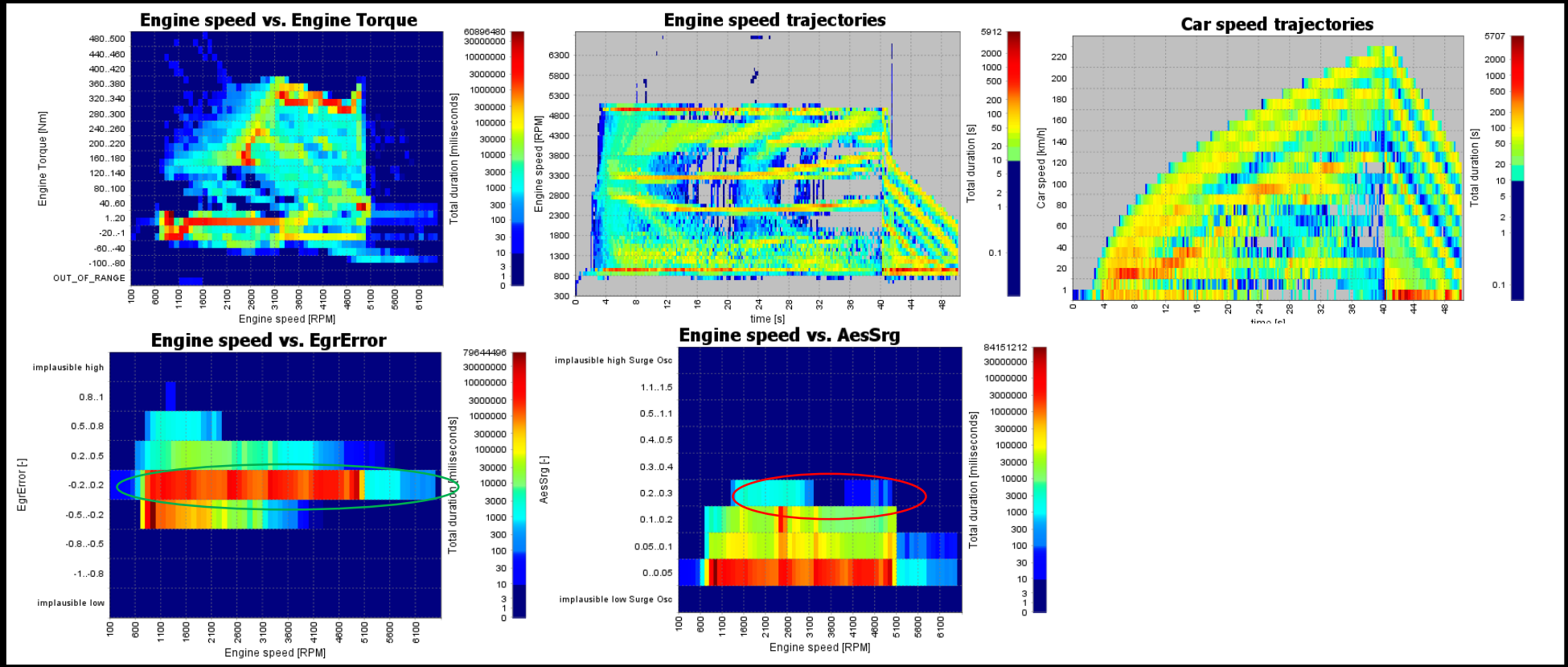
Discretized state space

EXPLORATIVE TESTS

Test configuration

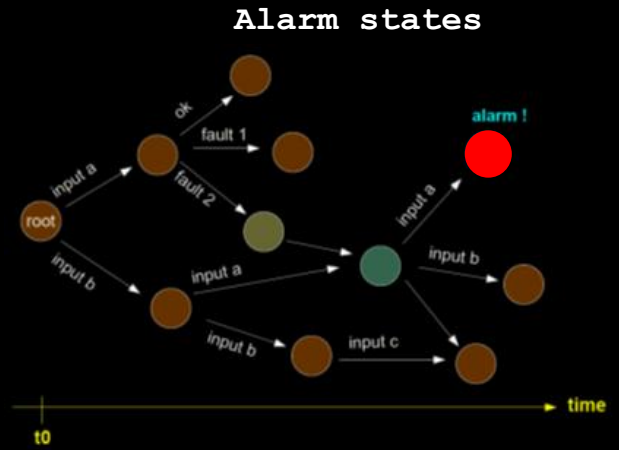
- Oscilations are detected with a state of the art ECM algorithm
- 1 minute cycles, focusing on Engine Speed, Torque exploration and Oscilations of the Intake Air Mass Flow and EGR control deviations.
- 3 days Simulation time, 1.5 days real time

