Systems Engineering Management Plan

Company C

TERMA Case

Document ID: 1

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Dictionary

Term	Definition
SEMP	System Engineering Management Process
SEP	Systems Engineering Process
ConOps	Concept of Operations
SRS	System Requirements Specification
PDR	Preliminary Design Review
CDR	Critical Design Review
TRR	Test Readiness Review
CPR	Customer Presentation
URP	Updated Reconnaissance Pod
SEIT	Systems Engineering and Integration Team
SoW	Statement of Work
STANAG	NATO Standardization Agreement
SCA	Safety Compliance Assessment
WBS	Work Breakdown Structure
SE	System Engineering
TRD	Technical Requirements Document
CSCI/HWCI	Computer Software Configuration Item/Hardware Configuration Item

Table 1. Definition of terms used in the document.

Scope

The scope of this document is to outline a high level overview of the systems engineering management plan, by providing examples on conducting the systems engineering effort for the URP at Terma. This scope defines the technical management activities, by elaborating on planning, scheduling, reviewing and auditing the systems engineering process.

System engineering process

Systems engineering planning

Decision database - deliverables

The project lifecycle will contain five main phases. Transitions from one phase to another are gated, meaning, some form of review in order to continue is needed. Overview of the gates is presented in figure 1. Each gate is associated with a number of deliverables which are listed in table 1.

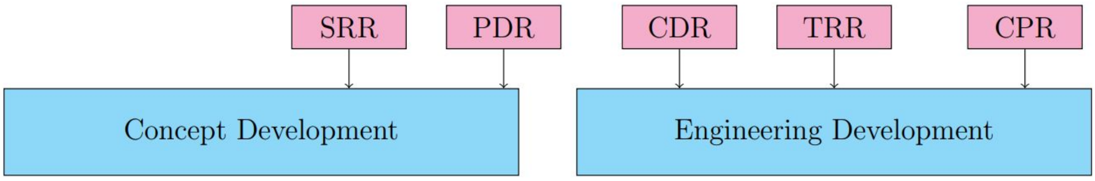

Figure 1. Project milestones.

Table 2. Milestones and associated deliverables.

Milestone	Deliverables
SRR	ConOps, SEMP, Time Plan, System Requirement Specification, RVTM
PDR	Preliminary Design Description, Preliminary Interface Control Document, RVTM
CDR	Detailed Design Description, Interface Control Document, Preliminary Verification Plan, RVTM
TRR	System Test Description (including verification plan, procedure and verification matrix), RVTM
CPR	Customer presentation of project, product & offer, Document Baseline

Process inputs

Project work and associated deliverables will be based on the documents provided by the customer. Input documents are listed in table 2.

Table 3. Process input documents.

Ref.	Doc. No.	Title
[SOW]	1034832-SO	Statement of Work for the Updated Reconnaissance Pod
[TRD]	1034832-DC	Technical Requirements Document for the Updated Reconnaissance Pod

Technical objectives

Main technical objective of the project is:

- Producing a complete design documentation for the URP including a conceptual model.

This objective must be achieved in correspondence to the SOW provided by the customer.

Work breakdown structure

The work breakdown structure in figure 2 gives an overview of key tasks in the project. SE Management part reflects on work associated with earlier mentioned project gates. Remaining part of the WBS reflects the parts of the system known at the present planning state.

