The 5 Lean Principles applied to Product Development

25th Oct 2012

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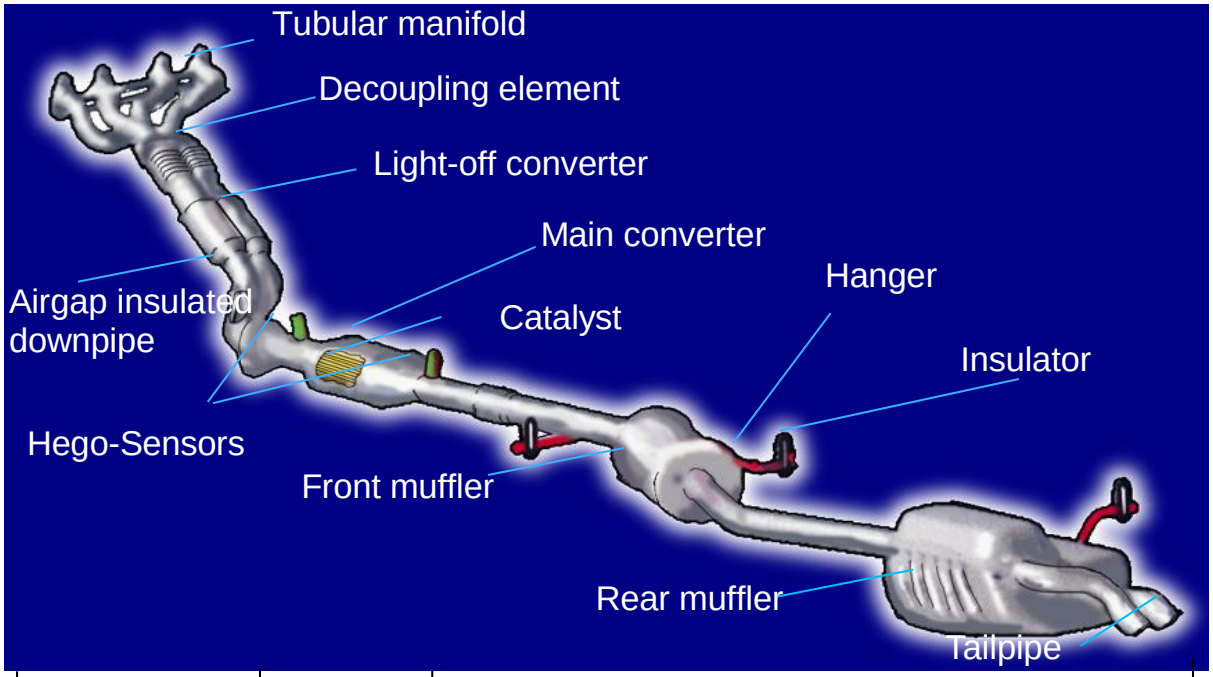
What is ‘Lean Thinking’ ?
The 5 Principles. (Womack & Jones)

- Principle 1. To specify Customer Value
- Principle 2. To identify the Value Stream of a service
- Principle 3. To make flow.
- Principle 4. To let the Customer pull the service from the service provider instead of pushing it.
- Principles 5. To strive for perfection.

Technical Requirements of an Exhaust System. Customer Value.



POWER
EMISSIONS
BACK PRESSURE
ACOUSTICS
HEAT RADIATION
DURABILITY

CUSTOMER ENG. SPECIFICATIONS

- POWER & TORQUE
- BACK PRESSURE
- ACOUSTICS
  - TAIL PIPE NOISE
  - SHELL NOISE
  - IN CABIN NOISE
  - SUBJ. NOISE
- EMISSIONS
  - LIGHT OFF
- DURABILITY
  - VIBRATION
  - CORROSION
- HEAT RADIATION
- PACKAGING
- MOUNTING
- DECOUPLING
- MATERIALS
- WEIGHT
- COST

What is ‘Lean Thinking’ ?
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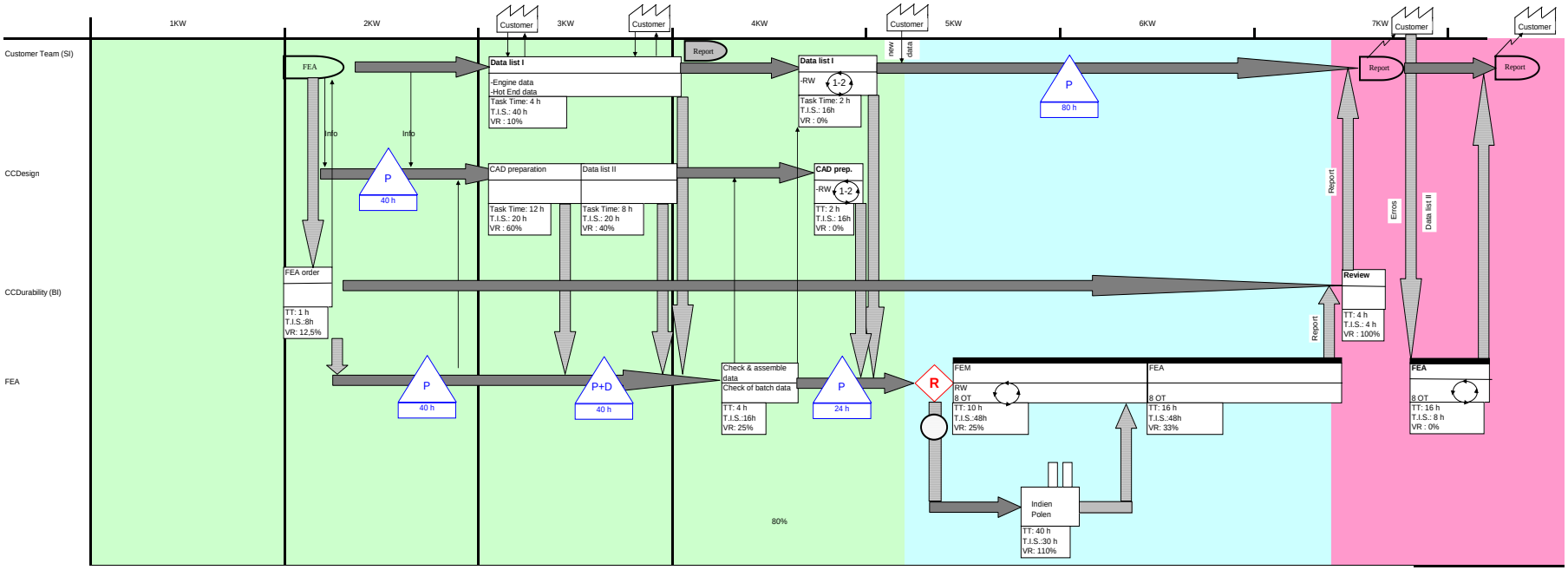
What is ‘Lean Thinking’ ?
The 5 Principles. (Womack & Jones)

- Principle 2. To identify the Value Stream of a service/ product.
  - This step consists of identifying the part of the service / product which do not add value from the customer point of view and needs to be eliminated.
  - How ? By performing some analysis (VSM) to establish which activities are really necessary (Value Adds) and which we can eliminate (Waste)

VSM of a CAE/FEM Process. Current Status.



VSM allows to analyze

The Value Add,

Non Value Add of the process

Comparison of Traditional vs. Lean Value Stream Cultures

TENNECO

Traditional Culture

- Most people understand only the functions in which they work
- Functions are competitors
- A function's Measures isolate it from other functions

Value Stream Culture

- People understand the big picture and the business of the other functions
- Functions are partners
- Common Goals (Order to Ship Time, Information accuracy and timeliness, etc.)

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What is ‘Lean Thinking’ ?
The 5 Principles. (Womack & Jones)

- Principle 3. To make flow.
  - This step consists of eliminating all types of waste in order to make flow to the service/ product.
  - Our task is to get rid of the waste by eliminating the waiting time, the rework associated to some defects, the work duplication, the lack of accuracy.
  - To get your service/ product leaner you need to apply some lean principles.
  - And to be creative to find some smart solutions

