Model-based system architecting

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System architects' challenges

System trends in high-tech

- Continuously evolving
- Series of 1
- Autonomous
- Systems of systems
- X as a service
- Parameters x 10

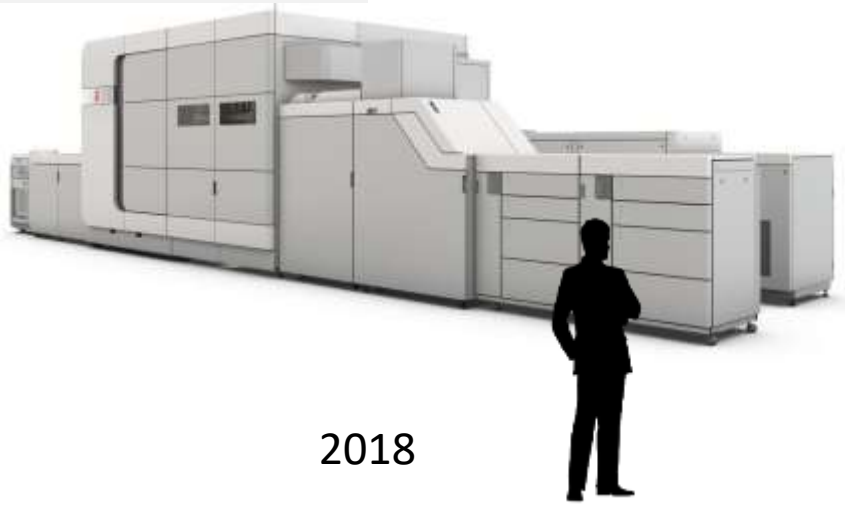
Global business and technology trends

- **Changing business models**
- **Increasing customization demands**
- **Data → AI**
- **Integration mobile-IT-embedded worlds**
- **Technology complexity increase**
- **Cybersecurity**
- **…**

1990

2005

2010



2018

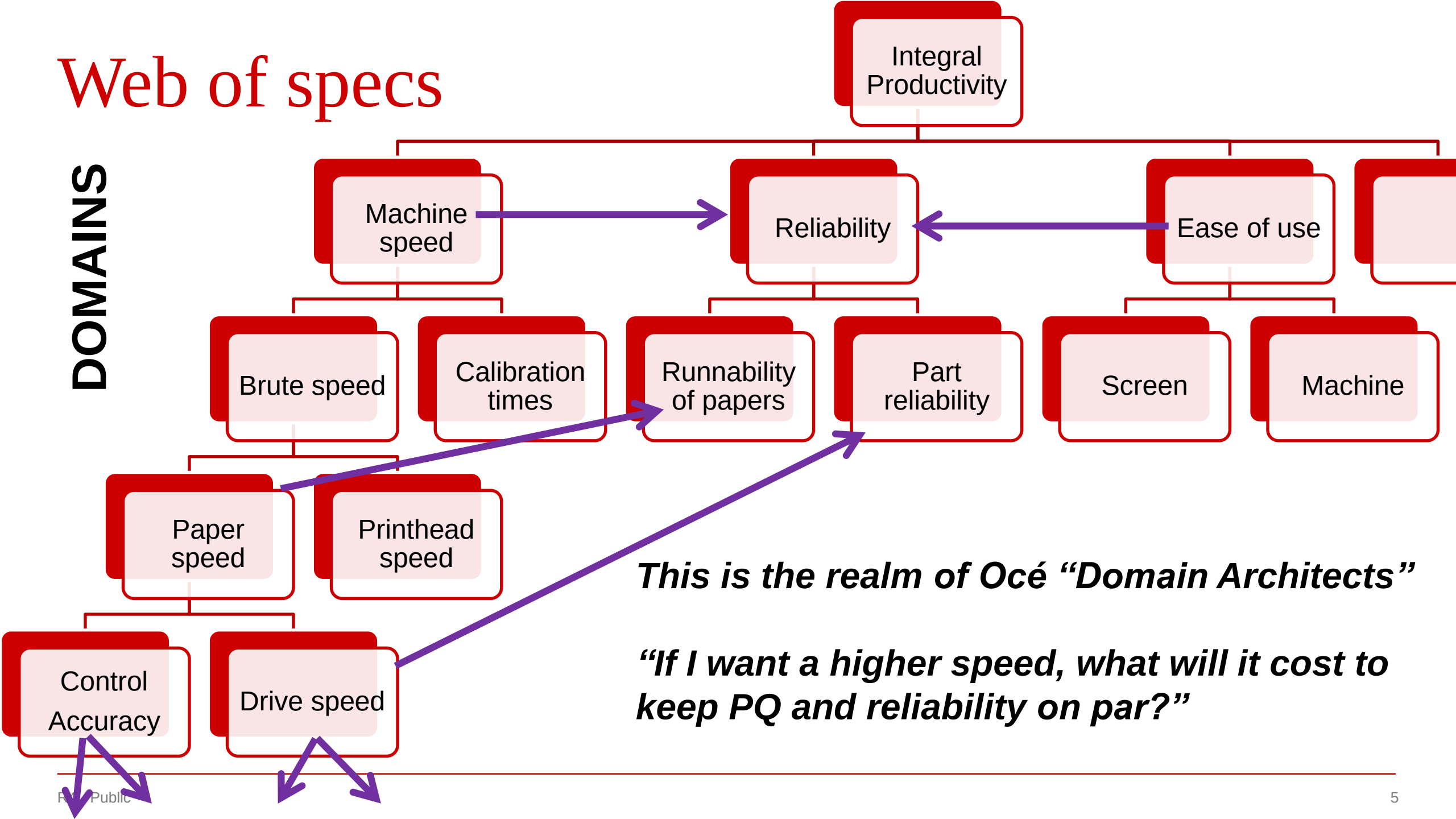
Our first digital printer

- Speed
- Print Quality
- Cost price
- Ease of use

Explosion of specs

Integral productivity	• **Machine speed,** ease of use, reliability, workflow and support software
Application range	• **Print quality,** consistency, types of paper/media, in/outdoor
Total cost of ownership	• **Cost price,** lifetime and service cost, operator labour cost, floor space/electricity
more...	• Design, ergonomics, time to install/repair, safety, security, EMC/SI, emissions, etc.

Web of specs



This is the realm of Océ "Domain Architects"