EXPLORATIVE TESTS



EXPLORATIVE TESTS

- First try gave oscilating air mass in 20 cases
- First case identified after 8 minutes



surge

AesSrgMeasTW	engineTorque	state
0.1..0.2	-60..-40	s190_6.22s
	-40..-20	s9_20.608s
	-20..-1	s9_20.644s
	-1..1	s9_20.672s
	1..20	s9_20.676s
	20..40	s167_5.716s
	40..60	s430_21.904s
	60..80	s8_22.02s
	80..100	s8_21.848s
	100..120	s8_21.756s
	120..140	s8_21.632s
	140..160	s8_21.564s
	160..180	s4_25.464s
	180..200	s4_20.56s
	200..220	s68_4.26s
	220..240	s68_5.5s
	240..260	s68_5.044s
	260..280	s90_5.588s
	280..300	s127_5.076s
	300..320	s127_5.156s
	320..340	s10_20.676s
	340..360	s10_20.64s
	360..380	s10_20.608s
	380..400	s136_5.772s
	400..420	s2273_3.248s
	420..440	s2273_3.24s
	440..460	s2273_3.224s
	460..480	s2273_3.22s
0.2..0.3	-40..-20	s194_6.008s
	-20..-1	s148_5.608s
	-1..1	s148_5.816s
	1..20	s148_5.548s
	20..40	s194_6.132s
	40..60	s4640_22.232s
	60..80	s4640_22.216s
	80..100	s1216_21.808s
	100..120	s1216_21.852s
	120..140	s4936_22.232s
	140..160	s4936_22.228s
	160..180	s172_5.808s
	180..200	s172_5.816s
	220..240	s153_5.704s
	240..260	s153_5.608s
	260..280	s153_5.696s
	280..300	s153_5.616s
	300..320	s153_5.628s
	320..340	s153_5.64s
	340..360	s1352_5.44s
	360..380	s1352_5.448s
	380..400	s1697_6.216s

EXPLORATIVE TESTS

engineSpeed	2306.377
engineTorque	183.893
AcceleratorPedal	25.000
BrakePedal	0.000
currentGear	8
prnd	D
targetGear	8
carSpeed	88.999
mdExhDsTw	57.661

a2l_sVcAesTx_X_EgrLrVlvTar	60.586
a2l_sVcAesRx_md_IntkMafSnsr	55.145
AesSrgMeasTW	0.105
a2l_yVcAesSrg_B_OscBool	1.000
a2l_sVcAesPs_p_BoostSp	223.058
a2l_sVcAesTcSys_p_IntkBoostSpFi...	223.951
a2l_sVcAesTx_X_TrbVntTar	77.123
a2l_sVcAesHw_X_ThrTar	100.000

