Project Control & Management

Dr Alireza Mousavi, Department of Electronics and Computer Engineering
Brunel University, UK

Technische Akademie Esslingen (TAE)

Lecture 10

We will be discussing

1. Project Management Challenges in **P**roduct **E**ngineering, **T**esting and V**al**idation process (PETAL)
2. Going through a typical product design, testing and evaluation process
3. Discuss the main PCM challenges through a case study
4. Leading to a new way of dealing and handling such challenges

Product **E**ngineering, **T**esting and V**al**idation process (PETAL)

- The testing and validation phase is the most challenging and costly phase of product engineering-manufacturing process.
- Whether a new product or an update or troubleshooting of an existing product is due, the product engineering testing and validation process will be the epicentre of activities in high-tech companies.
- Normally, the best and the most sought after engineering and technical talents of the organisation converge for the project to ensure that the demands of customers are met.
- Timely and successful outcome of each project brings a windfall of <u>commercial gain and prestige </u>for the company.

The Process of PETAL

The process of product engineering, testing and validation (PET) requires a set of meticulously planned tasks.

Relationship between Engineering Specifications & Actual Performance

Regardless of whether a new design is undergoing tests or an existing product requires modification or being fault analysed (e.g. fail claim) the activities ending in validation and verification may require:

- new resources,
- settings and understanding of the relationship between engineering specifications and actual performance of the product in different working environments.

Due to the importance of PET, high-tech companies treat them as **“projects”**; and deploy the project planning and management protocols for them.

The PETAL Diagram

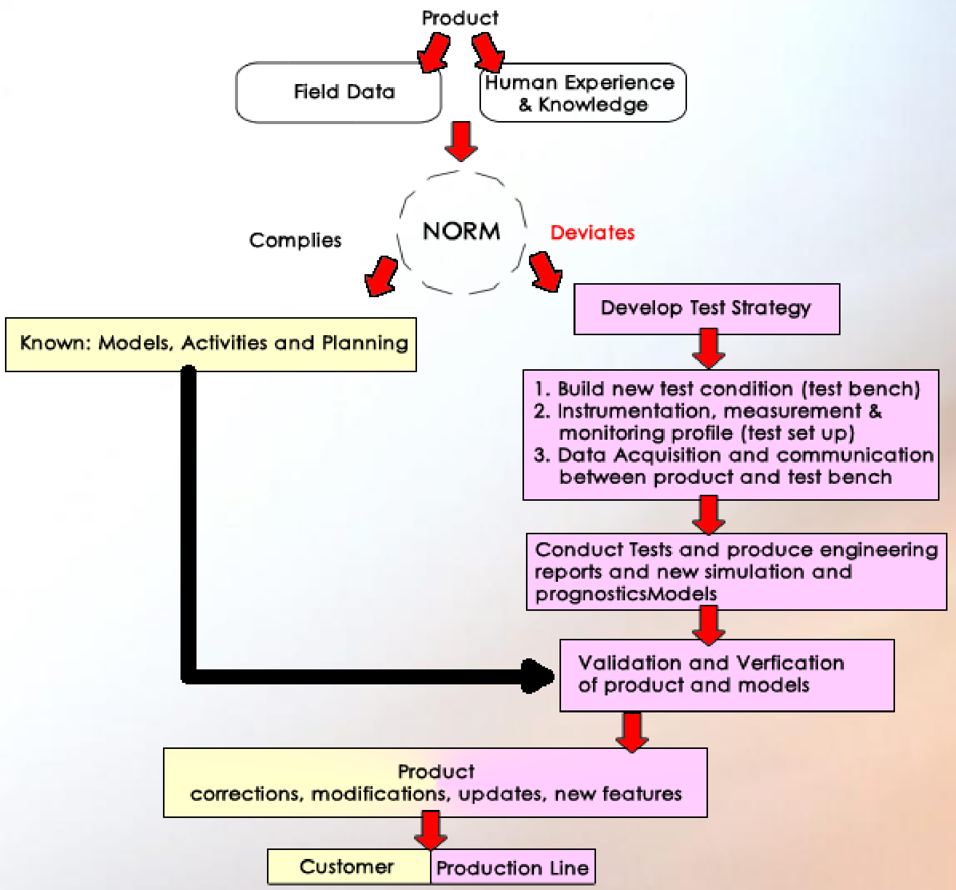


Figure 1: Product Engineering, Testing and Validation Process

Process and Conditions of PETAL

- The PET process starts from the analysis of product specifications and requires extensive studies of how the product performs in various environmental conditions.
- Classical engineering methods and the knowledge and experience gained in time, establishes the "Norm" (Fig 1). The "Norm" is when the engineering team has successfully established evidence of correlations between set of systems input/output and the control parameters explaining most of the causal relationships between design specifications and product performance.
- Under the "Norm" condition, a near to routine and repeatable settings from reliability and fidelity of models and testing would achieve the desired results.
- The companies normally have an established mechanism to meet its customers' requirements at these occasions.