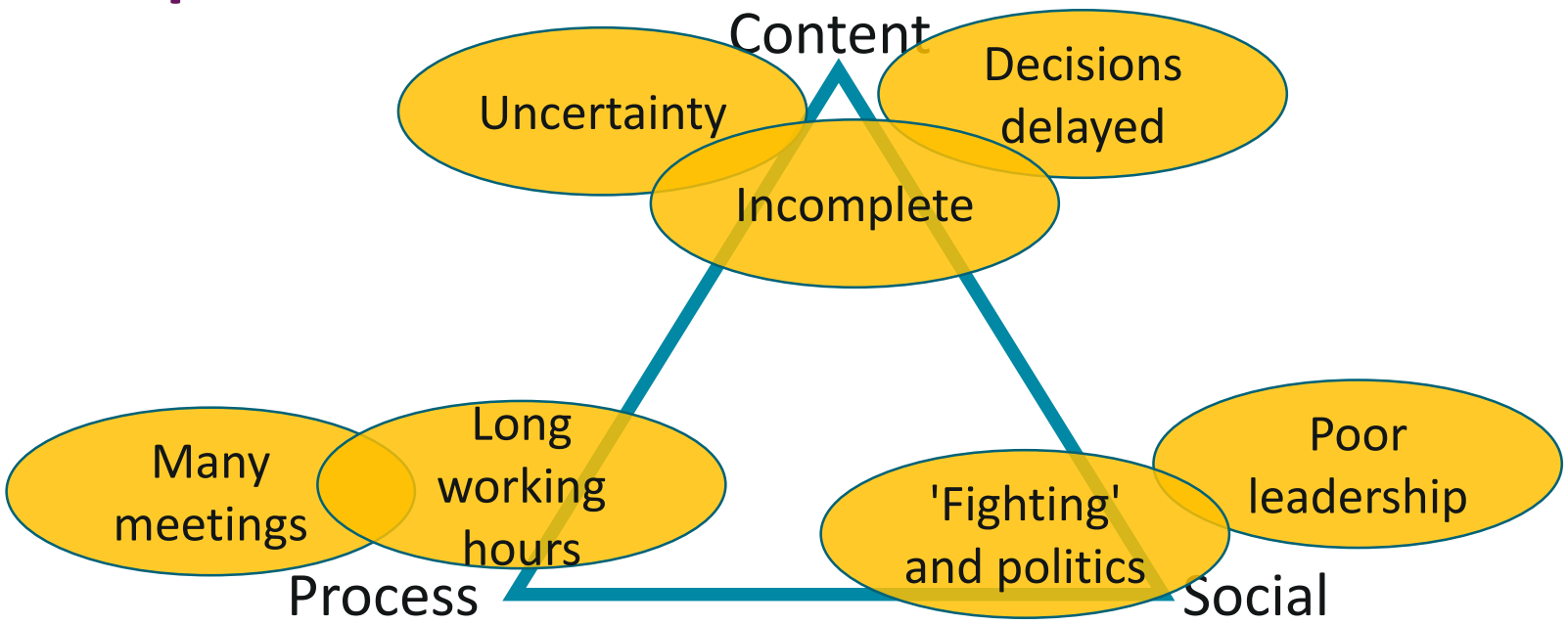
"If I want a higher speed, what will it cost to keep PQ and reliability on par?"

Océ challenges:

- How to control product specs in a structured way?
- How to juggle and balance specs, matching solution space and problem space?
- How to do this for a LOT of specs?
- Incl. cost and including qualitative specs?
- We like to model and connect the stuff to each other, but how?
- How to do all this in a truly multi-disciplinary way?

Architects in the squeeze...

Generic problem!



How to

get system overview? → ***"Too much for one brain!"***

keep a consistent system representation? → ***"Many, many stakeholders"***

understand consequences of decisions? → ***"Too many dependencies"***

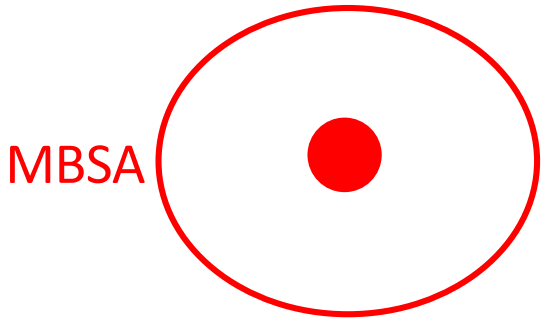
architect systematically? → ***"No concrete, operational methods"***

Model-Based System Architecting

A tool-supported decision making methodology for System and Domain Architects

Communication, connecting people with technical and business responsibility

By transparency and systematics



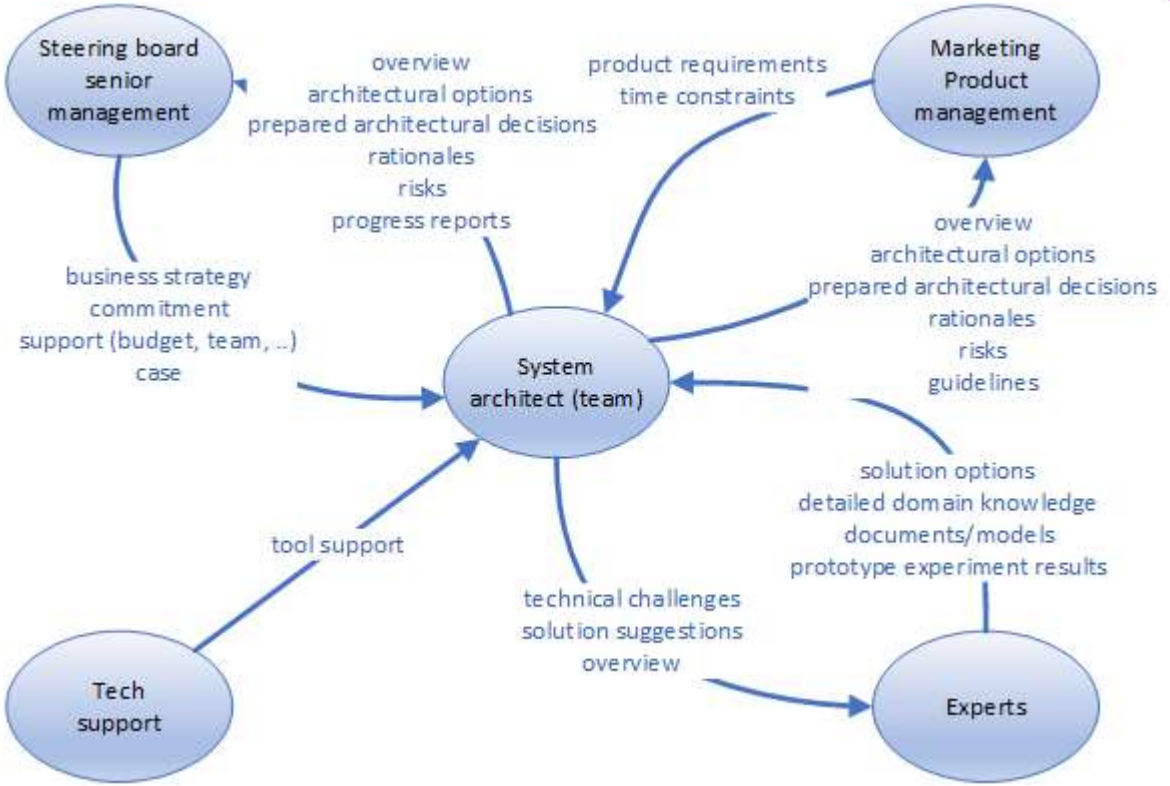
Early architecting phase

Lightweight (back of the envelope) reasoning

From qualitative to quantitative

Combining simple executable models

Organizing team architecting



- Goals
- Problem description
- Way of working (team, roles, role TNO-ESI)

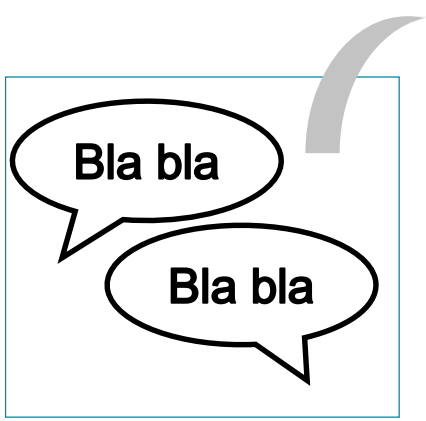
- CAFCR quick-scan
- Requirements, constraints
- Views, aspects
- Initial selection critical parameters

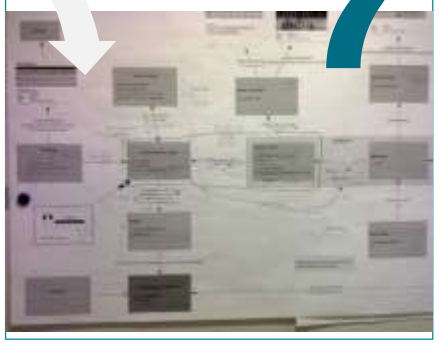
- Relations (*traffic lights*)
- Models, values, uncertainties
- Validation
- Options, concept solutions

- Agreement on current views
- Formalize decisions
- Present results and rationales

