Product Line Architecture

Systems

- Systems often come in families: basic, regular, professional, enterprise,…
- Can we share components?
- Is architecture useful is encouraging an approach that uses components as building blocks for systems.

Software Product Line

- A collection of software-intensive systems sharing a common, managed, set of features that satisfy the specific needs of a market segment or mission that are developed from a set of core assets in a prescribed way.
  - Product lines are a feature of many physical products (e.g. cars)
  - Useful in the context of software engineering

Software Product Lines

- Are directed by business goals in a particular application domain.
- The products in a product line share a software product line architecture
- Products are structured by the product line architecture and are built form services and components.
- Architercture and components are the core assets used to satisfy the business goals.
- Product line leverage commonality and limit variability of the product.

Product lines spread costs over several products

- Requirements and requirements analysis
- Domain model
- Architecture and design
- Performance engineering
- Documentation
- Test cases, data, and plans
- Skills
- Processes, methods and tools
- Defect fixing
- Components and services

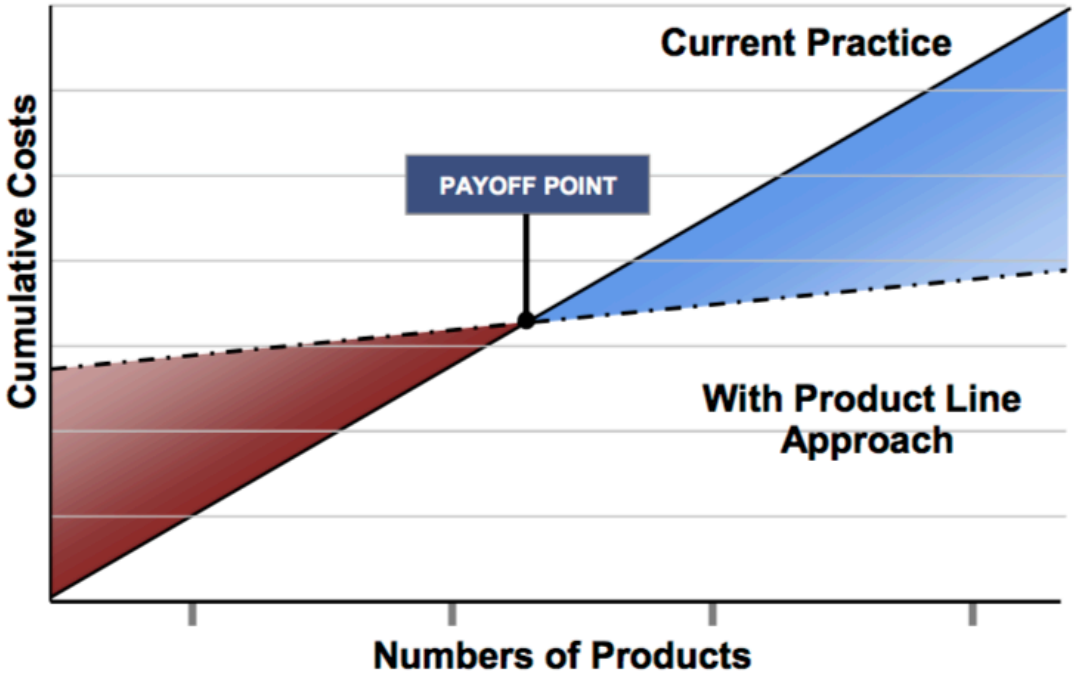
Benefits to the organisation

- Large-scale productivity gains
- Improve time to market
- Maintian market presence (rapidly evolving variants)
- Sustain growth
- Improved market agility
- Better use of skills
- Enable mass customisation
- Gain control of configuration
- Improve product quality
- Better predictability of cost, schedule and quality