Simples Measures to make flow

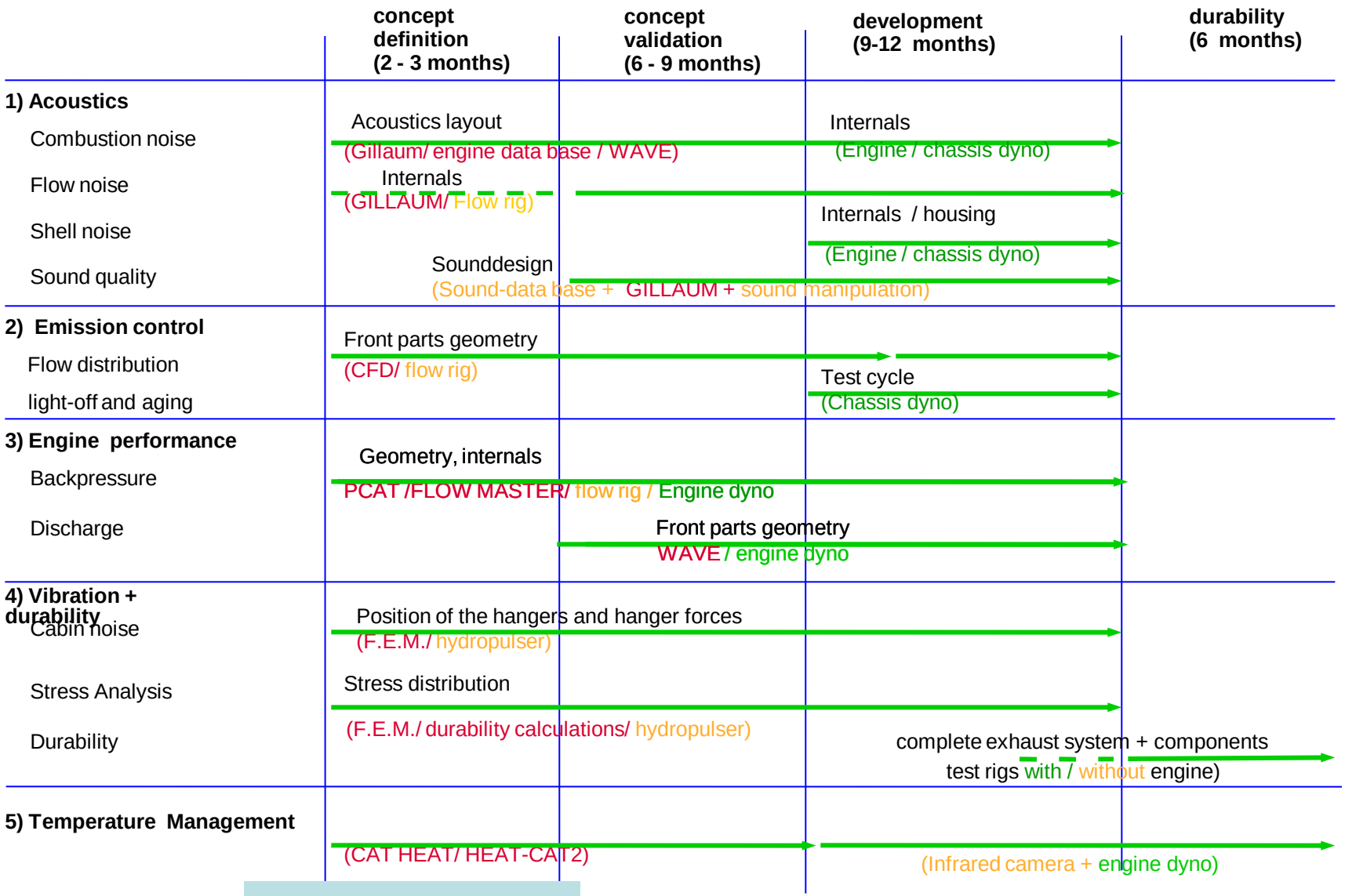
- Work layout should be aligned in the order that the action takes place.
  - The critical Layout creates a busy material Handling
- Move One piece at a time.
  - The Push and Batch systems creates a queue and waiting
- Conduct activities in parallel or series as appropriate.
  - It is one of the causes for a long lead time.

More complex Measures to make flow

- Frontloading. To anticipate on the potential barriers.
  - Concept Phase. See some illustration later.
- Development of Standards
  - Processes.
  - Products
  - Skills
  - Tools. Reporting templates, Checklist
  - Etc…
- Alignment, Communication and Commitment.
  - Kick off Meeting with clear rules and Roles & Responsibility of each Stakeholder.
- Training

