

# Qualitative System Dynamics Cycle Network of the Innovation Process of Product-Service Systems

by

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# Overview

- Synopsis
- Motivation
- Methodology
- Result
- Discussion

# Synopsis

A cycle based network, modeling the innovation process of Product-Service Systems, was created, based on the results of the collaborative research centre SFB 768, of the Technische Universität München and the Ludwig Maximilians Universität.

The network should

- help to analyze and anticipate the behavior of the innovation process,
- visualize interfaces between internal and external dependencies and
- serve as a basis for further research and the implementation of a System Dynamics model.

## Motivation

The need for such a model originates in the

- increasing number of dependencies, for example due to interdisciplinarity (mechanical, E/E, software)
- Shorter development times, due to higher competition and
- potential for optimizing innovation processes.

# Methodology

- Collection of relevant cycles
- Collection of characteristics
- Identification of dependencies and interconnections between these cycles
- Clustering of the cycles
- Creation of Cycle Information Sheets
- Development of the cycle network

## Collection of cycles

The collection of cycles within the research collaboration, in workshops lead to a pool of 30 Cycles and over 50 interconnections, between them.

Examples for these cycles are

- the development cycle,
- the engineering change cycle,
- the manufacturing resource cycle,
- the manufacturing change cycle,
- the requirements cycle,
- etc.







## Definition of interconnections

Possible relations between the cycles and clusters can be:

- triggers, which cause actions,
- catalysts, accelerating the speed of processes,
- delayers, decreasing the speed of processes,
- transportation of units/information
- conditional links
- etc.

# Relations

In further interviews and expert discussions the characteristics of the cycles and their relations were identified.

Has influence on:	DCY	ECC	MRC	MCC	RCY	...
Development cycle						
Engineering change cycle						
Manufacturing resource cycle						
Manufacturing change cycle						
Requirements cycle						
...						



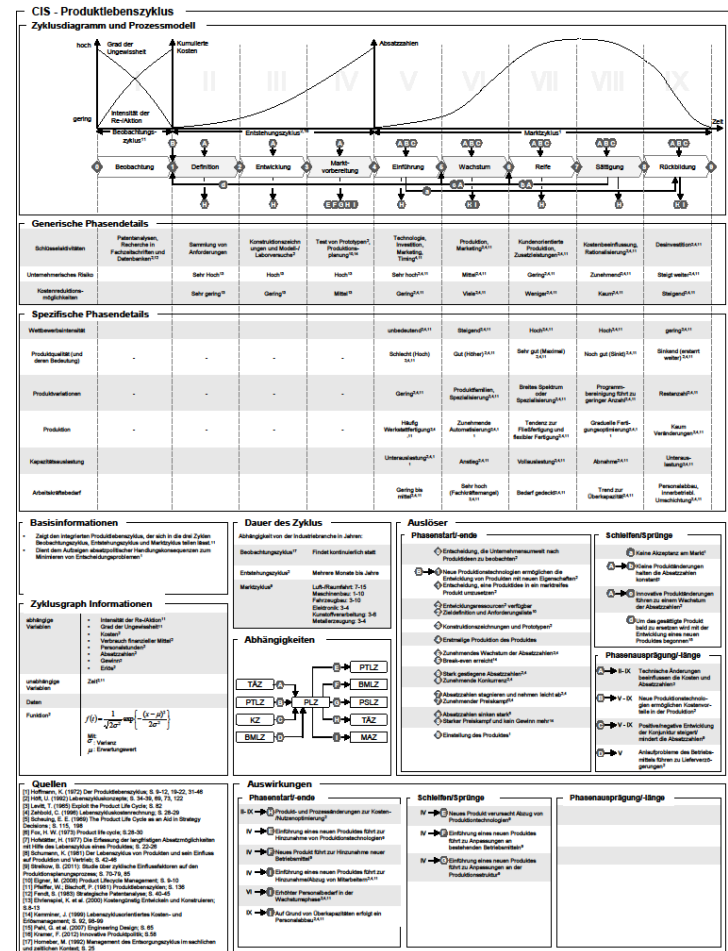
# Clustering

The Cycles were classified and clustered depending on the degree of interconnection. Key cycles were identified, each representing one of these 8 clusters.