Outside Norm

- Nowadays more challenging and complex products are being introduced to the marketplace,
- The "Norm" becomes much less and far in between.
- Encountering the new conditions of "unknowns", is putting the engineers and technicians under immense pressure to:
  - design new data acquisition setting,
  - new simulation and prognostic modelling at ever increasing time and resource constraints.
- The new high variation and timely project turnovers requires more efficient and agile ways of dealing with the PETAL process.

Engineering – Project Control & Management

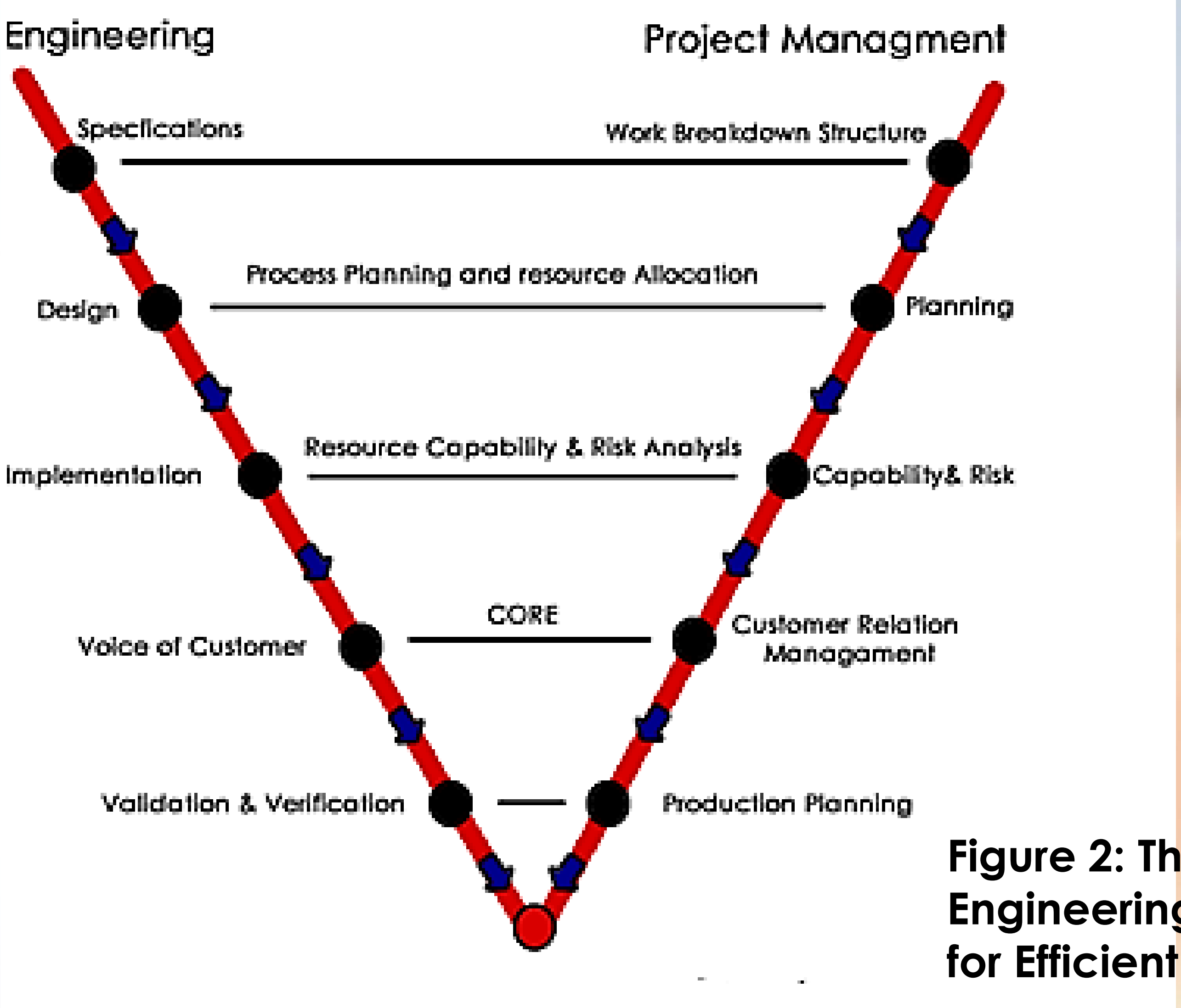


Figure 2: The conceptual integration of Engineering and Project Management for Efficient PETAL

Project management at breaking Point!

