2nd ESA - CNES SPACE COST ENGINEERING CONFERENCE

# A Visual Analytics Framework as an Enabler for Cost Competitiveness

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**By**

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# Value Engineering & Cost Management


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# Industry is our core business.
## Committed to optimize the performance of our clients while respecting their strategy.

A consulting company with a unique added value in the field of **Cost Management** & **Value Engineering**

**22%**
**Cost reduction on average**

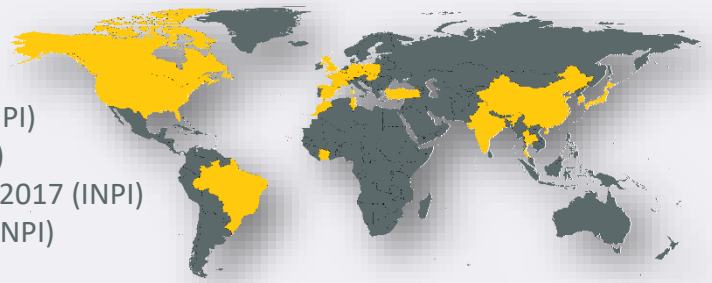
**10**
**Years of R&D investment**

**700**
**Projects**

**100**
**Technologies modeled**

**50**
**Clients**

- Should Cost® methodology registered in 2008 (INPI)
- Push-Pull® methodology registered in 2016 (INPI)
- Spec-to-Should Cost® methodology registered in 2017 (INPI)
- Drive-to-Cost® methodology registered in 2020 (INPI)



**Industry is our core business……**

# Our vision

Yes, we can innovate at a competitive price and profitably

## "Cost is not a result"

Cost should not be seen as the result of design, development and purchasing

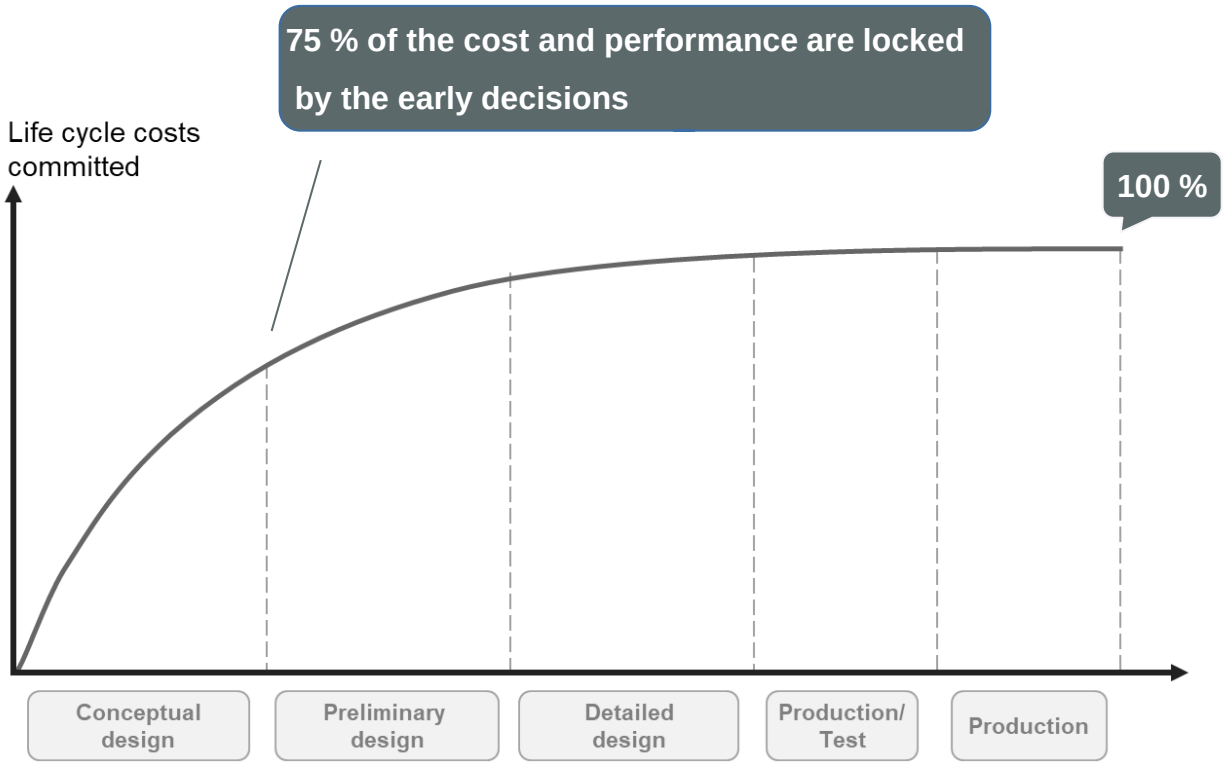
## "Cost is a performance driver"

The design team must keep in mind the target price to be achieved, as well as the expected functionalities

## "Cost is compared to created value"

Each cost corresponds to the value and therefore a profitability level. Innovation should improve profitability

# The first design decisions determine the success of your programme




It is critical to make the right decisions in the first design stages:

- To avoid costly iterations or even dead-ends
- To ensure a competitive edge

# The challenges of conceptual design

- Why is it difficult?
  - Many alternatives to study (including many good solutions), but with limited resources
  - Many design variables to take into account
  - Many performance criteria to take into account
  - High uncertainty in the early design phases
  - Many stakeholders and many disciplines involved in the design process… often leading to silos

# The traditional “point-based” approach

Architecture Selection

One requirement point
- Mission requirements
- Constraints
- Assumptions

Concept sizing (Optimization)

Cost

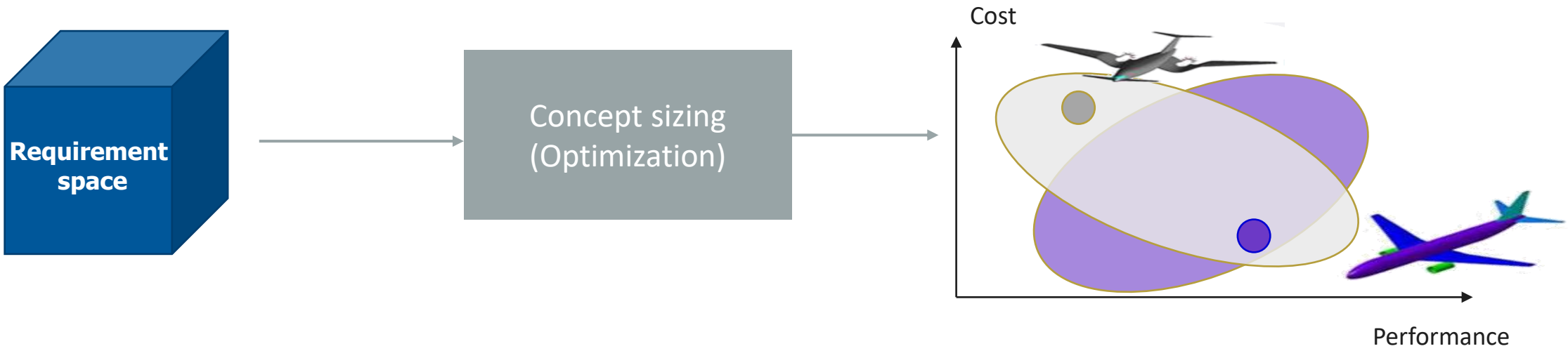
Optimized design point

Optimized design point

Performance

# The problems with the « point-based » approach

- High uncertainty:  on requirements, on economic assumptions, etc.