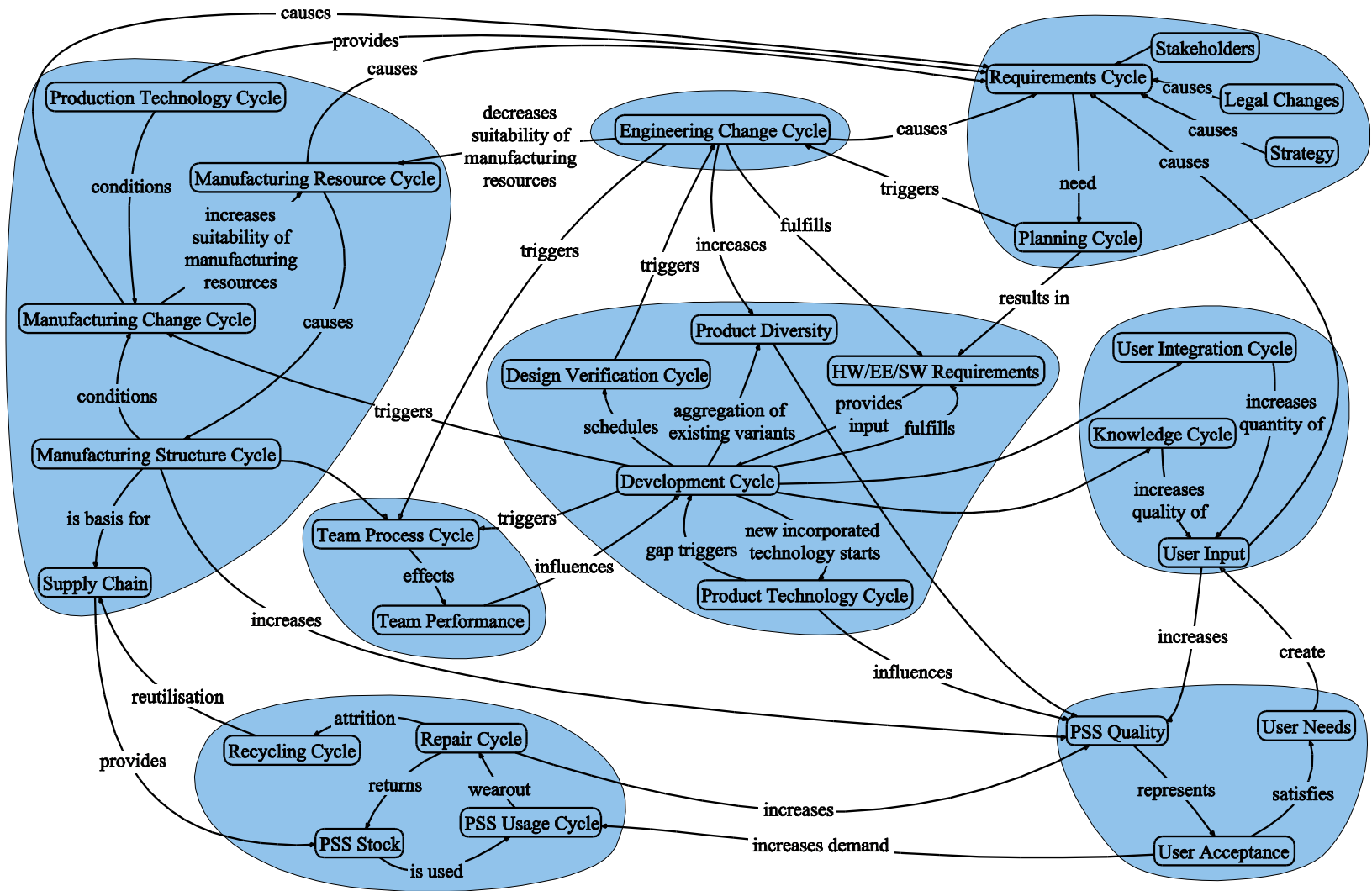
1. Requirements and Planning
2. Development
3. Engineering Changes
4. Team Processes
5. Manufacturing Structure
6. PSS Usage
7. User Acceptance
8. User Integration

# Cycle Information Sheets

- for key cycles
- developed by Koch et al.
- give a comprehensive overview over their characteristics



