June 22, 2011 (Wednesday) 55th EOQ Congress

KEMPINSKI HOTEL CORVINUS **Erzsébet tér 7-8, Budapest V.**
REGINA BALLROOM

25.1. CLOSING PLENARY SESSION — Wednesday 13:30 – 17:00

Session Chair: ***Pál Molnár****, President of the Hungarian National Committee for EOQ and Professor at the University Szeged, Congress Chairman, Hungary*

14.00 Innovation of Quality – Quality of Innovation
The Way how KNORR does it
István Lepsényi, Director General, Knorr Bremse Hungary Ltd., Hungary

Lepsényi, István (Hungary)

István Lepsényi was born in Budapest, Hungary on September 7, 1949. He earned a degree in mechanical engineering from the Technical University of Leningrad in Saint Petersburg, Russia, an economic engineering degree from the Technical University of Budapest, Hungary, and a special economist (university leaving certificate) from the University of Economics. Currently, he serves as Managing Director for Knorr-Bremse Fékrendszerek Kft., working to dynamically increase production, developing efficiency and quality, establishing, organizing, and extending the activities of a R&D centre, organising the sale in Central-Eastern Europe, and establishing Knorr-Bremse in Russia. Previously, he has worked with Hungarian Suzuki Rt. as Managing Director (1991-1994), focusing on starting and developing the company and its production network, AUTOKONSZERN Rt. as President and Managing Director (1990-1995) directing negotiations with the Suzuki projects, and developed robot technology and manufacturing with IKARUS (1974-1990). Lepsényi contributes actively to the representation of the Hungarian automotive sector's interests through his social and professional memberships: he was Vice President of the International Organization of Motor Vehicle Manufactures (2002-2006), he is the Honorary President of the Hungarian Manager Association and a member of the Academy of Engineers.

Lepsényi has also won the Széchenyi Prize (1996), the Gábor Dénes Prize (2000), the Award for Development of the Economy by the Chamber of Commerce and Industry of County Bács-Kiskun (2007), and the Commander's Cross Order of Merit of the Republic of Hungary (2009). In 2011 Lepsényi has been honoured with the „Manager of the Year 2010" award for long term business success at Knorr-Bremse Fékrendszerek Kft, the crisis management and his contribution to the success of the Hungarian economy, especially within the automotive industry.

KNORR-BREMSE

Quality of Innovation, innovation of Quality
…the way how Knorr does it…

Budapest, June 20-23, 2011

55th EOQ Congress, Budapest, Hungary
"World Quality Congress"

Structure

Knorr-Bremse
- General
- In Hungary

Reliability

Innovation process
- Ideas and advanced engineer
- Product development
- Process development

Knorr-Bremse is the world's leading manufacturer of braking systems for rail and commercial vehicles

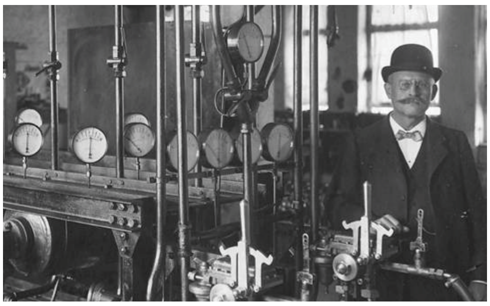
Rail Vehicle Systems

- Metros
- Streetcars
- Multiple units
- High-speed trains
- Locomotives
- Passenger rail cars
- Freight cars

Commercial Vehicles

- Trucks
- Buses
- Engines
- Special vehicles

100 years of experience with braking technology



Founding and initial development 1905-1945

- Knorr-Bremse GmbH first set up in 1905 in Berlin by Georg Knorr
- Development of compressed air brake for freight trains enables Knorr-Bremse to become the biggest manufacturer of rail vehicle brakes in Europe
- First Knorr air brake for trucks is patented

Post-war period and reconstruction 1945-1985

- Confiscation of Berlin plant at end of Second World War
- Munich becomes company's new headquarters
- KE control valve becomes new UIC standard
- Entrance into the USA market with AAR DB-60 valve for rail vehicles

Expansion through concentration 1985-2010

- 1985: Heinz Hermann Thiele takes over company
- Radical restructuring and expansion strategy
- Mass production of pneumatic disc brakes for commercial vehicles starts
- Joint venture with VEB Berliner Bremswerk and Robert Bosch AG
- Acquisition of NYAB, IFE, Westinghouse, Bendix, Zelisko, Microelettrica, Merak
- Joint ventures in rapidly growing Chinese and Russian markets
- 2009 SfS division in China won the largest order in its over 100-year history

Growth rate of Knorr-Bremse Group 1985-2010

Sales	2007	2008	2009	2010
Knorr-Bremse Group	3.25 billion €	3.38 billion €	2.76 billion €	3.71 billion €
Commercial Vehicle Systems	1.96 billion €	1.97 billion €	1.22 billion €	1.70 billion €
Rail Vehicle Systems	1.30 billion €	1.43 billion €	1.55 billion €	2.02 billion €
Employees worldwide				
Knorr-Bremse Group	13,943	14,999	14,432	16,277
Commercial Vehicle Systems	6,843	7,160	6,014	6,590
Rail Vehicle Systems	6,959	7,688	8,256	9,523

Knorr-Bremse in Hungary

Companies	Knorr-Bremse Fékrendszerek Kft.	Knorr-Bremse Vasúti Járműrendszerek Hungária Kft.
Sites	■ Kecskemét: - HQ, Production, R&D, Sales ■ Budapest : R&D, Global sourcing	■ Budapest: HQ, Production, R&D
Main figures (2010)	■ Employees: 1760 ■ R&D expenditure: 6,45 % of sales ■ Sales: 272 Mio EUR	

Knorr-Bremse Fékrendszerek Kft.

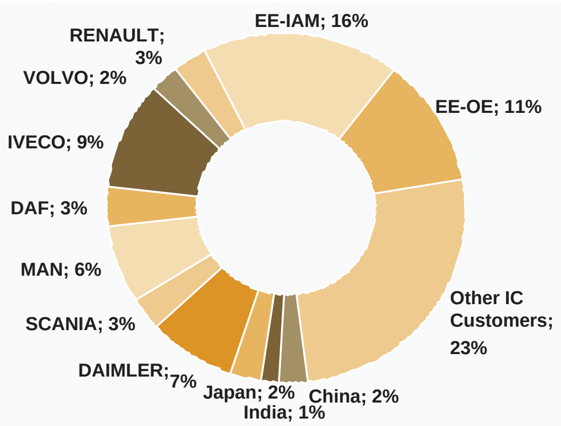
Production
- mainly producing air treatment units and valves for air brake systems
- ABS electronics