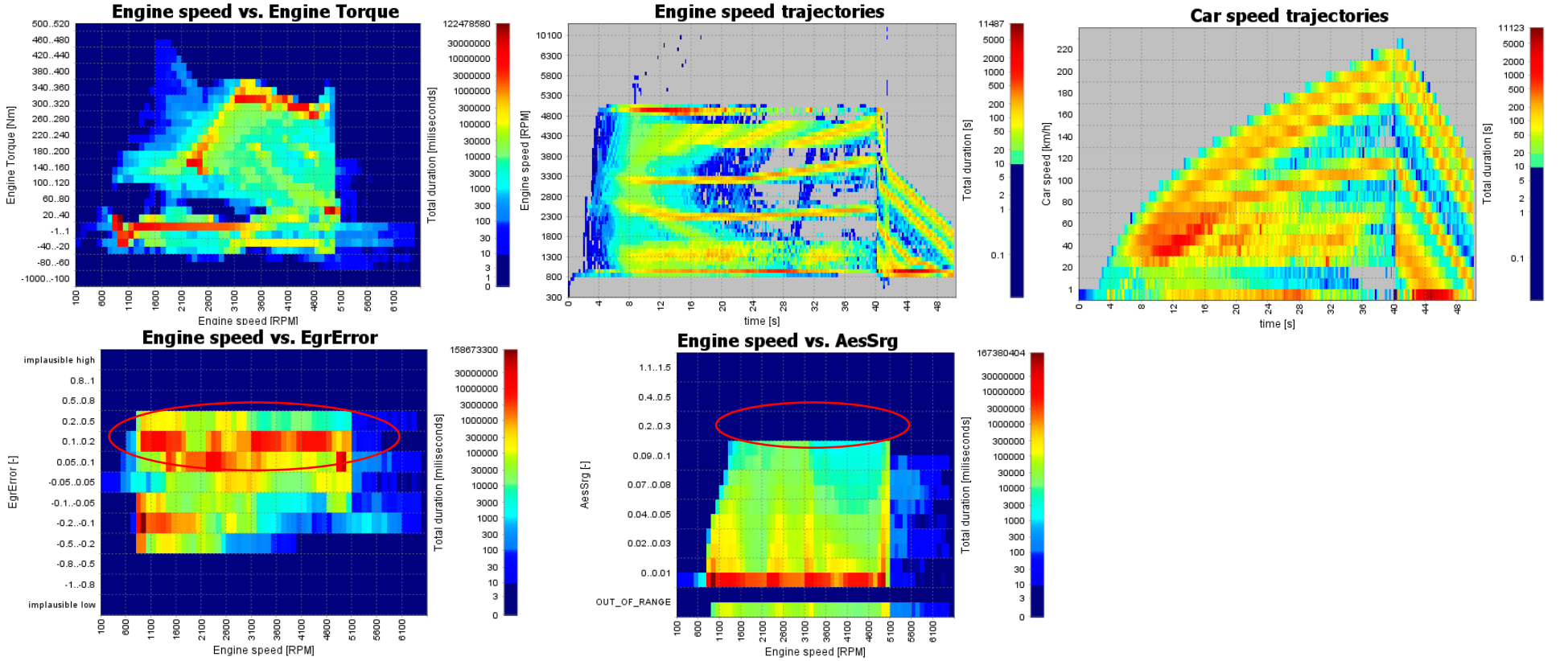
Similar oscilations where later found in Engine Test Lab

EXPLORATIVE TESTS

Second test

- After more calibration in Hällered proving ground as well as optimization in Python, all oscilations were removed.
- 9 days Simulation time (9*24h), 4.5 days real time
- No oscillation problems
- Maybe to much EGR?

EXPLORATIVE TESTS



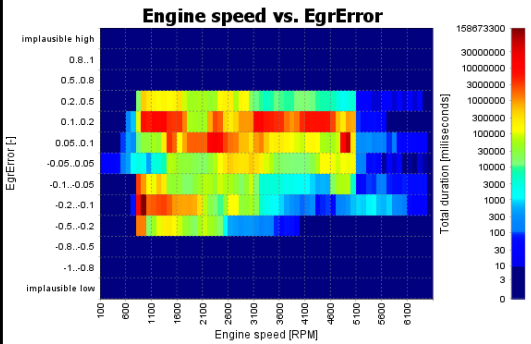
EXPLORATIVE TESTS

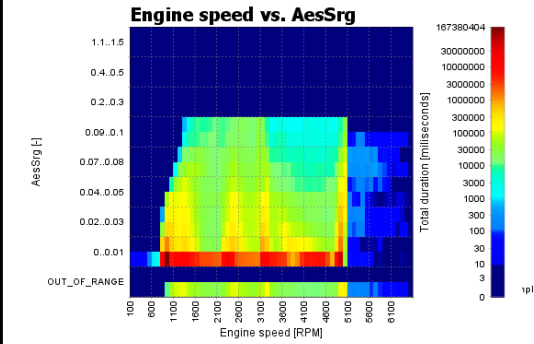
Third test

- Lifting the Software from release 40 to release 55
  - Fixing two SW buggs on the way...
  - New temperature model VcTeExh
  - Update plant models
- 23h simulation time
- New oscillation problems
  - Control instability
  - During Intake Air Throttle
- Boost Control more stable

