The Digital Twin Procedure Model

Project Initiation & Goal Definition

Input

| Access to information about the company | Willingness to digitize the company | Availability and acceptance of employees | BMA-D7.2 Identified & analyzed stakeholders | BMA-D5.1 Overview of the project organization |

Activities

PM-A1.1 Build a basic understanding of the Digital Twin
- PM-M1.1 Expert Interview

PM-A1.2 Define the goals of the Digital Twin project
- PM-M1.2 Modified 9-Fields Method
- PM-M1.3 Development of project goals
- PM-M1.4 Structuring project goals
- PM-T1.3 Evaluation criteria for method introduction
- PM-T1.4 SMART Goal Formulation
- PM-T1.5 Project Goals Checklist

PM-A1.3 Create a pre - selection of vague use cases
- PM-M1.5 Use Case Categorization
- PM-M1.6 Benefit-Effort Portfolio
- PM-M1.7 Cluster Analysis
- PM-M1.8 Pairwise Comparison
- PM-T1.6 Abstracted Use Cases
- PM-T1.7 Use Case Catalog
- PM-T1.8 Creativity Techniques
- PM-T1.9 Network Graph/Influence Matrix
- PM-T1.10 Strategy Roadmap
- PM-T1.15 Use Case Template

Link BMA: BMA-A1.3, BMA-A1.4, BMA-A1.6

PM-A1.4 Plan the procedure and activities of the project
- PM-T1.12 Digital Twin Adoption Plan

Link BMA: BMA-A5.1

PM-A1.5 Create a resource plan
- PM-T1.14 Resource Demand Questionnaire

Link BMA: BMA-A6.1, BMA-A6.2

PM-A1.6 Forming a project team
- PM-T1.13 Project Organization Structure of Digital Twins

Link BMA: BMA-A8.1

Output

| PM-D1.1 Basic understanding of the Digital Twin concept | PM-D1.2 Project Goals | PM-D1.3 Pre - selection of vague use cases | PM-D1.4 Adoption Plan |

Competencies

- Management
- Research & Development
- Business Development
- IT
- Production

Checklist

- ☐ Are the goals of the DT project defined?
- ☐ Is a rough collection of vague use cases documented?
- ☐ Is the adoption plan created?

Situation Analysis

Input

PM-D1.3 Pre-selection of rough use cases

PM-D1.4 Implementation Plan

Activities

PM-A2.1 Document the current process environment
- PM-M1.1 Expert Interview
- PM-T2.1 Use Case Template
- PM-T2.2 CPS Modeling Canvas

PM-A2.2 Document current process flow
- PM-M1.1 Expert Interview
- PM-M2.1 Swimlane Diagram
- PM-T2.1 Use Case Template

PM-A2.3 Document current data structure
- PM-M1.1 Expert Interview
- PM-T2.1 Use Case Template
- PM-T2.3 Questionnaire Modeling Data Structure

PM-A2.4 Determine current/target maturity level
- PM-M2.2 Evaluation of Usage Data
- PM-T2.4 Digital Twin Maturity Chart
- PM-M2.3 Modified SWOT Analysis

Link BMA: BMA-A1.5

PM-A2.5 Derive Implementation Strategies
- PM-M2.2 Evaluation of Usage Data
- PM-M2.3 Modified SWOT Analysis

PM-A2.6 Benchmark potential implementation partners

Link BMA: BMA-A7.2

Competencies

- **Management**
- **Research & Development**
- **Business Development**
- **IT**
- **Production**

Checklist

- ☐ Is the current state of the enterprise modelled and documented?
- ☐ Is an implementation strategy defined?

Output

PM-D2.1 Current state of the enterprise

PM-D2.2 Implementation Strategy

Target Conception

Input

PM-D2.1 Current state of the enterprise

PM-D2.2 Implementation Strategy

BMA-D9.2 Total cost of implementation

Activities

PM-A3.1 Develop target concept

PM-M3.1 Interface Analysis
PM-M3.2 Target Process Flow Conception
PM-M3.3 Target Process Environment Conception
PM-M3.4 Target Data Structure Conception
PM-T3.1 Checklist Target Concept

PM-A3.2 Analyze changes in the current situation

PM-M3.5 RACI Technology

PM-A3.3 Derive requirements & create specifications

PM-M3.6 Analysis of the user's perspective
PM-T3.2 Specification format
PM-T3.3 Typesetting template

PM-A3.4 Derive the first roadmap of the implementation

PM-M3.7 Determination of data requirements
PM-T3.4 Rough Roadmap of Implementation

Output

PM-D3.1 Target Concept

PM-D3.2 Adaption of the current situation

PM-D3.3 Requirements

PM-D3.4 Rough Roadmap of Implementation

Competencies

Management

Research & Development

Business Development

IT

Production

Checklist

☐ Is the target concept defined and documented?

☐ Are all measures taken to adapt the as-is situation to the DT?

☐ Are the requirements formulated and documented in the appropriate format?

Input

PM-D2.1 as-is situation of the company

PM-D3.1 Target Concept

Activities

PM-ASY.1 Analyze the interrelationships of use cases

PM-TSY.1 Digital twin meta model
PM-TSY.2 Link matrix

Competencies

Management

Research & Development

Business Development

IT

Production

Checklist

Output

PM-DSY.1 Relationships between the use cases

Implementation Preparation

Input

BMA-D7.1 Resources required by the vendor

PM-D3.3 Requirements

PM-D3.2 Adjustments to the current situation

PM-DSY.1 Relationships between the use cases

PM-D3.4 Rough roadmap of implementation

PM-D1.4 Plan for implementation

PM-D2.2 Implementation strategy

Activities

PM-A4.1 Derive specifications (with implementation partner)

PM-T4.1 Specification sheet
PM-T3.3 Typesetting template

PM-A4.2 Detail the implementation roadmap

PM-T4.2 Development methodology of Digital Twins
PM-T4.3 Implementation roadmap template

PM-A4.3 Check technical implementation

Output

PM-D4.1 Coordinated specifications

PM-D4.2 Detailed implementation roadmap

PM-D4.3 Assured technical feasibility

Competencies

Management

Research & Development

Business Development

IT

Production

Checklist

- ☐ Are the specifications agreed upon with the implementation partner?
- ☐ Is the detailed implementation roadmap ready for use?
- ☐ Is technical feasibility assured in theory?

Implementation

Input

PM-D4.2 Refined roadmap of implementation

PM-D4.1 Coordinated specifications

BMA-D5.3 Implementation support activities

PM-D3.2 Adjustments to the current situation

PM-D1.4 Plan for implementation

Activities

PM-A5.1 Pilot implementation of the use case

PM-M5.5 User Story Risk Map

PM-A5.2 Control and take over piloting

PM-M5.5 User Story Risk Map

PM-A5.3 Train and support users

Link BMA: BMA-A5.4

PM-A5.4 Communicating changes in the company

PM-M5.1 Change Barometer

PM-A5.5 Create Lessons Learned

PM-T5.2 Retrospective methods

Output

PM-D5.1 Implemented Use Case

PM-D5.2 Supervised Implementation & Communicated Changes

PM-D5.3 Lessons learned

Competencies

Management

Research & Development

Business Development

IT

Production

Checklist

- ☐ Are the test cases successfully verified?
- ☐ Is the implementation and change management process in action?
- ☐ What are the lessons learned from the project? Are they documented?

Implementation

Input

PM-D4.1 Coordinated specifications

PM-D4.2 Refined implementation roadmap

PM-D1.4 Plan for implementation

Activities

PM-ASY.2 Synchronize use case implementations

PM-ASY.3 Plan next steps

Output

PM-DSY.2 Synchronized use case implementations

PM-DSY.3 Next steps

Competencies

Management

Research & Development

Business Development

IT

Production

Checklist

Activity – How can the goal be reached?

Index
PM-A1.1

Title
Build a basic understanding of the Digital Twin

Priority
Should-Have

Overall Objective
PM-D1.1

Link to the Procedure Model

Procedure

1. Collect internal and external knowledge, as well as information material regarding Digital Twins

2. Capture the current interpretation of Digital Twins in the company

3. Develop a definition of the Digital Twin that everyone can agree on

4. Analyze general benefits and barriers of Digital Twins

5. Capture expectations on Digital Twins in the company

6. Derive potential benefits of the Digital Twin in the company and possible barriers to its introduction

7. Communicate the results within the company

Methods & Tools

PM-M1.1 Expert Interviews

Index
PM-A1.2

Title
Define the goals of the digital twin project

Priority
Must-have

Overall Objective
PM-D1.2

Link to the Procedure Model

Procedure

1. Outline the mission, values, vision of the company in general or project idea

2. Deriving an overall objective and project objectives

3. Structuring the project goals

4. Synchronization with benefit aspects from the collected use cases

5. Review and document project goals

Methods & Tools

PM-M1.2 Modified 9-field method
PM-M1.3 Development of project objectives,
PM-T1.3 Evaluation criteria for the introduction of methods,
PM-T1.4 SMART formulation of objectives
PM-M1.5 Structuring project objectives
PM-T1.5 Project objectives checklist

Activity – How can the goal be reached?

Index
PM-A1.3

Title
Create a preselection of rough use cases

Priority
Must-have

Overall Objective
PM-D1.3

Link to the Procedure Model

Procedure

1. Collecting ideas for use cases
2. Consolidate and categorize use cases
3. Evaluate use cases
4. Making connections between use cases visible
5. Clustering use cases and selecting a cluster
6. Detailing and evaluating the use cases in the cluster
7. Prioritization

Gather rough use cases

Categorize use cases

Assess use cases & identify commonalities

Cluster use cases & assess the clusters

Detail & select use cases

Strategy Roadmap

Number of Use Cases — Many / Few
Level of Detail — Low / High
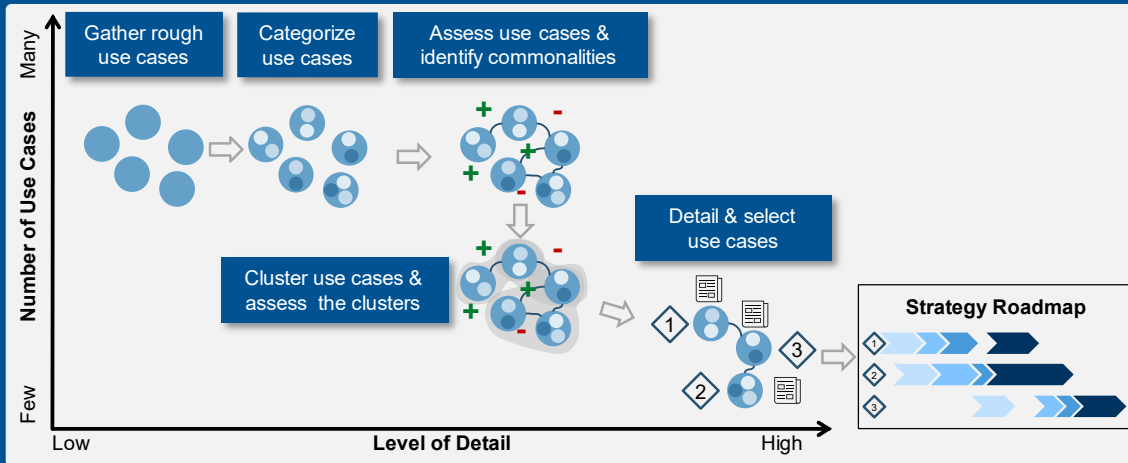
Methods & Tools

PM-T1.6 Abstracted use cases,
PM-T1.7 Use case catalog,
PM-T1.8 Creativity techniques,
PM-T1.15 Rough use case template
PM-M1.5 Use case categorization

PM-M1.6 Benefit-Effort Portfolio

PM-T1.9 Network graph/influence matrix

PM-M1.7 Cluster analysis

PM-M1.8 Pairwise comparison

PM-T1.10 Strategy roadmap

Activity – How can the goal be reached?

