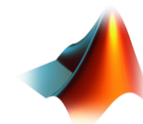




A Journey with Model Based Design

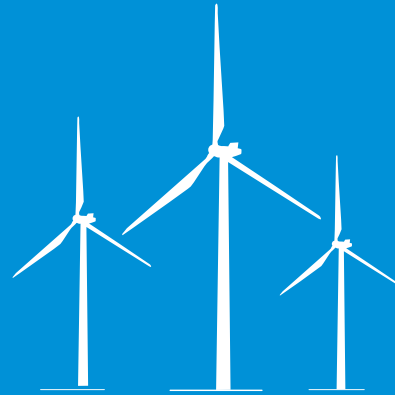
Per Hagen Nielsen :: Plant Controls :: Electrical BoP & Hybrid:: Vestas Wind Systems A/S





+24,400

We employ more than 24,400 people worldwide and have more than 35 years of experience with wind energy



+41,500

We have a total of 41,693 combined turbines under service, or more than 82 GW



+ 66,000

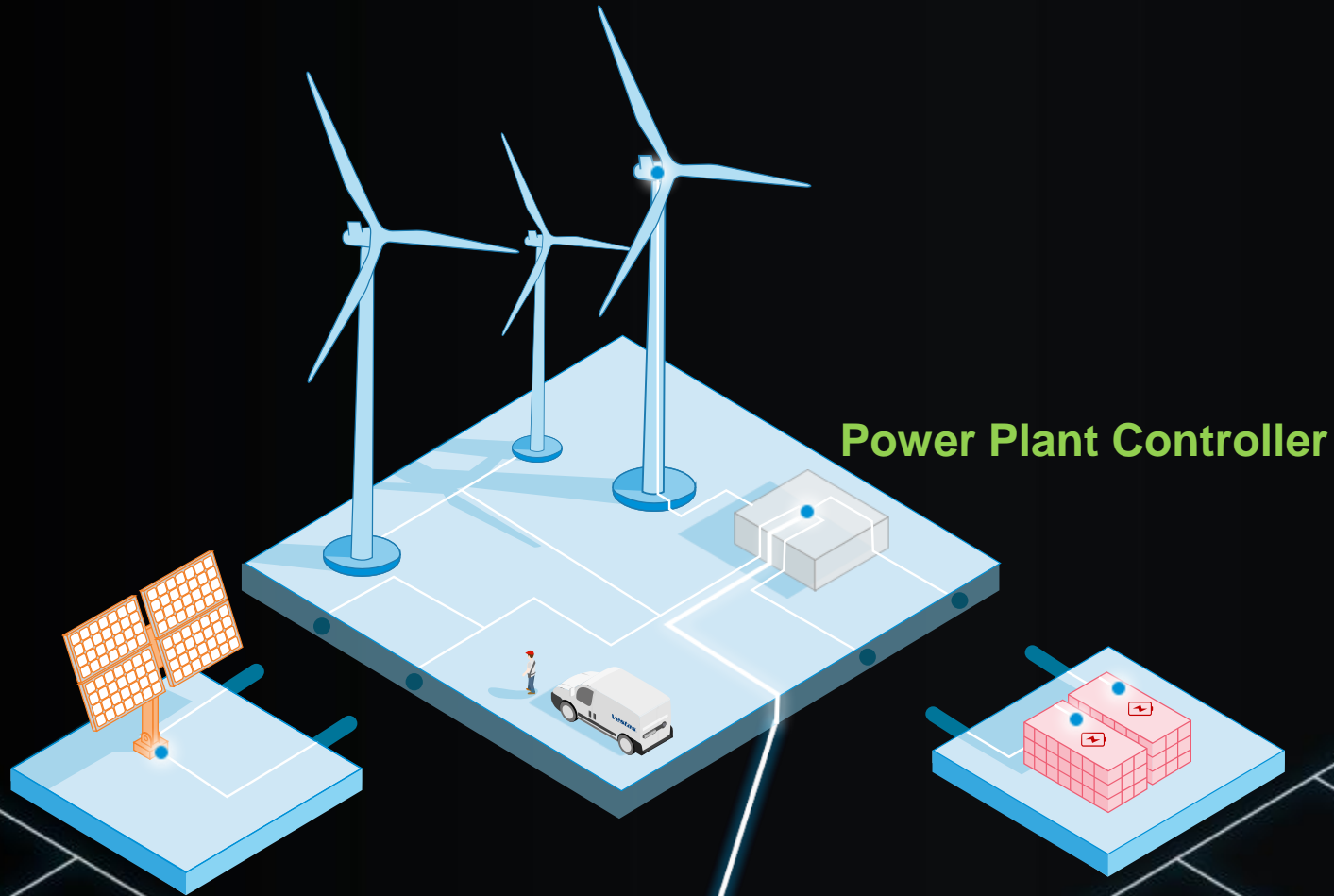
We have a total of 66,093 turbines or more than 97 GW of installed wind power capacity in 79 countries worldwide spanning six continents



