Towards Model-Based Decision-Telling: Design Evolution Through Decision Nodes

Authors: Nidhal Selmi, Jean-Michel Bruel, Sebastien Mosser, Matthieu Crespo

University of Toulouse, McMaster University, Airbus

The Context

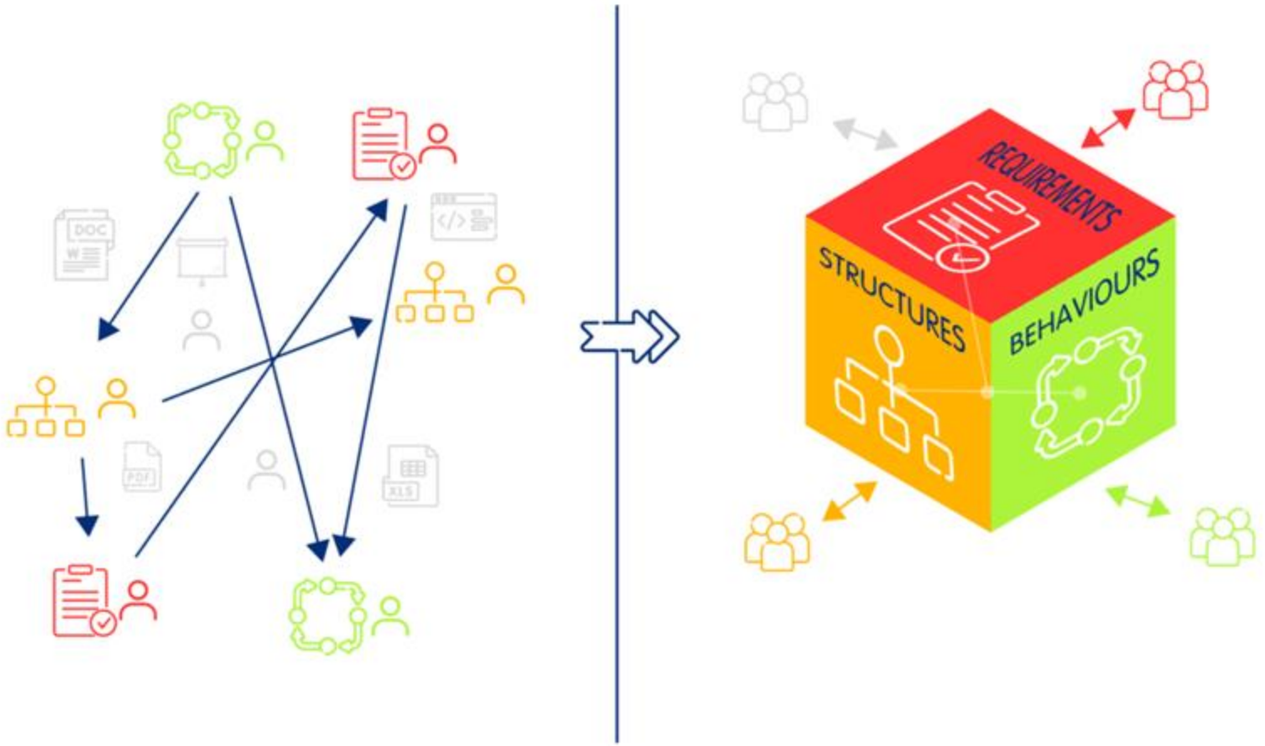
Airbus DDMS Digitalization Project

- **Digital-first** approach to design, manufacturing and services
- **Model-Based Systems Engineering** as a core element of the project

What is MBSE?

Model-Based Systems Engineering (MBSE) emerged to manage complexity by consolidating design artifacts into a single source of truth (SSOT).

- Improves consistency and collaboration
- Strengthens traceability across design artifacts
- Reduces development time
- Better manages information overload



The Challenge

Rising Complexity

Engineered systems like aerospace are becoming increasingly complex, overwhelming traditional design approaches.

Lost Evolution

MBSE focuses on static outcomes rather than how and why models evolved through design stages.

Scattered Decisions

Decision information is decentralized across documents, trackers, and presentations - making decision revisiting and reuse impossible.

The Gap We Address

1

Current State

MBSE emphasizes static outcomes - the final model state without evolution context.

2

Missing Link

Versioning remains disconnected from reasoning and decisions that drive evolution.

