

Development of a Web Based Application for the Implementation of an Integrated System Health Management (ISHM) Certification Process

Master Thesis Final Presentation

MD Mushfiqur Rahman

25.01.2016

Software Engineering für betriebliche Informationssysteme (sebis)

Fakultät für Informatik

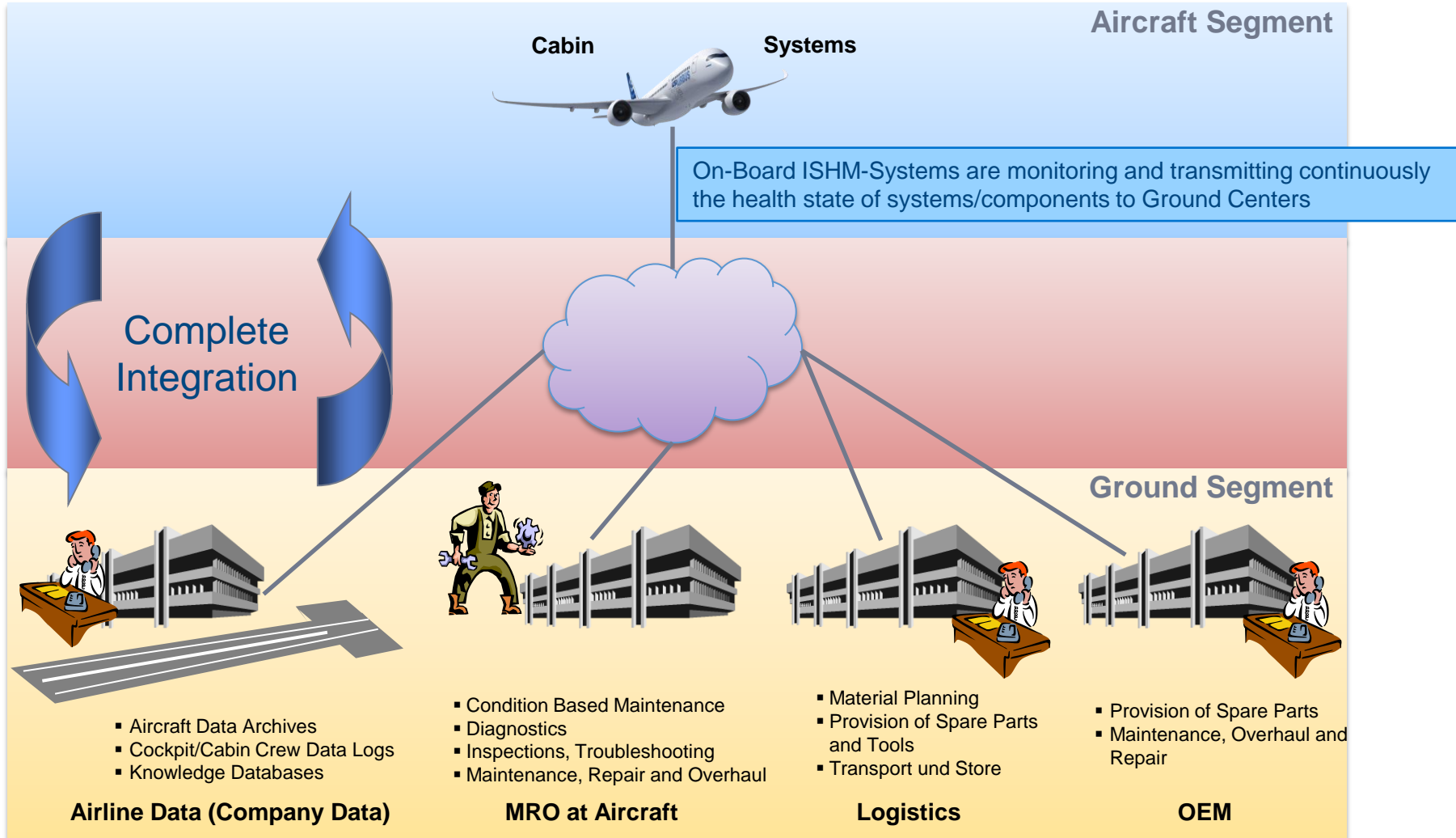
Technische Universität München

www.matthes.in.tum.de

1. **Motivation**
2. **Research Questions**
3. **Mx Credit Process Details**
4. **Existing Process Modelling and Execution Tools**
5. **Implementation Details**
6. **Live Demo**
7. **Evaluation**
8. **Conclusion & Future work**



ISHM - Integrated System Health Management



- With the integration of ISHM systems into new developed aircraft, new methods of aircraft maintenance are required.
- ISHM include diagnostics and prognostics approaches, which form the basis for a Maintenance Credit.
- A Maintenance Credit is characterized by an approval to an ISHM-System, that adds to, replaces, or intervenes in industry accepted maintenance practices (like inspections) to **improve** them.
- Introduced Maintenance Credits (Mx Credits) shall provide health **monitoring** and **prediction** capabilities to support advanced **diagnostics** and **prognostics** of aircraft systems/components.