The challenges posed by the complexity of product specifications and customers' ever-increasing demands has stretched the traditional project management approach of companies to breaking point.

Examples

- We use examples in Vehicle Injection Fuel Equipment and Marine Diesel Engine, but in our experience in addition to these industries, the same challenges exist in
  - aerospace,
  - marine technology,
  - high value electronics,
  - robotics,
  - Instrumentation – Precision Engineering and
  - machines tools industries.

Case 1: Powertrain Engineering

- The Powertrain Engineering division of a company produces advanced fuel injection systems for the heavy-duty market.
- These fuel systems operate at injection pressures of up to 2700 bar and must retain precise control of pressure, fuel delivery and the injection timing to maintain fuel efficiency and exhaust emissions.
- Such requirements on performance should be achieved throughout the life of the vehicle in various operational terrains.
- Powertrain components in this sector of the market carry an extensive warranty, typically 1.6 million kilometres or 20,000 running hours.
- The durability and environmentally friendliness of these designs must be rigorously validated before serial production begins.
- The importance of validation in addressing any potential failure modes and **protecting the reputation of the manufacturer and its customers satistifaction** cannot be emphasised more.

The classical Approach

- Conduct product **durability and reliability testing** for a new product.
- To achieve the required level of predicted product reliability and confidence a wealth of **statistical data** from system running hours at rated operating conditions would be required.
- **Costs** need to be reduced
- **Product development time** needs to be shortened
- Accelerated testing and targeted testing methods are used (shortened tests of increased severity designed to excite particular failure modes as identified by previous tests, FMEA or by customer field trials).
- These validation programmes are carried out against **financial and time pressures**.
- If validation is not completed on time, the business may be forced to commence production at an **increased risk** of warranty claims or litigation due to product failures.
- Start of production dates are contractually agreed with customers many months ahead in order that engine manufacturing lines can be commissioned and delivery dates to end users met.

Reliability of data

- The weakness of current engineering, testing and validation techniques could be categorised in the reliability of field data,
- the validity of the sensors networks (i.e. having the right data acquisition points in the right place and feeding the correct set of control parameters).
- Such shortcomings lead to ineffective causal relationships build-up, and as a compensatory action using complex data mining, pattern recognition and modelling methods (e.g. polynomials, statistical machine learning (SML), neural network (NN) and artificial intelligence (AI)).
- Each approach has its own strengths and weaknesses. For example, the more simpler polynomial methods suffer from inaccuracy when complexity increases, or in cases of more advanced methods that capture complexity, (i.e. NN, SML, AI) high levels of expert interference, over-fitting, and at times solutions that are not implementable.

The Engineering & Data Analytics Challenges –Possible Solution.