Bootstrap | **Startup** | **Reflect & Refine** | **Finalize** | **Maintenance**

Organizing architecting process

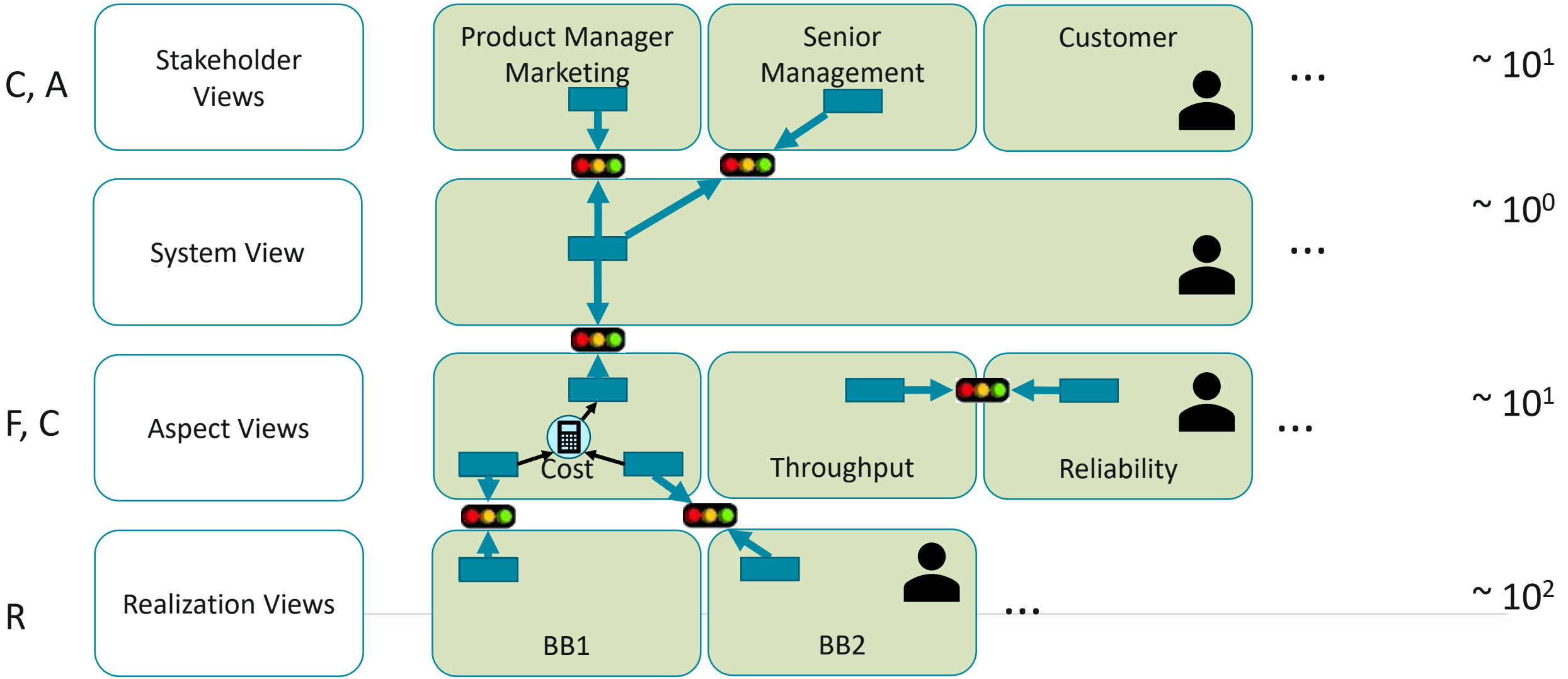




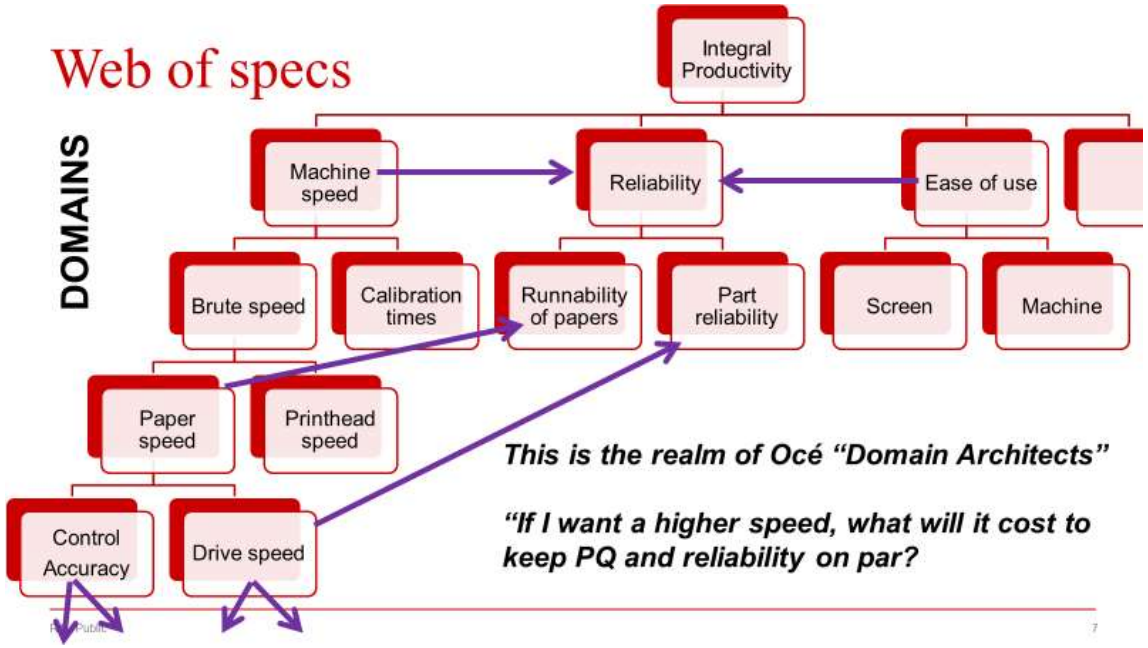
Office tools
Presentations
A3 overviews
Documents