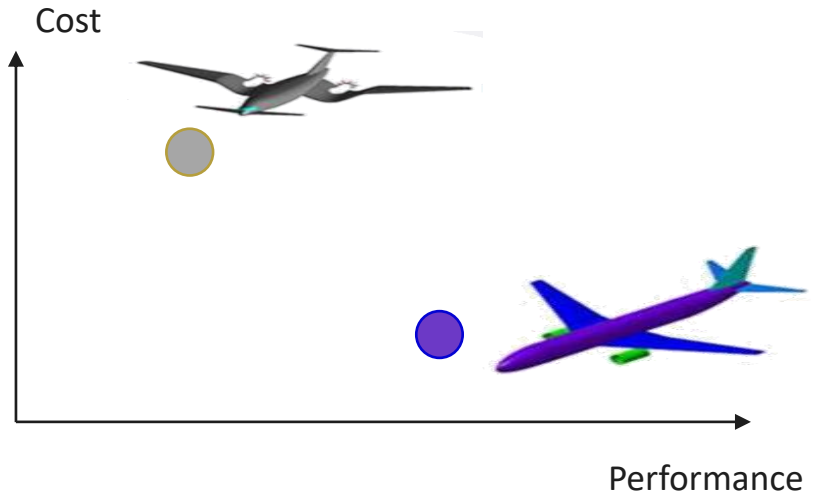


# The problems with the « point-based » approach

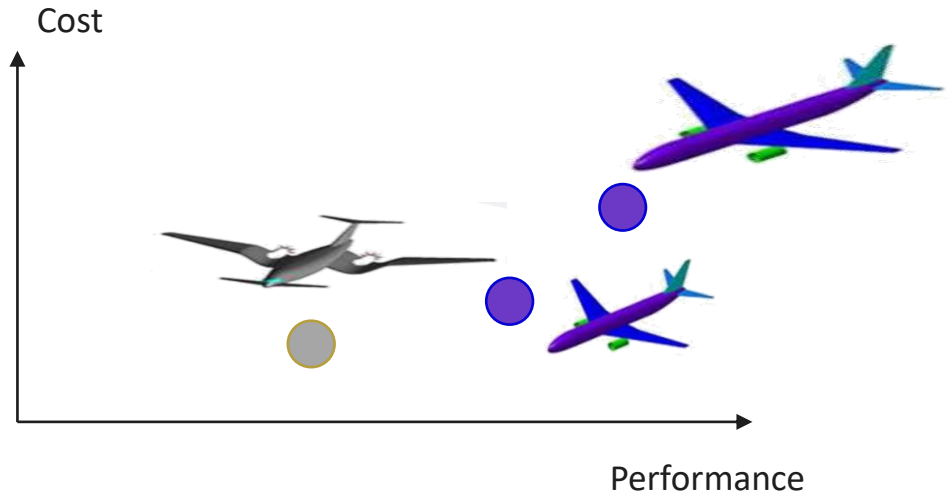
- Optimizing a concept with multiple performance criteria is almost always done through the aggregation of the criteria into an “objective function”.

$$Objective = \alpha.weight + \beta.cost + \gamma.fuel$$ ⟵ How do we define it?

- How do we choose between several dominant concepts (Pareto frontier)?



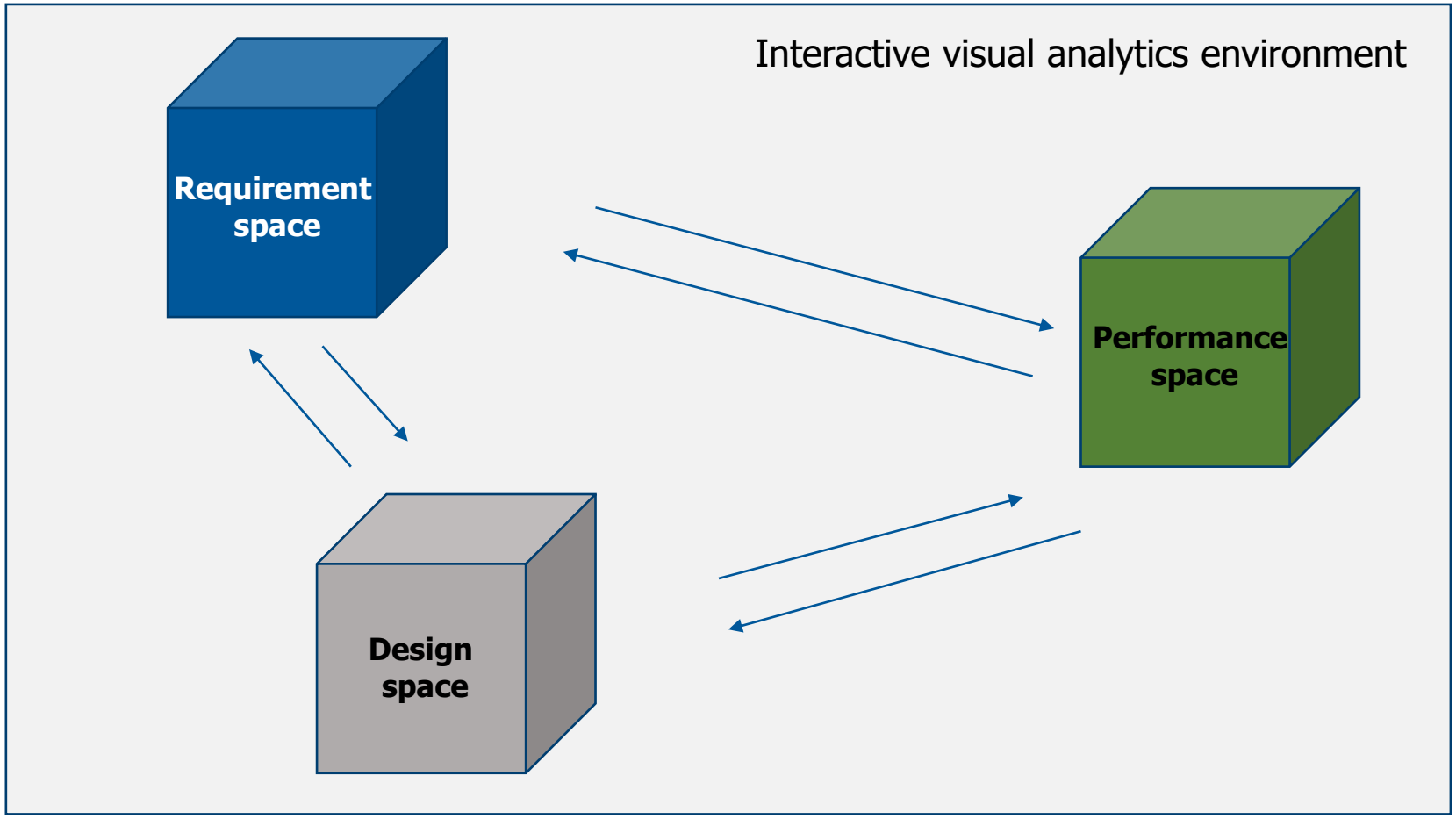

**Easy choice**



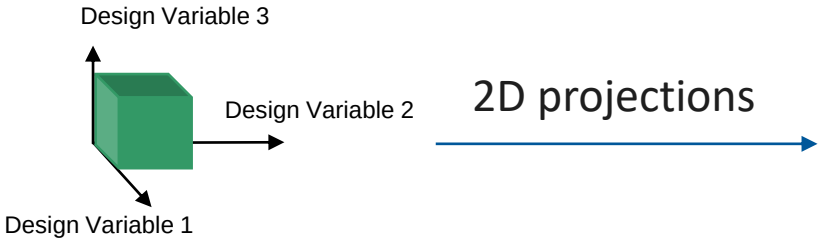

**Less easy…**

# Our solution: a set-based approach enabled by « visual analytics »

Visual analytics: "the science of analytical reasoning facilitated by interactive visual interfaces."