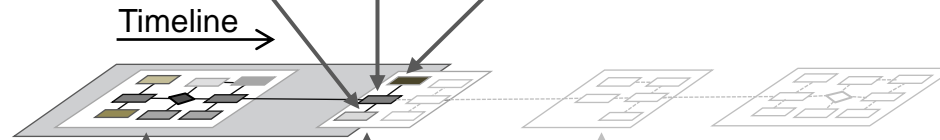
Presentation - UI

Content Inputs/Outputs, Process View,
Process Monitoring



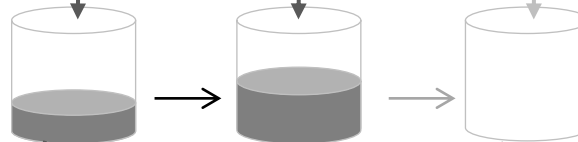
Mx Credit Process View

Process Execution



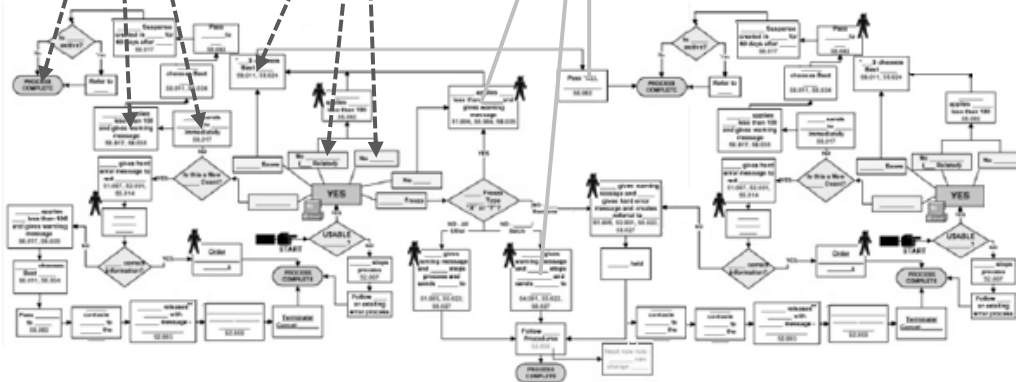
Mx Credit Process Repository

Content Storage

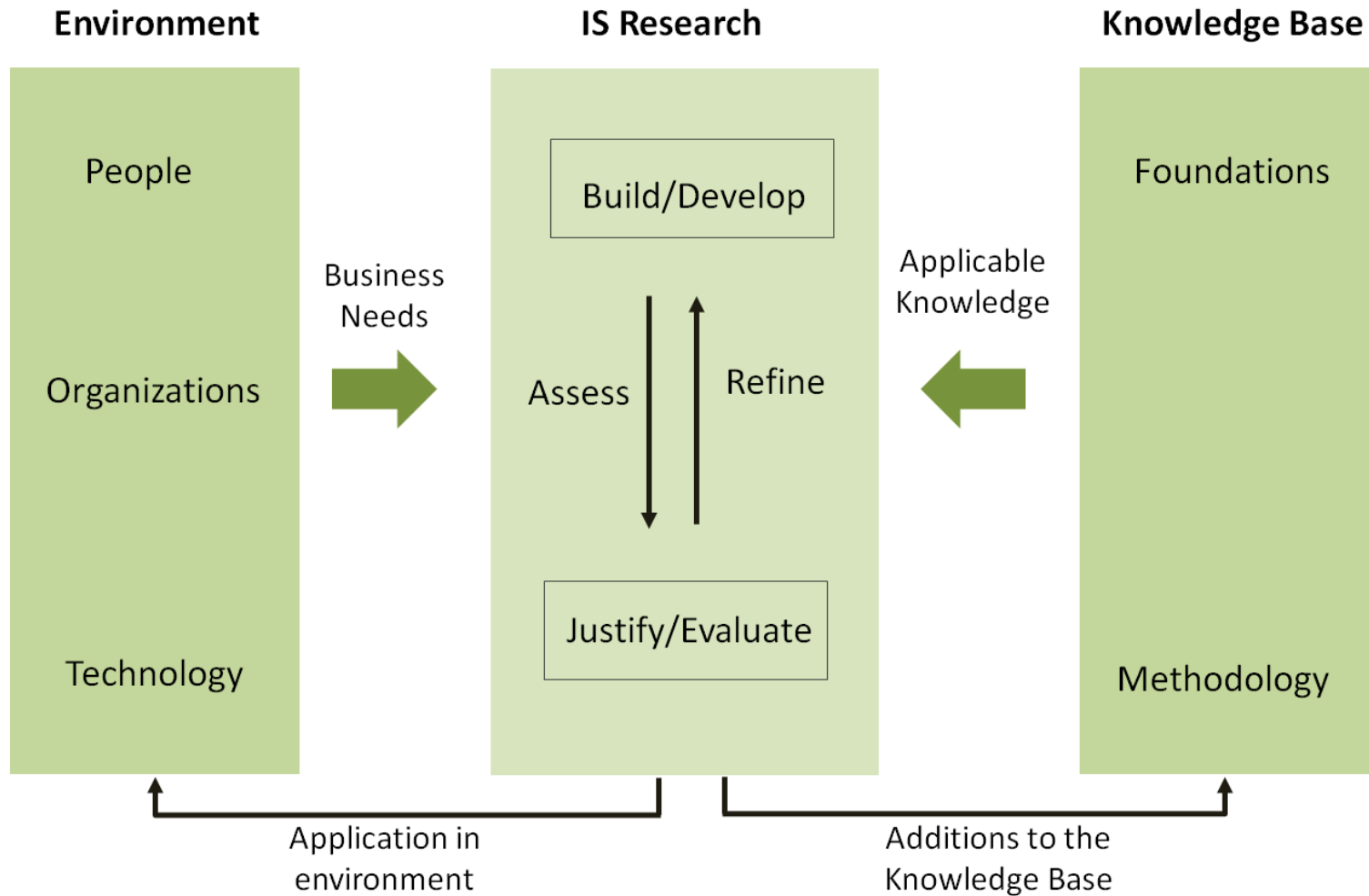


Complex Process Environment

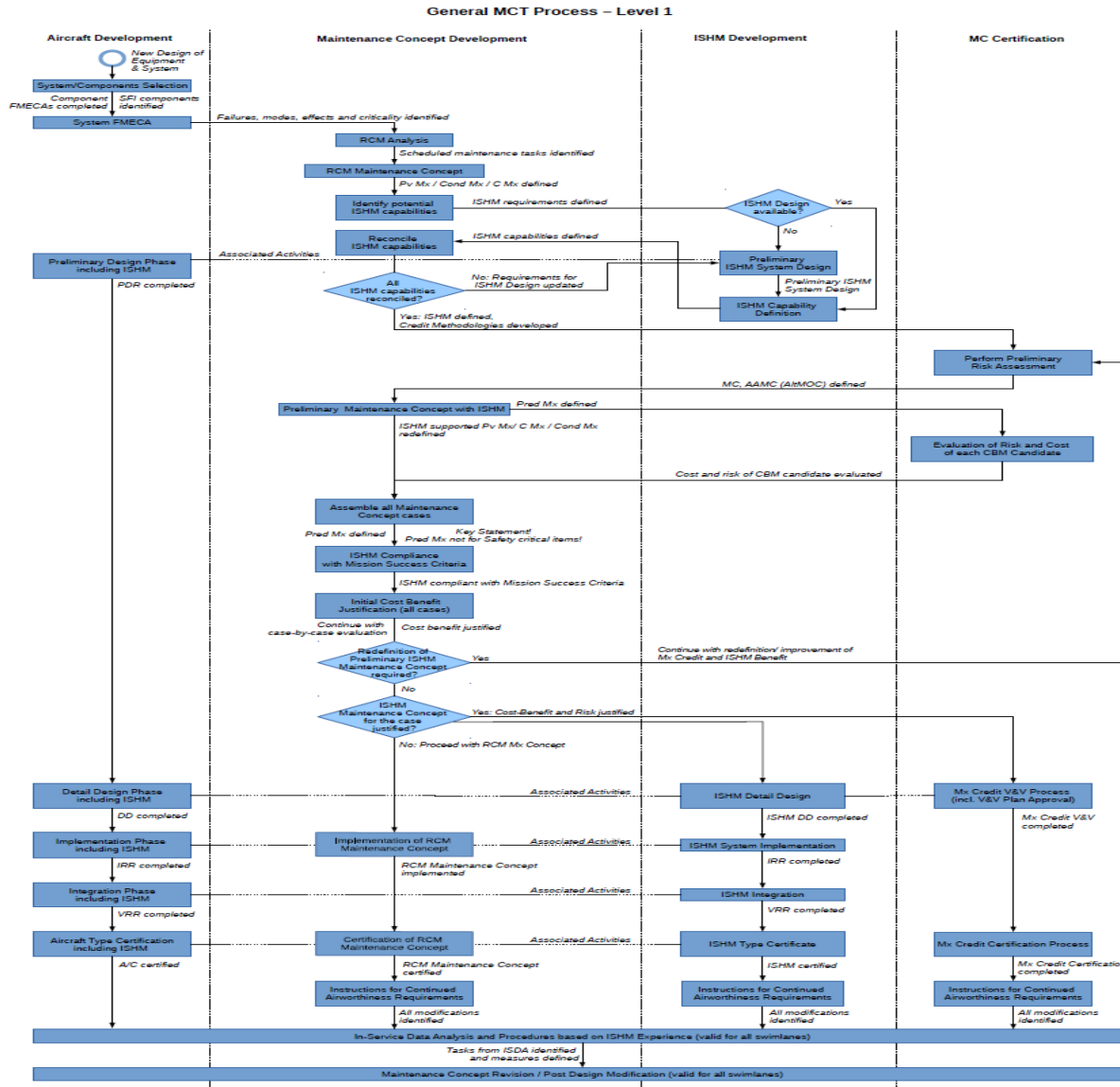
Product Development
Maintenance Concept
Development
ISHM Development
Mx Credit Certification