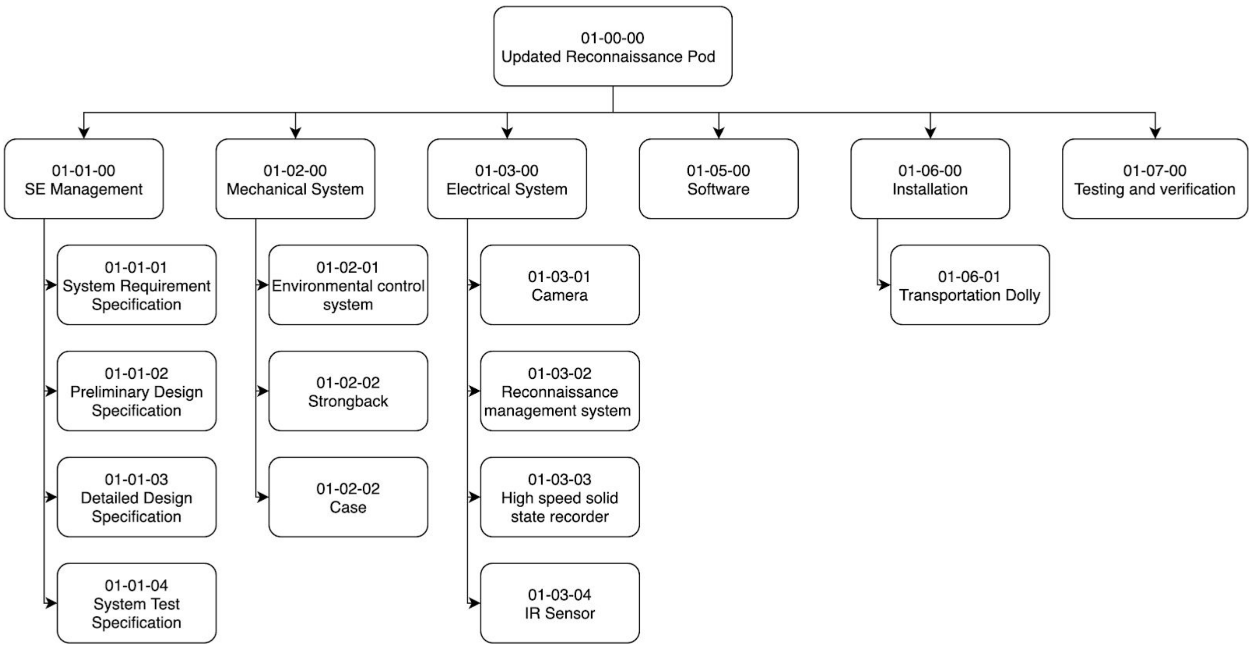

Figure 2. Work Breakdown Structure

Standards and procedures

The following standards will be used during the project:

Table 4. Standards to be used

Standard	Name
ISO 15288:2008	Systems and software engineering - System life cycle processes
Mil-STD-498	Military standard: software development and documentation

Additionally, standards specified in the TRD provided by Terma will be followed.

Resource allocation

Resource allocation during the project will be performed using Six main steps[1]:

1. Divide the Project into Tasks
2. Assign the Resources
3. Determine resource attributes
4. Resource Leveling
5. Re-allocate as necessary
6. Track resource utilization

Verification Planning

Verification process will follow ISO 15288:2008[2]. More elaborated verification process guidelines based on this standard may be found in the INCOSE Systems Engineering Handbook[3] chapter 4.9 Verification Process.

Requirements analysis

Requirements analysis process in accordance with ISO 15288:2008:

1. Analyze the integrity of the system requirements to ensure that each requirement, pairs of
2. Requirements or sets of requirements possess overall integrity. Each requirement should be consistent with all other requirements, implementable and verifiable. Deficiencies, conflicts and weaknesses are identified and resolved within the complete set of system requirements. Any further conflicts will be resolved through communication with the stakeholder.
3. Feedback the analyzed requirements to the stakeholder.
4. Document traceability between the system requirements and the stakeholder requirements.
5. Maintain throughout the system life cycle the set of system requirements together with the associated rationale, decisions and assumptions.
6. Define technical and quality in use measures that enable the assessment of technical achievement. The critical performance measures are analyzed and reviewed to ensure stakeholder requirements are met and to ensure identification of project cost, schedule or performance risk associated with any non-compliance.