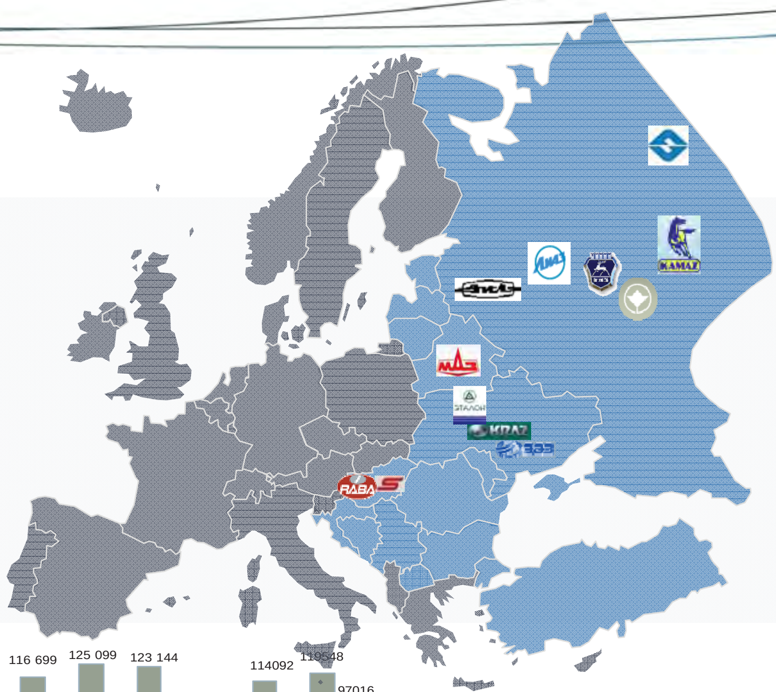
Sales
- sales of the whole Knorr-Bremse product portfolio into 21 countries, besides intercompany

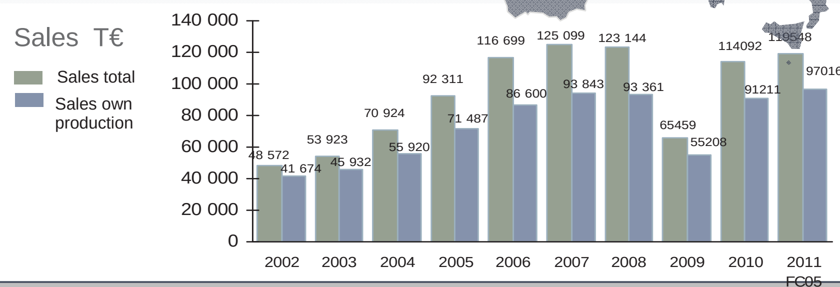
R&D
- predevelopment, researches of future products & technologies
- serial development
  - software & electronic development – Budapest
  - development of pneumatic units – Kecskemét
- application projects to fulfill the different customer requirements
- diagnostic, WTS

Production - Product Groups in Kecskemét

Sales 2010



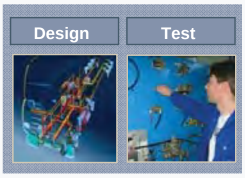




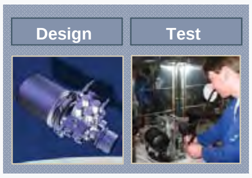
Research and Development activities in Kecskemét and Budapest

Kecskemét

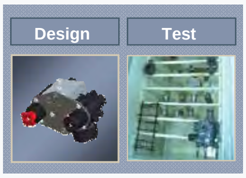
Engineering services & Levelling systems



Serial development CoC1.2 – Air Treatment



Serial development CoC2.2 – Valves



Industrial Engineering

Test Center

Support product development activities with technical validation tests of new pneumatic and electro pneumatic concepts

- Function test
- Endurance test
- Environmental test
- System and vehicle test
- Predevelopment test

Budapest R&D Centre

Advance Engineering

- research to prove new technologies and product fields

Series product development

- process oriented product development and release

Application

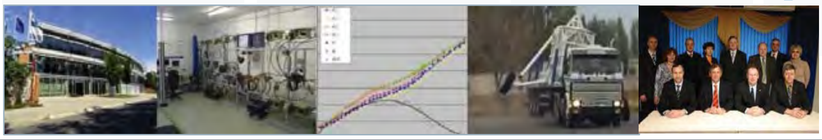
- adaptation of released products for customer application

Cooperation with Uni & Knowledge Center

- KB Research Lab
- Technical University, Nizhny Novgorod
- Technical University, Naberezhnye Chelny
- Advanced Vehicles & Vehicle Control Knowledge Center

Some projects in highlight:

PBS: **pneumatic booster system to improve engine dynamic**
New generation **ABS, EBS,TEBS,**
ELC **(electronic leveling control)**
EAC **(air supply management)** Clutch actuation and gearbox control
ACC**: Adaptive Cruise Control**
System design**: complete service for vehicle manufacturers**



Q-FIRST

Quality is the order of the day for any manufacturer of safety-relevant systems

Quality is a Core Value!

- We are committed to continuously advance the quality of our products and services.
- We are a customer driven company providing the most beneficial solutions for our customers.
- We comply with requirements and continually improve the effectiveness of our Quality management system.

Product Safety is a Critical Success Factor!

- We strive to design and produce products with Zero Defects through the entire supply chain to become considered the benchmark in quality and product safety.
- We are committed to be the technology and market leader with regard to product safety over the full product life cycle.
- We develop and provide products that enable our customers to operate vehicles safely to protect human life.

Individual responsibility and ownership is essential!

- We engage everyone in process and product improvements and foster an environment for continuous learning and development.
- We accept that the responsibility and ownership for quality and product safety rests collectively with each and everyone one of us.
- We leverage individual knowledge, experience, and competencies across global businesses and cultures.

Drivers for Enhancements in the Transportation Industry

Reduced costs

Costs OE

- Reduced component costs
- Reduced cost installed system
- Increased reliability
- Reduced working capital
  - Increased OES sales
- Energy saving

Costs of ownership

- Reduced operating costs
  - Energy
  - Wear (pads, tire)
- Increased reliability
- Simpler service
- Easier handling
- Enhanced safety

Costs for the society

- **Enhanced safety**
- Saving of resources
- Reduced emission
- Increased transportation capacity

Tolerable risk target

Figure –Tolerable risk and ALARP

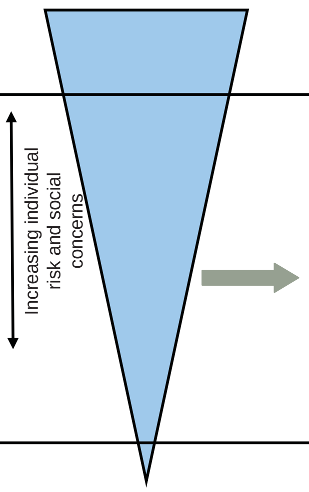
Intolerable region

Risk cannot be justified except in extraordinary circumstances.

The ALARP or torelability region

(Risk is undertaken only if a benefit is desired)

Tolerable only if further risk reduction is impracticable or if its cost is grossly disproportionate to the improvement gained.



As the risk is reduced the less proportionately, it is necessary to spend to reduce it further to satisfy ALARP. The concept of diminishing proportion is shown by the triangle.

Broadly acceptable region

Negligible risk

It is necessary to maintain assurance that risk remains at this level.