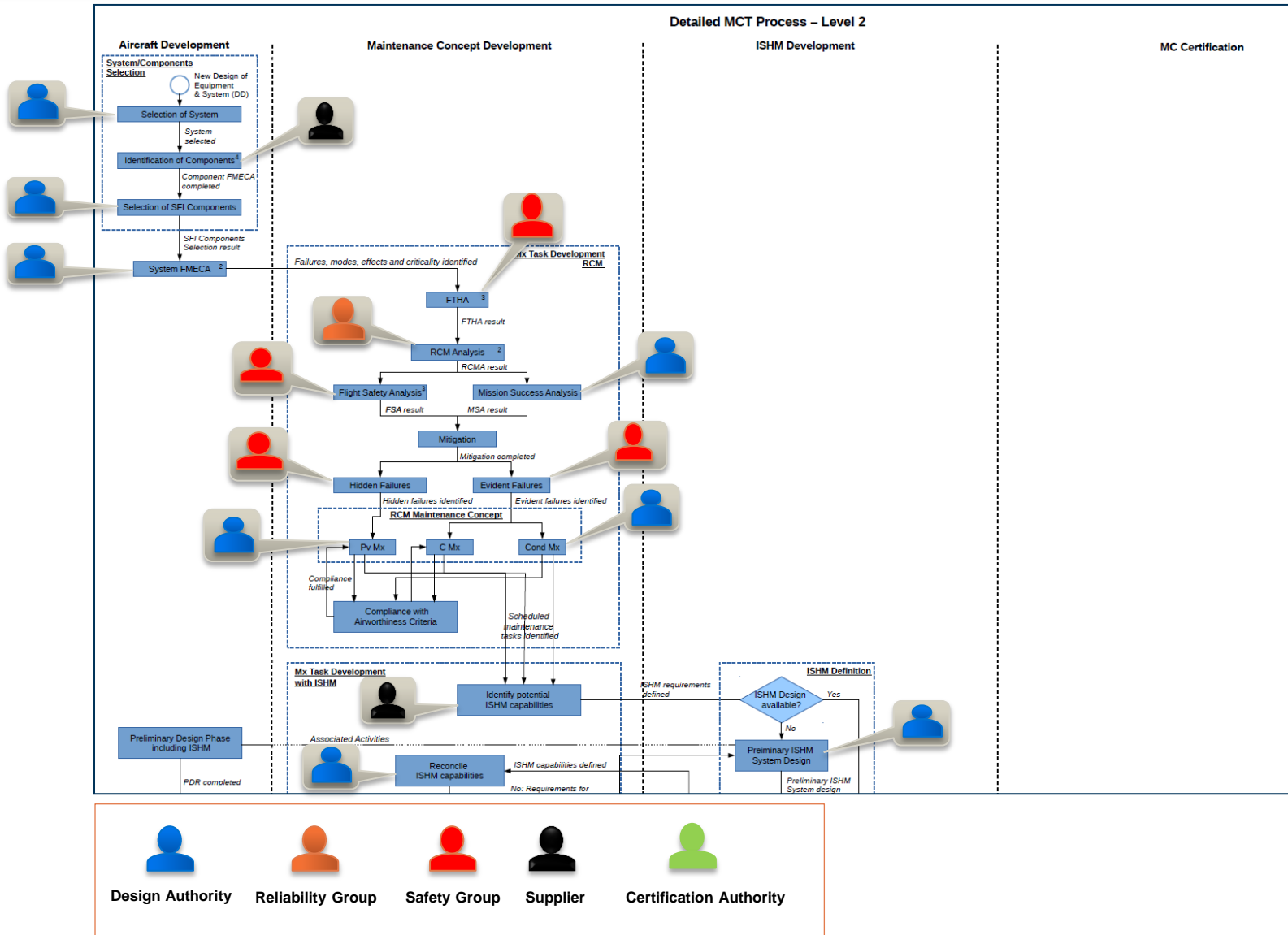
- **What are the state-of-the-art tools to model and execute process for modeling Mx Credit process ?**
- **What are the requirements for modeling the Mx Credit process ?**
- **How does the Mx Credit Framework (MCF) looks like?**
- **What are the specifications to evaluate proposed Mx Credit Framework adaptable with the requirements ?**

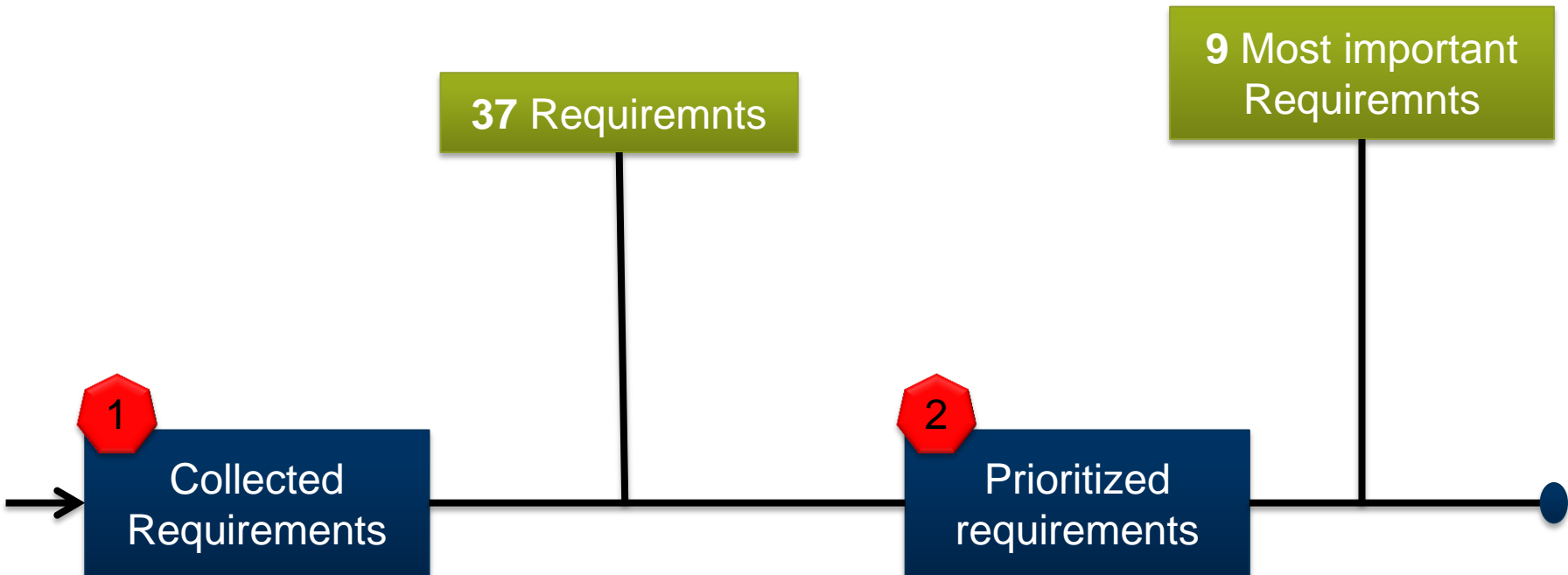


Detailed Mx Credit Process



Mx Credit Process- Involved Stakeholders



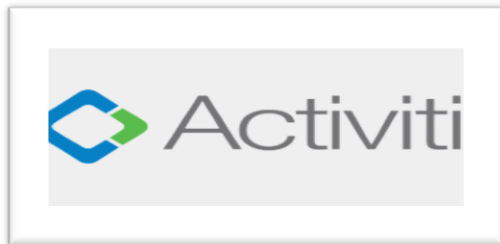


| No. | Requirement |
|-----|--|
| R1 | The Mx Credit Process Application shall provide during process execution access to all data and information related to the performed activities in the Mx Credit process. |
| R2 | The Mx Credit Process Application shall provide access to all descriptions (all required regulations and standards per activity) of the modeled Mx Credit process. |
| R3 | The Mx Credit Process application shall support the adding of content, annotations, data/documents (Upload) links and results at runtime for each process step. |
| R4 | The Mx Credit Process application shall provide rule-based process execution (e.g. after submit, application guides user to the next correspondent step). |
| R5 | The Mx Credit Process application shall provide access to complete Mx Credit Process data, including complete generated results per process step (after data submission in a process step no more changes are possible). |
| R6 | The Mx Credit Process application shall offer the functionality to implement a given Mx Credit Process model. |
| R7 | The Mx Credit Process application shall provide for specific process steps a functionality to add documents. |
| R8 | The Mx Credit Process application shall provide for specific process steps a functionality to add links (web links or links to data sources with a description). |
| R9 | The Mx Credit Process application shall provide for specific process steps the creation of tables, respectively rows, to modify and to delete them, if required. |