€ 2,811m

Vestas' revenue for Q3 2018 was EUR 2,811m

VESTAS HYBRID POWER PLANT SOLUTIONS DEPARTMENT



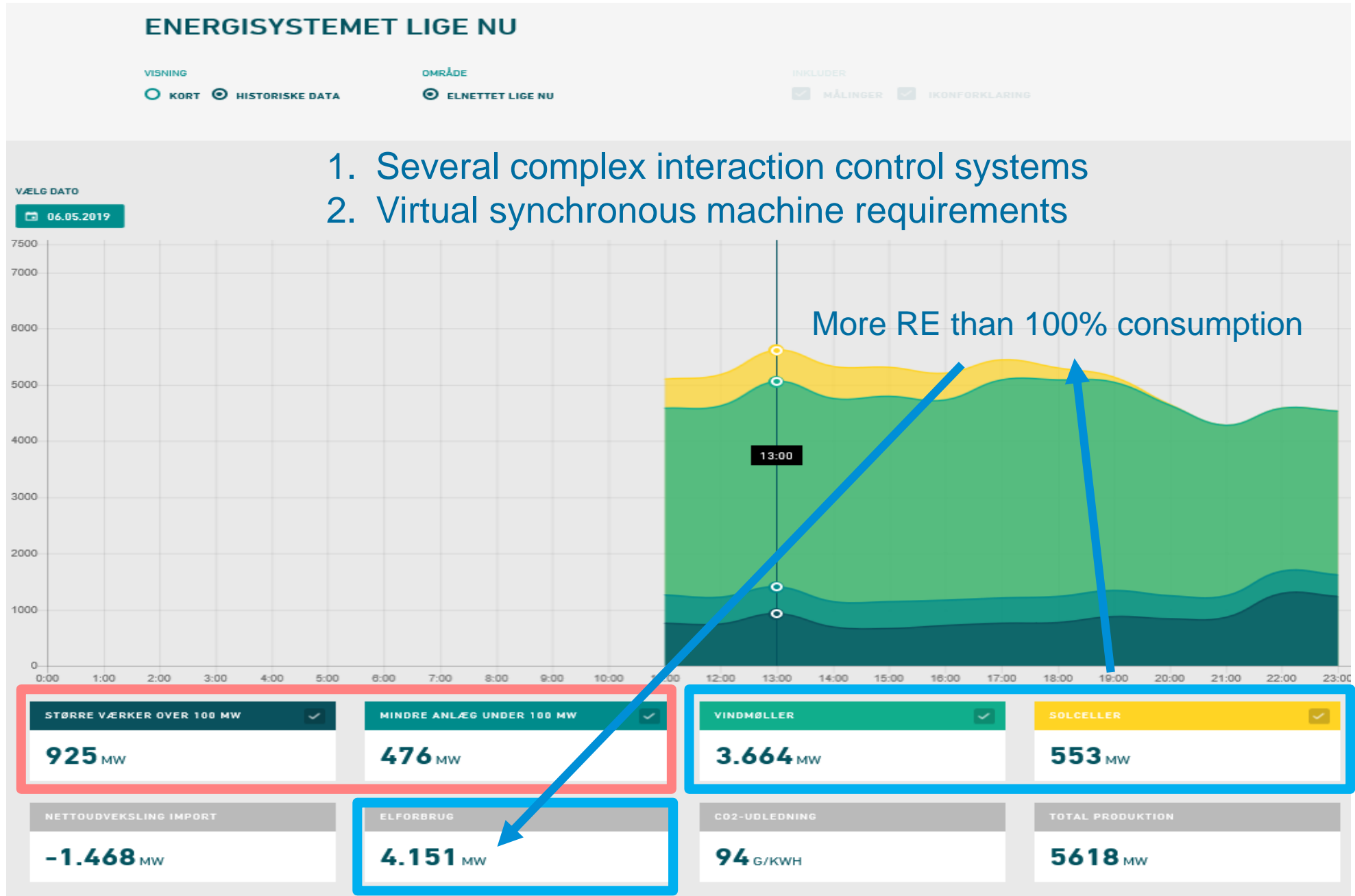
Power Plant Controller

Global Grid code requirements

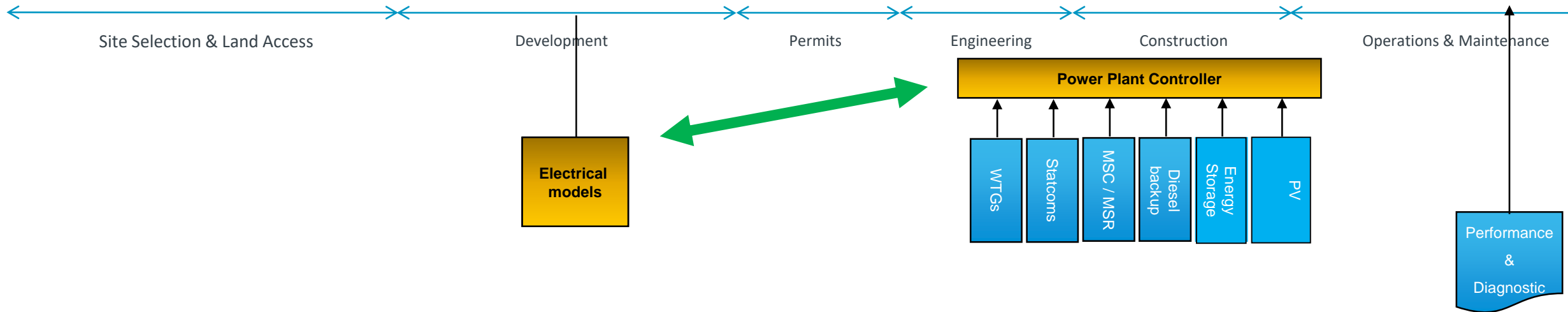
With **wind** as the core energy source, Vestas' hybrid power plant solutions leverage from the combination of wind power generation with either **solar PV** generation or **electrical storage**, or both of them.

Our department offers Power Plant Control software, hardware and models matching global grid code requirements

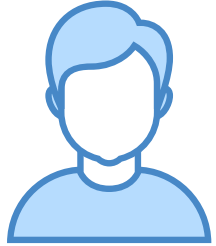
ActivePower, ReActivePower, Frequency, Power factor, Inertia, Voltage, FastRunBack control etc.



Power Plant Engineering



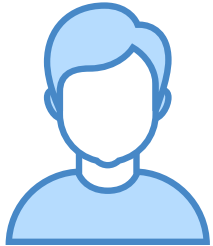
Pre-challenges before the Model Base Design approach. The Team in 2014 was approx 10 Engineers



Power Engineer

- Power Engineers doing paper design documents
- Main design test platform was PSCAD (power system analyze tool)
- Design component wise, no fully true model in design framework