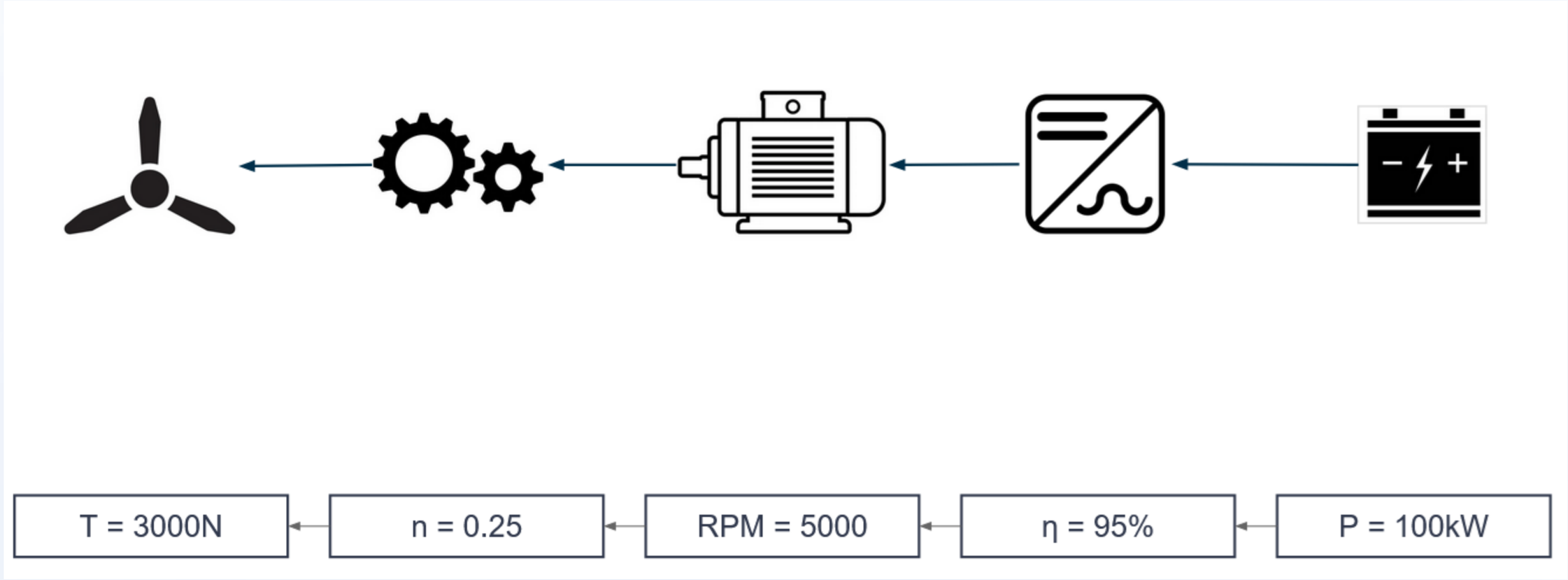
3

Our Solution

Capture model evolution through decision nodes with formalized decision documentation.

Motivating Scenario: Aircraft Propulsion System Architecture

Example from ZEROe zero-emission aircraft development showing how decisions drive architecture evolution.