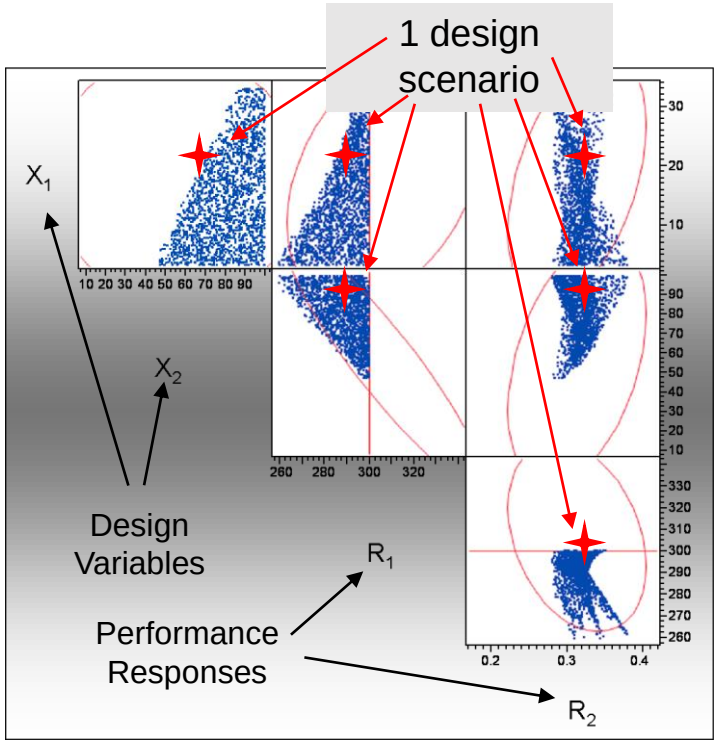


# Visual analytics : the « scatterplot matrix », a lever for the exploration of the design space




The design space

2D projections




- The scatterplot matrix enables the design team to visualize and filter the design space
- It is a collaborative engineering tool that maps the contribution of all disciplines and identifies correlations between them

# Our set-based approach: modelling coupled with « visual analytics »

Architecture 1

Architecture 2

Architecture 3

Sizing module 1

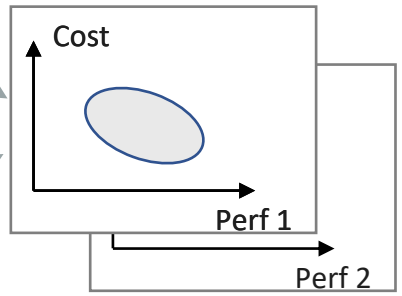
Parametric Should Cost® 1

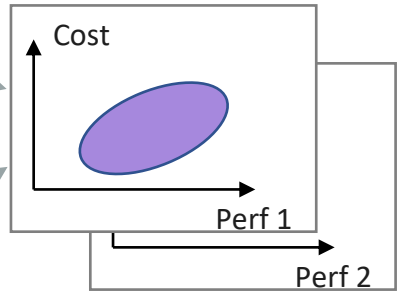
Sizing module 2

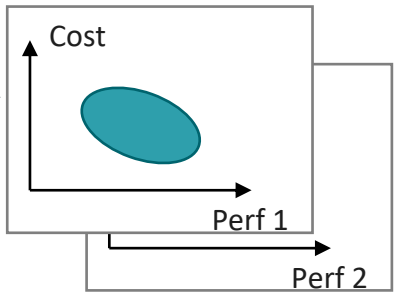
Parametric Should Cost® 2

Sizing module 3

Parametric Should Cost® 3




Design rules co-generated with our clients


**Decision making tool**

*Interactive scatterplot matrix*

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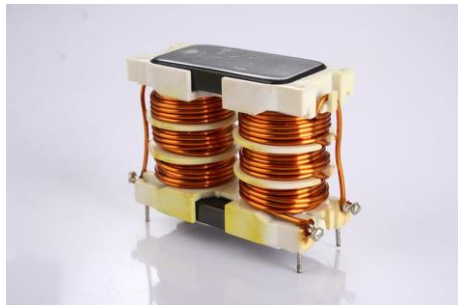
# Example

**Design space exploration for an electromagnetic system**

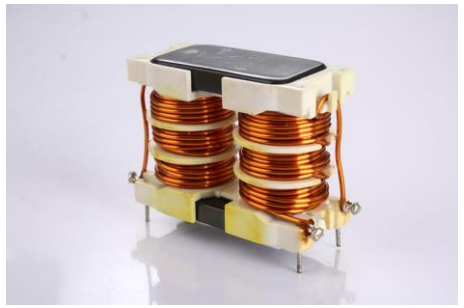
# Electromagnetic systems for a major industrial actor
## Mission context



- Context
  - Our client had launched a global design-to-cost programme, tackling all aspects of their product life-cycle
  - Our client wanted to improve their costing skills and tools, especially for their bidding process.
    - Cost estimation was performed at the end, once the design had converged towards a concept.
    - The design process heavily relied on analogy with past projects, guided by expertise of the architects and design team.

- Our client's objectives
  - Accelerate the bidding process (and lower its cost)
  - Be able to propose the best solution that meets the RFP requirements
  - Be able to propose cost / performance tradeoffs

# Electromagnetic systems for a major industrial actor
## Mission objectives



- Our mission
  - Develop a tool that could enable the bidding team to:
    - rapidly assess the cost target of their solution when answering an RFP,
    - propose cost/value trade-offs.

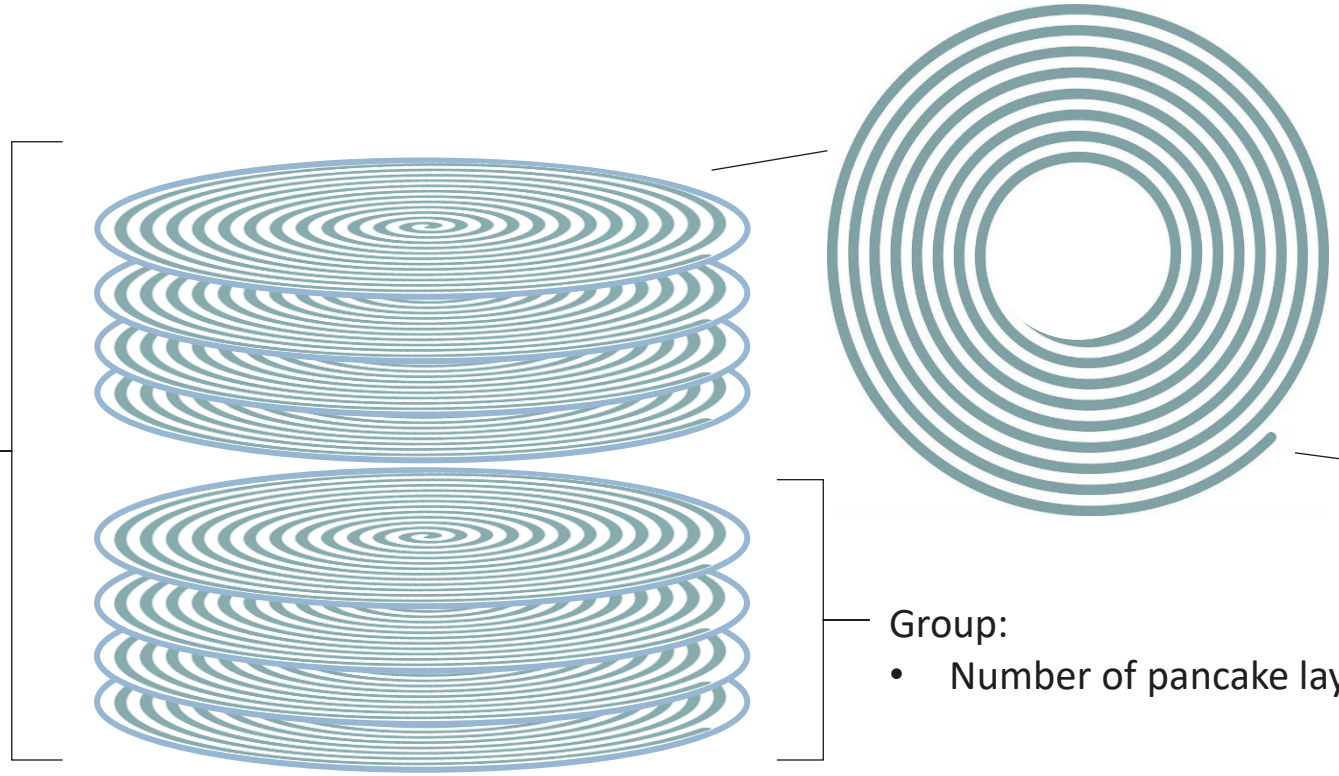
RFP High-level specifications → Spec-to-Should-Cost tool → Cost