Waste of time & opportunities



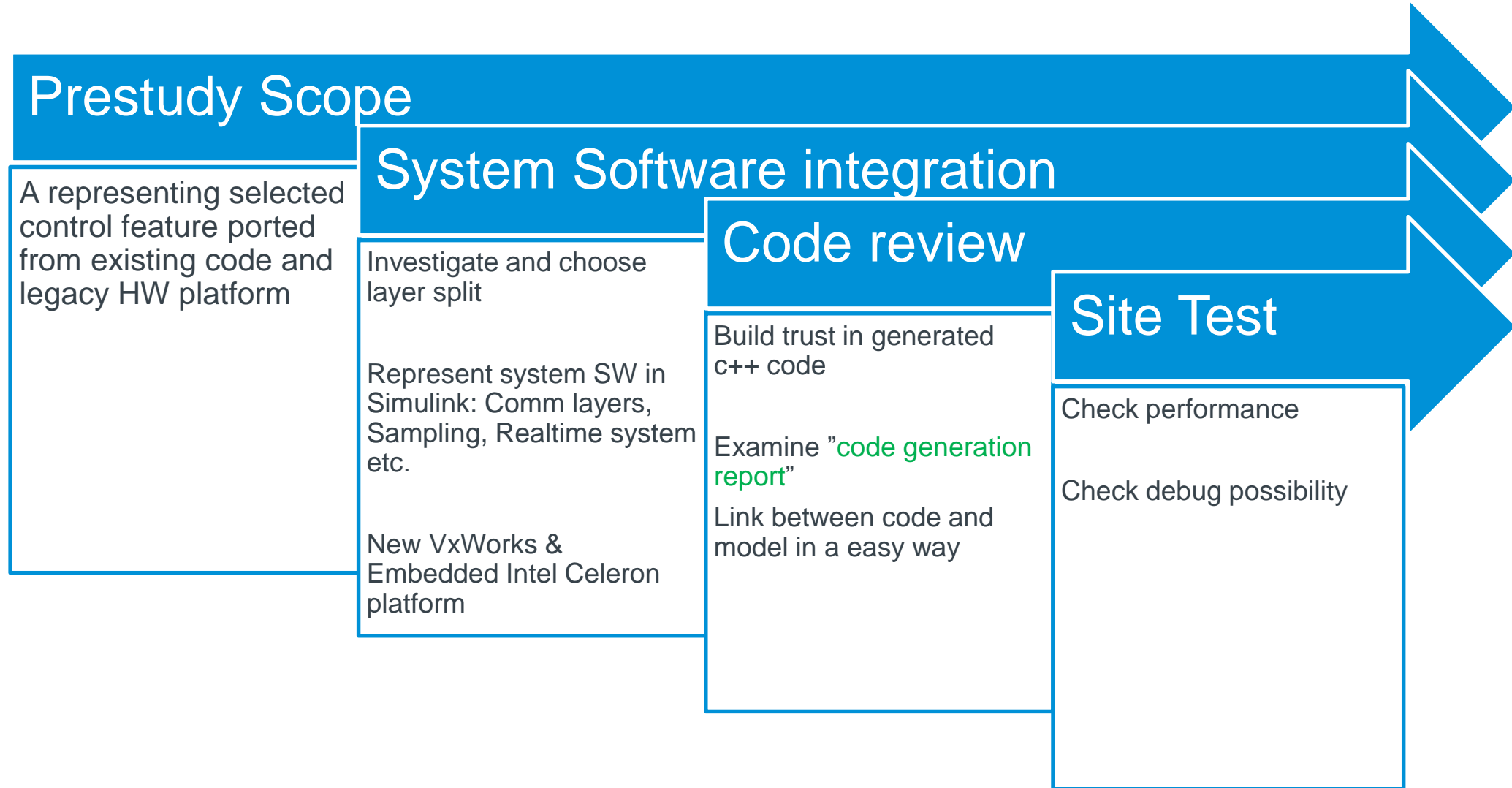
Software Engineer

- Software design/implementation from design documents
- Integration to full system discovered need for redesign iteration
- Handled both system software & application layer
- C++, Structured Text.