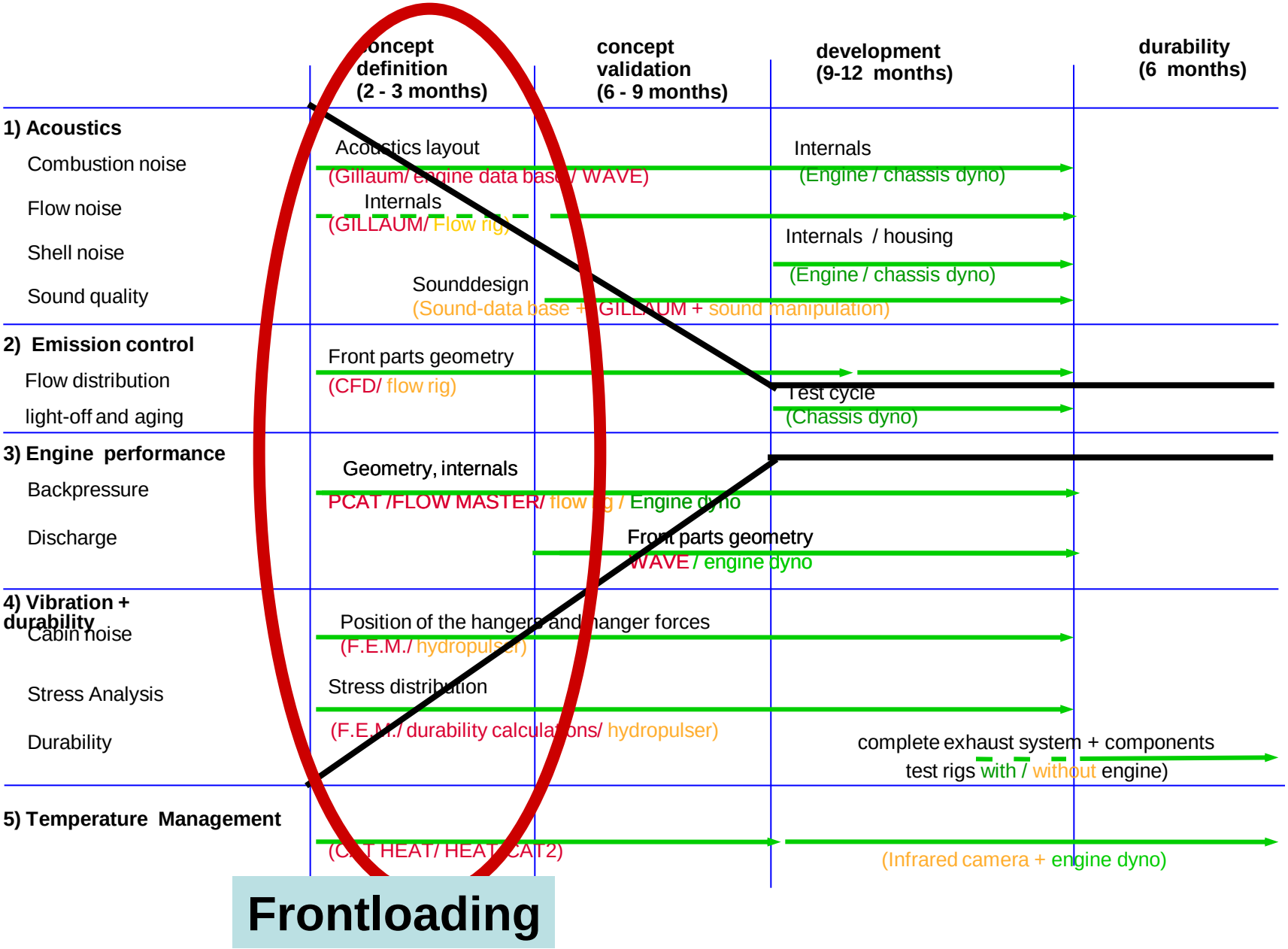
Front Loading. Trade off Curves

Development Cycle Exhaust System. Concurrent Engineering

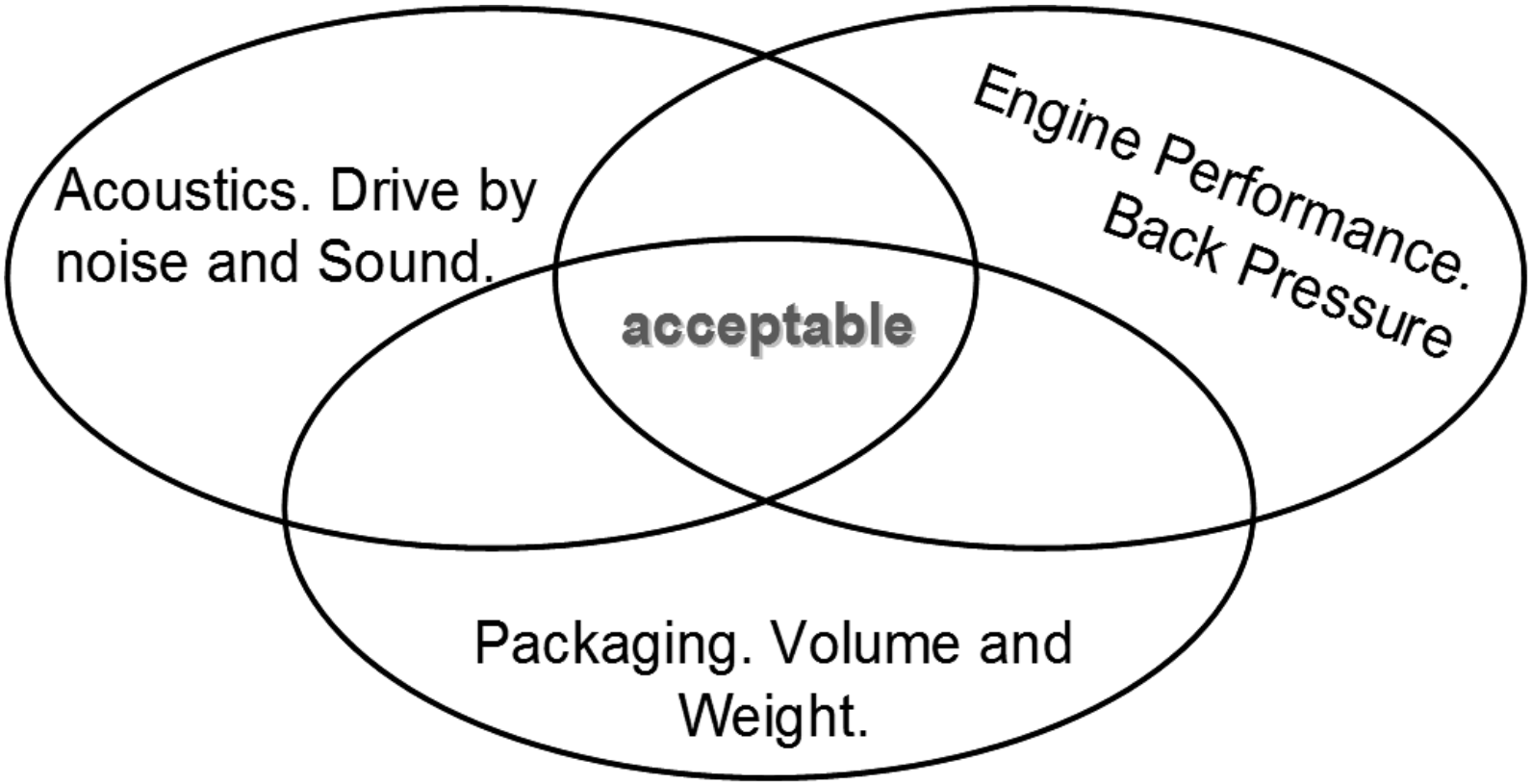


Frontloading

Development Cycle Exhaust System. Concurrent Engineering

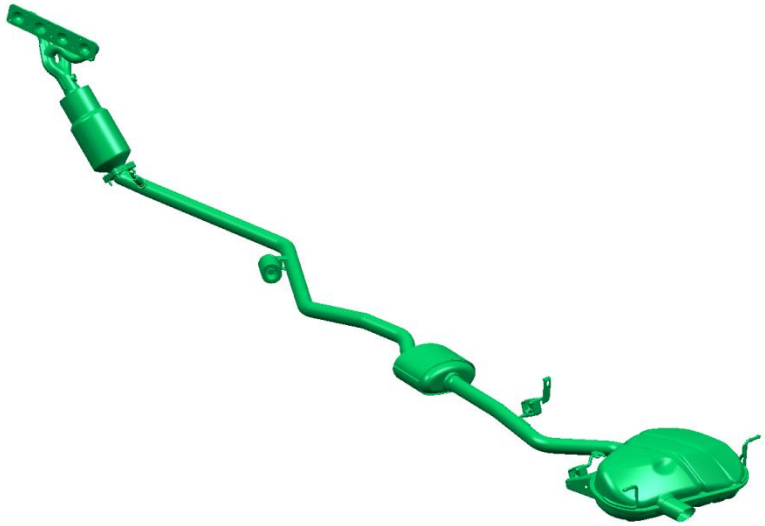


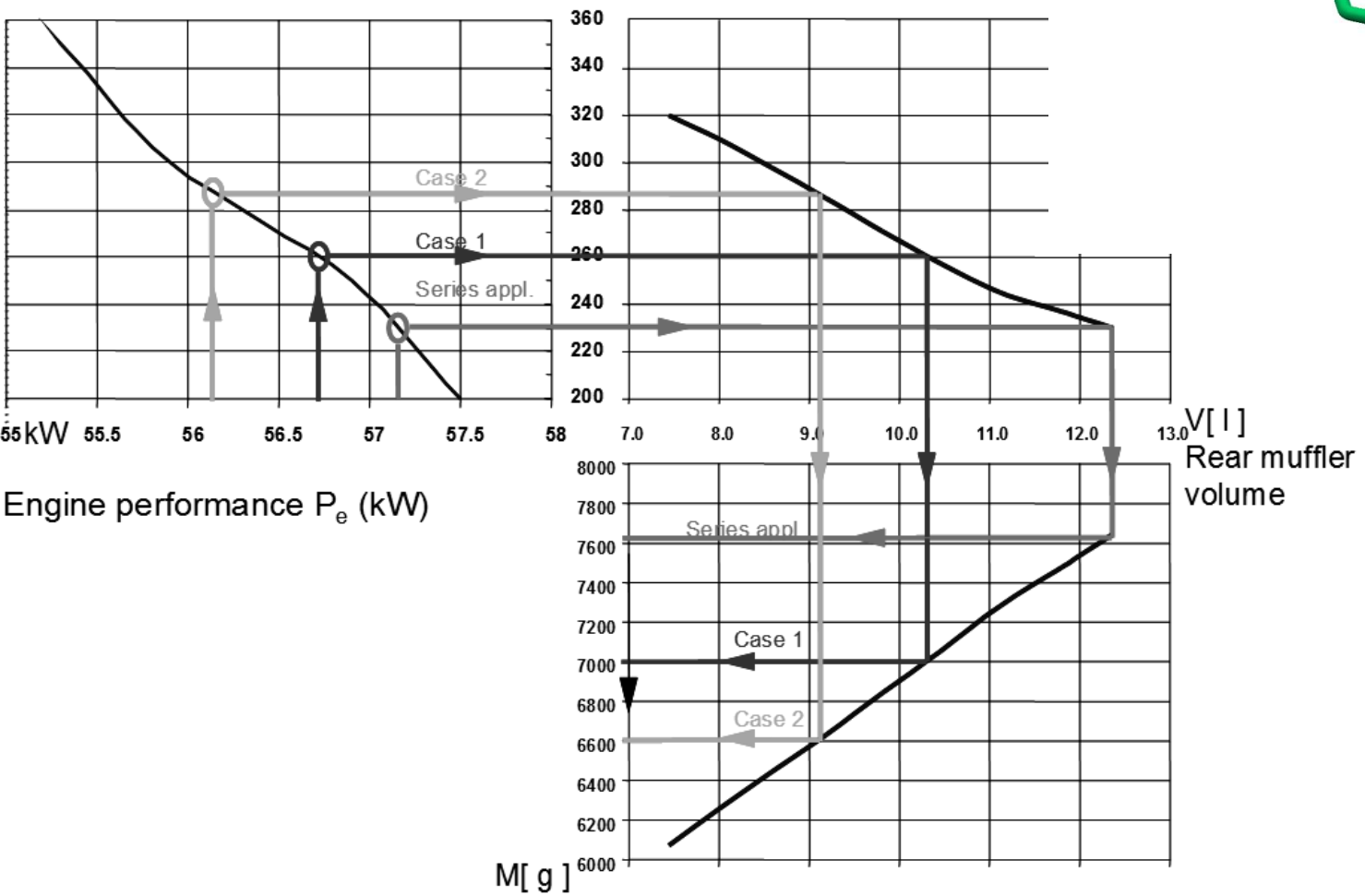
Design optimization. Trade off.



Criteria must be applied to end up with the best solutions
Trade Off principles

Trade off curves.





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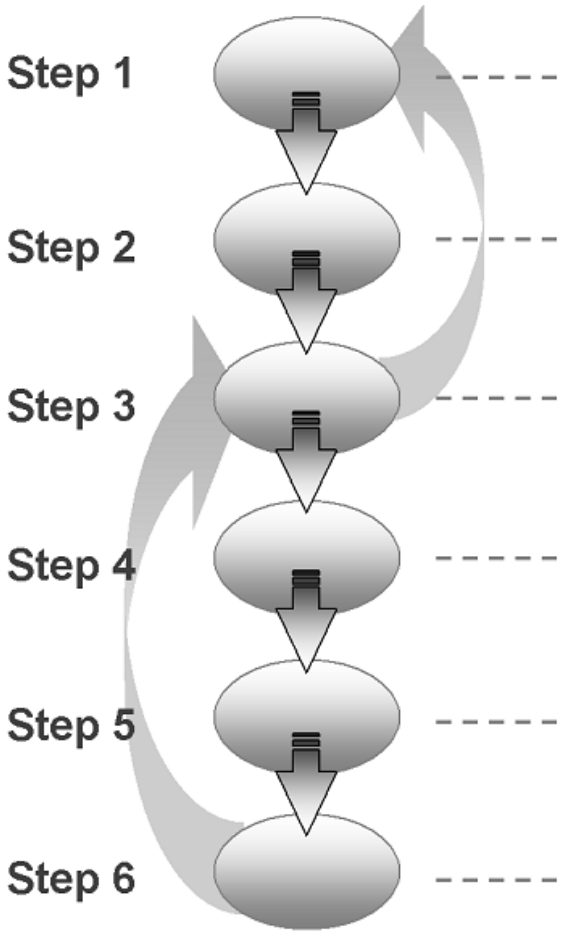
Frontloading. Example Sound Quality.

- Methodology. New Standards to create Sounds
- New Products developed for OEMs.

Sound Engineering. Guideline/ New Standard to create a Sound.



Definition of a target tailpipe sound based on Sound measurements of existing cars (Benchmark)

Binaural and harmonic analysis
Listening lab

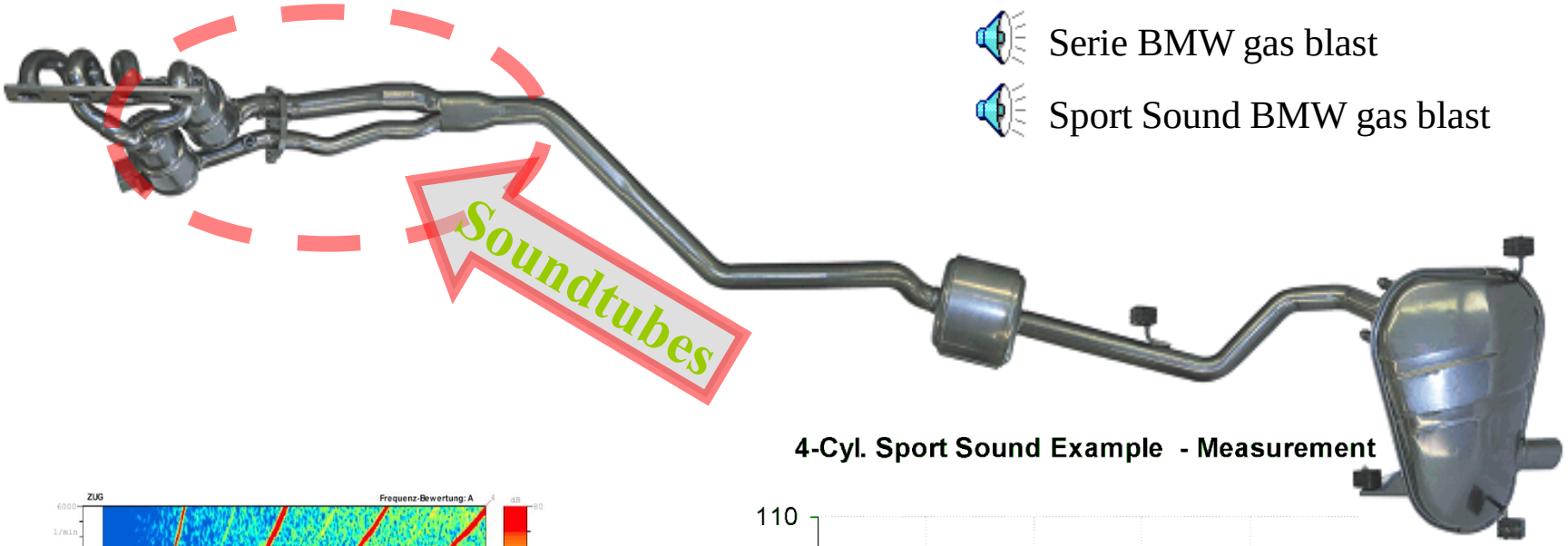
CAE-Prediction – Target reachable ? (Loop)
- **Gillaum – to optimise harmonics**
- **Wave / GT-Power – to optimize engine performance**