Figure 3: Adaptive product testing and evaluation platform

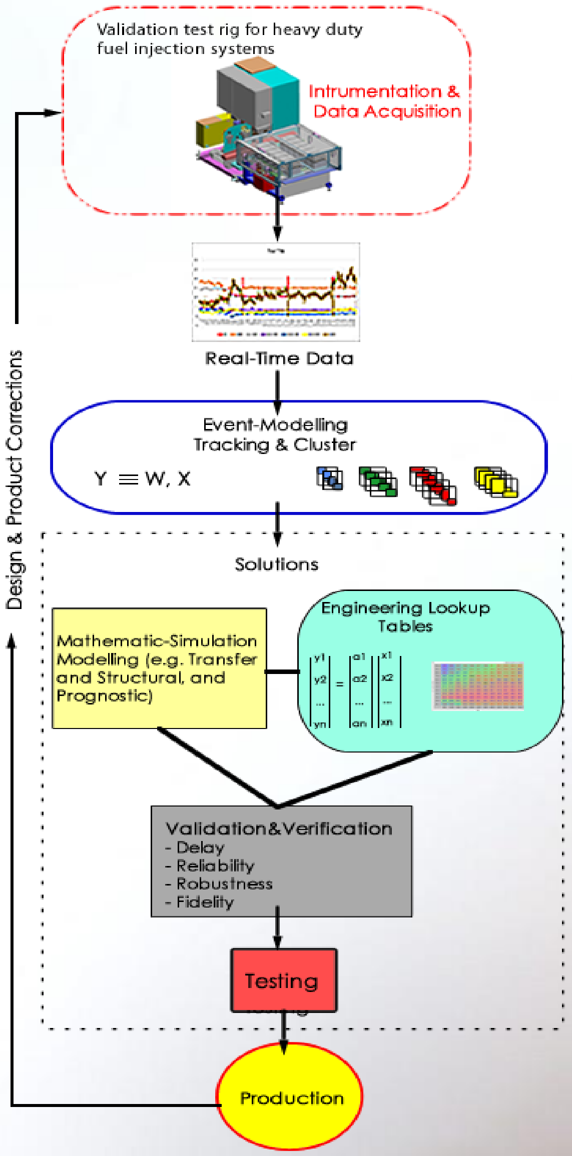
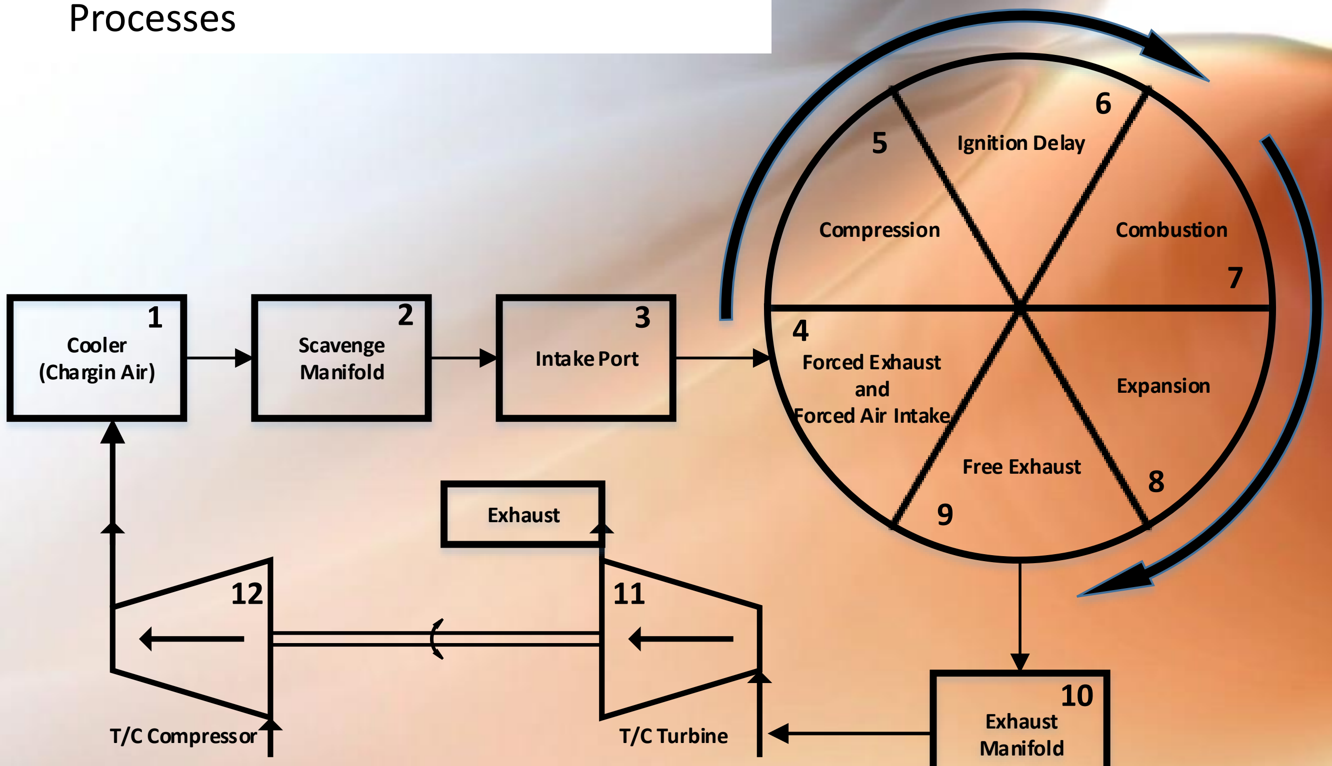


Figure 4: Two Stroke Marine Diesel Engine: Modelling the Engine Processes



System Parameters

- Modelling of sub-parts and processes are determined by considering the function of the modelled component in the system as well as the operational range of the parameters.
- System parameters such as engine speed, load, pressure, operation temperature of exhaust manifold, air mass, fuel injection profile, and other internal external input parameters.
- Output parameters such pollutant emissions CO2, Particles, NOx, …) or propulsion efficiency, noise and other metrics of interest.
- This analytical and process-based approach to problem solving and systems modelling allows for a pragmatic utilisation of mathematical approaches.

