

New PSS Design Method of a pneumatic energy system

by

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Presentation Plan

- Integrated design of PSS
 - Challenges
 - Contextualization of the work
- Model-based design method overview
- Case illustration of the method:
 - Brief overview of the modelling technique
 - Discussing the models integration

Integrated design of PSS

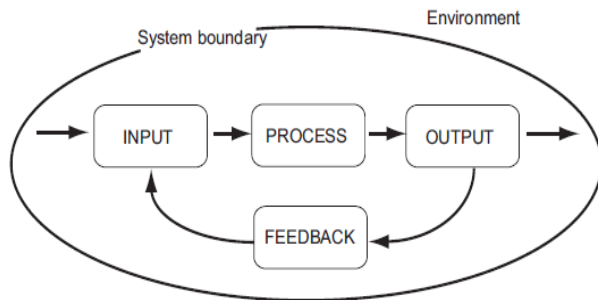
The overall design process for P/S integration well developed in the PSS literature*
 But still lacks of support in the **detailed design phase****.

Challenge of PSS detailed design : Integrating the sub-systems

- **Integrating the actors' practices**
- **Integrating current models**

Product engineering models

Hard system view

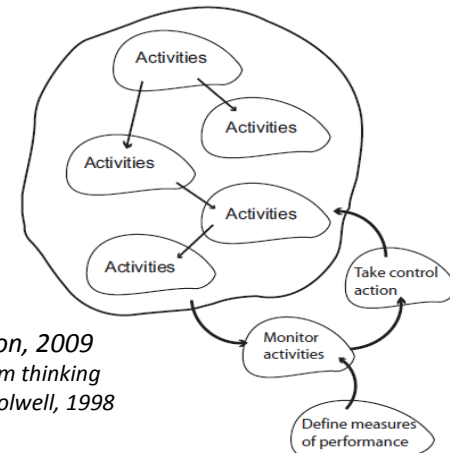


*Ericson and Larsson, 2009
 Adapted to systems theory
 Checkland and Scholes, 1999 ; von Bertalanffy, 1968*

⇒ **Black box model**

Service design models

Soft system view



*Ericson and Larsson, 2009
 Adapted to soft system thinking
 From Checkland and Holwell, 1998*

⇒ **Open box model (activity model)**

Integrated design of PSS

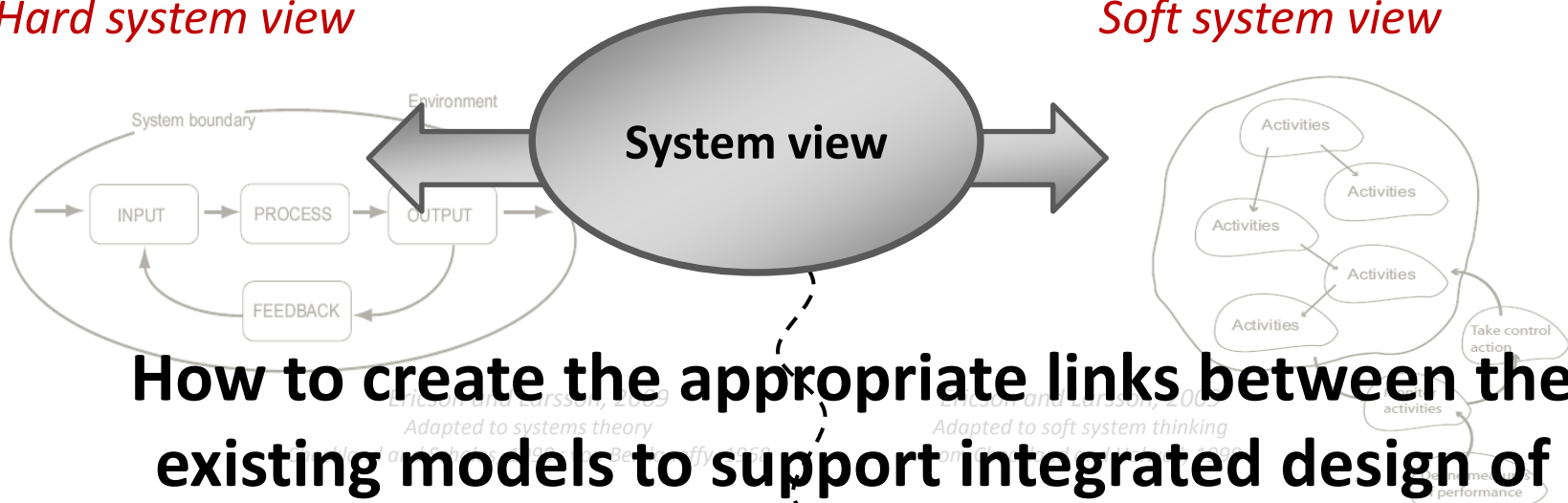
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Challenge of PSS detailed design : Integrating the sub-systems

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Product engineering models
Hard system view

Service design models
Soft system view

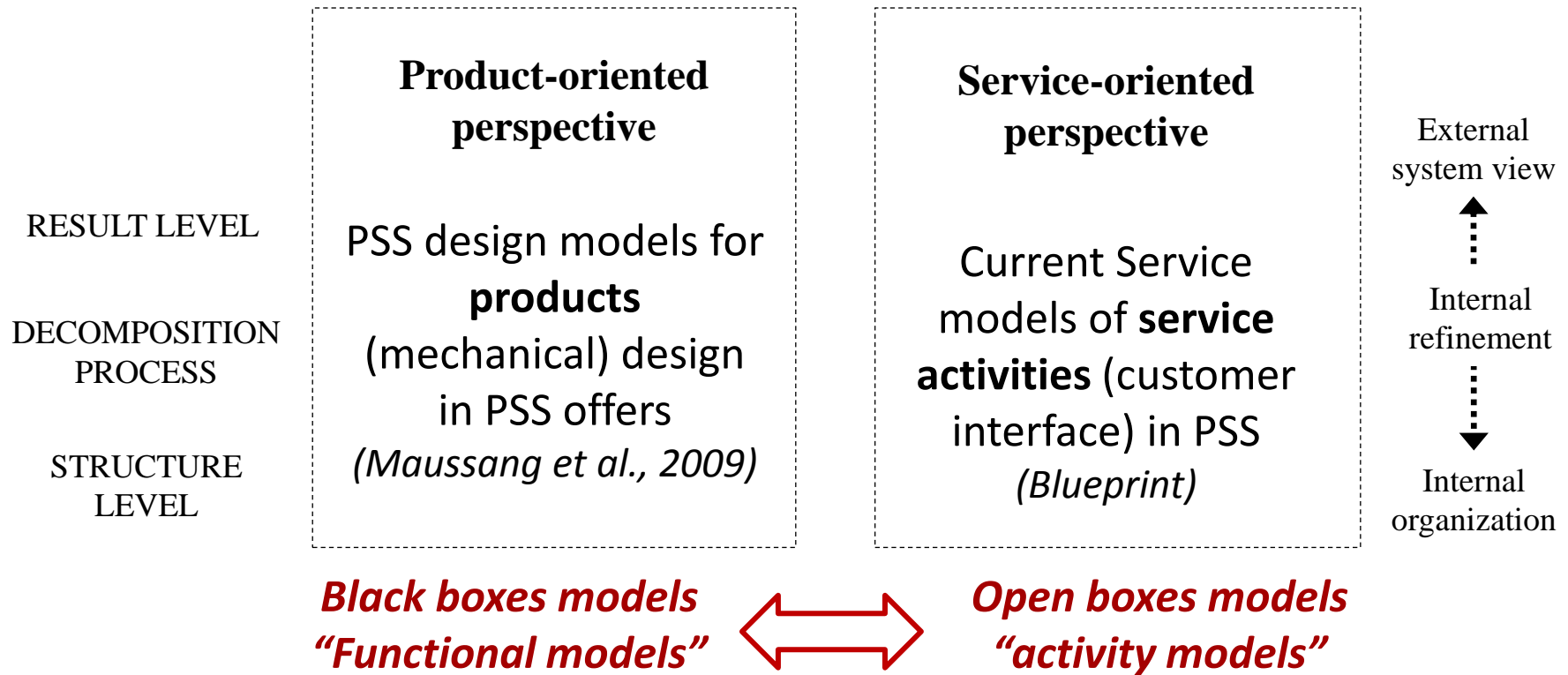


How to create the appropriate links between the existing models to support integrated design of product and services ?

⇒ Black box model product and services ?