Building hardware
- **CAD – Drawings**
- **Building of prototypes**

Measurements on proposed exhaust designs
- **Acoustics**
- **Power characteristics and backpressure simultaneously**

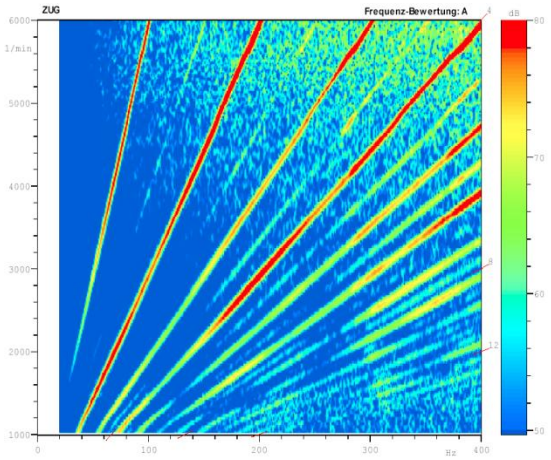
Final validation together with customer – Goal reached and confirmed. Otherwise Loop

Layout for a 4-Cylinder Sound Example

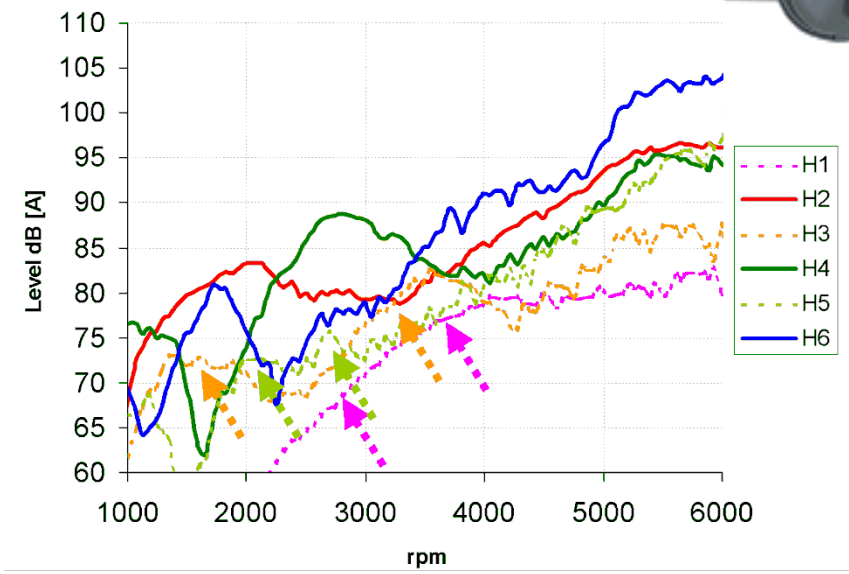


Serie BMW gas blast

Sport Sound BMW gas blast

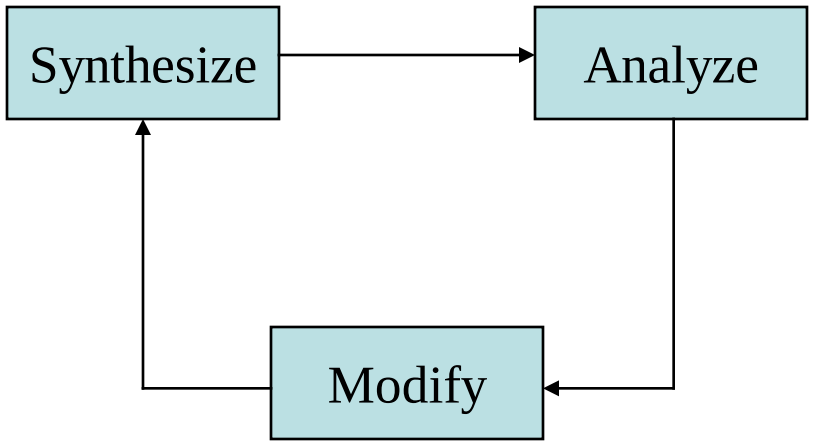


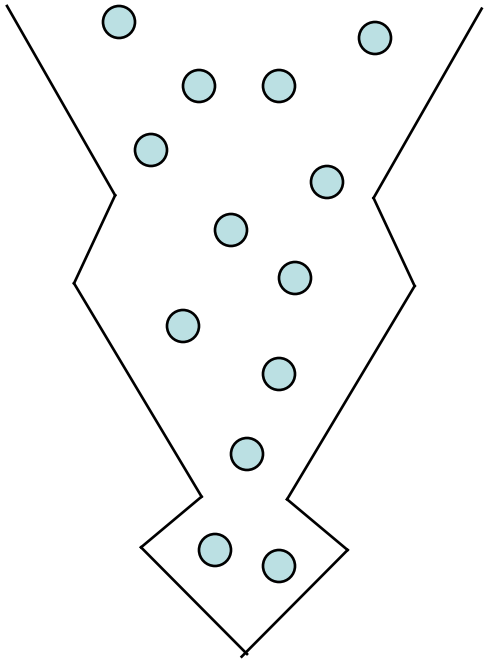
4-Cyl. Sport Sound Example - Measurement