Costs of a product line

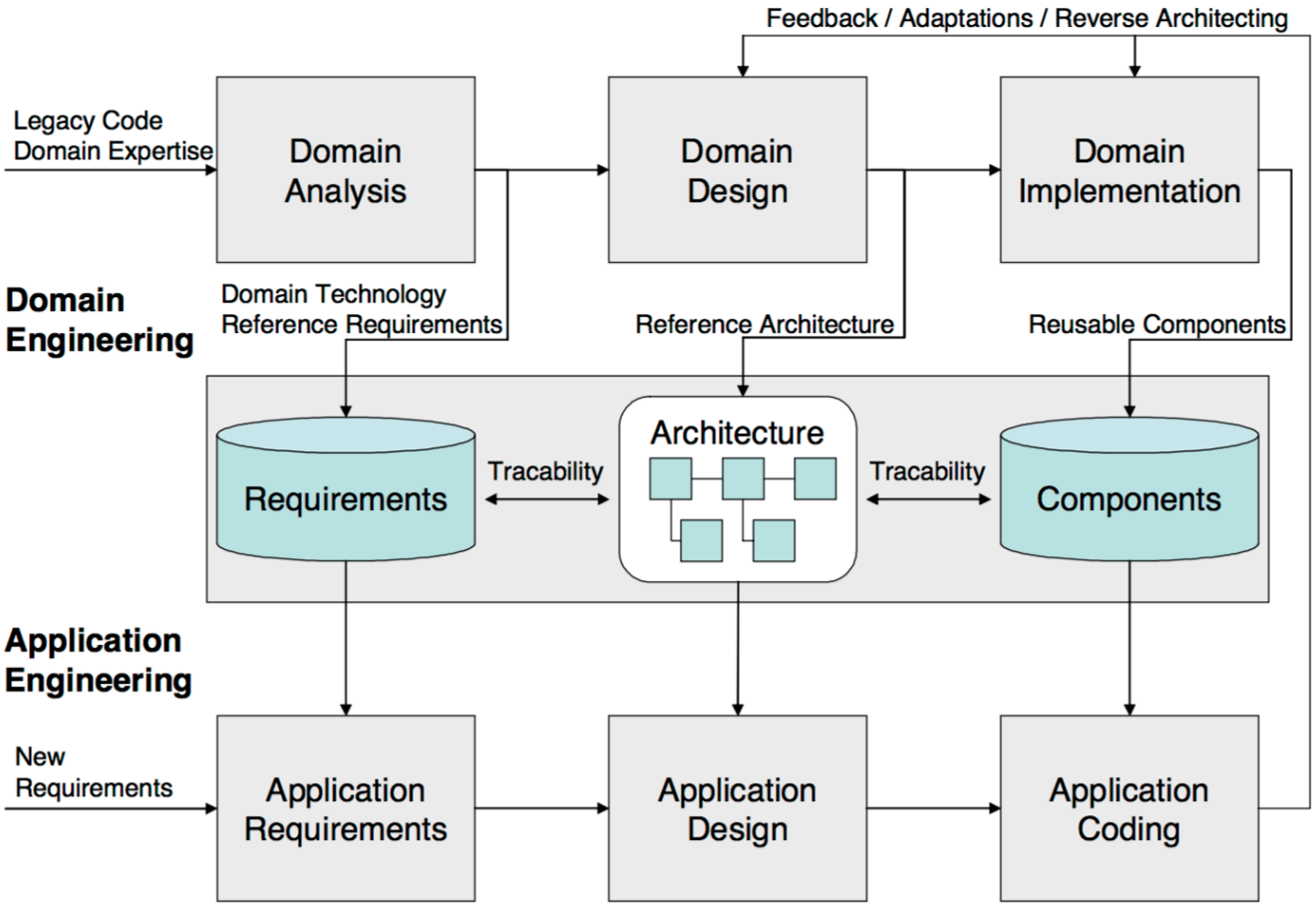
- Architecture: flexible enough to support variation in the products
- Software components: general enough to support variability
- Test plans, cases, data: take account of variation in components
- Business cases: must operate at the level of a product family
- Project plans: generic and extensible to deal with variation
- Tools and processes: must support architecture, variation, configuration, ..
- People, skills, training: need to be skilled in architecture and product lines.

Product Line Economics



Weiss, D. M. & and Lai, C. T. R.
Software Product-Line Engineering: A Family-Based Software Development Process.
Reading, MA: Addison-Wesley, 1999.

Product line summary



Van der Linden, F., (2002). Engineering Software Architectures, Processes and Platforms for System Families—ESAPS Overview, Proceedings of the Second International Conference on Software Product Lines (SPLC2), pp. 383-397, San Diego, CA, USA, August 2002.

Core Process Activities

- Core asset development: improving the base components in terms of qualities, products they support, and architecture.
- Product development: identifying and building products to meet market need inside the product line.
- Management: monitoring and improving the processes, tools and practices.

Introducing Product Lines

- **Proactive:** Up-front investment to develop the core assets – need to know the market well (maybe have an already established set of products)
- **Reactive:** Start with one or two products and use them to generate core assets.
- **Incremental:** Develop core assets as the business need evolves.

Example: Bosch Gasoline Systems

Based on: Software Product Lines in Action, Chapter 9, Frank van der Linden, Klaus Schmid, Eelco Rommes
Springer 2007, ISBN: 978-3-540-71436-1

Bosch Gasoline Systems

Company facts of Bosch Gasoline Systems

Organisational size: $\sim$ 1,000 developers.
Starting Mode: Strategic focus, based on existing assets.

Experienced improvements:
- Reduction of calibration effort (–20%) and maintenance.
- Reduction of the resource consumption (20–30%).
- Product line definition reflecting market variance.

Business: Addressing new business challenges was a major driver. Three market segments were identified as a starting point.

Architecture: A new software architecture was developed, but assets were derived from the existing asset base.

