How can a Global Travel Distribution Organisation reach CMMI 5? – Solution

Hur kan ett Globalt Resedistributionsföretag nå CMMI 5? – Lösning

SHANKAR GOPINATH
MARDIN NICKRAD
How to reach CMMI 5 level for a Global Travel Distribution Organization?

Abstract

An ISO 9001:2000 certified Global Travel Distribution Organization (GTDO) is aiming to achieve process improvement in its IT operations and services by adapting CMMI process improvement framework. This research work provides in-depth analysis of the quality procedures followed in GTDO, the gaps present in the GTDO in comparison to CMMI maturity levels and addresses the gaps to incrementally achieve CMMI 5.

Comparison of CMMI to various established quality frameworks such as ISO 9001:2000, PMBOK, Prince2, and ITIL was performed and best practices that are present in other frameworks were integrated into the process areas under CMMI to lay a path for the GTDO in reaching the CMMI level 5 maturity levels in incrementally steps.

An analysis of the quality methods and procedures in the organization was performed and a study was done to understand if staged/maturity representation or Continuous representation of CMMI is best suited for the organization. This study is based on CMMI v1.2 for Development. The staged representation is concluded to be the best representation for GTDO and the reasoning and judgment were established. Gap analysis (between the GTDO: s current quality procedures and different maturity levels of CMMI) was performed and the activities that needs to be undertaken to address the gaps were presented.

Given the size of the operations undertaken by the GTDO, there exist several areas of attention and improvement to be made. Some noteworthy areas of improvement are requirements management, project planning, project monitoring and control, Operational Process performance and Decision Analysis and resolution. This thesis work produces a sustainable model to incrementally reach the CMMI level 5 maturity level for the GTDO.

The research work was conducted by applying PMBOK (Project Management Body of Knowledge) in performing the planning and execution of the research project. The 5 phases of Initiation, Planning, Execution, Monitoring & Control and Closing were followed and 9 PMBOK knowledge areas were applied. The Execution phase was divided into 4 phases where there was pilot study on CMMI, learning the current processes and procedures in the GTDO, performing gap analysis, addressing the gaps to reach the different CMMI maturity levels. A reflection on the thesis work was performed. Recommendations and future work were summarized.

<table>
<thead>
<tr>
<th>Major Stakeholders in Project</th>
<th>Company / Division</th>
</tr>
</thead>
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<tr>
<td><strong>Names</strong></td>
<td></td>
</tr>
<tr>
<td>Project Sponsor</td>
<td>GTDO, Erika Bellander</td>
</tr>
<tr>
<td>Steering Committee</td>
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<td>Shankar Gopinath, Mardin Nickrad</td>
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<td>Examiner</td>
<td>Roland Langhe</td>
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<td>Employer</td>
<td>GTDO</td>
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<tr>
<td>Supervisor</td>
<td>Erika Bellander</td>
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</tbody>
</table>
Keywords: Reaching CMMI 5, Map CMMI 5, CMMI for Travel Organization, GTDO, Global Travel Distribution Organization, Capability Level Implementation, Maturity Level Implementation, Organizational Innovation and Deployment (OID), Causal Analysis and Resolution (CAR), Quantitative Project Management (QPM), Decision Analysis and Resolution (DAR), Integrated Teaming (IT), Organizational Process Performance (OPP), Risk Management (RSKM), Integrated Project Management for IPPD (IPM + IPPD), Organizational Training (OT), Organizational Process Focus (OPF), Verification (VER), Validation (VAL), Organizational Process Definition + IPPD (OPD + IPPD), Technical Solution (TS), Product Integration (PI), Technical Solution (TES), Requirements Development (RD), Configuration Management (CM), Product and Process Quality Assurance (PPQA), Measurement and Analysis (MA), Supplier Agreement Management (SAM), Project Monitoring and Control (PMC), Project Planning (PP), Requirements Management (REQM), Process Database, Process Capability Baseline.
Acknowledgements

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Frederic Barber – For very valuable support in discussions and inputs on GTDO’s processes and development methodologies

- Authors
  Stockholm

Disclaimer

Utmost care has been taken in meeting all Specific and Generic Goals of CMMI® so that this guide will serve as a bible to reach CMMI level 5 for an organization similar to the configuration of GTDO (The Global Travel Distribution Organization). Nonetheless, no warranty is expressed or implied in merchandise or marketable product or results in the execution of this “How to reach CMMI 5” shall be deemed nor claimed. All names of software products are pseudonyms of products in usage/ to be used in GTDO. Any resemblance of the pseudonyms with any other organizations past, present or future products are fully non-intentional and simply a coincidence.

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1 Introduction

This chapter provides a subtle view into the steps and the approach to be followed in execution of the thesis. It briefly introduces the user to CMMI, how the implementation of CMMI can solve some of the very common issues the GTDO faces, how various organizations have benefited from implementing CMMI. It describes how the implementation can be performed under various phases in the GTDO in order to reap quality improvement benefits.

1.1 Background

CMMI is a process improvement framework which consists of quality procedures for sustained quality improvement with a major focus on Software Development and Systems Engineering. [1] [4] It provides organizations with options of improving a set of key process areas for each level and to get appraised to different maturity levels (1-5) or focus on one or more process areas to reach Capability levels (0-5) [1] depending on the needs of the organization.

The GTDO has been facing common issues like many Software Organizations that have non-homogeneous and non-quantitative quality management procedures and processes in majority of areas. Although an ISO 9001:2000 certified organization, the concept of “measure, manage, learn and improve” is inadequate and in many departments non-existent. An example of a major ubiquitous problem that the GTDO faces in various projects across the departments is that of project monitoring and controlling. ISO does not address this area though it recommends Development Planning (Clause 5.4) and Corrective Action (Clause 4.4). ISO does not specify any methodology or technique that can be used to monitor and control the project. The following is an example of how CMMI could help with more concrete process improvement suggestions.

Project Monitoring and Control (PMC) [Maturity level 2]

The purpose of PMC process area is to significantly improve the understanding of the progress of the project in such a way that corrective actions are taken when the project’s deliverables and performance deviates significantly from the plan [3] [4]. PMC should be based on Process Database (PD) and Process Capability Baseline (PCB) where metrics from the past projects are classified according to the types and various phases of the projects. Using tools such as Control Charts, the performance and deviation can be detected early and corrected which will avert any schedule slippage. Refer to [41] for more details on PD and PCB respectively.

Example

(a) Monitoring Effort Data

Monitoring the effort spent on each activity can be done through a Weekly Status Report which shows CR, the activities within it and their statuses. This will enable us to monitor the effort/cost spent in each activity. This data will be continuously used in PCB to build percentage effort spent on each activity. Any deviation from expected or acceptable limits can be detected early and therefore corrected. For instance, in a project using 3rd Generation Programming language, approximately 20 – 25% of efforts are spent on Requirement Analysis and Design; about 45% are spent on Implementation and Unit Testing [3]. If the PCB value shows a deviation from these, this will raise an early warning by monitoring the Effort data. PD is a part of Organizational Process Focus (OPF) and PCB is a part of Organizational Maturity level 4 of CMMI.
PD and PCB will be implemented as under [41]. The vision of reaching CMMI 5 and beyond can be found under Figure 11: How to reach CMMI 5 and beyond: Phases of Implementation.

Currently in GTDO, there is no use of Control chart or any other control mechanism to check if the activities performed and reported are within the Control limits of a similarly sized project with the corresponding classification of technology used for development.

(b) Monitoring Defect Data

Although tracking defects exists within GTDO, there is no tracking of effort spent on defects, investigation and fixing. A PCB will also contain the stage in which a particular defect was injected and the stage in which it was detected [3]. This information can be used to compute Defect Removal Efficiency (DRE). See 9.3.4 Project Monitoring and Control (PMC) for more details on DRE.

ISO 9001:2000 is a necessary requirement for quality management system. It is a part of ISO 9000 family that consist of ISO 9000 (fundamentals and vocabulary), ISO 9001 (requirements), ISO 9004 (guidelines for performance improvements) and ISO 19011 (guidelines for quality and environmental management systems auditing). ISO 9001:2000 is an abstract and sparse document that can be applied to any category of business. ISO 9001 could be interpreted by ISO 9000-3[2] or Tick IT [3] when applied to organizations in the software industry. For every requirement in ISO 9001, an organization can choose to have two status, ‘satisfied’ or ‘not satisfied’. If every requirement is satisfied, then ISO registration is achieved. ISO 9004:2000 is not a requirements document, but rather a guidance document for process improvement of a greater level compared with ISO 9001:2000. ISO 9001:2000 and ISO 9004:2000 are both similar in terms of structure and terminology used to allow easy conversion from one to the other.

ISO 9001 requires that processes to be continuously improved even after achieving ISO registration. CMMI can be a good process framework to an organization in the software and systems industry to achieve further process improvement, because CMMI is quite detailed and contains more concepts for improvement of processes than ISO 9001:2000. Furthermore, considering that many ISO 9001:1994 registered organizations are trying to introduce SW-CMM[3] [7], it is expected that many ISO 9001:2000 registered organizations will be willing to adapt CMMI into their systems. It would be ideal for ISO registered organizations to adopt CMMI since the structure of CMMI is similar to that of ISO 9001:2000 [7].

An example of a Gap between CMMI and ISO 9001:2000 is shown below in Table 1: Gap in Project Planning Area between ISO 9001:2000 and CMMI. A complete list of Gap Analysis is available under [40].

<table>
<thead>
<tr>
<th>#</th>
<th>Concept/Process Area in CMMI</th>
<th>Gap in ISO 9001:2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Project Planning</td>
<td>Project Plan in an ISO organization is not strictly performed with estimates on time, cost and schedule albeit assumption exist that they are part of the planning process. An ISO company would have reviews and approval requirements from senior management on the plan and though. There is no specific estimation guideline nor is corroborated by Process Capability Baseline (See [41] for more information) to make educated estimates based on facts in Project Planning.</td>
</tr>
</tbody>
</table>

*Table 1: Gap in Project Planning Area between ISO 9001:2000 and CMMI*
1.1.1 CMMI-based Appraisals and their Advantage

An IT Organization in general and the GTDO specifically must move to CMMI 5 due to the following reasons:

- Reaching a CMMI level maturity undoubtedly provides an edge for GTDO over other competitors in marketing and increases customer confidence and subsequently customer satisfaction.
- Maturity level and Staged Representation of CMMI provides a perfect guided approach to planning an improvement strategy for the organization and improvement of processes to increase parameters that every organization wants to improve (Reduced Cost, Increased Quality and Increased Productivity) in a sustainable manner.
- It enables an organization to identify strengths and weakness of its current processes against the CMMI model and prioritizing improvement plans which means sustainable process and product improvement.
- Providing education regarding interpretation of process areas and practices
- Validating progress towards process maturity
- Generating maturity level or capability level ratings
- Mitigation of risks for production acquisition, development and monitoring

Many IT organizations have a suite of interim CMM/CMMI assessment processes in place for many years. The purpose of the interim assessments varies from education regarding interpretation of process areas and practices for a maturity level, to a readiness review for a formal assessment which results in a maturity level rating. In the development of CMMI, SEI (Software Engineering Institute) recognized that interim assessments were important, and has defined Appraisal Requirements for CMMI, Version 1.1 (ARC V1.1) to address multiple types of appraisals. [2]

1.2 The How to reach CMMI 5 – The “What” and a birds view of “How”?

The How to reach CMMI 5 for GTDO research report is a step by step guide for the GTDO to reach CMMI 5. The Approach for reaching CMMI has been divided into several phases. Each phase is aimed at addressing a set of process areas under two different modes namely Capability and Maturity Models.

The 2 different phases formulated for execution of How to reach CMMI 5 for GTDO [9.1.3 Devised Phases of Implementation and Formulation] are as follows:

(1) Implementation of a particular Maturity Level in order to satisfy a set of process areas at a particular capability level (A guided form of Quality Implementation)

(2) Reaching a Capability Level for a particular process area (Where a particular process area is chosen and resources and time is allocated to improve that particular process area to a certain level.)

This is shown in the Figure 1: Overview of How to reach CMMI 5 for GTDO Formulation
Map to CMMI 5 for GTDO is formulated in 3 phases of execution.
Each phase is a part of a package “Map to CMMI 5 for GTDO”. A total of 22 process areas are covered in different phases.

Each Process area could be targeted for one for the 4 levels of Capability Levels. [2,3,4 or 5]
A Maturity Level consists of several process areas. [Eg. Maturity level 2 consists of 7 process areas]
Each Process Area belongs to one of the Maturity Levels.

The Capability Level targeted for a process area could range from 2 to 5.
The Maturity Level targeted in a process area could range from 2 to 5.

The list of process areas and how they can be viewed under different capability and maturity levels is presented under [45]. The following Table 2: Process areas and phase outside the corresponding phase exclusion shows the process areas included under various phases for CMMI implementation, their planned Capability level (Target Capability Level), the maturity level they originally belong to and the phase in
which they are included. The rationale behind the inclusion of the process areas under different phases is illustrated under [41].

This project includes implementation of reaching CMMI 5 maturity level. It also includes the formulation of vision to reach beyond CMMI 5. Figure 11: How to reach CMMI 5 and beyond: Phases of Implementation and Table 2: Process areas and phase outside the corresponding phase exclusion describes the vision of reaching beyond CMMI 5.

<table>
<thead>
<tr>
<th>#</th>
<th>Process Area</th>
<th>Belonging to Maturity Level</th>
<th>Included in Phase</th>
<th>Target Capability level</th>
</tr>
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<tr>
<td>1</td>
<td>Organizational Process Focus (OPF)</td>
<td>3</td>
<td>1</td>
<td>3</td>
</tr>
<tr>
<td>2</td>
<td>Organizational Process Definition (OPD) +</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Integrated Process and Product Development (IPPD)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Organizational Process Performance (OPP)</td>
<td>4</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
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<td>Project Monitoring and Control (PMC)</td>
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<td>2</td>
<td>4</td>
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<td>Decision Analysis and Resolution (DAR)</td>
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<td>2</td>
<td>4</td>
</tr>
<tr>
<td>6</td>
<td>Product Integration (PI)</td>
<td>3</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>7</td>
<td>Product and Process Quality Assurance (PPQA)</td>
<td>2</td>
<td>1 &amp; 3 *</td>
<td>3 &amp; 5 *</td>
</tr>
<tr>
<td>8</td>
<td>Configuration Management (CM)</td>
<td>2</td>
<td>1 &amp; 3 *</td>
<td>3 &amp; 5 *</td>
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<tr>
<td>9</td>
<td>Requirements Management (RM)</td>
<td>2</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>10</td>
<td>Measurement and Analysis (MA)</td>
<td>2</td>
<td>4</td>
<td>5</td>
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<td>11</td>
<td>Organizational Process Performance (OPP)</td>
<td>4</td>
<td>2 &amp; 4 *</td>
<td>4 &amp; 5 *</td>
</tr>
</tbody>
</table>

* = For future. Not part of this research work to achieve this level.

1.2.1 **Major tasks of the project**

- Following the project management disciplines of Initiation, Planning, Execution, Monitoring and Control and Closing in performing the research work.
- Synthesis and Analysis of CMMI Representations
- Study of processes and procedures followed in GTDO and ISO 9001:2000
- Choose the best approach for the GTDO to implement CMMI with justification
- Perform Successive Gap analysis and assess the health of the GTDO
- Actions and Checklist to bridge the gaps in reaching the different CMMI Maturity Levels (2 to 5)
- Document Templates for the different process areas as applicable
- Provide Recommendations and Future work
2 Problem definition

The term project refers to the thesis work. The deliverable of the project is “How to reach CMMI 5 for GTDO”. This chapter defines the project charter with the business case, the problem statement, problem scope and constraints which together defines the opportunity (problem). The GTDO has been focusing on improving the quality of products and services that it delivers continuously. This shows its commitment in getting ISO 9001:2000 certifications and now is working towards a CMMI maturity level grading. The GTDO has good experience in quality procedures but to implement CMMI across the whole organization is quite a mammoth task.