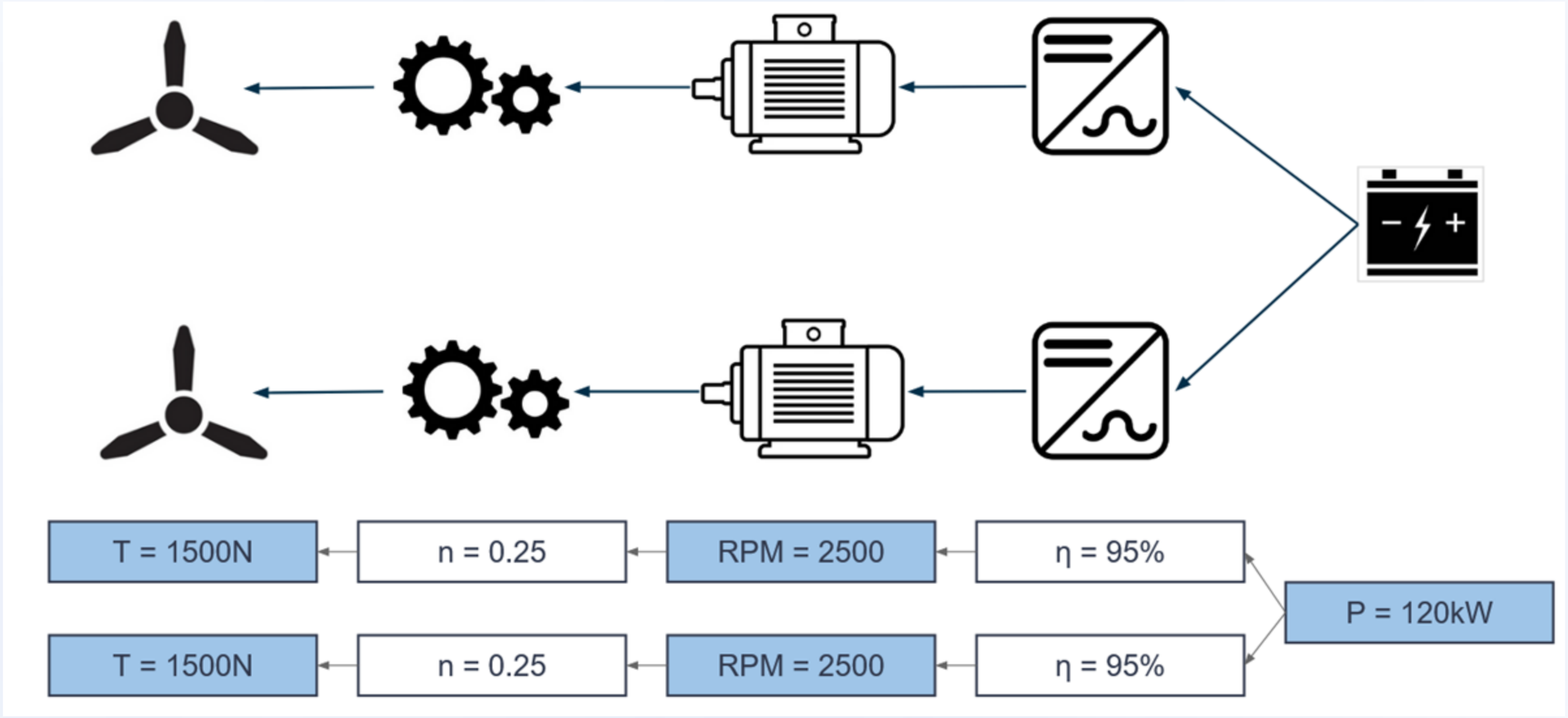
Initial Architecture

Twin drivetrain configuration

Shift to dual battery setup

Transition to hybrid-electric system

Final Design



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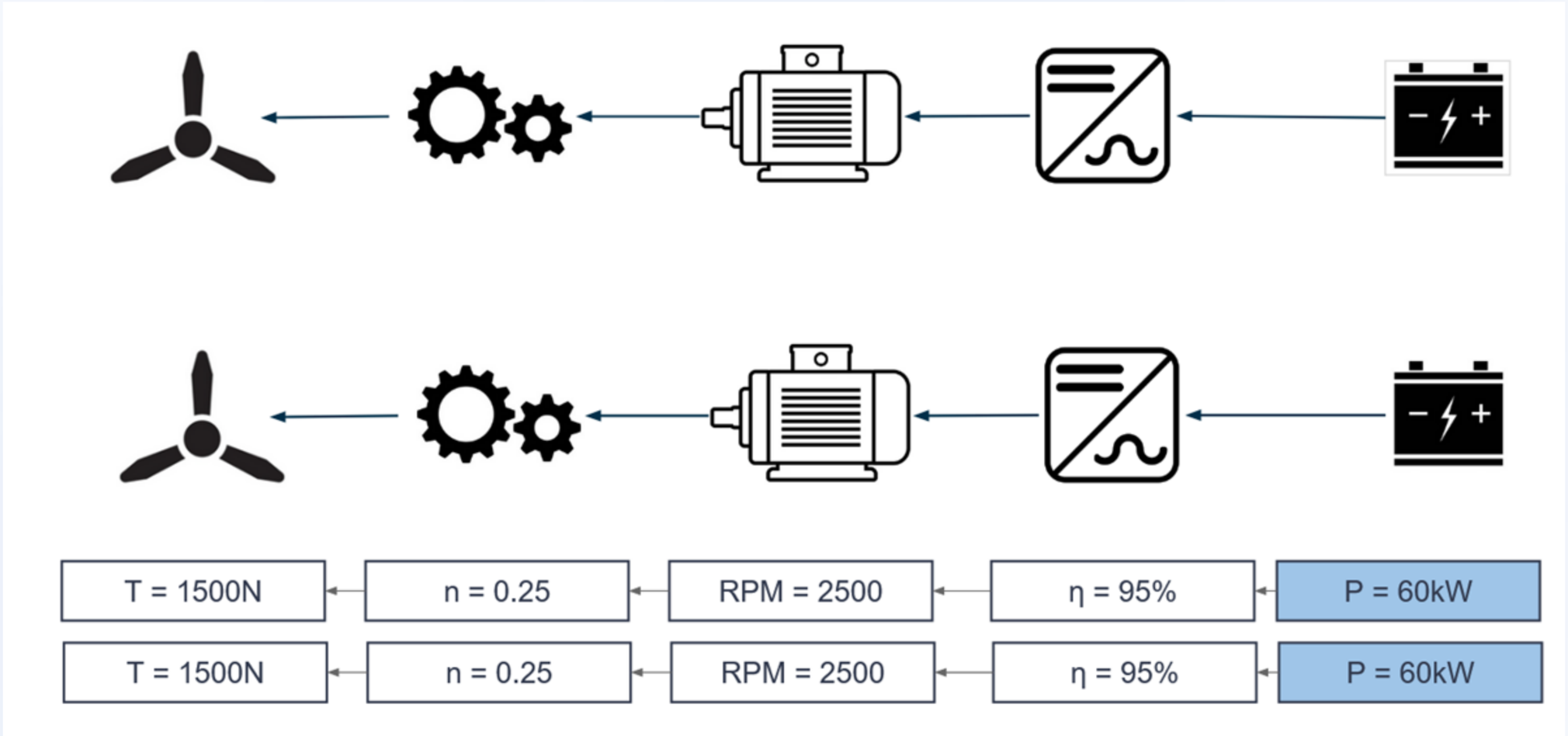