PROCESS. FRONT LOADING
SET BASED CONCURRENT ENGINEERING

Two Models of Design



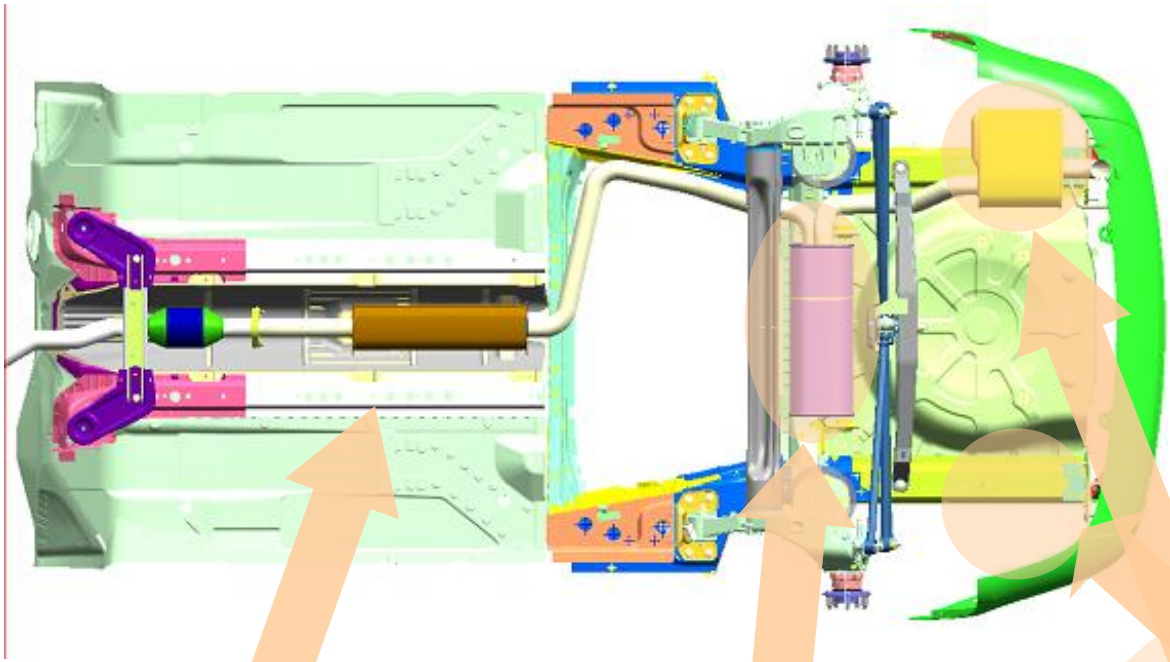


ITERATIVE MODEL

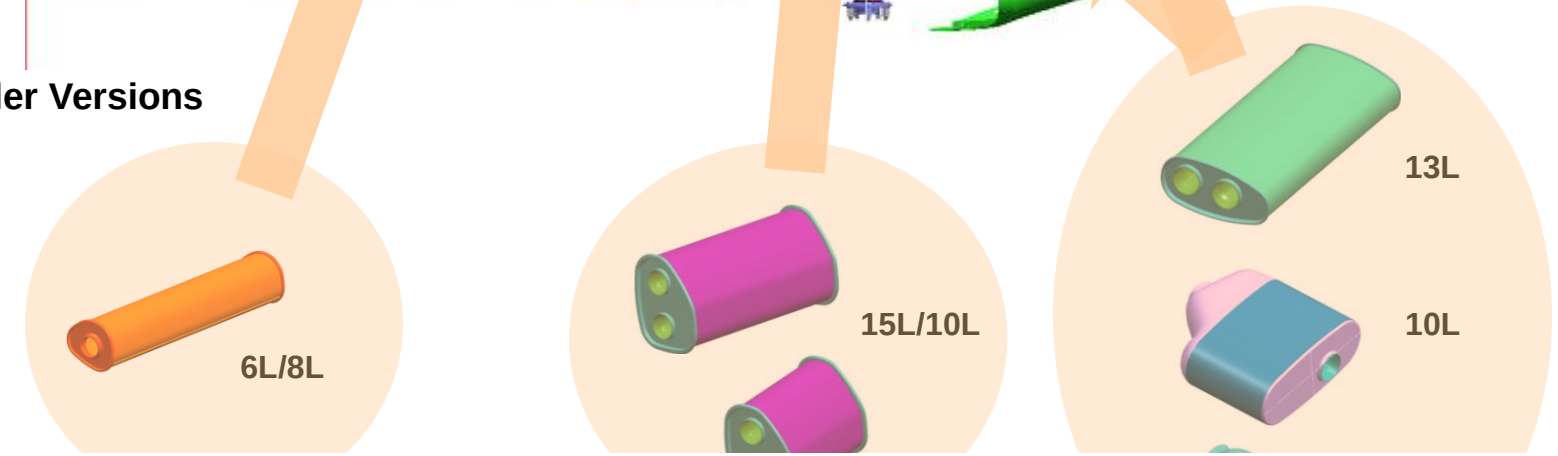
CONVERGENT MODEL

Package layout Muffler forms

Vehicle Underfloor for pipe routing and volume layout



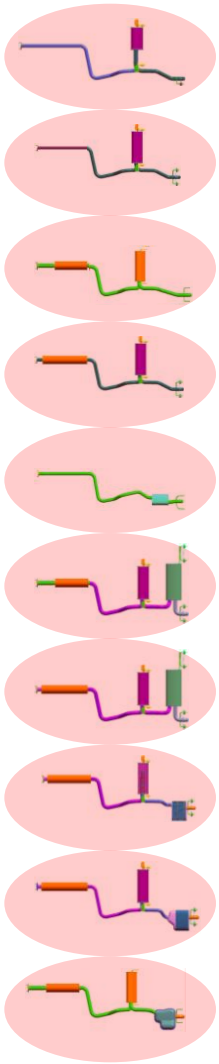
Feasible Muffler Versions

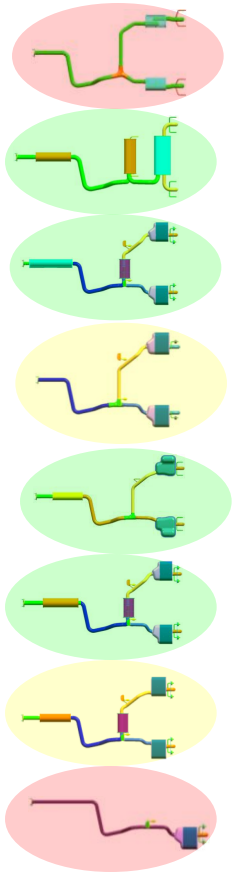


A lot of multiple combinations possible

Criteria must be applied to end up with the best solutions

Example 2.0L turbo petrol engine





Basic Requirements

Mach-no., backpressure and
overall tuning volume

Target Mach-No. tailpipe <0.25 @~750kg/h

Single flow Ø70mm

Double flow 2xØ50mm -> ***double flow tailpipe***

Target Mach-No. centerpipe <0.3 @~750kg/h

Single flow Ø65mm -> ***single flow center pipe***

Double flow 2xØ48mm

Specific Volume ~0.2L/kW @165kW

Tuning Volume required ~***33Ltr***

-> 6L + 15l + 13L -> 34L

-> 8L + 0L + 2x10L -> 28L

-> 6L + 0L + 2x13L -> 32L

-> 6L + 10L + 2x8L -> 32L

-> …

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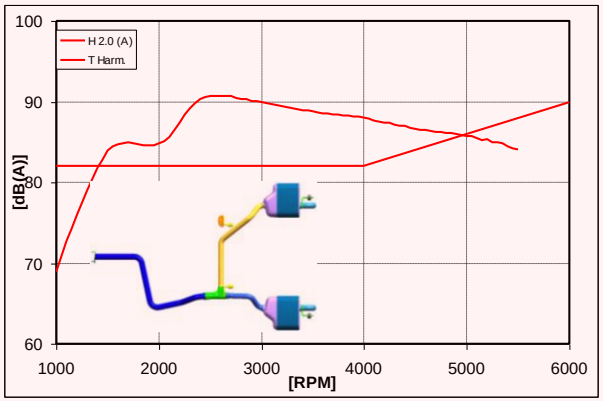
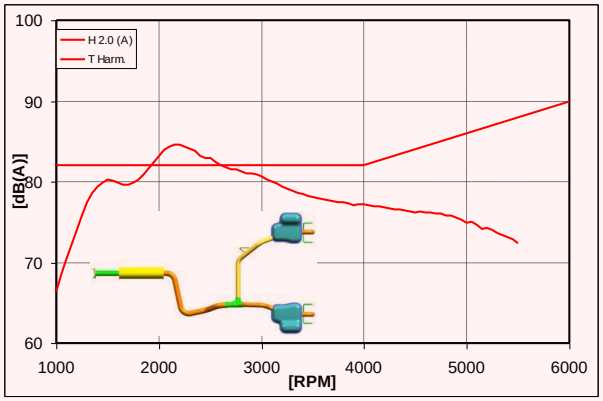
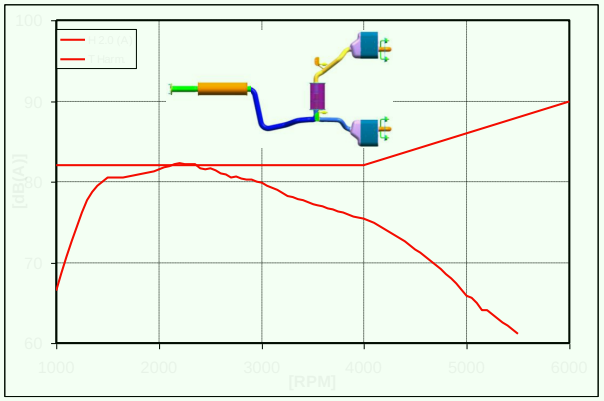


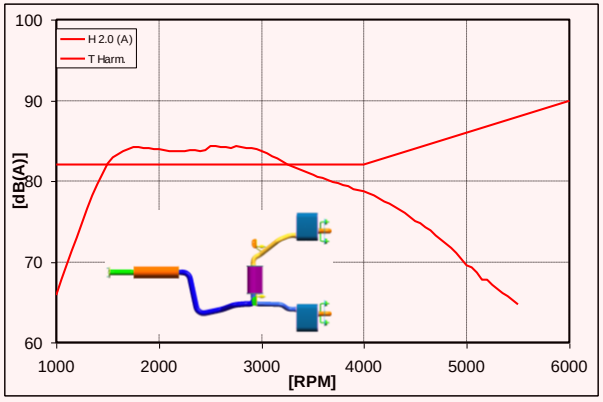
Volume Distribution

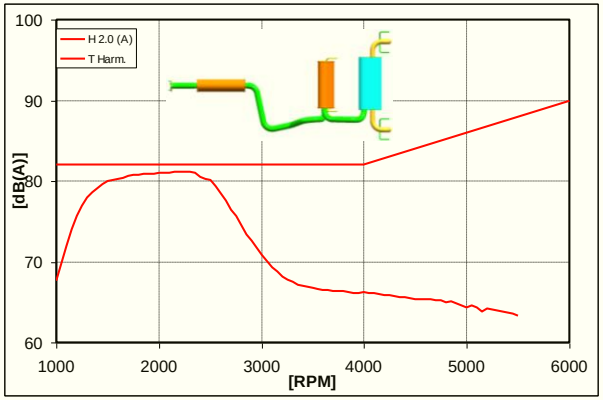
Standard Internal Layouts, tailpipe noise (Sounddesign), backpressure (performance), shell noise, cost

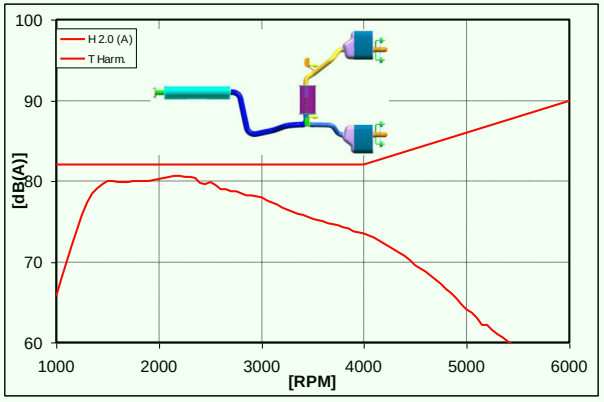
apprx. 3 layout variations left







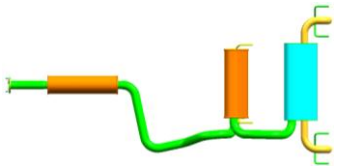
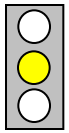
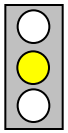
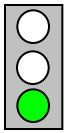
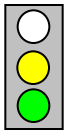
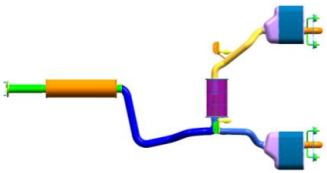
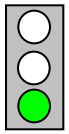
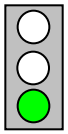
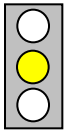
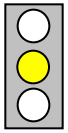
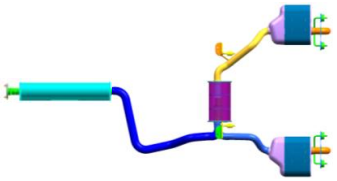
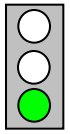
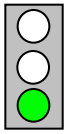
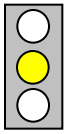
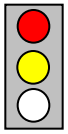