Integration and testing in accordance with Mil-STD-498:

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[1] "The 6 Steps of Resource Allocation - ProjectEngineer." 5 Jul. 2019, https://www.projectengineer.net/the-6-steps-of-resource-allocation/. Accessed 18 Feb. 2020.
[2] "ISO/IEC 15288:2008 - Systems and software ... - ISO." https://www.iso.org/standard/43564.html. Accessed 18 Feb. 2020.
[3] "SE Handbook - Incose." https://www.incose.org/products-and-publications/se-handbook. Accessed 18 Feb. 2020.

1. Specify system requirements and functions, as justified by risk identification or criticality of the system, that relate to critical qualities, such as health, safety, security, reliability, availability and supportability.
2. Developing and recording test cases, test procedures, and test data for conducting CSCI/HWCI integration and testing.
3. The testing shall be in accordance with the CSCI/HWCI integration test cases and procedures.
4. Make necessary revisions to the software, perform all necessary retesting, and update the appropriate software development files (SDFs) and other software products as needed, based on the results of CSCI/HWCI integration and testing.
5. Software-related analysis and test results shall be recorded in appropriate software development files (SDFs).

Functional analysis

The process involves analyzing each system requirement to identify all the functions that need to be performed to meet the requirement. Each function identified is described in terms of inputs, outputs, failure modes, consequence of failure, and interface requirements. The process is repeated from the top down so that sub-functions are recognized as part of larger functional areas[4].

Functional analysis process:

1. Translate top-level requirements into functions that should be performed to accomplish the requirements.
2. Decompose and allocate the functions to lower levels of the product breakdown structure.
3. Identify and describe functional and subsystem interfaces.

A system functional flow block diagram will be followed. This is presented in Figure 3.

[4] "NASA Systems Engineering Handbook Revision 2 | NASA." 27 Jan. 2020, https://www.nasa.gov/connect/ebooks/nasa-systems-engineering-handbook. Accessed 19 Feb. 2020.

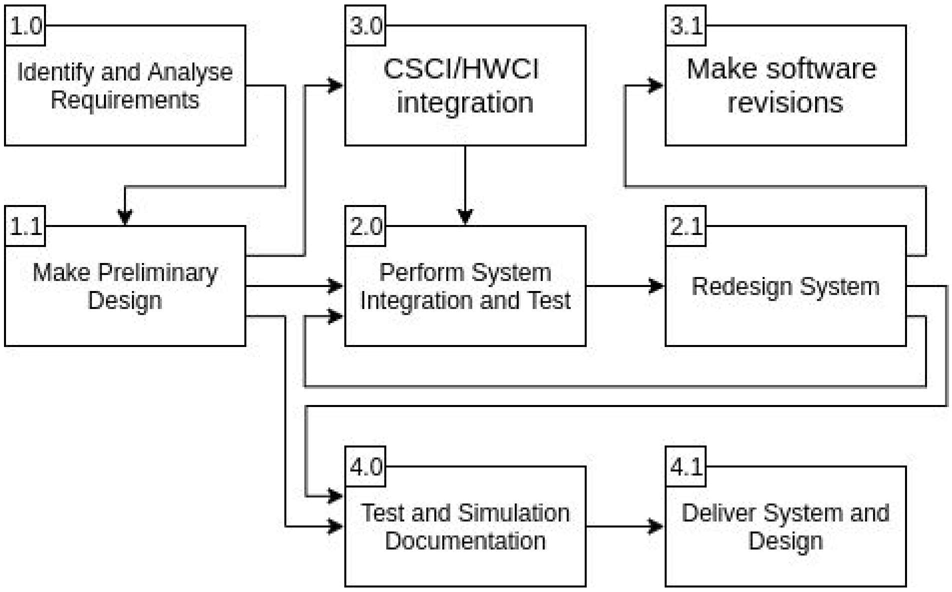

Figure 3. System FFBD

Synthesis

Synthesizing a possible solution should include carefully selected different types of system elements. The chosen elements shall be evaluated based on their characteristics. The most important step of synthesis is determining the most effective arrangement of those system elements that fits into the requirements and the design itself. The synthesis of the architecture shall be done iteratively and it is required to collect feedback from the subsequent steps. To have a much clearer view on the functionality of the complex system, different architecture views (operational view, physical view, logic view) are used throughout the synthesis.