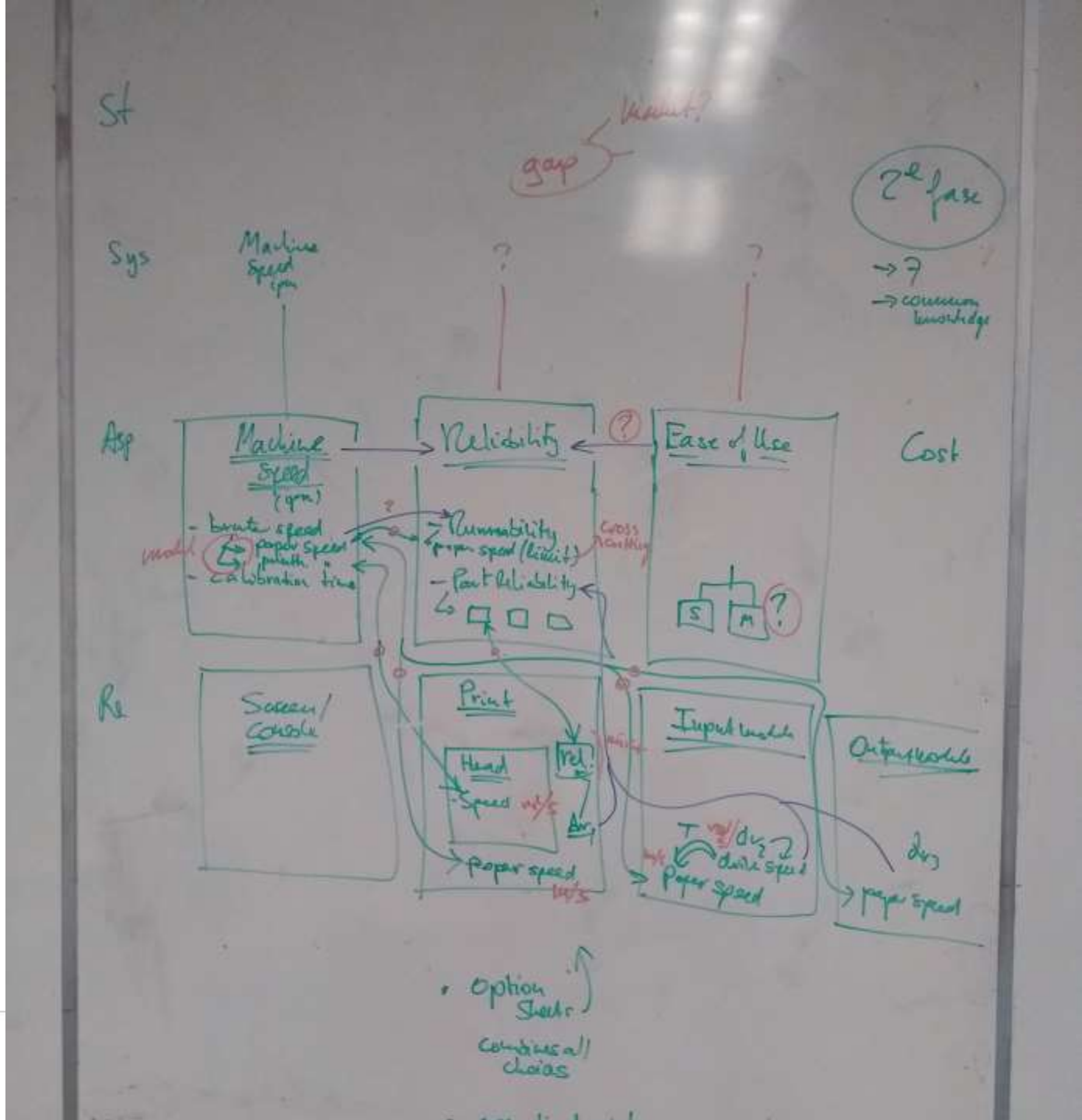
Design Framework
Multi-user
Connected information
Simple executable models