Important Aspects of the Mx Credit Process Framework





































- **Accessing** the model of the Mx Credit Process
- **Execution** of the Mx Credit Process at runtime, respectively **rule-based** process execution
- **Adding** of content, annotations, data/documents links and results at runtime for each process step
- **Traceability** of executed process at each point of time
- **Reporting** of results for specific process steps or grouped activities
- **Mx Credit Process history**, including complete generated results per process step
- **Navigation** of modeled, executed or logged process
- No **modifications or interventions from stakeholders (passive role)** to the existent complex process and the distributed data sources intended.

- A **State-of-The Art** study were conducted to identify potential process modelling solution taking into consideration the given requirement
- Business Process Modeling tools were analyzed in order to find out which features can be included in our application.







































Model Based User
Interface

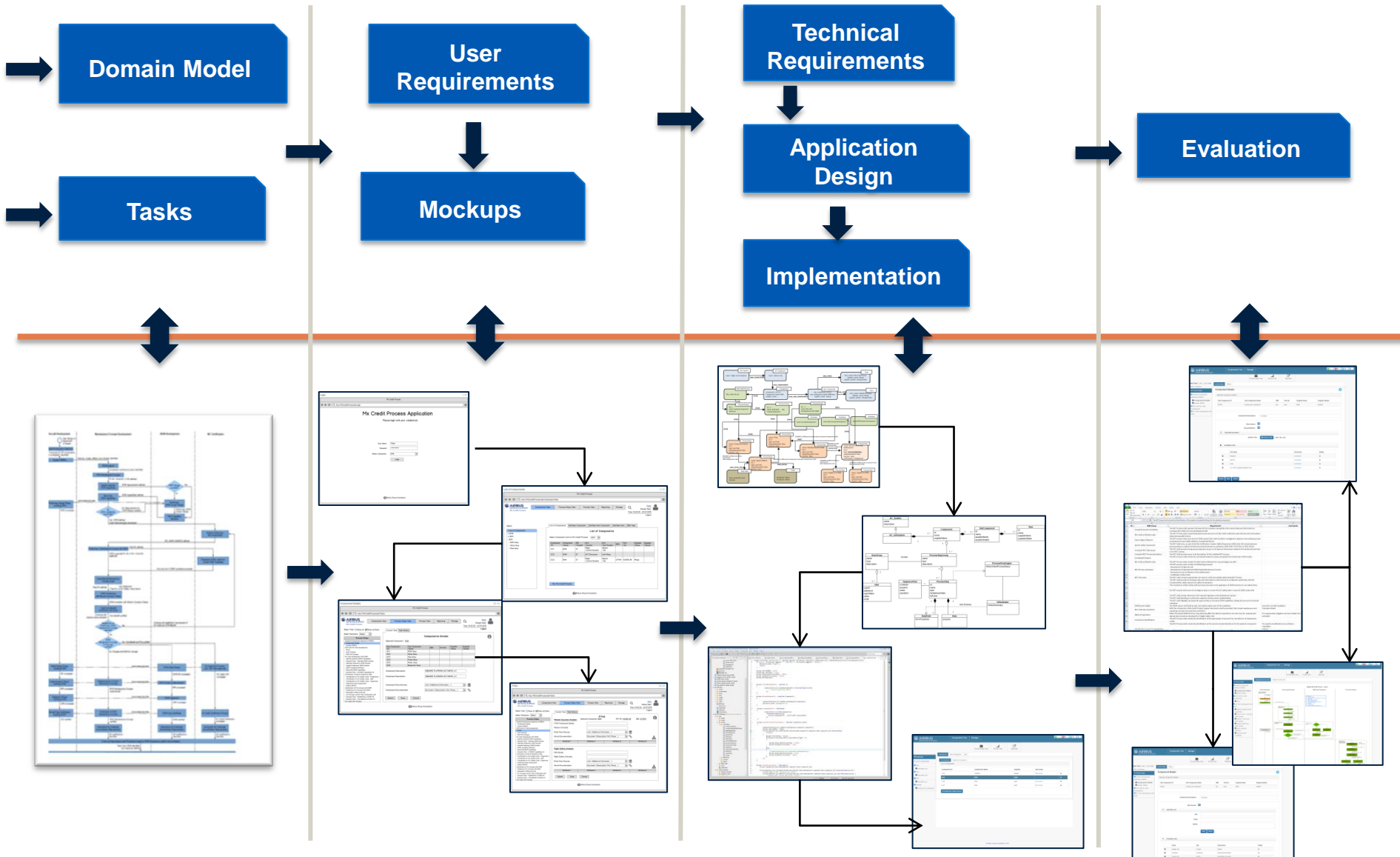
Comparison of Identified Technologies and Tools