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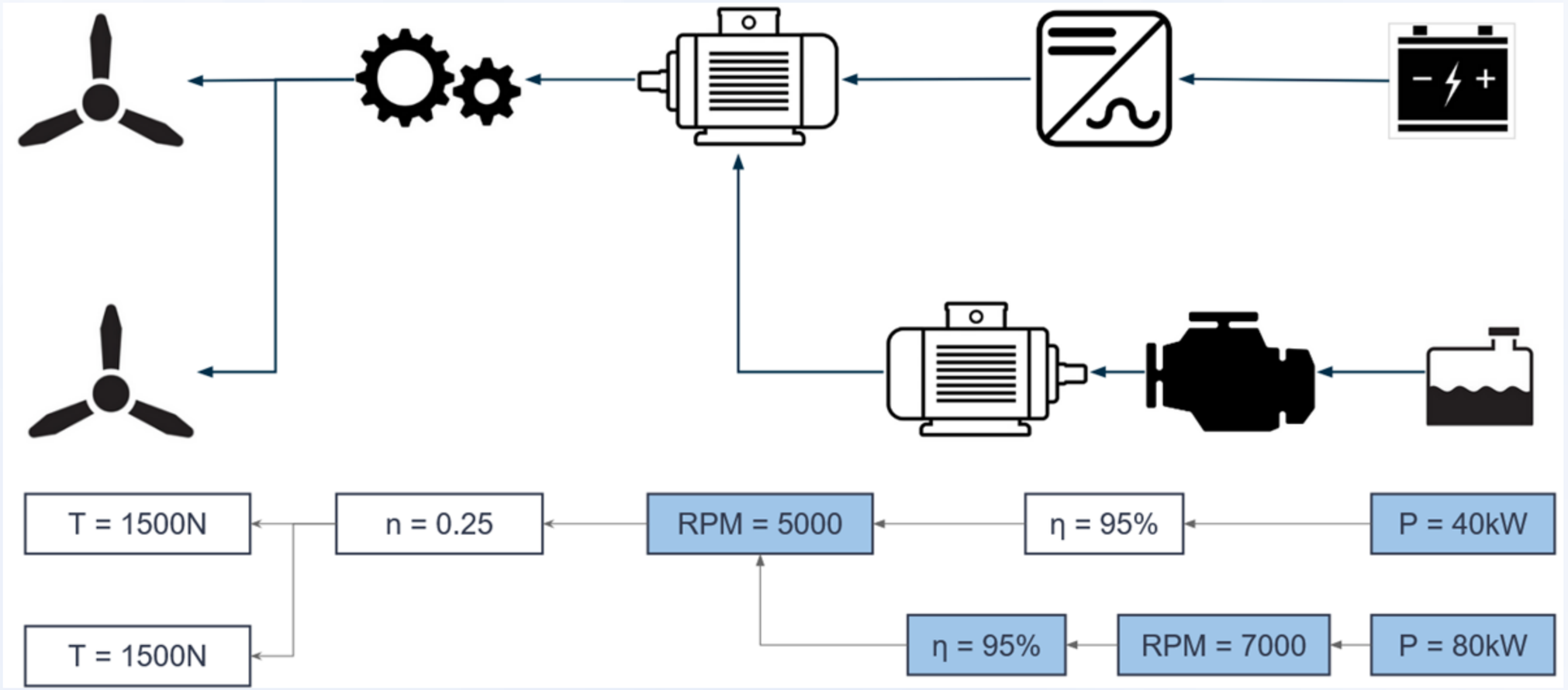

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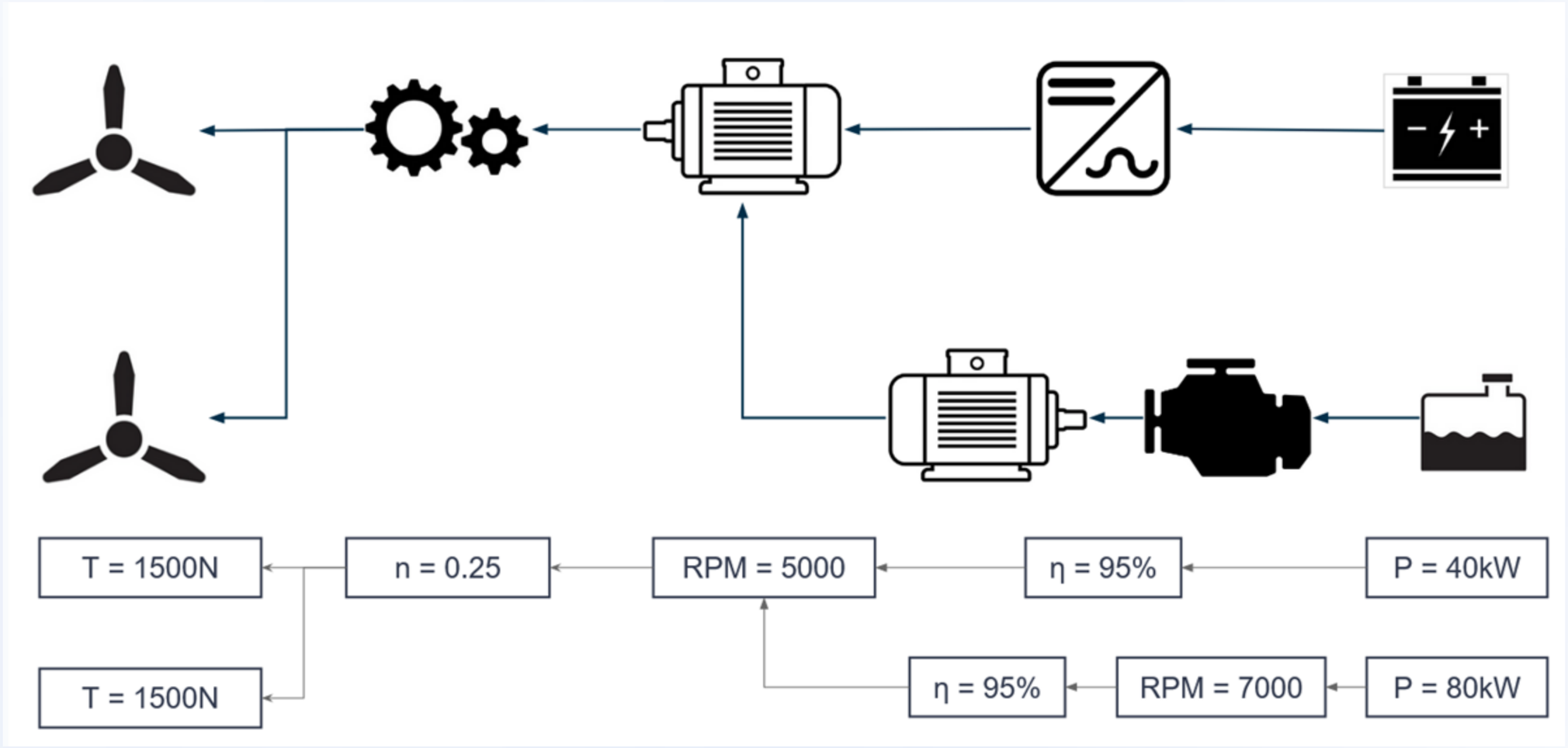