Organizing the architectural knowledge

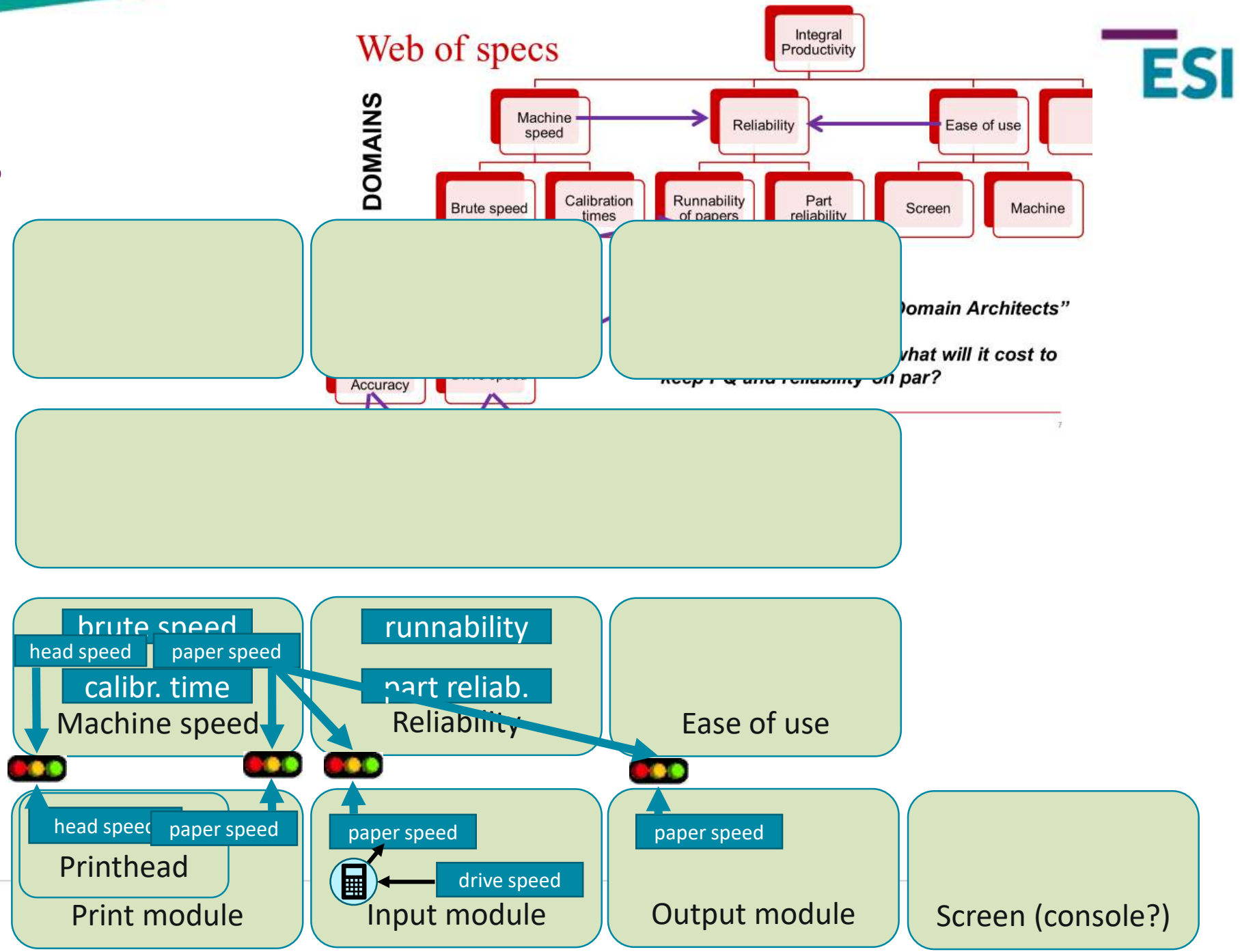


Océ web of specs

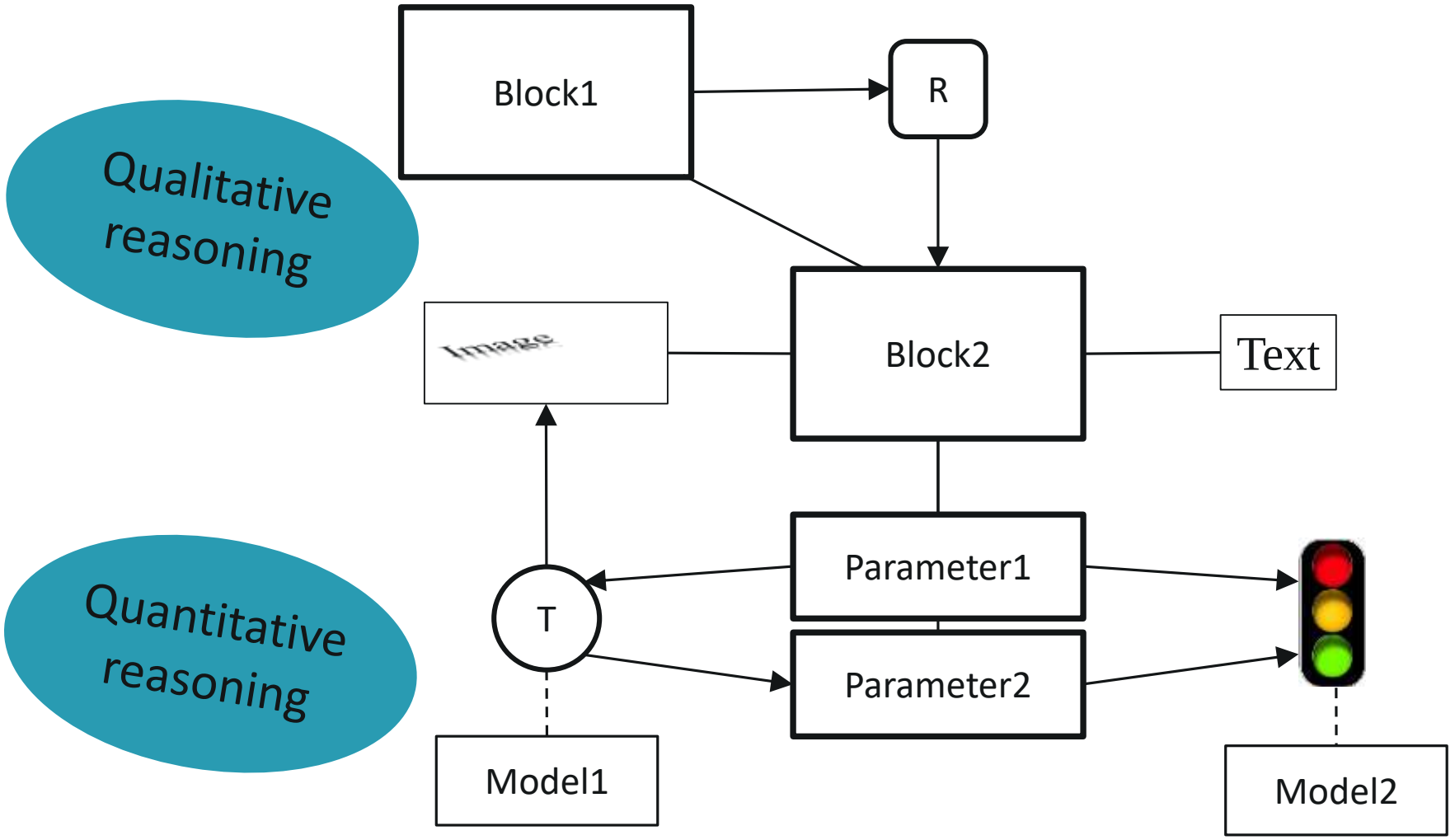




Océ web of specs



Architecting language elements



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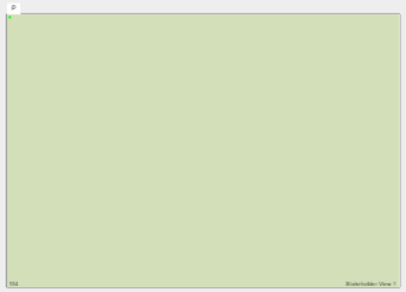
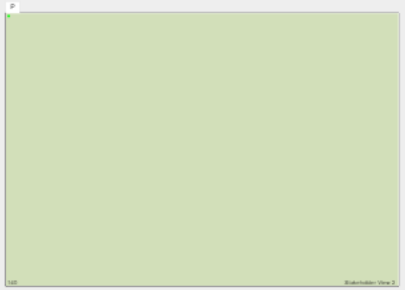
Stakeholder Views