2.1 Project Charter

The Project Charter for the project How to reach CMMI 5 for GTDO is described in Figure 2: Project Charter for PERFORMING research work for How to reach CMMI 5 for GTDO. The Project charter provided here incorporates all the requirements for creating a scope statement such as choosing Project Management Information System and Expert judgment.

According to PMBOK (Project Management Body of Knowledge) definition, “Project Stakeholders are individuals or organizations who are actively involved in a project, whose interests are affected as a result of project execution or project completion. These actors exert influence on the initiatives and the outcome of the project. The customer is the GTDO. So the project deliverables will be presented to GTDO as per implementation planning” [26].
Project Title: Research Work for How to reach CMMI 5 for a GTDO?

Project Sponsor: KTH GTDO

Examiner: Roland Langhe

Project Supervisor: Erika Bellander

Business Case:

Reaching CMMI 5 in quality standards is a major milestone and selling point for the business of GTDO. It guarantees sustainable improvement over time for GTDO in delivering its products and services. There is also an identified need to improve processes and procedures in areas such as Requirements Management, Project Monitoring and a systematic well grounded decision making. It is identified that the GTDO spends a significant of resources due to too many change requests which indicate a need in better Requirements Management. An estimated increase of revenue must be at least 25% within 2 years of implementation of CMMI. Attaining CMMI 5 maturity level also provides an edge over competitors as this GTDO will be the first to do so among the other major GTDO’s in the market. (At the time of updating this Charter: 15 Oct 2007)

Problem/Opportunity Statement (Preliminary Project Scope Statement):

The GTDO has identified the need to improve quality in the products and services offered and also reduce the cost of quality by investing in better quality assurance, processes and procedures. This has led to the decision on embracing CMMI within the GTDO and perform a research work which will identify the gaps of GTDO against the chosen model of implementation of CMMI.

Adhering to CMMI maturity levels will provide a good foundation for sustainable and continuous improvement, of processes and institutionalisation of quality processes.

Stakeholders:

KTH GTDO

Team Members:

Shankar Gopinath
Mardin Nickrad

Goal Statement:

To perform a research work in GTDO to formulate the activities and infrastructure that needs to be put in place to incrementally reach CMMI 5 level in the chosen model of CMMI representation.

Project Management Information System

Version Control of Documents : Win CVS
Information Distribution System : Google Groups (Within members), Lotus Notes Database (Inside Organization),
Project Website (For examiners)
Meetings : Lotus Notes, Google Calendar
Configuration Management : Excel Documents with configurable items

Project Scope and Constraints:

The “How to reach CMMI 5 for GTDO” thesis work will provide a customized solution for the GTDO to incrementally reach Maturity level 5 by identifying the gaps the GTDO has against the different to reach the goal of CMMI 5 maturity level. The business and the scope of the GTDO must be understood before researching on the methods to achieve CMMI 5. All 22 process areas under CMMI must be and procedures and processes to achieve them must be documented in the form of a check list and actions required to be taken. To have a realistic scope, the department chosen for implementation for verification purpose is the IT departments of Ground/Sea Travel and services (IT departments that handle Rail, Cruise, Hotels, Cars and Ferry) in GTDO.

Project Management Methodology:

The main methodology applied is the PMBOK methodology ranging from Integration to Procurement Management.

<table>
<thead>
<tr>
<th>Timeline</th>
<th>Target Date</th>
<th>Actual Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project start</td>
<td>August 11, 2007</td>
<td>August 23, 2007</td>
</tr>
<tr>
<td>Pilot study on CMMI and other quality standards</td>
<td>December 9, 2007</td>
<td>December 10, 2007</td>
</tr>
<tr>
<td>Learning quality procedures followed in the GTDO</td>
<td>February 26, 2008</td>
<td>March 3, 2008</td>
</tr>
<tr>
<td>Gap analysis of GTDO procedures and CMMI maturity levels</td>
<td>July 10, 2008</td>
<td>July 13, 2008</td>
</tr>
<tr>
<td>Bridging gaps and documentation of results</td>
<td>November 4, 2008</td>
<td>November 10, 2008</td>
</tr>
<tr>
<td>Project closure</td>
<td>November 28, 2008</td>
<td>December 8, 2008</td>
</tr>
</tbody>
</table>

Figure 2: Project Charter for PERFORMING research work for How to reach CMMI 5 for GTDO
3 Goals

The goals of the project can be broadly classified into quantitative and qualitative goals. These goals are tied to a checklist to perform a follow-up. The chapter is also intended to break down the goals into sub goals or milestones. A vision is provided for a general direction in the execution of the project and any assumptions made are documented in the chapter.

3.1 Quantitative Goals

- To have 100% coverage on all process areas for CMMI according to the chosen CMMI model for realization.
- Approval of at least 95% of the results of the research work by the SEPG (Software Engineering Process Group).

3.2 Qualitative Goals

- To perform a gap analysis of the GTDO with respect to reaching CMMI 5 maturity level.
- A documented incremental approach devised with different phases where the selected process areas are targeted to reach the different maturity level in the GTDO.
- To provide steps to address the gaps in the GTDO to achieve CMMI 5 maturity level with checklists and examples.

3.3 Vision

To produce a comprehensive, practical model and a check list for the implementation of CMMI 5 maturity level in the GTDO. The project should also comprehensively evaluate if capability level or maturity level could be followed for the GTDO. The research result will be arrived at following a PMBOK plan which is produced beforehand. The vision of the project shall appear in both Research plan and the PMBOK plan. The PMBOK plan is documented under Chapter 5 Methodology.
3.4 **Milestone List (Major Tasks/Project Deliverables)**

Milestone list is a part of Project Schedule Management under project and will also be also presented under the project plan. The elements under the Milestone list are present in the Project Schedule Development Plan and they can be considered as major achievements along the way in the implementation of the project. The Major Milestones of the project are as follows:

<table>
<thead>
<tr>
<th>Milestone</th>
<th>Realized under</th>
</tr>
</thead>
<tbody>
<tr>
<td>Milestone 1. PMBOK Plan for CMMI Realization</td>
<td>Chapter 5: Methodology</td>
</tr>
<tr>
<td>Milestone 2. Documentation of Learning from Pilot Study</td>
<td>About CMMI maturity and capability models under [45] and more specifically Section 8.1:8.1 Analysis of the current situation in GTDO 8.2 Comparison of CMM with ISO 9001:2000</td>
</tr>
<tr>
<td>Milestone 3. CMMI Realization for GTDO – Choice and Approach</td>
<td>Section 9.1 CMMI Realization for GTDO – The Choice and approach Prerequisites under [41]</td>
</tr>
<tr>
<td>Milestone 4. Gap between ISO GTDO processes and CMMI</td>
<td>Gap analysis documented under [40]</td>
</tr>
<tr>
<td>Milestone 5. Phase 1 Implementation which targets maturity level 2 implementation</td>
<td>Under 9.3 Phase 1: Maturity Level 2 implementation</td>
</tr>
<tr>
<td>Milestone 6. Phase 2 Implementation which targets maturity level 3 implementation</td>
<td>Phase 2 implementation under [42]</td>
</tr>
<tr>
<td>Milestone 7. Phase 3 Implementation which targets maturity level 4 implementation</td>
<td>Phase 3 implementation under [42]</td>
</tr>
<tr>
<td>Milestone 8. Phase 4 Implementation which targets maturity level 5 implementation</td>
<td>Phase 4 implementation under [42]</td>
</tr>
<tr>
<td>Milestone 9. Project Report Closing</td>
<td>Chapter 12 Recommendations and Future Work</td>
</tr>
<tr>
<td>Milestone 10. Project Presentation</td>
<td>Presentation of Results, Not part of the report here.</td>
</tr>
</tbody>
</table>

*Table 3: Milestones and Realization Points*
3.5 Assumptions and Constraints (Limitations)

- The organization is adhering to at least one quality standard [ISO 9001:2000] in the departments offering 40% of services/products.
- The departments and the procedures followed in them are documented and personnel are available for one to one interviews.
- A Check list on Quality Assurance (section C3 under [44]) was devised after identifying significant factors influencing the conduction and result of the thesis work.

Example:

Although there are standard and independent criterions such as reductions in variation in schedule, Schedule Performance Index, No of Problems Reported after release etc. (Time, Cost, Quality, Performance), there could be a sub level additional criteria such as an increased throughput time which will increase performance on a particular process. If this is overlooked, the Performance might show slight variation.

- Comprehensive templates and documentation as a detailed guide of addressing all process area is out of scope of this report. The result can be primarily delivered in the form of check lists with in depth detail being documented in selected areas.
4 Scope

The term project refers to the thesis work and the deliverable of the project is How to reach CMMI 5 for GTDO. The scope chapter of the project draws boundaries on what is expected as results/deliverables of the project and what is outside the scope of the project. The scope of the project is defined through the best practices advocated under Project scope management in PMBOK [26]. Primarily, the chapter addresses the scope with defining a scope statement, the entry criteria with inputs, verification procedure and the exit criteria of the project.

4.1 Preliminary Scope statement

The “How to reach CMMI 5 for GTDO” thesis work will provide a customized solution for the GTDO to reach maturity level 5 by identifying the gaps against maturity levels and incrementally addressing them. The business and the scope of the GTDO must be understood before researching on the methods to achieve CMMI 5. All 22 process areas under CMMI must be analysed and procedures and processes to achieve them must be documented in the form of a check list and actions required to be taken.

4.2 Scope Definition

A good understanding of the scope statement is critical to the success of this project. The major identified activities that are part of the scope definition are as follows:

<table>
<thead>
<tr>
<th>#</th>
<th>Activity in scope</th>
<th>Description of activity</th>
<th>Realized in chapter/section</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A Pilot Study</td>
<td>A pilot study that compares the capability Model and maturity model of CMMI and provides an insight into the similarities and differences.</td>
<td>[45]</td>
</tr>
<tr>
<td>2</td>
<td>Plan for implementing “How to reach CMMI 5 for GTDO”</td>
<td>Devising an incremental approach to CMMI implementation in the GTDO. Evaluating and deciding which model (capability or maturity model of CMMI) is best suited for the GTDO.</td>
<td>9.1 CMMI Realization for GTDO – The Choice and approach</td>
</tr>
<tr>
<td>3</td>
<td>Gap Analysis</td>
<td>A detailed study in identifying gaps between the different process areas defined in CMMI and the GTDO.</td>
<td>[40]</td>
</tr>
<tr>
<td>4</td>
<td>Preconditions for realization of CMMI 5 for GTDO</td>
<td>Identifying which are the first foundation blocks that needs to be put into place before filling the gaps in the GTDO against CMMI maturity levels</td>
<td>[41]</td>
</tr>
<tr>
<td>5</td>
<td>Check list of actions and deliverables in realizing CMMI 5 for GTDO</td>
<td>The checklists describe which actions need to be taken to address the gaps to incrementally appraise the organisation to CMMI 5.</td>
<td>Phase 1: Maturity Level 2 implementation [42]</td>
</tr>
<tr>
<td>6</td>
<td>Example templates for activities connected to fulfilling the gaps.</td>
<td>The templates describe the different structures and formulations that aid in addressing some of the gaps in selected process areas.</td>
<td>Appendix A - Templates and Essential Elements</td>
</tr>
</tbody>
</table>

Table 4: Check List of actions and deliverables in realizing CMMI 5 for GTDO
The Project Scope Statement is formulated as follows:

The Map to CMMI 5 for a GTDO covers the analysis of current quality procedures of IT Operations in the GTDO, analysis of CMMI maturity and capability model and proposing a model for approaching and implementation of CMMI 5. The research work shall be presented on which gaps needs to be filled for the GTDO to reach CMMI 5 level in the chosen CMMI model (capability or maturity). Verification will be done through implementation in selected departments and through an approval from the process improvement department in the GTDO.

4.3 Included in Scope

1. Study of organizational structure of the GTDO
2. Analysis of which representation of CMMI would be more appropriate for the GTDO. There are 2 different representations of CMMI namely Staged representation and Continuous representation (It is acceptable to have several departments choosing one representation while the others choose another if it is more appropriate and meets the strategy of the GTDO)
3. Comparison of the current quality standard and CMMI level 2 and improvement to level 3, 4, 5 (Gap Analysis)
4. Action Planning and Map Formulation (Even if some of the actions in the How to reach CMMI 5 for GTDO plan can be out of scope. (See Point #5 under 4.4 Out of Scope)
5. Presentation of results covering all process areas as a check list with in depth details of implementation in selected process areas.
6. The steps and checklists that are documented for reaching each Maturity level compliance also includes the Capability level compliance required for that phase. Example: To reach maturity level 3, only Capability Level 3 will be targeted for all the process areas included in Maturity Level 3 and not higher. This means that with reference to Figure 11: How to reach CMMI 5 and beyond: Phases of Implementation, only Part 1 in each phase is part of scope of this project. Part 2 and Part 3 is an extra bonus plan for future work.

4.4 Out of Scope

1. Analysis of Quality Procedures in individual teams (Only quality procedures under selected departments are analysed)
2. Actual implementation of the devised CMMI plan in all departments is selected
3. In depth detail on implementation of each process area. (It should be rather countered with point #7 under 4.3 Included in Scope
4. Documentation of the methodology or documentation of the execution technique to be followed in reaching a target in addition to CMMI 5 Maturity level for GTDO.

Explanation: Reaching Maturity of 3 is enough for the process area Requirements Development [RD] to get appraised for Maturity level 3. (Note that Maturity Level 3 in RD will mean that it should also satisfy Capability Level 3 [45])

Targeting to reach Capability Level 4 in the process area RD is out of scope of the documentation in this thesis report. Nonetheless, the thesis work will present additional targets beyond CMMI 5 Maturity level and will be part of the future work.
4.5 **Method of administration**
To have a realistic scope, the department chosen for implementation for verification purpose is the IT departments of Ground/Sea Travel and services (IT departments that handle Rail, Cruise, Hotels, Cars and Ferry) in GTDO.
This is in line with what is expressed under *Chapter 3.1 Quantitative Goals*.

4.6 **Entry Criteria & Inputs**
- Pilot Study on current quality and standards landscape
- Devisal of a Plan in not more than 4 phases
- Interviews with personnel from Ground and Sea Travel Service department
- Data needed for identifying gaps between current quality procedures and targeted CMMI standard.

4.7 **Verification and Validation**
- Verification will be done in the selected department as under section 4.5 *Method of administration*. Verification will be done through implementation of 2 specific process area gaps namely 9.3.2 Requirements Management (REQM) and 9.3.8 Measurement and Analysis (MA)
- Validation is done through approval from process improvement group responsible.

4.8 **Exit Criteria & Outputs**
- The gap analysis and the results section has been reviewed by the SEPG in the GTDO.
- As specified under Quantitative Goals, there should be a measurable approval rate of at least 95% of the contents of the report by an SEPG or equivalent group (process improvement responsible)
- Checklist with results documented to realize “How to reach CMMI 5 for GTDO”
5 Methodology

This chapter explains the methodology followed in performing the research work. This research project involves the use of theory even though the theory is not made explicit in the design framework of the work. This chapter presents a short description of a few research methodologies and then focuses on specifics of the method followed (deduction) in performing the research work.

The following research methodologies were evaluated: [47]

Abduction: A method through which a system of beliefs is modified in order to generate hypotheses that can then be tested.

Design Science Research: The process through which novel artefacts are built in order to solve a relevant problem in a rigorous fashion that can contribute to the existing body of knowledge. This method was evaluated and decided not to be chosen since CMMI is a fully developed body of knowledge with well defined maturity levels.

Induction: The process of reasoning through which observations are generalized into hypothesis that can be tested.

Interpretivism: An approach in which models of reality are constructed inter-subjectively in a specific context in order to arrive at an understanding of the phenomena.

Positivism: An approach in which reality is empirically responsive to study in order to produce generalizations.

Pragmatism: An approach in which the truth of a concept is directly related to the consequences or effects of this concept in reality.