Index
PM-A1.4

Title
Plan the procedure and activities of the project

Priority
Must-have

Overall Objective
PM-D1.4

Link to the Procedure Model

Procedure

1. Definition of an implementation plan

2. Selection of a suitable process model

3. Determination of the required activities

4. Adaptation of the process model to the project at hand

5. Creation of a project plan

Methods & Tools

PM-T1.12 Implementation plan for digital twins

Index
PM-A1.5

Title
Create resource plan

Priority
Nice-To-Have

Overall Objective
PM-D1.4

Link to the Procedure Model

Procedure

1. Determining which resources are needed to achieve the goal (people and material resources)

2. Determination of when these are required

3. Analysis of which resources are currently available in the company and where additional resources are required

4. Determining how the additional resources required can be procured

Methods & Tools

PM-T1.14 List of questions on resource requirements

Index

PM-A1.6

Title

Form a project team

Priority

Must-have

Overall Objective

PM-D1.4

Link to the Procedure Model

Procedure

1. Clarification of the project organization structure to be used

2. Determination of roles required for the implementation of the project

3. Defining the responsibilities and tasks of the roles

4. Assigning company employees to the roles of the project organization structure

Methods & Tools

PM-T1.13 Project organization structure Digital twin

Activity – How can the goal be reached?

Index
PM-A2.1

Title
Record actual process environment

Priority
Must-have

Overall Objective
PM-D2.1

Link to the Procedure Model

Procedure

1. Collect information material on the process environment (documentation, images, ...)

2. Map the architecture of the relevant hardware components

3. Mark information/energy/material flows between the components

4. Visualization of the entire system architecture including the process interrelationships and documentation

Methods & Tools

PM-M1.1 Expert interview

PM-T2.2 CPS modeling canvas

PM-T2.1 Use Case Template

Activity – How can the goal be reached?

Index
PM-A2.2

Title
Record actual process flow

Priority
Must-have

Overall Objective
PM-D2.1

Link to the Procedure Model

Procedure

1. Collect information material on the process flow (e.g. employee interviews)

2. Identify stakeholders and components of the CPS

3. Define areas/departments of stakeholders and components

4. Record the activities of the stakeholders and functions of the components (Who performs which activities, or what performs which function?)

5. Networking of activities/functions in a chronological and logical sequence (When is which activity/function carried out?)

6. Adding information regarding data/information (use, anchoring)

7. Checking the chronological and logical sequence

8. Documentation of the actual process

Methods & Tools

PM-M1.1 Expert interview

PM-M2.1 Swimlane diagram

PM-M2.1 Swimlane diagram

PM-M2.1 Swimlane diagram

PM-T2.1 Use Case Template

25 activity slide

Activity – How can the goal be reached?

Index
PM-A2.3

Title
Record actual data structure

Priority
Must-have

Overall Objective
PM-D2.1

Link to the Procedure Model

Procedure

1. Identification of basic elements of the data structure, i.e. initial/final states, stakeholders, important components of the system, activities, functions, data/information

2. Networking the basic elements by analyzing data/information flows and communication channels

3. Specify the basic elements by adding knowledge of supporting tools, system anchors, description of data/information

4. Documentation of interim/final results

Methods & Tools

PM-M1.1 Expert interview,

PM-T2.3 Questionnaire Modeling data structure

PM-T2.1 Use Case Template

Index
PM-A2.4

Title
Determine actual/target maturity level

Priority
Must-have

Overall Objective
PM-D2.2

Link to the Procedure Model

Procedure

1. Evaluation of the data structure and IT landscape -> Identification of strengths and weaknesses

2. Determination of the technology maturity level and process maturity level -> Derivation of strategies to achieve a better maturity level

3. Identification of potentials and barriers to the introduction of DT (see project objectives and general barriers to DT)

4. Deriving strategies for utilizing potential and overcoming barriers

Methods & Tools

PM-M2.2 Evaluation of usage data

PM-T2.4 Maturity level table for digital twins

PM-M2.3 Modified SWOT analysis

Activity – How can the goal be reached?

Index
PM-A2.5

Title
Derive implementation strategies

Priority
Must-have

Overall Objective
PM-D2.2

Link to the Procedure Model

Procedure

1. Evaluation of the data structure and IT landscape -> Identification of strengths and weaknesses

2. Identification of potentials and barriers to the introduction of DT (see project objectives and general barriers to DT)

3. Deriving strategies for utilizing potential and overcoming barriers

Methods & Tools

PM-M2.2 Evaluation of usage data

PM-M2.3 Modified SWOT analysis

Index

PM-A2.6

Title

Benchmark possible providers

Priority

Nice-To-Have

Overall Objective

PM-D2.2

Link to the Procedure Model

Procedure

1. Determination of possible implementation partners

2. Definition of evaluation dimensions

3. Collection of data on the evaluation dimensions for each implementation partner

4. Analysis and comparison of data (identification of performance gaps/strengths)

5. Determination of one or two selected implementation partners

Methods & Tools

-

Activity – How can the goal be reached?

Index

PM-A3.1

Priority

Must-have

Title

Develop target concept

Overall Objective

PM-D3.1

Link to the Procedure Model

Procedure

1. Identify and mark possible interfaces

2. Development of a possible target process flow, based on the marked interfaces -> Determination of DT functions

3. Development of a corresponding target process environment -> Determination of the DT architecture

4. Development of a target data structure -> Determination of the functionality of the DT

5. Final check of the target concept

Methods & Tools

PM-M3.1 Interface analysis

PM-M3.2 Target process flow concept

PM-M3.3 Target process environment design

PM-M3.4 Target data structure concept

PM-T3.1 Checklist target concept

Activity – How can the goal be reached?

Index
PM-A3.2

Title
Analyze changes to the current situation

Priority
Nice-To-Have

Overall Objective
PM-D3.2

Link to the Procedure Model

Procedure

1. Documenting the changed activities in the process flow

2. Analysis of changes to the process environment (architecture, hardware, software)

3. Analysis of changes in the data/information flow or data structure

4. Redefinition of stakeholder responsibilities and activities in the target concept

Methods & Tools

PM-M3.4 RACI technique

Activity – How can the goal be reached?

Index
PM-A3.3

Title
Derive requirements & create specifications

Priority
Must-have

Overall Objective
PM-D3.3

Link to the Procedure Model

Procedure

1. Defining the request format

2. Definition of a "transfer key" for transferring the previous work results to the specifications

3. Transfer of the previous work results into the requirement format

4. Deriving the requirements

5. Documentation of the requirements in the specifications

Methods & Tools

PM-T3.2 Specification format

PM-T3.3 Record template

PM-M3.6 Analysis of the user perspective

Activity – How can the goal be reached?

Index
PM-A3.4

Title
Derive initial roadmap for implementation

Priority
Should-Have

Overall Objective
PM-D3.4

Link to the Procedure Model

Procedure

1. Derive measures that need to be implemented on the system (e.g. new sensor)

2. Derive measures that need to be taken on tools and the IT landscape (e.g. new linking of IT systems, new tools)

3. Derive measures regarding changing activities and responsibilities of the organization (e.g. adaptation of existing processes, new skills required)

4. Prioritize measures and estimate the time required

5. Putting measures in a logical chronological order

Methods & Tools

PM-M3.7 Determination of data requirements

PM-T3.4 Rough implementation roadmap

Activity – How can the goal be reached?

Index
PM-A4.1

Title
Create specifications (with provider)

Priority
Must-have

Overall Objective
PM-D4.1

Link to the Procedure Model

Procedure

1. Definition of the specification format

2. Checking the consistency and feasibility of the requirements in the specifications (provider)

3. Development of the technical implementation of the requirements by detailing them with regard to realization (provider)

4. Definition of test cases and acceptance criteria

5. Documentation of the realization in the specifications (provider)

6. Acceptance of the specifications

Methods & Tools

PM-T4.1 Specification format

PM-T3.3 Record template

PM-T3.3 Record template

Index
PM-A4.2

Title
Detailing the implementation roadmap

Priority
Must-have

Overall Objective
PM-D4.2

Link to the Procedure Model

Procedure

1. Defining the work packages from the rough roadmap and the specifications

2. Assigning roles to the individual work packages

3. Defining a logical chronological sequence for processing the work packages

4. Check and review the roadmap

Methods & Tools

PM-T4.3 Implementation roadmap template

PM-T4.2 Development methodology of digital twins

Activity – How can the goal be reached?

Index
PM-A4.3

Title
Check technical implementation

Priority
Should-Have

Overall Objective
PM-D4.3

Link to the Procedure Model

Procedure

1. Comparison of requirements specification and functional specification

2. Selection of the provider

3. Adaptation of the target concept as required

4. Checking the implementation roadmap for potential problems/barriers

5. Adaptation of the implementation roadmap

6. Grant approval for implementation

Methods & Tools

-

Activity – How can the goal be reached?

Index
PM-A5.1

Title
Pilot implementation of the use case

Priority
Must-have

Overall Objective
PM-D5.1

Link to the Procedure Model

Procedure

1. Selection of the pilot team

2. Determining the procedure for piloting

3. Realization of the implementation based on the roadmap and piloting of the use case

Methods & Tools
-

Activity – How can the goal be reached?

Index
PM-A5.2

Title
Check and adopt piloting

Priority
Must-have

Overall Objective
PM-D5.1

Link to the Procedure Model

Procedure

1. Checking the functionality of the digital twin based on the previously defined acceptance criteria

2. Verification of fulfillment of the requirements in the specifications

3. Transfer of the pilot project to normal operation

Methods & Tools

-

Index
PM-A5.3

Title
Train and support users

Priority
Should-Have

Overall Objective
PM-D5.2

Link to the Procedure Model

Procedure

1. Definition of a training concept, including training documents

2. Creation of trainer documents

3. Description of the training implementation (content and organization)

4. Implementation of the training concept

Methods & Tools

-

Index

PM-A5.4

Title

Communicating changes within the company

Priority

Should-Have

Overall Objective

PM-D5.2

Link to the Procedure Model

Procedure

1. Dealing with the emotions of employees

2. Creation of a communication concept with measures, target groups and frequency

3. Use of communication measures

Methods & Tools

PM-M5.1 Change Barometer

PM-T5.1 Direct/indirect communication

Index
PM-A5.5

Title
Create lessons learned

Priority
Must-have

Overall Objective
PM-D5.3

Link to the Procedure Model

Procedure

1. Collection of experience from previous steps

2. Derivation and documentation of lessons learned

3. Conception of the integration of lessons learned

Methods & Tools

PM-T5.2 Retrospective methods

Activity – How can the goal be reached?