Example 2.0L turbo petrol engine

Detailed Analysis

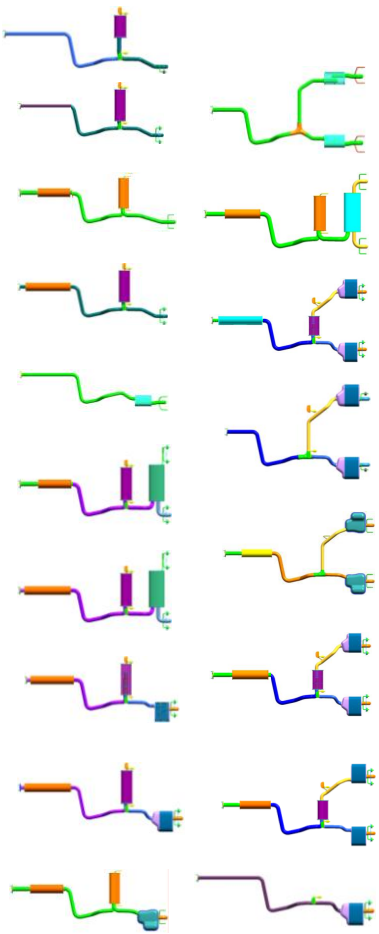
Optimizing internal layouts, hanger forces, Risk-Assessment, feasibility, cost, standardization

	Acoustic tailpipe noise & shell noise	Durability & NVH	Manufacturing feasibility & standardization	Cost	
					Cost Oriented Concept ←
					Performance Oriented Concept ←
					

Example 2.0L turbo petrol engine

Package Layout

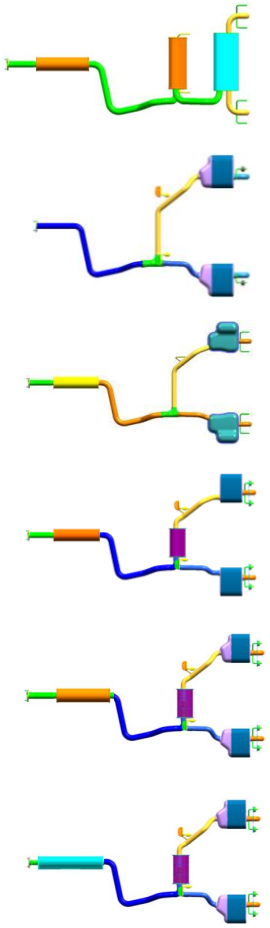
apprx. 20 layout variations



Basic Requirements

Mach-no., backpressure and overall tuning volume

apprx. 6 layout variations left



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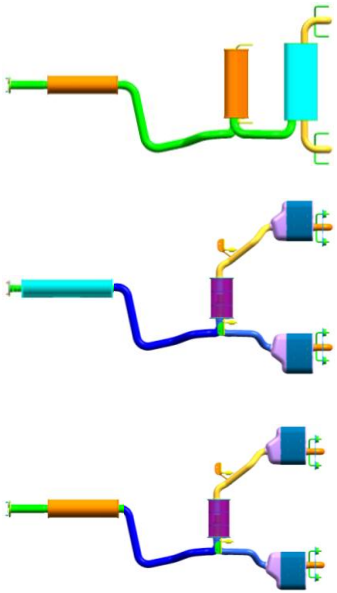
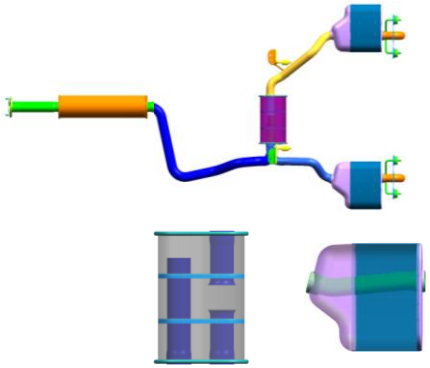
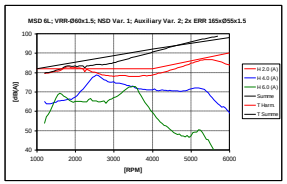


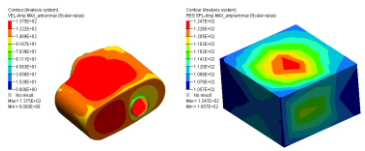
Detailed Analysis

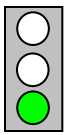
Optimizing internal layouts, hanger forces, Risk-Assessment, feasibility, cost, standardization



Inlet Pipe	Ø65x1.5
Common Muffler	8 L
Center Pipe	Ø60x1.5
Rear Muffler V2	10 L
Center Pipe	2xØ55x1.5
Auxiliary Muffler V2	2x10.2 L
Tailpipe	2xØ60x1.5
spec. Volume	0.21 L/kW
Backpressure	25kPa @ 228g/s
Target	tbd







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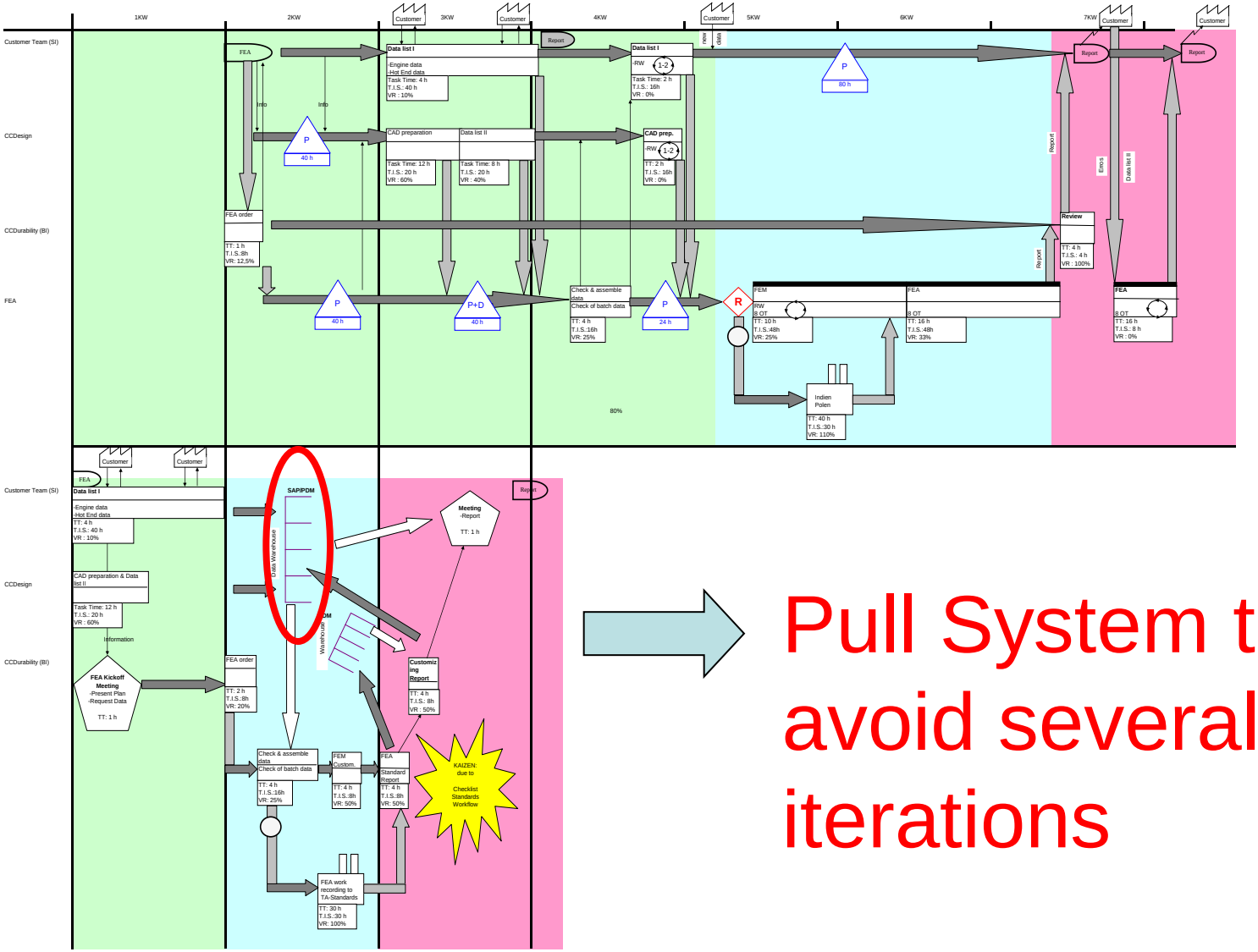
The 5 Principles. (Womack & Jones)

- Principle 4. To let the Customer pull the service from the service provider instead of pushing it.
  - Pull principle. Only the service/ product is produced if it is required by the Customer.
  - The Customer set the pace he wants to be delivered.
  - The aim of this step is to prevent from any overproduction (Waste) or shortage (No fulfillment of the Customer need)).

FEA. Current and Future status.



Pull System to avoid several iterations

What is ‘Lean Thinking’ ?
The 5 Principles. (Womack & Jones)

- Principle 1. To specify Customer Value
- Principle 2. To identify the Value Stream of a service
- Principle 3. To make flow.
- Principle 4. To let the Customer pull the service from the service provider instead of pushing it.
- Principles 5. To strive for perfection.

Principles 5. To strive for perfection.

- You can continuously improve only if you have
  - The people as problem solver. Right trained, skilled and motivated
  - And the tools to do it
    - Soft tools, i.e. Communication, Learning, Alignment
    - And the culture to develop and retain your people.

Lean Management.