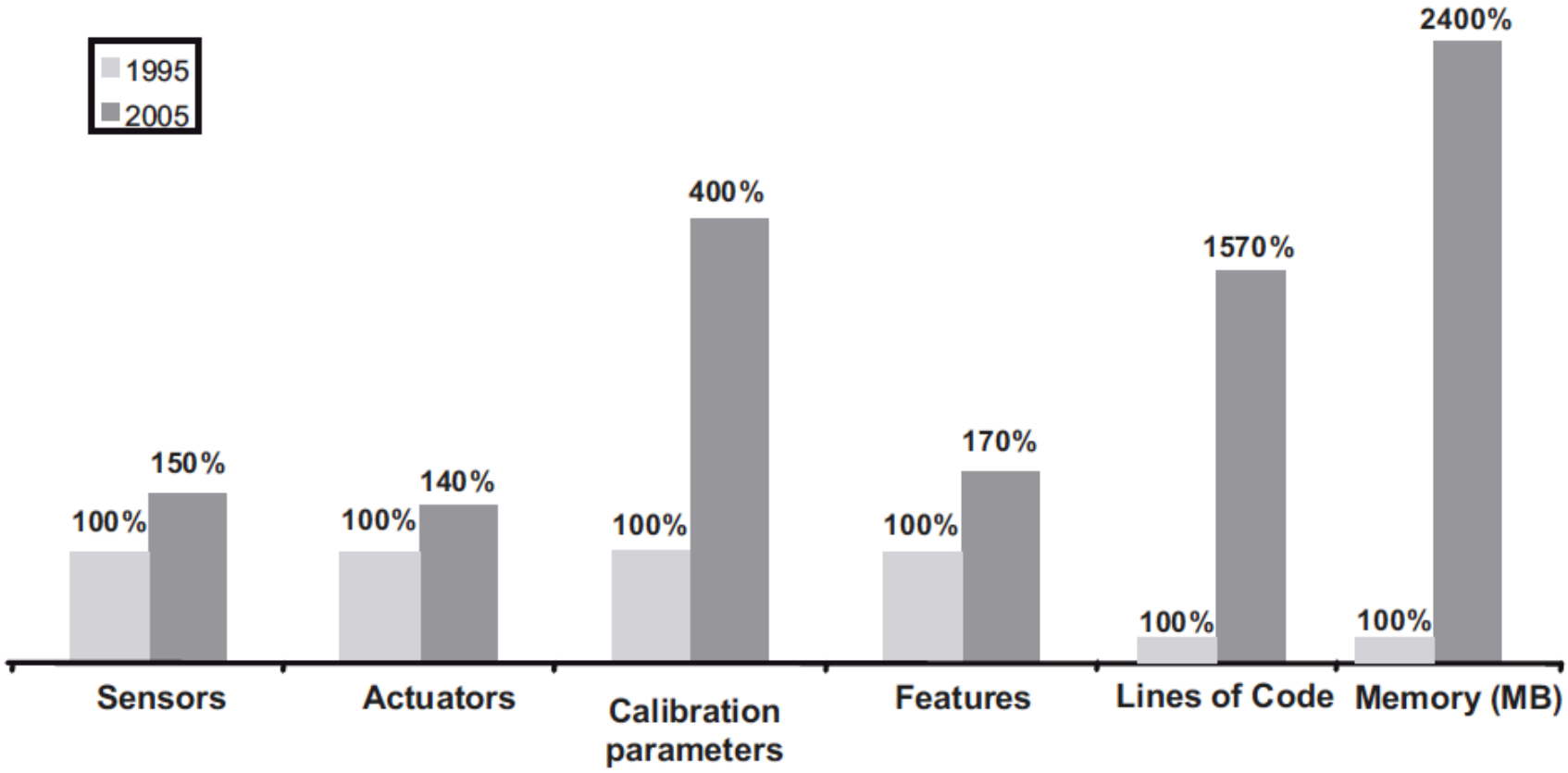
Process: Bosch works on CMMI level 3. Systematic process engineering provided an important basis for product line development.

Organisation: A restructuring of the organisation was necessary to reflect the different roles in a product line organisation.

Bosch

- Employed 250,000 people in 2006, now 375,000
- Revenue €70.6 bn in 2015
- Gasoline systems is one of the largest divisions in 2006, employing 1000 developers.
- Every new engine controller leads to a new variant
- Thousands of controllers are in use.