Index
PM-ASY.1

Title
Analyze correlations of use cases

Priority
Must-have

Overall Objective
PM-DSY.1

Link to the Procedure Model

Procedure

1. Determination of the main fields of investigation or related domains

2. Closer examination of the main fields of investigation

3. Identification of synergies between the use cases

4. Deriving potential uses for the roadmap for implementing the use cases

Methods & Tools

PM-TSY.1 Digital twin meta model

PM-TSY.2 Link matrix

Activity – How can the goal be reached?

Index
PM-ASY.2

Title
Synchronize use case implementations

Priority
Must-have

Overall Objective
PM-DSY.2

Link to the Procedure Model

Procedure
Coordination of the functionality of the individually implemented use cases with the help of the identified similarities and differences

Methods & Tools
-

Activity – How can the goal be reached?

Index
PM-ASY.3

Title
Plan the next steps

Priority
Nice-To-Have

Overall Objective
PM-DSY.3

Link to the Procedure Model

Procedure

1. Analysis of the current status after implementation

2. Comparison of the current status with the original implementation plan and the implementation strategies

3. Adaptation and modification of the original implementation plan

4. Definition of the next steps based on the updated implementation plan

Methods & Tools

-

Methods & Tools – How can the activities be supported?

Index
PM-M1.1

Title
Expert Interview

Application for…
| PM - A1.1 | PM - A2.1 | PM - A2.2 | PM - A2.3 |

Link to the Procedure Model

Procedure / Description

- Purpose: Information acquisition of tacit knowledge.

- Procedure:
  1. Narrow down topic area
  2. Determine interview goal and guiding questions
  3. Acquire knowledge on the interview topic
  4. Select stakeholders/experts
  5. Conduct interview (in individual/group meetings)
  6. Document and analyze results
  7. Review of the expert interview

Visualization / Example

References & Links

Bogner et al. (2009)

Templates

-

Index

PM-M1.2

Title

Modified 9-field method

Application for…

PM-A1.2

Link to the Procedure Model

Procedure / Description

1. Determine the current situation of the system in the company based on the definition of the digital twin (tile in the middle left)

2. Abstraction at super-system level and concretization at sub-system level

3. Defining the medium-term and long-term position of the digital twin in the company

Visualization / Example
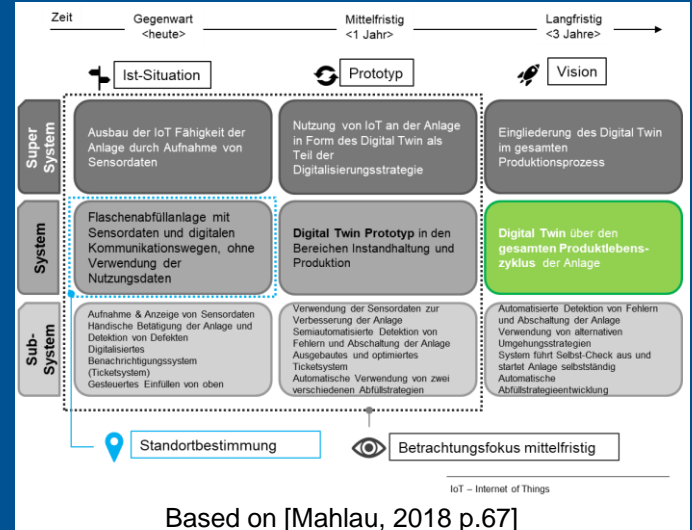
Based on [Mahlau, 2018 p.67]

References & Links

[Ehrlenspiel, 2017 p.549ff], [Mahlau, 2018 p.66f]

Templates

PM-M1.2 Modified 9-field method

Index
PM-M1.3

Title
Development of project goals

Application for…
PM-A1.2

Link to the Procedure Model

Procedure / Description

1. Definition of a global/coarse target

2. Derive further project objectives under the key question: WHAT is to be achieved within the framework of the project?

Global/coarse target:
Brief, concise description of the project task that characterizes the final state to be achieved [Kuster.2008 p.356].
- What is to be achieved? (quality, functionality, scope)
- Who should achieve this? (person, group of persons)
- When should this be achieved? (Time limit)
- How is this to be achieved? (cost framework)

Visualization / Example

Global/coarse target:
Reducing the spread of damage to the pump in the event of defects occurring in the system. Implementation of the project within six months with a project manager and a core team consisting of business, engineering and IT specialists.

Project goals:
Automatic stop of the system if a defect is detected.

Improving trust in digitalization technologies, including digital twins.

References & Links

[Kuster, 2008 p.352ff]

Templates

-

Methods & Tools – How can the activities be supported?

Index

PM-M1.4

Title

Structuring project goals

Application for…

PM-A1.2

Link to the Procedure Model

Procedure / Description

1. Classification into outcome objectives (describe the product after completion of the project) and process objectives (describe the project approach) [Drews, 2021 p.44]

2. Creation of target classes

3. Classification of detailed objectives into target classes

Visualization / Example

Result targets	Procedure goals
E.g.: performance/quality targets, deadline target, economic targets	E.g.: Defined milestones, use of certain tools, requirements to avoid disruptions

References & Links

[Drews, 2021 p.44]

Templates

-

Methods & Tools – How can the activities be supported?

Index
PM-T1.3

Title
Evaluation criteria for the introduction of methods

Application for…
PM-A1.2

Link to the Procedure Model

Procedure / Description

Run through the evaluation criteria to generate project objectives.

Visualization / Example

- **Internal stakeholder satisfaction** → Has the quality of a work product created in a process step and used by an internal customer been improved?
- **Production costs** → Are production costs reduced in an initial estimate?
- **Defects** → Was the number of defects in the production process reduced at a certain point in time?
- **Workload** → Has unnecessary workload due to faulty processes been minimized?
- **Process time** → Has the time taken to complete a process been reduced?
- **Preparation time** → Has the time for preparing the activity been reduced?
- **Coordination** → Has the effort required to coordinate different activities been reduced?

References & Links

[Stetter, 2000 p.143]

Templates

-

Index

PM-T1.4

Title

SMART target definition

Application for…

PM-A1.2

Link to the Procedure Model

Procedure / Description

Formulate goals according to the SMART criteria.

Visualization / Example

S = Specific
M = Measurable
A = Attractive
R = Realistic
T = Terminated

References & Links

[Drews, 2021 p.43], [Kuster, 2008 p.354]

Templates

-

Index
PM-T1.5

Title
Project objectives checklist

Application for…
PM-A1.2

Link to the Procedure Model

Procedure / Description

Final check to ensure that the project objectives have been properly formulated.

Visualization / Example

- Do the objectives match the project brief and the benefit aspects of the use cases?
- Are the goals SMART (Specific, Measurable, Actual, Realistic, Time-bound)?
- Are goals mutually exclusive?
- Does one goal interfere with the fulfillment of another?
- Does the pursuit of one goal simultaneously promote another?
- Is there an overall objective and associated more detailed objectives?
- Are the objectives known and understood by all project participants?

References & Links

[Drews, 2021 p.44]

Templates

-

Index

PM-M1.5

Title

Use case categorization

Application for…

PM-A1.3

Link to the Procedure Model

Procedure / Description

1. Specify categories for clustering use cases. General categories could be "benefiting stakeholders", "lifecycle phase", or "input data".
2. Define the attributes of the categories.
3. Build a Domain-Mapping Matrix (DMM) of use cases and attribute
4. Calculate the Design Structure Matrix (DSM) by multiplying the DMM with its transposed matrix (cf. visualization)
5. Cluster DSM to identify commonalities in use cases.
6. Calculate combined benefit effort for the clusters to select the most promising one.

Visualization / Example

Computation Scheme: $X = H^T \cdot H$ $Y = H \cdot H^T$
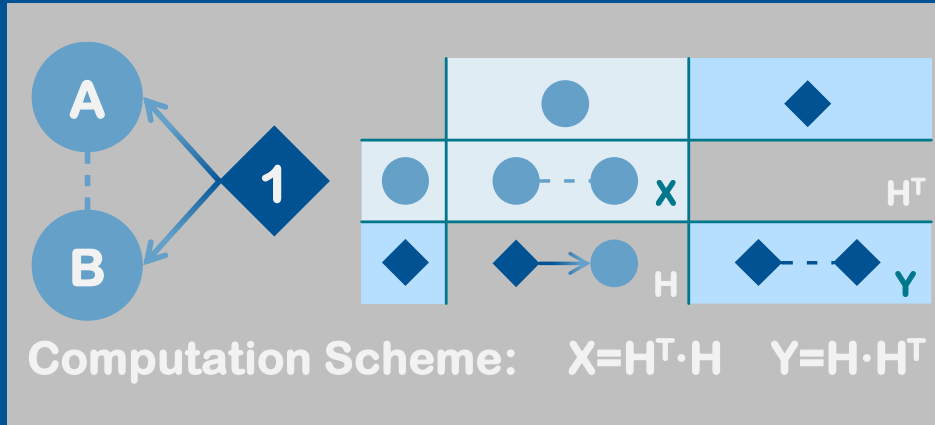
References & Links

Lindemann et al. (2008)

Templates

-

Index

PM-M1.6

Title

Benefit-Effort Portfolio

Application for…

PM-A1.3

Link to the Procedure Model

Procedure / Description

1. Present consolidated use cases in a workshop with all relevant stakeholders
2. Select a scale for the assessment. E.g. 1-5 for a linear scale or 1-3-9 for a progressive. Best practice is to do both and compare the outcome.
3. Let all participants anonymously assess the use cases' benefit
4. Let all participants anonymously assess the use cases' effort
5. Map all use cases in a portfolio
6. Identify use cases with the best benefit/effort ratio

Visualization / Example
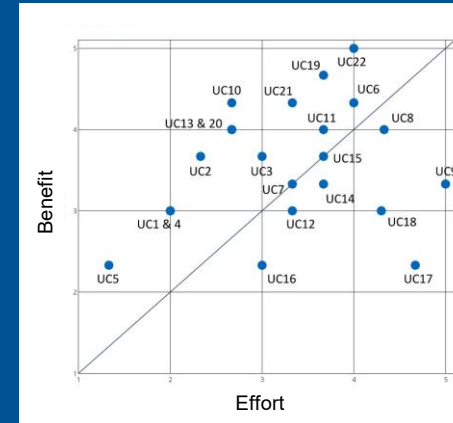
References & Links

Lindemann (2009)

Templates

-

Methods & Tools – How can the activities be supported?

Index
PM-M1.7

Title
Cluster analysis

Application for…
PM-A1.3

Link to the Procedure Model

Procedure / Description

1. Creation of clusters in the Portfolio diagram

2. Creation of clusters in the network graph

3. Creation of clusters in the influence matrix

4. Merging the cluster results

5. Critical scrutiny of the clusters created

Visualization / Example

References & Links

-

Templates

-

Methods & Tools – How can the activities be supported?

Title
Pairwise Comparison & Weighted Scoring Analysis

Application for…
PM-A1.3

Link to the Procedure Model

Procedure / Description

Pairwise Comparison:
1. Put the elements in columns and rows of a matrix.
2. Assess for each cell, whether the element in the row is *less important (-1), equally important (0)* or *more important (1),* than the column.
3. Calculate row sums to derive scoring.