Example of risk classification of accidents

Risk classes	Consequence			
Frequency	**Catastrophic**	**Critical**	**Marginal**	**Negligable**
Frequent	I	I	I	II
Probable	I	I	II	III
Occasional	I	II	III	III
Remote	II	III	III	IV
Improbable	III	III	IV	IV
Incredible	IV	IV	IV	IV

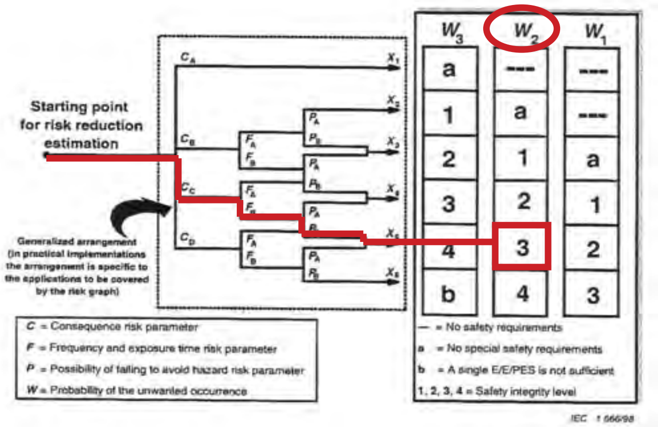
Table Interpretation of risk classes

Risk class	Interpretation
Class I	Intolerable risk
Class II	**Undesirable risk, and tolerable only if risk reduction is impracticable or if the costs are grossly disproportionate to the improvement gained**
Class III	**Tolerable risk if the cost of risk reduction would exceed the improvement gained**
Class IV	**Negligible risk**

Evaluating risk: a qualitative example

Brake system

- C3:
  - Death of one or more person
- F2:
  - Frequent application of brake system
- P2:
  - No other measures against danger
- W2:
  - The frequency of the unwanted event is low



Evaluating risk: a quantitative example

Data1 1

~ 4 person/day
1500 person/year

Mortality in Hungary, caused by traffic

Data 2

Caused by human error

90%

10%

Caused by technical systems
150 person/year

Brake (20%) 30 pers./y
Steering
Undercarriage
Tires
Other

Assume 1

Assume 2

240 Brake error / year

Every eighth brake error causes accident

Assume 3

0,33 brake error/ working hour

An average vehicle runs 2 hours a day

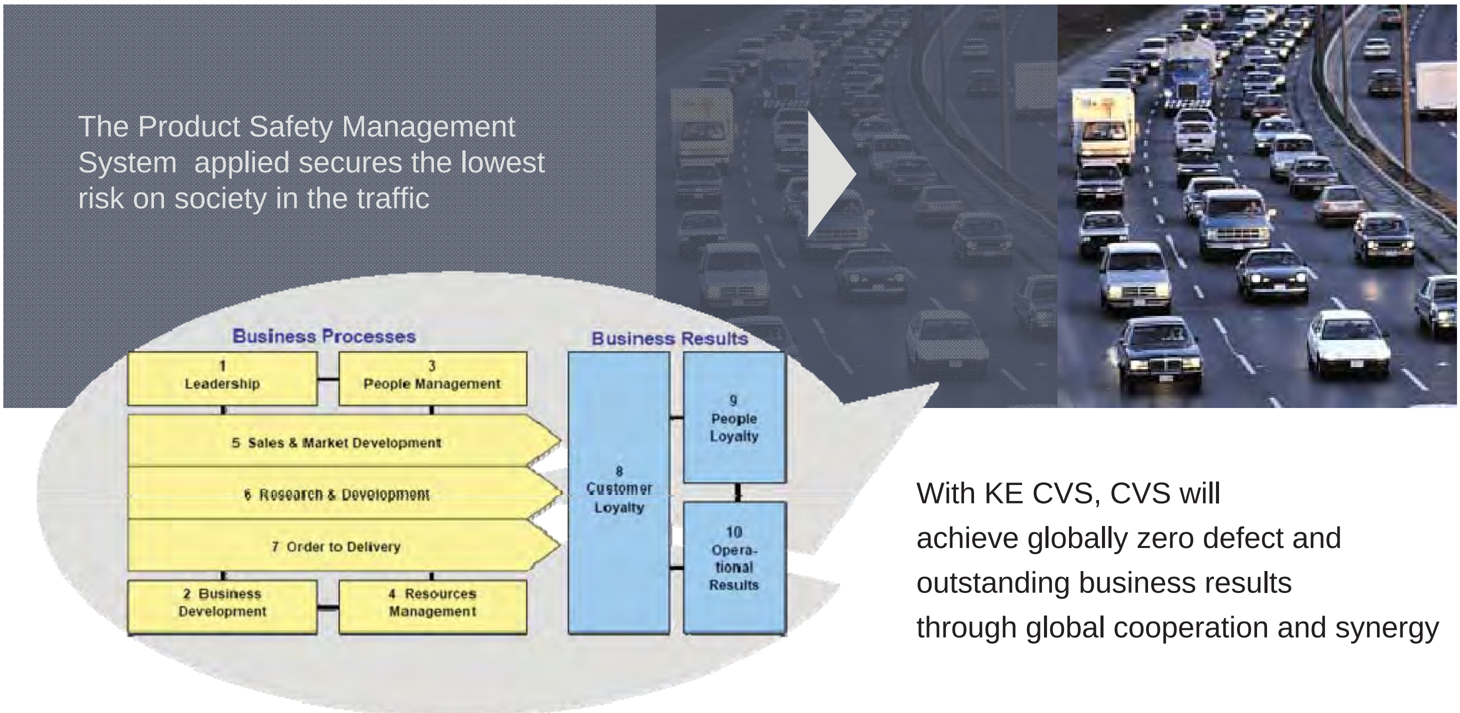
Data 3

$1{,}65*10^{-7}$ brake error/ working hour

In Hungary: 2 miillion vehicle

SIL3

Integrated Management System within the frame of Knorr Excellence



With KE CVS, CVS will achieve globally zero defect and outstanding business results through global cooperation and synergy