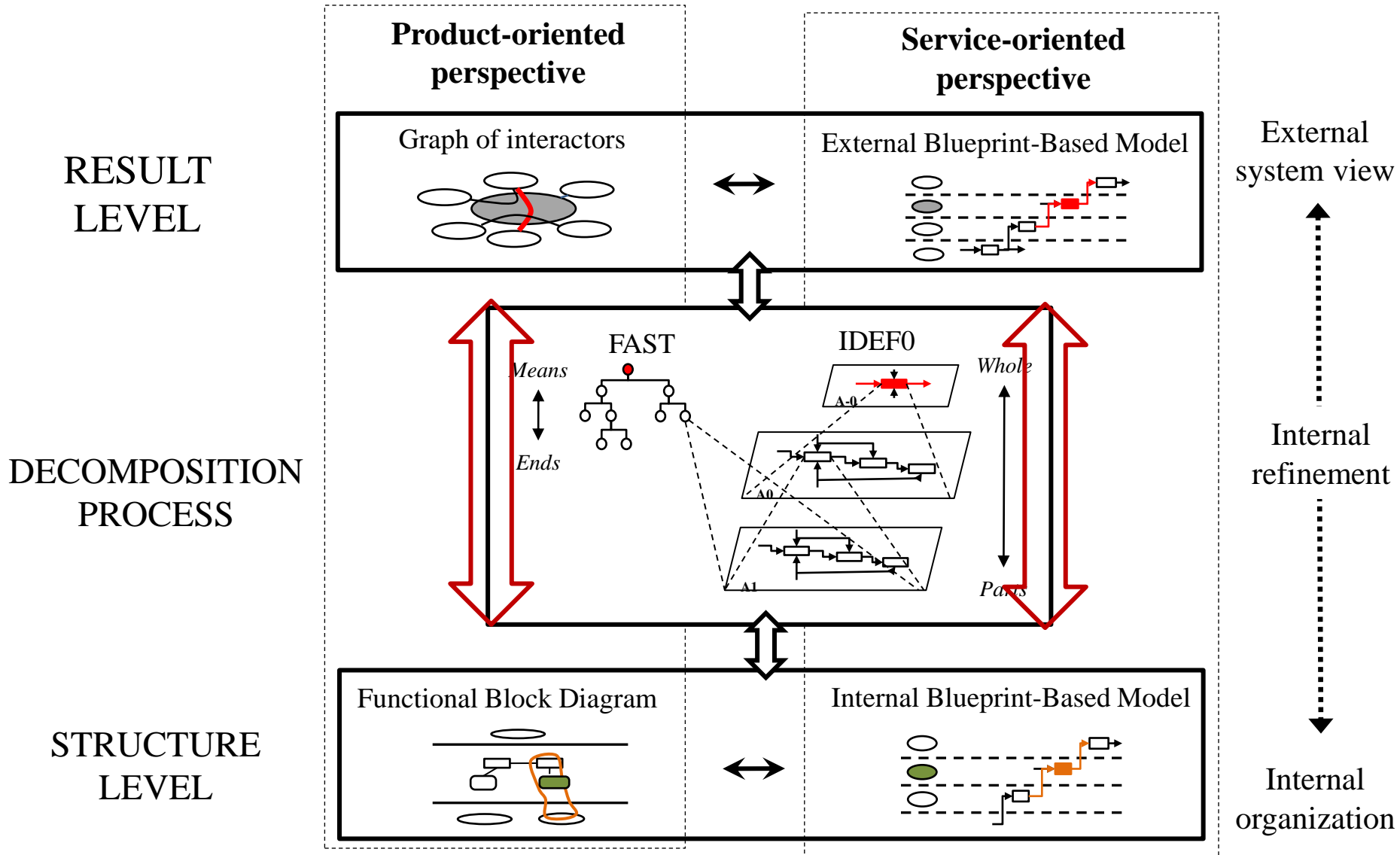
Model-based design framework

The research process: using the existing models in product and service design concurrently



- Links and complementarity of models
- Necessary enrichments of models for integration

Model-based design framework



Model-based design presentation

Aim of this presentation

⇒ Model-based design of a compressed air system

Provide an overview

- ✓ Presenting how the models are coupled in a design process
- ✓ Showing the links between the models
- ✓ Discussing the necessary enrichments of the models

⇒ Conceptualization and theoretical foundations of the method built not dealt in depth here – work in progress

Proposal of a design method: Framework

PSS: A set of

- physical **Products**
- **Service Units**: business units / “departments” of a business organization
 - Composed of Products
 - And human teams or staffs
- and their **Structure organization**

Introduction to the case

Design of a compressed air system

PSS provider

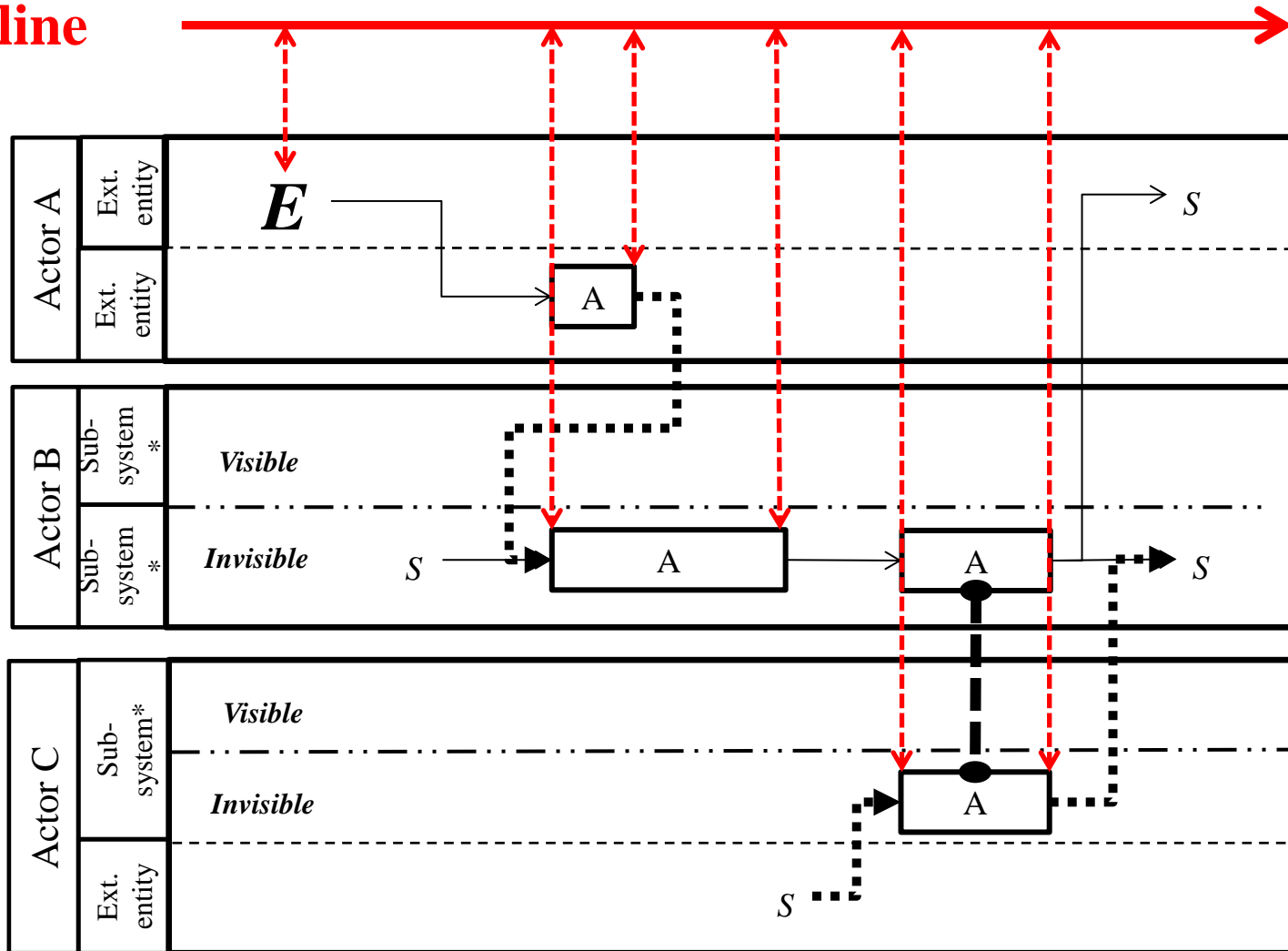
- Provides pneumatic energy - Expected level of air quantity, quality and **availability**
 - compressed air plant
 - technical services: maintenance, repair services and remote monitoring of the equipment

PSS customer

- Needs the pneumatic energy to **supply his production engines continuously (24/7)**