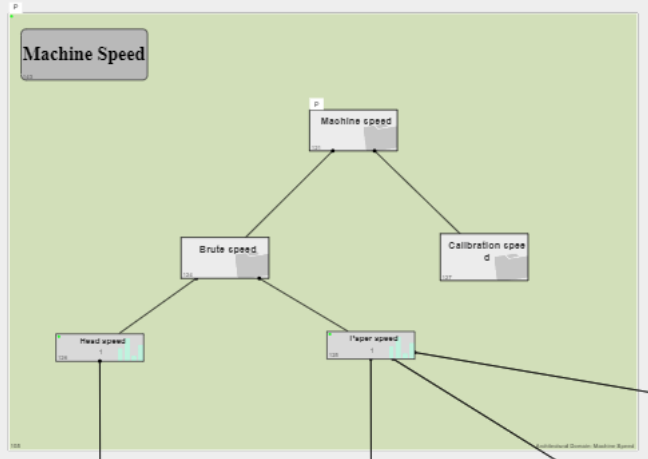
System View

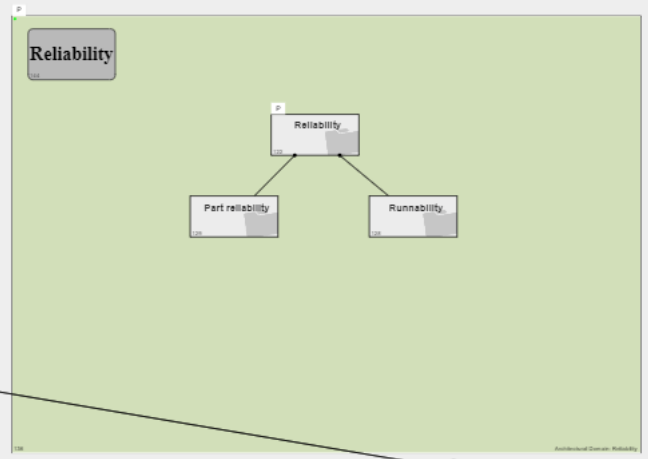
Aspect Views

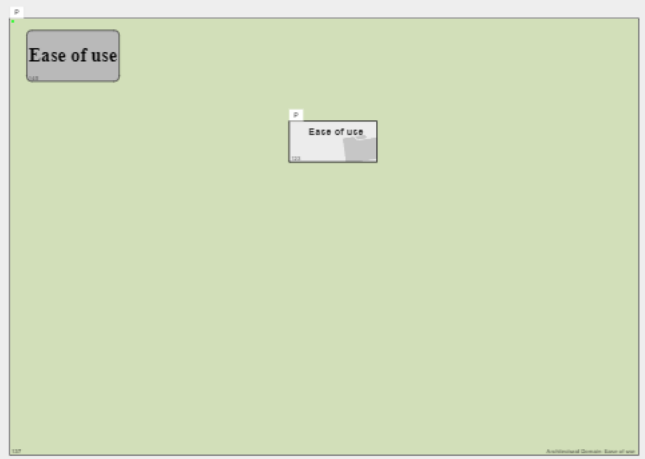
Realization Views

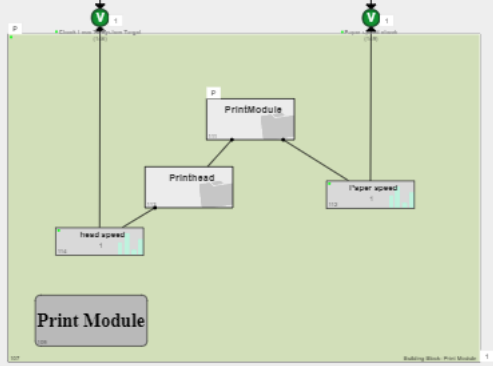


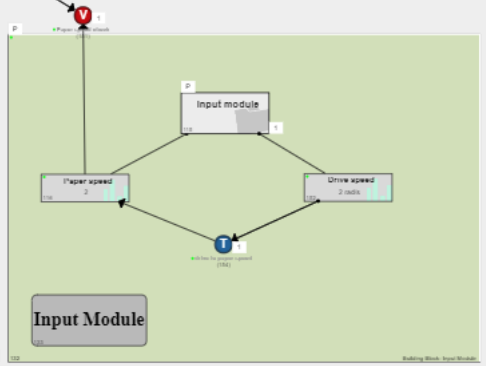


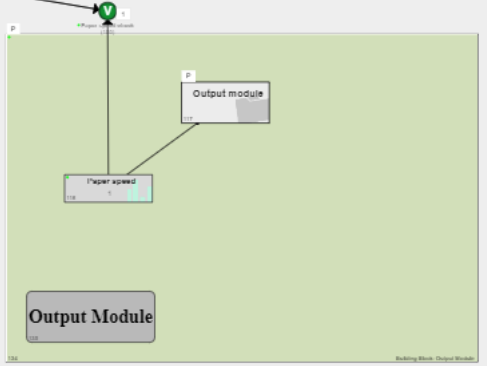












Challenges

No free lunch: investment in creation of models

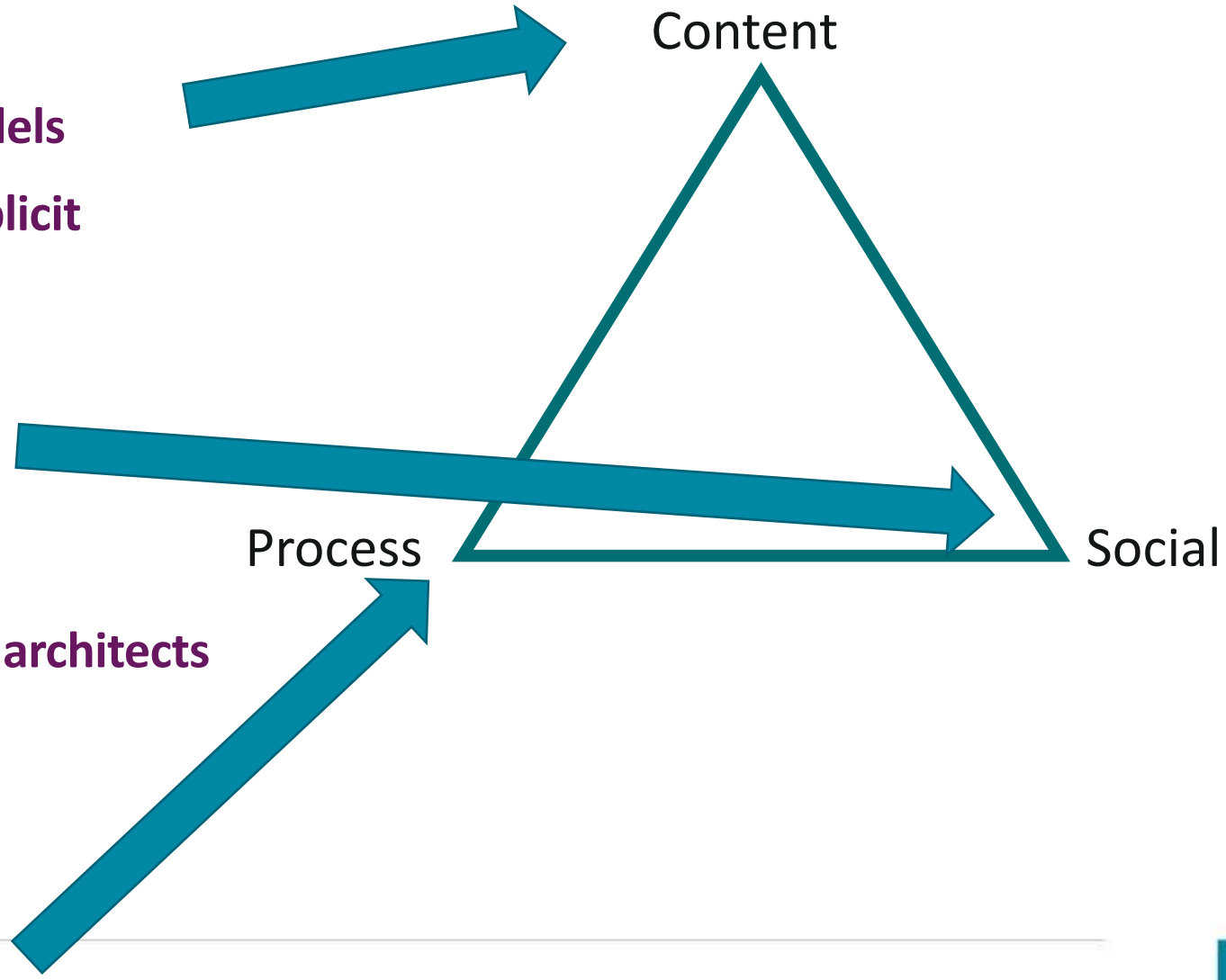
- **Knowledge is in heads, must be made explicit**

Culture change

- **Change towards transparency**
- **From local heroes to team players**
- **Education and personal growth for junior architects**

Change of existing way-of-working

- **Fit to company processes and tools**
- **Away from document-based processes**



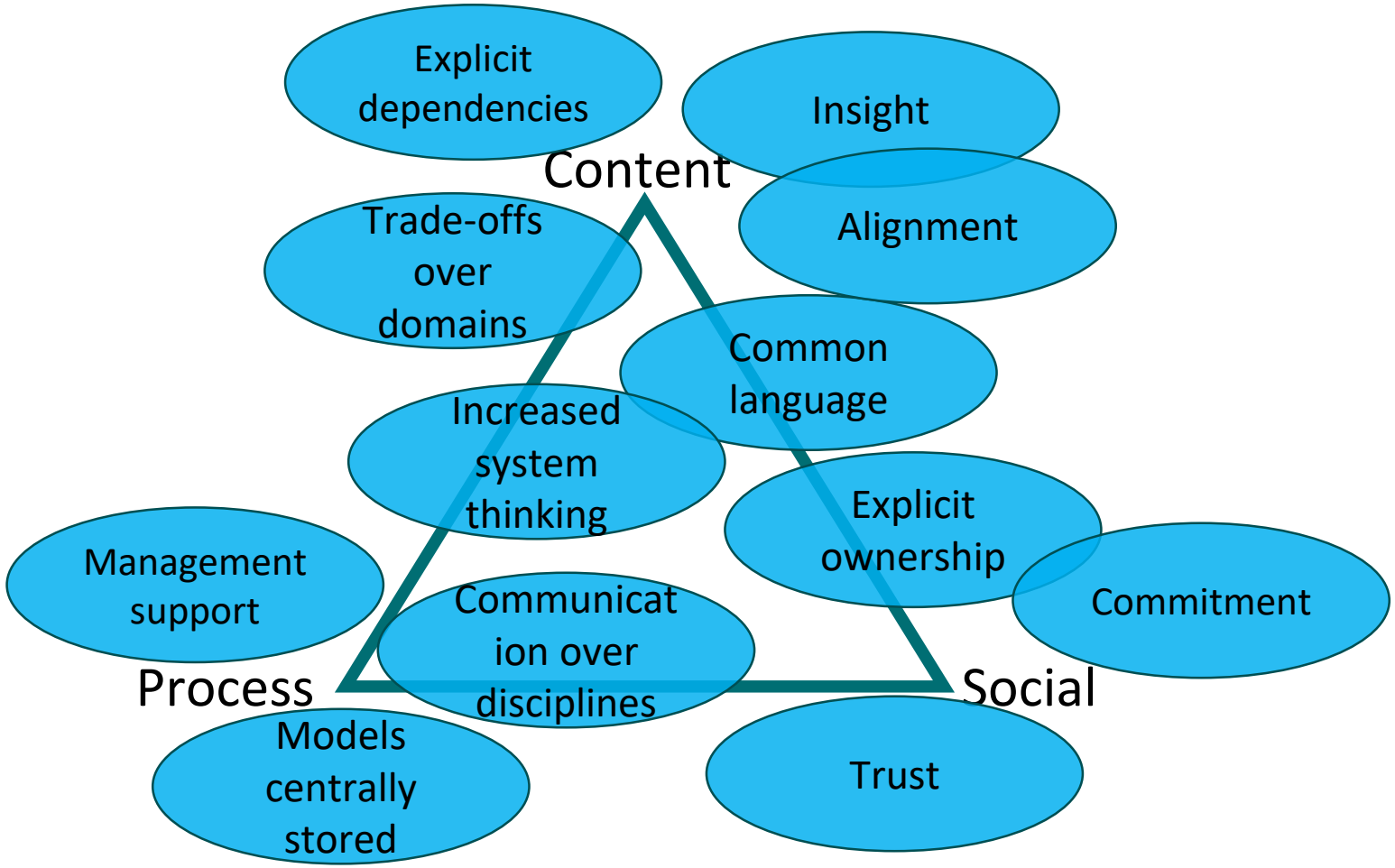
Benefits

get system insights and overview

keep a consistent system representation

understand consequences of decisions

architect systematically



Evaluation results

An initiative of industry, academia and TNO

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Back-up slides: Model-based system architecting

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Wouter Tabingh Suermondt

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What is new?