Innovation: from idea to customer processes

1.5. Managing Projects, Programs & Initiatives

6. Research & Development

1.5.1 Project management

PDC specific PM documents and templates, e.g.: gps

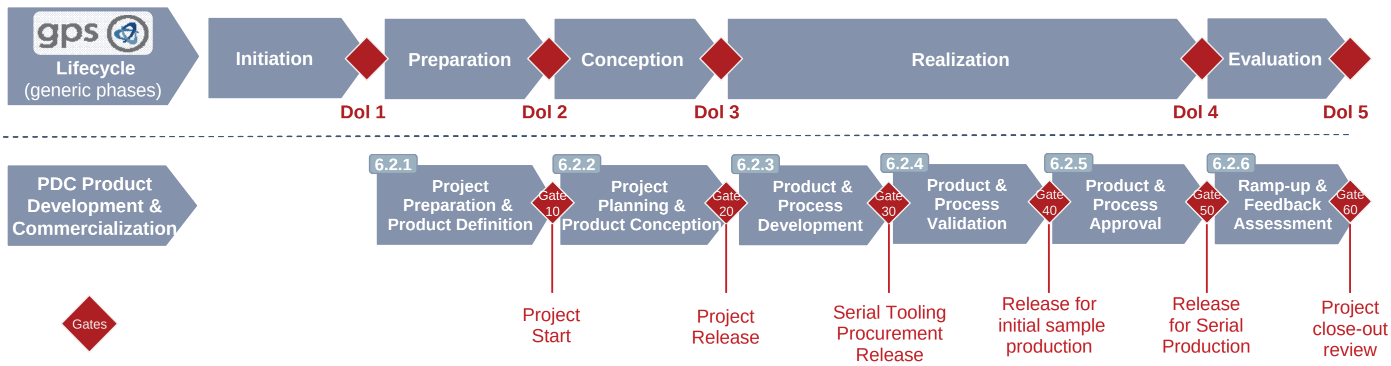
6.1.1. Innovation Management

6.1.2. Advanced Engineering

6.2 Product Development & Commercialization

6.3 Serial Product Support

Main phases of Product Development and Commercialization (PDC) process



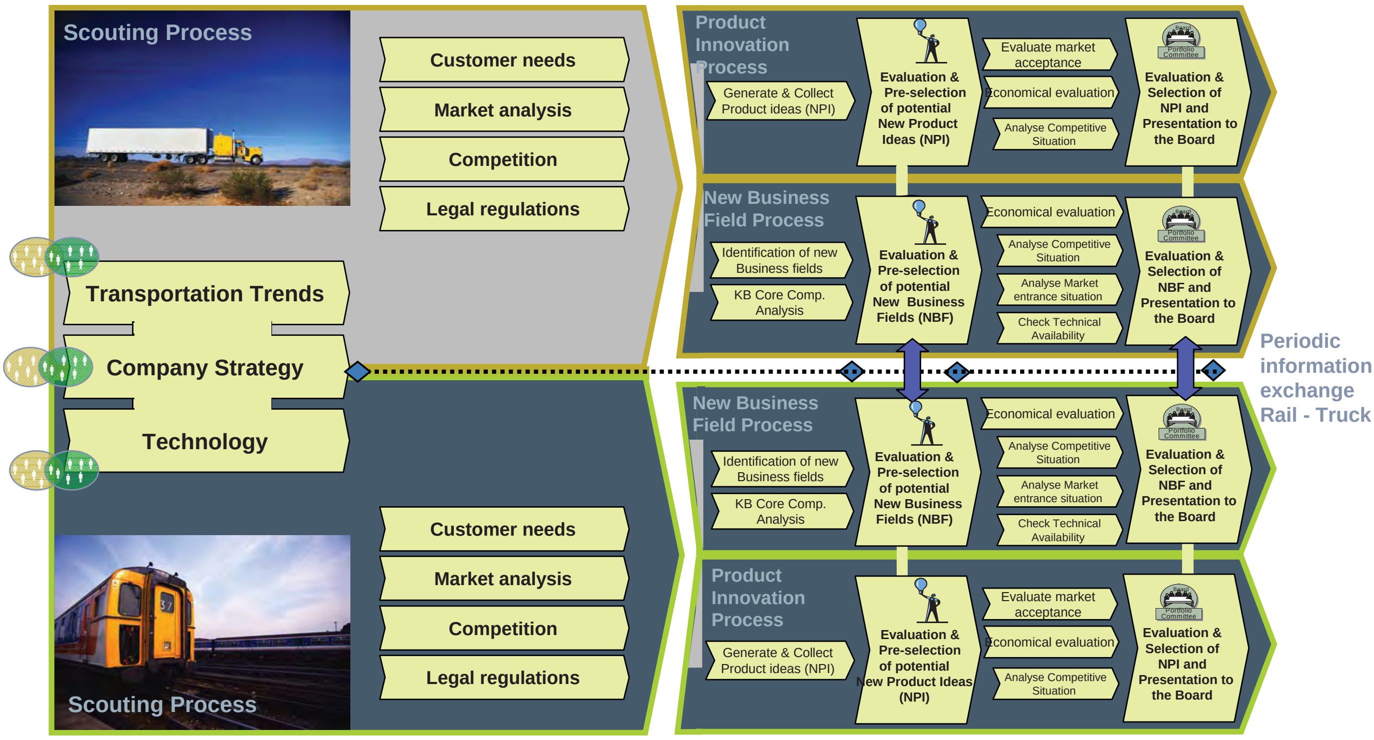
Interface with global project management system

- PDC is embedded in the global project management system (gps)
- gps is divided in generic project phases and links the Strong Focus DoIs

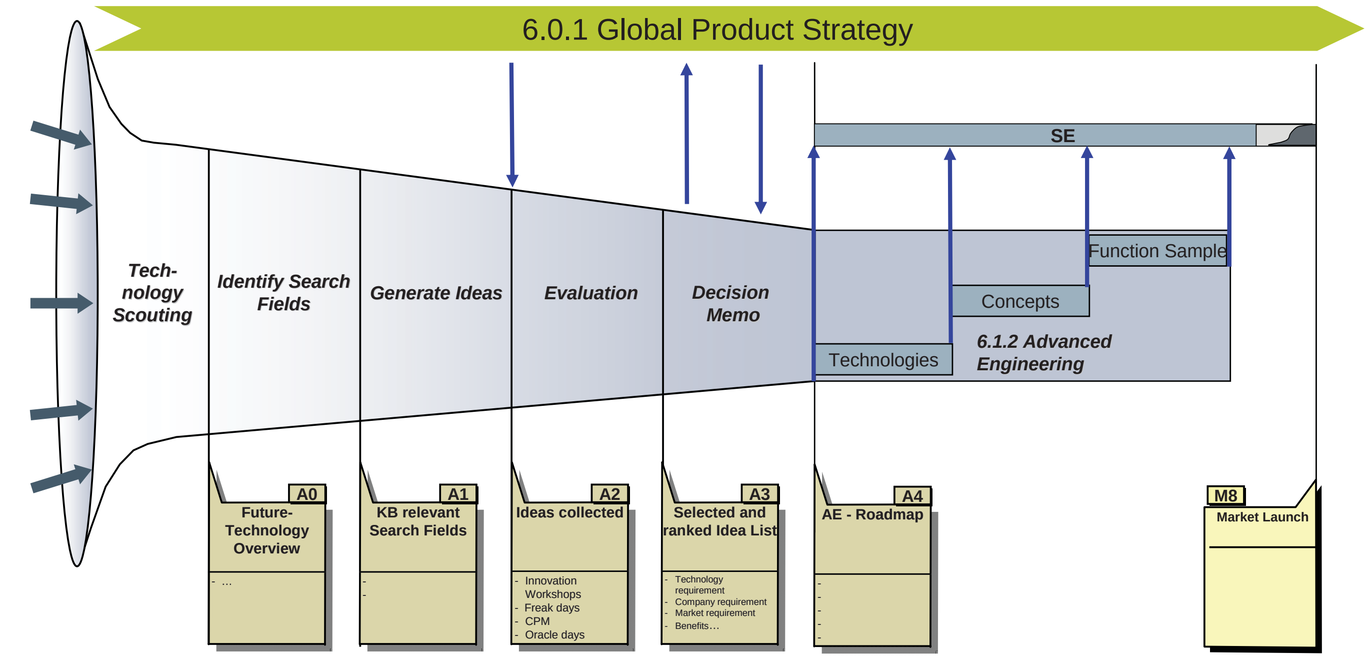
Gate driven structure

- The PDC project has specific phases related to the generic phases
- Project phases are completed by gates