***For inductors:***

- Current intensities
- Inductance requirement
- Winding resistance requirement
- Allocated volume and weight
- Thermal class

# Description of an inductor: design variables for the coil

Coil:
- Number of groups



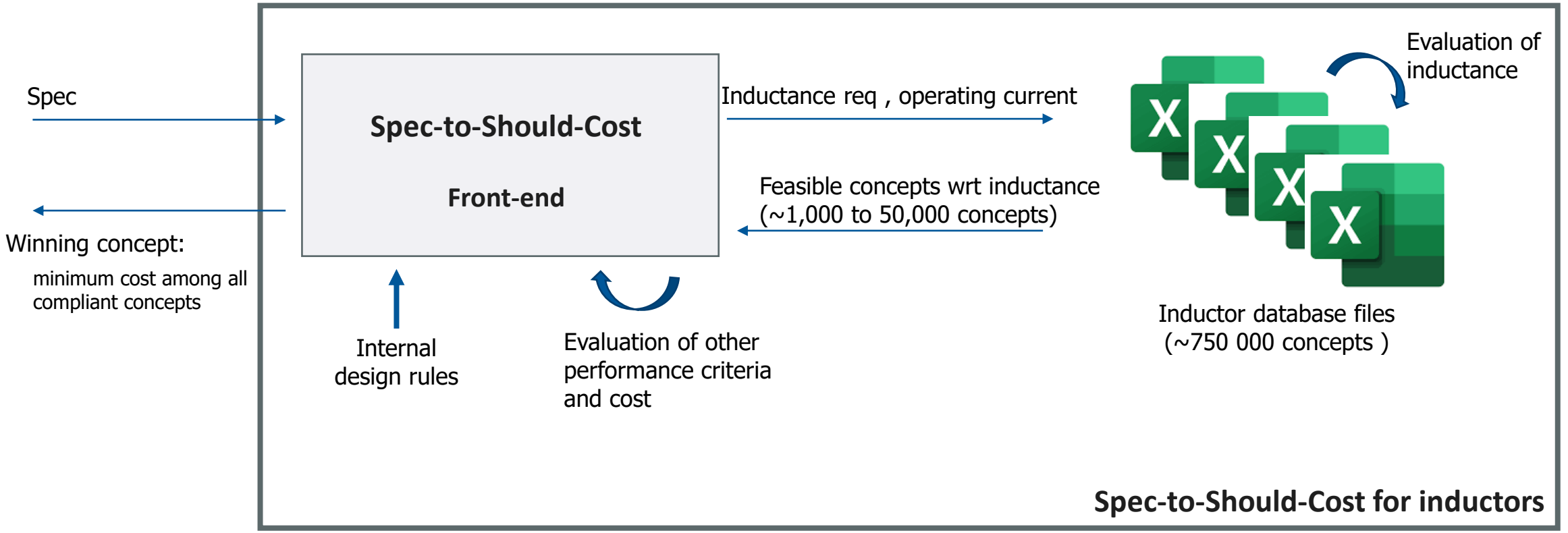
Group:
- Number of pancake layers

Pancake layer:
- Internal radius
- Number of turns
- Insulation strategy : class A or F

Conductor:
- Cross section size
- Single or double cable
- Cu or Al

**Size of the design space : ~750,000 concepts**

# Inductor Spec-to-Should-Cost Tool workflow



# Opportunity : implement a visual analytics approach

Spec

**Spec-to-Should-Cost**

**Front-end**

Inductance req , operating current

Feasible concepts wrt inductance
(~1,000 to 50,000 concepts)

Evaluation of inductance

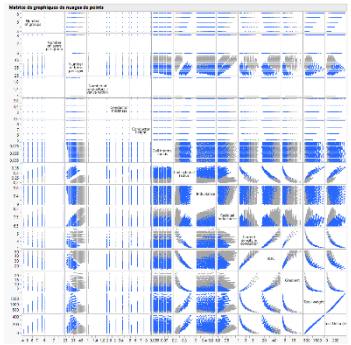
Inductor database files
(~750 000 concepts )

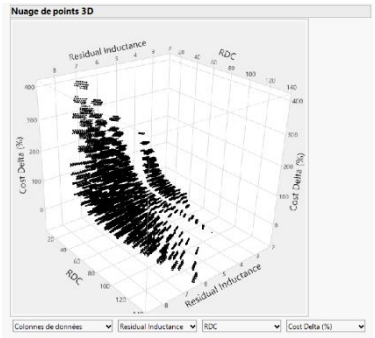
Internal design rules

Evaluation of other performance criteria and cost

Requirement
Scenario

Winning concept






**Visual analytics environment**

jmp
Statistical Discovery™ From SAS.