Weighted Scoring Analysis:
1. Select relevant criteria
2. Weigh the criteria using pairwise comparison
3. Score the options with respect to the criteria using pairwise comparison
4. Multiply the scores by the associated weights
5. Total the weighted scores
6. Rank the options and decide

Visualization / Example

"A is more important/ Better than C"

	A	B	C	Sum
A		-1	1	0
B	1		1	2
C	-1	-1		-2

Resulting Ranking

		Weight	Options			
			O_A		O_B	
Criteria	C_1	w_1	p_{A1}		p_{B1}	
				$p_{A1} * w_1$		$p_{B1} * w_1$
	C_2	w_2	p_{A2}		p_{B2}	
				$p_{A2} * w_2$		$p_{B2} * w_2$
Sum			$\sum_i p_{Ai} * w_i$		$\sum_i p_{Bi} * w_i$	
Rank						

References & Links

Lindemann (2009), Daenzer et al. (2002)

Templates

Pairwise Comparison

Index

PM-T1.6

Title

Abstracted use cases

Application for…

PM-A1.3

Link to the Procedure Model

Procedure / Description

Derivation of specific use cases for the use case at hand by specifying abstracted use cases.

Visualization / Example

"In the Predictive Maintenance Use Case the current condition of wear components is observed and compared with usage specifications in order to derive a forecast of the remaining useful lifetime." [Gundlach, 2022 p.28]

→ In order to avoid downtimes and to utilize the service life of current components (e.g. pump), components should be replaced in good time and appropriately as part of strategically planned maintenance work. In addition, the procurement of spare parts should be carried out in a timely and controlled manner.

References & Links

[Gundlach, 2022]

Templates

Methodology for creating abstracted use cases

Index
PM-T1.7

Title
Use Case Catalog

Application for…
PM-A1.3

Link to the Procedure Model

Procedure / Description

Within a use case catalog, various applications of digital twins are collected according to specific categories. These can serve as a basis for analogy building, which can be used to develop new use cases.

Visualization / Example

Degree of abstractness

Use Case Catalog

Analogy

Customization & Transfer

Original problem

Barrier

Use case idea

Degree of solution
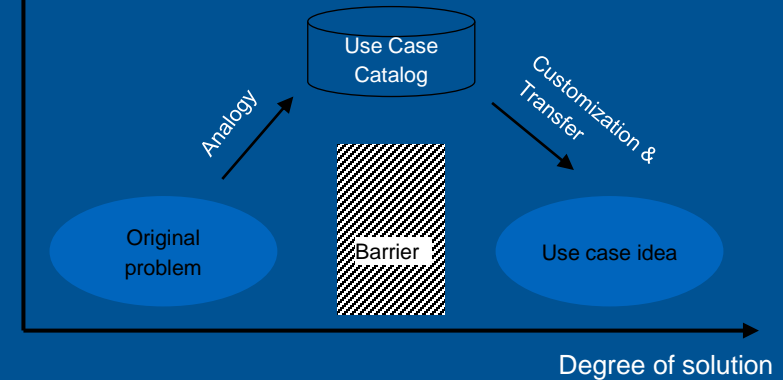
[Wilberg, 2018 p.1458]

References & Links

[Wilberg, 2018]

Templates

Use Case Catalog Wilberg

Index

PM-T1.8

Title

Creativity techniques

Application for…

PM-A1.3

Link to the Procedure Model

Procedure / Description

Use of advanced creativity techniques to generate new use case ideas.

Visualization / Example

intuitives Denken

hoch

Brainstorming
Brainwriting
Lotus-Blüte
Methode 635

Laterales Denken

TRIZ

hohe Garantie auf innovative Produktideen

mittlere Garantie auf innovative Produktideen

niedrige Garantie auf innovative Produktideen

○ einzelne Methode

◯ Methodensammlung

mittel

Galeriemethode
Analogiebildung
Delphi-Methode
Bionik
Synektik

Morphologischer Kasten
Konstruktionskataloge
Analyse natürlicher Systeme
Analyse bekannter technischerSysteme

niedrig

Suchmethoden

Mindmapping

niedrig   mittel   hoch

diskursives Denken

[Lindemann, 2016 p.744]

References & Links

[Lindemann, 2016 p.744]

Templates

-

Index

PM-T1.9

Title

Network graph/influence matrix

Application for…

PM-A1.3

Link to the Procedure Model

Procedure / Description

Netgraph

Representation of the use cases as nodes with a certain size, which results from the benefit-effort ratio (the higher the benefit with low effort, the larger the node)

Based on the assigned attributes from the categorization, connections are created between the nodes, depending on how many overlapping attributes two use cases have. The more overlaps, the thicker and redder the connecting line is displayed.

Influence matrix

1. Transfer of the categorization into a matrix format (domain mapping matrix) Use Case - Attribute
2. Visualization of the connections of the use cases by matrix multiplication -> Use Case - Use Case (Design Structure Matrix)

Visualization / Example

References & Links

[Lindemann, 2009]

Templates

Matlab network graph

Methods & Tools – How can the activities be supported?

Index

PM-T1.10

Title

Strategy roadmap

Application for…

PM-A1.3

Link to the Procedure Model

Procedure / Description

Prioritization and planning of the introduction of the use cases
- Determining the sequence of the individual use case implementations
- The steps can run in parallel or one after the other
- Steps can also wait for the completion of another use case step, e.g. if synchronization is required
- It should start with the most promising use case -> easy to implement and highly visible benefits (quick win) -> relevance of the digital twin is made clear

-> Complexity reduction through strategy development for the implementation sequence of the use cases
-> Additional delimitation of the project focus

Visualization / Example
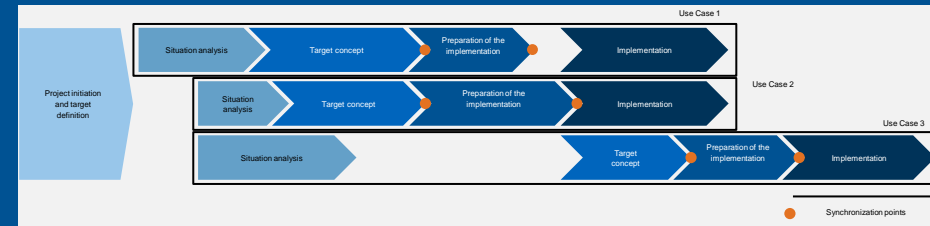
References & Links

-

Templates

PM-T1.10 Strategy roadmap

Methods & Tools – How can the activities be supported?

Index
PM-T1.12

Title
Implementation plan for digital twins

Application for…
PM-A1.4

Link to the Procedure Model

Procedure / Description

Localization of the characteristics of the dimensions for the given project:

Factual dimension
- Object dimension → How much should be introduced?
- Context dimension → Where should be introduced?

Behavioral dimension
- How is it introduced?

Visualization / Example

Einführungsstrategie-dimensionen		Gestaltungsoptionen	
Objekt-dimension	**Wieviel** einführen?	Gesamten Digital Twin einführen	**Stufenweise Einführung des Digital Twin**
Kontext-dimension	**Wo** einführen?	Einführung im gesamten Unternehmen	**Sukzessive Einführung im Unternehmen**
Verhaltens-dimension	**Wie** einführen? (Einführungsstil)	Direktiv ◄──────► Partizipativ	

(Sachdimension spans the Objekt-, Kontext-, and Verhaltens-dimension rows)

[Stöhr, 2018 p.86]

References & Links

[Stöhr, 2018 p.86f], [Daniel, 2001]

Templates

-

Index

PM-T1.13

Title

Project organization structure of digital twins

Application for…

PM-A1.6

Link to the Procedure Model

Procedure / Description

Project organization similar to projects for the introduction of PLM methods (PLM = Product Lifecycle Management).

Visualization / Example
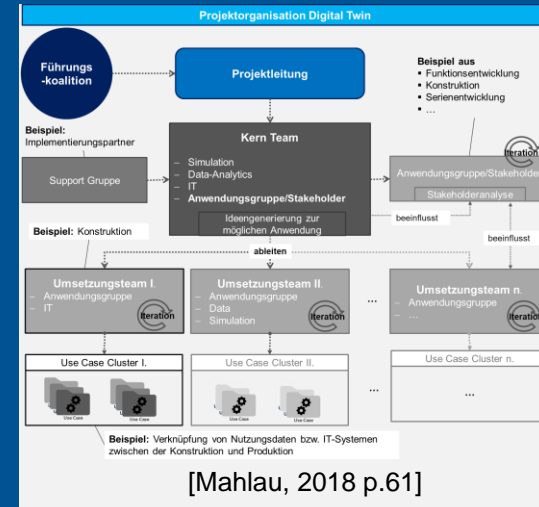
[Mahlau, 2018 p.61]

References & Links

[Eigner, 2013 p.395], [Mahlau, 2018 p.61]

Templates

-

Methods & Tools – How can the activities be supported?

Index
PM-T1.14

Title
List of questions Resource requirements

Link to the Procedure Model

Application for…
PM-A1.5

Procedure / Description

Supporting questions to determine resource requirements.

Visualization / Example

- What qualifications/training do the employees or the project team need to have for this task?
- What material resources (machines, materials, aids) are required for implementation?
- Are there any resources that are not available or cannot be procured?
- Are the employees or the project team available at the time?
- Is there already a fixed team or does the group for the work package have to be put together first?

References & Links

[Drews, 2021 p.74f]

Templates

-

Methods & Tools – How can the activities be supported?

Index
PM-T1.15

Title
Use case template rough

Application for…
PM-A1.3

Link to the Procedure Model

Procedure / Description

Template for collecting initial use case ideas that can be used for categorization.

Visualization / Example

Collection of rough use cases of the digital twin				
Use case title	Explanation	Source	Stakeholder	Problem
Idea 1	Description 1	Source 1	Stakeholder X	Problem 1, Problem 2, ...
Idea 2	Description 2	Source 2	Stakeholder Y	Problem 3, Problem 4, ...
...	...	...	...	...

References & Links

[Mahlau, 2018 p.86]

Templates

PM-T1.15 Use case template coarse

Index
PM-T2.1

Title
Use Case Template

Application for…
PM-A2.1, PM-A2.2, PM-A2.3, PM-A3.1

Link to the Procedure Model

Procedure / Description

Step-by-step documentation of all results for the use case from steps one to three (S1-S3).

Contents:
- Overview of the use case
- Business model of the use case
- Recording the current situation
- Target concept
- Implementation roadmap
- Additional information

Visualization / Example

References & Links

Based on [Mahlau, 2018 p.85f]

Templates

PM-T2.1 Use Case Template

Methods & Tools – How can the activities be supported?

Index
PM-T2.2

Title
CPS Modeling Kanvas

Application for…
PM-A2.1

Link to the Procedure Model

Procedure / Description

To create the digital twin environment, the questions from the CPS modeling canvas can be answered in sequence. This allows the components of the digital twin to be systematically developed.