Deduction: The process of reasoning through which existing theoretical propositions are narrowed down into testable hypothesis. A method where a theory is used to develop a proposition and then a research framework is designed to test that proposition. CMMI maturity level framework is a theory that exists and in our thesis work we have used techniques such as interviews, comparison of quality methods to apply testable hypothesis specific to GTDO

Deduction was therefore employed to collect, analyse the information needed to produce and document the results from the research and thesis work. Project management methods were applied in performing the research work. The 9 project management areas namely integration, scope, time, quality, cost, risk, communication, human resource and procurement were taken into consideration.

Quantitative methodology: Quantitative research can be seen as a hypothesis testing research. [48] An empirical investigation of observable phenomena through statistical, mathematical and computational methods [49] in our research work, we have used quantitative methods under gap analysis and the health assessment of the GTDO under Chapter 8 Technical Analysis

To summarize, we applied the following:

1) Conducted a study of the theoretical literature in CMMI capability and maturity models.
2) Conduct interviews to assess the general challenges GTDO faces and identify the gaps.
3) Applied deduction techniques to collect, analyze the information needed to produce and document results from the research work.
4) Quantitative methodologies in performing the gap analysis and comparison between CMMI to ISO 9001:2000.
5) Conducted workshops and validation techniques to validate the hypothesis of how to bridge the gaps in GTDO.
5.1 Application of deduction techniques

The information collected for performing the thesis can be described through *Figure 3: Thesis analysis/deduction* that describe the major tasks, goals, methods used and the results/output produced from the tasks.

There are 6 major tasks with separate goals for which different techniques were used in collecting the information, devising procedures and performing workshops to discuss, refine the results and get them validated by with the relevant stakeholders. There is 1 supporting task which was regarding the execution of the research project itself to arrive at the results. Apart from the techniques presented against each task, the following methodologies were used in the research work.
Goal: Identify the generic challenges that GTDO faces
Technique: Interview
Participants: Process improvement group of the GTDO, Department leaders of Airlines, Hotel, Rail, Ferry and Cruise and Infrastructure
Output: Generic challenges in GTDO

Goal: Identify the current quality methods followed in the GTDO
Technique: Analyzing quality documentation and status reports
Participants: Authors
Tools: Quality Documentation database
Output: Current situation in GTDO

Goal: Identify which CMMI model best suits the GTDO
Technique: CMMI maturity and capability model pilot study, GTDO Business Model analysis
Participants: Authors and Process improvement department responsible
Output: CMMI Model selection

Goal: Perform a pilot study of different quality standards such as ISO, Tick IT, CMMI and establish an understanding. Compare CMMI
Technique: Comparison techniques
Participants: Authors, documentation on the different quality standards.
Output: Comparitive study of CMMI with other standards

Goal: Perform gap analysis in the GTDO in the different departments
Technique: Workshops, Interviews, Validation
Participants: Process improvement department responsible, Department architects for Airline, Hotel, Rail, Ferry and Cruise, Team Leaders, Solution Architects
Output: Gap analysis of GTDO
Health situation of GTDO compared to CMMI

Goal: Produce Checklists, templates and activities to fill the gaps
Technique: GTDO Business Model analysis, Workshops, Validation
Participants: Authors and Process improvement department responsible, Department Manager for Rail, Department Manager for Hotel, Cruise and Ferry
Output: Activities needed to adress the gaps for appraisal towards the different maturity levels Verified example templates as models for implementation

Technique: PMBOK best practices, Knowledge acquired based on the courses in PDOM
Participants: Authors and thesis supervisor (both internal and external)
Output: Project Plan, Scope statement, Goal definition, qualitative and quantitative goals, verification goals, communication statement, risk management summary

Legend:
- Core tasks for thesis analysis and deduction
- Supporting tasks and method of project management

Figure 3: Thesis analysis/ deduction tasks and supporting tasks
# 6 Introduction to GTDO and CMMI

This chapter gives an introduction to GTDO and its primary operations. It provides enough basic knowledge in CMMI, the different models/representations of CMMI. It also introduces the user to fundamental concepts such as tailoring, institutionalisation and the limitations of CMMI. In-depth coverage on CMMI theoretical framework will be covered in Chapter 7 Theoretical Framework.

## 6.1 Business Domain of GTDO

The main business of GTDO is to build and maintain systems integrating core functionalities of booking related operations in Airlines, Rail, Cruise, Hotels, Cars and Ferry so as to provide a common platform to perform all travel booking related operations. The booking related operations range from availability search to performing ticketing, after sales operations, back office such as accounting and reporting and billing of travel agents and other clients.

The GTDO has its main customer focus in the following sectors
- Business to Business (B2B) [Example: Travel Agents, Airline companies, Rail companies]
- Business to Customer (B2C) (Example: Web based reservation tools)

While the products that the GTDO offers can be combined to produce several Solution Proposals, the range of major Business Areas can be classified under 4 different categories as in Table 5: Business Areas and their values.

<table>
<thead>
<tr>
<th>#</th>
<th>Area</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sales and Ecommerce</td>
<td>Solutions that provide solutions to sell travel based on availability and perform various After Sales operations.</td>
</tr>
<tr>
<td>2</td>
<td>Distribution and Content Provision</td>
<td>Major Business Area which is responsible for serving as a Distribution Organization in aggregation of content and performing various operations in synchronization with the inventory of the various content providers and hosting infrastructure.</td>
</tr>
<tr>
<td>3</td>
<td>Business Management</td>
<td>Responsible for Solution Proposals and maintain and maximize Customer satisfaction and Partnership</td>
</tr>
<tr>
<td>4</td>
<td>Services and Consulting</td>
<td>Provide Business Processes enhancement and investing in IT and concentrating on optimizing customer relationships</td>
</tr>
</tbody>
</table>

*Table 5: Business Areas and their values*

## 6.2 Brief: What is CMMI?

CMMI (Capability Maturity Model Integration) is an integrated framework of process and quality improvement which enables improving processes and quality procedures in selected product lines/departments in an organization or across the whole organisation by following a set of guided procedures. CMMI consists of quality procedures for sustained quality improvement with a major focus on Software Development and Systems Engineering. It provides organizations with options of improving a set of key process areas for each level and to get appraised to different maturity levels (1-5) or focus on one or more process areas to reach Capability levels (0-5) depending on the needs of the organization.
6.3 Literal Semantics - CMMI

CMMI supports 2 different models or representations.

- Continuous Representation corresponding to Capability Model
- Staged Representation corresponding to Maturity Model

When the capability level for selected process area(s) is/are focused on, and when the organization complies with the specifications, the organization becomes “capable” of a particular level in CMMI. [1]

When maturity level (a set of predefined process areas are targeted) is on focus and the organization satisfies the specifications it will be appraised to a particular CMMI level. It is not that it will be certified with a maturity level of CMMI but rather “appraised” to a certain level of CMMI. [1]

6.3.1 Continuous Representation/Capability Model

Continuous Representation is an approach where an organization chooses to continuously improve a selected set of process area(s) in CMMI for one or more product lines in the organization and progressively reach different levels in it. Capability Models are generally used when the organization wants to apply focus on specific processes in selected product line(s) of the organization. Thus for a Capability model the 3 indispensable selection criterion are:

1. Process Area(s) that the organization wants to focus on
2. The Level that the organization wants to reach in the selected Process Area(s)
3. The Product Line(s) the organization wants to apply this on

The first 2 criterion are more important as Capability Levels concerns with the granularity of improvement within a process area. [1] In other words, it’s not only improving what is done but also how it is done. Under [45], the different levels of appraisals in Continuous Representation/Capability Level Model are described and comparison to Maturity Model is performed.

Figure 4: Progressing through Capability and Maturity Levels  shows the different levels of the Maturity Model and Capability Model.

6.3.2 Staged Representation/Maturity Model

Staged Representation or Maturity Model is an approach to CMMI where the organization chooses to follow the systematic, structured approach in improving the process based on the CMMI model. In staged representation, each “stage” / level includes several process areas and the organization must satisfy the process areas to progress or be appraised to a particular stage.

6.4 Understanding the Levels of CMMI

These two improvement paths are associated with the two types of levels that correspond to two representations. For the continuous representation, we use the term “capability level.” For the staged representation, we use the term “maturity level.” Regardless of which representation you select, the concept of levels is the same. Levels characterize improvement from an ill-defined state to a state that uses quantitative information to determine and manage improvements that are needed to meet an organization’s business objectives. To reach a particular level, an organization must satisfy all of the appropriate goals of the process area or set of process areas that are targeted for improvement, regardless of whether it is a capability or a maturity level. Both representations also provide ways to implement process improvement to achieve business objectives. Both representations provide the same essential content and use the same model components.
Both representations have many of the same components (e.g., process areas, specific goals, and specific practices), and these components have the same hierarchy and configuration. The continuous representation focuses on process area capability as measured by capability levels and the staged representation focuses on organizational maturity as measured by maturity levels. These dimensions (the
Capability/maturity dimensions) of CMMI are used for benchmarking and appraisal activities, as well as guiding an organization’s improvement efforts.

- Capability levels, which belong to a continuous representation, apply to an organization’s process improvement achievement in individual process areas. These levels are a means for incrementally improving the processes corresponding to a given process area. There are six capability levels, numbered 0 through 5.
- Maturity levels, which belong to a staged representation, apply to an organization’s process improvement achievement across multiple process areas. These levels are a means of predicting the general outcomes of the next project undertaken. There are five maturity levels, numbered 1 through 5.

A Comparison between the 6 capability levels and the 4 maturity levels is provided under [45]
The classification of CMMI can be done along with the process areas under different levels as described under Table 2: Process areas and phase outside the corresponding phase exclusion can be depicted in the following Figure 5: Process Areas in maturity level.
6.5 What is Institutionalization of processes?

Institutionalization means that the process is ingrained into the organization’s activities in such a way that there is commitment and consistency in performing the process.[1] This essentially means that an institutionalized process will be followed even in times of too early promised delivery dates or targets by higher management; for example to deliver a product early to the market before a competitor. [1] In simple words an institutionalized process is part of the company culture and policy and won’t be avoided to be implemented in times of stress. This is depicted in the following diagram Figure 6: Institutionalization of a Process.

![Figure 6: Institutionalization of a Process]

6.6 What is tailoring of a process?

Tailoring is the process of mending the standard process of an organization to suit a particular instance of process application (implementation in a particular type of project). Tailoring is not a method to avoid following the rules but adjusting them to the suitability of a particular type of project.[3] Tailoring is possible only when there are established tailoring guidelines which specify which processes can be changed/ mended under what criteria and for which type of project. This is shown in Figure 7: Tailoring for a Project based on Tailoring Guidelines. Process Tailoring is an important part of Capability Level 3 and Maturity Level 3 (Defined). An institutionalized project may be tailored.

Tailoring Guidelines are broadly based on the following factors

1. Complexity of a project
2. Skill Level of the team
3. Application Criticality
4. Peak Team Size (the highest head count during the entire life of the project)
In general, Tailoring Guidelines are prepared for different combinations of the above (4) parameters and the options available and they become part of Process Definition Database (PDD).

Example of Tailoring for a Development Project

In the following example only instances of possible entries of selected activities are presented. Not all activities or all combinations are provided here.

<table>
<thead>
<tr>
<th>#</th>
<th>Activity</th>
<th>Property that can be tailored</th>
<th>Criteria</th>
<th>Options Available</th>
<th>Tailoring Guideline</th>
</tr>
</thead>
</table>
| 1  | Initiating Requirement Gathering and Analysis  
-Methodology of Gathering Requirements | Channels and Methodology followed | Complexity of Application – Low  
Skill of Team – High  
Size of Team – >= 12  
Application Criticality - Medium | Use similar existing application and User Presentation to present solution | When an application that already exists covering requirements of the users in most part. |
|    |          |                               |          | Customer Interviews, Joint Application Development (JAD)/Agile Software Methodology | When there are new requirements and for a thorough understanding of requirements and development with frequent delivery of small functionalities. |
| 2  | Analyse Requirements  
-Develop Process Model and Comparison Document | Level of Detail | Complexity of Application – High  
Skill of Team – Medium  
Size of Team – >= 12  
Application Criticality - Medium | Detailed Process Model | In case of critical and complex business functions (Even if the overall complexity is high, there could be still some medium complexity or low complexity functions). In case of presence of multiple level API and interfaces, they have to be made in detailed manner. |
|    |          |                               |          | Brief Process Model                                                                 | For medium complexity, brief process model would suffice. |

Figure 7: Tailoring for a Project based on Tailoring Guidelines
### IMPLEMENTATION

<table>
<thead>
<tr>
<th>Activity/Review</th>
<th>No. of Reviewers</th>
<th>Complexity of Application</th>
<th>Skill of Team</th>
<th>Size of Team</th>
<th>Application Criticality</th>
<th>Do Group Review</th>
<th>When complexity is High or Medium and Server Oriented Programs and basic functionalities such as creation of Sale Item in PNR or creation of Ticket Element or in performing major functionalities such as Billing of Travel Agent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perform Code Review</td>
<td>No. of Reviewers</td>
<td>Complexity of Application – High/Medium</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Skill of Team – Medium/Low</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Size of Team – &gt;= 12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Application Criticality – Medium/High</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Do Group Review</td>
<td>When complexity is High or Medium and Server Oriented Programs and basic functionalities such as creation of Sale Item in PNR or creation of Ticket Element or in performing major functionalities such as Billing of Travel Agent</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do a one person Expert Review</td>
<td>When Skill Level is High and complexity is medium, the functionality delivered is not highly critical such as retrieving conditions of a Fare etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### SYSTEM TESTING

<table>
<thead>
<tr>
<th>Activity/Review</th>
<th>Execution</th>
<th>Complexity of Application – High/Medium</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Skill of Team – Medium/Low</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Size of Team – &gt;= 12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Application Criticality – Medium/High</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Activity to be performed to Generate Data Driven Test Scripts [3]</td>
</tr>
<tr>
<td></td>
<td></td>
<td>When data/data scripts cannot be reused/ If no previous Data exist to be injected to test results</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Can be skipped</td>
</tr>
<tr>
<td></td>
<td></td>
<td>If test data/data driven scripts is already available from the existing system and could be reused.</td>
</tr>
</tbody>
</table>

Table 6: Example of Process Tailoring for a Development Project
6.7 **What is not CMMI?**

The CMMI does not address all process and quality improvement issues. Issues that are addressed indirectly, or by implication, include the following described under *Table 7: What is not CMMI?*

<table>
<thead>
<tr>
<th>Item</th>
<th>How is this Countered?</th>
</tr>
</thead>
</table>
| Specific tools, methodologies and techniques | Tools: Addressed by research on the different tools such as the 7 Quality Control tools and 7 Management tools  
Methodologies: Best practices of methods such as PMBOK, RUP are used to imply and comply with the various methods and processes.  
Techniques:  
Management consulting, marketing, etc.                                                                                                         |
| Management consulting, marketing, etc.    | The Management, marketing techniques are used based on the various specialized management methods other than Project Management technique obviously.                                                                 |
| Human Resources                           | The Human Resource Management has a good set of defined procedures that could be used from PMBOK.                                                                                                                   |
| Organizational Behaviour                  | Literature on leadership and Organizational structure and behaviour and models such as Process-Content Model, FIRO(Fundamental Interpersonal Relationship Orientation) Model                                             |

*Table 7: What is not CMMI?*
7 Theoretical Framework

In this chapter we will have a close look at the currently applied quality standard in GTDO. We motivate why implementation of CMMI is beneficial for an IT organisation with some facts and figures. We provide an example of how to apply CMMI Capability theory in practice.

7.1 ISO 9001:2000: GTDO’s current quality standard

ISO 9001:1987 was primarily aimed at supporting service organizations [19]. The successor of ISO 9001:1987 was ISO 9001:2000 which was aimed to provide more focus on process management. ISO 9001:2000 is a combination of three standards namely 9001, 9002 and 9003.

The following are the 8 basic principles of the ISO 9001:2000 [20] [21]:

1. Customer Focus
2. Leadership
3. Involvement of People
4. Process Approach
5. System Approach to Management
6. Continuous Improvement
7. Factual Approach to Decision Making
8. Mutually Beneficial Supplier Relationships

The QMS (Quality Management System) process of functioning must adhere to the model formulated by ISO which is aimed at Management taking the main responsibility to secure the resources for realizing the customer requirements through a product realization group. The process used in product realization must be monitored and measured for Continuous Improvement. This model can be described as follows.
The above figure shows the Continuous Improvement model of a Quality Management System according to ISO 9001:2000 principles implemented in the GTDO. The Demand of the Customer and the market has to be well understood and a strategy is developed by the Management.