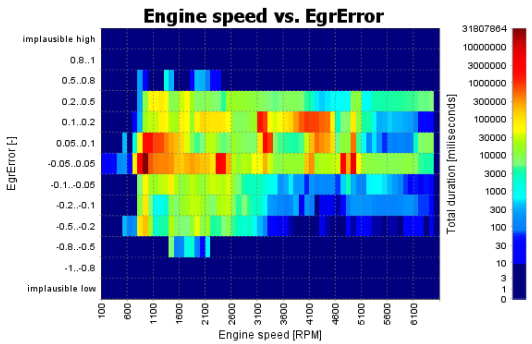
EXPLORATIVE TESTS, TIMELINE

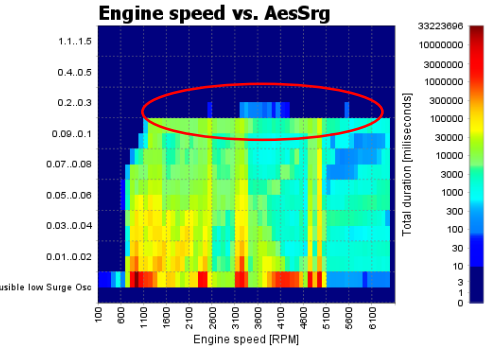
Second test





Third test





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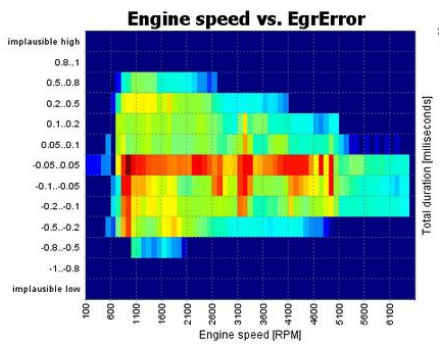
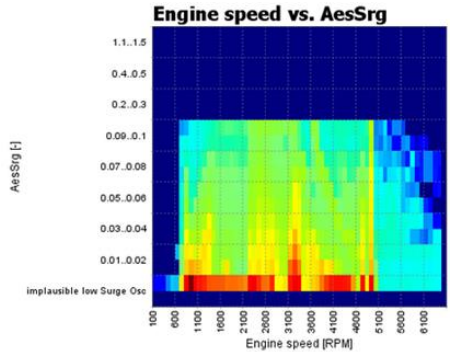
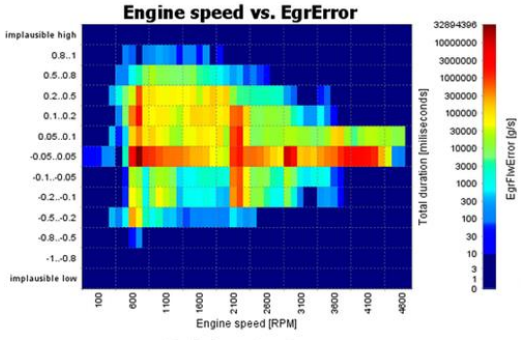
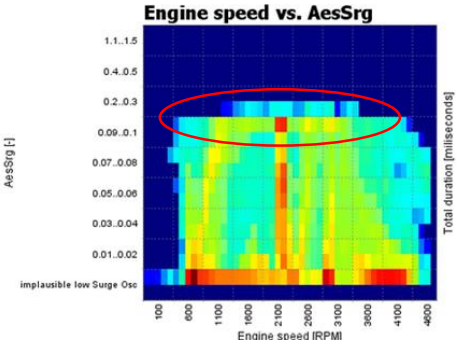




Fith test, New WCaC





EXPLORATIVE TESTS, CONCLUSIONS

- Catches SW errors and some unrobust calibrations.
- Merge tests/Smoke tests for the air charge system uses the same Silver setup.
- We see that calibration of different parts like temp model, egr and boost pressure all influence each other, and change the overall behaviour.
- Air charge OBD, trials but there is a greater need for accuracy in plant model.
- Problems found are real, they replicate on the real engine, althogh not exactly the same.