Visualization / Example

Basic System	Information Processing	Networked Subsystems
What is the physical basic system?	What are the options for the subsystem to process information?	Which other systems does the subsystem interact with?
e.g. Separator	e.g. Industrial-PC	e.g. Manufacturing Exectution Systems
Sensory	**Communication**	**Data**
Which sensors for the acquisition of physical quantities does the subsystem have?	Which interfaces does the system have for communicating with other systems?	Which other systems does the subsystem interact with?
e.g. Vibration Sensors	e.g. Industrial Ethernet	e.g. Operating Data
Actuatory	**Human-Machine-Interface**	**Services**
Which actuators does the subsystem have to influence physical processes?	Which human-machine-interfaces does the subsystem have?	Are there services in the context of the subsystem that are based on the collection and interpretation of data?
e.g. Drives, Valves	e.g. Touchscreen	e.g. Condition Monitoring

[Westermann, 2018 p.3045]

References & Links

[Westermann, 2018]

Templates

-

Index

PM-T2.3

Title

Questionnaire Modeling data structure

Application for…

PM-A2.3

Link to the Procedure Model

Procedure / Description

Run through the questionnaire as a support for recording the elements and linking the data structure.

Visualization / Example

Prioritization	Questions
Primary - Basic elements	• Which events/states are associated with the use case at the beginning and at the end (e.g. normal operation, system failure, ...)? • ...
Primary - Networking	• Where does the data/information required for activities/functions come from? • ...
Secondary - Specification	• How can the data/information be described in terms of content and form? • ...

Based on [Mahlau, 2018 p.75f]

References & Links

Based on [Mahlau, 2018 p.75f]

Templates

PM-T2.3 Questionnaire Modeling data structure,

Index

PM-T2.4

Title

Maturity level table for digital twins

Application for…

PM-A2.4

Link to the Procedure Model

Procedure / Description

Classification of the recorded current situation in a maturity level table for digital twins → awareness of where the current position is and starting point for the development of measures to achieve a higher digital twin level.

Visualization / Example

Digital Model	Digital Thread	Digital Shadow	Digital Twin	
Descriptive	Diagnostic	Predictive	Prescriptive	Data Analytics Level
Manual	Manual & Automated	Unidirectionally Automated	Bidirectionally Automated	Data Connection Requirement
Monitoring	Control	Optimization	Autonomy	Level of Decision Making
Medium	Medium - High	High	Very High	Effort

References & Links

[Neelam, 2018 p.6], [Schweigert-Recksiek, 2022]

Templates

PM-T2.4 Maturity level table for digital twins

Index

PM-M2.1

Title

Swimlane diagram

Application for…

PM-A2.2

Link to the Procedure Model

Procedure / Description

1. Structure of the pool (delimitation of the process under consideration and definition of the level of detail)
2. Classification of the lanes (determination of the units involved in the process)
3. Definition of activities (recording activities and their sequence)
4. Marking of dependencies (networking of activities with arrows)

Visualization / Example
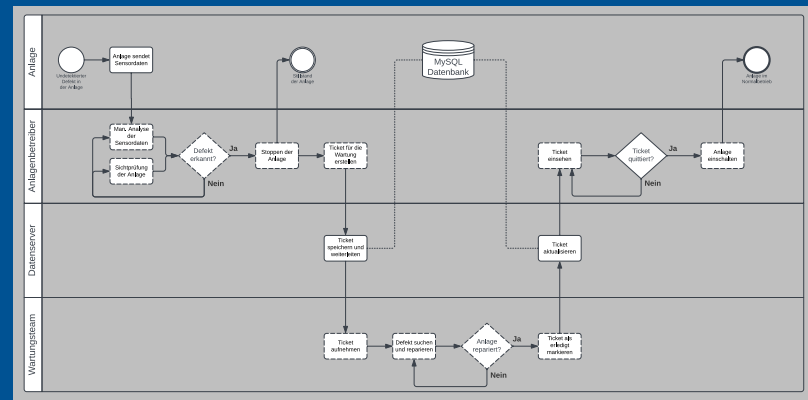
References & Links

[LucidChart, 2022], [ViCon, 2022]

Templates

PM-T2.1 Use Case Template

Index

PM-M2.2

Title

Evaluation of usage data

Application for…

PM-A2.4, PM-A2.5

Link to the Procedure Model

Procedure / Description

1. Determining the relevance of data quality dimensions for the use case at hand

2. Evaluation of the individual criteria with selected evaluation scale (e.g. 1-5)

3. Justification of the assessment if necessary

4. Deriving problems from usage data

5. Proposal of a solution approach for the derived problems

Visualization / Example

Datenphase	Datenqualitätsdimension	Relevanz für den Use Case	Erfüllungsgrad für den Use Case			Anmerkung/Beschreibung
			hoch	mittel	niedrig	
Datenquelle	Daten Menge*	4		X		
	Genauigkeit*	3			X	
	Vollständigkeit*	1	X			
Datenstrecke & Zugriff	Zugänglichkeit*					
	Zugangssicherheit*					
	Zeitnähe*					
	Speicherung*					
	Vernetzung*					
Prüfung / Visualisierung	Glaubwürdigkeit*					
	Prüfbarkeit*					
	Überwachung*					
Datenimport & Integartion	Strukturgrad					
	Einheitlichkeit*					
	Importierbarkeit*					

References & Links

Based on [Mahlau, 2018]

Templates

PM-M2.2 Evaluation of usage data

Methods & Tools – How can the activities be supported?

Index
PM-M2.3

Title
Modified SWOT analysis

Application for…
PM-A2.5

Link to the Procedure Model

Procedure / Description

SWOT is a method to assess a businesses or project's internal Strengths, and Weaknesses and external Opportunities, and Threats.

- **Strengths**: attributes that help to outperform others
- **Weaknesses**: elements of the business or project that give a disadvantage to others
- **Opportunities**: aspects of the environment in which the company is operating, that could be used for an advantage.
- **Threats**: aspects of the environment in which the company is operating, that might impede the progress of the business or project.

1. Identify the internal (Strength & Weaknesses) and external factors (Opportunities & Threats) in a workshop (e.g. using brainstorming)
2. Assess and identify the most crucial factors
3. Derive relations existing between internal and external features. E.g. how can opportunities be turned into strengths? How can strengths be used to overcome threats?

Visualization / Example

	Helpful	Harmful
Internal	STRENGTHS	WEEKNESSES
External	OPPORTUNITIES	THREATS

References & Links

Lindemann (2009), Thompson and Martin (2010)

Templates

PM-M2.3 Modified SWOT analysis

Index
PM-M3.1

Title
Interface analysis

Application for…
PM-A3.1

Link to the Procedure Model
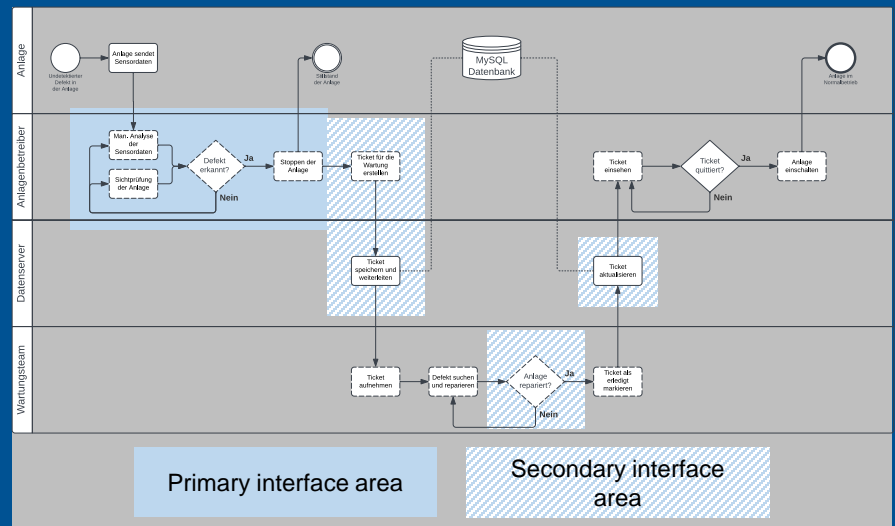
Procedure / Description

1. Using the implementation strategies, weaknesses and potentials, consider possible characteristics of the DT

2. Insert DT with its characteristics mentally

3. Consider which areas are influenced by the DT

4. Consider which activities in these areas would be affected by the DT

5. Marking the areas and activities in the process flow, process environment and data structure

Visualization / Example

Primary interface area

Secondary interface area

References & Links

[Mahlau, 2018 p.102]

Templates

PM-T2.1 Use Case Template

Index

PM-M3.2

Title

Target process flow Concept

Application for…

PM-A3.1

Link to the Procedure Model

Procedure / Description

1. From the implementation strategy and the interfaces, consider the functions of the DT

2. Consider where and how functions are added, omitted, outsourced, combined or parallelized, see [Gadatsch, 2010 p.21]

3. Analyzing changes in decision-making processes

4. Analyze changes to the storage of data in system anchors

Visualization / Example
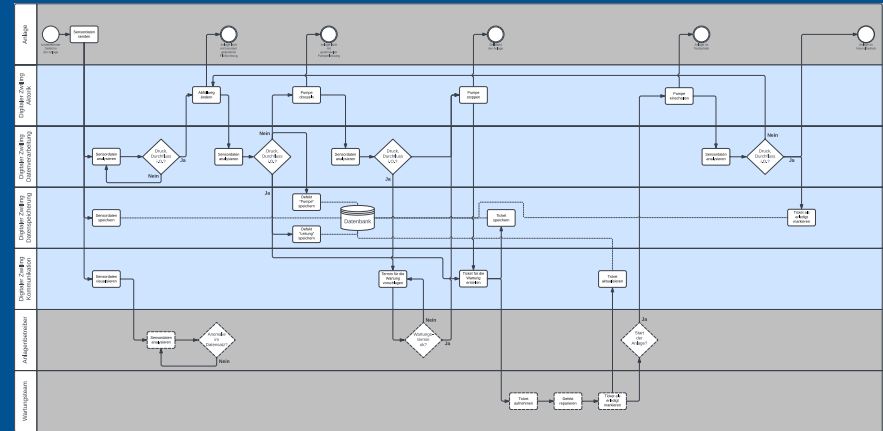
References & Links

[Gadatsch, 2010 p.21], [Mahlau, 2018 p.102f]

Templates

PM-T2.1 Use Case Template

Index

PM-M3.3

Title

Target process environment concept

Application for…

PM-A3.1

Link to the Procedure Model

Procedure / Description

1. DT architecture superior

2. Insert required architectural elements at the marked interfaces

3. Inserting additional components (e.g. system anchors, sensors, actuators)

4. Check whether the proposed architecture fulfills the functions of the DT

Visualization / Example
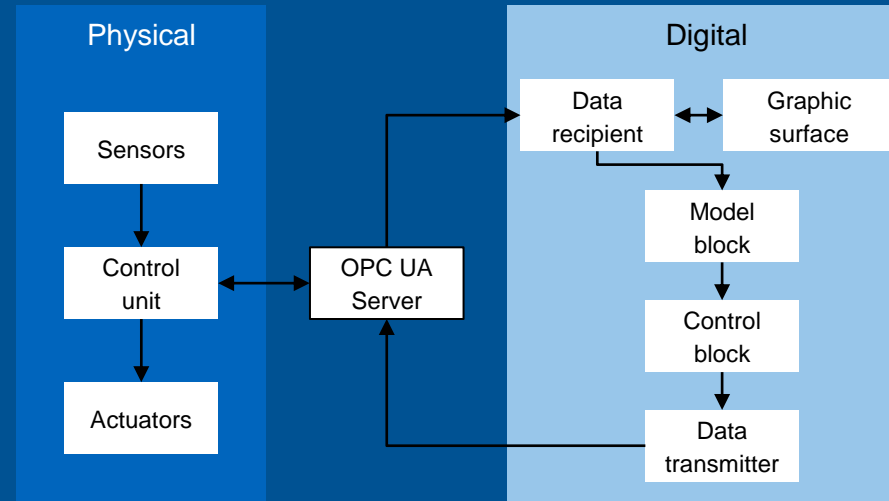
[Andrade, 2022 p.136]