The Management secures the resources required to contribute to the project created for Product Realization. The Resources understands, analyses, and develops the requirements of the customer to realize it into a product. The Product realization has to be measured and analysed against the requirements of the customer and customer satisfaction. The results of Measurement and Analysis must prove as an important factor for Continuous Improvement of the QMS and ultimately better quality of the product delivered to the customer. The Measurement analytics will also provide as a critical input for the Management to perform the next iterative planning knowing how good the organization is performing and strategically adjusting and serving the demands of the customer.

Figure 8: Process Based QMS of usage in GTDO in accordance with ISO 9001:2000
7.2 Why CMMI for an IT Organisation?

7.2.1 Some Benefits of usage of CMMI for an IT Organisation
The following are some of the benefits of using CMMI in an IT Organization [4]

- CMMI applies to process management and quality improvement concepts to system development and maintenance
- Helps prioritize organizational and process improvement opportunities
- Describes the stages through which organizations evolve as they define, implement, measure, control and improve their processes
- Provides a method of determining current process capability and identifying issues critical to quality and process improvement
- Provides an underlying structure for reliable and consistent process assessments
- Leads to a culture of engineering excellence

7.2.2 Impact of having ad-hoc Processes
By implementing the CMMI, organizations can improve quality, time to market, and reduce costs. Immature organizations and ad-hoc processes (CMMI Level 1) have serious consequences. The following are some of the examples from [36]

- 35% to 50% of all software development effort is devoted to rework
- $75 billion was spent in 1998 on failed projects
- $22 billion was spent in 1998 on cost overruns
- 50% of large projects run late, exceed budget, or are cancelled
- 70% more time was incurred than scheduled for major DoD (Department of Defence) contracts
- 50% of all projects are challenged by reduced functionality, costs overruns, and slipped schedules
- 70% of all software organizations operate at or below the chaos level

7.2.3 Impact of CMMI implementation
The Table 8: Performance Results of CMMI in 18 Organizations shows results from 18 organizations who reported performance change over time when they implemented CMMI [18]

<table>
<thead>
<tr>
<th>Performance Category</th>
<th>Median</th>
<th>Number of Data Points</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost</td>
<td>34%</td>
<td>29%</td>
<td>4.5%</td>
<td>87%</td>
</tr>
<tr>
<td>Schedule</td>
<td>50%</td>
<td>22%</td>
<td>2%</td>
<td>95%</td>
</tr>
<tr>
<td>Productivity</td>
<td>61%</td>
<td>20%</td>
<td>11%</td>
<td>329%</td>
</tr>
<tr>
<td>Quality</td>
<td>48%</td>
<td>34%</td>
<td>2%</td>
<td>132%</td>
</tr>
<tr>
<td>Customer Satisfaction</td>
<td>14%</td>
<td>7%</td>
<td>-4%</td>
<td>55%</td>
</tr>
<tr>
<td>Return on Investment</td>
<td>4:1</td>
<td>22</td>
<td>1.7:1</td>
<td>27.7:1</td>
</tr>
</tbody>
</table>

Table 8: Performance Results of CMMI in 18 Organizations
The following Table 9: Process Improvement example of an Organization which implemented CMMI shows the performance improvement of an organization who implemented CMMI (from Maturity Level 1 to 3) [7].

<table>
<thead>
<tr>
<th>Maturity levels</th>
<th>Schedule (Months)</th>
<th>Effort (Person Months)</th>
<th>Peak Staff</th>
<th>Mean Time to Discovery (MTTD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1</td>
<td>20</td>
<td>309</td>
<td>24</td>
<td>1.3</td>
</tr>
<tr>
<td>Level 2</td>
<td>16 (-20%)</td>
<td>168 (-46%)</td>
<td>16 (-33%)</td>
<td>1.9 (+46%)</td>
</tr>
<tr>
<td>Level 3</td>
<td>13 (-35%)</td>
<td>79 (-74%)</td>
<td>9.5 (-60%)</td>
<td>3.2 (+146%)</td>
</tr>
</tbody>
</table>

Table 9: Process Improvement example of an Organization which implemented CMMI

The table above denotes the impact at different levels of the SEI's CMMI on schedule, staff, effort and MTTD of defects for a commercial application containing 1,000,000 Lines of Code (LOC) and 1,000 Function Points (FP) [1FP = 1000 LOC in the above example]
7.3 Example of Capability Level Implementation

The 3 indispensable selections for implementing capability level model as described under 6.3.1/Continuous Representation/Capability Model 5 namely the Process Area to Focus on, the Product or Product Line, The Capability Level to focus on is described under the following Table 10. The different phases of implementation, the process areas focused, their targeted Capability and Maturity levels is depicted under Figure 11: How to reach CMMI 5 and beyond: Phases of Implementation.

<table>
<thead>
<tr>
<th>Process Area Recommended to be selected</th>
<th>Reason for Choice at Capability Level, Product Line chosen for Capability Level.</th>
<th>Capability Level Target</th>
<th>Phase of planned Implementation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organization Process Focus (OPF)</td>
<td>OPF is required as a foundation in building up the Process Database (PD) [41]. It will be used for set up of OPD (Organizational Process Definition, also a part of phase 1). Organizational Process Focus will identify the areas of foundation required for the organization to focus on in its development strategy. It has an emphasis on understanding the current situation, the strengths and weaknesses of the organization, its processes and the assets [4]. Product Line/ Product chosen for implementation : All Products under Travel &amp; Services department</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>The Process Database infrastructure and the related activities [See [41] for more details] is an essential infrastructure required but the data might not available in all the different project areas and some projects being very long, it is difficult to collect the data from the Project Closure Report relatively quickly. Therefore the scope is limited to the projects in Travel &amp; Services department. Since the deliverables of OPF play the role of a foundation for the rest of the process improvement areas, it is placed in the first phase in the map for implementation of CMMI.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
**Organizational Process Performance (OPP)**

OPP is required to establish and maintain a quantitative understanding of the performance of the organization. This is possible after a time when the tools and procedures are put in place for measuring the performance of the organization.

After having identified the metrics required to be measured, established the foundation with the process focus and tools to measure the performance (OPF), it is important to be able to actually start measuring them.

**Product Line/ Product chosen for implementation : All Products under Travel & Services department**

The process performance data, baselines and models must be established to be able to quantitatively manage the project. Since the collection of all performance related data for all products is difficult, it is chosen for one of the products called Dominican Rail in the Travel & Services department.

<table>
<thead>
<tr>
<th>Product Line/ Product chosen for implementation : All Products under Travel &amp; Services department</th>
</tr>
</thead>
<tbody>
<tr>
<td>PI is required to have a structured approach to the integration of various components / systems to deliver a product or a service.</td>
</tr>
<tr>
<td>Since the benefits of streamlining PI processes is highly beneficial for the organization, the PI process area is established into the Core Ticketing process in the GTDO as it is one of the highest critical revenue generating area for the GTDO.</td>
</tr>
<tr>
<td><strong>Product Line/ Product chosen for implementation : Core Ticketing Process in the whole GTDO</strong></td>
</tr>
<tr>
<td>The Ticketing area chosen here for Product Integration process area is not specific to the ticketing for a particular product such as Dominican Rail, rather a generic ticketing process which is shared and used by Ticketing in all products within the GTDO.</td>
</tr>
</tbody>
</table>

*Table 10: Example of a Capability Level Implementation in selected areas*
8 Technical Analysis

This chapter contains analysis of the current quality procedures followed in the GTDO. It also documents the precondition and foundation processes required for the start of the realization of CMMI 5 for GTDO. It deals with performing a high level comparative study of CMMI with several other process improvement/quality standards such as ISO 9001:2000, Tick IT, ITIL v3 and development frameworks PMBOK and RUP. It covers gap analysis between GTDO (with ISO 9001:2000 standard abidance) and CMMI Processes and provides both qualitative and quantitative gaps.

8.1 Analysis of the current situation in GTDO

GTDO is in a phase of rapid expansion through scaling its operations and in acquiring some new strategic markets like India [11]. It aims at satisfying the entire needs of both B2B and B2C sectors with respect to bookings and reservations. The B2C sector includes mostly travel agencies who use the GTDO system to make bookings for their customers and also third party search engines that interface with the GTDO system to query across various travel routes. The B2B sector includes hosting content of some airlines, hotels, rail providers, cars, hospitality services and consists mostly of travel agencies and some third party search engine services.

The GTDO has positioned itself as a technology partner for a huge customer base and hence it is pivotal to follow and adhere to best process improvement frameworks and practices. The GTDO has huge development centres and data centre(s). It’s important that design, development work, testing, production load are streamlined as much as possible and optimized for better efficiency. This is also because most of the SLA’s the GTDO has with its various content providers involve a penalty when there is an incident unsolved for a short duration: The maximum time for resolution of the incident is 16hrs or lesser in most of the SLA’s that the organization signs with airlines whose content is hosted by GTDO. [12] A service or a system failure resulting in a system restore in many cases has a maximum time span of 5 hours or less for recovery. [12] (2007). With such criticality to business it is highly important to have mature procedures and processes to streamline the services and solutions that could be offered by the organization.

Apart from following ISO 9001:2000 for the most generic processes [13], the GTDO is currently in a situation where different procedures are followed in different departments of the same category in the organization and hence a homogeneous process improvement is not implied or applied across the organization.

8.1.1 Quality Policy, Processes and Procedures followed in GTDO

The GTDO has its own Problem Management and Change Management Procedures which are built on ISO 9001: 2000. The main method of Software Development across the organization follows a unique software development model combination of Spiral model and waterfall model. There has been discussion forums conducted about Scrum and other iterative development solutions such as RUP but they haven’t materialized so far.

In many cases, development starts even before the specification is written based on some common understanding of the functionality. The situation often ends up with a lot of problems records that would be discovered later during the testing phase.

The Generic procedure of Problem Handling, Service Level Fulfilment and Software Development follows Deming’s Plan, Do, Check, Act [PDCA] lifecycle [13] [14].
The PDCA lifecycle is applied in designing and practicing process management process [13] in the GTDO. The Quality Management process is modularized in seven processes listed as follows:

- Identifying customers and their requirements
- Strategic Planning
- Manage Business Processes
- Cross functional process support
- Process Measurement
- Performance Management Review
- Business Process Improvement
8.1.2 Addressing some Common issues in GTDO

<table>
<thead>
<tr>
<th>#</th>
<th>Common Issue in GTDO</th>
<th>Solution for the problem in CMMI</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Schedule Slippage</td>
<td>(a) Project Monitoring and Control (PMC) [Maturity level 2] is to significantly improve the understanding of the progress of the project in a way such that corrective actions are taken when the project’s deliverables and performance deviates significantly from the plan [3] [4]. PMC should be based on Process Database (PD) and Process Capability Baseline (PCB) where metrics from past projects are classified according to the types and various phases of the projects. Using tools such as a Control Charts, the performance and deviation can be detected early and corrected which will avert any schedule slippage. See sections Process Database and Process Capability Baseline under [41] for more details on PD and PCB respectively.</td>
<td></td>
</tr>
</tbody>
</table>

Example

Monitoring Effort Data
Monitor the effort spent on each activity can be done through a Weekly Activity Report which decomposes to activities within each CR (Change Request) to monitor the effort/cost spent in each activity. This data will be continuously used in PCB to build percentage effort spent on each activity. Any deviation from expected or acceptable limits can be detected early and therefore corrected. For instance, in a project using 3rd Generation Programming language, approximately 20 – 25% of effort is spent on Requirement Analysis and Design, about 45% is spent on Implementation and Unit Testing [3]. If the PCB value shows a deviation from these, this will raise an early warning by monitoring the Effort data. PD is a part of Organizational Process Focus (OPF) and PCB is a part of Organizational Maturity level 4 of CMMI. PD and PCB will be implemented in phase 0 as under [41]. Organisational Process Focus implementation is performed in phase 2 as under [42]. This is depicted under Figure 11: How to reach CMMI 5 and beyond: Phases of Implementation

Monitoring Defect Data
Although tracking defects exists within GTDO, there is no tracking of effort spent on defects investigation and fixing. A PCB will also contain the stage in which a particular defect was injected and the stage in which it was detected [3]. This information can be used to compute Defect Removal Efficiency (DRE). Refer to Defect Distribution data under Process Database section in [41] for details.

(b) Quantitative Project Management (QPM) [Maturity level 4] process area emphasizes on using measurement of various process performance factors and quantitatively managing the project’s defined process to achieve established quality and process performance [1]. This enables measurement and analytical techniques to be effectively applied and perform statistic and analytical techniques in managing sub processes [3]. This can be compared to Statistical Process Control (SPC) where processes are quantitatively managed whereas here along with statistical process control of the selected processes and monitoring them and detecting early if there is a likely chance that objectives won’t be met using analytical techniques. When PMC is implemented at Capability
<table>
<thead>
<tr>
<th>#</th>
<th>Common Issue in GTDO</th>
<th>Solution for the problem in CMMI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>level 4, it will closely resemble and complement Quantitative Project Management (QPM) as they both will be at this point heavily metric based to make decisions.</td>
</tr>
</tbody>
</table>
|  |  | **Example**  
**Manage Project Performance**  
Project Performance is measured along with the estimates of project quality achievement. Using trend analysis and using the obtained measures of critical properties to predict the Defect Density in the delivered product using interim measures of defect identified during peer reviews and system testing. Statistical Process Control (SPC) is closely linked to Quantitative Project Management for statistically monitoring and controlling a project’s output. SPC will make determining the actions needed to address the deficiencies in achieving the project’s quality and performance objectives. This could be done through  
- Changing revising quality and process performance objectives to stay within expected range. [3]  
- Improving the implementation of project defined process and addressing any other causes of hindrance to achieve projects quality objectives to reduce variability (This will bring down the variability without any change to mean). [3] |
| 2 | Learning from experience documented | **Project Planning (PP) [Maturity Level 2]**  
The purpose of PP is to analyse and define activities and their scheduling with appropriate resources allocated to them. A Project plan describes how the project shall be executed, monitored, controlled and closed [1]. Project Planning generally includes the following activities [1]  

1. Activity Identification and Sequencing  
2. Project Scope Management Plan  
3. Schedule Management Plan  
4. Cost Management Plan  
5. Quality Management Plan  
6. Process Improvement Plan  
7. Staffing Management Plan  
8. Communication Management Plan  
9. Risk Management Plan  
10. Procurement Management Plan  
11. Milestone List  
12. Schedule Baseline  
13. Cost Baseline  
14. Quality Baseline  
15. Risk Register  

Although PP is part of many organizations, it’s often underestimated in terms of performing it with proven and explainable estimates. Sometimes “gut feeling” or a “rough sizing” serves as a basis for Schedule Estimation. Many Organizations, as well as the GTDO, do not have a Process Database (PD) that would aid with the metrics to make effective estimation decisions in Project Planning. A PD is a repository of metrics and information of all past experiences with metrics about the General Data of the Project, Effort Data of the project, Schedule, Size and Defects.[3]. See [41] for more details on Process Database. |
<table>
<thead>
<tr>
<th>#</th>
<th>Common Issue in GTDO</th>
<th>Solution for the problem in CMMI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Example Estimation</td>
<td>When the GTDO implements a new project, it should be looked up in the PD for previous implementation under the same classification. Generic types of classification of Projects could be</td>
<td></td>
</tr>
<tr>
<td>The Process Database must contain details on projects with its classification and the different parameters recorded. For instance a Development project called Aristocratic Rail with an Estimated Effort size of 40 Person-Years in the beginning of the project ends up with an Actual Effort Data in which the Actual Effort amounts to about 60 Person-Years. This shows that there was a significant gap in estimate and actual effort.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>For a project of this size, the data on how much time was spent on each of the phases is recorded in the PD. [4]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>i. The Actual effort information can be used while performing another Development Project with similar characteristics of this project. ➔ This will provide an estimate of effort</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ii. This has to be used together with productivity measurement (No of Functional Points / Person Month) from PCB for the process type. [3]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iii. Overall effort estimate with productivity and size estimates.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>iv. With the Effort Distribution data from PCB, the effort for different phases can be also estimated.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>v. Refining the estimates is required, after taking project specific characteristics is considered.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The above steps will ensure that a proper judgment and estimation is used instead of “rough sizing” leading to a bad estimation and thereby making the project going over budget and sometimes causing the failure of the project. In such a case when this information is reused from Aristocratic Rail for estimation, a Top-Down estimation technique could be followed.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>When no information is previously available in estimation for a particular project, Bottom-Up estimation technique could be used (4) where first the functionalities must be classified into Simple, Medium, Complex along with the effort required for each of the functionalities to compute the total build effort. This together with the PCB data on the percentage distribution of effort under different phases can give the effort required under different phases contributing to a more realistic and more accurate project plan</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Organizational Process Focus (OPF) [Maturity Level 3]

OPF is aimed at planning and implementing process improvement inside the Organization based on analysis of current strengths and weaknesses (3) of the GTDO’s processes and process areas. Some of the examples of process-performance objectives include the improving of the following

- Cycle Time
- Defect Removal Efficiency (DRE)
- Productivity

The Organizations need and objectives must be first found out through appraisals and candidate process improvements are formulated. While making an appraisal or analysis PD is required for analysing data along with PCB to find out the quality, productivity metrics of the processes so as to find out the potential areas of improvement. Doing so will improve the processes in the organization in areas that would prevent future mistakes from happening and reduces the probability of repetition of mistakes as decisions will be based on Past data and their performance.