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Current Approach Limitations

Disconnected Tools

Presentations prepared outside MBSE tools limit consistency and traceability to actual models.

Temporary Value

Presentations serve review meetings but provide no ongoing maintenance of design evolution.

Additional Workload

Creating presentations becomes extra burden on top of core MBSE modeling activities.

Inefficient Revisiting

Revisiting the right decisions due to changed context is not straightforward

Proposed Solution: Integrated Decision Capture

Ensure **traceability** between system models and the underlying decisions while capturing model evolution through **decision nodes**.

Same Storytelling Approach

Maintain narrative flow but **integrate with system models**

Evolution Capture

Capture model changes and requirements evolution through underlying decisions

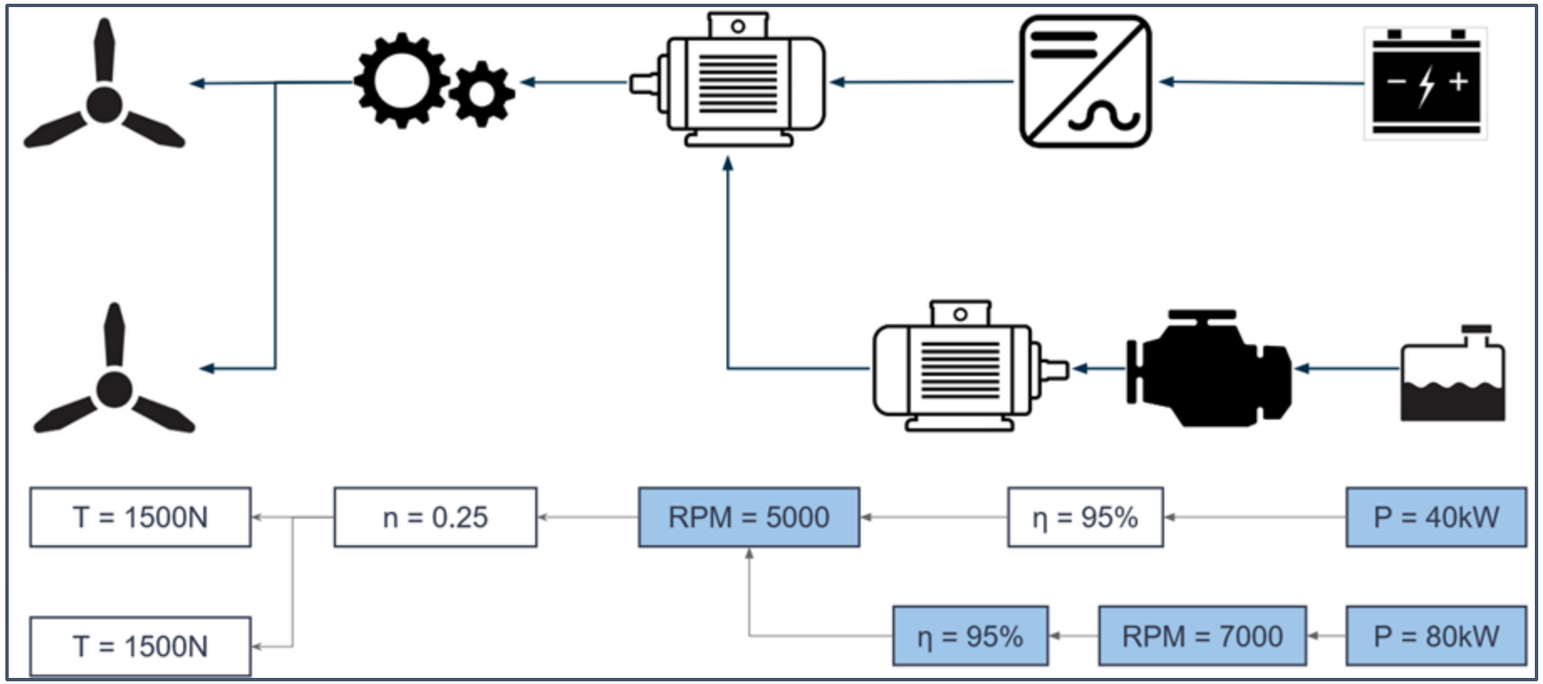
Structured Documentation

Flexible yet formal capture of rationale, alternatives, and context

Traceability Links

Direct connections between models and decision elements.

Decision Documentation Template Example



In the context of A/C Drivetrain Development,

facing insufficient battery specific energy,