Service-oriented perspective: The Blueprint-based model

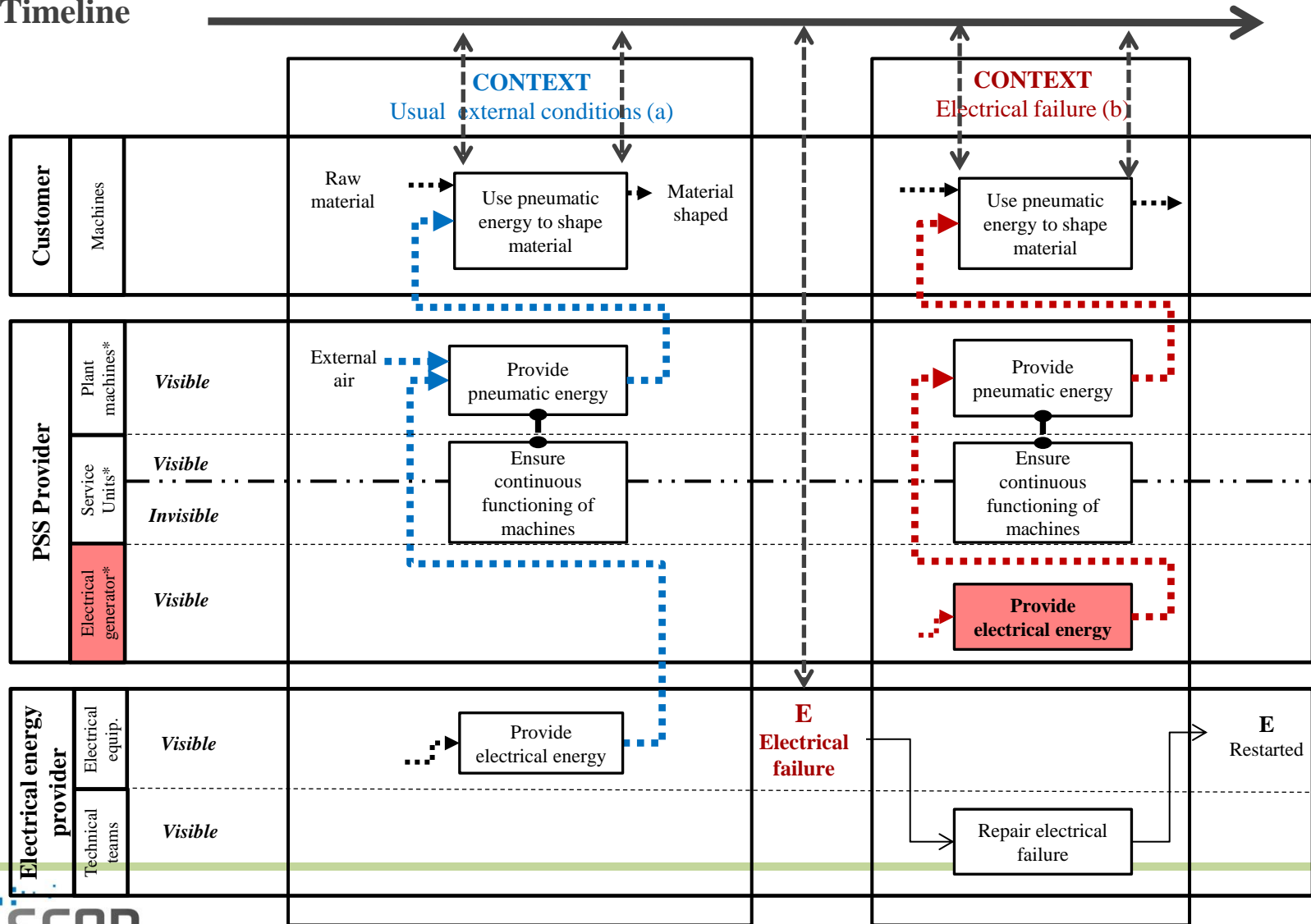
Timeline



Design of a compressed air system: Result level

Service-oriented view: The External Blueprint-Based Model (BBM) – The “open box”

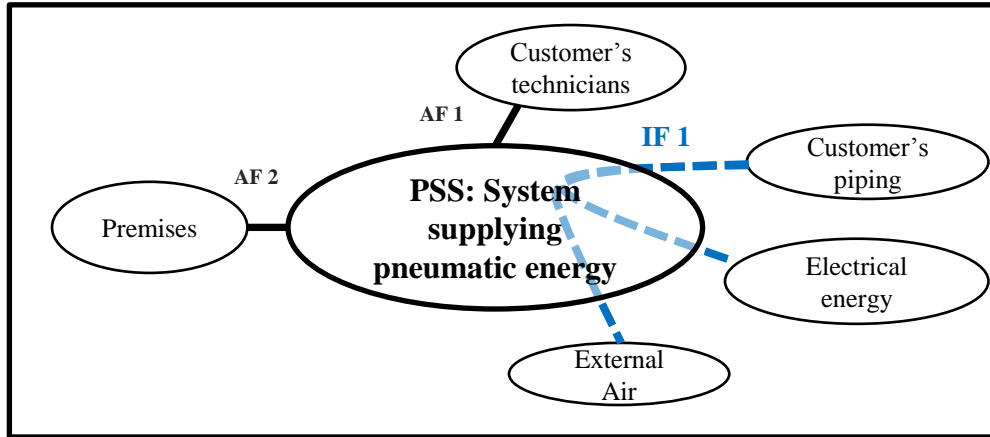
Timeline



Design of a compressed air system: Result level

Product-oriented view: Graph of interactors – The “black box”

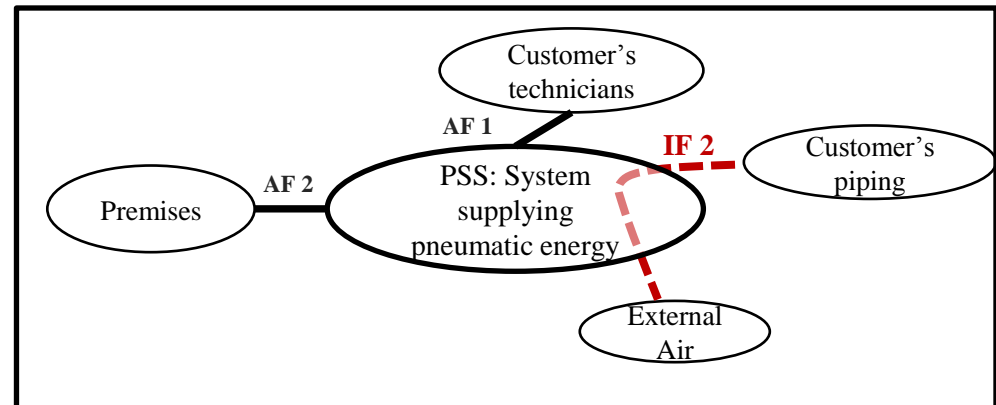
EXTERNAL CONTEXT: Usual external conditions (Ca)



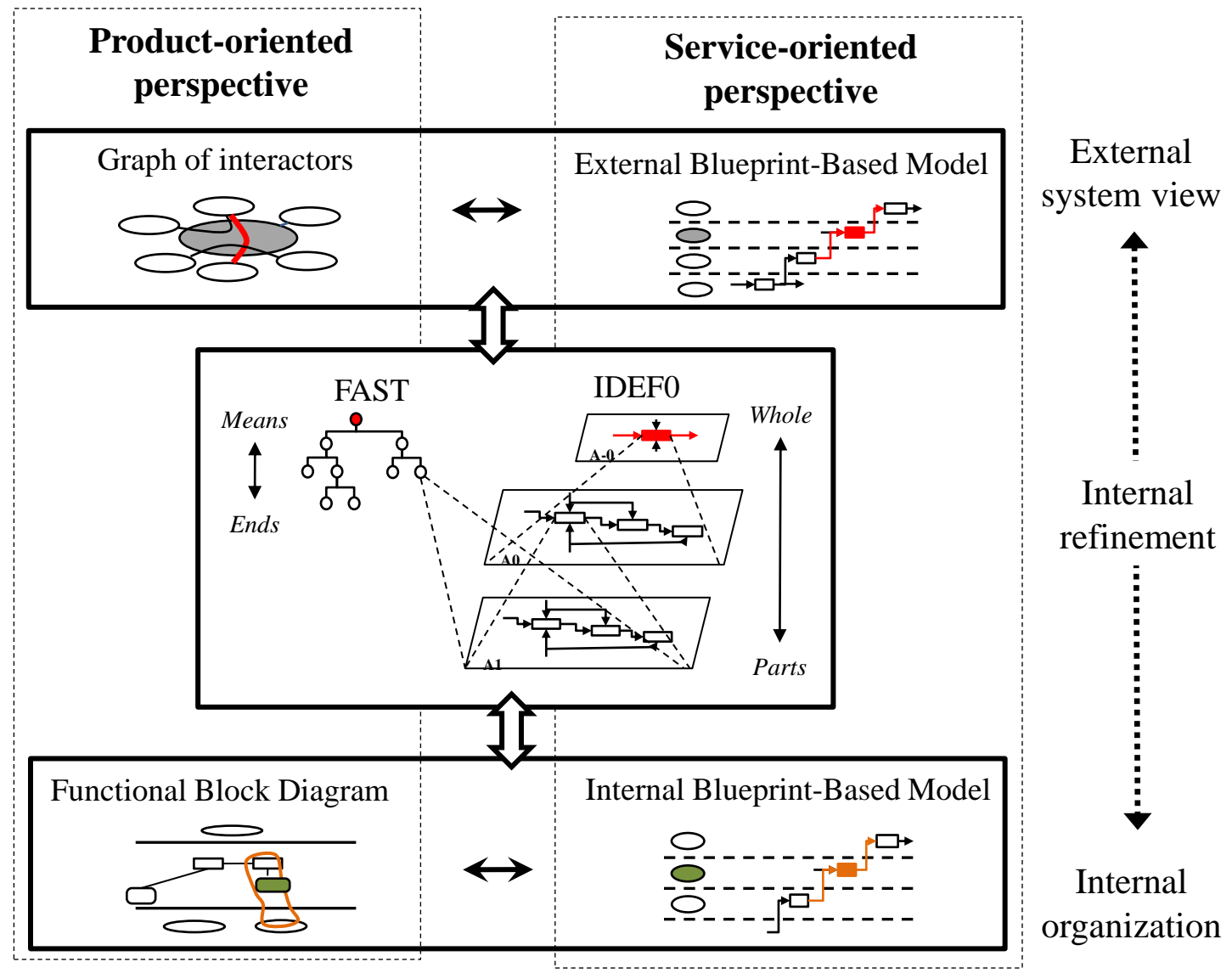
- **IF1: Use external air and electrical energy to continuously supply the customer's pipes with pneumatic energy**
- *AF1: Ensure comfort and safety for the customer's technicians*
- *AF2: Be adapted to the premises*