It shall be checked that every architecture level meets the requirements (as they are described in SLR-141) during the verification process (inspection, analysis, similarity, demonstration, test). If the solution is not eligible, the verification cycle must be restarted after the appropriate changes, and it continues until the architecture is found to be adequate.

The verification methods (as they are described in SLR-103) should achieve the following:

1. The architecture performs all the functions of the defined system.
2. It is capable of meeting all the requirements and satisfies all constraints.
3. The resource usage is within acceptable limits.
4. All the elements are compatible.
5. All the interfaces are satisfied.

System Analysis and Control

Normally the Systems Analysis and Control[5] manages the overall SEP along with identifying the work to be done as well as develop schedules and estimates for the cost. In this project its focus is on decision management. As the project develops and the initial Requirements Analysis, Functional Analysis, and Synthesis begins to yield usable outputs, more informed decisions can be taken for the further development of the product. Such decisions could for example be which component(s) to select for a specific task.

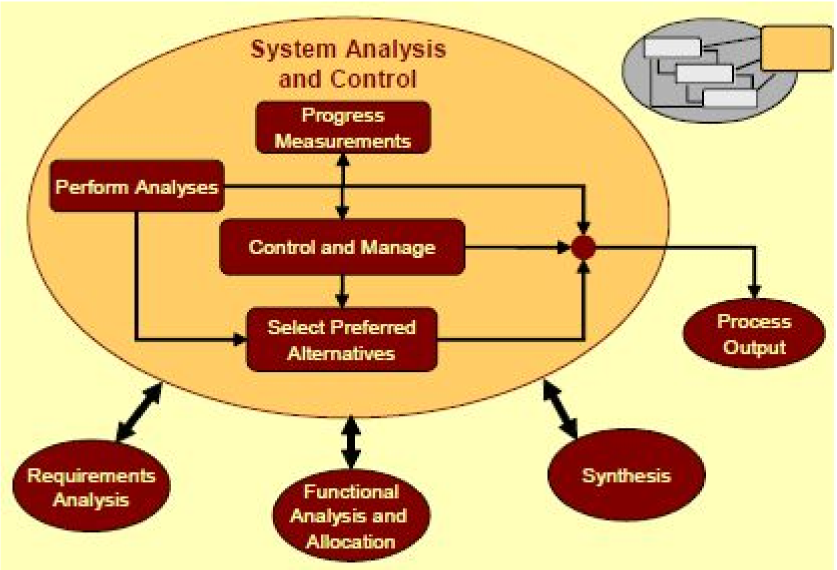

Figure 4. Image is from SMC Systems Engineering Handbook, Figure 19 - System Analysis and Control.[6]

The Systems Analysis and Control activity will take in the outputs of the previously mentioned analyses and add a few of its own to reach decisions about which approaches are best for the product, considering both cost and effectiveness with the requirements in mind. This includes which equipment to incorporate into the product.

To do this, trade-off studies and system and cost-effectiveness analyses are conducted. These studies and analyses should consider the Risk Managements outputs.

- Trade-off studies will place a metric on various characteristics of for example a physical part needed, but of which several models exist of. Metrics could be price, weight, power consumption, effectiveness. Then a value can be calculated for each option.
- System effectiveness analysis considers systems of elements and determines their expected performance.