References & Links

[Andrade, 2022 p.136]

Templates

PM-T2.1 Use Case Template

Index

PM-M3.4

Title

Target data structure Concept

Application for…

PM-A3.1

Link to the Procedure Model

Procedure / Description

1. Transferring the additionally inserted architecture elements and components from the target process environment

2. Transferring the changed activities from the target process flow

3. Enter changed data/information flows or adapt the data structure to the changes

Visualization / Example
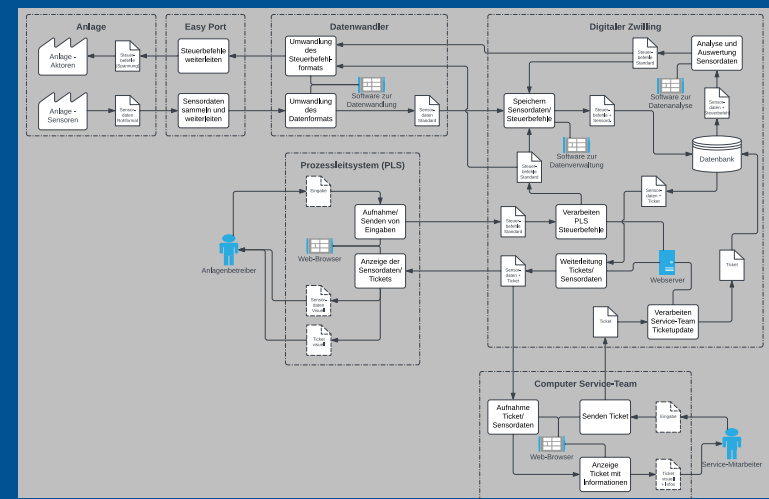
References & Links

-

Templates

PM-T2.1 Use Case Template

Methods & Tools – How can the activities be supported?

Index
PM-M3.5

Title
RACI technology

Application for…
PM-A3.2

Link to the Procedure Model

Procedure / Description

1. Transferring the decision nodes (diamonds in the swimlane diagram) from the process flow

2. Entering the roles involved and the DT

3. Assign the attributes E (decision-maker) / M (co-decision-maker) / I (to inform) / B (advisor)

4. Derive the overall responsibilities of each role

Visualization / Example
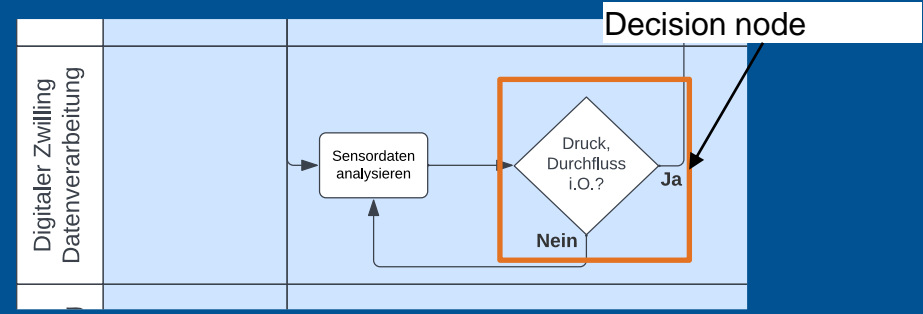
Decision node

Decision node		Role	Roll 1	Roll 2	Roll 3	…
EK1	Node text		E	I		
EK2	Node text			E	I	
EK3	Node text		E	I	M	
…	…					

References & Links

[Saygin, 2019 p.56f]

Templates

PM-M3.5 Template RACI technique

Index

PM-M3.6

Title

Analysis of the user perspective

Application for…

PM-A3.3

Link to the Procedure Model

Procedure / Description

1. Defining the relevant stakeholders for the use case

2. Definition of representative personas for the identified stakeholders -> profile, key needs, key pains

3. Collection of the previously defined user stories and assignment to the personas

4. Deriving characteristics of the digital twin

5. Determining the user perspective on the tools and communication used

Visualization / Example

"Pragmatischer Service-Mitarbeiter", PETER

"Die Reparaturarbeiten der Arbeiten sollten sich einfach durchführbar und in geringem Ausmaß gestalten, damit wir den geplanten Betrieb nicht zu lange stören."

References & Links

[Mahlau, 2018 p.116f]

Templates

PM-M3.6 Persona template

Index
PM-M3.7

Title
Determination of data requirements

Application for…
PM-A3.4

Link to the Procedure Model

Procedure / Description

1. List of all existing data points from situation analysis

2. Supplementing the data list with additionally required data points from the target concept

3. Evaluation of the data points

4. Deriving strategies for data management

Visualization / Example

	Expenditure	Benefit
Data point 1	X1	Y1
Data point 2	X2	Y2
New data point 3	X3	Y3
...	...	...
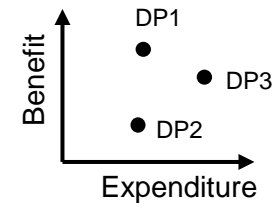
References & Links

[Saygin, 2019 p.43ff]

Templates

-

Methods & Tools – How can the activities be supported?

Index
PM-T3.1

Title
Checklist target concept

Application for…
PM-A3.1

Link to the Procedure Model

Procedure / Description

Checking the key points of the checklist for the target concept to verify the completeness and quality of the target concept.

Visualization / Example

- Are all new activities noted and in the correct form (noun + verb)?
- Are the links with the digital twin clear?
- Have all user interfaces been taken into account?
- Are decisions meaningful and fully labeled?
- Is the timing correct?
- Has the architecture of the system been sufficiently supplemented to enable the functions/activities?
- Have the data/information flows been rearranged to guarantee the functionality of the DT?
- Are all elements fully and completely labeled?

References & Links

[Mahlau, 2018 p.104]

Templates

-

Methods & Tools – How can the activities be supported?

Index
PM-T3.2

Title
Specification format

Application for…
PM-A3.3

Procedure / Description

Example format for the specification sheet.
The task definition makes up the main part of the document with requirements and tasks.

Visualization / Example

Table of contents:
1. Introduction to the project
2. Description of the initial situation
3. Task
4. Requirements for project management

References & Links

[VDI3694, 2014], [Mahlau, 2018 p.113ff]

Templates

PM-T3.2 Template specification sheet

Index

PM-T3.3

Title

Record template

Application for…

PM-A3.3, PM-A4.1

Link to the Procedure Model

Procedure / Description

Formulation of requirements according to selected sentence schema.

Visualization / Example

" When? Under what conditions?

must

should

becomes

the system

the

Stakeholders

be able to

offer the possibility

Functionality "
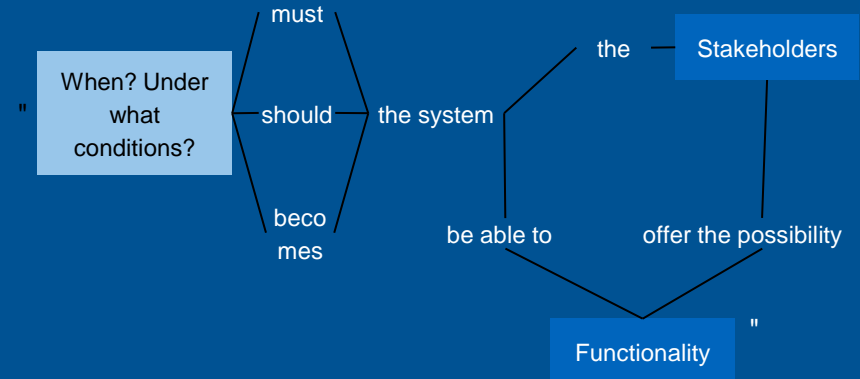
Example:
In the event of damage to the system, the system must be able to prevent further damage from spreading.

References & Links

[Lindemann, 2016 p.442]

Templates

PM-T3.3 Record template

Index
PM-T3.4

Title
Rough roadmap for implementation

Application for…
PM-A3.4

Link to the Procedure Model

Procedure / Description

Applying the identified changes to the system, the tools/IT landscape and the processes/organization on a timeline. Consideration of the degree of novelty as an indicator of the implementation effort.

Degree of novelty:
- How new is the technology on the market?
- How new is the technology for the company?

Visualization / Example
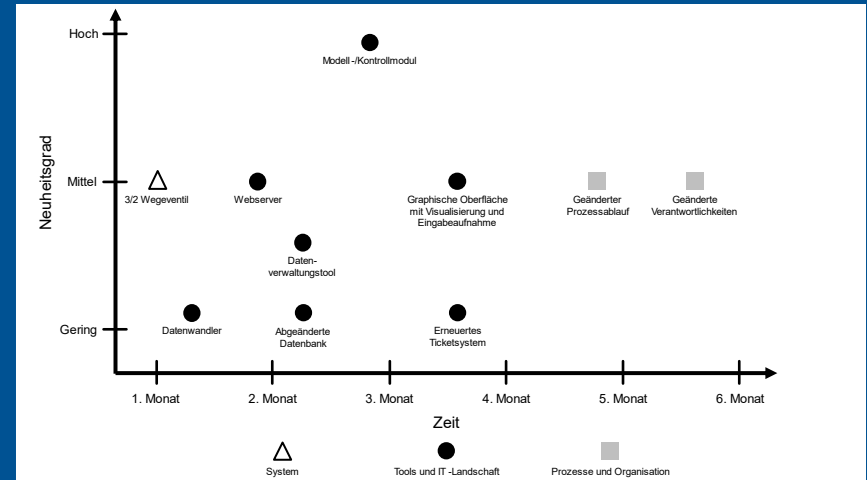
References & Links

[Stöhr, 2018 p.99]

Templates

PM-T3.4 Rough implementation roadmap template

Methods & Tools – How can the activities be supported?

Index
PM-T4.1

Title
Specification format

Application for…
PM-A4.1

Link to the Procedure Model

Procedure / Description

Example format for the specification sheet.
The main part is the description of the partial solutions used to fulfill the requirements and tasks.