EXTERNAL CONTEXT: Electrical failure (Cb)

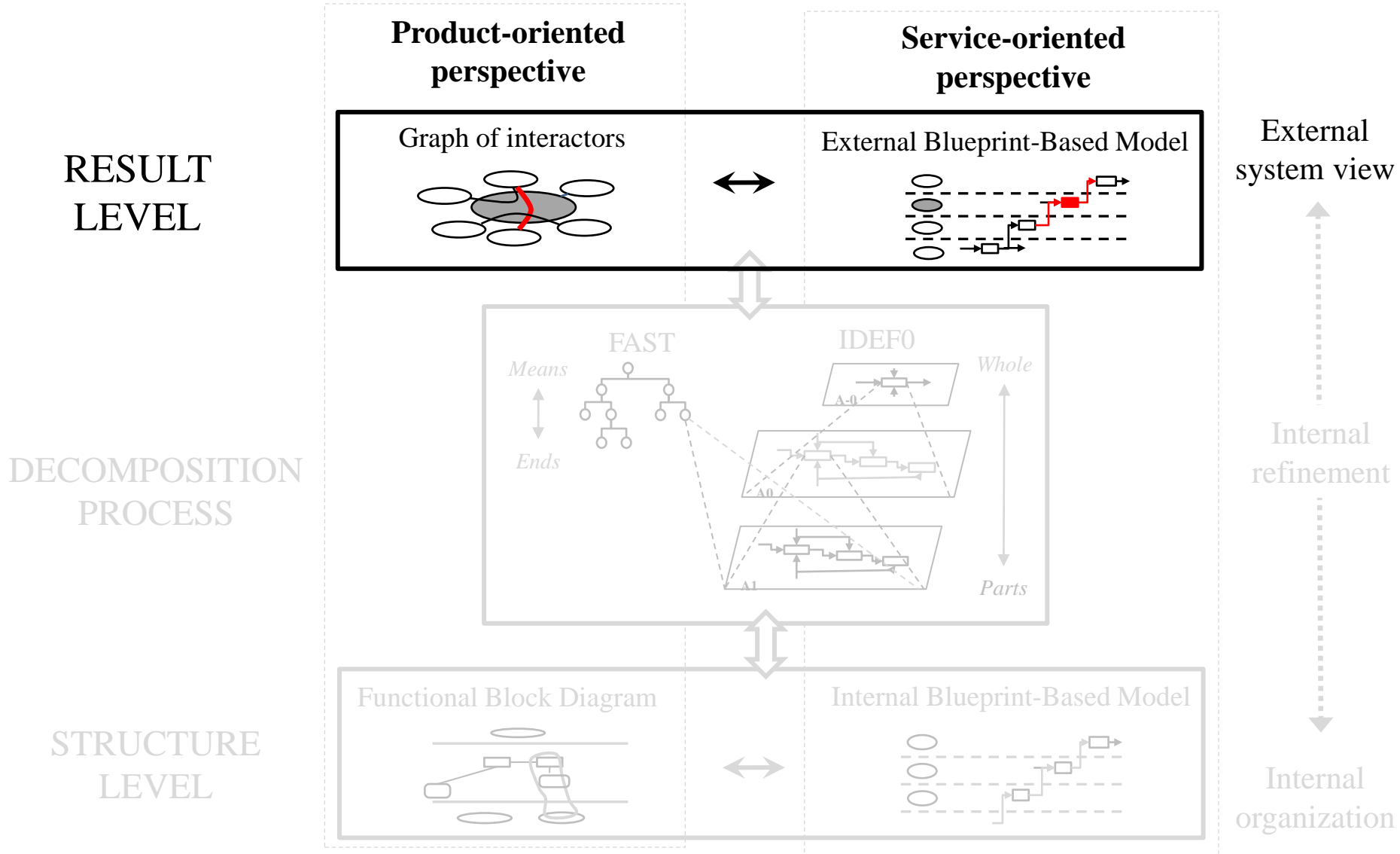
- **IF2: Use external air to ensure the supply of the customer's pipes with pneumatic energy**



A model-based design method



A model-based design method

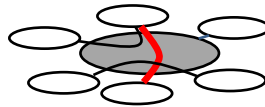


A model-based design method

RESULT
LEVEL

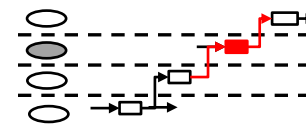
**Product-oriented
perspective**

Graph of interactors



**Service-oriented
perspective**

External Blueprint-Based Model



External
system view

Complementary perspectives

The “black box” model

Physical environment (spatial aspects)

✓ Influence on the result (constraints)

The “open box” model

Evolving environment (temporal aspects)

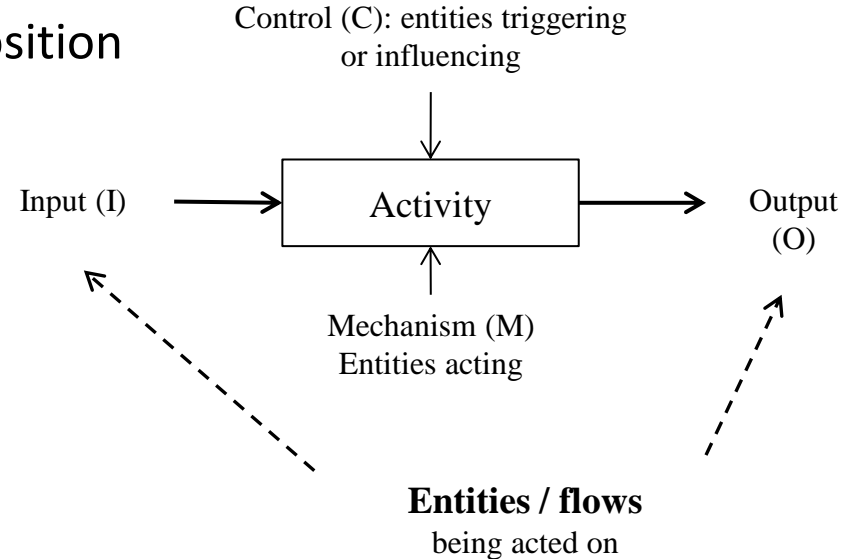
✓ Share of responsibilities in the evolving result

⇒ **Adaptations of existing models for complementarity**

Design of a compressed air system: Decomposition process

Two models:

- Functional Analysis System Technique (FAST): Why-How decomposition
- **IDEF0 model: What-how decomposition**
 - Adaptations on the activity models
 - Adaptations of the diagram decomposition
 - ❖ **Configurations** of diagrams



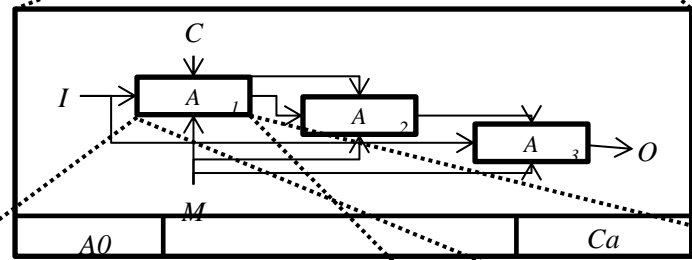
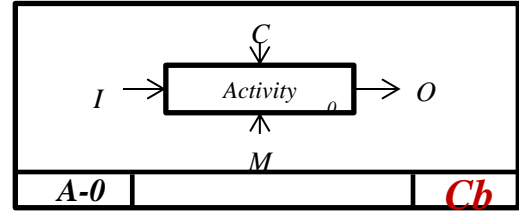
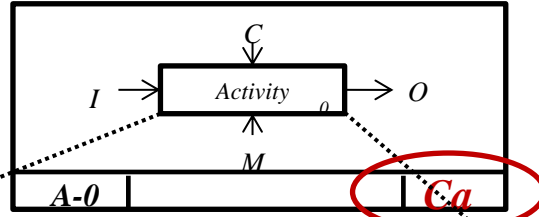
Design of a compressed air system: Decomposition process

IDEF0 Model Enrichments

Several configurations of diagrams for external functions

External context a

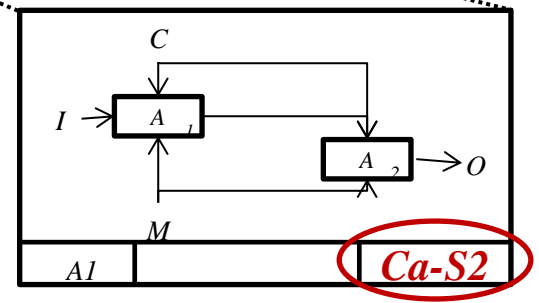
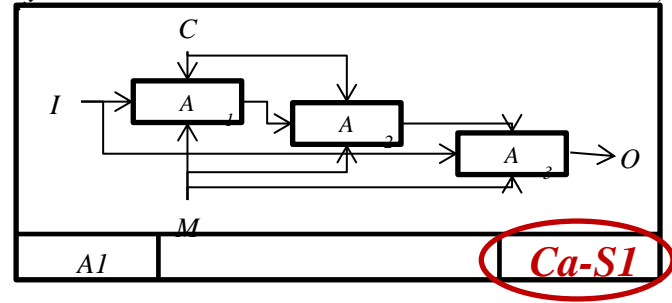
External context b