# Qualitative System Dynamics cycle network

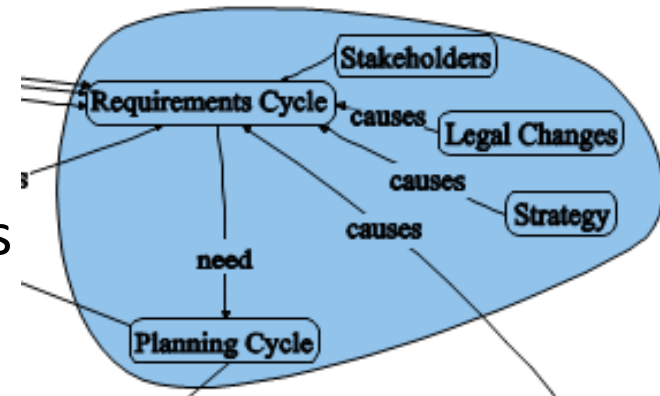
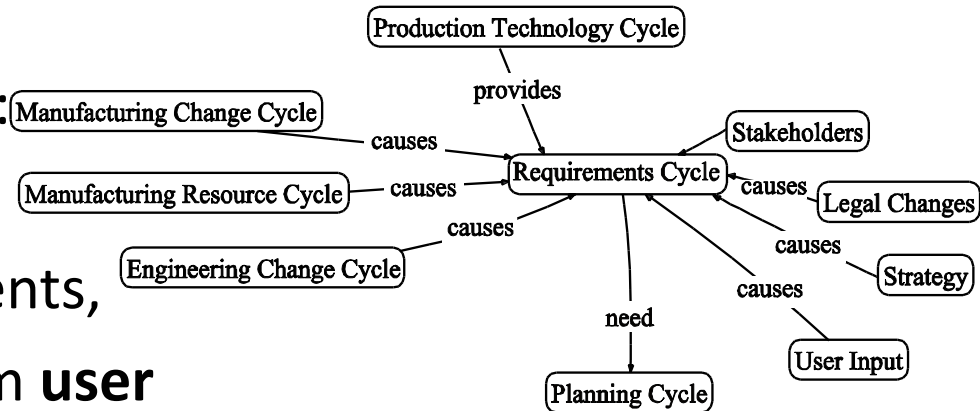


# Requirements and planning

The requirement cycle manages:

- **stakeholder** requirements,
- **legal and strategic** requirements,
- requirements originating from **user inputs** or
- requirements caused by **manufacturing and engineering changes**.

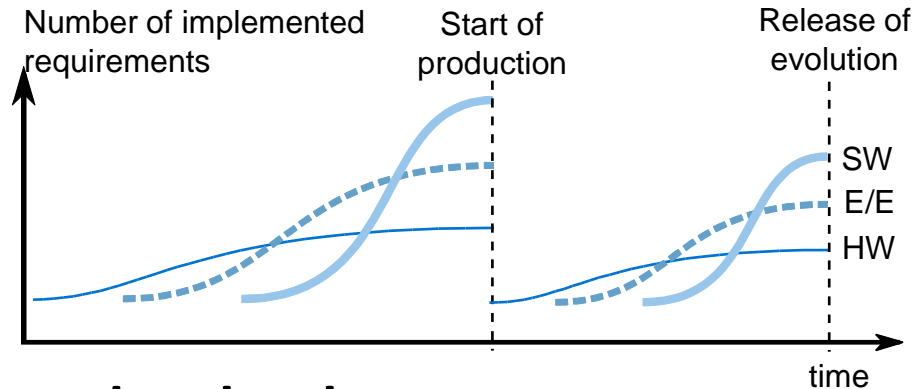
The planning cycle coordinates and provides this input to the development process.