System architecting process with *exploitation of the transparency of models*

- **The process of creating models is as important as the final result**
- **Connecting models across domains**
- ***Analysis of system (aspect) models* and the *architectural reasoning* for identifying risks and architectural decision making**

Complexity is handled by combination of a large number of simple models

ARCHITECTURE AND TECHNOLOGY

Frond End
- Web-app based
- Chrome (not specific)
- JavaScript (ES6): 26k sloc
- React
- Redux

Interface: RESTful (HTTP)

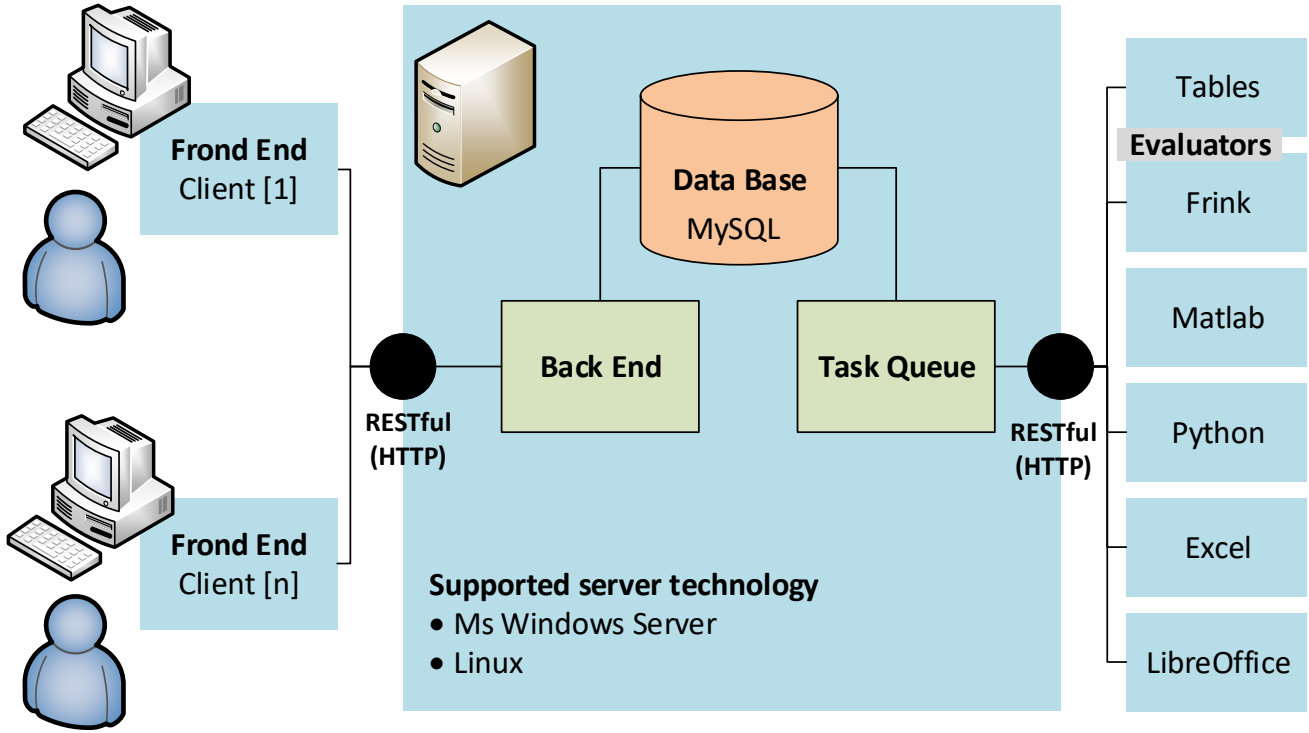
Back End
- Apache
- MySQL
- PHP: 12k sloc
- Phalcon
- Linux, Windows server

Interface: RESTful (HTTP)

Evaluators
- Java
- Python
- C#

Development
- Webpack
- Jenkins
- ESlint
- NPM
- Composer

Test
- BDD Gherkin, Behat, Selenium.
- Back end (1800)
- Front end (380)



Dashboard

Stakeholders

Entrepreneur

Grid Capacity Planner

Representative of Citizens

System Parameters

Architectural Views

Levelized Cost Of Electricity [€/MWh]

Power Generation [MW]

Noise Pollution [..]

Building Blocks

Wind Farm

Wind Turbine

Noise pollution domain

KPA Demo Index
125
1965

Location
ZuidelijkFl → Vlissingen
1859 Input 4

Check Location
(1872)

Location
ZuidelijkFl → Vlissingen
1863 Input

Calculate Distance To Citizens
(1869)

Distance To Citizens
1866 0 → 1 Result

System Parameters
1505 Architecting, Océ 26

Calculate Effective Noise Level
formula model
1903

Calculate Effective Noise Level
(1870)

Effective Noise Level
1904 2 → 0 Result

Check System Noise Acceptance
(1871)

Allowed Noise Level
1802 2 → 0 Input 1

Turbine Noise Level
1897 1 Result 1

Check Wind Turbine Noise
(1874)

Turbine Noise Level
1862 1 Input

Calculate Wind Farm Noise Level
(1868)

Farm Noise Level
1865 2 Result

Number Of Wind Turbines
1348 30 Input 4

Check Number Of Wind Turbines
(1873)

Number Of Turbines
1864 30 Input

Noise levels can be expressed in [dB]. However currently we don't have hard values, so we use a kind of weighted score which represents the noise level.

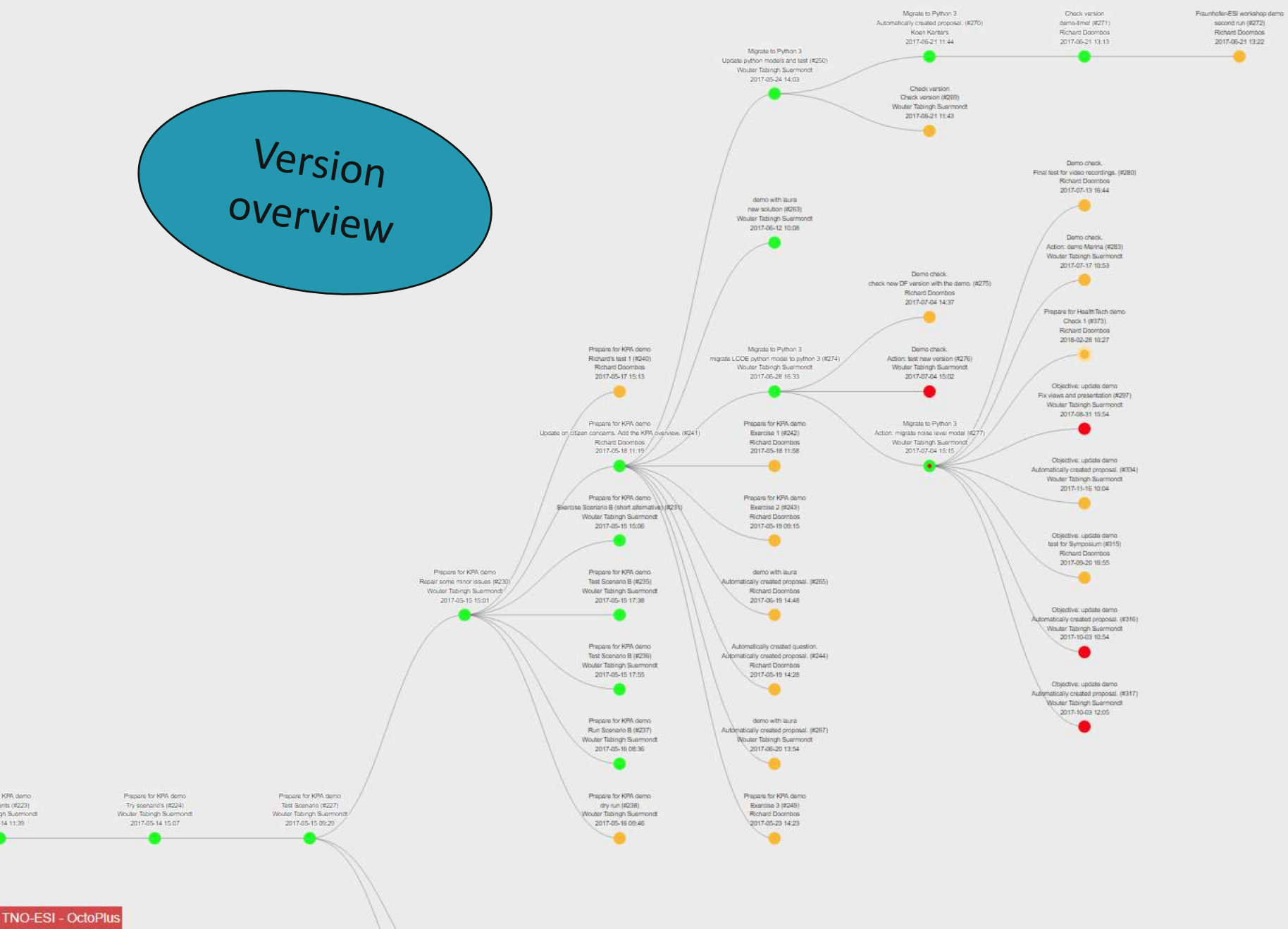
- +2: much more than background level
- +1: more than background level
- 0: comparable with actual background level at indicated location
- -1: less than background level
- -2: far less than background level