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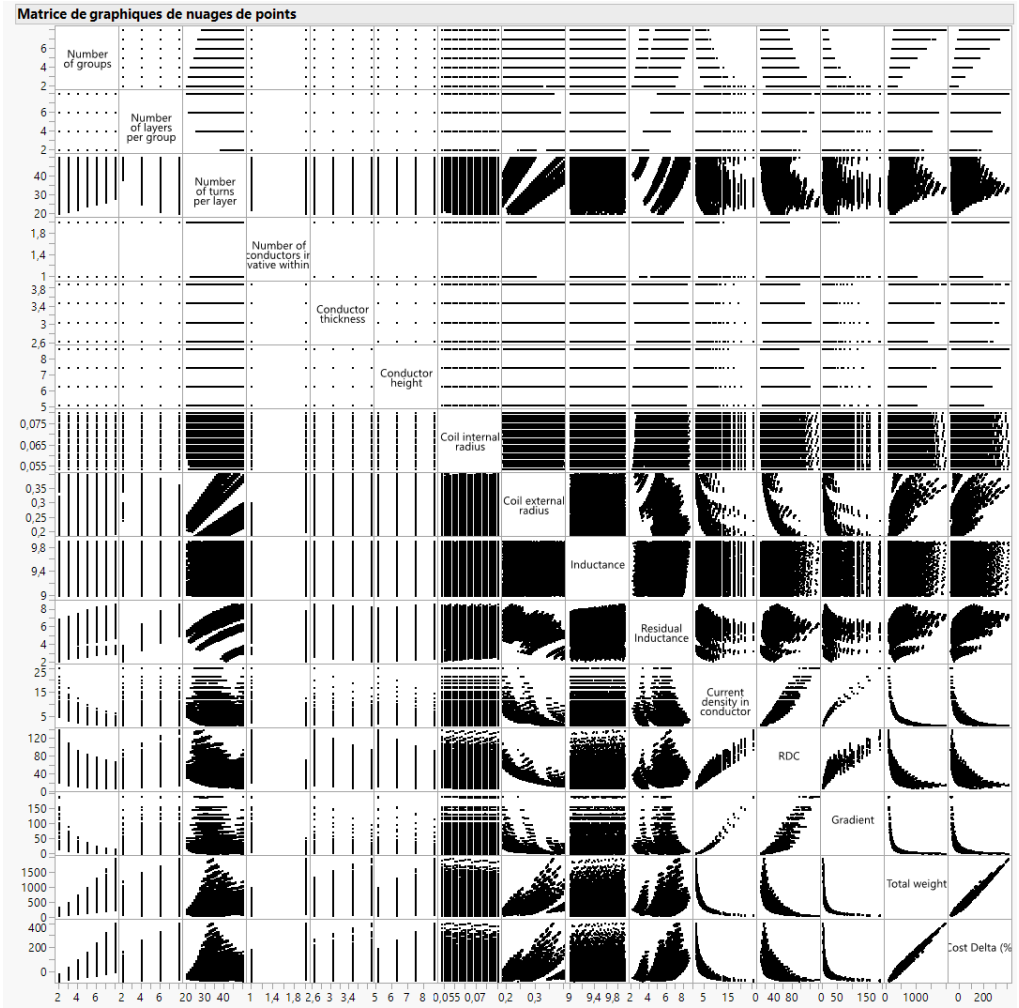
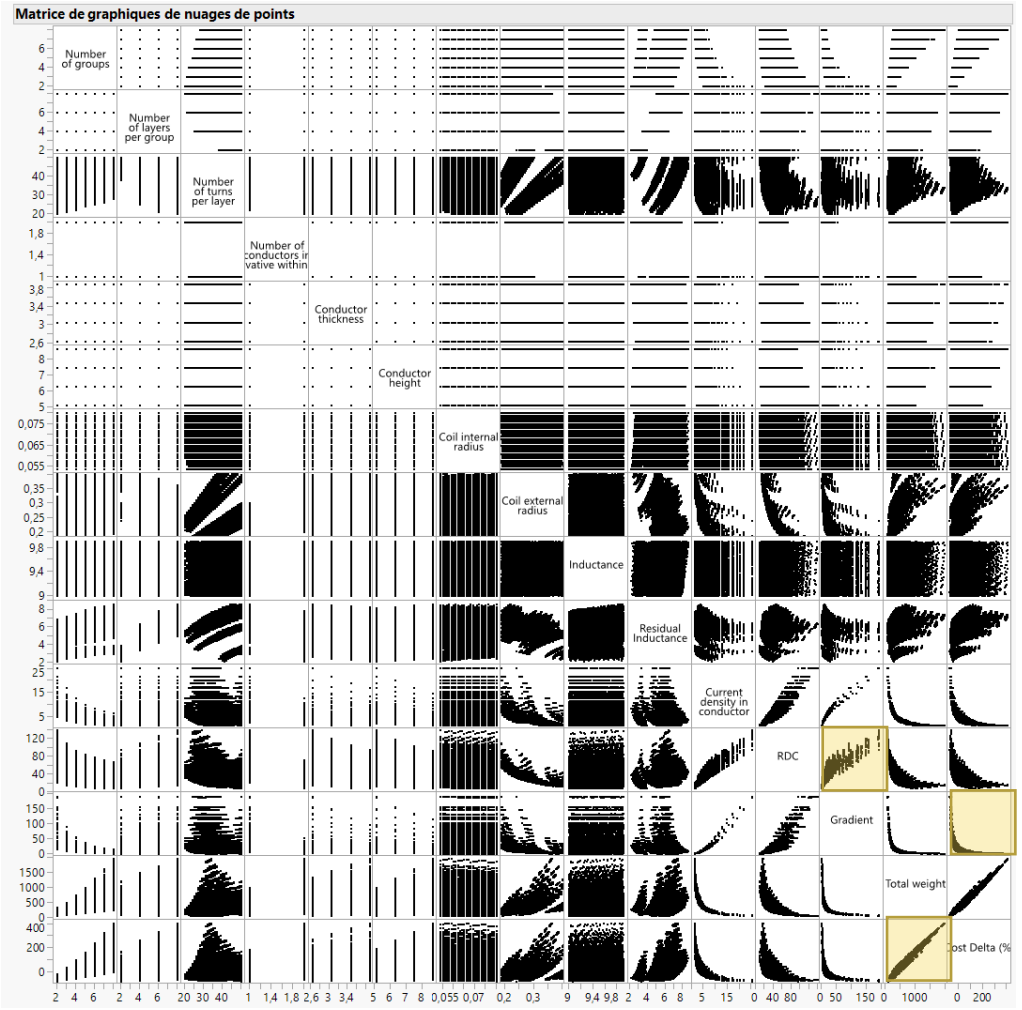
# Visual analytics for design space exploration of inductors
# DEMO (on JMP software, SAS Institute)