Internal State 1

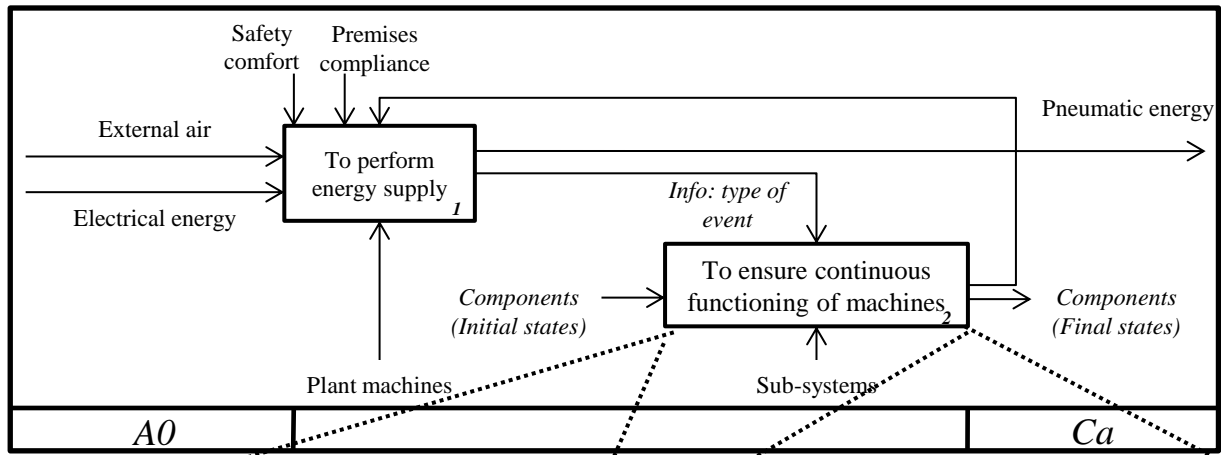
Internal State 2

Several configurations of diagrams for an activity



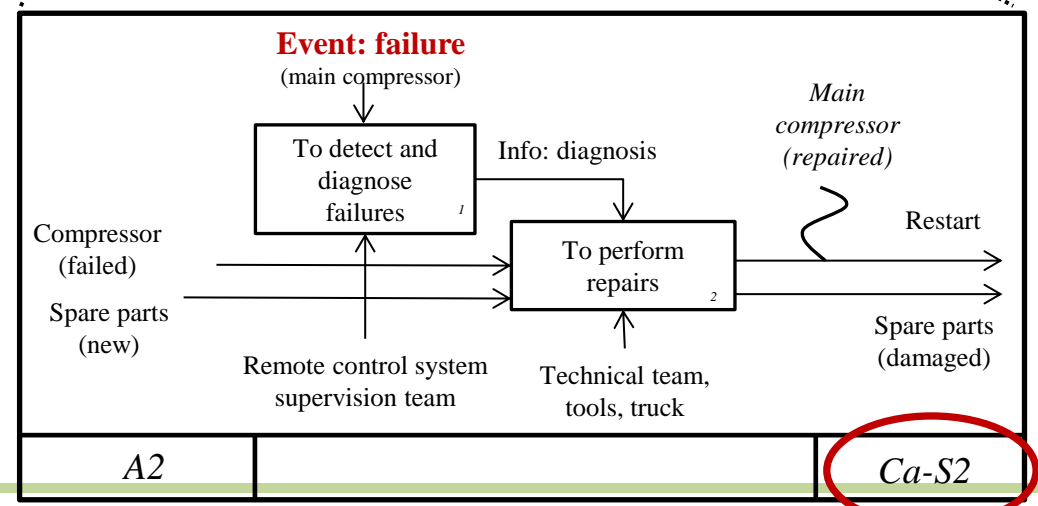
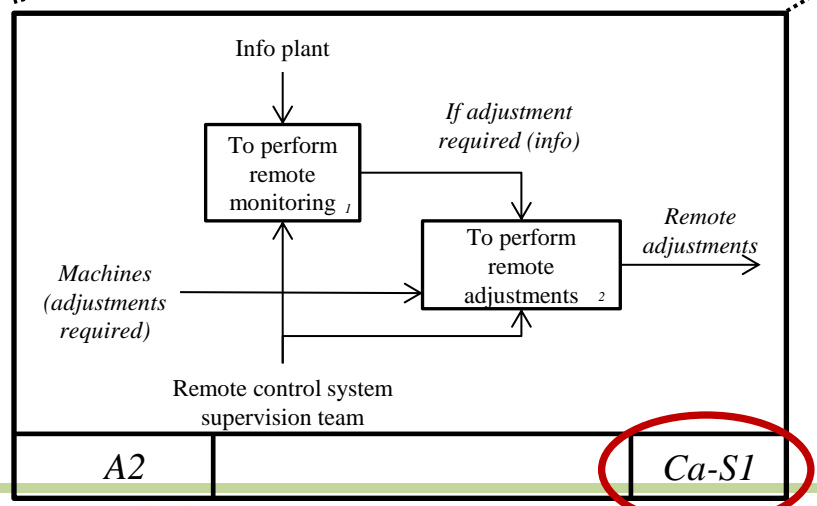
Design of a compressed air system: Decomposition process

Example

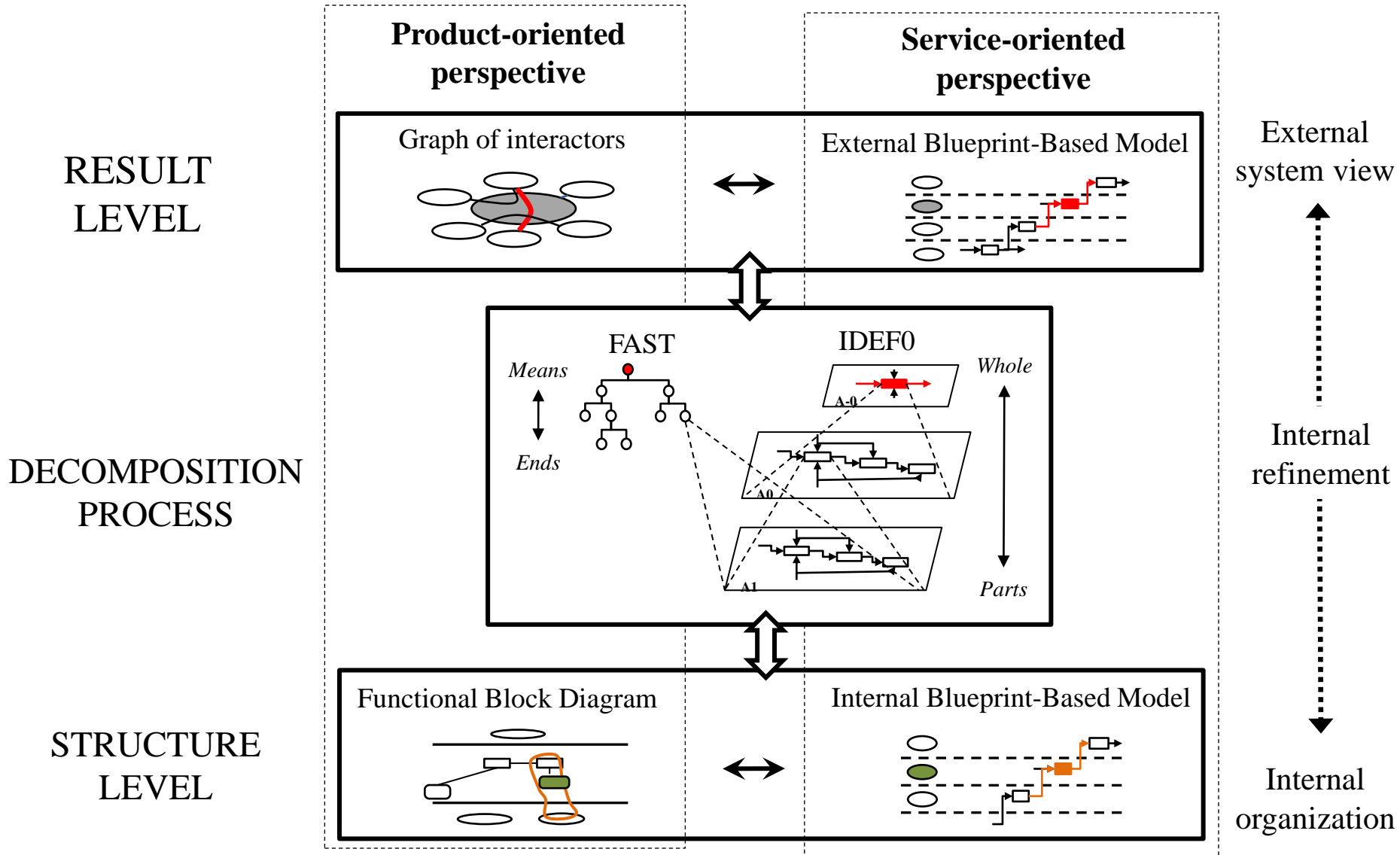


Internal State 1: Usual running conditions (S1)

