Starting Framework Proposal
**Objectives of the model**

- Classification of the present state of the art.
- Classification and positioning of the research needs;
- Framing of the methods and tools concerning evolution which are suitable for research and industry.
- First formalization of the new vision proposed by SPECIES.
- Individuation of promising research topics.
The interest of the SPECIES WG is focused on configuration problems, methods and tools.

The IDEF representation

Configuration constraints

Information
  data, knowledge

To Configure

Configuration goals

Evaluation tools

Methods

Configuration solution
(Product/Process/System)
In particular, the interest of the SPECIES WG is focused on those **configuration problems, methods and tools** considering **evolution and integration**.

- **Level of Integration**: the capability of a methodology to provide configuration solutions or guidelines taking into account product, process and production system aspects.

- **Level of Evolution**: the capability of a methodology to provide configuration solutions or guidelines considering the influence of possible changes in the future.
The objects that are mapped in the integration space are the methodologies used to configure the

- product
- process
- system

The mapping criterion for a configuration methodology is the relative importance that the knowledge on product, process and system have within the configuration process.
The logic we propose to follow for mapping the methods is that of *ternary diagrams*.

To position the point characterized by \((0.2, 0.2, 0.6)\):
Example 1:

**Production System**

Configuration output (red=product)

- Product
- Process

To Configure the Product

Conf. constr.  Conf. goals

Product Info

Evaluation tools

PRODUCT CONFIGURATION

Example 1:

THE FRAMEWORK

IDEF MODEL

INTEGRATION

EVOLUTION

MFG. STRATEGY

STATE OF THE ART
Example 1:

The mapping criterion is the relative importance of product/process/system information used in the configuration process

in this case (1,0,0)
EXAMPLE 2: Design for Assembly (DFA)

Configuration output
(red=product)
Example 2: Design for Assembly (DFA)

Configuration output (red=product)

The mapping criterion is the relative importance of product/process/system information used in the configuration process in this case (0.5,0.5,0)
DEF: A *configuration approach* is a procedure that allows to configure the product, the process and the production system.

Example:
- Product (0.8, 0.2, 0)
- Process (0.1, 0.9, 0)
- System (0.1, 0.3, 0.6)
The surface of the region is a metric for the level of integration of the approach.

The larger is the region the lower is the level of integration of the approach.
Integration Map - Sequential configuration

To Configure the Product
- Product Info
- Evaluation tools
Conf. constr. → Conf. goals

To Configure the Process
- Process Information
- Evaluation tools
Conf. constr. → Conf. goals

To Configure the System
- System Information
- Evaluation tools
Conf. constr. → Conf. goals

Outputs:
- (red=product)
- (blue=process)
- (green=system)

(0.25,0.25,0.5)
(1,0,0)  (0.25,0.75,0)
(0.25,0.25,0.5)
Integration Map - Design for assembly

The product configuration is based on information of product and process (0.5, 0.5, 0)

The process configuration is based on product configuration output (product data) (0.25, 0.75, 0)

The system configuration is based on product and process configuration output (pd,pc data) (0.25, 0.25, 0.5)
Integration metrics

Sequential configuration

Design for Assembly

The triangle shows that an approach which uses a DFA methodology to configure the products is more integrated than a pure sequential configuration approach.
The process configuration is based on information on product and process and system data (0.5, 0.25, 0.25)

The process configuration is based on information on process and product and system data (0.25, 0.5, 0.25)

The system configuration is based on information on system and product and process data (0.25, 0.25, 0.5)
Integration metrics

Sequential configuration

Design for Assembly

Iterative configuration
Summary of the mapping procedure

✓ The Output of the configuration can be mapped according to the relative importance of the information on product, process and system used by the configuration method.

✓ Pair-wise comparison can be used for determine weights

✓ The approaches are mapped positioning all the configuration objects in the integration space.

✓ A simple metric is used for determining the integration level.
In particular, the interest of the SPECIES WG is focused on those configuration problems, methods and tools considering evolution and integration.

- **Level of Integration**: the capability of a methodology to provide configuration solutions or guidelines taking into account product, process and production system aspects.

- **Level of Evolution**: the capability of a methodology to provide configuration solutions or guidelines considering the influence of possible changes in a time horizon.
The turbulence of the market and frequent changes of the environment lead to the need of considering the configuration problem in an evolutionary way (vertical axis).

In the new evolutionary vision of the problem all the three basic objects are involved.

Goal: co-evolutionary configuration and management of production system-product-process.
At first, we can define a simple metric for the evolution level, i.e. a 0-1 metric. We just say if the evolution is considered or not in the configuration method.

In a complete approach the three methods can have a different evolution level. Thus the triangle will be inclined in the 3D space.
Is a complete and full integration the optimal goal for every manufacturing case?

The Manufacturing Strategy decides the target level of evolution and integration to be considered in the configuration phase and how changes impact on the product, process or production system.
The Manufacturing Strategy is part of the Company Strategy that defines the level of evolution to be considered at each company function.
Objectives of the Co-Evolution model

- Classification of the present state of the art.
- Classification and positioning of the research needs;
- Framing of the methods and tools concerning evolution which are suitable for research and industry.
- First formalization of the new vision proposed by SPECIES.
- Individuation of promising research topics.
A procedure has been followed in order to collect papers in the topic of the SPECIES WG and to carry on a state of the art analysis:

- Selection of papers from the Annals of the CIRP and other important journals in the production area. The list of papers will be continuously improved during the life of the WG;

- Any suggestion about the articles to be inserted in the database is very welcome;

- Is there anyone willing to be a referee for the papers which must be analyzed to be filled in the Database?
The bibliographic search Tool is under development. A first version is available at:

http://www.species.polimi.it/resources.html
Thank you
How can the vector of weights \((w^{pd}, w^{pc}, w^{sys})\) which characterize a configuration process be defined?

The suggestion is to use pairwise comparison:

1. **Product** vs **Process**: \(0 \leq J_{pr/pc} \leq 9\)
2. **Product** vs **Production System**: \(0 \leq J_{pr/sys} \leq 9\)
3. **Process** vs **Production System**: \(0 \leq J_{pc/sys} \leq 9\)
How does AHP works?

\[
\begin{align*}
\text{PROD} & \quad \text{vs} \quad \text{PROC} \quad = \quad 0 \leq X_1 \leq 9 \\
\text{PROD} & \quad \text{vs} \quad \text{SYST} \quad = \quad 0 \leq X_2 \leq 9 \\
\text{PROC} & \quad \text{vs} \quad \text{SYST} \quad = \quad 0 \leq X_3 \leq 9
\end{align*}
\]

Judgments are consistent!
Weights = [0.717; 0.195; 0.088]

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- Consistency index: 0.047
- Random consistency index: 0.52
- Consistency ratio: 0.09
Outline of the presentation

Starting framework

- Objective of the framework
- The configuration activity
- Evolution and Integration levels
- A metric for the integration level
- Dealing with the evolution level
- The impact of the manufacturing strategy

First application: bibliography search tool