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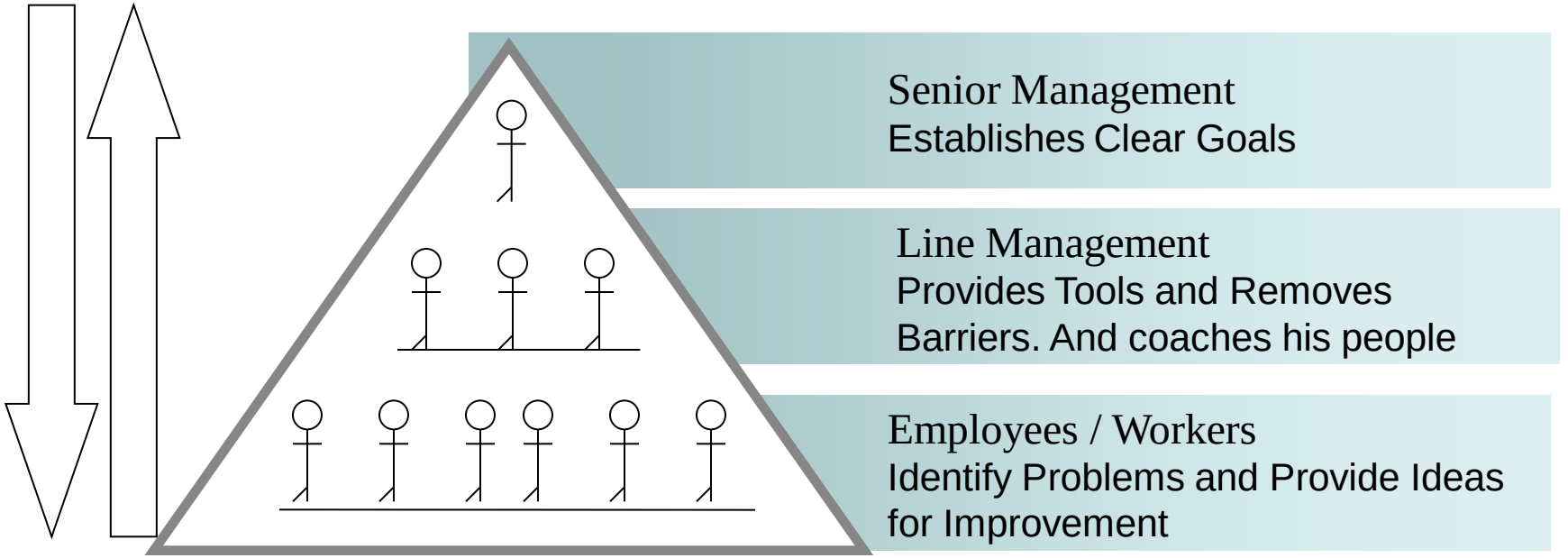
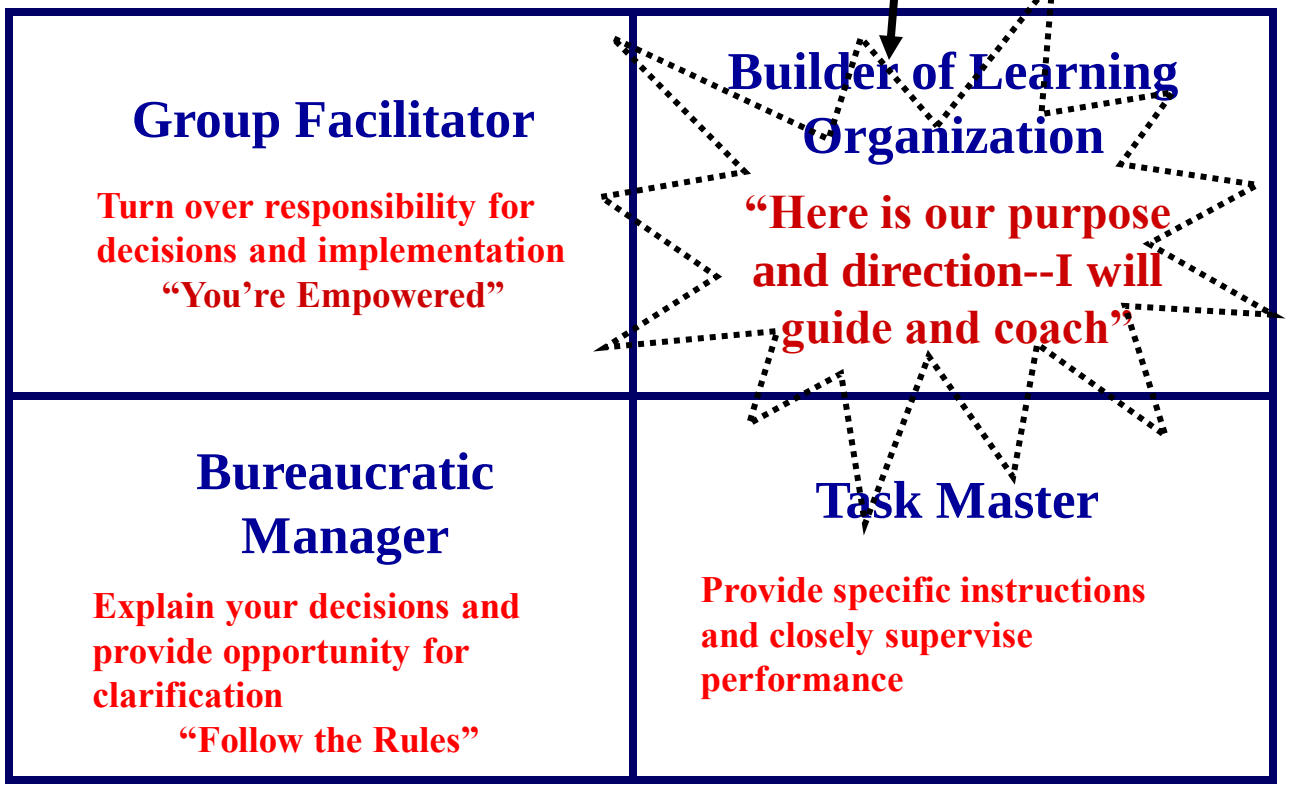
Lean
Top Down and Bottom Up.
Everyone Thinking



Lean Leadership Model

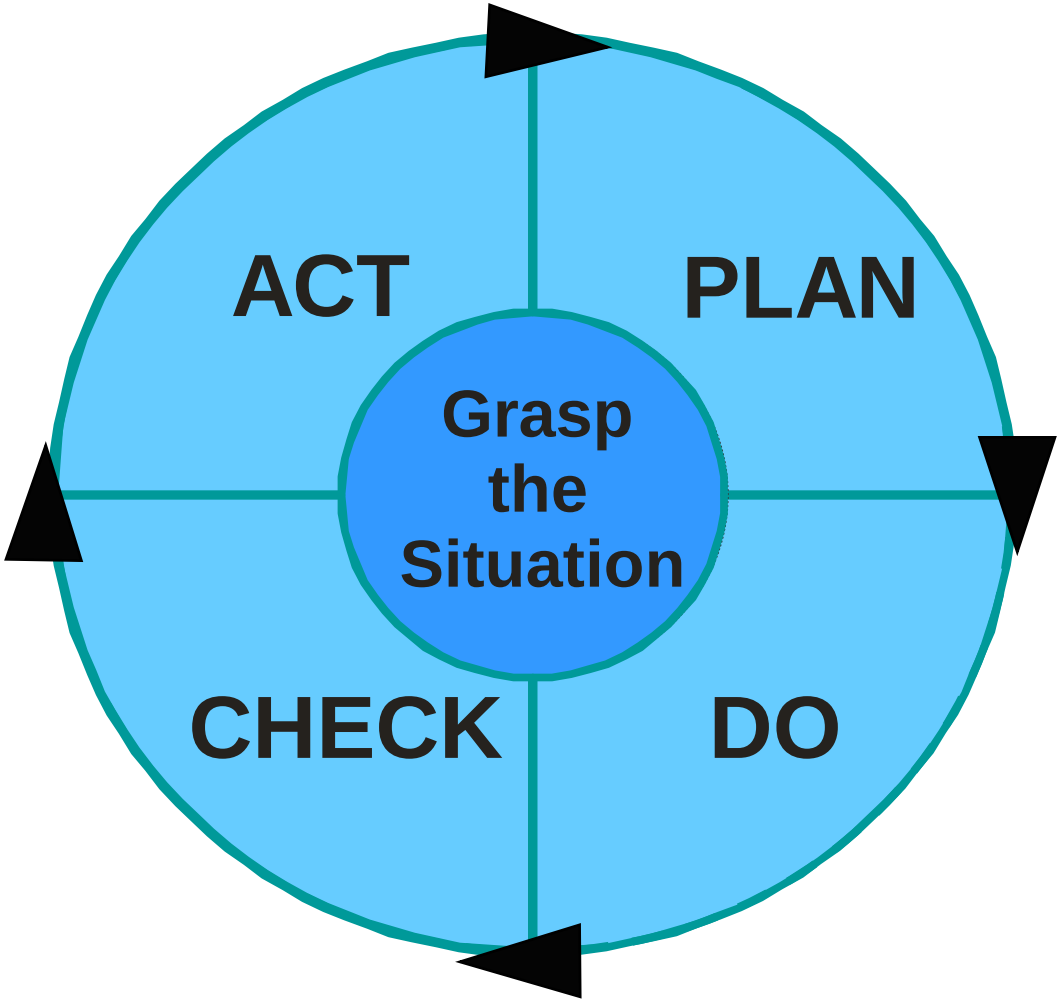


Soft Tools

- Problem Solving.
  - Overview

- Learning Tools. Communication and Alignment
  - Alignment. Visual Management.
  - Learning.
    - Reflections.
    - Guidelines,…

The PDCA Cycle



A3 PROBLEM SOLVING REPORT LAYOUT

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THEME

Answers the question – "What are we trying to do?"

PROBLEM SITUATION

- **The standard**
- **Current situation**
- **Discrepancy / Extent of the problem**
- **Rationale for picking up the problem (Importance to business activity, goals, or values of the organization)**

COUNTERMEASURES

(Resulting from Cause Analysis)

- **Temporary Measure**
- **Long Term Countermeasure**

T/

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PDCA is supported by a Tool

called A3 Problem Solving or 8D

CAUSE ANALYSIS

PROBLEM:

Potential Causes

Most likely direct cause:
Why? → Why? → Why? → Why?