Rapid Change



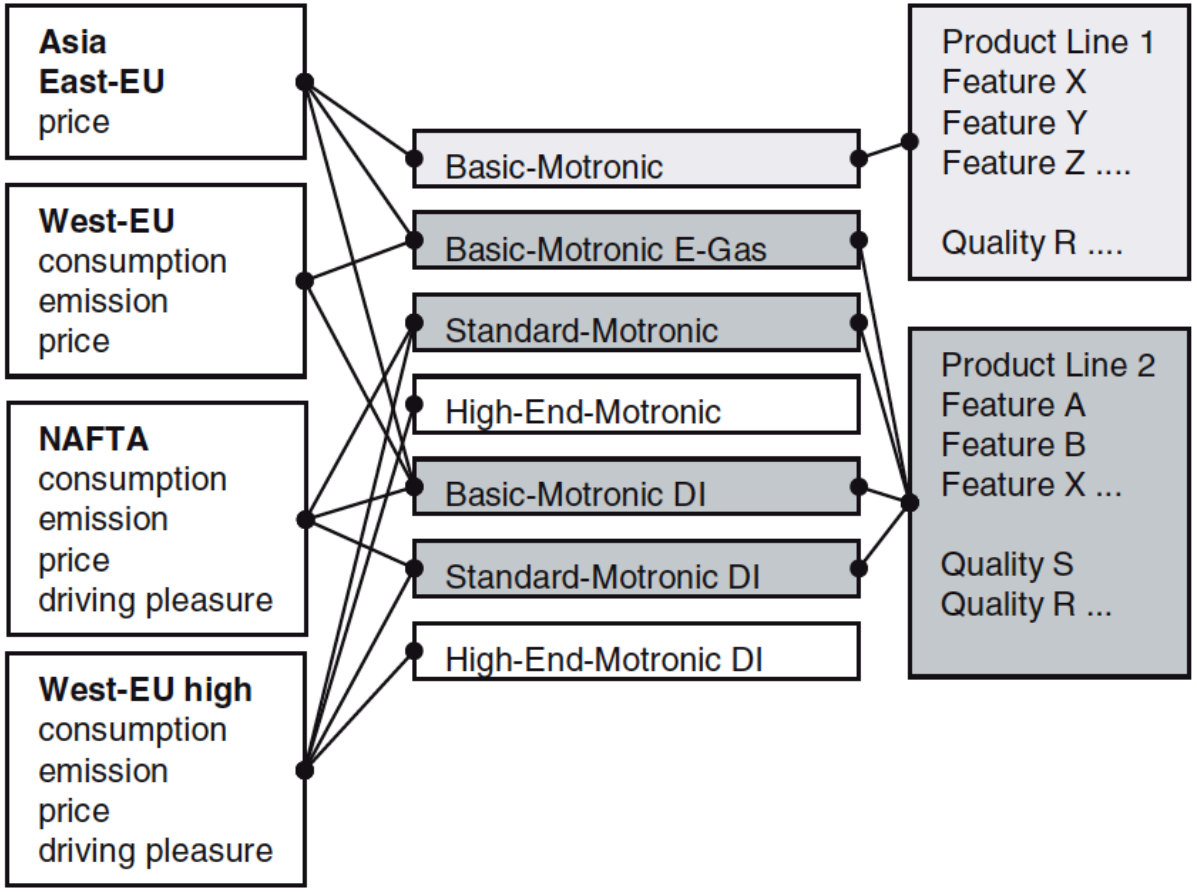
Goals

- Competitiveness:
  - Reduced hardware resource consumption
  - Reduced time to market for new features
- Development efficiency
  - Reuse
  - Easy configuration of software products
  - Increased planning accuracy
- Quality
  - Interface integrity
  - Reuse of core assets
- Customer needs
  - Differentiation by individual software solutions
  - Clear feature-cost mapping