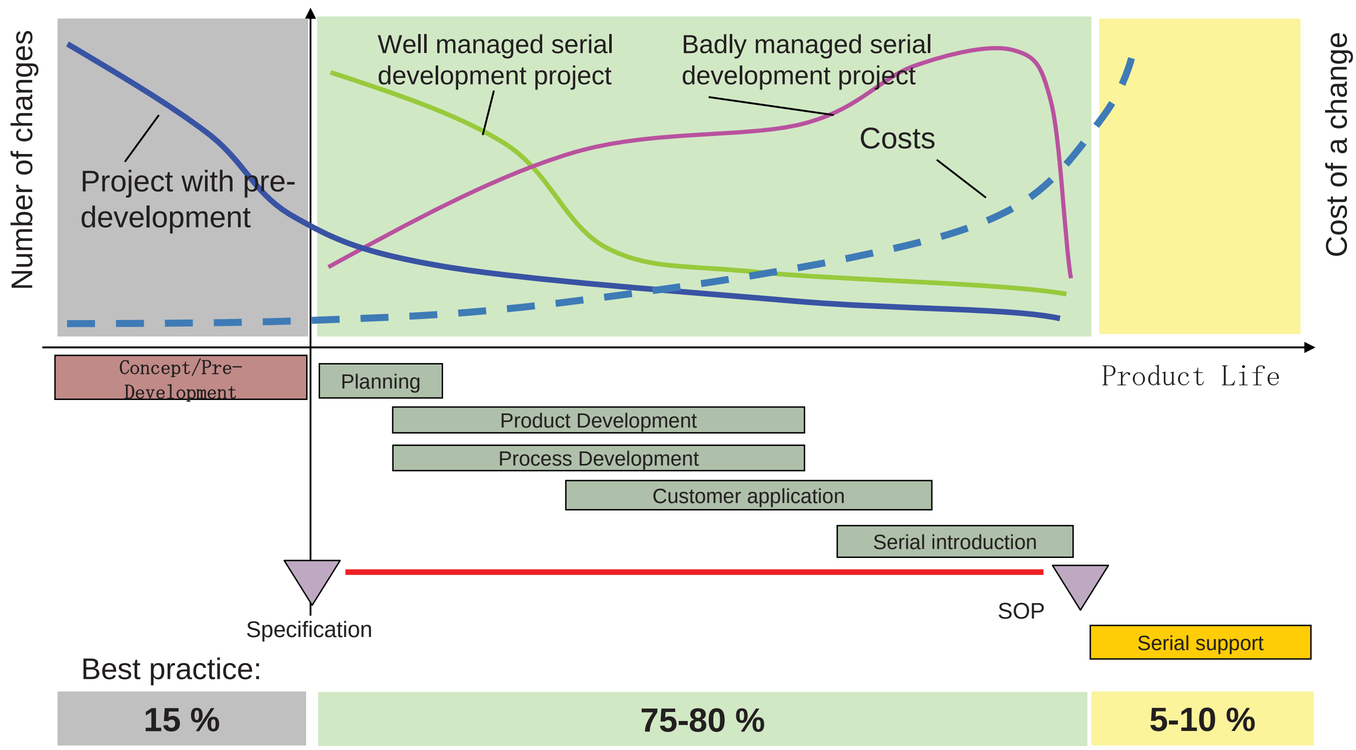
Innovation Process Overview of Knorr Bremse



6.1.1 Innovation Management



Advanced Engineering
Importance of Investment into the Pre-Development



Key Performance Indicator

KNORR-BREMSE

SPP	6.1.1	Innovation Management	GRP		Fonseca	002	EN

AE Load - innovation (SfN)

Target required?	Responsible person for this KPI
Yes	Dr. Palkovics / Fonseca

Method of calculation
Count projects for existing business fields and new projects dedicated to innovations in AE-Roadmap

Purpose
AE – Load - innovation indicates the effort for the preparation to enter new business fields

Definition / Explanation

$$AEL_{inn} = \frac{\sum P_{inn}}{\sum P}$$

P_{inn} = amount of new AE-projects dedicated to innovations
P = amount of AE-projects

Consolidated KPI

Consolidation method

Reporting level and frequency

Board	Monthly
Group Driver	Monthly
CoC/Location Manager	Monthly
Local Driver	Monthly

Time basis for calculation
- annual for all running projects

Deadline to report the data to group
- One month after Strap report

Reporting tool / document
- Excel Sheet

Point of measurement
- Release of AE-/product roadmap

KPI

6.0.1. Product strategy process:

- Innovation growth (SfN)
- Innovation growth
  - AE projects (SfN)
- Innovation growth
  - CoC projects (SfN)

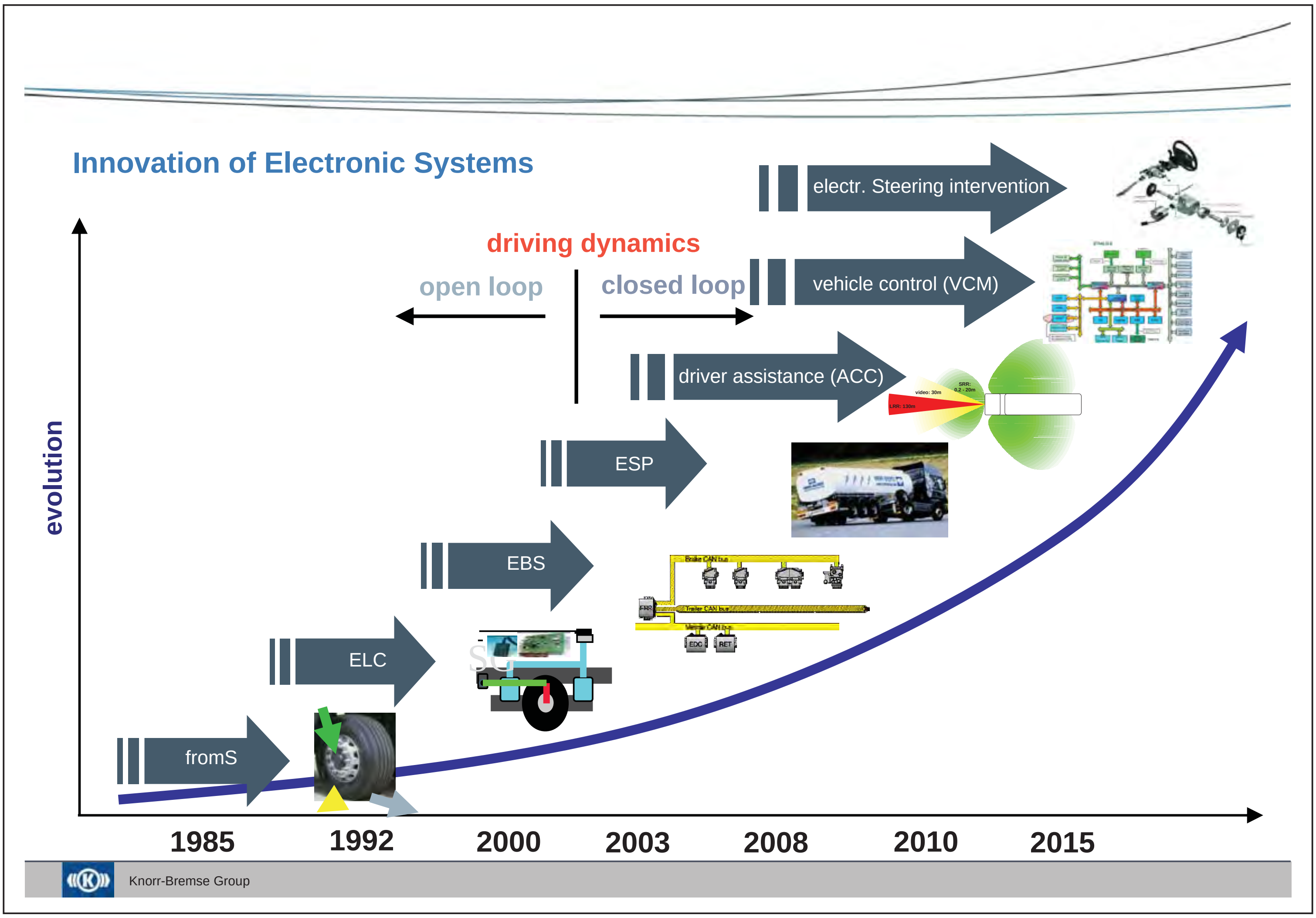
6.1.1. Innovation management:
AE-Load innovation (SfN)