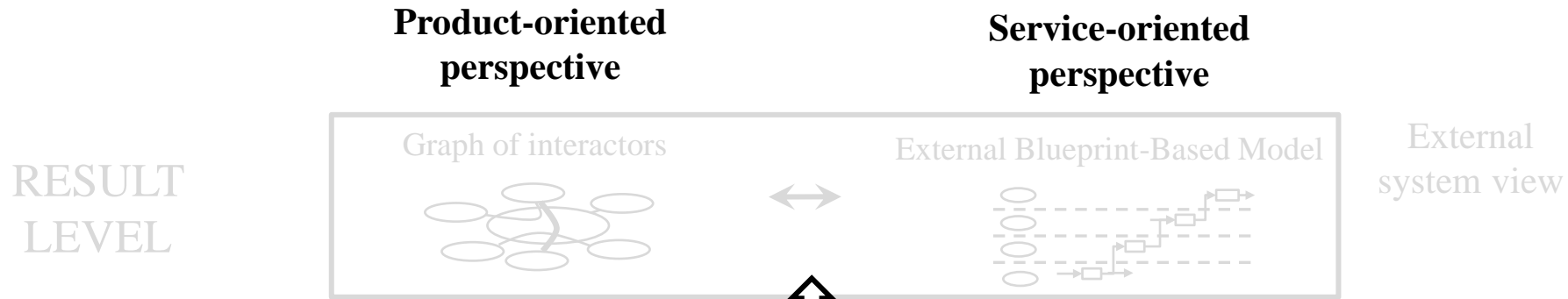
Internal State 2: Compressor failed (S2)



A model-based design method

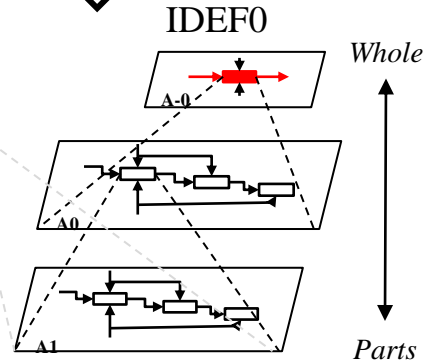
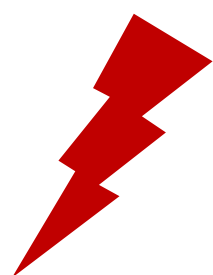


A model-based design method



IDEF0 model: Represent **ALL** the activities performed in the system

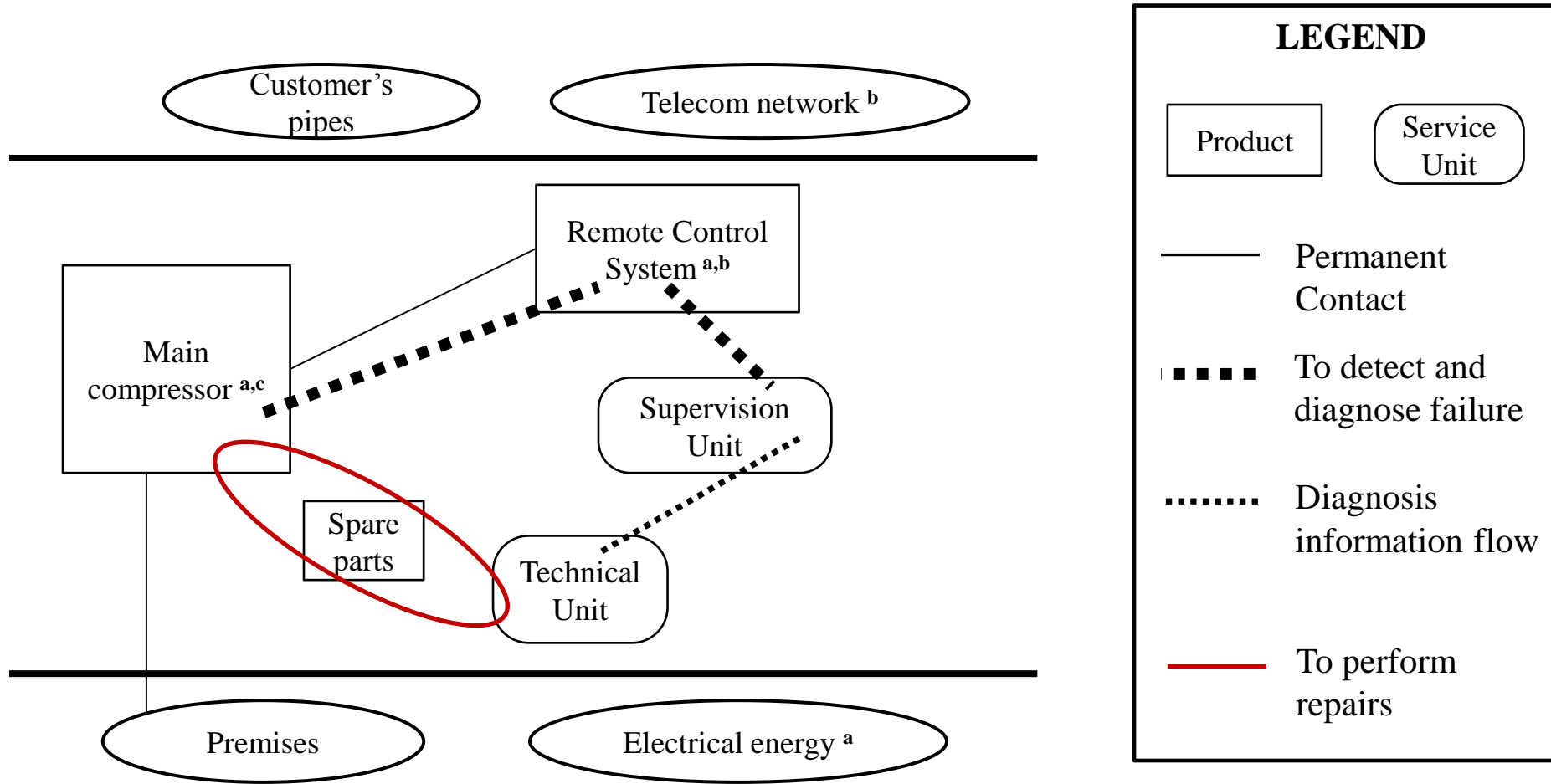
- **Activity model : *organizes transformations*** to achieve results
 - Through **logical links (ICOMs)**
 - Within a **hierarchy**



Different from **process models** of service (timeline)

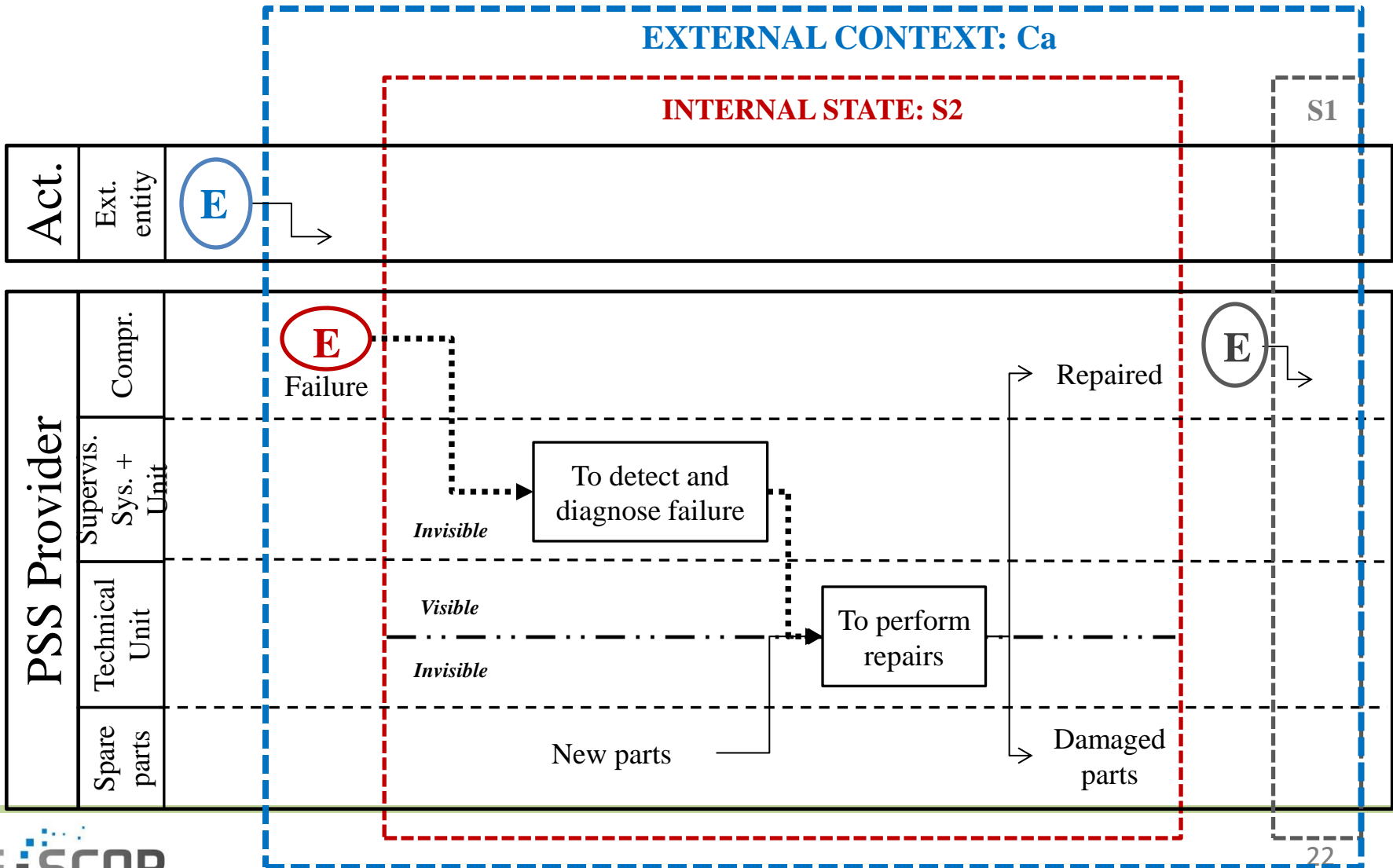
- **Structure model: *Organizes the components interactions***