Hardware in The Loop and Software in the Loop

A typical product engineering project life cycle would consist of 7 steps: (Bosch Project Engineering and Management Manual):

(1) Instrumentation and Data Acquisition,

(2) HiL-SiL development,

(3) Application development,

(4) Design Validation plan (Beta sample development),

(5) Production Validation plan,

(6) Pre-Serial Production trials, and

(7) Full Production Plan.

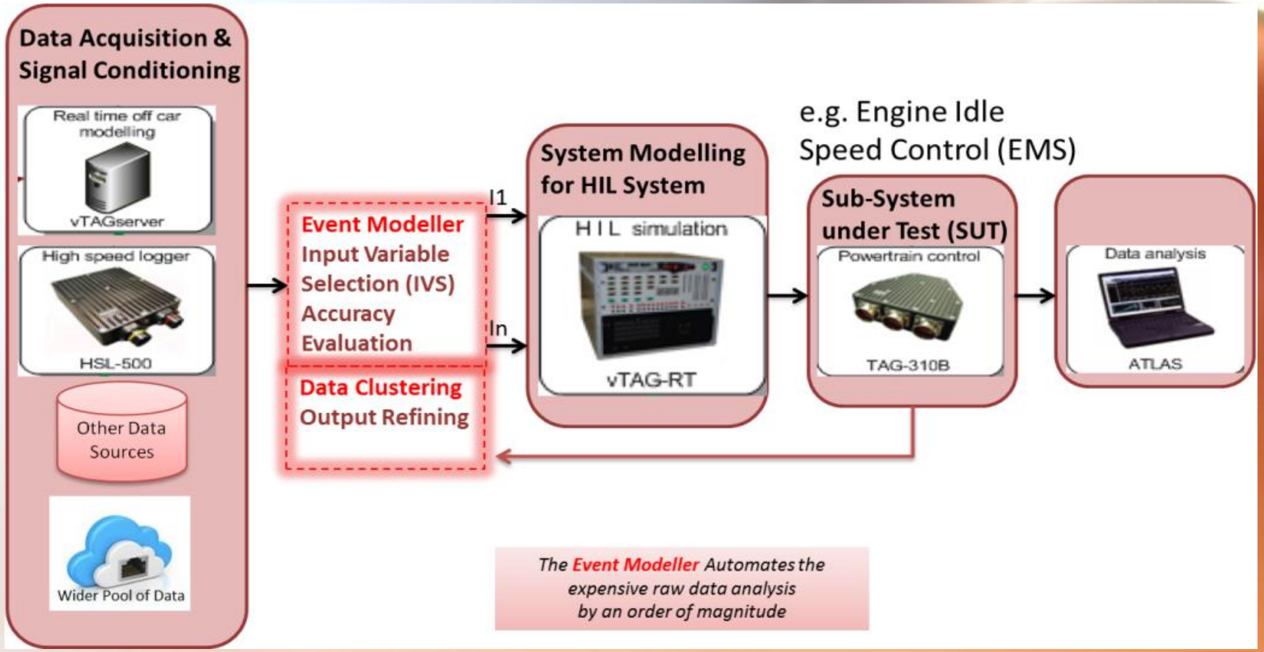


Figure 5: SERG Novel HIL and SIL, example Automotive Industry

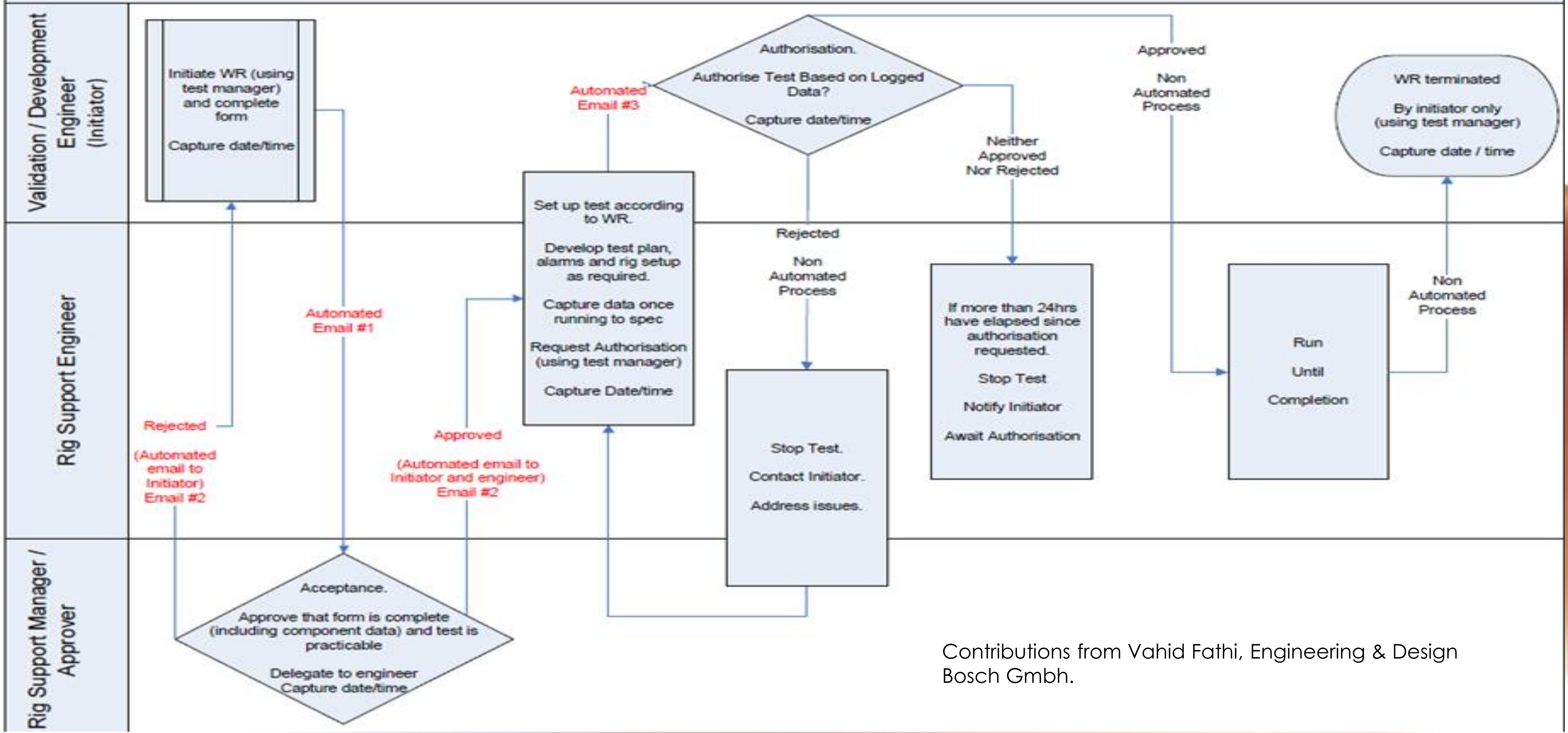
PETAL implmentation

- The objectives for meeting the challenges of project control and management of efficient PET are to:
- Design an improved an integrated Data Acquisition and information network that records, processes and disseminates the necessary monitoring and control information of day-to-day operations and availability of resources.
- Develop an ontology based monitoring and control of project management KPIs. The ontology based models will provide real-time and predictive measurements of efficiency, productivity, resource utilisation, work flow, and customer relationship Management

The Potential Gains based on Computer Simulation (DES) of operations

- In a recent study of product engineering testing and validation project life cycle in a high-tech company in the UK, by us we observed:
- With respect to ISO22400 guidelines show that there is a potential for improving efficiency and productivity. The completion of projects is highly sensitive to engineering staff and resources;
- a simple increase of over 5% workload causes major delays.
- Even though investments in test-bed capacities allows for a 25% increase in workload with little impact on production flow, but lack of engineering capabilities restricts higher productivity and production rates.
- We believe by implementing the engineering and project management capability enhancing techniques proposed in this research project, it is possible to increase productivity and efficiency by 25%.

Figure 6: Engineering Validation and Approval Process



Contributions from Vahid Fathi, Engineering & Design Bosch Gmbh.