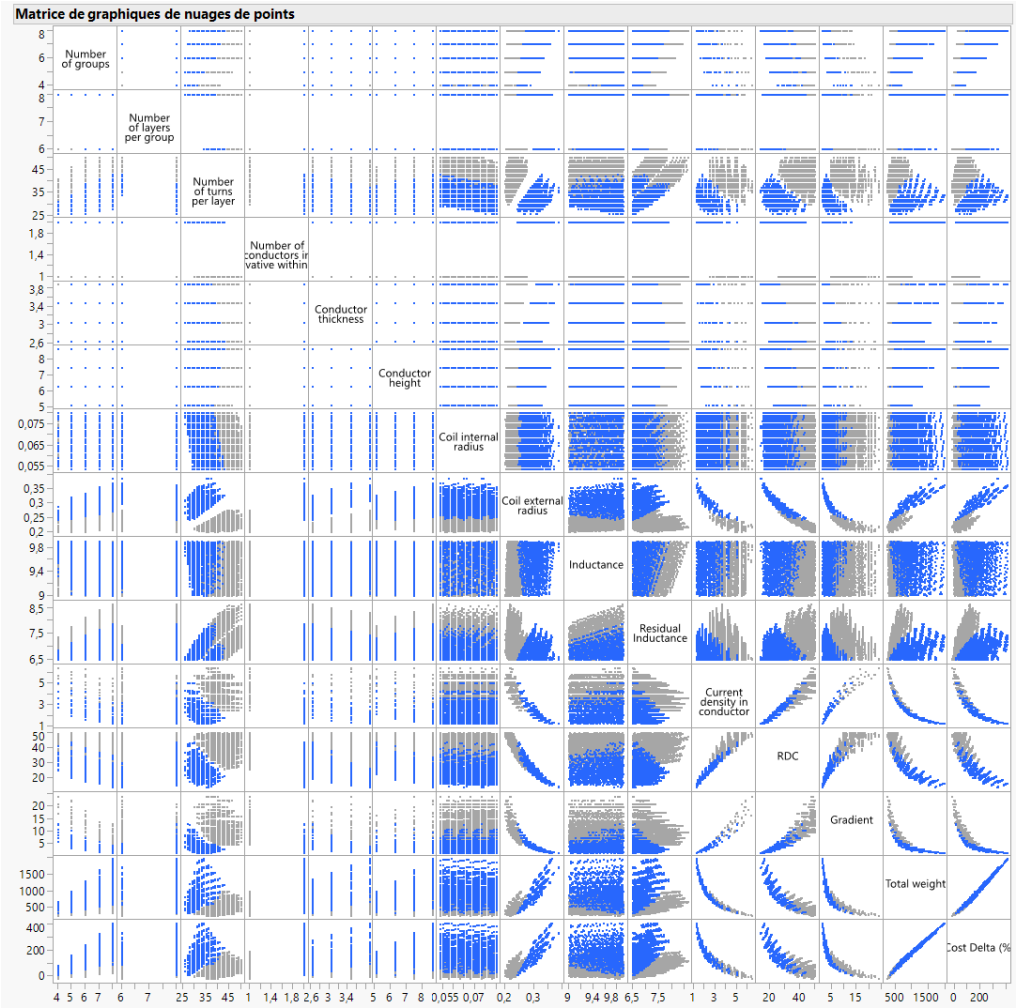


# Visualizing correlations




Examples of correlations between performance criteria

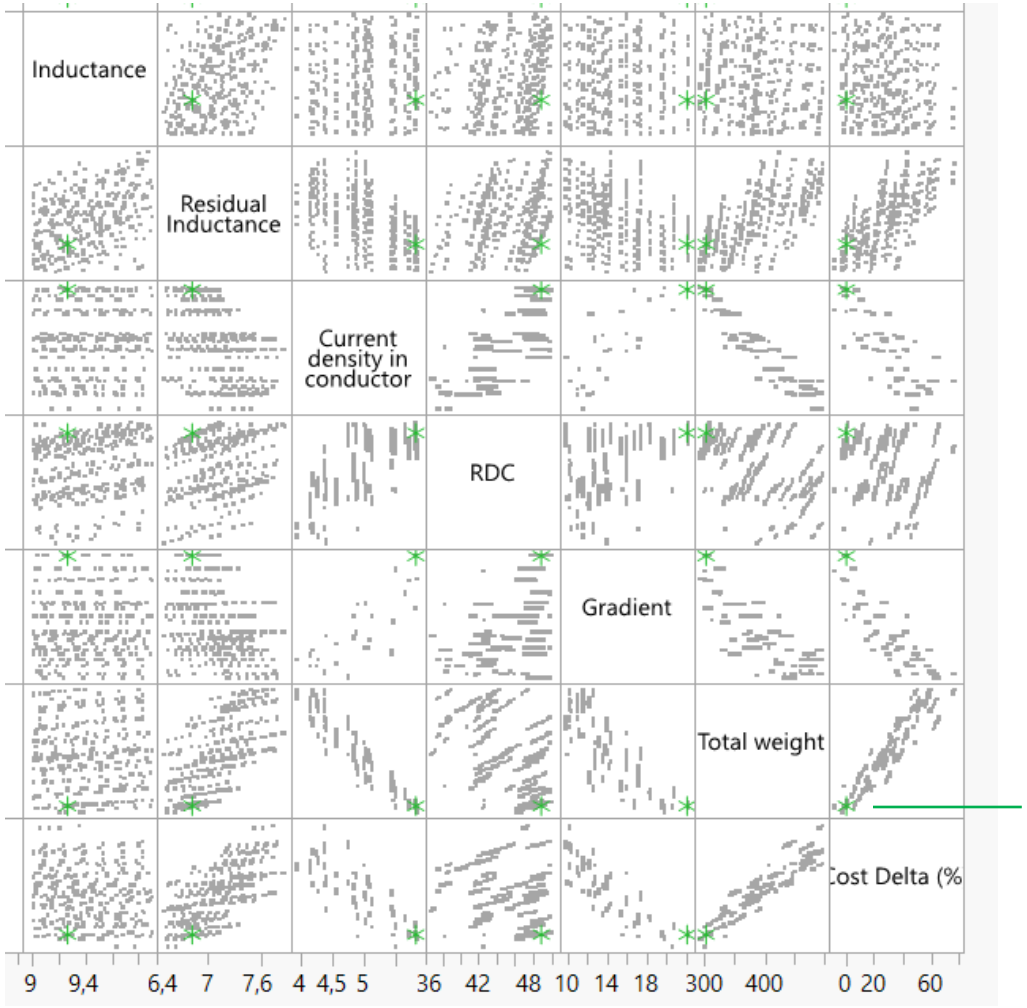
# Architecture clustering




In blue : dual cable architectures

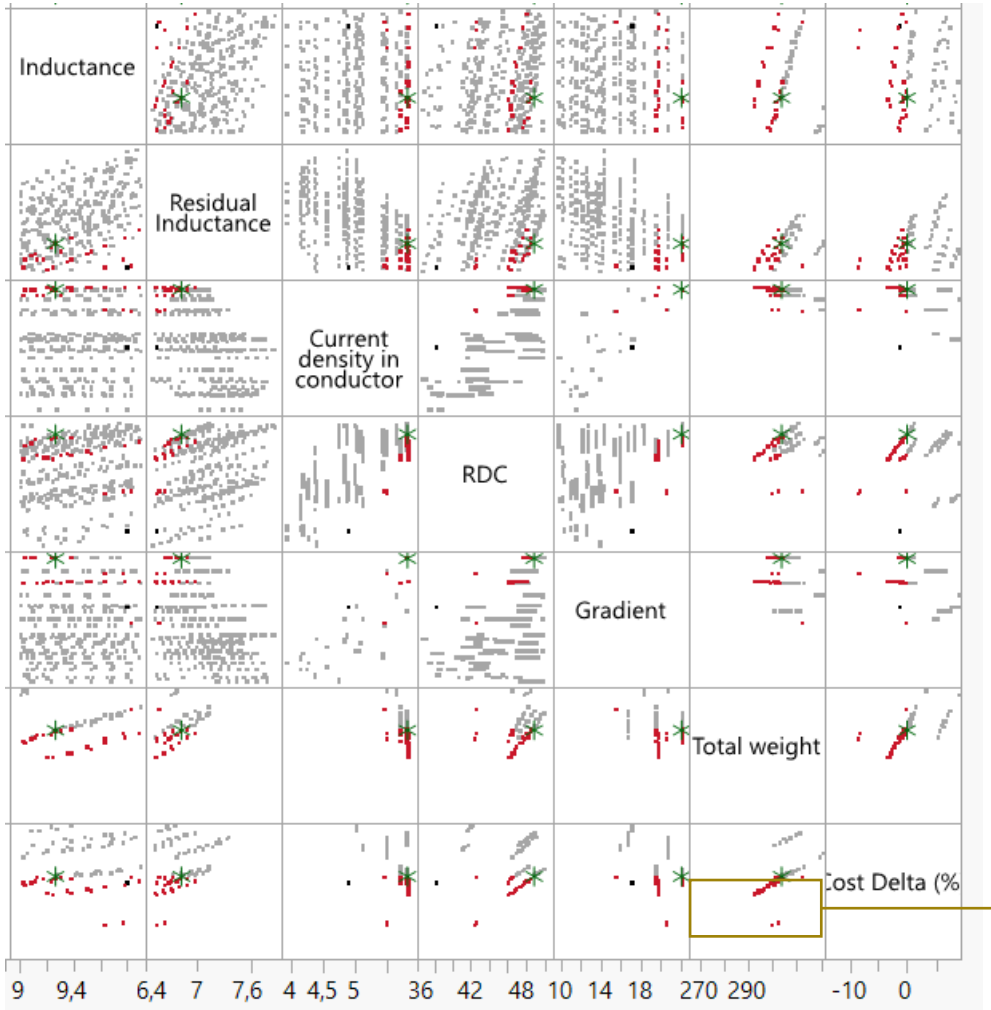
- Lower resistance
- Higher costs

# Exploring and filtering
# Entering RFP requirements and design rules




The baseline was in the low cost region

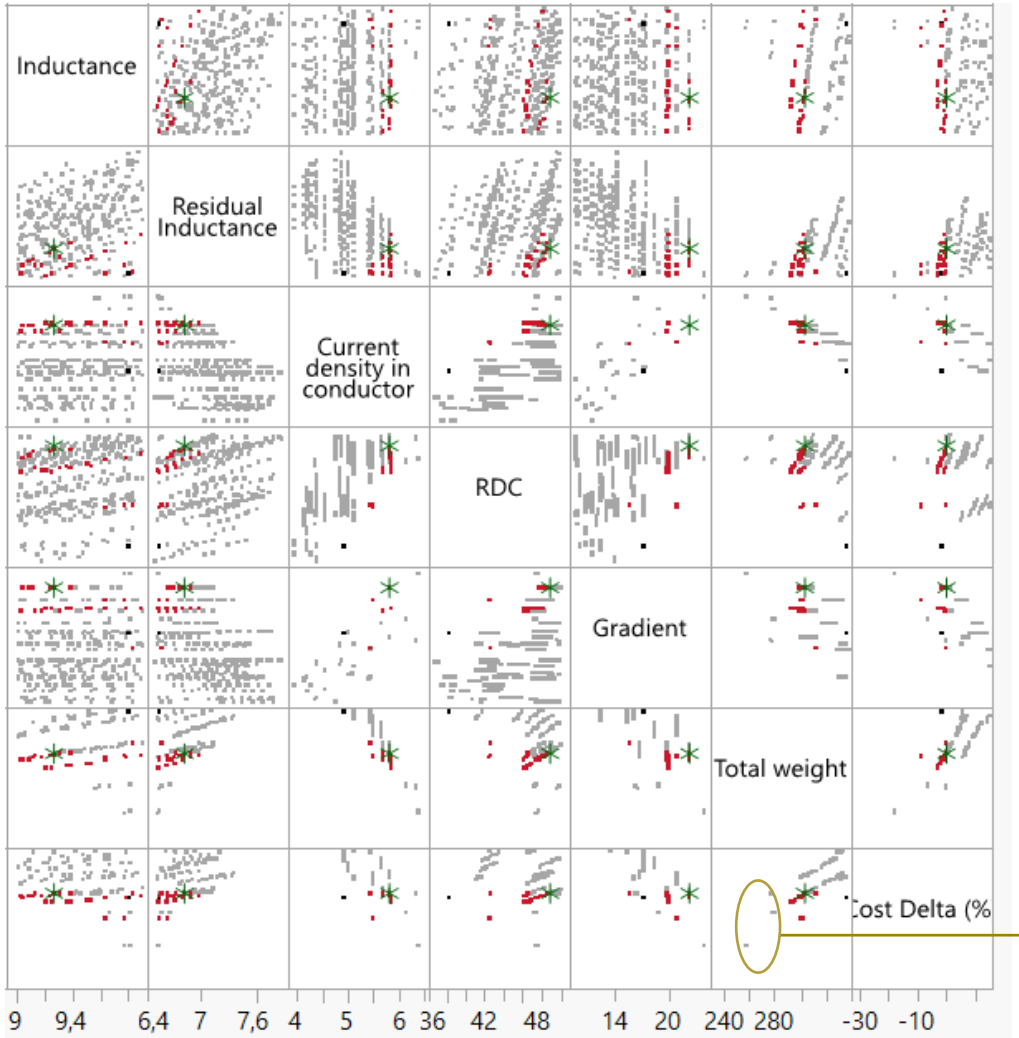
# Exploring the low cost region




✳ : baseline

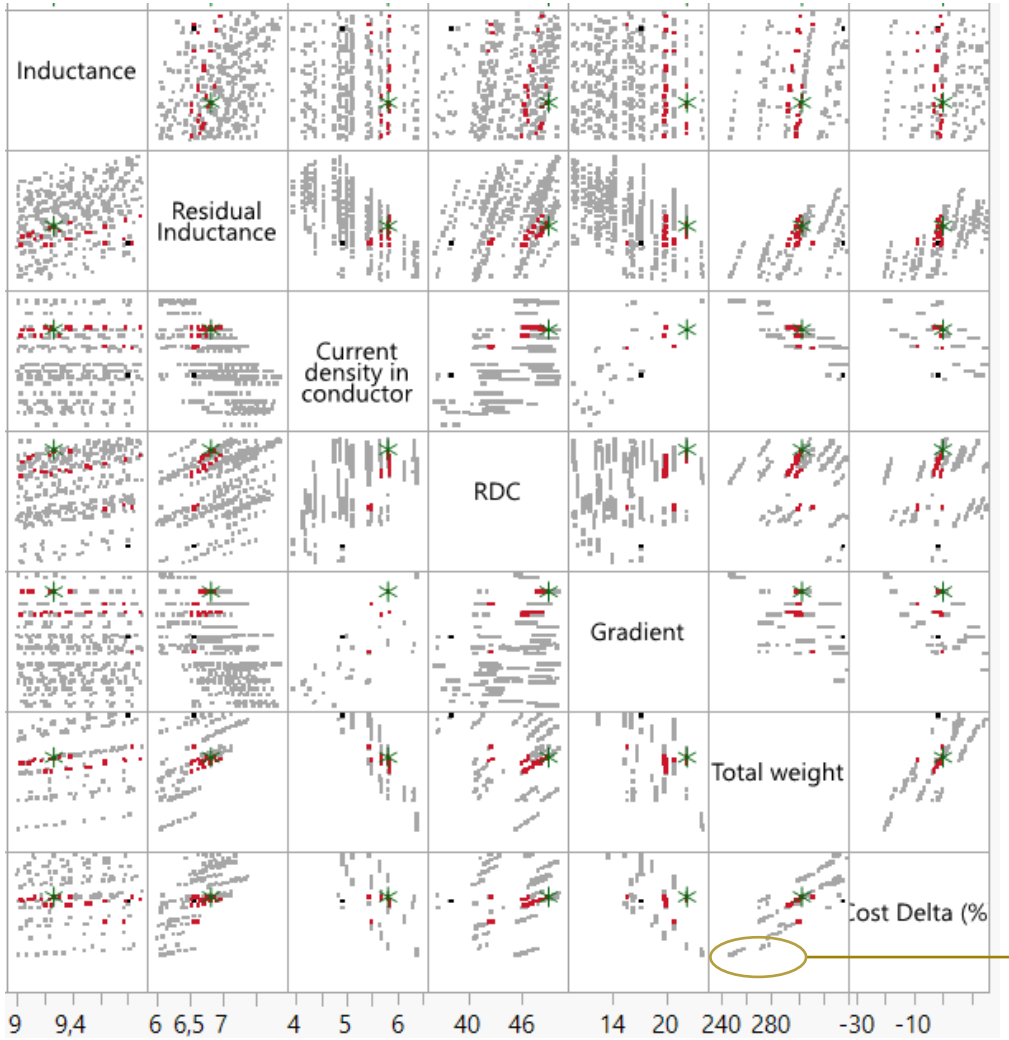
Region of solutions with lower cost than baseline (red points)

# Questioning internal design rules
# What if we reduce the design margin for max current density ?




Additional (lower cost) points appear when relaxing internal design rules

# Relaxing RFP requirements
# What if we reduce the required residual inductance?




More (lower cost) points appear when relaxing RFP requirement on residual inductance



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# Conclusions