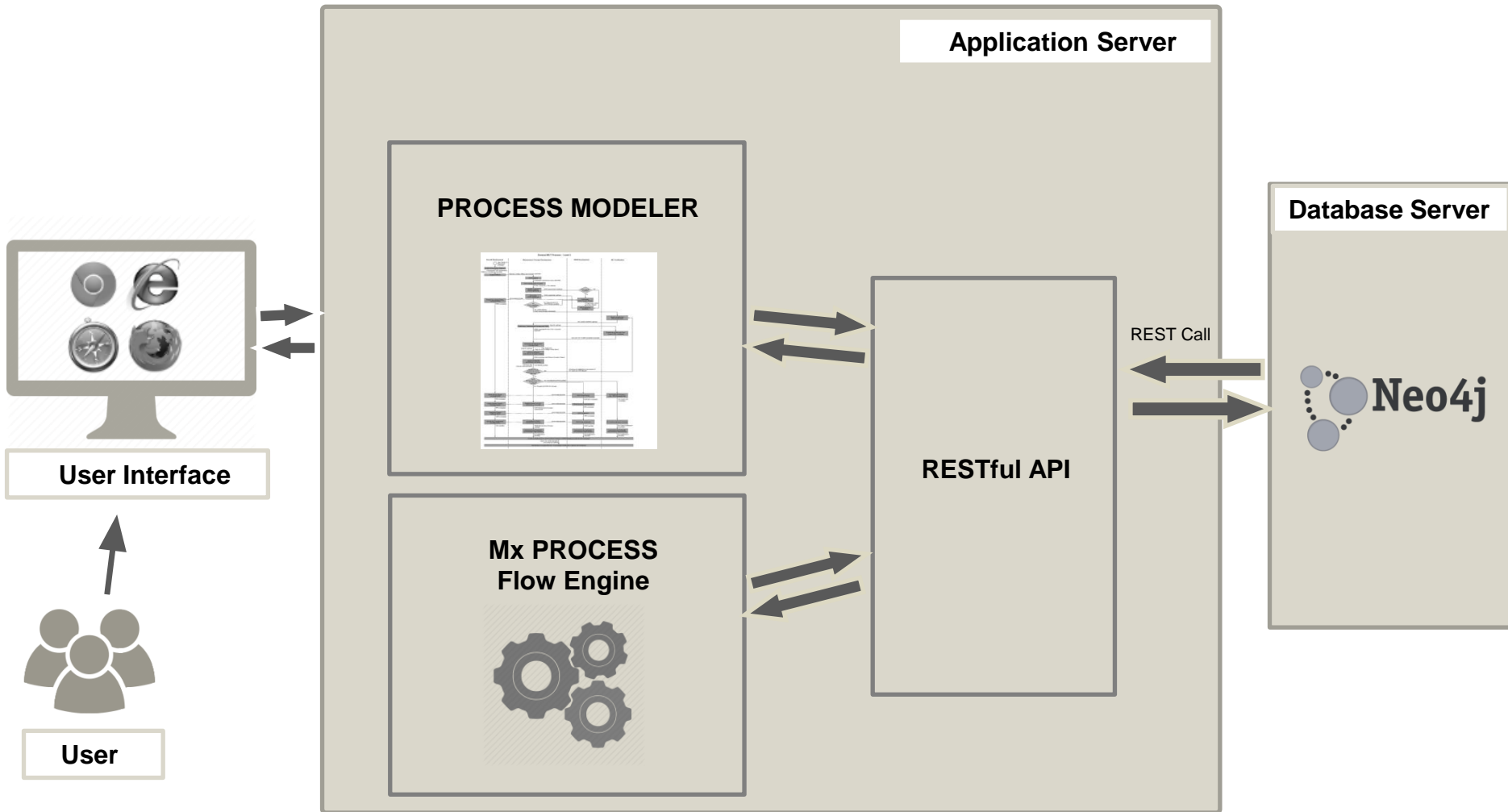
| Requirements | Activity | BonitaSoft | jBPM | Model Based UI |
|--|---|---|---|---|
| R1. User Interface Customization |  |  |  |  |
| R2. Rule Based Implementation |  |  |  |  |
| R3. Access to Executed Process steps |  |  |  |  |
| R4. Model Mx Credit Process steps |  |  |  |  |
| R5. Tabular Process View |  |  |  |  |
| R6. Add Document to process steps |  |  |  |  |
| R7. Set Customized Process Step status |  |  |  |  |
| R8. Add Links to Process steps |  |  |  |  |
| R9. Creation of tables for process step status |  |  |  |  |

Comparison of Identified Technologies and Tools

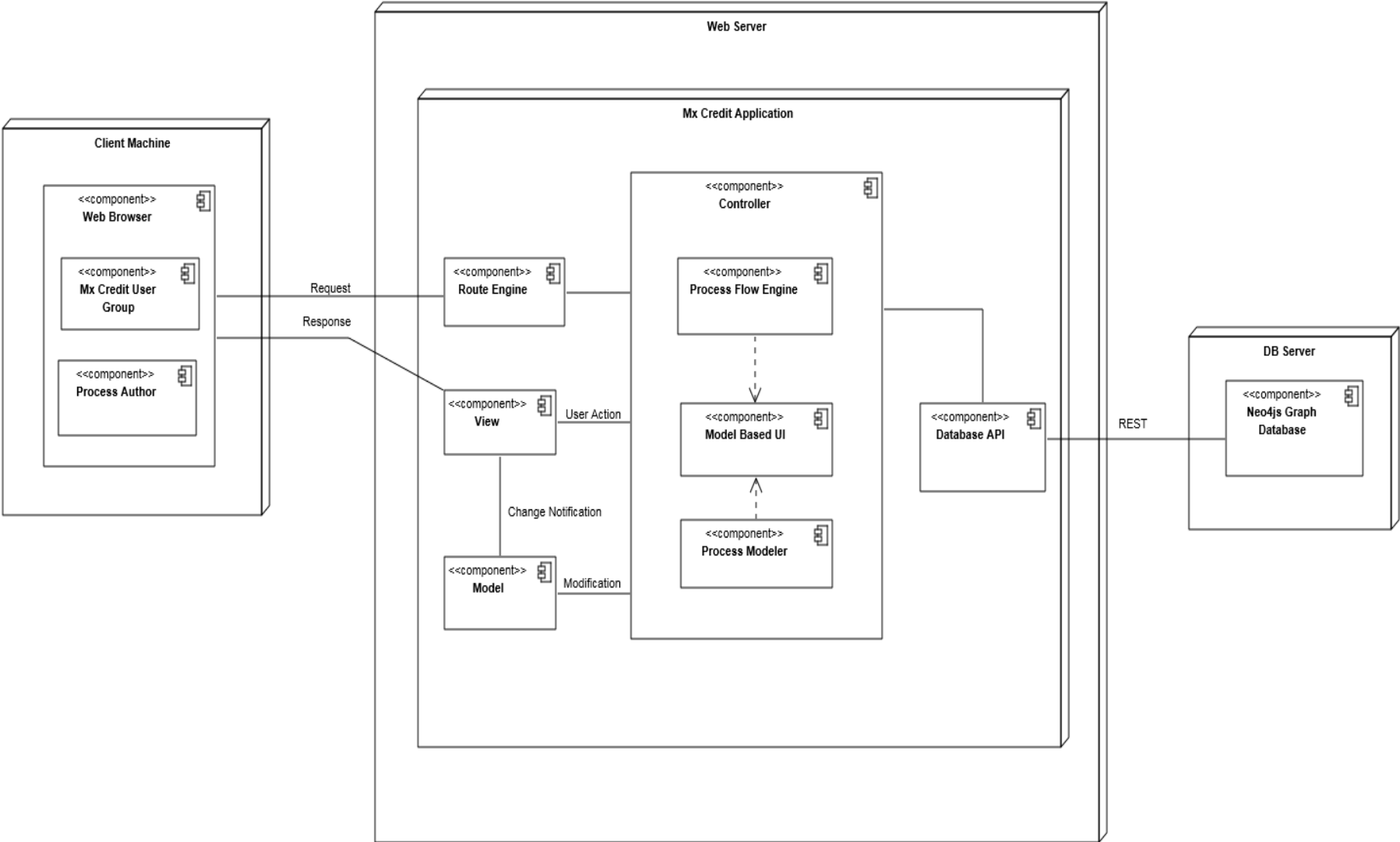
| Requirements | Activity | BonitaSoft | jBPM | Model Based UI |
|--|---|---|---|---|
| R1. User Interface Customization |  |  |  |  |
| R2. Rule Based Implementation |  |  |  |  |
| R3. Access to Executed Process steps |  |  |  |  |
| R4. Model Mx Credit Process steps |  |  |  |  |
| R5. Tabular Process View |  |  |  |  |
| R6. Add Document to process steps |  |  |  |  |
| R7. Set Customized Process Step status |  |  |  |  |
| R8. Add Links to Process steps |  |  |  |  |
| R9. Creation of tables for process step status |  |  |  |  |