# Development

2. The development cluster,

- **specifies the requirements,**
- **develops the PSS,**
- **verifies the design and**
- **controls the product diversity and technology.**



highly connected to

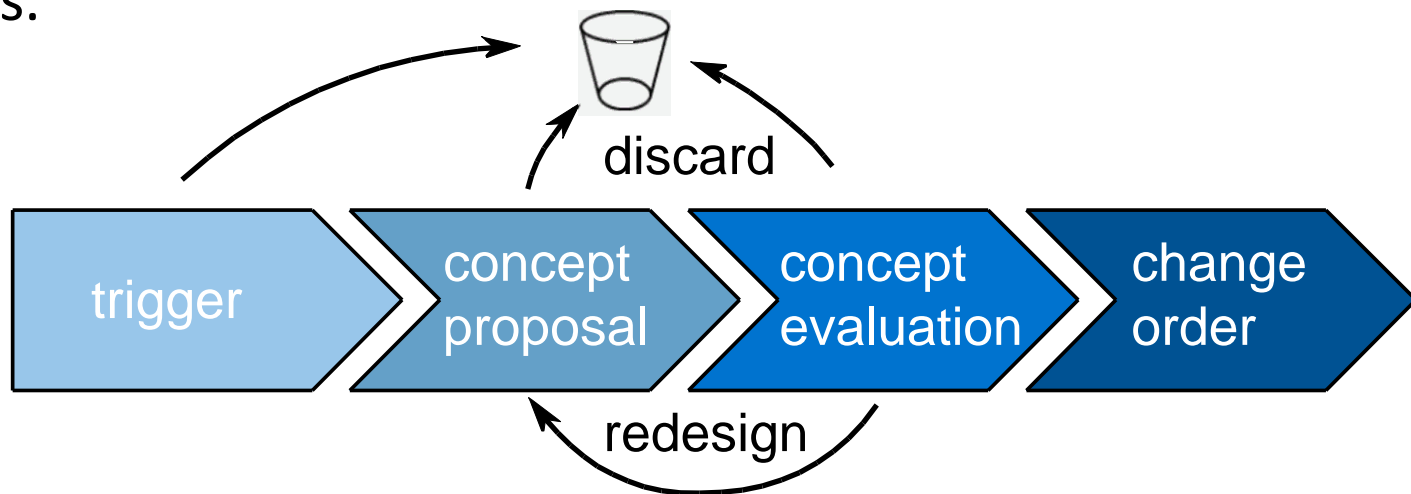
- the engineering change cycle,
- the requirements cycle,
- product/production technology, etc.

The development cycle includes different phases, like HW, EE and SW development, and covers profound and evolutionary advancements.

# Engineering change

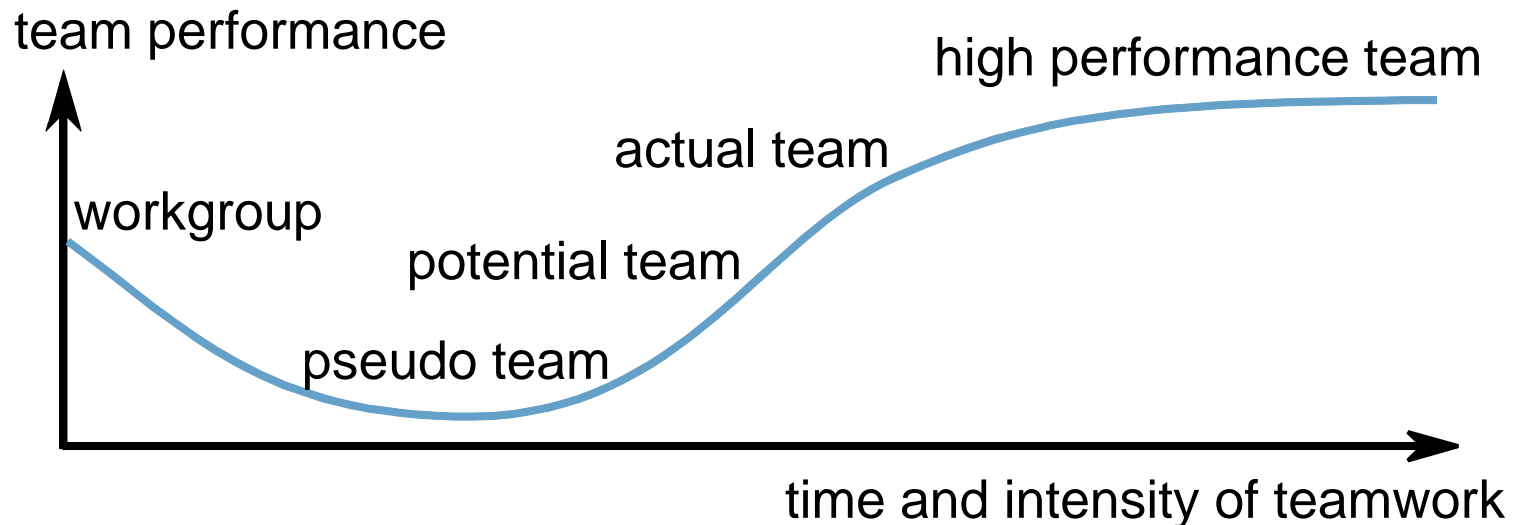
3. The engineering change cycle **implements measures, to close deviations or to react on requirement changes.**