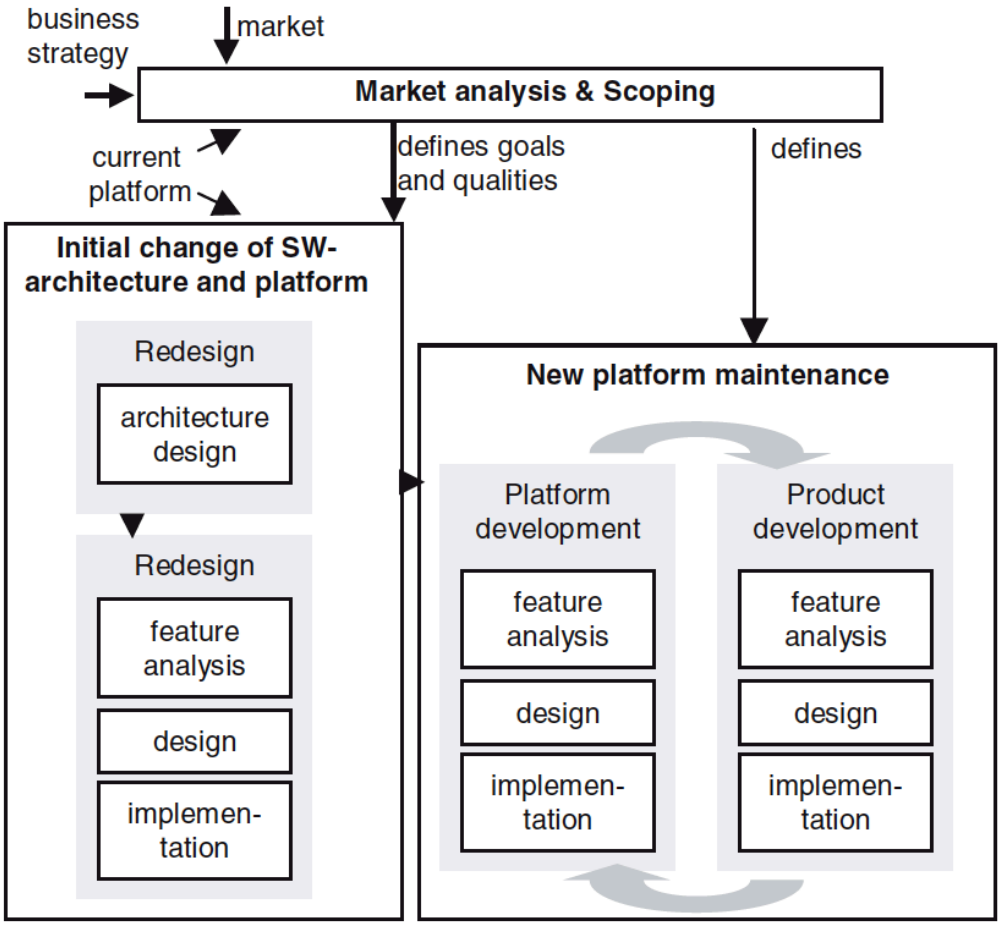
Approach

- Process:
  - Consider business strategy
  - Consequences for products
  - Consequences for processes and methods
  - Consequences for tools
  - Consequences for the organisation

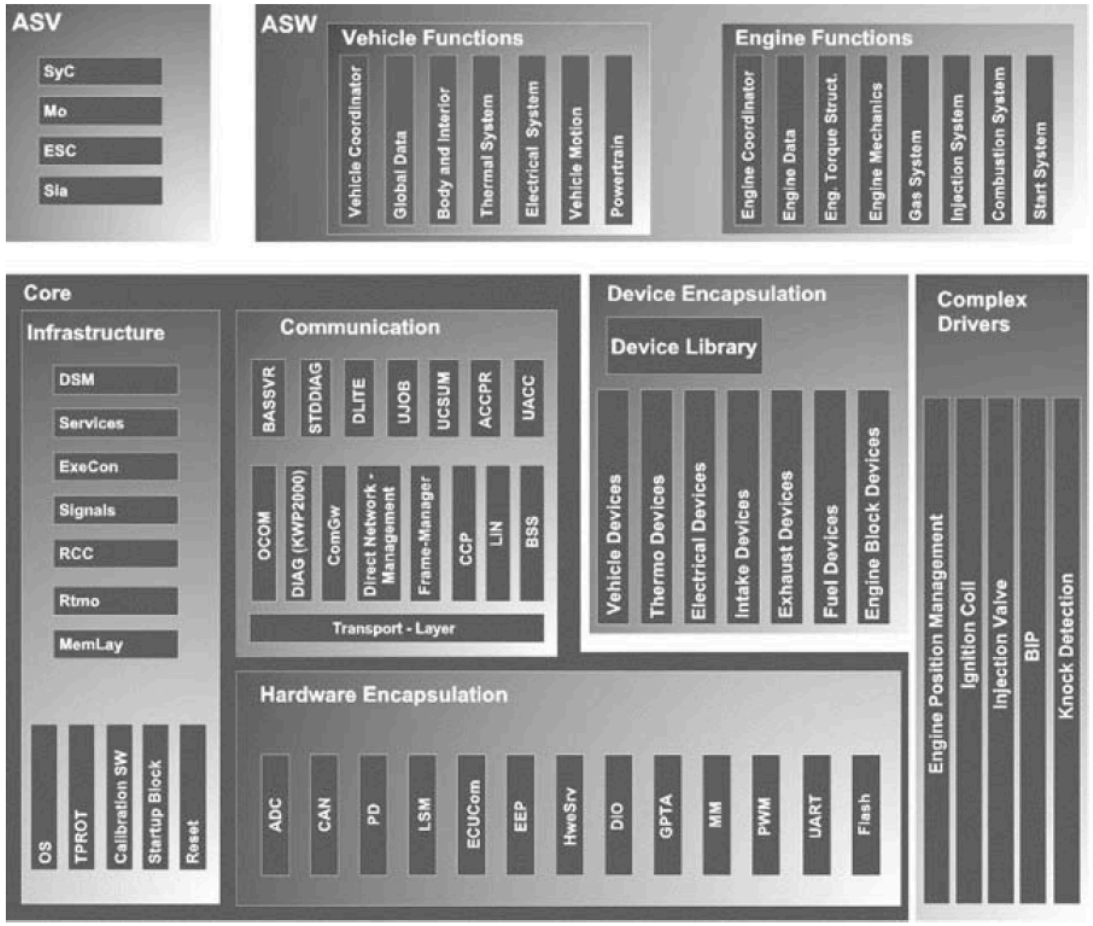
Business Strategy



Production


business strategy
market
Market analysis & Scoping
current platform
defines goals and qualities
defines
Initial change of SW-architecture and platform
Redesign
architecture design
Redesign
feature analysis
design
implemen-tation
New platform maintenance
Platform development
feature analysis
design
implemen-tation
Product development
feature analysis
design
implemen-tation