MCF Tool Implementation Approach

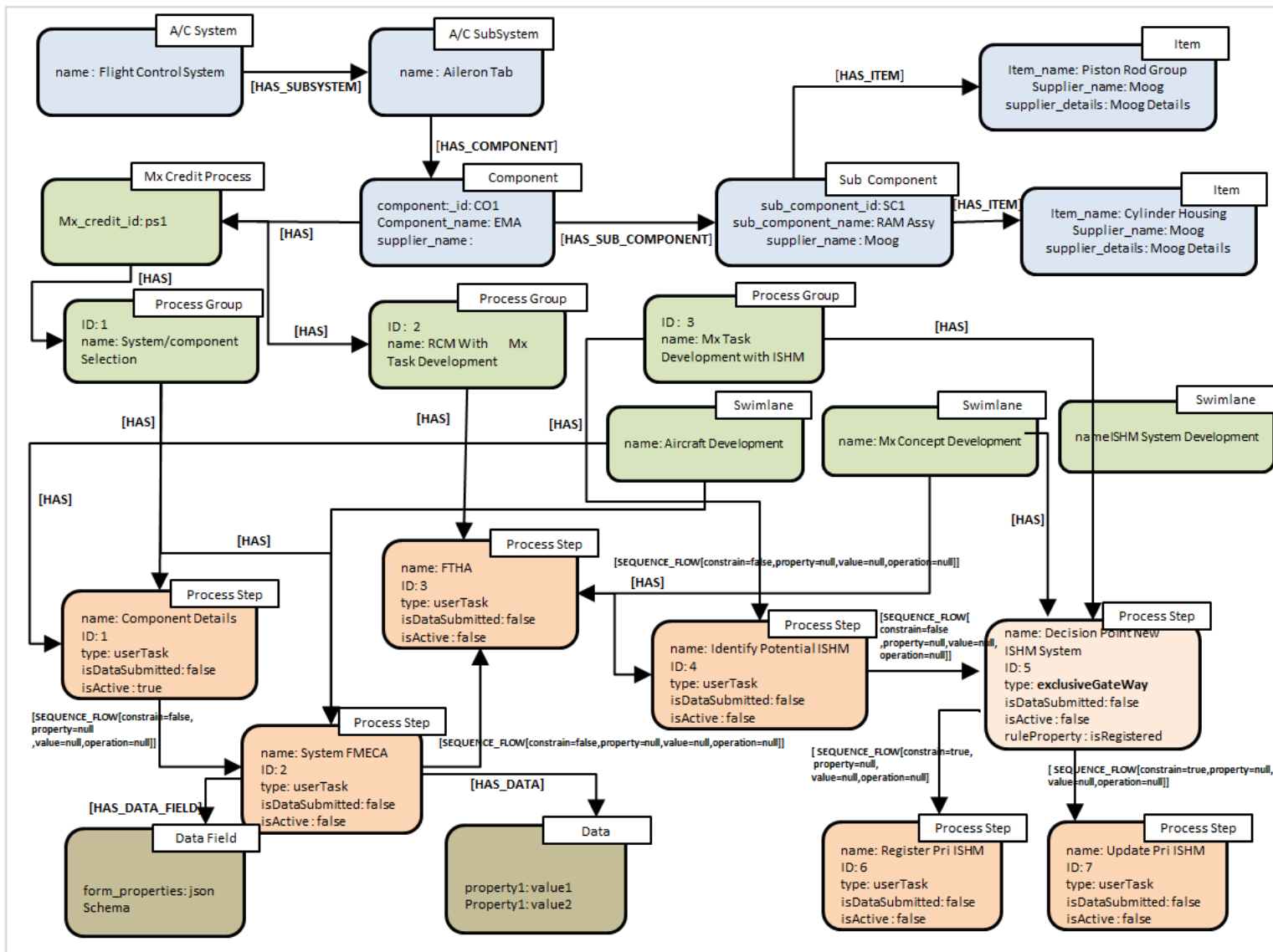




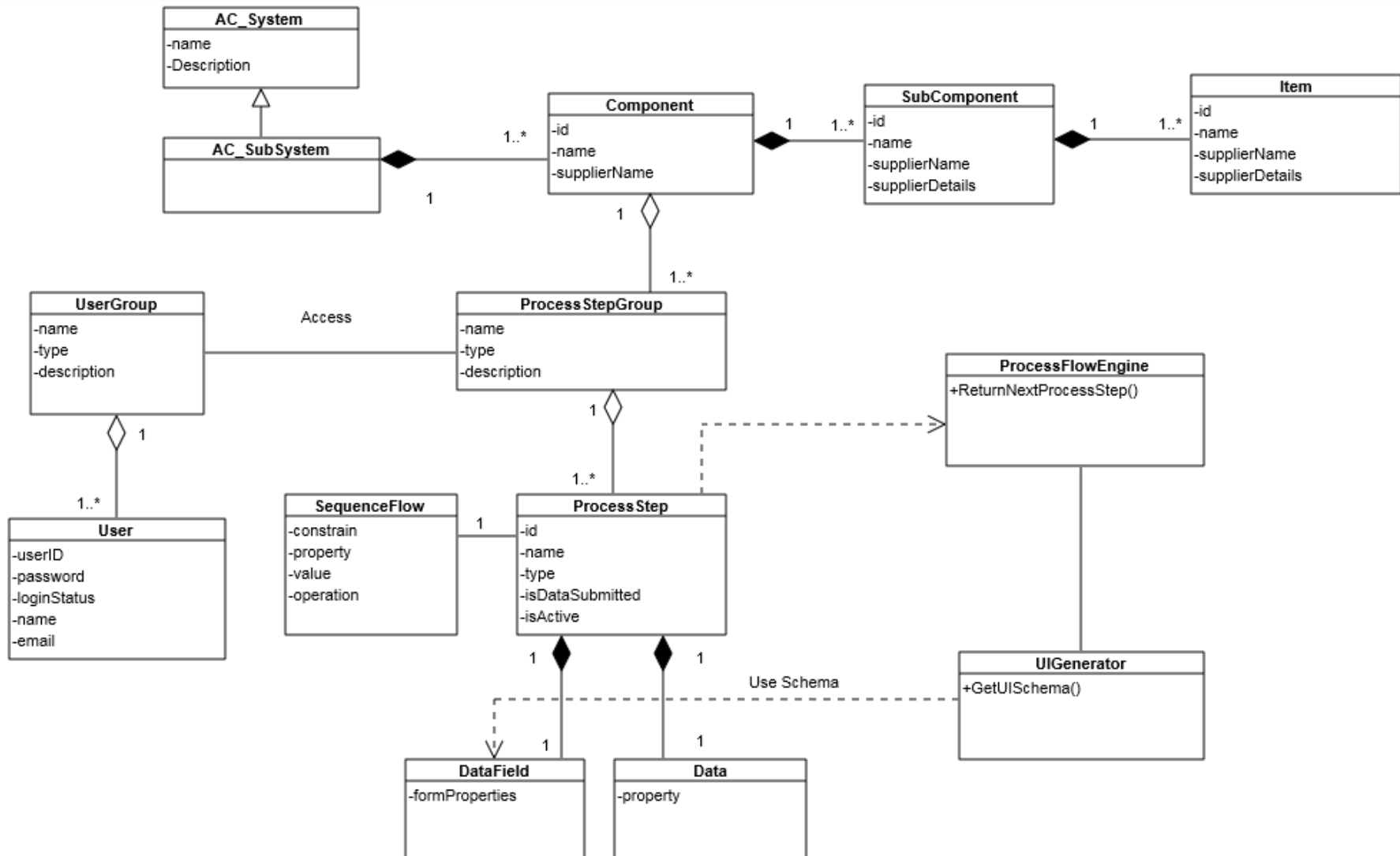
Implementation Details – MCF Tool component diagram



Graph Data Model



Implementation Details– MCF Tool Class Diagram



Live Demo

Implementation Details - Results

Process Steps View Process View Reporting

- Explorer
- List of Components
- Ram Assembly
 - Earth End Assy
 - Cylinder Housing
 - Gland Assy
 - Piston Rod Group
- Motor Assembly
- Pump Assembly