1945

System Parameters
90
1857

1896
Architecting Domain: Wind Farm Noise

Version overview



Summary of Design Framework features

Few basic concepts

Calculation propagation, consistency checks (traffic lights), generation of graphs, linking of views

Interoperability with external modeling tools

Central storage (single source)

Multi-user, web-based

Industry scalable

Versioning


Wind Farm
Cost
location
Societal acceptance
Infra-structure

Stakeholders

Entrepreneur




Grid Capacity Planner

Representative of Citizens


System Parameters

System Architect

Architectural Views

Levelized Cost Of Electricity [€/MWh]


Power Generation [MW]

Noise Pollution [..]

Building Blocks

Wind Farm


Wind Turbine

Stakeholders

Entrepreneur




Renewable energy
Wind or Photo voltaic?

Grid Capacity Planner

Unpredictable,
Grid stability

Representative of Citizens


Noisy!
Not in my backyard

System Parameters

System Architect

How to deal with concerns and technology?

Architectural Views

Levelized Cost Of Electricity [€/MWh]


How to make the plant competitive?


Power Generation [MW]

How to deliver the maximum power performance?

Noise Pollution [..]

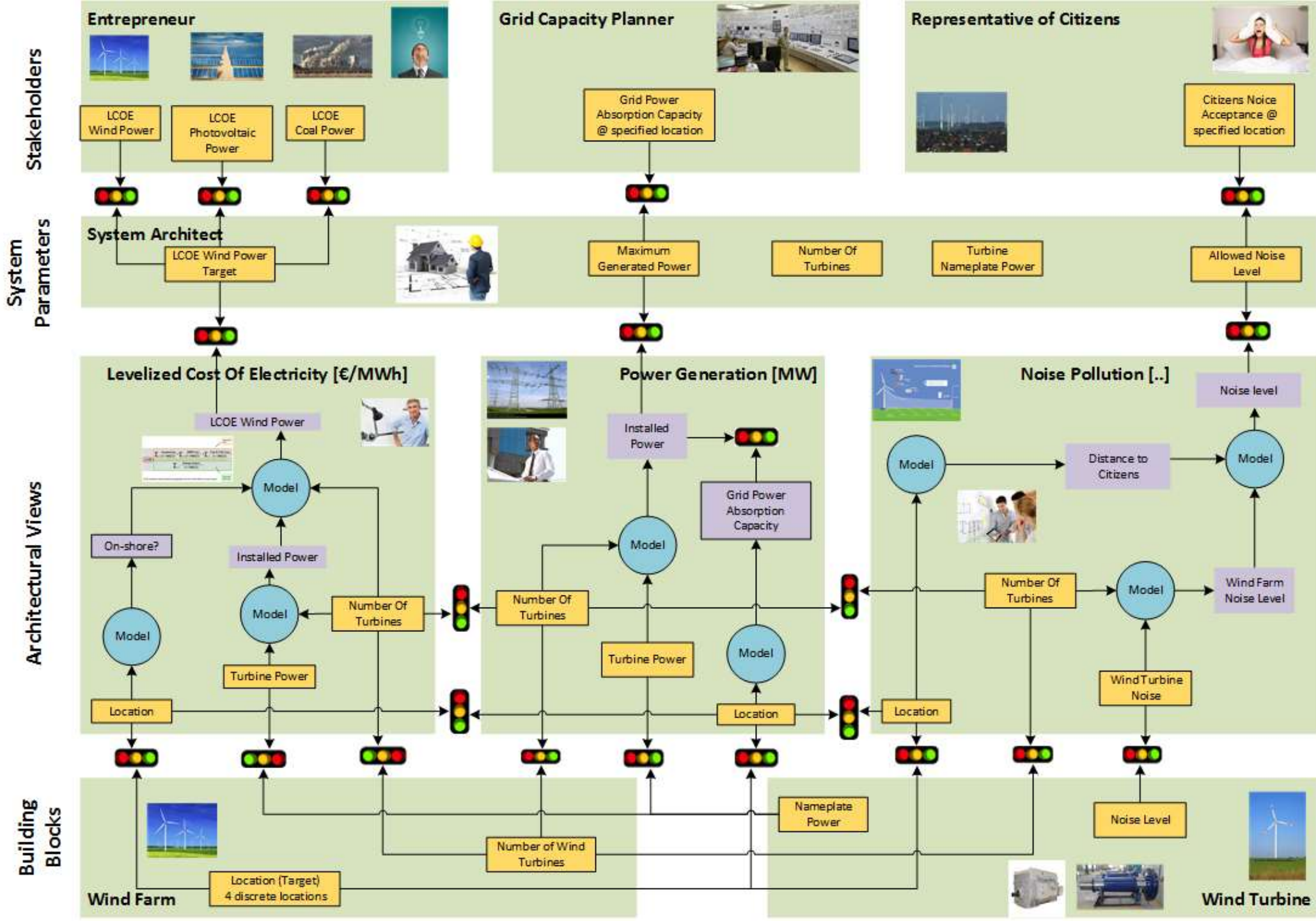
How to keep noise within acceptable level?

Building Blocks

Wind Farm



Wind Turbine


Stakeholders
System Parameters
Architectural Views
Building Blocks
Entrepreneur
LCOE Wind Power
LCOE Photovoltaic Power
LCOE Coal Power
Grid Capacity Planner
Grid Power Absorption Capacity @ specified location
Representative of Citizens
Citizens Noice Acceptance @ specified location
System Architect
LCOE Wind Power Target
Maximum Generated Power
Number Of Turbines
Turbine Nameplate Power
Allowed Noise Level
Levelized Cost Of Electricity [€/MWh]
LCOE Wind Power
Model
On-shore?
Installed Power
Number Of Turbines
Turbine Power
Location
Power Generation [MW]
Installed Power
Grid Power Absorption Capacity
Noise Pollution [..]
Noise level
Distance to Citizens
Wind Farm Noise Level
Wind Turbine Noise
Wind Farm
Location (Target) 4 discrete locations
Number of Wind Turbines
Nameplate Power
Noise Level
Wind Turbine