## Example of use case for design space exploration

- Benefits of the Visual analytics framework for the bidding process:
  - Rapidly identify feasible solutions
  - Integrate cost as a performance criteria that drives the design
  - Perform trade-off analyses and identify most competitive solutions
    - Explore the lower cost regions of the design space
    - Question internal design rules (sometimes just a legacy from old projects)
    - Identify and propose alternative « out-of-specification » solutions which may bring value to the customer (e.g. +5% residual inductance with 1.5% cost saving)

# THANK YOU

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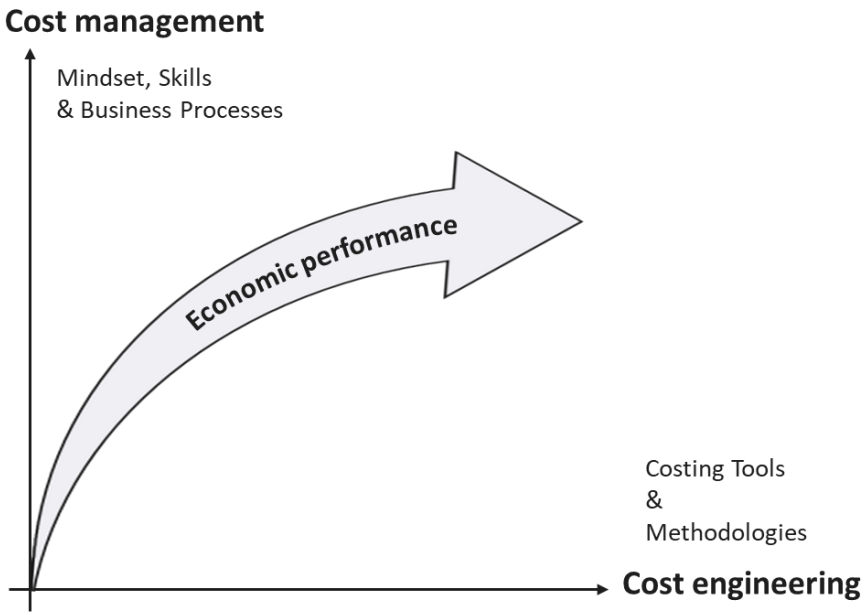
# Back up

## Spec-to-Should-Cost

# What about cost estimation?

- Verbatim (in the aerospace industry):

> *"Cost cannot drive the design.*
> *First we design and optimize our solution, then we estimate its cost."*



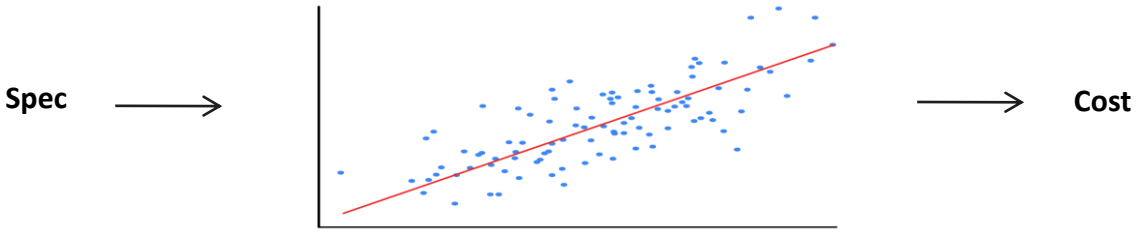

Cost needs to be considered as a performance criteria when designing and optimizing solutions.