In a typical ISO 9001:2000 organization as is the case with GTDO, has a group for Process Improvement Performance and Process Improvement (PPI) unit, which has to be brought in fully in coordination with CMMI implementation and OPF should be their taskforce. PPI unit should become responsible for planning organization level process development and improvement activities. They should hold frequent presentations on quality improvement; share the process assessment and the planning for improvement of organizational level process improvement.

Example

**Process Database Implementation**

Process Database is the core repository to be used for past project related metrics. This Process Database shall be built based on Closure Analysis Report (CAR) which is submitted by the Project Manager (Coordinating with Team Leaders of Development Teams) which upon approval by SEPG (Software Engineering Process Group) shall go into the Process Database.

3 Traceability

**Requirements Management (RM)**

The major activities of RM are requirements elicitation & analysis, Requirements Change management and most importantly Requirements Tracing. Currently in GTDO there is inadequate and poor requirement tracing which results in loss of time, functionalities not implemented. The implemented functionalities not properly tested and bugs gone unfixed. This results in loss of quality, productivity and ultimately leads to increase in cost and delays.

One of the most important tasks of the project after Project Charter is Requirements Management. This task is responsible for managing the requirements of tall the projects deliverables and components and identifying inconsistencies between the requirements,
# Common Issue in GTDO

<table>
<thead>
<tr>
<th>#</th>
<th>Common Issue in GTDO</th>
<th>Solution for the problem in CMMI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>project plans, test plan design documents and work products.</td>
<td></td>
</tr>
</tbody>
</table>

**Example**

“MultiApproach” is a tool currently used in GTDO to log, document and track Change Records (CR), Problem Tracking Records (PTR), Request for Proposal (RFP), Change Proposal (CP)

The MultiApproach tool in GTDO must be enhanced such that it allows a view and also will have each of the following parameters inside each of CR (Change Record), PTR (Problem Tracking Record), RFP (Request for Proposal), Change Proposal (CP) [Including References to each other inside each artefact]

- Requirement Number (Req #) from Statement of Requirements (SOR),
- Package Id (PID) and Use Case Number (UcN) from Functional Specifications (Funct. Spec)
- Package Id (PID) and Use Case Number (UcN) from High Level Design Document (HLD Doc)
- Implementation Module/Inherited Class/Class/Procedure/ Other No(INo)
- Unit Test Nr (UTNr)
- Test Case Nr (TCNr)
- PTR (Problem Tracking Record) No. Reference / CR (Change Record) No. Reference / RFP (Request for Proposal)/ Change Proposal (CP) Reference [Having a reference to each other]

For e.g. If It’s a PTR, It will have reference to CR (Change Record) No. Reference and RFP (Request for Proposal)/ Change Proposal (CP) Reference (whichever present)

A View that needs to be made in MultiApproach tool called “Requirements Traceability Matrix” which should show the following artefact as shown in Table 27: Requirement Traceability Matrix Populated by MultiApproach Tool.

Table 11: Addressing some ubiquitous problems in GTDO with CMMI
8.2 Comparison of CMM with ISO 9001:2000

The following table shows the major differences between CMMI and ISO 9001:2000/Tick IT plus

<table>
<thead>
<tr>
<th>#</th>
<th>Topic</th>
<th>CMMI</th>
<th>ISO 9001:2000/Tick IT plus</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nature of the Quality Standard/Process</td>
<td>Process Improvement</td>
<td>Quality Management System Standard</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Framework</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Levels of Adherence</td>
<td>1-5</td>
<td>1 [Either adheres or not adheres] –</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Boolean Approach</td>
</tr>
<tr>
<td>3</td>
<td>Main domain of specialization</td>
<td>Engineering Software</td>
<td>Generic</td>
</tr>
<tr>
<td>4</td>
<td>Total Number of Process Areas/Disciplines/Clauses</td>
<td>22</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>Level of Detail and Guidance in Implementation</td>
<td>High (Specific with</td>
<td>Low (Generic)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>details) – Institutionalization is a major concept [1]</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Know-How/Familiarity in IT Organizations (Global)</td>
<td>High</td>
<td>Very High</td>
</tr>
<tr>
<td>7</td>
<td>Number of Organizations adhering to standard (Global)</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>8</td>
<td>Primary Focus</td>
<td>Process [1]</td>
<td>Customer [27]</td>
</tr>
</tbody>
</table>

Table 12: Comparative analysis of CMMI with other quality standard

8.3 Health of GTDO with respect to CMMI Maturity

The Health of the GTDO with respect to CMMI Maturity can be summarized in Figure 9: Compliance of Individual CMMI Processes/Disciplines in GTDO and the details behind each of the individual process area assessment is described under [40].
Figure 9: Compliance of Individual CMMI Processes/Disciplines in GTDO
9 Results

This Chapter covers the devised plan to reach CMMI 5Maturity level. The Chapter begins with Preconditions/Foundation required for successful implementation of the “How to reach CMMI 5 for GTDO” The Gaps precluded in Chapter 7 will be used to formulate the methods to bridge the shortcomings in the identified process areas within the GTDO. It will also provide a checklist for CMMI implementation based on the current gaps in the different process areas.

9.1 CMMI Realization for GTDO – The Choice and approach

9.1.1 Practice-Goal representation

During Technical Analysis, it was realized that the establishment of Process Database (PD) and Process Capability Baseline (PCB) would directly provide the necessary infrastructure to base several process improvements for GTDO. Analysis of the PD and PCB is provided under [41] will also aid in achieving the implementation of the following process areas enormously.

- 9.3.3 Project Planning (PP)
- Quantitative Project Management [42]
- Organizational Process Focus (OPF) [Enterprise Wide] [42]
- Organizational Process Definition + IPPD (OPD + IPPD) [42]

It was therefore concluded to have a Foundation phase for starting the implementation of CMMI under the various phases and this foundation phase would include the establishment of Infrastructure for Process Database and Process Capability Baseline as under [41]. This Foundation phase is called Phase 0 and is depicted in the following Figure 10: Foundation - Phase 0 - CMMI Realization of GTDO. These activities will serve as a pre-runner to the establishment of a foundation for implementing CMMI in various phases in the right steps.

Figure 10: Foundation - Phase 0 - CMMI Realization of GTDO
9.1.2 CMMI in GTDO: Devised method of Implementation

PHASE 1:

PART 1:

MATUREITY LEVEL 2 (All process areas shall be planned for Capability Level 2 acceptance) [Included activity: Bridge gap between ISO 9001:2000 and maturity Level 2]

PART 2:

CAPABILITY LEVEL 3 in the following areas:
- Organizational Process Focus (OPF) under all Product lines in Travel, Services & Leisure
- Organization Process Definition (OPD) in a Product Line in Travel Services and Leisure in Hospitality Department under Travel Services and Leisure department

PHASE 2:

PART 1:

MATUREITY LEVEL 3 (All process areas shall be planned for Capability Level 3 acceptance. If a process area under Maturity 3 is already increased to Capability 3, it is still included under this part of Phase 2. Reason: Maturity level implementation aims at organization wide implementation of a process area whereas Capability level is concentrated only in select departments & maturity level 3 has to be secured for strategic external communication for the organization.)

PART 2:

CAPABILITY LEVEL 4 in the following areas:
- Organizational Process Performance (OPP) in the Product line Dominican Rail
- Project Monitoring and Control (PMC) in Product Line Hotel Distribution
- Decision Analysis and Resolution (DAR) in Travel services and Leisure

PHASE 3:

PART 1:

MATUREITY LEVEL 4 (All process areas shall be planned for Capability Level 4 acceptance. If a process area under Maturity 4 is already increased to Capability 4, it is still included under this part of Phase 3. Reason: Same as described under Phase 2)

PART 2:

CAPABILITY LEVEL 4 in the following areas:
- Product Integration (PI) under Product Line Core Ticketing System

PART 3:

CAPABILITY LEVEL 5 in the following areas:
- Product and Process Quality Assurance (PPQA) in Development across GTDO
- Billing of Travel Agents, Accounting applications of Travel Agent
- Configuration Management (CM) in Cruise, Ferry and Insurance

PHASE 4:

PART 1:

MATUREITY LEVEL 5 (All process areas shall be planned for Capability Level 5 acceptance. If a process area under Maturity 5 is already increased to Capability 5, it is still included under this part of Phase 4. Reason: Same as described under Phase 2)

PART 2:

CAPABILITY LEVEL 4 in the following areas:
- Requirements Development in the Product line Aristocratic Rail
- Integrated Project Management (IPM) across all departments
- Organizational Training (OT) across all departments

PART 3:

CAPABILITY LEVEL 5 in the following areas:
- Requirements Management (RM) in across all departments
- Measurement and Analysis (MA) in Aristocratic Rail
- Organizational Process Performance (OPP) across all departments

Figure 11: How to reach CMMI 5 and beyond: Phases of Implementation
The plan above as stated under Figure 11: How to reach CMMI 5 and beyond: Phases of Implementation is the result of devised plan to implement CMMI in GTDO in 4 phases which positions the organization in a highly advanced position. The formulation of the plan to achieve process maturity also takes into account the future needs of the organization and targets additional capability levels in selected process areas.

9.1.2.1 Basics of CMMI in GTDO Plan

Each Phase starting from 1 to 4 is comprised of 2 parts as described under Figure 11: How to reach CMMI 5 and beyond: Phases of Implementation

Part 1: Maturity Level Implementation
Part 2, Part 3: Capability Level Implementation

To reach a particular Maturity level “M”, it is a prerequisite that all the process areas in that maturity level have a capability of “M” or more. This is described under [45]

Example:
Requirements Management (REQM) which belongs to Maturity level 2 should be at least Level 2 Capable when it is targeted to be realized as a part of appraisal for maturity level 2.

Under each of the phase, when there will be Specific Goals and Generic Goals, the first result would be a Gap Analysis between the previous Level and the Current realization level in GTDO and actions required to bridge the gaps shall be identified. This step is called Identifying and Bridging Gap.

Once the Identifying and Bridging Gap step is done, the supporting steps for Bridging Gap is formulated in the form of Guidelines/Templates/Artefacts required for executing those actions are presented. This phase is called Realization Support

Example:
(a) Identifying and Bridging Gap: In case of Requirements Management (REQM), in the first phase to reach Maturity Level 2, there will be a gap analysis between ISO 9001:2000 handling of requirements management and the current requirement of CMMI Requirement Management. The gaps are correspondingly bridged by suggested actions under “Actions required”. See 9.3.2 Requirements Management (REQM) [43] for example and gaps in one of the areas in Requirements Management as under [40]

(b) Realization Support: In REQM, in order to provide Statement of Requirements evaluation criteria
9.1.3 Devised Phases of Implementation and Formulation

The CMMI implementation is devised and divided into 4 different phases of implementation, each of it combining a particular Maturity Level and one or more Capability Levels in selected Process areas. In general, such a design purports a sustainable improvement of quality processes following a guided/staged representation but at the same time focusing on process areas that are important areas of improvement in respective stages. The full picture of devised implementation phases is shown under Figure 11: How to reach CMMI 5 and beyond: Phases of Implementation.

Motivation for including some of the process areas above in one or many capability levels as targets in addition to the maturity level is explained under the Section 7.3 Example of Capability Level Implementation.

Reaching additional Capability levels is an additional bonus work performed in documenting the results of this thesis. The main target of the thesis work is to reach How to reach CMMI 5 maturity level for the GTDO. Refer to point #5 in the section 4.4 Out of Scope for more details.

9.1.3.1 Prioritization of Tasks

In devising the tasks needed to bridge the gaps in each process area, there are prioritizations made. The different priorities specified are High, Medium and Low.

**High** – Signifies that it is ideally supposed to be implemented first or should be among the first tasks within that process area. It is an absolute must task that needs to be implemented.

**Medium** – Signifies that it is supposed to be implemented after all “High” priority activities within that process area are implemented unless it is practically impossible to do it in that order. It is an absolute must task that needs to be implemented.

**Low** - Signifies that it is supposed to be implemented after all the High and Medium activities are implemented in that order. The activities identified under Low are good to implement activities which strengthen the maturity of the organization but not an absolute must.
9.2 Data Collection, analysis and information formulation

It’s highly important to document learning from each of the phases of Goal oriented task execution and effectively document them. A Cyclic L-GADEVI approach is formulated as in the above figure. It’s imperative that a task that needs to be performed is identified after planning. Once the tasks are identified through Planning, identify the list of all tasks (to the best of knowledge) and plan their execution according to a cycle of following steps:

(a) Goals for the Task are formulated. [G]
(b) The Tasks are Analysed [A]
(c) Solution is Designed [D]
(d) Solution is Executed [E]
(e) The Executed Solution is Verified for compliance and Measured.[V]
(f) The measurement together with a comparison to the original goal will provide a Gap Identification which can lead to the next iteration of L-GADEVI. [I]
(g) Go to (a) if there are gaps that are more than acceptable levels. If the gaps are acceptable, it has to be logged mentioning that the gaps identified in step (g) are at acceptable levels. If the Gaps are not acceptable, then in step (a), the Goal is formulated to address the Gap.

Learning and its documentation is performed between several stages namely when transitioning from (b) to (c), (c) to (d), (d) to (e), (e) to (f), (f) to (g) and (g) to (a). [L]
9.3 **Phase 1: Maturity Level 2 implementation**

9.3.1 **Goal**

To reach Maturity level 2, all processes in it should reach Capability level 2 as described under [45]

1. Requirements Management (REQM)
2. Project Planning (PP)
3. Project Monitoring and Control (PMC)
4. Supplier Agreement Management (SAM)
5. Measurement and Analysis (MA)
6. Process and Product Quality Assurance (PPQA)
7. Configuration Management (CM)

An analysis performed on each Specific Goal and process step in a detailed manner will be presented for Requirements Management and Project Planning. [40] For all process areas there will be a checklist provided which summarizes all the checkpoints which needs to be taken into consideration in order to fill the gaps that exist today in achieving the maturity level desired [Example: Table 13: Checklist for Compliance in Maturity Level 2 for Requirements Management]
9.3.2 **Requirements Management (REQM)**

REQM for a Software Organization is used to manage requirements of the required components and products [4] of a project through tracing requirements through the different phases and activities of Software Lifecycle and identify inconsistencies between requirements and project plans and work products. [4]

<table>
<thead>
<tr>
<th>Goals to be fulfilled From [4]</th>
</tr>
</thead>
<tbody>
<tr>
<td>SG 1 Manage Requirements</td>
</tr>
<tr>
<td>SP 1.1 Obtain an Understanding of Requirements</td>
</tr>
<tr>
<td>SP 1.2 Obtain Commitment to Requirements</td>
</tr>
<tr>
<td>SP 1.3 Manage Requirements Changes</td>
</tr>
<tr>
<td>SP 1.4 Maintain Bidirectional Traceability of Requirements</td>
</tr>
<tr>
<td>SP 1.5 Identify Inconsistencies between Project Work and Requirements</td>
</tr>
</tbody>
</table>

The following is the result of Gap Analysis of Requirement Management under [40] representing the health of the GTDO in Requirements Management process area prior to How to reach CMMI 5 implementation.