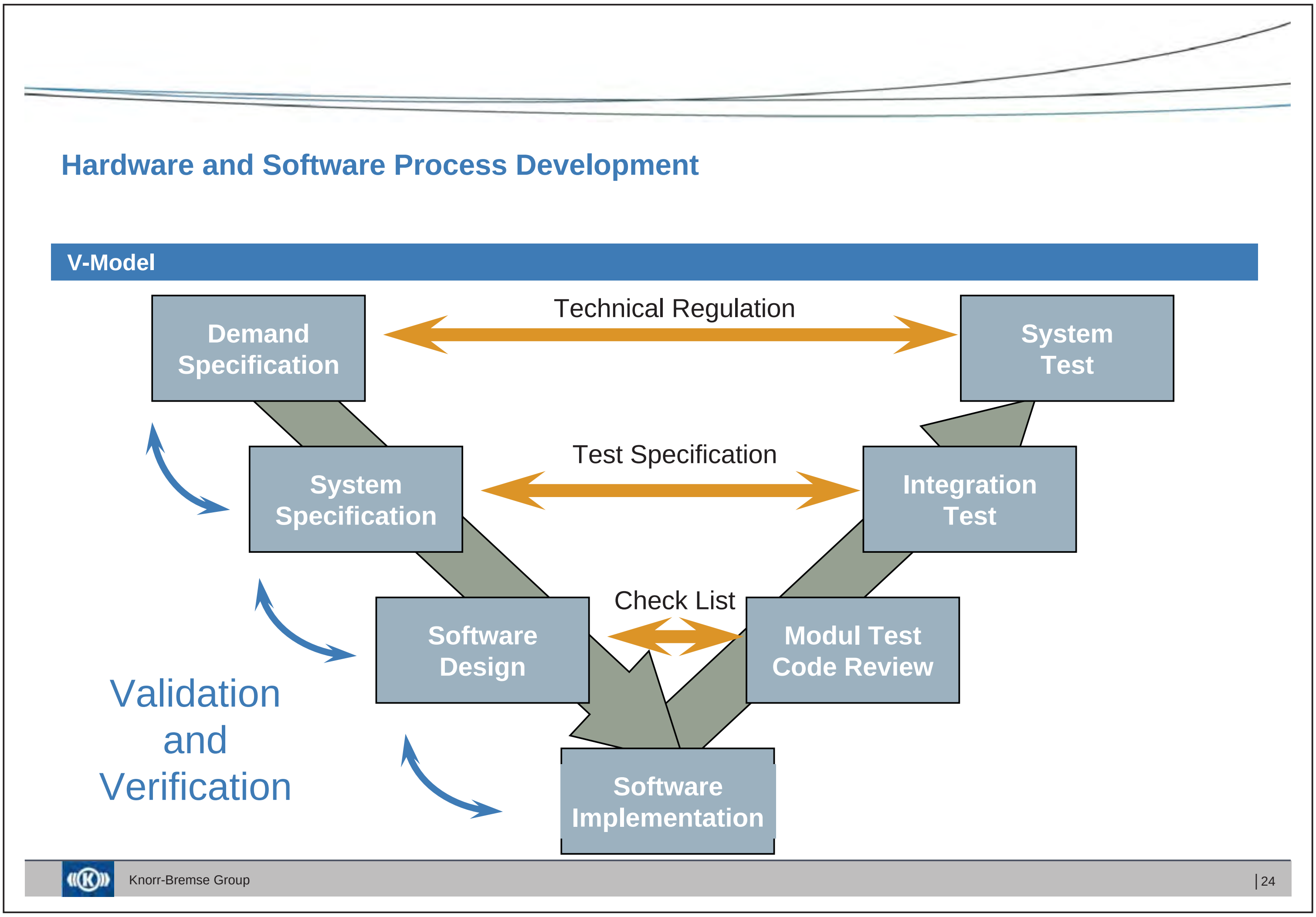
6.1.2. Advanced Engineering

- Advanced Engineering Checklist Fulfillment (%)
- Innovation Speed (SfN)
- Innovation Turnover per Employee

PDC defines phase targets for all project phases

Phase Name	6.2.1 Project Preparation & Product Definition	6.2.2 Project Planning & Product Conception	6.2.3 Product & Process Development	6.2.4 Product & Process Validation	6.2.5 Product & Process Approval	6.2.6 Ramp-up & Feedback Assessment
Gates	Gate 10: Project Start	Gate 20: Project Release	Gate 30: Serial Tooling Procurement Release	Gate 40: Release for initial sample production	Gate 50: Release for Serial Production	Gate 60: Project close-out review
Phase targets	Assure that customer needs and expectations are clearly under-stood and aligned with business goals	Development of concepts into verified product design for requirement freeze	Product and process development for design freeze and serial tooling procurement	Validate design & production process using samples from series tools & series production equipment	Production of initial samples to get technical approval from the customer	Product launch activities after SOP & evaluation of overall project vs. targets


Innovation of Electronic Systems
evolution
driving dynamics
open loop
closed loop
electr. Steering intervention
vehicle control (VCM)
driver assistance (ACC)
ESP
EBS
ELC
fromS
1985
1992
2000
2003
2008
2010
2015
Knorr-Bremse Group


Hardware and Software Process Development
V-Model
Demand Specification
Technical Regulation
System Test
System Specification
Test Specification
Integration Test
Software Design
Check List
Modul Test Code Review
Software Implementation
Validation and Verification
Knorr-Bremse Group