As changes may also create new requirements, the cycle is linked to the requirements cycle. Changes also affect the suitability of manufacturing resources, or the productivity of teams.



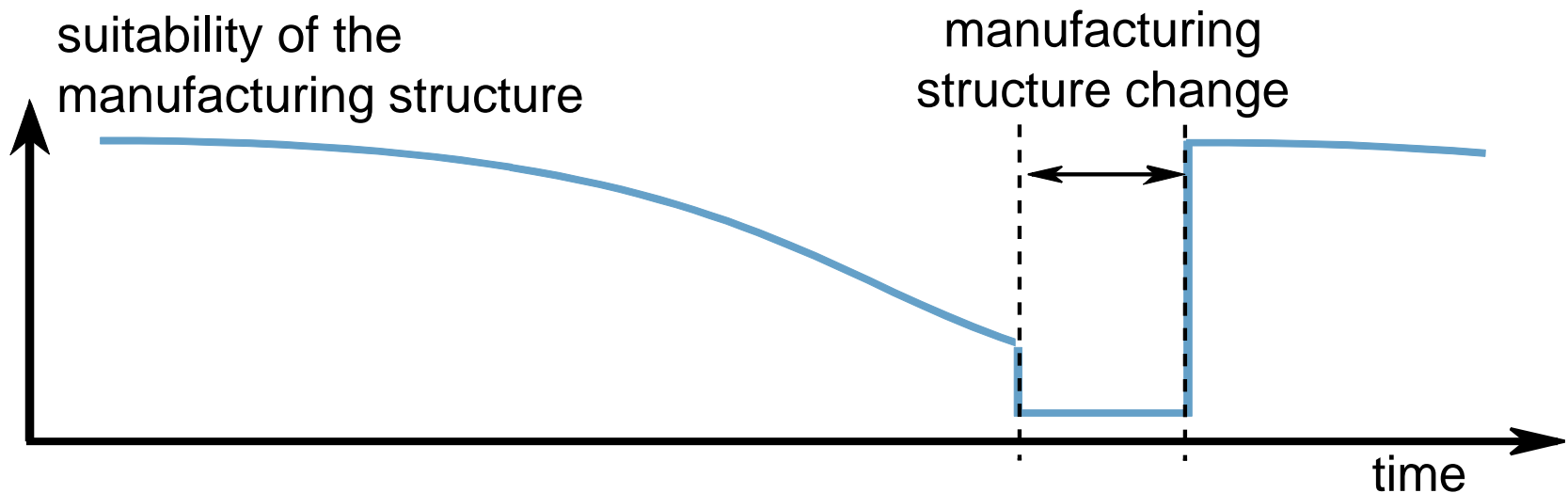
## Team processes

4. The team processes cluster **represents the productivity of a team**, depending on the phase of their collaboration. This cluster is connected to the phase of the development cycle, as new teams may be created, or to changes in the product or manufacturing structure.