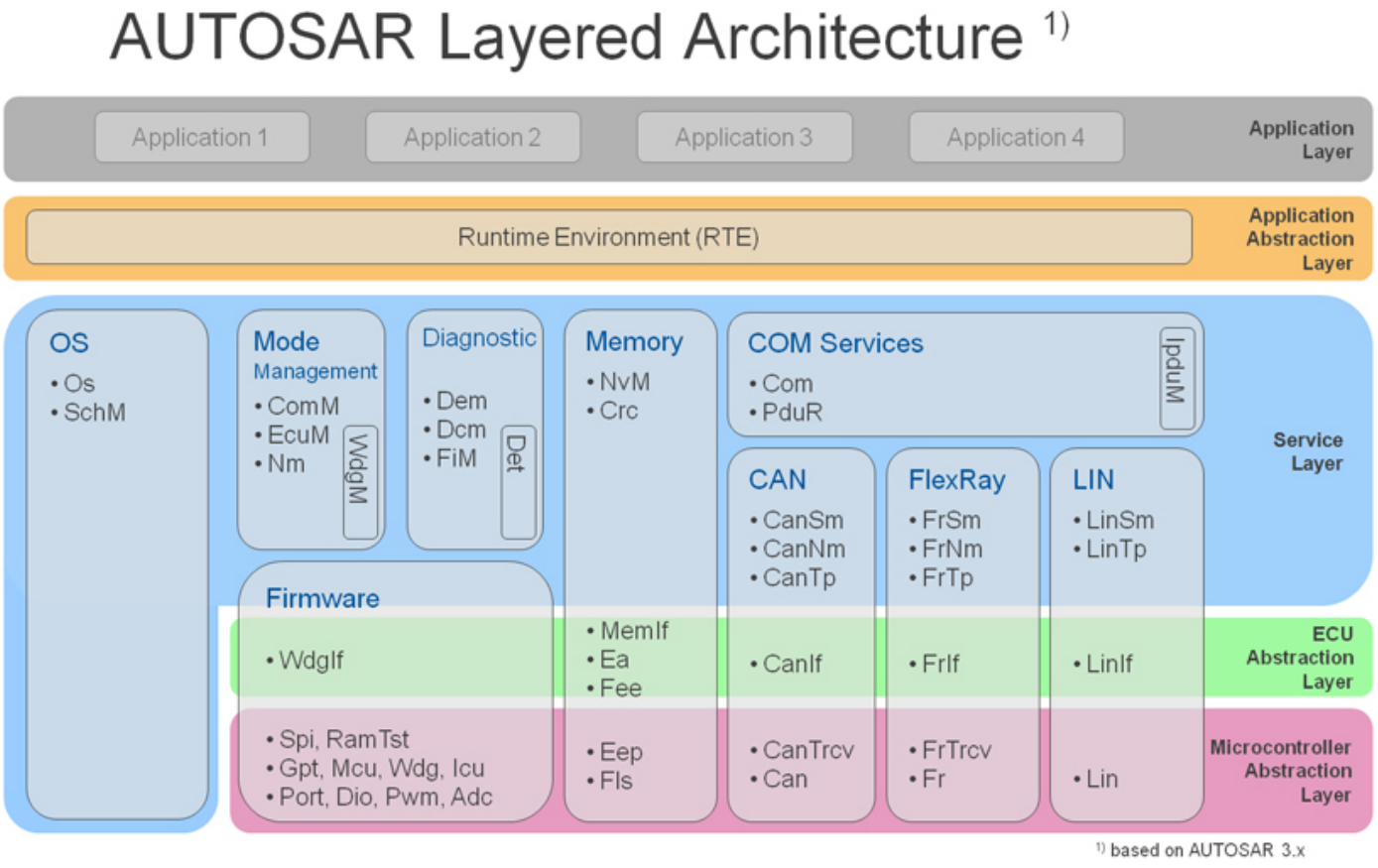
Architecture



Architectural Features

- Control of resource consumption e.g. memory (because of cost).
- Distributed development requires good interface management.
- Layers provide the possibility to share applications without knowing the details of particular sensors or actuators
- Reuse goals: Applications can be used across different generations of system; “core” software is highly configurable and is reused via reconfiguration; “Vehicle functions” can be used across gasoline and diesel engines
- Standardisation is important, Bosch play an important role in AUTOSAR: http://www.autosar.org

Architecture Standardisation



Component Redesign

- Focussed on: reuse; simplification of calibration; resource consumption; stabilisation of interfaces (within the architecture)
- Redesign progressed by:
  - Analysing existing software inventory: features, sources of variability; relation to product line; document interdependency.
  - Concept development and design of components: simplification; configurability; architecture driven structure; document relations between features and components;
  - Baselines for variants of software components: document baselines; implement; maintain up-to-date document and implementation.