we decided for hybrid-electric architecture

and neglected full-electric architecture

to achieve better performance

accepting higher complexity

because fuel systems offer a higher specific energy.

Y-Statements: Structured Decision Capture

> *"In the context of [context] facing [problem], we decided for [solution] and neglected [alternatives] to achieve [benefits], accepting [trade-offs] because [additional rationale]."*

O. Zimmermann, "Y-Statements: A light template for architectural decision capturing," ZIO's Blog (Medium), May 7, 2020..

Natural Language

Engineers capture reasoning in familiar, flexible format without rigid constraints.

Structured Elements

Formal knowledge representation enables automated traceability and impact analysis.

Model and Decision Drift

What if, **after** taking a decision:

- A requirement **changes**
- New opportunities **arise**
- The prioritization scheme of objectives **evolves**

→ We need to ensure **systematic revisiting** of the concerned decisions

Y-Statement Link to MBSE Concepts

In the context of <Building Block, Viewpoint, Disciplines, Design Activity>,

facing <Problem Statement: Risk/Opportunity, Task at hand>,

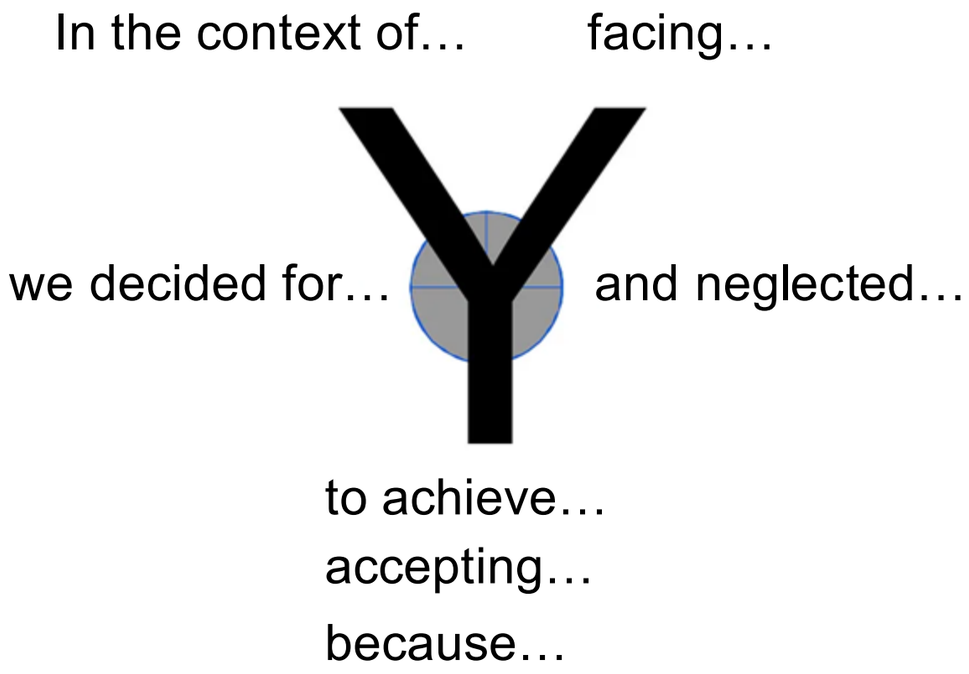
we decided for <Architecture and Requirement evolution>