Software Quality Assurance: Analytical Steps

Analytical steps:

- **Review process**
- **Testing**
  - test protocols, failure simulation report, function check lists
  - files from test cabinet, documentation of SW and HW test routine
  - driving test

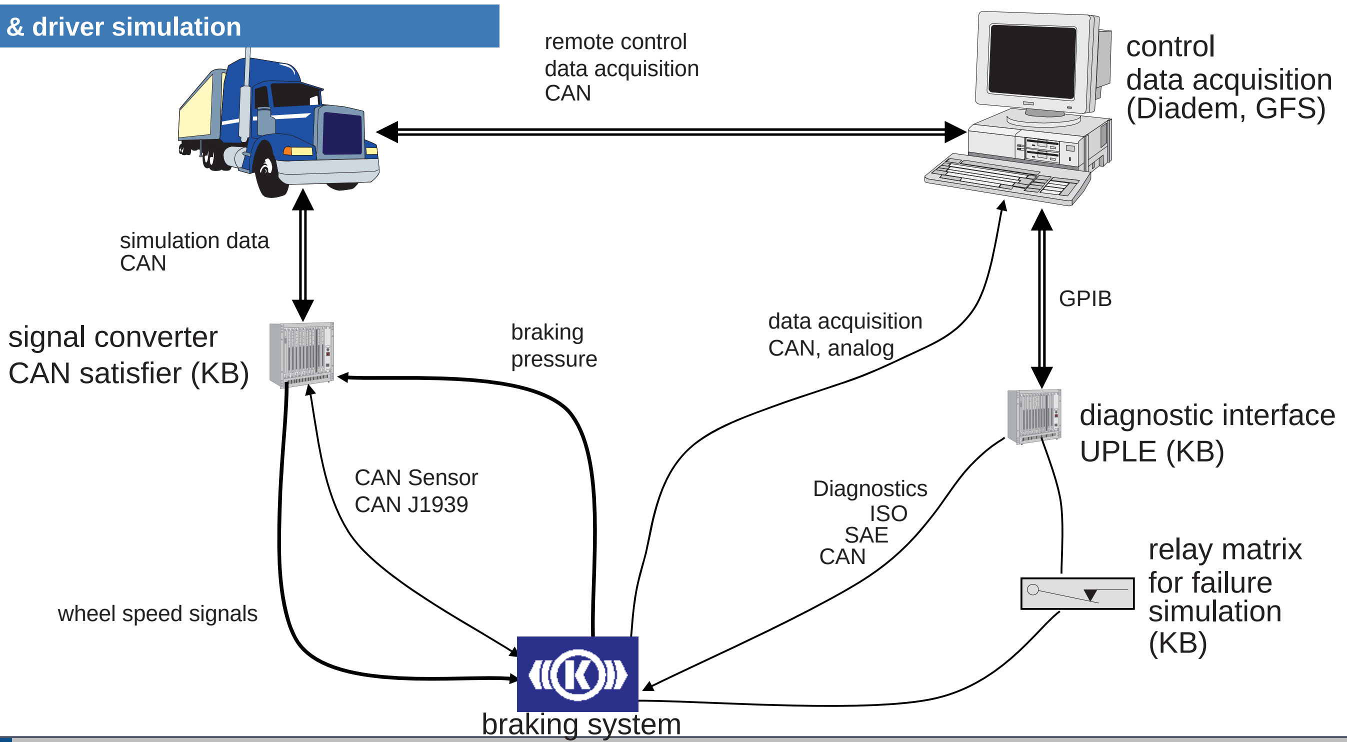
Validation and verification :

- **Acceptance test**
- **SW acceptance protocol,**
- **SW quality assessment,**
- **QE1 (before SW development),**
- **QE2 (after implementation).**
- **QE3 (just before SW release).**

Certificate: SIL 3
IEC 61508
(Functional Safety of Electrical / Electronic Safety-Related Systems)

Hardware – In-The-Loop Simulation

Truck & driver simulation



H-I-L Simulationsmodel

Failure Simulation

- **Safety verification of the braking system**
  - short circuits in the wiring harness
  - and interruptions and on the PCB
- **Verification by simulation**
- **Automated execution**
- **Automated valuation with regard to e.g.**
  - controllability
  - braking distance
  - stability (ESP)
  - warning lamps and error storage
- **Automated documentation**
- **Graphical charts for manual evaluation**
- **Adds to FMEA**

Calculation Example

Number of driving cycles for connector failure simulation:

- No of pins * (No of pins - 1) / 2 * Number of tests time

Combinations that will destroy ECU or test bench will not be short circuited (Ubatt - GND)

- Example EBS2: 55 * 54 / 2 * 6 = 8910 cycles – so many potential failure opportunities only for the ECU

Duration with 120 seconds per cycle: ~ 13 days and nights

Cannot be done manually!

Use of Tools During Development Process

Tool	A sample	B sample	C sample
Endurance test			Hardware test of ECU and mechatronic components
Failure Simulation		Check of vehicle behaviour in case of error Check of error detection Check of error codes	Vehicle behaviour in case of error Check of error detection Check of error codes
Automated test bench		Automatic function test Automatic diagnosis test	Automatic function test Automatic diagnosis test Check for error detection Check of diagnosis
HIL	Basic function development	Basic function development Test of functions Search for effects	Test of functions Search for effects
Modulab	Data measurement Simulation	Function test for software in Lab (Automatic Software check) Data measurement in vehicle	Function test for software in Lab Automatic Software check Data measurement in vehicle
ASCET	Rapid Prototyping Function development	Rapid prototyping Function development Automatic code generation	Function development Automatic code generation

PDC defines phase targets for all project phases

Phase Name	6.2.1 Project Preparation & Product Definition	6.2.2 Project Planning & Product Conception	6.2.3 Product & Process Development	6.2.4 Product & Process Validation	6.2.5 Product & Process Approval	6.2.6 Ramp-up & Feedback Assessment
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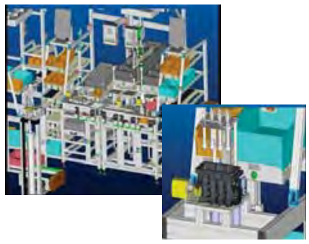
6.2.3 and 6.2.4. process: Industrialization

Industrial Engineering

Product and process development for design freeze and series tooling procurement	Validate design and production process using sample from series tools and series production equipment
▪The documentation of the production equipment is created (specification, PFMEA) ▪The production equipment specification is submitted to possible suppliers for RFQ ▪the investment release is prepared	▪The supplier for the production equipment is selected. ▪The documentation is reviewed and released by KB CVS for realization ▪An Equipment Tryout is performed at the supplier location ▪the equipment installed at KB ▪An Equipment Tryout is also performed at KB

Concept Development

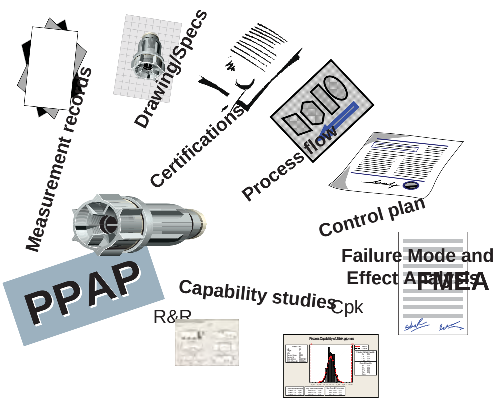


Concept Evaluation

Concept Realization

Verification by trial run

6.2.5. process: Product and Process Approval



Commercial Sales Phase Targets
- The processing of order is completed in the ERP System

Logistics Phase Targets
- The logistics basis for replaced products is set
- The basis for the logistics ramp up is set

Project Management
- Performing team/ executed tasks
- Cost, quality/ scope, time under control
- Released DoI 4 (implemented project)

IE Phase Targets
- The initial sample production for the customer (PPAP) is performed

R&D Phase Targets
- Production support
- R&D initial sample test.