We needed one model one team

Prestudy for ModelBasedDesign using Simulink with C++ code generation

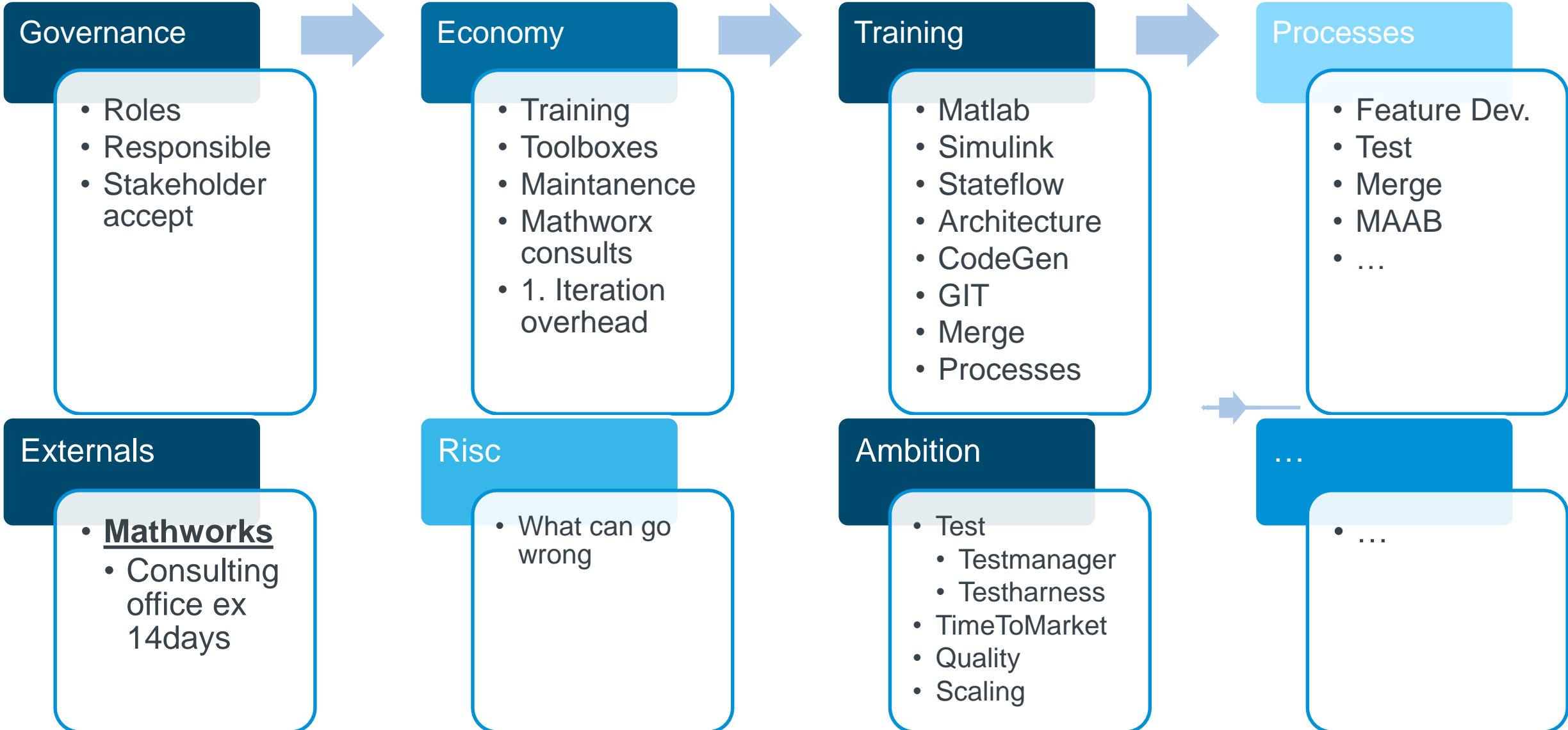
One man-month work