![Figure 13: Health of GTDO in Requirements Management before How to reach CMMI 5](image-url)
9.3.2.1 Checklist for bridging gap in Requirements Management

Checklist is based on the health of GTDO in RM. The goals and practices that have already been fulfilled (fully compliant) by the GTDO currently today are not provided deep focus. Extensive details on Requirement Management implementation in GTDO for the CMMI initiative can be found under [43].

<table>
<thead>
<tr>
<th>#</th>
<th>Activities</th>
<th>Tools/Meth-odology</th>
<th>Typical Output</th>
<th>Responsibility</th>
<th>Stage</th>
<th>Priority</th>
<th>Rationale and Comments on Activity</th>
<th>Verification Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Are the Project Authorization Document (PAD)/ Project Directive (PD)/ Project Charter (PC) document obtained before time of start of Requirements Management Processes? (Requirements Elicitation or Requirement Analysis)?</td>
<td>Customer Relationship Management Tool / Excel/ Word Document</td>
<td>Project Charter (See an example under Figure 2: Project Charter for PERFORMING research work for How to reach CMMI 5 for GTDO)</td>
<td>PM</td>
<td>Initiation &amp; Planning</td>
<td>Medium</td>
<td>An authorization document stating the vision of the project and a high level directive is imperative when conducting the Requirements Elicitation and Analysis work primarily to have guidance in direction and scope of the project.</td>
<td>Project Charter was defined for all the new projects that were approved to be started and shared with the team.</td>
</tr>
<tr>
<td>2</td>
<td>In case of Procuring services/products from external suppliers :</td>
<td>Word, Excel, Project Management Tool</td>
<td>LOE (Level of Effort) SOW (Statement of Work)</td>
<td>PM</td>
<td>Initiation &amp; Planning</td>
<td>Medium</td>
<td>When Procuring a service or a product as a part of the project from an external service partner (Example: Service from an API provider for completing a booking or reservation), it is important to know the effort needed to perform any configurations or customizations to the solution.</td>
<td>One of the projects where there was an ongoing procurement process, the GTDO asked the supplier to provide the LOE. (The supplier was already providing SOE).</td>
</tr>
<tr>
<td>#</td>
<td>Activities</td>
<td>Tools/Methodology</td>
<td>Typical Output</td>
<td>Responsibilit y</td>
<td>Stage</td>
<td>Priority</td>
<td>Rationale and Comments on Activity</td>
<td>Verification Procedure</td>
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</tr>
<tr>
<td>3</td>
<td>Is there an Initial Understanding of Requirements secured with all the stakeholders?</td>
<td>MultiApproach Tool and a Functional Presentation (A Functional presentation covers functionalities of the system in the form of a presentation)</td>
<td>SOR Baseline</td>
<td>Marketing, FA</td>
<td>Executio n</td>
<td>Medium</td>
<td>Securing the understanding of the requirements with the stakeholders is highly imperative during the Requirements Management process.</td>
<td>After the request, both the LOE and SOE were provided.</td>
</tr>
<tr>
<td>4</td>
<td>Is the bi-directional traceability between requirements and other work products developed &amp; maintained?</td>
<td>MultiApproach Tool</td>
<td>ReqTracer view as in Table 27: Requirement Traceability Matrix Populated by MultiApproach Tool</td>
<td>PM [Primary]</td>
<td>Executio n</td>
<td>Medium</td>
<td>The traceability between requirements and other work products such as Use cases, Test Cases etc. are important for successful Requirements Management.</td>
<td>This was not done through the MultiApproach tool since the tool needed some changes. The baseline was stored in a version controlled archive. An Excel list was created, one for each project and the Functional analyst got the responsibility to...</td>
</tr>
<tr>
<td>#</td>
<td>Activities</td>
<td>Tools/Meth</td>
<td>Typical Output</td>
<td>Responsibility</td>
<td>Stage</td>
<td>Priority</td>
<td>Rationale and Comments on Activity</td>
<td>Verification Procedure</td>
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</tr>
<tr>
<td>5</td>
<td>Has Requirements Elicitation responsible uploaded the Mini-SOR (with Req No and Short Description) into MultiApproach? Are the requirements changes logged and tracked?</td>
<td>SOR History logged into MultiApproach tool</td>
<td>Requirements Change Log in SOR as shown in Table 22: Essential Elements in Feasibility Study</td>
<td>Marketing, PM [Primary]</td>
<td>Execution</td>
<td>Medium</td>
<td>Requirements Changes should be tracked in History of SOR Version Document as described under Table 23: Essential Elements in SOR</td>
<td>fill the traceability of requirements to use case, the architects from use case to design component and test cases. However, the developers did not have time to fill in the developed code. This was not done through the MultiApproach tool since the tool needed some changes. The change log Table 22: Essential Elements in Feasibility Study was incorporated into the Feasibility Study templates.</td>
</tr>
<tr>
<td>#</td>
<td>Activities</td>
<td>Tools/Methodology</td>
<td>Typical Output</td>
<td>Responsibility</td>
<td>Stage</td>
<td>Priority</td>
<td>Rationale and Comments on Activity</td>
<td>Verification Procedure</td>
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</tr>
<tr>
<td>6</td>
<td>Is the impact of requirement changes on effort, Q&amp;P (Quality and Productivity) goals and project schedule evaluated and impact analysis made? [Inclusive of any additional costs incurred]</td>
<td>Impact Analysis Template and Feasibility Study Template</td>
<td>Impact Analysis Template (Table 25: Essential Elements in Impact Analysis with an example) Feasibility Study Document (Table 22: Essential Elements in Feasibility Study) SOR Review document (Table 21: SOR Review Template - Functional Analyst) Update of Project Charter / Vision of the Project if it impacts the scope of the Project.</td>
<td>PM [Primary] Functional Analysis</td>
<td>Executio n</td>
<td>Medium</td>
<td>Impact of each requirement change has to be analysed and all impacted documents needs to be documented.</td>
<td>The templates mentioned under the output have been made official inside the department for all new projects and the projects welcomed this update.</td>
</tr>
</tbody>
</table>

Table 13: Checklist for Compliance in Maturity Level 2 for Requirements Management

A more in-depth analysis of Requirement Management and the actions taken to meet CMMI maturity level 2 is presented under [43]

9.3.2.2 Verification

Implementation of gaps in Requirement Management in Ground/Sea Travel and services was part of the verification of the results as a proof of concept of the research work. Details on how each activity was verified is presented under Table 13: Checklist for Compliance in Maturity Level 2 for Requirements Management
9.3.3 **Project Planning (PP)**

Project Planning is a vital part during the entire project lifetime and CMMI states specific practices to be followed in planning the project’s successful execution [4]. Linking the Goals to the Gap analysis presented under Project Planning under *Figure 9: Compliance of Individual CMMI Processes/Disciplines in GTDO* and the overall health of the GTDO with respect to Project Planning practice looks relatively better since there is 77% Compliance before implementing “How to reach CMMI 5 for GTDO?”

![Project Planning](image)

*Figure 14: Health of GTDO in Project Planning before “How to reach CMMI 5”*

The following is the set of process areas which should be addressed in Project Planning.

<table>
<thead>
<tr>
<th>Goals to be fulfilled from [4]</th>
</tr>
</thead>
<tbody>
<tr>
<td>SG 1 Establish Estimates</td>
</tr>
<tr>
<td>SP 1.1 Estimate the Scope of the Project</td>
</tr>
<tr>
<td>SP 1.2 Establish Estimates of Work Product and Task Attributes</td>
</tr>
<tr>
<td>SP 1.3 Define Project Lifecycle</td>
</tr>
<tr>
<td>SP 1.4 Determine Estimates of Effort and Cost</td>
</tr>
<tr>
<td>SG 2 Develop a Project Plan</td>
</tr>
<tr>
<td>SP 2.1 Establish the Budget and Schedule</td>
</tr>
<tr>
<td>SP 2.2 Identify Project Risks</td>
</tr>
<tr>
<td>SP 2.3 Plan for Data Management</td>
</tr>
<tr>
<td>SP 2.4 Plan for Project Resources</td>
</tr>
<tr>
<td>SP 2.5 Plan for Needed Knowledge and Skills</td>
</tr>
<tr>
<td>SP 2.6 Plan Stakeholder Involvement</td>
</tr>
<tr>
<td>SP 2.7 Establish the Project Plan</td>
</tr>
<tr>
<td>SG 3 Obtain Commitment to the Plan</td>
</tr>
<tr>
<td>SP 3.1 Review Plans That Affect the Project</td>
</tr>
<tr>
<td>SP 3.2 Reconcile Work and Resource Levels</td>
</tr>
<tr>
<td>SP 3.3 Obtain Plan Commitment</td>
</tr>
</tbody>
</table>

53
### 9.3.3.1 Checklist for bridging gap in Project Planning

Checklist is based on the health of GTDO in PP. The goals and practices that are already fulfilled (fully compliant) by the GTDO currently today are not provided deep focus.

<table>
<thead>
<tr>
<th>#</th>
<th>Activities</th>
<th>Tools/Met hodology</th>
<th>Typical Output</th>
<th>Responsibility</th>
<th>Stage</th>
<th>Priority</th>
<th>Rationale and Comments on Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Was the Project kick conducted in presence of all key stakeholders?</td>
<td>Integrated Project Management</td>
<td>Project Charter (See an example under Figure 2: Project Charter for PERFORMING research work for How to reach CMMI 5 for GTDO)</td>
<td>Project Manager</td>
<td>Initiation &amp; Planning</td>
<td>Medium</td>
<td>An authorization document stating the vision of the project and a high level directive is imperative when conducting the Requirements Elicitation and Analysis work primarily to have guidance in direction and scope of the project.</td>
</tr>
<tr>
<td>2</td>
<td>Is the past data from Process Database /Similar Project/Unit Level Process Capability Baseline (PCB) /Org level PCB used for project planning</td>
<td>Process Database (PD), Process Capability Baseline (PCB)</td>
<td>LOE (Level of Effort) SOW (Statement of Work)</td>
<td>Project Manager</td>
<td>Initiation &amp; Planning</td>
<td>Medium</td>
<td>When Procuring a service or a product as a part of the project from an external service partner (Example: Service from an API provider for completing a booking or reservation)</td>
</tr>
<tr>
<td>#</td>
<td>Activities</td>
<td>Tools/Met hodology</td>
<td>Typical Output</td>
<td>Responsibili ty</td>
<td>Stage</td>
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<td>Rationale and Comments on Activity</td>
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</tr>
<tr>
<td>3</td>
<td>Is the Project Scope, Technical Approach and Project Life Cycle Phases determined?</td>
<td>PDM</td>
<td>SOR Baseline</td>
<td>Marketing, Functional Analyst/Business Analyst</td>
<td>Execution</td>
<td>Medium</td>
<td>Securing the understanding of the requirements with the stakeholders is highly imperative during the Requirements Management process.</td>
</tr>
<tr>
<td>4</td>
<td>Are commitments from Contractual documents, SLA (Service Level Agreement), Proposal, SOW etc. considered during Project planning?</td>
<td>WBS (Work Breakdown Structure) that reflects the identified dependencies.</td>
<td>ReqTracer view as in Table 27: Requirement Traceability Matrix Populated by MultiApproach Tool</td>
<td>Project Manager [Primary] Marketing, Dev., Functional Analyst/Business Analyst, Testers</td>
<td>Execution</td>
<td>Medium</td>
<td>The traceability between requirements and other work products such as Use cases, Test Cases are important for successful Requirements Management. This needs to be monitored at the Project planning level and in verification and validation.</td>
</tr>
<tr>
<td>5</td>
<td>Is the basis and methodology used for effort estimation clearly identified and followed?</td>
<td>Requirements Change Log in SOR as shown in Table 22: Essential Elements in Feasibility Study</td>
<td>Marketing, Project Manager [Primary]</td>
<td>Execution</td>
<td>Medium</td>
<td>Requirements Changes should be tracked in History of SOR Version Document as described under Table 23: Essential Elements in SOR</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Is the Project Effort, Defect and Cost estimated and baseline created and stored in GTDO Process Database (PD)?</td>
<td>Process Database</td>
<td>Impact Analysis Template (Table 25: Essential Elements in Impact Analysis with an example) Feasibility Study Document (Table 22: Essential Elements in Feasibility Study) SOR Review document</td>
<td>Project Manager [Primary] Functional Analysis</td>
<td>Execution</td>
<td>Medium</td>
<td>Impact of each requirement change has to be analysed and all impacted documents needs to be documented.</td>
</tr>
<tr>
<td>#</td>
<td>Activities</td>
<td>Tools/Met hodology</td>
<td>Typical Output</td>
<td>Responsibility</td>
<td>Stage</td>
<td>Priority</td>
<td>Rationale and Comments on Activity</td>
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</tr>
<tr>
<td></td>
<td>(Table 21: SOR Review Template - Functional Analyst)</td>
<td></td>
<td>Update of Project Charter / Vision of the Project if it impacts the scope of the Project.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Are the project milestones identified, aligned to customer deliverables and based on critical risk points?</td>
<td>Project Plan and entry in Process Database</td>
<td>Project Plan: Phases identified in Project Plan and the entry of the milestones in the Process Database.</td>
<td>Project Manager</td>
<td>Initiation and Planning</td>
<td>Medium</td>
<td>The customer deliverables needs to be in synch with the plan and the milestone identification to set the right expectations and secure small consistent deliveries throughout the project.</td>
</tr>
<tr>
<td>8</td>
<td>Is MultiApproach set up and customization done for the Project with appropriate parties given right access rights?</td>
<td>MultiApproach Configuration Management Set up Files</td>
<td>Configuratio n Manager Planning</td>
<td>Configuration Manager Planning</td>
<td>Medium</td>
<td>During the course of the project, it is expected that there will be Changes that arise and there needs to be a mechanism for the members in the project to request for change (Throughout the project), log defects (Construction phase)</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Is the phase of injection and phase of detection of defects selectable and able to be logged?</td>
<td>Process Database (PD)</td>
<td>Defect Logging</td>
<td>Functional Analyst</td>
<td>Initiation &amp; Planning Execution</td>
<td>Medium</td>
<td>The logging of defects together with the phase when the defect was detected can be used in the PCB.</td>
</tr>
<tr>
<td>10</td>
<td>Are Activity Codes set up for the Project and Is the MultiApproach Tool set up to log Project issues?</td>
<td>MultiApproach Tool Set up</td>
<td>Configuratio n Manager Execution</td>
<td>Configuration Manager Execution</td>
<td>Medium</td>
<td>It’s better to get the practical set up of MultiApproach to perform</td>
<td></td>
</tr>
<tr>
<td>#</td>
<td>Activities</td>
<td>Tools/Met hodology</td>
<td>Typical Output</td>
<td>Responsibility</td>
<td>Stage</td>
<td>Priority</td>
<td>Rationale and Comments on Activity</td>
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</tr>
<tr>
<td>11</td>
<td>Is the Project Schedule developed and uploaded to Common Project Database where Project Related Documents are stored and is everyone made aware of it?</td>
<td>Project Management Doc DB, Process Database</td>
<td>Project Schedule</td>
<td>Project Manager</td>
<td>Initiation, Planning and Execution</td>
<td>Medium</td>
<td>The Project Schedule and Project Plan will be available for all the project members.</td>
</tr>
<tr>
<td>12</td>
<td>Does the Project Schedule contain all the Project Manager, CM activities planned in the Project and program level activities of Tasks, Reviews, Testing and Rework?</td>
<td>Project Management Doc DB, Process Database</td>
<td>Project Plan</td>
<td>Project Manager</td>
<td>Initiation and Planning</td>
<td>Medium</td>
<td>Including testing, rework, and Configuration Management activities can make the project plan more realistic.</td>
</tr>
<tr>
<td>13</td>
<td>Is the Project Plan reviewed, base lined and shared with the team members?</td>
<td>Project Management Doc DB, Process Database</td>
<td>Project Communication Plan</td>
<td>Project Manager</td>
<td>Initiation and Planning</td>
<td>Medium</td>
<td>It is imperative to review the Project Plan after building it through a Bottom-Up planning process and the baseline should be shared with the team members.</td>
</tr>
</tbody>
</table>

Table 14: Checklist for Compliance in Maturity Level 2 for Project Planning
9.3.4 Project Monitoring and Control (PMC)

The activities that need to be performed with respect to Project Monitoring and Control to ensure compliance with project Monitoring and Control for Maturity Level 2 are tabulated as follows. Linking the Goals to the Gap analysis for PMC under [40] the overall health of the GTDO with respect to PMC practice looks relatively better since there is 90% Compliance before implementing How to reach CMMI 5 for GTDO.