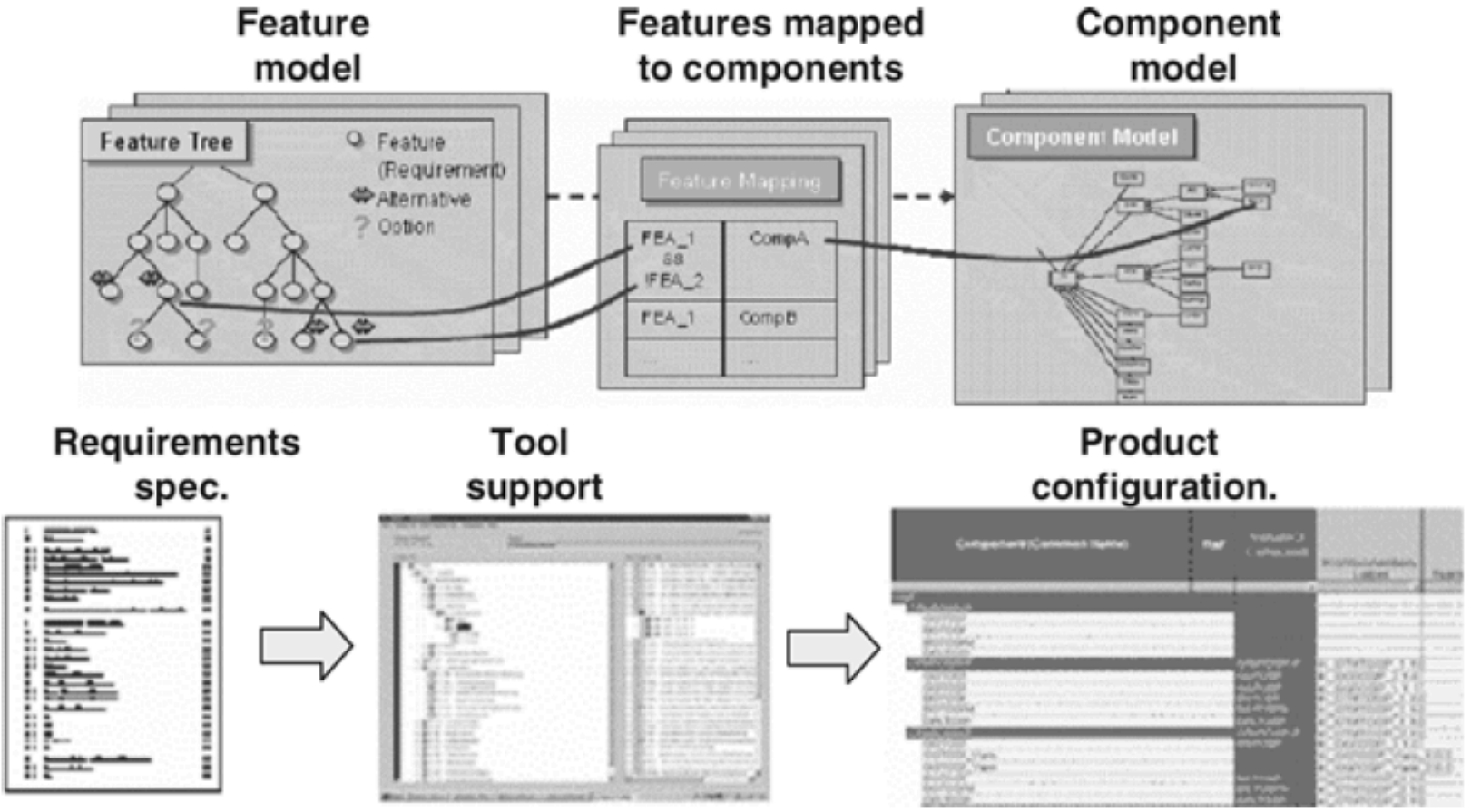
Phased Introduction

- Investigate and customise product line engineering.
- Design and pilot adequate processes and methods.
- Roll out and institutionalise in the standard development process.

Roll out

Action:	**Roll out by redesign of existing platform.**
Purpose:	Initial development of work products like interfaces, feature trees, overview functions, etc.
Helpful:	Product line engineering coaches.
Action:	**Series of product line process workshops with middle management.**
Purpose:	Understanding, acceptance and management support.
Helpful:	Management commitment.
Action:	**Embody new process steps in standard development process.**
Purpose:	Visibility of product line engineering integration in process infrastructure.
Helpful:	Management commitment, existing process infrastructure.
Action:	**Training program for product line engineering and architecture.**
Purpose:	Understand product line engineering and internalise new methods.
Helpful:	Use of domain-specific examples.