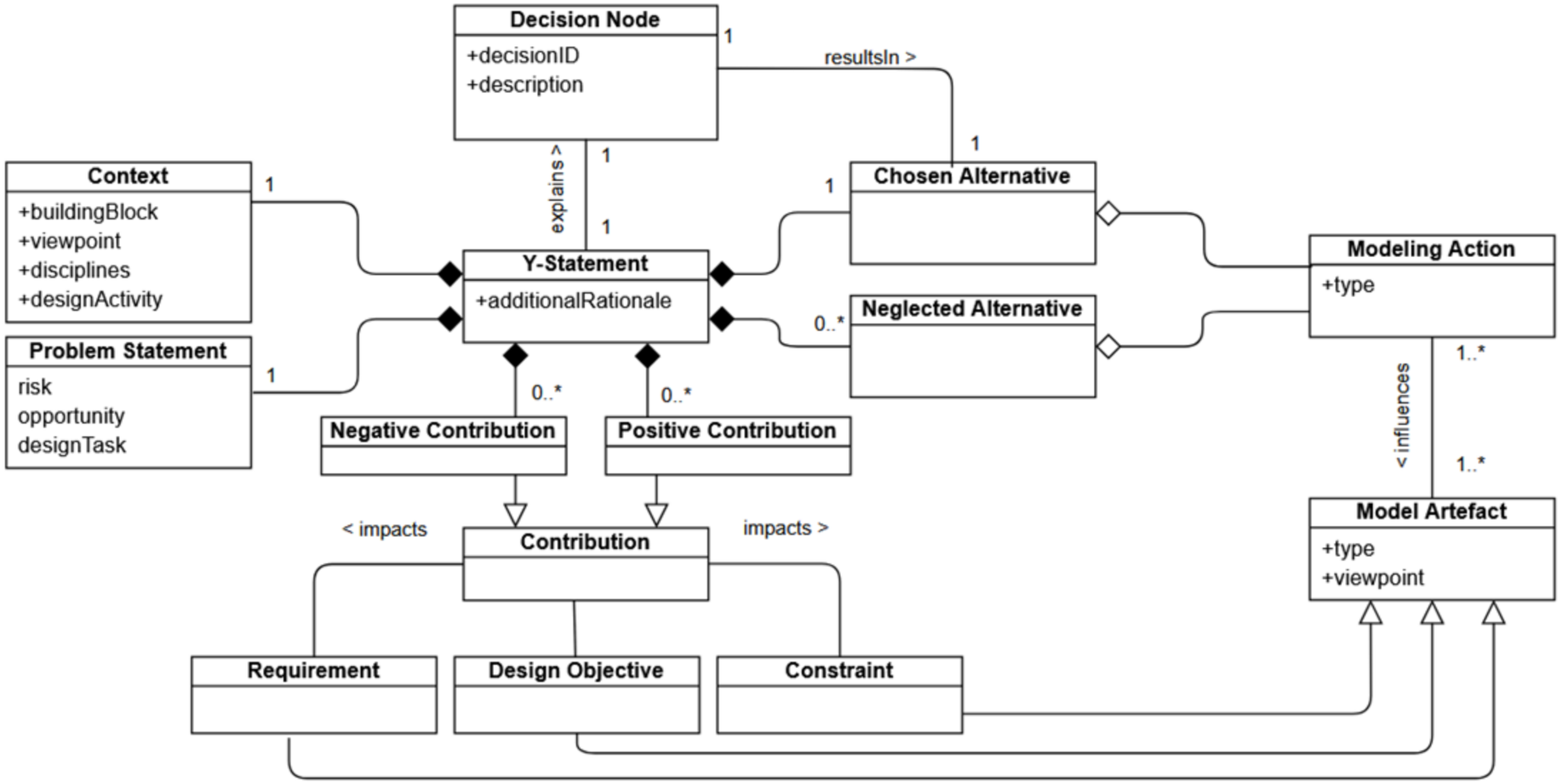
and neglected <Architecture and Requirement evolution>,

to achieve <Requirement, Design Objective, Design Rule>,

accepting <Design Objective, Constraint>,

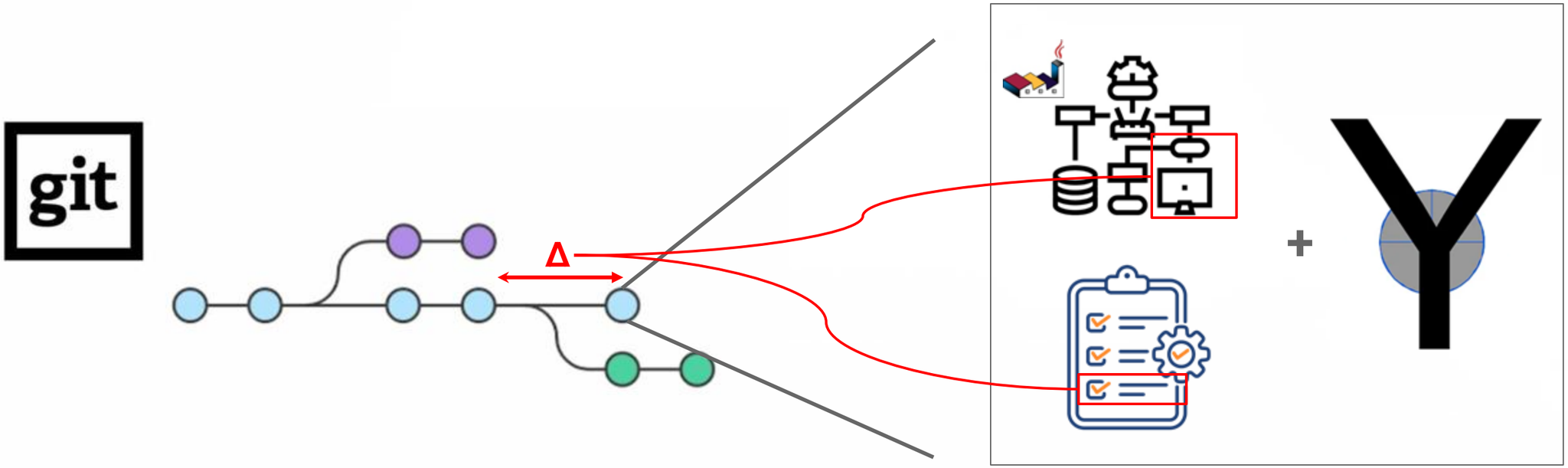
because <additional rationale>.