# Manufacturing structure

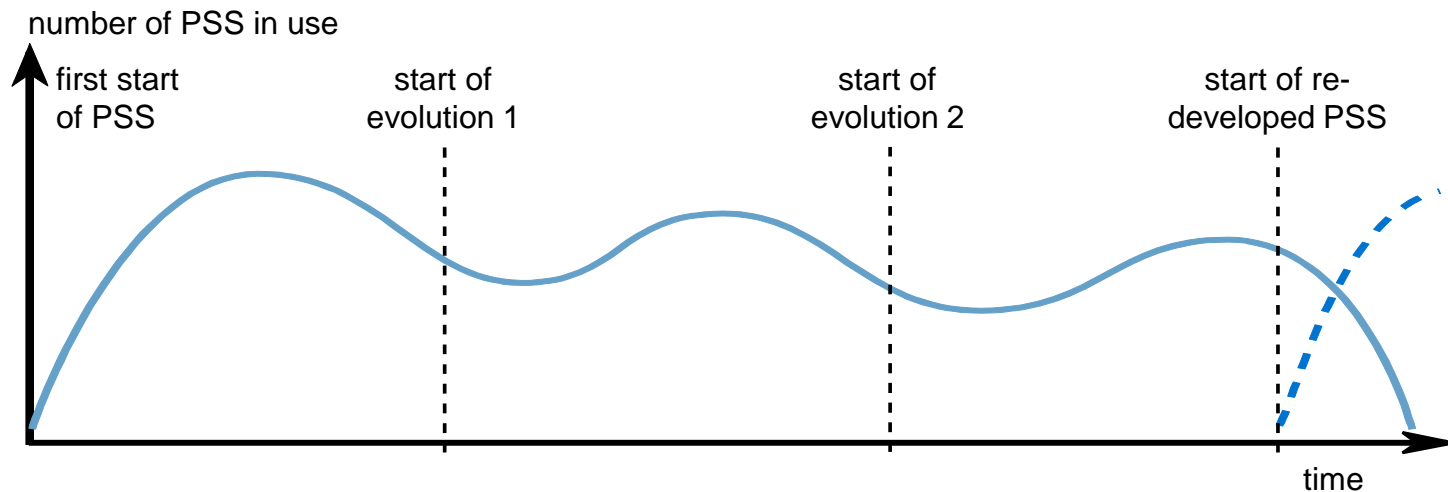
5. The manufacturing structure cluster **represents cycles, concerning manufacturing resources, production technology and manufacturing changes**. This cluster is also connected to i.e. development, usage, engineering changes and requirements.





# Usage

6. The PSS usage cluster includes **cycles concerning stock, usage, repair and recycling of the PSS**. It mainly depends on the user acceptance and the availability of the PSS.

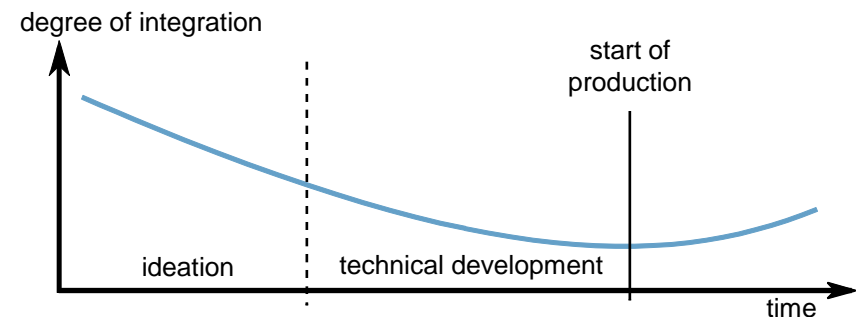
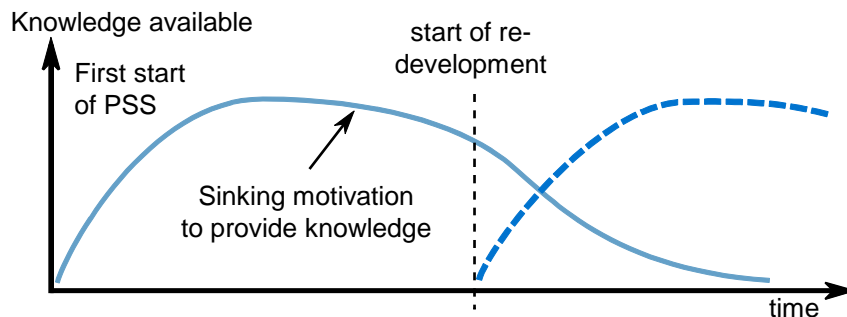


7. As a result of the user needs and the quality of the PSS, the user acceptance cycle describes the likeliness of users, to use the PSS.

# User integration

8. User integration depends **on the available knowledge of the users and the degree of integration, demanded by the development department.**

This cluster is highly connected to the development, the user acceptance and the requirements cluster.



# Discussion & Outlook

- Basis for further research
- Examination of interconnections and impact analysis
- Visualization of reinforcing and balancing loops
- Possible quantitative realization, for simulations and validation