Visualization / Example

Table of contents:
1. Brief description of the solution
2. Structure of the technical system solution
3. Description of the partial solutions
4. Test cases and acceptance criteria

	Requirement 1 ID 1	Requirement 2 ID 2	Requirement 3 ID 3	Requirement 4 ID 4
Partial solution 1	X	X		
Partial solution 2		X		
Partial solution 3			X	X

References & Links

[VDI3694, 2014]

Templates

PM-T4.1 Requirements specification template, PM-T4.1 Requirements solution matrix

Index

PM-T4.2

Title

Development methodology of digital twins

Application for…

PM-A4.2

Link to the Procedure Model

Procedure / Description

Proposed procedure for the technical implementation of the digital twin.
1. Identifying and recording process data
2. Modeling of the system and, if necessary, training of the algorithm used
3. Establishing the communication paths between the model and the system
4. Preparing and setting up the model for the application
5. Development of the control logic
6. Development of a graphical user interface

Visualization / Example

1. identifying and recording process data

2. model creation & training

3. establishment of communication structure

4. configuring the real-time simulation

5. development of control logic

6. development of graphical interface
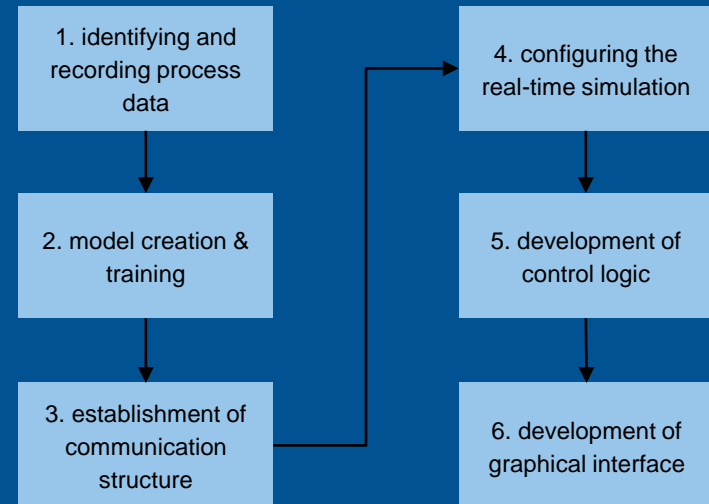
References & Links

[Andrade, 2022 p.136]

Templates

-

Methods & Tools – How can the activities be supported?

Index

PM-T4.3

Title

Implementation roadmap template

Link to the Procedure Model

Application for…

PM-A4.2

Procedure / Description

Enter the created work packages in the intended format.
Enter the created test cases in the intended format.
Assigning responsibilities, processors and supporters to the work packages and test cases.
Creation of a logical chronological sequence of work packages and test cases.

Visualization / Example
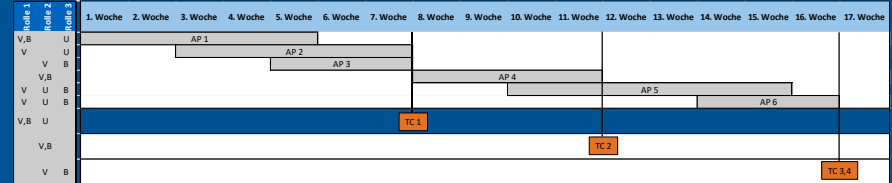
Arbeitspaket			
Nr.:	Name	Verantwortlich	Bearbeiter	Unterstützer
1				
Teillösung		Zugeordnete Anforderungen		
Aufgabenbeschreibung				

Test Case			
Nr.:	Name	Verantwortlich	Bearbeiter	Unterstützer
1				
Beschreibung		Abnahmekriterium		

References & Links

[Saygin, 2019 p.56f]

Templates

PM-T4.3 Implementation roadmap template

Index

PM-M5.1

Title

Change Barometer

Application for…

PM-A5.4

Link to the Procedure Model

🎯 〉 🗺 〉 💡 〉 📍 〉 💡

Procedure / Description

Capturing the emotional state of the organization in the introductory phases of the digital twin.
1. Survey of employees regarding technical content, project approach, general opinion and recommendations

2. Deriving measures from the results to address employees' emotions

Visualization / Example

	Do not agree at all	Do not agree	Agree	Fully agree
Statement 1	● ●			
Statement 2		●		
Statement 3		● ●		
Statement 4			● ●	● ●
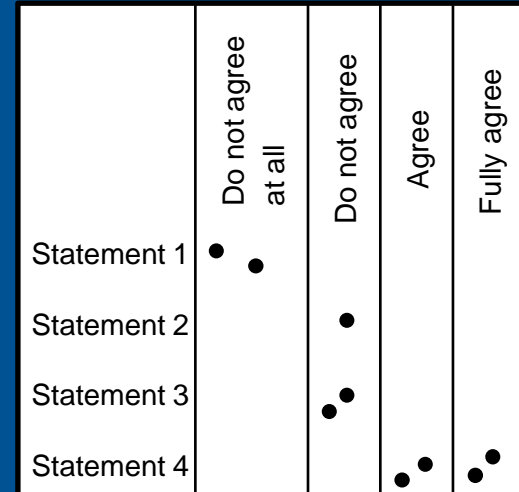
[Stolzenberg, 2021 p.216]

References & Links

[Leiting, 2021 p.105f], [Stolzenberg, 2021 p.216]

Templates

-

Index
PM-T5.1

Title
Direct/indirect communication

Application for…
PM-A5.4

Link to the Procedure Model

Procedure / Description

Ways of communicating changes in the company. Direct communication is preferable to indirect communication due to its greater effectiveness.

Visualization / Example

Direct communication:
- Project Kick-Off
- Works meetings
- Project information event
- Conversations or group discussions

Indirect communication:
- Notices
- Video messages
- Emails
- Employee survey
- Intranet portal
- Social Media

References & Links

[Leiting, 2021 p.107]

Templates

-

Methods & Tools – How can the activities be supported?

Index
PM-T5.2

Title
Retrospective methods

Application for…
PM-A5.5

Link to the Procedure Model

Procedure / Description

Answering the questions: What did we do well, what can we improve next time?
1. Collect data
2. Generate insights
3. Deciding what to do
4. Determine goals and plan actions

Visualization / Example


```
Collect data ──────────┐           ┌─────► Deciding what to do
                       │           │              │
                       ▼           │              ▼
                 Generate insights ┘        Determine goals &
                                                plan actions
```
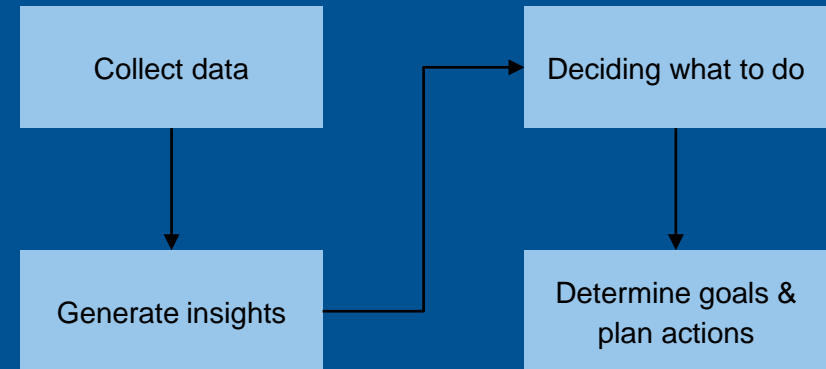
References & Links

[Wirdemann, 2018 p.206f], [Derby, 2006]

Templates

-

Index
PM-M5.5

Title
User Story Risk Map

Link to the Procedure Model

Application for…
PM-A5.1, PM-A5.2

Procedure / Description

Every open user story is placed within the user story risk map with special regard to external factors like the probability of a part from a supplier not being delivered in time or a person getting ill so that they can no longer perform the tasks they have been assigned. As a result, all open user stories are assigned to one of the three categories Low Risk Zone, Observation Zone, Problem Zone

Low Risk Zone: As there is no high damage to be feared and the probability of not being able to complete a user story is not very high, no further measures have to be taken. A standard sprint planning according to the given prioritization can be performed.

Observation Zone: In contrast to the standard Scrum procedure of evaluating outcomes at the end of a sprint, user stories in the observation zone might need more management attention in order not to pose a threat to the overall project goals. Therefore, additional short reviews within the sprint just regarding these specific user stories shall be performed. Depending on the chosen sprint length, there might be two or even more short reviews in the duration of one sprint.

Problem Zone: As they set the overall project at risk, user stories in the problem zone have to be dealt with immediately. Counter measures like early warnings towards the costumer, a reduction of the expected outcome, a weakening of some acceptance criteria, an increase of resources, or the prioritization in relation to other projects have to be chosen. As in the observation zone, some shorter review cycles should be installed, leading to some short reviews within the sprint to check the effectiveness of counter measures and whether other immediate measures are necessary

Visualization / Example
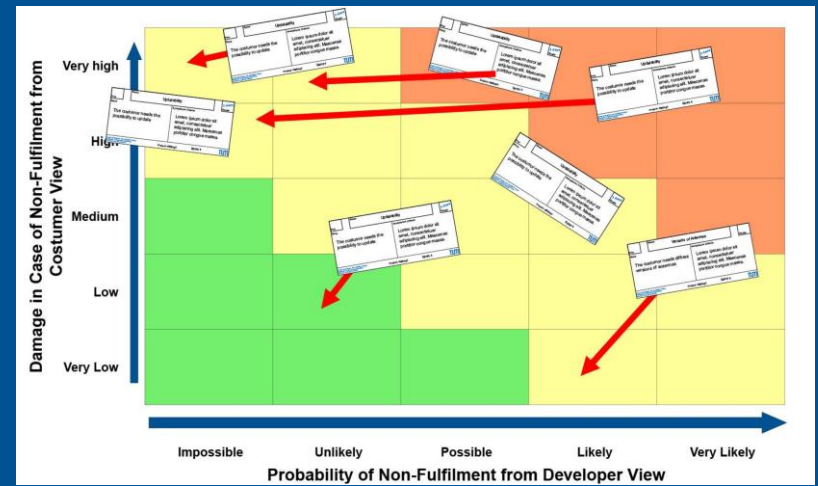
References & Links

[Trauer et al. 2020]

Templates

Methods & Tools – How can the activities be supported?

Index
PM-MSY.1

Title
Digital twin meta model

Application for…
PM-ASY.1

Link to the Procedure Model

Procedure / Description

Select the domains (fields) that are relevant for further analysis of the relationships.

Visualization / Example

Zeile und Spalte hängen zusammen	⚠	👥	🔳	🔧	🧬
Problem	⚠	Hängt zusammen mit			
Stakeholder	👥	Ist betroffen von		verwendet	
Use Case	🔳	adressiert	Erzeugt Mehrwert für	benötigt	adressiert
Tool	🔧				
Digitaler Zwillings Charakteristik	🧬		Hängt zusammen mit		

[Mahlau, 2018 p.109]

References & Links

[Mahlau, 2018 p.108f]

Templates

PM-TSY.1 Digital twin meta model

Methods & Tools – How can the activities be supported?

Index
PM-TSY.2

Title
Link matrix

Application for…
PM-ASY.1

Procedure / Description

Identify the domain-specific relationships between the use cases.
1. Defining the rows and column elements from the meta model
2. Define categories of row and column elements if necessary
3. Determine the evaluation scheme for the degree of correlation
4. Evaluating the correlations

Visualization / Example

Row required Column	Tools			
	Tool 1	Tool 2	Tool 3	Tool 4
Use Case 1	X		-	
Use Case 2		O		
Use Case 3		X		X
Use Case 4		-		O
Use Case 5	O		O	

Legend:
X = High utilization
O = Medium use
- = Low utilization

Based on [Mahlau, 2018 p.111]

References & Links

[Mahlau, 2018 p.108f]

Templates

PM-TSY.2 Link matrix

Deliverable – What has to be achieved?