Component Sub Component Item

List of Components

System Component Selection

| Component ID | Component Name | ATA Chapter | A/C System | A/C Sub System | SBC | Part No. | Supplier Name | Supplier Details | | |
|--------------|----------------|-------------|-----------------------|----------------|-----|----------|---------------|------------------|----------|---|
| CO1 | Ram Assembly | ata chapter | Flight Control System | Aileron Tab | sbc | part no | supplier | ---- | Sub Comp | ✘ |
| CO2 | Pump Assembly | ata chap | Flight Control System | Aileron Tab | sbc | part no | supplier | ---- | Sub Comp | ✘ |
| CO3 | Motor Assembly | ata chapter | Flight Control System | Aileron Tab | sbc | part no | supplier | ----- | Sub Comp | ✘ |

+ Add New Component

Implementation Details - Results

Process Steps View
 Process View
 Reporting

- Explorer
- List of Components
- Ram Assembly
- Motor Assembly
- Pump Assembly

Component Sub Component Item

List of Components

System Component Selection: EHA

| Component ID | Component Name | ATA Chapter | A/C System | A/C Sub System | SBC | Part No. | Supplier Name | Supplier Details | | |
|--------------|----------------|-------------|-----------------------|----------------|-----|----------|---------------|------------------|----------|---|
| CO1 | Ram Assembly | ata chapter | Flight Control System | Aileron Tab | sbc | part no | supplier | ---- | Sub Comp | ✘ |
| CO2 | Pump Assembly | ata chap | Flight Control System | Aileron Tab | sbc | part no | supplier | ---- | Sub Comp | ✘ |
| CO3 | Motor Assembly | ata chapter | Flight Control System | Aileron Tab | sbc | part no | supplier | ---- | Sub Comp | ✘ |

[Create Mx Credit Process](#)
[Add New Component](#)

Implementation Details - Results

Components View

Manage

Process Steps View

Process View

Reporting

Component Sub Component Item

Explorer

List of Components

- Ram Assembly
- Motor Assembly
- Pump Assembly

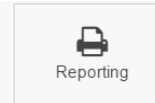
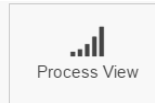
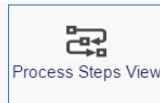
List of Components

System Component Selection **EHA**

| Component ID | Component Name | ATA Chapter | A/C System | A/C Sub System | SBC | Part No. | Supplier Name | Supplier Details | | |
|--------------|----------------|-------------|-----------------------|----------------|-----|----------|---------------|------------------|----------|---|
| CO1 | Ram Assembly | ata chapter | Flight Control System | Aileron Tab | sbc | part no | supplier | ---- | Sub Comp | x |
| CO2 | Pump Assembly | ata chap | Flight Control System | Aileron Tab | sbc | part no | supplier | ---- | Sub Comp | x |
| CO3 | Motor Assembly | ata chapter | Flight Control System | Aileron Tab | sbc | part no | supplier | ----- | Sub Comp | x |

Run Mx Credit Process

+ Add New Component



Select Task All My Tasks

Select Swimlane

Aircraft Development

Process Steps

System Component Selection

Selection

Component Details

System Design Assessment

RCM with Mx Task Development

Current Step History

Component Details

Selected Component Ram Assembly

| Sub Component ID | Sub Component Name | Items | |
|------------------|--------------------|-------|-------------------|
| SC1 | Piston Rod Group | 1 | Dynamic Seal |
| SC2 | Earth End Assy | 1 | Spherical Bearing |
| SC3 | Cylinder Housing | 1 | Seals |
| | | 2 | Static Seals |
| SC4 | Gland Assy | 1 | Static Seals |
| | | 2 | Dynamic Seals |

Select Task All My Tasks

Select Swimlane
Aircraft Development

Process Steps

- System Component Selection
- System Design Assessment
- System FMEA**
 - System FMECA
 - RCM with Mx Task Development

Current Step History

System FMEA

6

System Bottom Up FMEA

Select Sub Component

| Item ID | Failure Mode | Defect Description | Defect Effects | Component Reliability | |
|---|--------------|---|---|---------------------------|---|
| <input type="text" value="Static Seals (1)"/> | FM1 | Leaking due to ageing condition, exposure to high temperature, abrasion or faulty seal installation | Damaged seal, minor internal leakage No functional effect | 2 (0,5*10 ⁻⁶) | ✘ |
| <input type="text" value="Static Seals (2)"/> | FM2 | Leaking due to ageing condition, exposure to high temperature, abrasion or faulty seal installation | Damaged seal, major internal leakage No functional effect | 0.3 (3*10 ⁻⁶) | ✘ |

+ Add New Item

Selected Component : Ram Assembly

Data Source :

Documentation :

Select Task All My Tasks

Select Swimlane

Aircraft Development

Process Steps

System Component

Selection

System Design Assessment

System FMEA

System FMECA

RCM with Mx Task

Development

Current Step

History

System FMECA



System Bottom Up FMEA

Select Sub Component

Gland Assy

| Item ID | Criticality ID | Criticality Class | Mitigation Required | |
|------------------|----------------|-----------------------|---|---|
| Static Seals (1) | CR1 | 4 Minor (Spoiler) | No Mitigation required => Corrective Mx | ✘ |
| Static Seals (1) | CR2 | 3 Major (Aileron) | No Mitigation required => Corrective Mx | ✘ |
| Static Seals (1) | CR3 | 3 Major (Spoiler) | No Mitigation required => Corrective Mx | ✘ |
| Static Seals (2) | CR4 | 2 Hazardous (Aileron) | Maintenance | ✘ |

+ Add New Item

Selected Component : Ram Assembly

Data Source :

Documentation :

Submit

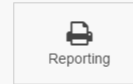
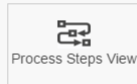
Save

Cancel

Implementation Details - Results

Components View

Manage



Graphical Process View

Tabular Process View

- ⇒ Process Steps
- System Component Selection
- Component Details**
- System Design Assessment
- RCM with Mx Task Development

Selected Component

| | Activity | Process Swimlane |
|---|--------------------------|-----------------------------|
| 1 | Component Details | Aircraft Development |
| 2 | System FMEA | Aircraft Development |
| 3 | System FMECA | Mx Concept Development |
| 4 | RCM Maintenance Concept | Mx Concept Development |

Verification and Validation of Mx Credit Process have been realized by **exemplary use cases** containing:

- Representative aircraft components
- Results for each task, represented by text descriptions and linked documents
- The evolution of the verification, validation and certification of correspondent Maintenance Credits for selected components

Analysis of MCF Tool Evaluation

- Process flow navigation is in the **simplest form** now available, and **no logic based navigation** was implemented.
- Experienced some bugs while filling out the data from the use cases and some UI modifications were made.
- The graphical view in the “process view” section should show the updated status of the process steps using the status color.

