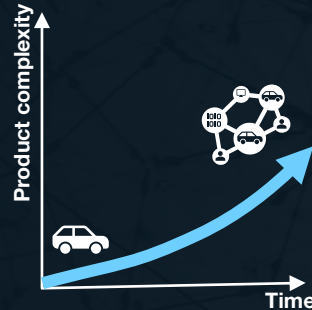


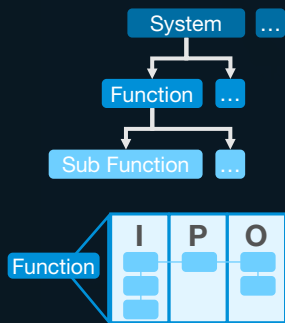
# Effect chain modeling as a prerequisite to meet the increasing product requirements and complexity.

## WHY is there a need for effect chain modeling?

In the past, products were primarily mechanical and component-oriented. Influences such as autonomous driving, connectivity and regulatory requirements lead to an increase in product complexity and completely new architectural approaches. To develop new system architectures, it is essential to consider end-to-end effect chain modeling from the very beginning. By doing so a better understanding of interrelationships between systems is obtained. Furthermore, costs of change and increased failure rates are visible and counter measures enabled at an early stage of product development.



## WHAT is effect chain modeling?

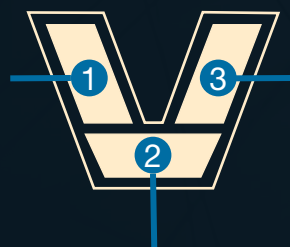


In the context of system architecture development, effect chain modeling is used to describe cause-effect relationships between systems. Using the IPO (Input, Processing, Output) principle, the interaction between functions and/or sub-functions of different systems is described. Effect chain modelling can be done with graphical development environments such as Rational Rhapsody or MagicDraw.

## WHERE are effect chains applied in Systems Engineering?

Along the Systems Engineering V-model effect chains are used for various purposes. The three main areas for the application of effect chains are shown in the following figure.

- Development of system architectures
- Elicitation of system and component requirements



- Verification of system requirements and granting of system release
- Analysis and evaluation e.g. of software updates to ensure SUMS compliance

- Transparency regarding dependencies and changes along the system development process

## HOW to successfully model effect chains?

Successful implementation and application of effect chain modelling goes beyond providing a graphical development environment. Management commitment, user friendly tools and convincing experts for the added value to contribute their system knowhow into the collaboration are further considerations.

To sustainably establish effect chain modelling it is key to consider the following four building blocks:

1. Methodology & Tools
  2. System & Content
  3. Roles & Responsibility
  4. Boundary conditions
- Enable the organization in the application of Systems Engineering processes and methods to ensure system thinking.
  - Define and communicate a coordinated modeling methodology.
  - Establish close interaction between modelers and methodology developers with regular feedback loops.
  - Enable responsible roles for operational effect chain modeling including hands-on tool support.
  - Strengthen generic product structure ("architecture backbone") for end-to-end effect chain modelling.
  - Provide preconfigured IT infrastructure and user friendly modeling environment.
  - Ensure commitment, especially at management level, and communicate the need for x-functional collaboration.
  - Collect contribution of respective system knowhow from relevant experts.