Decision making – What do the management say yes to

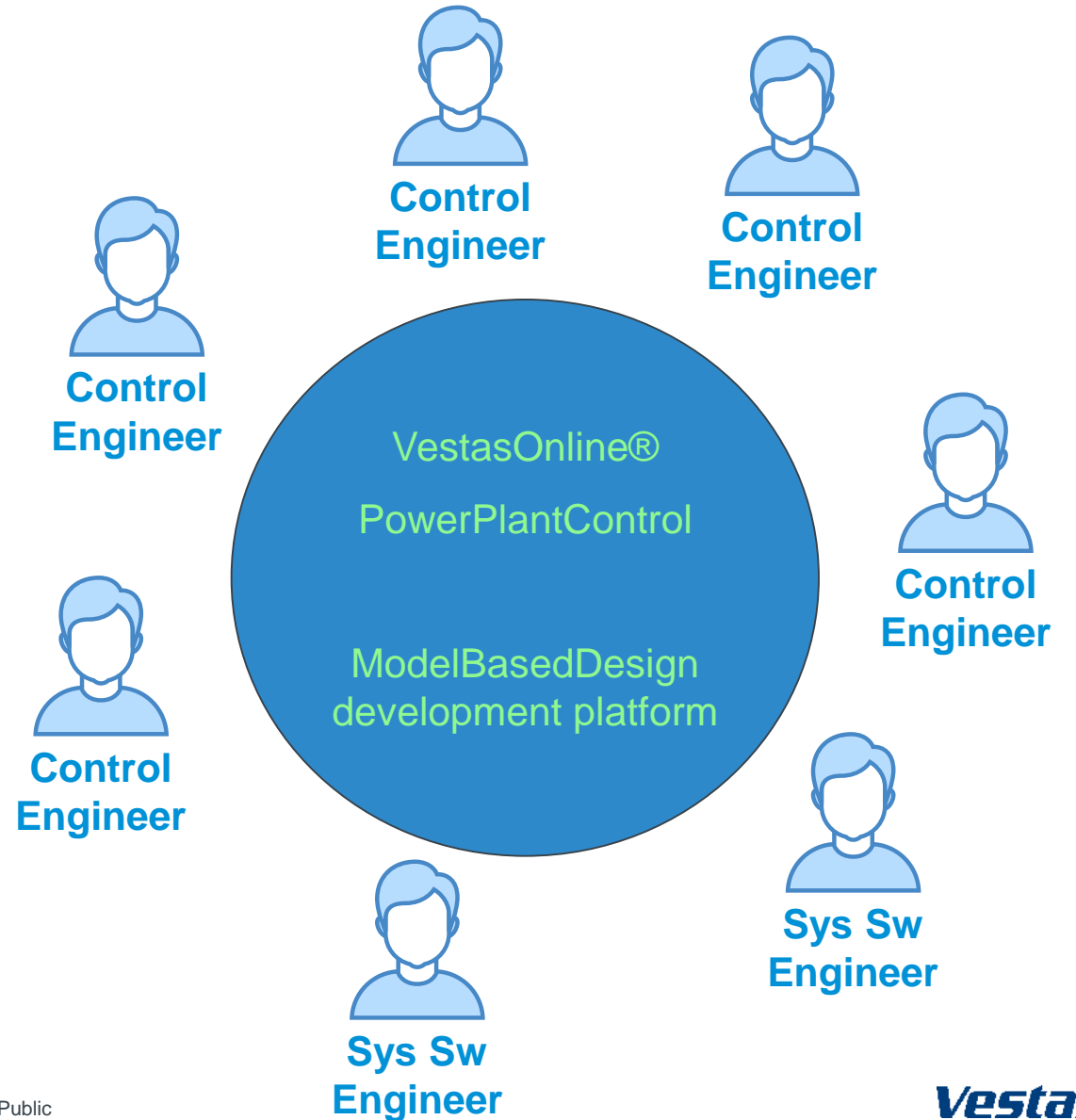
TIP: Address everything but use only a few hours and move ahead...