![Project Monitoring and Control](image)

*Figure 15: Health of GTDO in Project Monitoring and Control before How to reach CMMI 5*

The following is the set of process areas which are supposed to be addressed in Project Monitoring and Control.

Goals to be fulfilled from [4]:

```
SG 1 Monitor Project against Plan
  SP 1.1 Monitor Project Planning Parameters
  SP 1.2 Monitor Commitments
  SP 1.3 Monitor Project Risks
  SP 1.4 Monitor Data Management
  SP 1.5 Monitor Stakeholder Involvements
  SP 1.6 Conduct Progress Reviews
  SP 1.7 Conduct Milestone Reviews

SG 2 Manage Corrective Action to Closure
  SP 2.1 Analyse Issues
  SP 2.2 Take Corrective Action
  SP 2.3 Manage Corrective Action
```

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Checklist for bridging gap in Project Monitoring and control

Checklist is based on the health of GTDO in PMC. The goals and practices that are already fulfilled (fully compliant) by the GTDO today are not provided deep focus.

<table>
<thead>
<tr>
<th>#</th>
<th>Activities</th>
<th>Tools/Methodology</th>
<th>Typical Output</th>
<th>Responsibility</th>
<th>Stage</th>
<th>Priority</th>
<th>Rationale and Comments on Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Is the actual data on activities crafted in the Project Schedule, Defect Information properly captured and maintained by all the team members on a regular basis?</td>
<td>Process Database, MultiApproach</td>
<td>Entry into Process Database</td>
<td>Project Manager</td>
<td>Execution</td>
<td>Medium</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>Is Project issues logged, analysed and tracked to closure?</td>
<td>MultiApproach</td>
<td>Tracking Information logged in MultiApproach tool.</td>
<td>Project Manager</td>
<td>Execution</td>
<td>Medium</td>
<td>Daily critical Status Report</td>
</tr>
<tr>
<td>3</td>
<td>Are Service Level Agreements tracked?</td>
<td>MultiApproach</td>
<td>Status Reports populated with the information regarding SLA compliance</td>
<td>Project Manager</td>
<td>Execution</td>
<td>Medium</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>Is the Milestone analysis performed at the milestones and Milestone Reports prepared and submitted on time? Corrective and Preventive actions are taken to bring the project under control?</td>
<td>PDM PD</td>
<td>Milestone Reports</td>
<td>Project Manager</td>
<td>Execution</td>
<td>Medium</td>
<td>-</td>
</tr>
<tr>
<td>#</td>
<td>Activities</td>
<td>Tools/Methodology</td>
<td>Typical Output</td>
<td>Responsibility</td>
<td>Stage</td>
<td>Priority</td>
<td>Rationale and Comments on Activity</td>
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</tr>
<tr>
<td>6</td>
<td>Are the statuses of all aspects of project reviewed periodically by senior Management? If it is a large project (More than 30 FTE working) involving multiple groups, are all stakeholders involved in the review?</td>
<td>PDM PD</td>
<td>MoM (Minutes of meeting), Milestone Reports</td>
<td>Project Manager</td>
<td>Execution</td>
<td>Medium</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>Are milestone discussed and shared with team members?</td>
<td>PDM PD</td>
<td>Milestone Reports</td>
<td>Project Manager</td>
<td>Execution</td>
<td>Medium</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>Is the Project Plan revisited and updated at milestones?</td>
<td>PDM PD</td>
<td>Project Plan</td>
<td>Project Manager</td>
<td>Execution</td>
<td>Medium</td>
<td>-</td>
</tr>
<tr>
<td>9</td>
<td>Is Engagement Feedback initiated, collected on regular basis, and action taken, if required?</td>
<td>PDM PD</td>
<td>Engagement Feedback Reports</td>
<td>Project Manager</td>
<td>Closure</td>
<td>Medium</td>
<td>-</td>
</tr>
</tbody>
</table>

*Table 15: Checklist for Compliance in Maturity Level 2 for Project Monitoring and Control*
9.3.5 Supplier Agreement Management (SAM)

The activities that need to be performed with respect to Supplier Agreement Management to ensure compliance with Supplier Agreement Management for Maturity Level 2 are tabulated as follows. Linking the Goals to the Gap analysis presented under SAM under [40], the overall health of the GTDO with respect to Supplier Agreement Management practice looks relatively better since there is 75% Compliance before implementing How to reach CMMI 5 for GTDO.

![Supplier Agreement and Management](image)

Figure 16: Health of GTDO in Supplier Agreement and Management before “How to reach CMMI 5”

The following is the set of process areas which are supposed to be addressed in Supplier Agreement Management

Goals to be fulfilled from [4]:

```
SG 1 Establish Supplier Agreements
   SP 1.1 Determine Acquisition Type
   SP 1.2 Select Suppliers
   SP 1.3 Establish Supplier Agreements
SG 2 Satisfy Supplier Agreements
   SP 2.1 Execute the Supplier Agreement
   SP 2.2 Monitor Selected Supplier Processes
   SP 2.3 Evaluate Selected Supplier Work Products
   SP 2.4 Accept the Acquired Product
   SP 2.5 Transition Products
```

### 9.3.5.1 Checklist for bridging gap in Supplier Agreement and Management

Checklist is based on the health of GTDO in SAM. The goals and practices that are already fulfilled (fully compliant) by the GTDO today are not provided deep focus.

<table>
<thead>
<tr>
<th>#</th>
<th>Activities</th>
<th>Tools/Methodology</th>
<th>Typical Output</th>
<th>Responsibility</th>
<th>Stage</th>
<th>Priority</th>
<th>Rationale and Comments on Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Are the vendors selected based on an evaluation of their ability to meet the specified requirements and established criteria?</td>
<td>• Request For Information</td>
<td>Vendor Scoring Card</td>
<td>Functional Analyst Lead</td>
<td>Planning</td>
<td>Medium if Suppliers involved</td>
<td>It’s highly important that when external suppliers are required to be involved in the GTDO in offering a service, the suppliers go through a methodological, fair and comprehensive process of selection based on criteria such as requirements, future possibilities, functionalities, flexibility of the solution and soft factors such as partnership and cooperation.</td>
</tr>
</tbody>
</table>
| 2  | Are the contracts with the supplier established and maintained?          | Statement of Work                | Completed Statement of Work          | Project Manager           | Planning    | Medium       | It’s imperative to set up the terms and conditions of delivery of the service from the Supplier to have a reference to the following:  
  • The methodology to be administered in the delivery of service  
  • The list of deliverables  
  • The frequency of delivery  
  • Penalties due to lack of delivery on time/lack of quality  
  • Other terms and conditions. |
| 3  | Are the Deliverables & Services reviewed to ensure that they meet the specified requirements covered under contracts and then accepted? | Delivery and Milestone Tracker  | Reviewed Statement of Work          | Project Manager           | Execution   | Medium       | This is typically the work undertaken before a Statement of Work is signed by the different parties involved. |

*Table 16: Checklist for Compliance in Maturity Level 2 for Supplier Agreement Management*
9.3.6 **Product and Process Quality Assurance (PPQA)**

The activities that need to be performed with respect Product and Process Quality Assurance to ensure compliance for Maturity Level 2 are tabulated as follows. Linking the Goals to the Gap analysis presented under PPQA under [40], the overall health of the GTDO with respect to PPQA practice is not worrying but not very promising either, there is 50% full Compliance before implementing “How to reach CMMI 5 for GTDO.”

![Graph of Process and Product Quality Assurance](image)

*Figure 17: Health of GTDO in Process and Product Quality Assurance before How to reach CMMI 5*

The following is the set of process areas which are supposed to be addressed in Process and Product Quality Assurance

<table>
<thead>
<tr>
<th>Goals to be fulfilled from [4]:</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;</td>
</tr>
<tr>
<td><strong>SG 1 Objectively Evaluate Processes and Work Products</strong></td>
</tr>
<tr>
<td><strong>SP 1.1 Objectively Evaluate Processes</strong></td>
</tr>
<tr>
<td><strong>SP 1.2 Objectively Evaluate Work Products and Services</strong></td>
</tr>
<tr>
<td><strong>SG 2 Provide Objective Insight</strong></td>
</tr>
<tr>
<td><strong>SP 2.1 Communicate and Ensure Resolution of Non-compliance Issues</strong></td>
</tr>
<tr>
<td><strong>SP 2.2 Establish Records</strong></td>
</tr>
<tr>
<td>&quot;</td>
</tr>
</tbody>
</table>
### Checklist for bridging gap in Product and Process Quality Assurance (PPQA)

Checklist is based on the health of GTDO in PPQA. The goals and practices that are already fulfilled (fully compliant) by the GTDO today are not provided deep focus.

<table>
<thead>
<tr>
<th>#</th>
<th>Activities</th>
<th>Tools/Methodology</th>
<th>Typical Output</th>
<th>Responsibility</th>
<th>Stage</th>
<th>Priority</th>
<th>Rationale and Comments on Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Are the Software Engineering Process Group (SEPG) Compliance Checks/Internal audits planned and conducted in the Project?</td>
<td>SEPG Schedule, Internal audit</td>
<td>Compliance Check/Internal audit schedule</td>
<td>SEPG</td>
<td>Execution</td>
<td>Medium</td>
<td>The SEPG has the responsibility to ensure the compliance in different areas, especially process quality assurance in the project. The SEPG does this through audits and other checking mechanisms.</td>
</tr>
<tr>
<td>2</td>
<td>Are the findings of SEPG Compliance Checks/Gap Report of Internal audits recorded and shared with the stakeholders?</td>
<td>Internal audit</td>
<td>Compliance Check/Internal audit reports</td>
<td>SEPG</td>
<td>Execution</td>
<td>Medium</td>
<td>It’s extremely important that the results of the compliance checks are presented to the stakeholders with no manipulated data. Areas of concern should be highlighted and actions/mitigation plan must be also presented to them.</td>
</tr>
<tr>
<td>3</td>
<td>Are the findings of SEPG Compliance Checks / Gap Report of Internal Audits tracked to closure?</td>
<td>Internal Audit System</td>
<td>Compliance Check/Internal audit reports</td>
<td>PM</td>
<td>Execution</td>
<td>Medium</td>
<td>The results of the SEPG Compliance checks should be monitored and controlled. The actions taken to ensure compliance should be tracked to closure.</td>
</tr>
<tr>
<td>4</td>
<td>Before releasing any deliverable to the customer, are the quality of the deliverable as well as completion of all necessary reviews (including Check Points) &amp; testing is verified independently?</td>
<td>Configuration Management tools</td>
<td>CM Form, Release Checklist, Gating process</td>
<td>Configuration Manager</td>
<td>Execution</td>
<td>Medium</td>
<td>To ensure that all the quality activities conducted translates into results, a checklist of reviews and pre-identified checkpoints must have passed. E.g. IT Functional Testing must have passed without any failed test cases on Business Critical and Business Important Scenarios. All failed test cases, known bugs which are not deemed to be serious or considered as showstoppers must be documented and included in the Release notes to the customer.</td>
</tr>
</tbody>
</table>

Table 17: Checklist for Compliance in Maturity Level 2 for PPQA
9.3.7 **Configuration Management (CM)**

The activities that need to be performed with respect Configuration Management to ensure compliance with Maturity Level 2 are tabulated as follows. Linking the Goals to the Gap analysis presented under CM under [40], the overall health of the GTDO with respect to Configuration Management practice is very promising, there is 100% full Compliance before implementing How to reach CMMI 5 for GTDO. Therefore only some sanity checks in the CM process is needed.

![Configuration Management](image)

*Figure 18: Health of GTDO in Configuration Management before “How to reach CMMI 5” implementation.*

The following is the set of process areas which should be addressed in Configuration Management. Although, there is 100% compliance in the GTDO, the checklist 9.3.7.1 *Checklist for bridging gap in Configuration Management (CM)* is still provided for reference to know which key aspects need to be taken into account.

Goals to be fulfilled from [4]:

```
SG 1 Establish Baselines
   SP 1.1 Identify Configuration Items
   SP 1.2 Establish a Configuration Management System
   SP 1.3 Create or Release Baselines

SG 2 Track and Control Changes
   SP 2.1 Track Change Requests
   SP 2.2 Control Configuration Items

SG 3 Establish Integrity
   SP 3.1 Establish Configuration Management Records
   SP 3.2 Perform Configuration Audits
```

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9.3.7.1 Checklist for bridging gap in Configuration Management (CM)

Checklist is based on the health of GTDO in CM. The goals and practices that are already fulfilled (fully compliant) by the GTDO today are not provided deep focus.

<table>
<thead>
<tr>
<th>#</th>
<th>Activities</th>
<th>Tools/Meth odology</th>
<th>Typical Output</th>
<th>Responsibility</th>
<th>Stage</th>
<th>Priority</th>
<th>Rationale and Comments on Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Is the CM Plan present, approved and maintained?</td>
<td>Excel/Word</td>
<td>Configuration Management Plan</td>
<td>Configuration Manager (Preferred)</td>
<td>Planning</td>
<td>Medium</td>
<td>The ideal responsibility for creating and maintaining CM Plan rests within a Configuration Manager. However, the GTDO does not have a separate Configuration Manager. If a separate Configuration Manager cannot be put in place, the Project Manager should take this responsibility and should be made clear in the Project charter. There is an excel document maintained which describes the different deliverables at different points of time and should be synchronized with the Project Plan as described in the checklist for Project Planning. The Configuration Management Plan among several other information includes the Items that are configurable in the project and the tool used for Configuration Management in the project.</td>
</tr>
<tr>
<td>2</td>
<td>Is the CM Tool identified, set up and established as per CM Plan?</td>
<td>MultiApproach</td>
<td>Communication of the choice of CM plan in the Project Dashboard and all members of the</td>
<td>Configuration Manager (Preferred)</td>
<td>Planning</td>
<td>Medium</td>
<td>It is highly imperative that there is a CM Tool identified before the Project is Executed. It is also important to have a Master Change Request that represents the whole Project since this enables better</td>
</tr>
<tr>
<td>#</td>
<td>Activities</td>
<td>Tools/Meth odology</td>
<td>Typical Output</td>
<td>Responsibility</td>
<td>Stage</td>
<td>Priority</td>
<td>Rationale and Comments on Activity</td>
</tr>
<tr>
<td>----</td>
<td>---------------------------------------------------------------------------</td>
<td>--------------------</td>
<td>----------------</td>
<td>----------------</td>
<td>--------</td>
<td>----------</td>
<td>--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>Change Request representing the whole Project?</td>
<td>Tool</td>
<td>Project</td>
<td></td>
<td></td>
<td></td>
<td>control where other change requests which are born during the course of Project execution are referenced in the Master CR. This way there will be more control and traceability over which changes are originating from which Project and which Product eventually.</td>
</tr>
<tr>
<td>2</td>
<td>Change Request representing the whole Project?</td>
<td>Tool</td>
<td>Project</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Are the Change Requests for configuration items tracked? Are other changes to Configuration Items controlled?</td>
<td>MultiApproach</td>
<td>Change Requests in Multi Approach Tool, Revision and Approval History in the documentation of Configurable Items</td>
<td>Configuration Manager (Preferred) Project Manager</td>
<td>Execution</td>
<td>Medium</td>
<td>To make sure that the changes are followed up, it is imperative to make sure that they are tracked through the progress status in the Change Request tracking in Multi Approach tool. In cases where there is no Change Request to the Change Control of a Configuration Item (e.g. Project Charter), this is done through the Revision and Approval History of the Item.</td>
</tr>
<tr>
<td>4</td>
<td>Are the CM Audits (Baseline / Work Product Completion / Release) planned and conducted and CM Audit Reports prepared and shared with the team members?</td>
<td>MultiApproach</td>
<td>Configuration Audit Reports</td>
<td>Software Engineering Process Group (SEPG)</td>
<td>Execution</td>
<td>Medium</td>
<td>It is important to conduct routine audits by an independent body responsible for the Process and Quality Assurance of the projects that deliver Products for the GTDO. The SEPG is best suited for performing this task and sharing the information about the compliance with the Team Members. An external entity could also perform these Audits.</td>
</tr>
</tbody>
</table>

*Table 18: Checklist for Compliance in Maturity level 2 for CM*
9.3.8 Measurement and Analysis (MA)

MA involves in building and maintaining a measurement capability which can be used as a supporting discipline in managing information flow [4]. The activities that need to be performed with respect to Measurement and Analysis (MA) to ensure compliance for Maturity Level 2 are presented as follows. Linking the Goals to the Gap analysis presented under MA under [40], the overall health of the GTDO with respect to Measurement and Analysis practice is not up to the mark. It has only 38% compliance.