Economic performance requires a combination of:

- Mindset, skills and processes
- Costing tools and methodologies

# Traditional “Spec-to-Cost” approach

## TRADITIONAL “SPEC-TO-COST” MODELS ARE BASED ON PAST DATA





## LIMITATIONS

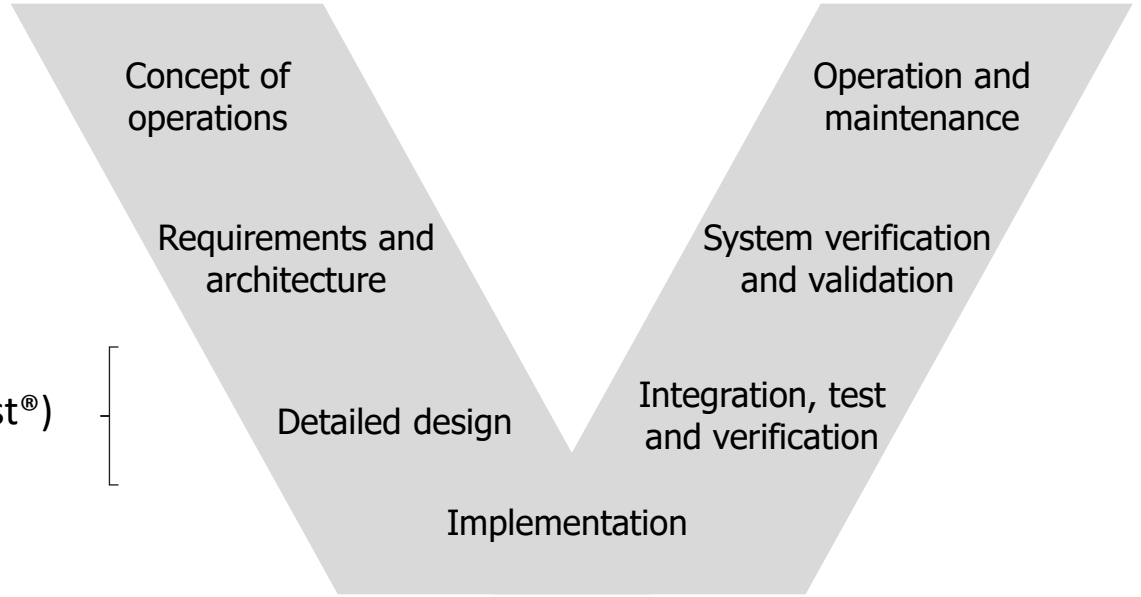
- Limited number of reference points (big data is required)
- Consistency of reference points (year, design, supply chain, techno, …)
- No cost reduction levers
- Uneasy matching with analytical tools

# Our solution : Reconciliate early stage costing tools and analytical tools

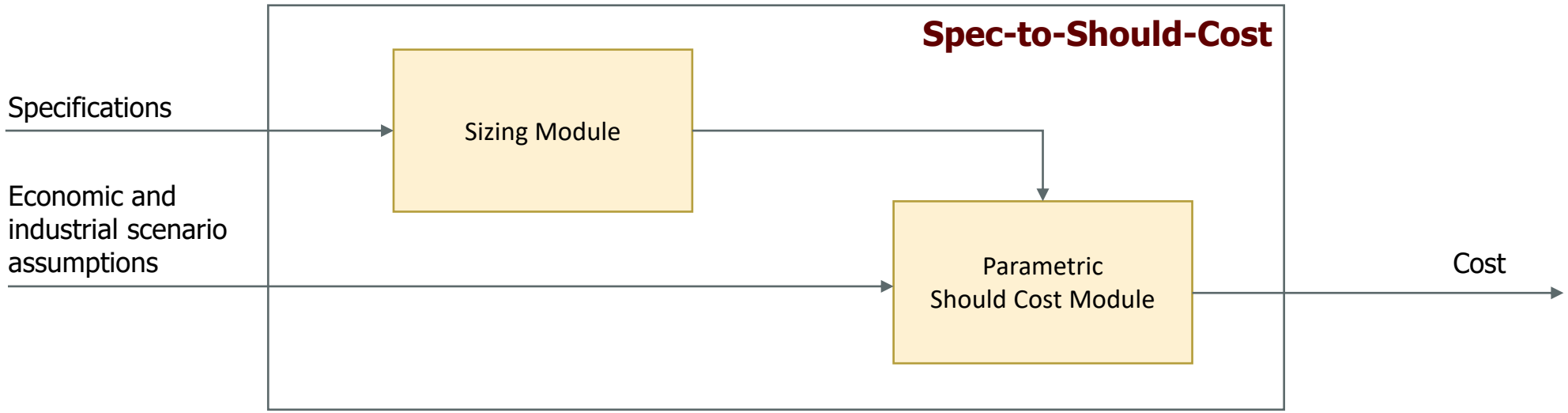
- Expert estimation by analogy
- Parametric models based on historical data

- Analytical cost models (Should Cost®)

**Spec-to-Should-Cost**



# Spec-to-Should-Cost®

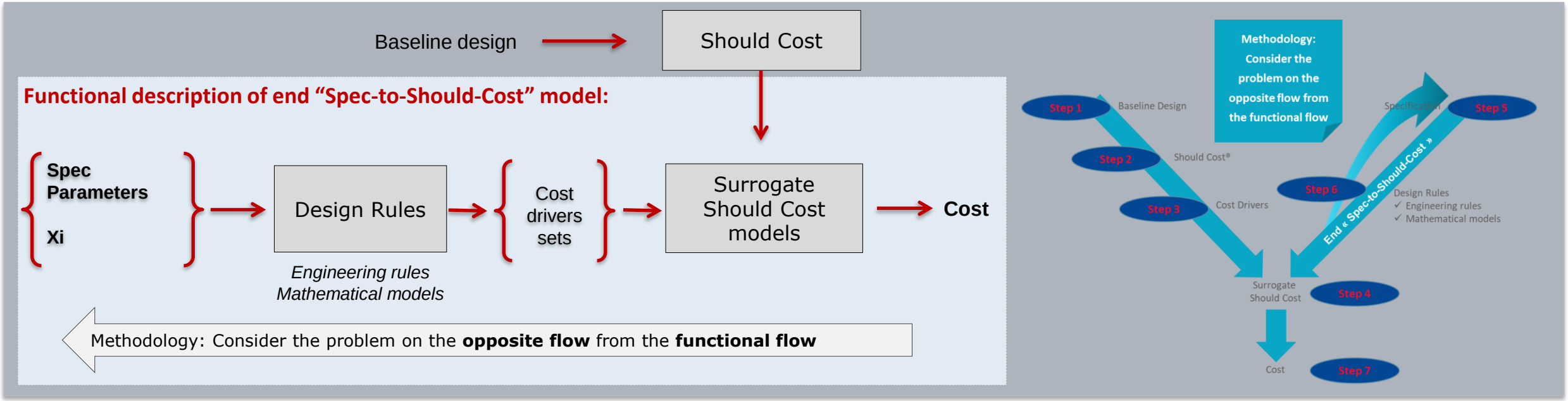



## APPROACH : SPEC-TO-SHOULD COST®

- Reconciliate early stage costing tools and analytical tool
- Combine accuracy, traceability and speed
- Combine spec-value arbitration and engineering optimization levers
- Formalize implicit assumptions
- Learning methodology

Extensive

# Spec-to-Should-Cost Methodology



THANK YOU

# HOW MUCH DO YOU THINK IT SHOULD COST?

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