[5] "(SMC) Systems Engineering Primer & Handbook - AcqNotes." 29 Apr. 2005, http://www.acqnotes.com/Attachments/SMC%20Systems%20Enegineering%20Handbook.pdf. Accessed 19 Feb. 2020.
[6] "System Analysis & Control - AcqNotes." 17 Jul. 2017, http://acqnotes.com/acqnote/careerfields/system-analysis-and-control. Accessed 19 Feb. 2020.

- Cost-effectiveness analysis takes both the cost into account and the benefits/effectiveness of the options available[7].

Furthermore, a version of Decision Analyse[8] where decision trees are used to represent the process can be used for better visualization to allow for greater overview of the options. Whether there should be a separate analysis for this or it should be applied to the analyses above is not yet decided.

Risk management

Definition: Risk Management is the identification, evaluation, and prioritization of risks. Risk is the combination of likelihood and consequence. A risk that is likely to occur and has severe consequences is considered as high risk. A risk that is unlikely to happen and have negligible consequences is considered as low risk.

The risk management will be performed in the following way:
1. Identify risks.
2. Assess risks.
3. Mitigation.
4. Consequence handling.
5. Track and control.

Risks may come from various sources. These are leading to the risk that will be identified. After, the risks are assessed based on the level of consequence and probability. The levels of consequence and probability are defined as follows:

Table 5. Probabilities

1	2	3	4	5
Unlikely happen	Slightly chance to happen	May happen	Likely to happen	Very likely to happen

Table 6. Levels of consequence

E	D	C	B	A
Almost no effect	Minor	Major	Hazardous	Catastrophic

Different roles will be defined, each role will categorize a different level of risk. Following categories will be employed:

[7] "Cost-effectiveness analysis - Wikipedia." https://en.wikipedia.org/wiki/Cost-effectiveness_analysis. Accessed 19 Feb. 2020.
[8] "Decision Analysis and Cost-effectiveness Analysis - NCBI." https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3746772/. Accessed 19 Feb. 2020.

Table 7. Risks Categories

TR	CR	SR	PR
Technical Risks	Cost Risks	Schedule Risks	Programmatic Risks

- Technical Risks: Technical risk exists if the system may fail to achieve performance requirements
- Cost Risks: cost exceeds the allocated budget.
- Schedule Risks: the team fails to reach the milestone on time.
- Programmatic Risks: The programmatic risks are beyond the control of a project manager. These risks can be produced by higher level personnel. It can for example be that a project gets a lower prioritization.

The image below demonstrates the relationship between these risk categories:

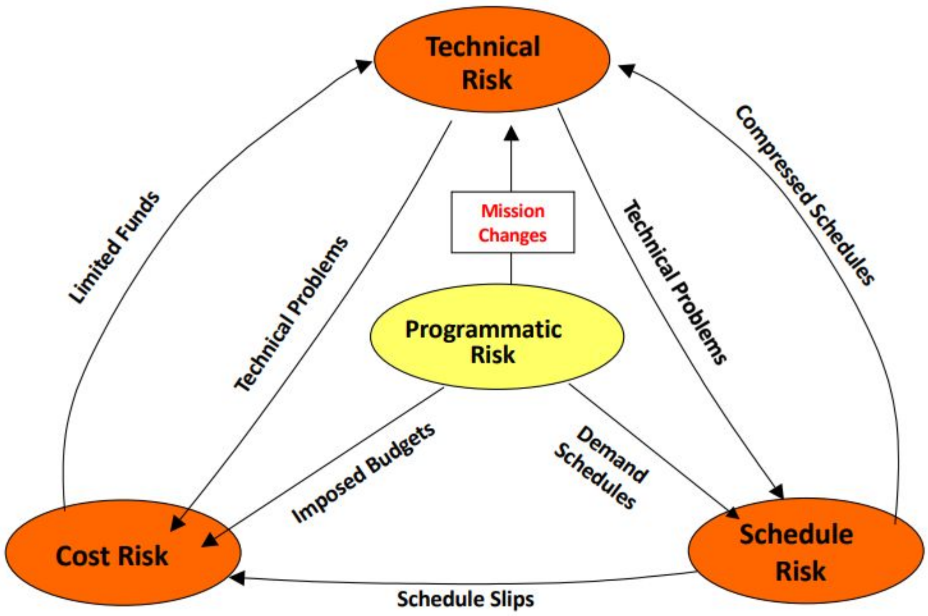

Figure 5. Risk Categories

As the case is analysed, detailed risks will be identified. Next, mitigation methods will be determined for each risk. Risk tracking and control will be performed to assure that the team gets feedback on new issues and fix them in a timely manner.

Transitioning critical technologies

Through basic theory on the subject, a suited Technology will be implemented. The basic theory of this will be The Seven Steps method. Each aspect of this is described below. [9]

[9] "Transition engineering - Wikipedia." https://en.wikipedia.org/wiki/Transition_engineering. Accessed 19 Feb. 2020.

1. The historical aspect: how products like this were designed and how these fit into a given environment through time. This includes cultural, political and environmental aspects evaluated in a way that relates what issues were then, in relation to now and the future.
2. Current aspects: managing current capabilities, assets and liabilities in the technology to be transitioned.
3. Future aspects: As the historical aspect, cultural, political, environmental limitations and trends and more are considered
4. Path Break Concept aspects: an innovative process is used to freely discuss how the project can be changed to work in a future operating environment.
5. Back casting aspects: How the path break aspects vary from the current situation, and what is needed to change the system to work as imagined with the PBC.
6. Trigger event aspects: It is discussed what serious events could make the project be changed or discontinued.
7. Shift project aspects: By planning supply and demand for the future, the changes are implemented.

These points are all necessary to correctly transitioning critical technologies into the system.

Integration of the system engineering effort

The technology verification, system end design and engineering test articles, as well as the verifications and process proofing for the URP, shall be conducted by the respective SEIT, consisting of members responsible of regular contact with the stakeholders (including the subcontractor and reviewer), as well as the development team.

As for the standardization, the system shall make use of respective standardization when appropriate. The units of measurement included in the design documents should follow the same standards, present in the SoW. The design for both the URP and the transportation dolly shall follow standardized guidelines, in particular, the STANAGs, Mil Standards and Mil Handbooks.

Physical, safety and security constraints shall be addressed as part of the planning process. A respective team shall be assembled (depending on the constraint) and a representative/responsible for the said issue shall be assigned. The development team will produce verification reports based on the results from the verification efforts and the SCA. The representative will then ensure the consideration of the constraint during the development test and evaluation process.

The system and cost-effectiveness shall be tracked regularly by the development team, including management cost, equipment purchases, reduced costs and avoidances. Since the system implementation cost is to be estimated by the SEIT, further changes to the estimations shall be reflected in the contract with the stakeholders.

As for the sustainment and problem solution support, it is expected that several processes are to be evaluated for improvements. Once an improvement is made (concerning the implementation), all respective documentation shall be updated, including communicating the change to all involved employees (if applicable) and new metrics shall be tracked by performing new verifications and validations.

Additional system engineering activities

The additional system engineering activities that will be discussed in this section are: long-lead items, engineering tools, cost analysis and system integration plan.

The long-lead items[10] are equipments that will negatively impact the project's time to delivery (the equipments have a very long delivery time and assembly). In this project, these items will be identified in the design phase, and they will be assigned to subcontractors responsible for preparing and maintaining them.

The following engineering tools will be used in this project: context diagram, functional modeling, Pugh matrix, QFD, stakeholder influence map, holistic requirements model. These are defined here[11].

For the cost analysis, there will be used a value engineering approach. As defined here[12], using this technique, the cheapest equipments that still satisfies all the requirements will be acquired.