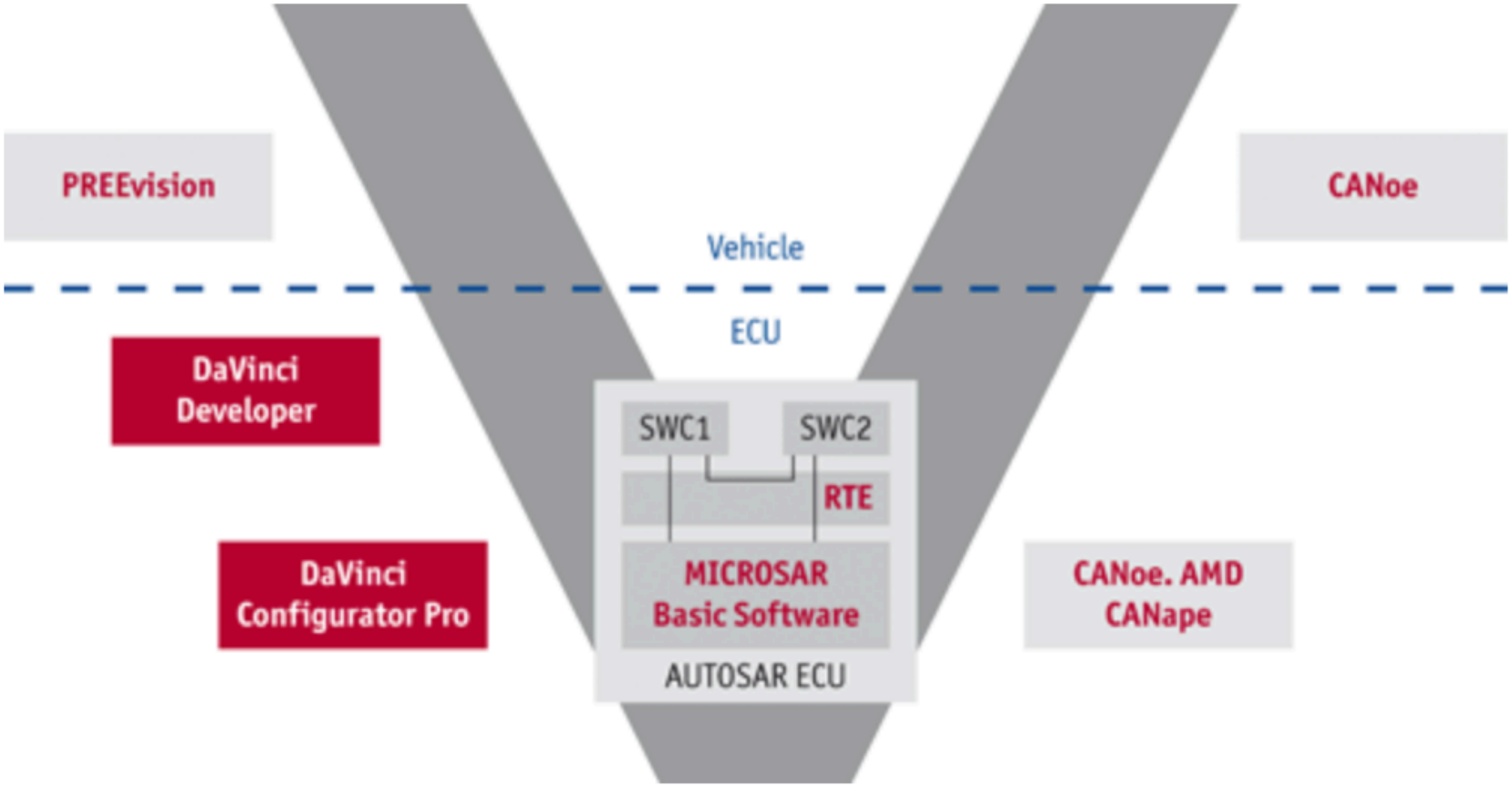
Toolchains


Feature model
Features mapped to components
Component model
Feature Tree
Feature (Requirement)
Alternative
Option
Feature Mapping
FEA_1
SS
FEA_2
CompA
FEA_1
CompB
Component Model
Requirements spec.
Tool support
Product configuration.

Toolchains

- Tools were primitive and not well adopted – strong requirements for: feature modelling; architecture documentation; interface documentation, checks and management; linkage between features and implementation; feature-based product derivation.
- Strong drive to standardise to develop tools and ease interchange between Bosch as a supplier and purchasers of Bosch products

Maturing Toolchains



Key Elements

- Management commitment to: build up product line knowledge; establishing a product line business unit to drive product line engineering; commitment to rollout.
- Process excellence: in parallel to adoption of product line Bosch to achieve Capability Maturity Model Integration level 3 (i.e defined process characterised for the organisation and is proactive)