You wont be more accurate anyway and you wont regret



TEAM ORGANIZATION CHANGES

➔ Software engineers & Power engineers became **Control Engineers**



Challenges along the first 2 years

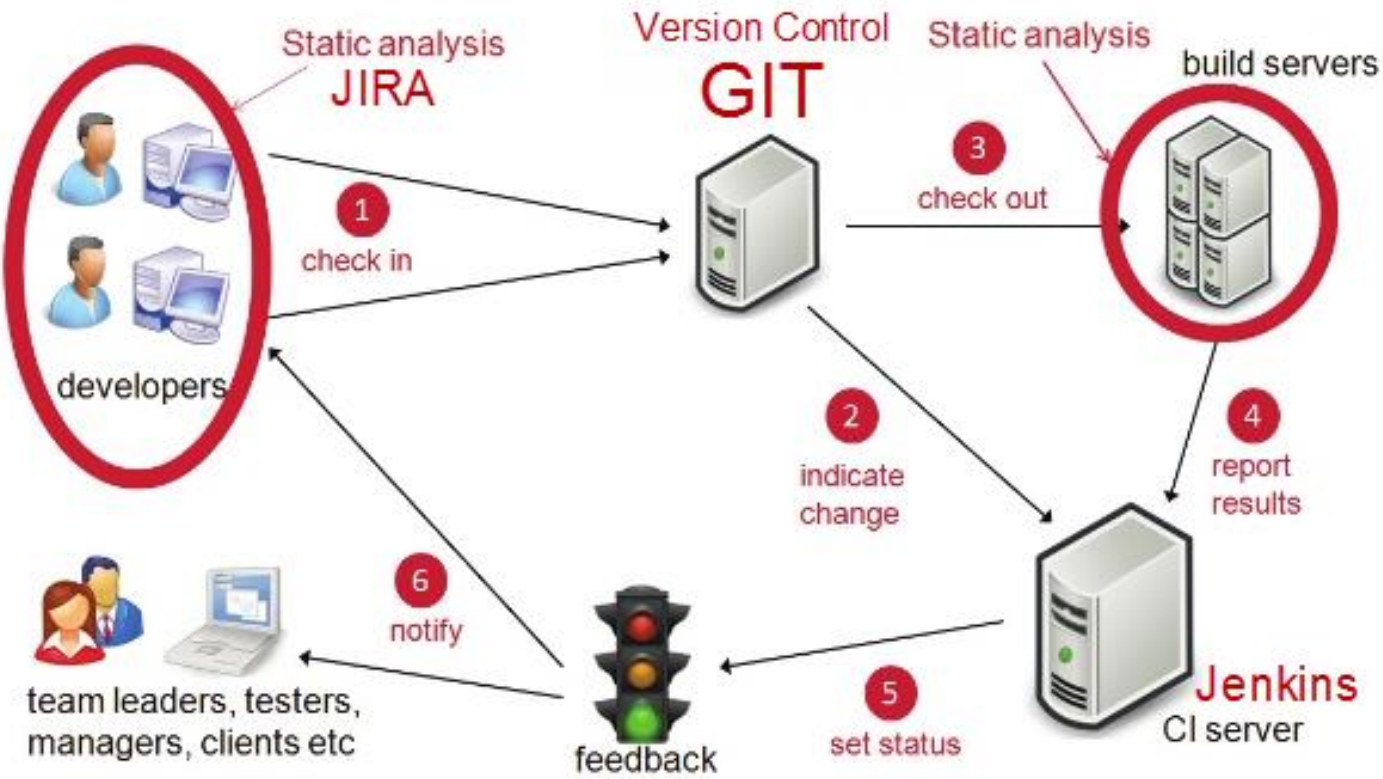
- Merge tool and GIT for concurrent development issues was underestimated.
- Team size increased up to 30 worldwide (Denmark, Sweden, Porto, Ukraine, Singapore)
- New way of working inefficiency under estimated (you'll get it back later)
- Simulation and build speed exhausted on the platform (+20min compile & simulate)

Upgraded development platform 2 man-month + 14days Mathworks consulting


- Upgrade 2017b tools
- New internal development platform
 - Refactored layer design, build structure, dependency issues
 - Dataviewer usage
 - Accelerated executions, extended scripting
 - MathWorks Automotive Advisory Board (MAAB) rules introduction

From 2017 Jenkins build integration server

CONTINUOUS INTEGRATION WORK FLOW



Test and Validation

- Usage of Mathworks '*Simulink Test*' was not considered in the start, validation of design was following legacy procedure in Vestas eg. Lab test with generated code on real hardware and partly matlab test.
- In 2018 *Simulink Test* in form of Testmanager and TestSequences was introduced.
 - Every legacy written cases are baselined, so a “curve” of all signals outcome where recorded and checked when developer delivered to the GIT master stream with a low default tolerance. An easy quick check but not very intelligent so time was used on analyzing faulty faults. Also the setup is very sensitive to interface changes.
 - A more intelligent assessment for each case is necessary but takes time (**..a lot**), but how mission critical are your code  And front load your work, write assessment a dev time
 - All Tests runs at night on Jenkins integrations servers.
 - MAAB checks, Warning Error check, Test check, are reported through



Wrapping up

- Identify your current situation
 - Where are your product development?
 - Where would you like to be?
- Involve stakeholders
 - PreStudy
 - Get commitments
 - Governance & Economy
 - Don't sell ModelBasedDesign on short term, takes years
- Use special attention to you continues integration workflow



Thanks for your interest

Q&A