Product perspective: Functional Block Diagram (FBD)

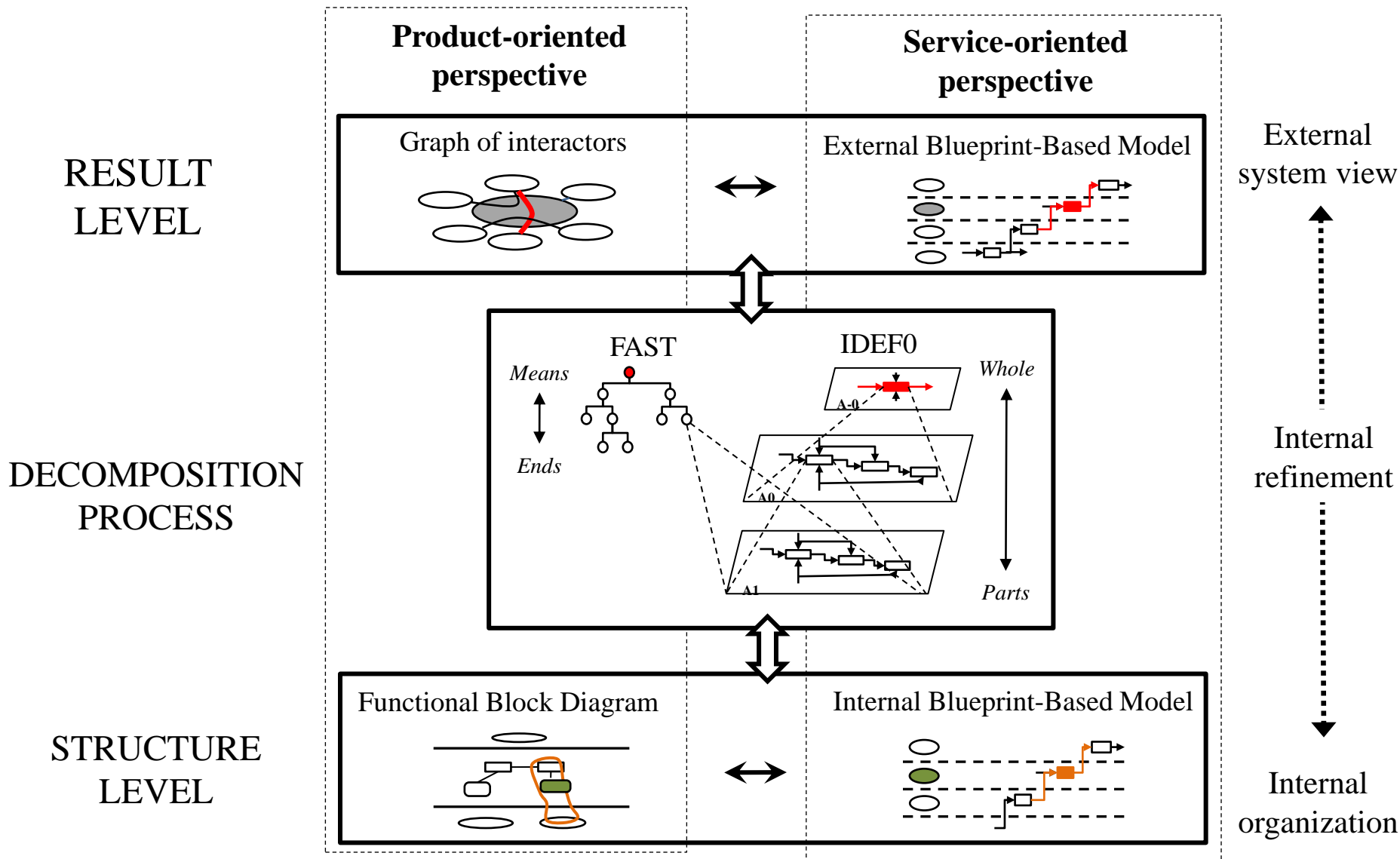


Design of a compressed air system: Structure level

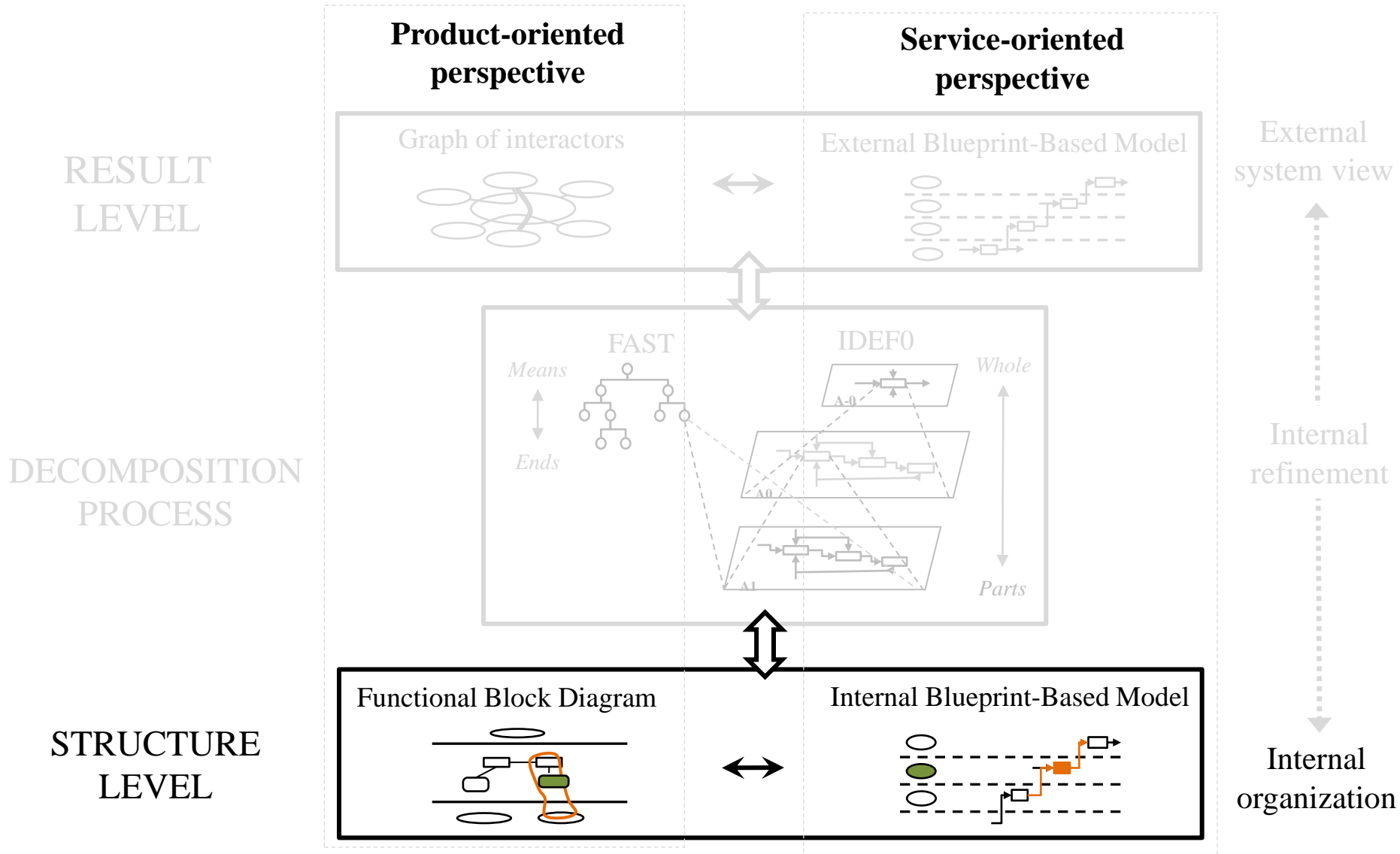
Service perspective: Internal Blueprint-Based Model (BBM)