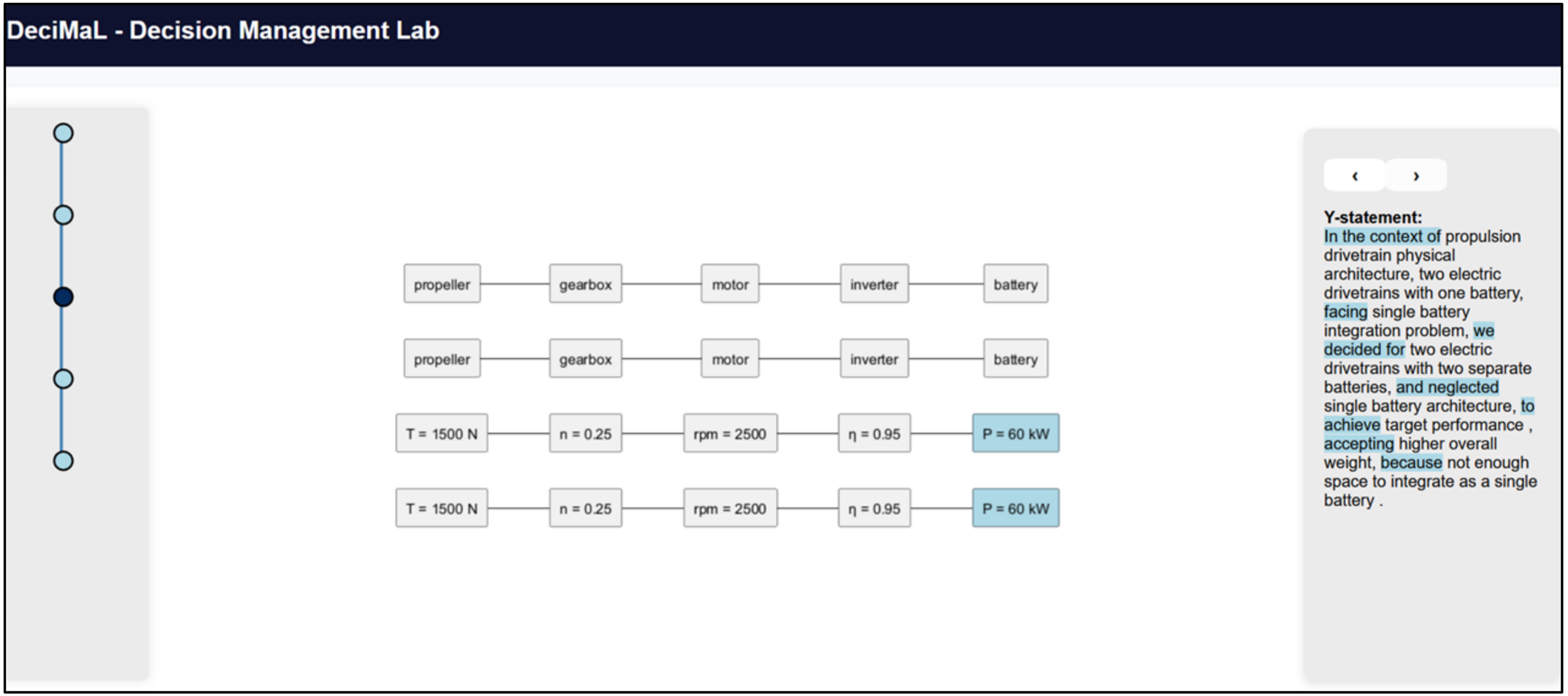
Conceptual Model

Y-Statements serve as the central entity that links all the MBSE elements relevant to the decision.



Implementation

Each decision directly triggers changes in the system architecture and requirements, creating traceable evolution paths through structured Decision Nodes.



Evaluation: PoC Tool Demonstration

Same propulsion example, Y-Statements only textual

Evaluation Results

Feedback from Airbus systems engineers, modelers, and architects through tool demonstrations:

✓

Evolution Tracking

Commit history effectively describes design evolution progression.

✓

Enhanced Traceability

Y-Statements provide lightweight, valuable format for capturing decision rationale.

Cost-Value Balance

Importance of balancing effort with generated value.

Limitations & Future Work

Current Limitations

- Full mapping to MBSE not yet validated
- Only sequential decision examples considered
- Y-Statement capture can still be burdensome

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Future Directions

- Investigate decision dependencies
- Automatic completion and suggestions
- More comprehensive cost-benefit evaluation

Thank You

Questions?

Nidhal Selmi

PhD Candidate, IRIT

E-Mail: nidhal.selmi@irit.fr