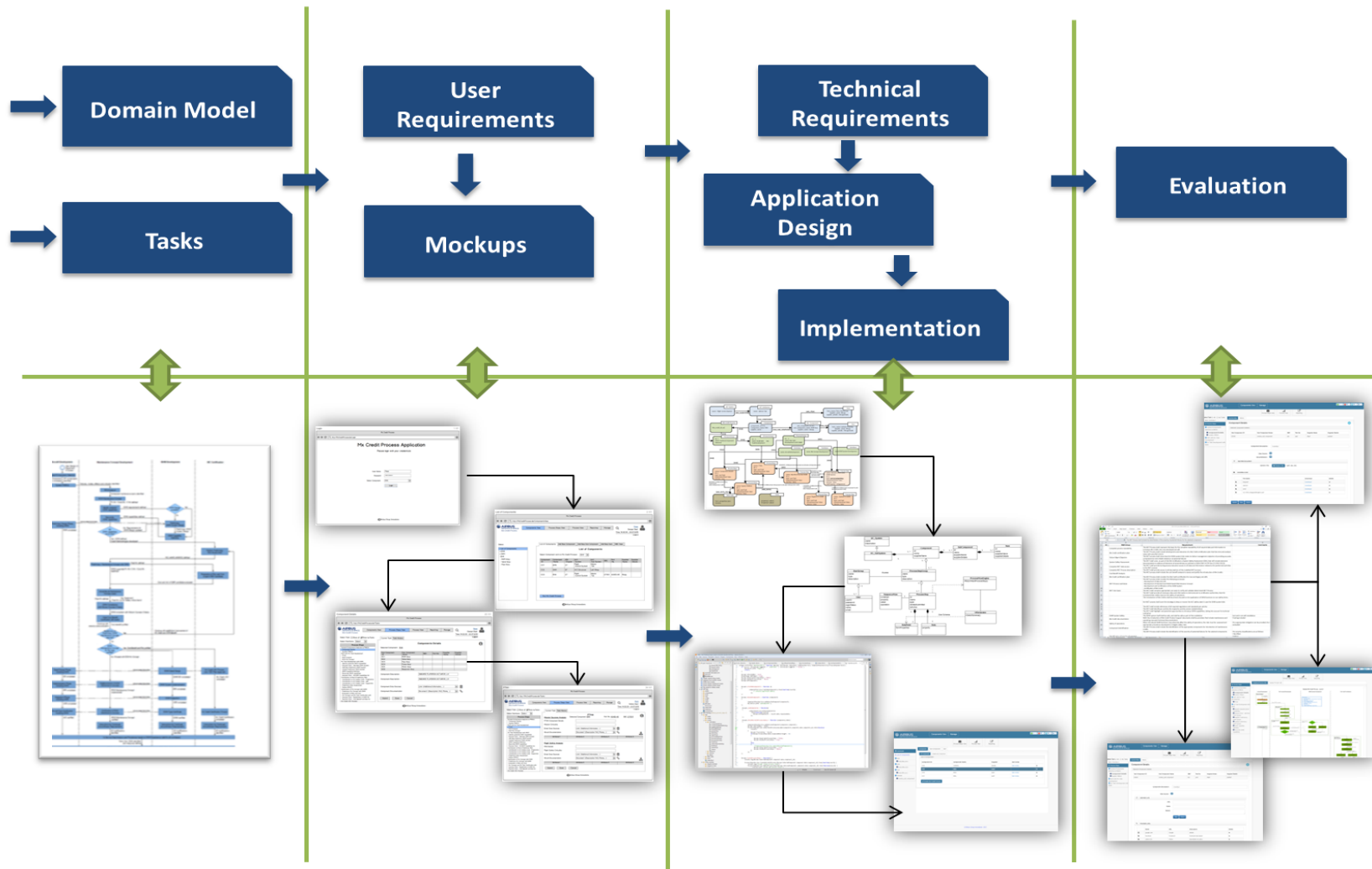
- The main objective of the thesis was the **design and implementation** of a web-based application to support all stakeholders of the Mx Credit Framework (MCF).
- **Model-Based UI** approach provided a useful solution to accommodate most of the requirements of the MCF Tool. Therefore, Model-Based UI approach was followed to implement the MCF Tool.
- The implemented Web UI showed at a glance the advantages of storing, processing, linking and retrieving the collected content along the process navigation using graph data model and model-based UIs.

- There are some important requirements like **advance rule implementation** for the process model, **graphical visualization** of the process execution are not available. These unsolved requirements could be the starting point of the next phase of the MCF Tool development.
- The acceptance of ISHM will depend to a large degree on the cooperation of regulatory authorities and, as well as, on the ability to calculate a positive cost-benefit for manufacturers and airlines.
- Future work will keep continuously focusing on the adaptation of the MCF to the ongoing changes in the ISHM community, while extending and validating the MCF approach and refining accordingly the MCF tool.

Thank you for your attention.

Questions ?

Backup slides



Thesis Timespan : July 15, 2015 – January 15, 2016

Supervisor :

Prof. Dr. Florian Matthes, sebis

Advisors:

- Adrian Hernandez-Mendez, sebis
- Milton Amador, Airbus Group Innovations

- Development of a process, called Mx Credit Process, for the certification of ISHM Systems and Mx Credits:
 - Provide a framework to get all necessary inputs from the respective stakeholders (A/C Design Dept, Safety Dept, Supplier...)
 - Provide required evidence to the certification authorities for the approval of ISHM-Systems and Mx Credits
 - Provide the involvement of the following processes:
 - A/C development process
 - Maintenance concept development
 - ISHM system development
 - Mx Credit certification

Requirements Overview

| No. | Requirement |
|-----|--|
| R1 | The Mx Credit Process Application shall provide during process execution access to all data and information related to the performed activities in the Mx Credit process |
| R2 | The Mx Credit Process Application shall provide access to all descriptions (all required regulations and standards per activity) of the modeled Mx Credit process |
| R3 | The Mx Credit Process application shall support the adding of content, annotations, data/documents (Upload) links and results at runtime for each process step |
| R4 | The Mx Credit Process application shall provide rule-based process execution (e.g. after submit, application guides user to the next correspondent step) |
| R5 | The Mx Credit Process application shall provide access to complete Mx Credit Process data, including complete generated results per process step (after data submission in a process step no more changes are possible). |
| R6 | The Mx Credit Process application shall offer the functionality to implement a given Mx Credit Process model |
| R7 | The Mx Credit Process application shall provide for specific process steps a functionality to add documents |
| R8 | The Mx Credit Process application shall provide for specific process steps a functionality to add links (web links or links to data sources with a description) |
| R9 | The Mx Credit Process application shall provide for specific process steps the creation of tables, respectively rows, to modify and to delete them, if required. |
| R10 | The Mx Credit Process application GUI shall be easy and intuitive to use |
| R11 | During process execution the stakeholders shall be easily and intuitively guided along the Mx Credit Process at runtime |
| R12 | The Mx Credit Process application shall provide a graphical process view to retrieve current process status (submitted => completed, active => saved, open => step not initiated) |
| R13 | The Mx Credit Process application shall provide a tabular process view to retrieve descriptions of the available Mx Credit Process |
| R14 | Users (Stakeholders) shall be associated to their respective process steps. |
| R15 | The Mx Credit Process application shall provide reporting of results for specific process steps or grouped activities |
| R16 | The Mx Credit Process application shall provide access to complete Mx Credit Process history (Login Date, Process Step ID, Process Step Access Date) |
| R17 | The Mx Credit Process application GUI shall be web based |
| R18 | The Mx Credit Process application shall provide an easy and intuitive modeling of the Mx Credit Process |
| R19 | The access to the description of the modelled Mx Credit Process shall be easy and intuitive. |
| R20 | Users (Stakeholders) shall be classified by user groups. |
| R21 | The Mx Credit Process application shall include a global model of related components, sub components and items |
| R22 | The Mx Credit Process application shall provide for specific process step views text fields. |
| R23 | The Mx Credit Process application shall provide for specific process step views correspondent drop down menus. |
| R24 | The Mx Credit Process application shall provide a login functionality to the users. |
| R25 | The Mx Credit Process application shall provide a simplified user rights management |

| Requirements | Activity | BonitaSoft | jBPM | Model Based UI |
|--|----------|------------|------|----------------|
| R1. User Interface Customization | | | | |
| R2. Rule Based Implementation | | | | |
| R3. Access to Executed Process steps | | | | |
| R4. Model Mx Credit Process steps | | | | |
| R5. Tabular Process View | | | | |
| R6. Add Document to process steps | | | | |
| R7. Set Customized Process Step status | | | | |