A model-based design method



A model-based design method



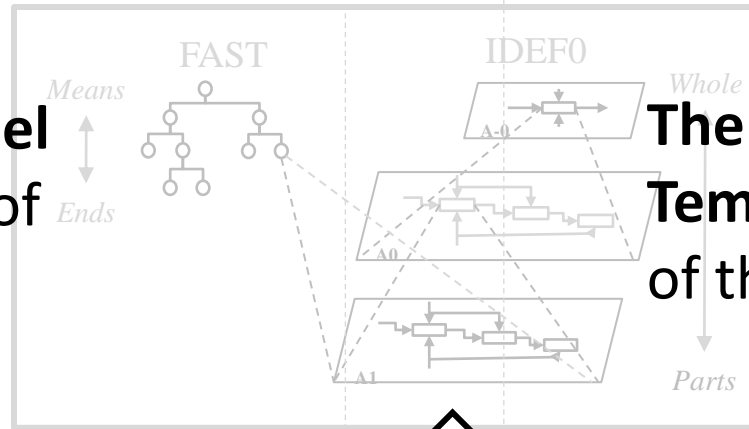
A model-based design method

Product-oriented perspective

Service-oriented perspective

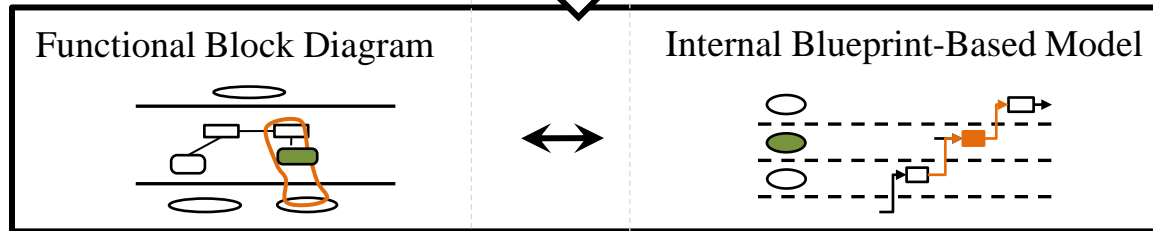
Complementary perspectives

The “black box” model
 Spatial organization of components



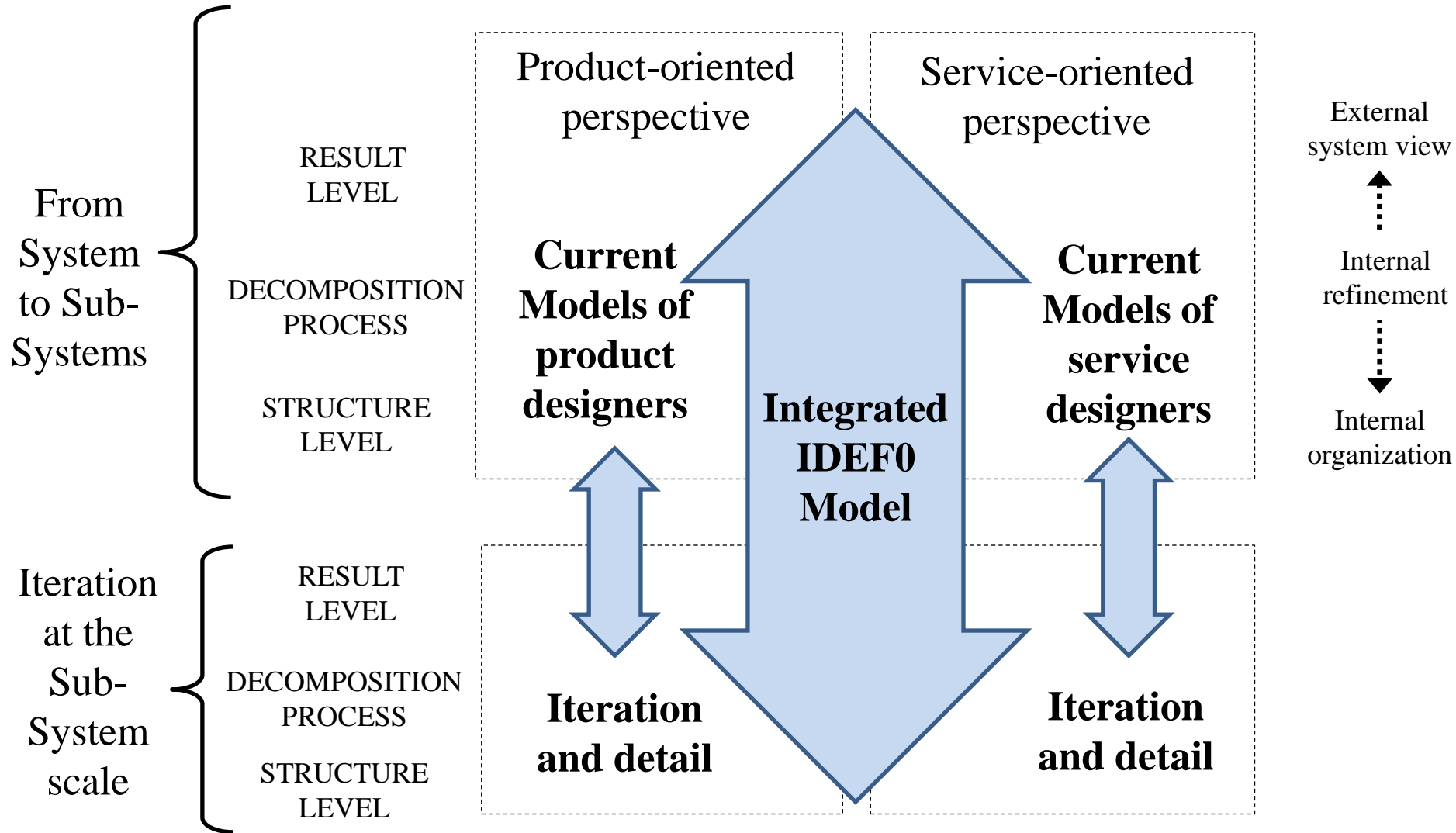
The “open box” model
 Temporal organization of the service process

STRUCTURE LEVEL



Internal organization

Model-based design framework

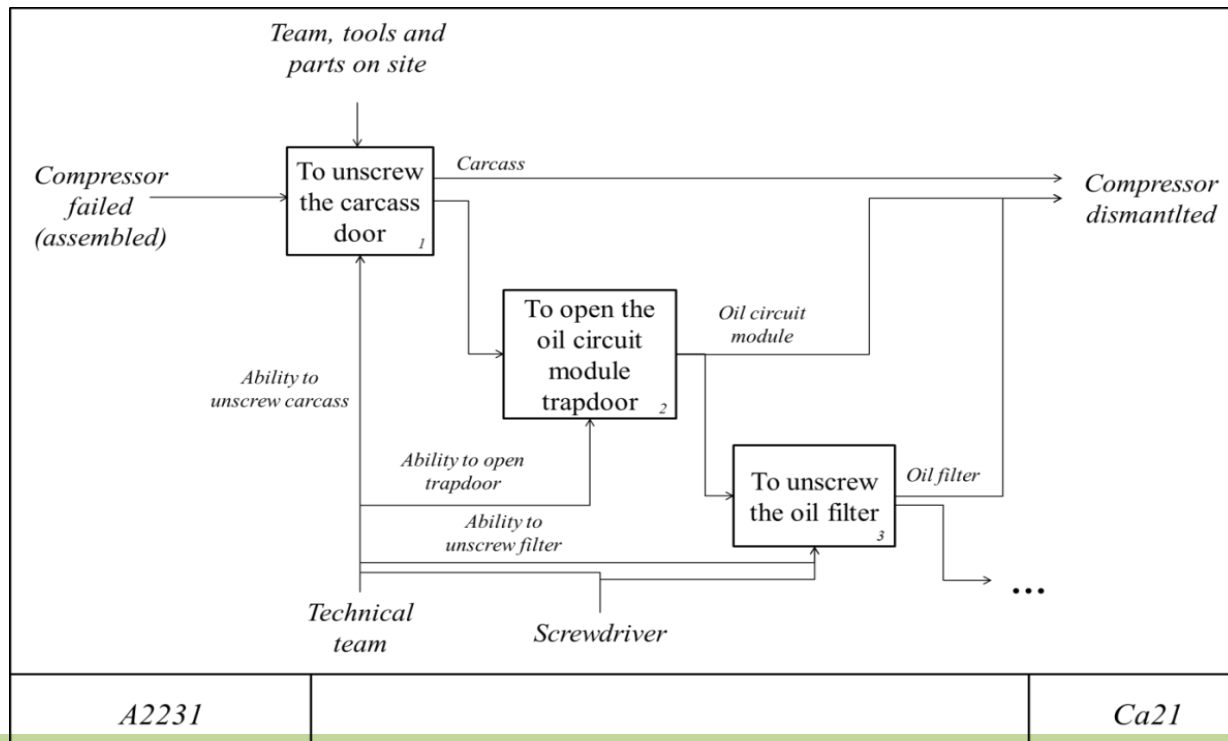


Design of a compressed air system: Requirements traceability

IDEFO:

Through the bundling property of ICOMs

Supporting **concurrent design until detailed levels** (product parts and human skills)



Conclusion and perspectives

- Development of the model-based design on the basis of the case application
- Enrichments of the current models from product and service design
- Theoretical basis building => in progress – journal publications

Part of a work of conceptualization for a full **system approach in PSS integrated design**

Including:

- Stakeholders' requirements integration
- Whole life cycle
 - Modelling the system life cycle
 - for evaluation of environmental impacts during design

Thanks for your attention