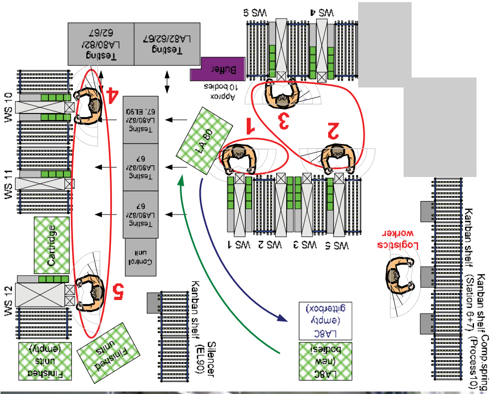
Purchasing Phase Targets
- Handover released parts to parts procurement

Technical Sales Phase Targets
- The PPAP Release is submitted and approved

Quality Phase Targets
- Delivered PPAP packages to customer

Customer approval for series delivery

Process industrialization



Development steps:

Main steps for product and process industrialization

- Product specification and development
- DFMEA, PFMEA and control plan creation and deployment
- Manufacturing process concept development
- Manufacturing process fine tuning and equipment specification
- Equipment development with supplier
- Manufacturing release at the supplier
- Manufacturing trial runs at supplier together with customer
- Final manufacturing release on site

Early involvement of customers increases customer comittment and confidence and significantly increases speed for final equipment release.

Standardized work on standardized workplaces

Basic standards for workplaces are defined and implemented

For manufacturing all steps can be consolidated to four main elements that are repeated in complex processes

- Manual assembly
- Greasing
- Pressing
- Screwing

Target is to create modular process elements for each of these manufacturing steps

- Standardization including complete documentation such as SOS, PFMEA or control plans.
- Standardize interfaces between the process elements to be able to combine easily without additional modification.

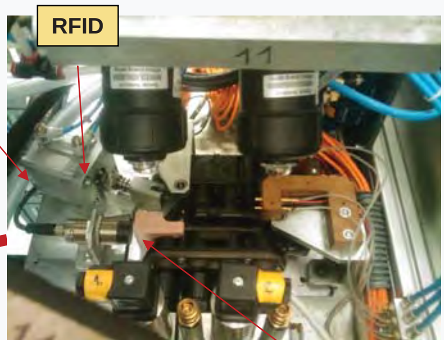
Workplace standardization

KB Kecskemét developed three standards for workplaces.
Workplaces are adjusted to the criticality and complexity of the products.
Target were cost optimized workplaces with adjusted process requirements

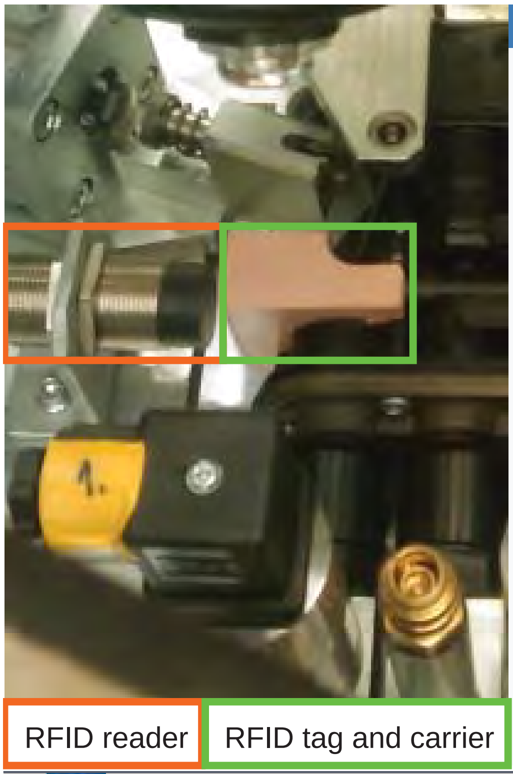
		Full process control workplace	Sensor controlled manual workplace	Low cost manual workplace
Product Quality	Electronic screw drivers	X		
	Tool monitoring by sensor	X	X	
	Type label checked by camera	X		
	Clear separation of good and rejected tests	X	X	
	Pick to light	X	X	
	Automatic label printing after good test	X		
	Auto feeding for type label		X	
	Shuttle control to avoid mixing		X	
	Shelf identification (material in / out)	X	X	X
	Poka-Yoke	X	X	X
	Jidoka	X	X	
Standardized work	Dedicated place for every process	X	X	X
Material Flow	One piece / X-piece flow	X	X	X
	Two bin Kanban for material feeding	X	X	X
Cost optimization	Manual shuttle system		X	
	Standard Aluminium frame	X	X	X
	Simple fixtures			X

EOL test of products – full traceability by RFID

- More independent test rig on a conveyor, fully automatic test process
- Individual RFID identification for each palettes and parts (15 palette)
- All measurement results are stored in a SQL database
- The parts are tested together with the palettes.



Process monitoring



Equipment and methods:

- RFID provides the technology to record all process parameters

  Product parameters
  - All parameters are linked to the product
  - Full traceability is given

  Closed loop and self adjusting
  - Manufacturing parameters can vary due to different component lots
  - Learning software and closed loop can be applied by connecting manufacturing parameters and test results using the RFID tracing

  Online manufacturing supervision
  - Online capability studies are performed to initiate corrective actions before 6 Sigma limits are reached
  - All manufacturing parameters are continuously monitored and capability studies are calculated by the system

Full process control and forced sequence

Examples of new assembly lines:

- Main policy for new equipment are
  - Full process control, recording and forced sequence
  - Standardised and modular work place principle allowing easy orientation for operator
  - 0-defect and full traceability

- New manufacturing lines at Knorr are developed with the Zero defect approach
- These new lines are the main contributors to a high customer satisfaction during the last years
- The 0-defects aren’t fully reached yet, but these new lines contribute with a very minor 0-mileage defects

Every day, more than 1 billion people put their trust in systems from Knorr-Bremse

- …in Light Rail Vehicles, Metros, Commuter Trains and High Speed Trains
- …in Buses, Coaches and Commercial Vehicles

We are aware of the responsibility and reflect to it in an innovative way

KNORR-BREMSE

Thank you very much for your attention!

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