Root Cause:

FOLLOW-UP and LESSONS LEARNED

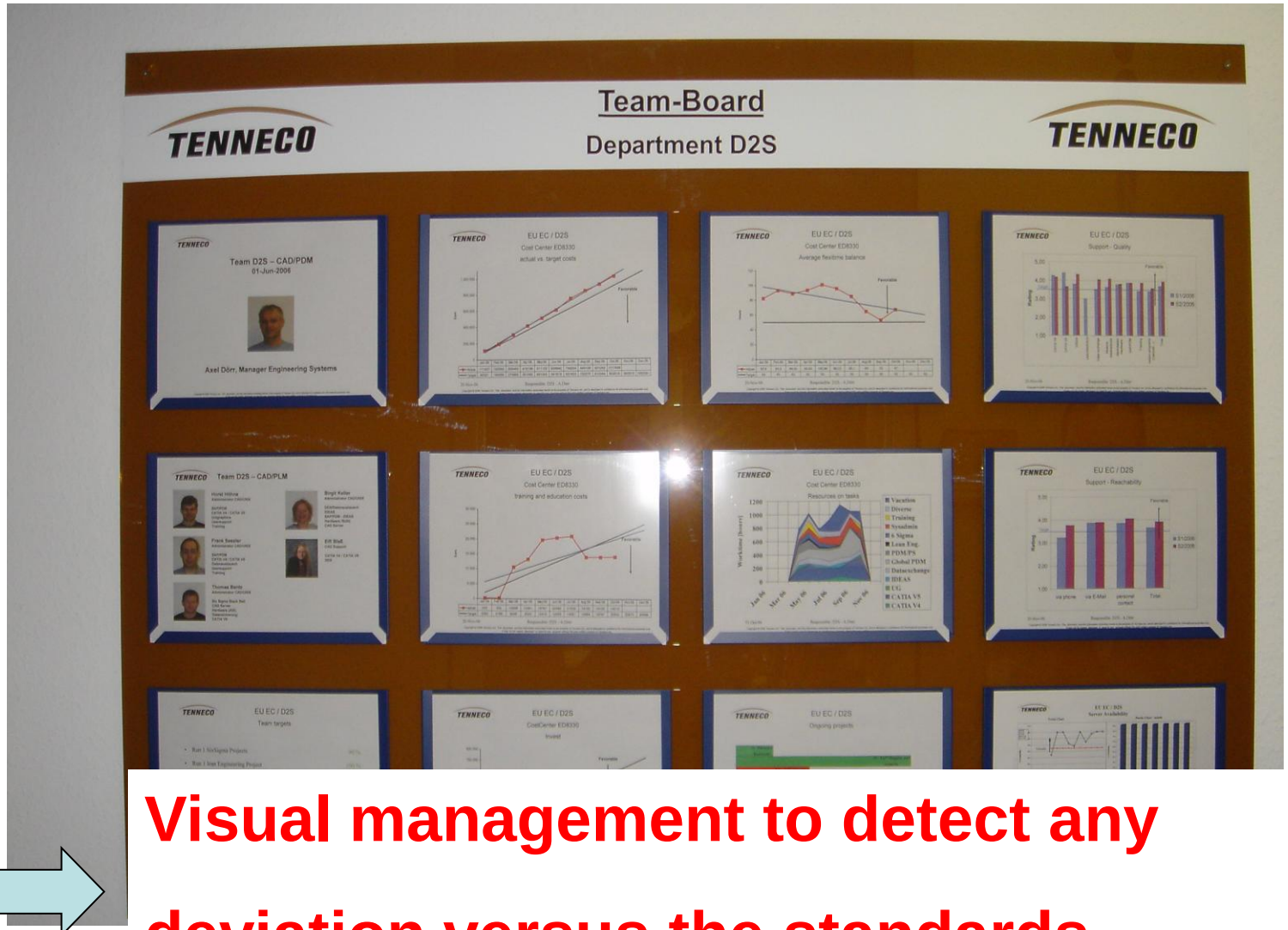
- **Unresolved issues and actions to address them**
- **How will you check effects?**
- **When will you check effects?**
- **How will you report finding?**
- **When will you report findings?**

AUTHOR: _____ DATE: _____

Soft Tools

- Problem Solving.
  - Overview
- Learning Tools. Communication and Alignment
  - Alignment. Visual Management.
  - Learning.
    - Reflections.
    - Guidelines,…

BOS Board or Cockpit for each Department



Visual management to detect any deviation versus the standards

OBEYA ROOM AT REC

TENNECO

Vision REC_Vision_and_Strategy.ppt	**Road Map**	**Organi-zation** REC_Organisation_Team.ppt	**People** REC_People_Allocation.ppt	**Invest & Cost** REC_Invest_and_Cost_Investment_current_status.ppt	**Projects** \\taede034\workgroups$\BCC Engineering\Project_Meeting_Action List - Stein\BCEE action and project list KOPIE
	REC_RoadMap_Capability_Development.xls	REC_Organisation_Deputy_plan.xls	REC_People_Organigram_2008.xls	REC_Running_spending_2008.xls	\\taede037\common$\Light PDC\IBR-List\...
Objectives REC_Objectives_2008.xls		REC_Organisation_Edk_REC_Organigram.ppt	REC_People_hiring_progresses.xls	REC_Invest_and_Cost_Detailed_Invest_plan.xls	**Actionlist HR** REC_Action_plan\REC_Action_plan_HR.xls
Safety REC_Safety.xls		**Partner-ship** REC_Partnership.xls	Separate A0 print out: REC_People_Detailed	**Cash Flow Analysis 2008** REC_CAPEX_detailed_planning.xls	**Actionlist Finance** REC_Action_plan\REC_Action_plan_Finance.xls
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Visual management to Communicate ,

Alignment und Commitment

Obeya

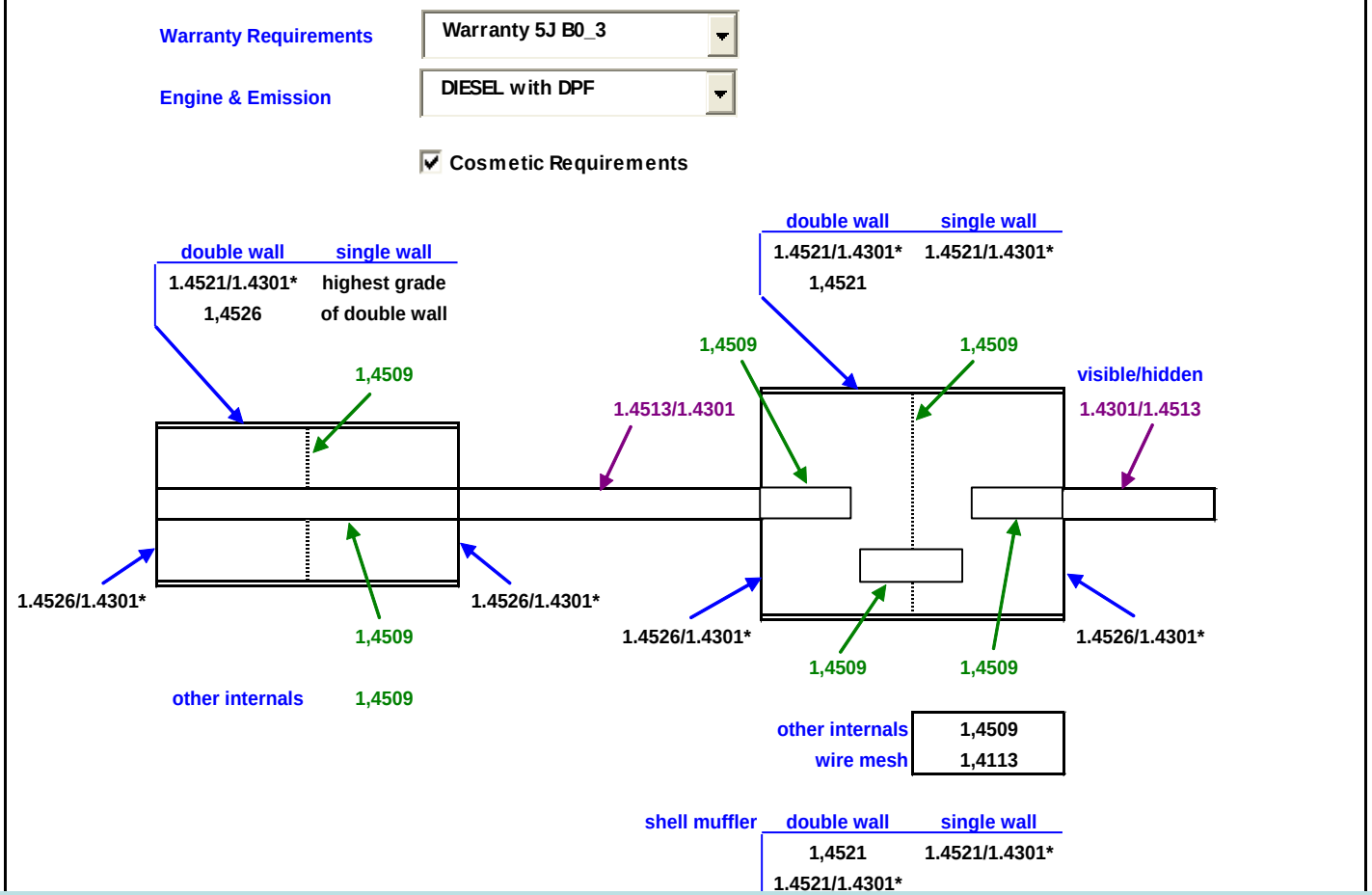
Responsibility: Jan Brand / Status: 14.04.2008

Soft Tools

- Problem Solving.
  - Overview
- Learning Tools. Communication and Alignment
  - Alignment. Visual Management.
  - Learning from experience.
    - Reflections.
    - Guidelines,…

Material Guidelines.

Marek Rybarz Dr. Patrick Garcia Dirk Wiemeler	**Corrosion Material Guideline**	TENNECO



Lessons Learned. To create a new guideline to prevent the issue from any reoccurrence.

Conclusions.

- Tenneco has been applying the lean key principles for more than 8 years.
  - First in Germany, then in all R&D centers.
  - In all Product segments (EC, RC and AM)

- In the meantime these key principles have been transferred to
  - the transactional world (Sales, Finance, HR)
  - The complicated Cross Functional Processes

  with success

- Tenneco has been developing some Change Agent position in order to enhance the Bottom Up approach and therefore to make the Kayzen Mindset more sustainable.