Index
PM-D1.1

Title
Basic understanding of the Digital Twin concept

Priority
Should-Have

Input for…
-

Link to the Procedure Model

Content

- Definition of a Digital Twin

- Characteristics of a Digital Twin

- Benefits of Digital Twins in general

- General challenges in implementing Digital Twins

- Communication of the basic aspects and definitions within the enerprise

Goal

- Sharpening the understanding of the project (What is it all about?)

- Prevention of misunderstandings during the processing of the project

- First approaches to the justification of the project → pointing out potentials

- Overview of possible challenges in the implementation

- Increasing transparency of the project

- Keeping expectations realistic

Check List

- ☐ Has the term "digital twin" been defined and characteristics been elaborated?

- ☐ Have general benefits of DT technology been identified?

- ☐ Have challenges in the implementation of Digital Twins been investigated?

- ☐ Has the basic understanding been communicated within the company?

Deliverable – What has to be achieved?

Index
PM-D1.2

Title
Project goals

Priority
Must-have

Input for…
PM-A2.5

Link to the Procedure Model

Content

- Rough description of the current situation, medium-term goal (prototype) and long-term goal (vision)

- Global/coarse target

- Structured project goals

Goal

- Creation of a project idea as the cornerstone for the project

- Derive an initial idea of the objectives [DIN69901, 2009 p.19].

- Gives the project team direction and an idea of expected results [Beskow, 1998 p.179].

- Serve the management to monitor the achievement of objectives at the end [Mahlau, 2018 p.63]

Check List

- Is there clarity about the rough current situation of the system, as well as medium-term and long-term goals?

- Has a global/coarse target been defined?

- Are there structured project objectives?

Deliverable – What has to be achieved?

Index
PM-D1.3

Title
Preselection of rough use cases

Priority
Must-have

Input for…
PM-A2.1, PM-A2.2, PM-A2.3

Link to the Procedure Model

Content

- First collection of use case ideas

- Structuring and evaluating the collection of use case ideas

- Preselection of use cases in rough form for implementation

Goal

- Restricting the broad scope of application of DTs

- Early pre-selection reduces the implementation effort

- Concretizing the abstract project goals

- Facilitate implementation of the DT by creating manageable use cases

- Specifying a concrete direction for implementation

Check List

- Were a reduced number of use cases selected from the initial collection of ideas?

- Are the use cases roughly described (e.g. overview use case template)?

- Are the use cases synchronized with the project goals?

Deliverable – What has to be achieved?

Index
PM-D1.4

Title
Plan for the introduction

Priority
Must-have

Input for…
PM-A2.5, PM-ASY.3, PM-A5.5

Link to the Procedure Model

Content

- Plan that sets out the next steps and activities

- Determination of the implementation sequence of the preselected use cases

- Resource plan

- Project team formed

Goal

- Concretizing the implementation -> Making the next steps tangible

- Create the organizational prerequisites for processing the project

- Enable estimation of the project costs

Check List

- Has a plan been drawn up with the next steps and activities?

- Is the sequence of use case implementation defined?

- Is there a resource plan?

- Has a project team been formed with roles and responsibilities?

Deliverable – What has to be achieved?

Index
PM-D2.1

Title
Actual state of the company

Priority
Must-have

Input for…
PM-A3.1, PM-A3.2, PM-ASY.1

Link to the Procedure Model

Content

- Sketch of the use case specific process environment

- Outline of the use case-specific process flow

- Sketch of the use case-specific data structure

Goal

- Basis for recording the current status of the company with regard to digitalization and DT

- Starting point for the design of the DT

- Provides insights into data handling and process flows

- Technical presentation helps with the concrete design of the DT

Check List

- Has the process environment been recorded and documented?

- Has the current process flow been recorded and documented?

- Has the current data structure been recorded and documented?

Deliverable – What has to be achieved?

Index
PM-D2.2

Title
Implementation strategy

Priority
Must-have

Input for…
PM-A4.3, PM-A3.1, PM-A3.3, PM-A3.4

Link to the Procedure Model

Content

- Actual maturity level with strategy for achieving target maturity level

- Implementation strategies based on the analyzed current situation

- List of potential implementation partners

Goal

- Preliminary stage of the target concept -> Specifying the direction in which the DT should go

- Implementation strategies support the determination of the target concept -> Where and how should the DT be used?

- Identify the current situation in the company -> How much effort is required for digitization?

- Gives an overview of which departments and possibly external companies need to be collaborated with

Check List

- Has the actual maturity level been determined and strategies developed to achieve the next levels?

- Have implementation strategies been formulated on the basis of the current situation?

- Is a list of potential implementation partners available?

Index
PM-D3.1

Title
Target concept

Priority
Must-have

Input for…
PM-ASY.1

Link to the Procedure Model

Content

- Defined interfaces of the DT

- Desired target process flow with DT support

- Target process environment with modified/new hardware/software

- Target data structure with changed/new data/information flows

Goal

- Formalize the desired end state for each use case to concretize the goal

- Creating a clear idea of the desired functionality of the DT

- Starting point for technical implementation -> serves as a basis for planning and acceptance

Check List

- Are the interfaces to which the DT docks defined?

- Have the target process, the target process environment and the target data structure been defined?

Deliverable – What has to be achieved?

Index
PM-D3.2

Title
Adjustments to the current situation

Priority
Nice-To-Have

Input for…
PM-A5.4, PM-A4.2

Link to the Procedure Model

Content

- Changes to the process flow, process environment and data structure

- Changes to roles and responsibilities

Goal

- Better understanding of changing processes and activities

- Early determination of how to deal with the DT increases the chance of acceptance and use of the intended DT

Check List

- Are all changes from the actual situation to the target concept documented?

- Have roles and responsibilities been redefined?

Deliverable – What has to be achieved?

Index
PM-D3.3

Title
Specifications

Priority
Must-have

Input for…
PM-A4.1, PM-A4.2

Link to the Procedure Model

Content

- Coordinated requirements structure

- Transfer key for transferring the use cases to the specifications

- Requirements derived from the target concept and the use cases

Goal

- Basis for the preparation of the specifications

- Used for acceptance of the solution implemented later

- Specifies development direction for implementation

- Clarity about the people/groups involved in the implementation

- Coordination of cooperation for efficient implementation without misunderstandings

Check List

- Has the requirements structure been coordinated?

- Has a transfer key been defined for the use cases?

- Were requirements defined according to the question "What should be implemented"?

Deliverable – What has to be achieved?

Index
PM-D3.4

Title
Rough roadmap for implementation

Priority
Should-Have

Input for…
PM-A4.2, PM-A4.3

Link to the Procedure Model

Content
Rough procedure for implementing the use case in the company in terms of tools/systems, processes/organization, product

Goal
- Shows the measures for implementing the use case

- Assists with the scheduling of the next steps

Check List
Is there a timeline where the required steps regarding system, tools & IT landscape and processes & organization are recorded?

Deliverable – What has to be achieved?

Index
PM-D4.1

Title
Coordinated specifications

Priority
Must-have

Input for…
PM-A5.2, PM-ASY.2

Link to the Procedure Model

Content

- Coordinated specifications with details of the intended way of implementing the requirements (how and with what)

- Definition of tests and acceptance criteria

Goal

- Clarify the concrete implementation of the requirements

- Create commitment with the implementation partner regarding implementation

- Ensuring efficient and solution-oriented implementation

Check List

- Has a specification sheet been drawn up with details of how and with what the specifications will be implemented?

- Have test cases and acceptance criteria been defined?

Deliverable – What has to be achieved?

Index
PM-D4.2

Title
Refined implementation roadmap

Priority
Must-have

Input for…
PM-ASY.2, PM-ASY.3, PM-A5.1, PM-A5.3

Link to the Procedure Model

Content

- Defined work packages for the implementation of selected use cases

- Precise plan of who does what and when

Goal

Precise plan helps with efficient and effective implementation

Check List

- Have work packages been defined for the technical realization (implementation)?

- Is there a precise plan of who does what and when?

Deliverable – What has to be achieved?

Index
PM-D4.3

Title
Assured technical feasibility

Priority
Should-Have

Input for…
-

Link to the Procedure Model

Content

- Assured feasibility of the implementation roadmap, coordinated with the implementation partner

- Possible problems/barriers to implementation, including suggestions for overcoming them

- Selected providers

Goal

- Early identification of where problems may arise during introduction/implementation

- Impression of the effort required for implementation -> Is this feasible within the scope of the possibilities?

- Final check whether the implementation roadmap is possible with the help of the implementation partner's know-how

Check List

- Has the feasibility of the intended implementation roadmap been ensured?

- Have potential barriers/problems to implementation been identified and have solutions been developed to overcome them?

Deliverable – What has to be achieved?

Index
PM-D5.1

Title
Implemented use case

Priority
Must-have

Input for…
PM-ASY.2

Link to the Procedure Model

Content
- Implementation of the use case

- Controlled test cases and acceptance criteria

Goal
- Final result of the process model

- Shows the success/failure of the project

Check List
- Has the use case been implemented?

- Have the test cases and acceptance criteria been checked?

Deliverable – What has to be achieved?

Index
PM-D5.2

Title
Supervised implementation & communicated changes

Priority
Should-Have

Input for…
-

Link to the Procedure Model

Content

- Training concept for the pilot phase and subsequent takeover of the implementation

- Communication of changes to activities and functionalities with the new system

Goal

- Ensure use and acceptance of the use case / digital twin

- Facilitating collaboration with new technologies in the company

Check List

- Is there a training concept for the stakeholders affected by the application?

- Have the changes been communicated within the company?

Deliverable – What has to be achieved?

Index
PM-D5.3

Title
Lessons Learned

Priority
Nice-To-Have

Input for…
-

Link to the Procedure Model

Content
- Findings from the implementation in documented form

Goal
- Use of the know-how from the implementation of the use case for further implementations

Check List
- Has the previous procedure been retrospectively reviewed and analyzed?

Deliverable – What has to be achieved?

Index
PM-DSY.1

Title
Interrelationships of the use cases

Priority
Must-have

Input for…
PM-A4.2

Link to the Procedure Model

Content

- Relationships between the use cases in terms of data structure, process flow and process environment

- Strategy for utilizing the connections

Goal

- Recognize whether several use cases can be covered with little additional effort

- Intelligent design of the implementation by utilizing synergies of the use cases (e.g. same data structure)

Check List

- Have all correlations been identified?

- Have strategies been derived to utilize the correlations?

Deliverable – What has to be achieved?

Index
PM-DSY.2

Title
Synchronized use case implementations

Priority
Must-have

Input for…
-

Link to the Procedure Model

Content
Successfully implemented digital twin

Goal
Overall objective of the

Check List
Does the synchronization of the use case implementations provide an overall picture of the digital twin?

Index

PM-DSY.3

Title

Next steps

Priority

Nice-To-Have

Input for…

-

Link to the Procedure Model

Content

- Further procedure for introducing the additional components of the DT

Goal

- Pursuing the next step towards fulfilling the DT vision

Check List

- Has the further procedure been planned on the basis of the current implementation?