Because this project's system is composed of multiple subsystems, the following system integration plan will be used:

1. Identify all the sub systems with their required inputs and desired outputs
2. Define an interface for each subsystem
3. Implement the interfaces in each subsystem
4. Maintain and replace subsystems if needed

Systems engineering schedule

This section provides a schedule that will be followed during the whole development process. The work is divided into several parts that represent milestones of the project. Each milestone will be achieved according to their deadlines. Below is the diagram that shows the timeline of this project and describes what milestones will be achieved in each step.

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[10] "Long lead item - 2B1st Consulting." 8 Jun. 2012, https://www.2b1stconsulting.com/long-lead-item/. Accessed 16 Feb. 2020.
[11] "List of Systems Engineering Tools and ... - Burge Hughes Walsh." Accessed February 16, 2020. https://www.burgehugheswalsh.co.uk/systems-engineering/tools.aspx.
[12] "Value Engineering Definition - Investopedia." 17 Apr. 2019, https://www.investopedia.com/terms/v/value-engineering.asp. Accessed 19 Feb. 2020.

The abbreviations from the figure above are explained in the dictionary section at the beginning of the document.

Systems engineering process metrics

This section describes metrics[13] establishe to measure, analyse and possibly increase performance of development during the project. Actual implementation is not in the scope of the project, that means measurements will focus on the fact that all documents planned should be delivered on time.

Document delivery time

There are 5 milestones mentioned in Figure 6 on which documents will be delivered. The milestones in the figure provide an estimate of document delivery in each phase.

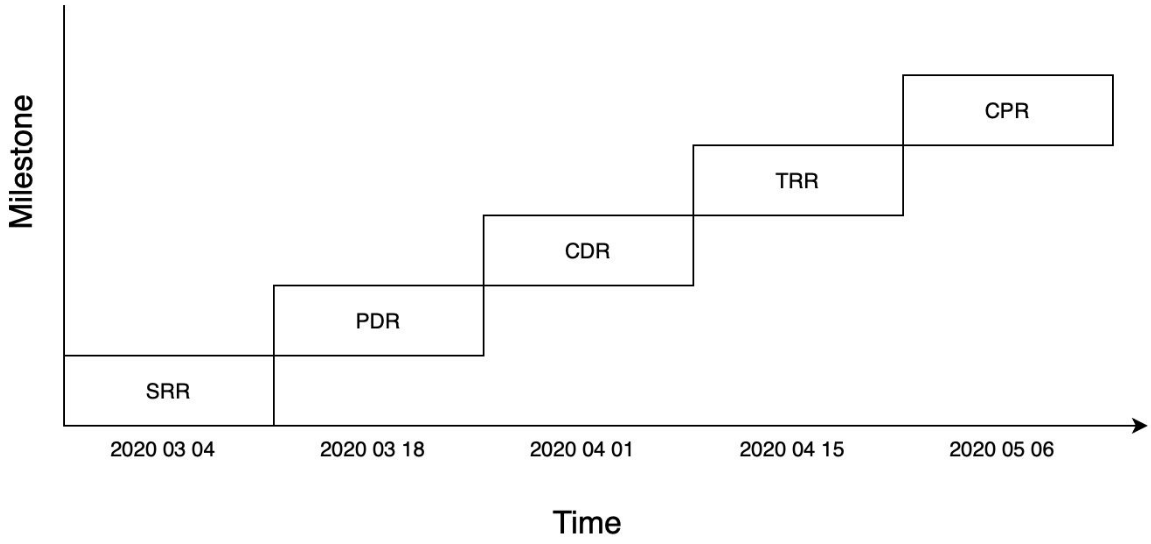

Figure 6. Time schedule of development process

Customer satisfaction

Documents will be reviewed by the stakeholder which will provide feedback on the delivered documents. Feedback will be used to analyse customer satisfaction.

[13] "The 8 IT service management metrics that matter most ...." https://techbeacon.com/enterprise-it/8-it-service-management-metrics-matter-most. Accessed 19 Feb. 2020.