![Measurement and Analysis Graph]

Figure 19: Health of the GTDO in Measurement and Analysis before “How to reach CMMI 5” implementation

The following is the set of process areas which should be addressed in Measurement and Analysis process area. There is only 38% compliance in the GTDO when it comes to the measurement and analysis process discipline.

The following are the main processes

<table>
<thead>
<tr>
<th>Goals to be fulfilled according to [4]:</th>
</tr>
</thead>
<tbody>
<tr>
<td>SG 1 Align Measurement and Analysis Activities</td>
</tr>
<tr>
<td>SP 1.1 Establish Measurement Objectives</td>
</tr>
<tr>
<td>SP 1.2 Specify Measures</td>
</tr>
<tr>
<td>SP 1.3 Specify Data Collection and Storage Procedures</td>
</tr>
<tr>
<td>SP 1.4 Specify Analysis Procedures</td>
</tr>
<tr>
<td>SG 2 Provide Measurement Results</td>
</tr>
<tr>
<td>SP 2.1 Collect Measurement Data</td>
</tr>
<tr>
<td>SP 2.2 Analyse Measurement Data</td>
</tr>
<tr>
<td>SP 2.3 Store Data and Results</td>
</tr>
<tr>
<td>SP 2.4 Communicate Results</td>
</tr>
</tbody>
</table>

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9.3.8.1 **Checklist for bridging gap in Measurement and Analysis (MA)**

Checklist is based on the health of GTDO in MA. The goals and practices that are already fulfilled (fully compliant) by the GTDO today are not provided deep focus.

<table>
<thead>
<tr>
<th>#</th>
<th>Activities</th>
<th>Tools/Methodology</th>
<th>Typical Output</th>
<th>Responsibility</th>
<th>Stage</th>
<th>Priority</th>
<th>Rationale and Comments on Activity</th>
<th>Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Are the items to be measured identified and the measurement objectives established?</td>
<td>Project Document Management (Established Measurement Objectives)</td>
<td>Key Performance Indicators (KPI) Document and Targets to be achieved established. Measurement Items logged and set up as templates in Process Database.</td>
<td>Configuration Manager (Preferred) / Project Manager</td>
<td>Planning</td>
<td>High</td>
<td>Before measuring anything, it is important to decide what to measure. The different Items that are identified to be requiring measurement is often driven by a motivation. Example: Improve Quality of Delivery by 40% Improve Quality of Testing of the Software by 80% Reduce Time to Deliver by 20% The measurement objectives which describe which Items needs to be observed and measured are identified ideally in a forum with SEPG members, Project Manager, Customer Representative/Business Manager and the Configuration Manager. It is imperative that the Customer Representative/Business Manager represents the customer’s interest in the identification of the different performance indicators for the Project.</td>
<td>All teams within Ground/Sea travel and services were asked to define KPI’s together with the Project Charter. This was positively received There was no Process Database set up for verification within the thesis.</td>
</tr>
<tr>
<td>2</td>
<td>Is the method of measurement for the Items established?</td>
<td>Project Document Management Process Database (Storage of measuring formulas)</td>
<td>Measurement &amp; Analysis (M&amp;A) realization document</td>
<td>Software Engineerin g Process Group</td>
<td>Planning</td>
<td>Medium</td>
<td>It is important to agree on how a measurement will be made and established. This is done by establishing formulae for the different measurement items identified in the KPI document. To ensure consistency in the measurement of the different objectives, SEPG will be ultimately responsible for setting up the formulas. Example of Measurement formulas corresponding to KPI:</td>
<td>A guide on how to measure each KPI, when to measure them was written by the process improvement department (SEPG)</td>
</tr>
<tr>
<td>#</td>
<td>Activities</td>
<td>Tools/Methodology</td>
<td>Typical Output</td>
<td>Responsibility</td>
<td>Stage</td>
<td>Priority</td>
<td>Rationale and Comments on Activity</td>
<td>Verification</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Quality of the Delivery (How : Number of Defects/Functionality) Quality of Testing (How : Defects detected during Development phase/ Total no. of defects) Reduce Time to Deliver (How: Weighted Functionality/Time to deliver)</td>
<td>This was done in one of the projects through Meeting Minutes where it was documented 1. How the collected data will be used 2. What will the different measurement values mean/indicate 3. Where the collected data will be recorded.</td>
</tr>
<tr>
<td>3</td>
<td>Are storage and analysis procedures for the collected data established and agreed?</td>
<td>Meetings</td>
<td>M &amp; A realization document</td>
<td>Configuration Manager (Preferred) / Project Manager</td>
<td>Execution</td>
<td>Medium</td>
<td>To ensure that storage and analysis procedures are agreed, the Configuration Manager makes sure that they are documented in the Measurement &amp; Analysis realization document and approved by the Project Manager.</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Are the data collected, analysed and follow up and check point meetings</td>
<td>Follow up and check point meetings</td>
<td>Process Database (storage of measurement data) aligned</td>
<td>Configuration Manager</td>
<td>Execution</td>
<td>High</td>
<td>Regular checkpoints to ensure that the collected data and analysis is in line with the requirements agreed in the KPI Document and the M&amp;A document ensures the quality of the data collection and analysis. Configuration Manager will take the responsibility for the result of the data</td>
<td>All the data collected must have a direct connection to the goals in the Project Charter and/or KPI.</td>
</tr>
<tr>
<td>#</td>
<td>Activitie s</td>
<td>Tools/Metho dology</td>
<td>Typical Output</td>
<td>Responsi bility</td>
<td>Stage</td>
<td>Prio rity</td>
<td>Rationale and Comments on Activity</td>
<td>Verification</td>
</tr>
<tr>
<td>---</td>
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<td>-------</td>
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<td>----------------------------------</td>
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</tr>
<tr>
<td></td>
<td>reported aligned to customer and Project objectives?</td>
<td>with the KPI document</td>
<td></td>
<td></td>
<td></td>
<td>collection and reporting.</td>
<td>This was added in the Meeting Minutes and stored.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>IN an ideal implementation, this is part of Process Database as mentioned under the column “Typical Output”.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Process database was not in place while performing verification.</td>
<td></td>
</tr>
</tbody>
</table>

Table 19: Checklist for compliance in Maturity level 2 for MA

9.3.8.2 Verification
Implementation of gaps in Measurement and Analysis in Ground/Sea Travel and services was part of the verification of the results as a proof of concept of the research work. Details on how each activity was verified is presented under Table 19: Checklist for compliance in Maturity level 2 for MA

Section 9.3 aimed at describing phase 1: Maturity level 2-implementation. This was also part of the proof of concept. The details on Phase 2, Phase 3 and Phase 4 implementation can be found under [42]
10 Discussion

This chapter aims at reviewing and reflecting on the thesis work and the results by the authors.

10.1 General reflection

This thesis has been one of the most fabulous research works that we have ever performed. To provide a solution for an international organisation with customers in all continents in the globe with several thousand employees in the travel industry domain was challenging, exciting and satisfying. The task was tremendously huge and we had to get into the details of several processes that GTDO follows today and all the 22 CMMI processes in detail to provide an incremental approach towards the implementation of CMMI 5 maturity level.

10.2 How we started, how we progressed

We started the thesis work with Task 1 specified under Figure 3: Thesis analysis/ deduction tasks and supporting tasks. After identifying the challenges faced in the different IT departments in GTDO, we worked on understanding the current quality methods followed in the different departments and we were positively surprised to find well-structured processes in some of the areas such as defining Technical Solution and Verification.

It was quite confusing in the beginning which model of CMMI we should apply and what is the difference they make. We did a pilot study on this subject and documented the findings under [45] and arrived at the conclusion of following a staged model or maturity model to incrementally appraise the organization to CMMI 5 maturity level. However, we were very ambitious and tried to reach beyond CMMI 5 maturity levels and chose some process areas for additional capability level appraisals as pictured under 9.1 CMMI Realization for GTDO – The Choice and approach. We later realized that the scope of such a work would become even bigger and complex. So we limited the scope to achieving the respective maturity levels with the additional capability levels identified as potential future work.

One of the most interesting tasks of the project was to perform the gap analysis between the GTDO’s current processes and the CMMI process areas and specific goals for each maturity level. Several interviews, workshops were conducted to collect information over a period of 1 year. By this time the project had broken the timelines that were initially set but we had to analyse a lot of details. Checklists, templates helped a lot in the workshops to discuss about more concrete aspects. Examples could be drawn from current active projects to make it more concrete. The gap analysis gave a solid result to work on. Activities that need to be performed were devised in the form of checklists. We also identified the preconditions before starting the implementation of CMMI 5 maturity level. This was the implementation of Process Database and Process Capability Baseline. We concluded that the implementation of PD and PCB was vital for all the activities since we could see the dependencies when analysing the CMMI for Development version 1.2 [2] [1] [3]. This was documented with the details under [41]
10.3 **Reflection on the way of conducting the research work**

Some of the major methods used in collecting information for the research work were

- Pilot study on different quality methods and their comparison.
- Study of quality processes in force in the GTDO.
- Interviews
- Workshops
- Proof of concept

We started with the pilot study on the different quality methods in software engineering, followed by the study of quality processes in force in the GTDO. Interviews were done in parallel to study of quality processes in the GTDO. We found that workshops were more effective approach once we had gained enough knowledge and understanding of the GTDO’s quality processes. When we could conduct workshops, it soon became very effective method to collect information and also a good platform to obtain feedback when we could present some of our results. The results that we produced by following each of the tasks are documented under *Figure 3: Thesis analysis/ deduction tasks and supporting tasks*

Applying self-criticality in this reflection, we could have also performed some site visits to similar organisations as that of GTDO which have taken the path of embracing CMMI and documented results as part of the pilot study. When it comes to the verification of proposed results (steps to CMMI 5 in different phases), we could have sent out questionnaire to the interviewed departments and received a subjective fulfilment score on the different process areas. Based on the score provided as feedback, optimized recommendations for future could have been provided as a complement. In our thesis instead of subjective feedback, we have followed a factual feedback, where the steps proposed under the results for phase 1 were followed and an overall judgement was provided by the stakeholders.
10.4 What we did well, what could have been done better

We had worked methodologically and systematically by performing the pilot study, trying to understand the current situation in GTDO, learning the current quality standards and processes in GTDO, performing gap analysis etc. We also received good guidance with respect to details from the process improvement responsible, our internal supervisor in the GTDO and our external supervisor in KTH. This also meant that we could present the results to the GTDO much quicker. The results were appreciated by the department managers in the GTDO and therefore were satisfying.

What we could have done better would have been to limit the scope of the project. This project became much bigger than what we initially thought of and planned for. On the other hand, it was quite difficult to draw boundaries when we were already in the middle of details. Project Scope Management and Project Time Management are certainly areas where we could have done better.
11 Conclusion

This chapter aims at concluding the Map to CMMI for GTDO research work by summarizing the different stages of analysis, results, implementation advice and future work.

The How to reach CMMI 5 for GTDO was a research project to devise a plan and methodology to be able to appraise the IT services and development of the GTDO to maturity level 5 in a phased and incremental approach. The research work started with introducing the user to the basic foundation concepts of CMMI and explaining the differences between the capability model and the maturity model. The maturity model is chosen for the implementation for GTDO.

A PMBOK methodology was followed in planning and executing the research work covering the relevant PMBOK disciplines that were applicable. The appraisal methods were discussed, the goals, scope, methodology followed by a technical analysis. In the Technical analysis part, the GTDO’s current situation, the process areas that are compliant with the CMMI process areas and the process areas that needed attention were identified. This is summarized under [40] and 8.3 Health of GTDO with respect to CMMI Maturity. The gap analysis is used as a basis for all the work documented under results. Each process area in CMMI is addressed with the ambition of appraising according to the CMMI maturity model appraisal. A total of 4 phases were recommended for the implementation of 22 CMMI process areas. The limitations, options available for further optimization and the activities that remained to be done for future is also assessed in the final chapters.

Note that the research work is applicable for the GTDO and its current maturity at the time of conducting this research. Even though parts of the report can be used for several other organisations in structuring, strategizing and organising the appraisal towards CMMI 5 maturity model; it cannot be applied into a different business without tailoring. In the case of the GTDO, the How to reach CMMI 5 for GTDO will provide a solid basis for implementation and successively appraising it to level 5 in a phased, controlled and sustainable manner with best practices forming the foundation.
12 Recommendations and Future Work

This chapter covers the recommendations from the authors while implementing and appraising the different CMMI maturity levels in the GTDO. It also highlights the limitations of the How to reach CMMI 5 for GTDO actions that can be taken to optimize the process and factors that needs to be taken into account for future work.

12.1 Limitations

1. When implementing the Process Capability Baseline as described in [41], the data that can be fed into the PCB will be limited to the data that is available from the previous projects in the form of Project Closure Reports and other metrics that Product Managers have maintained for their product. However, with time, when more data is provided as input into the PCB it starts acting as a much mature set of historical data which can be used in projects.

2. When implementing the different phases of CMMI 5 Maturity levels, departments need to be identified where the successive process improvement phases need to be concentrated on and “big-bang” approach to implementation is not recommended.

3. The checklists for each process area in the different phases of maturity level appraisal are based on the current gaps in the GTDO. Hence they need to be used to make sure that the organisation has reached that level but it also needs to be secured that the areas that are already compliant (as analysed under chapter [40] still remains compliant.

4. Cultural change and mind-set change for the employees and consultants alike is a very important part of the success of any change in the way of working. The focus should be on creation of business value and hence the different process areas are meant to create and add value to the business by ensuring and raising the quality of IT deliveries. This awareness needs to be provided to the co-workers so that they are all working towards the same goal. This is a political and social change together with process change and needs to be handled professionally. This report does not go into the details of how to achieve the people and culture part of the change involved in implementing CMMI 5 maturity level.

12.2 Options available for Optimization

1. Implementing the infrastructure recommended under [41] can be implemented as a separate project and could be also a first step before performing the implementation of Maturity level implementations in the different phases.

2. The gap analysis results could be published on the intranet for creating awareness among the employees regarding the areas the GTDO is already good at and those areas that need improvement. This could be circulated to a certain amount of time before the prerequisites for realization of CMMI 5 maturity is implemented.

3. It is also wise to list all the enhancements needed to be done to the existing tools and the new tools and methodologies needed to achieve the different maturity levels and perform a cost-assessment so that there is a budget estimated for each level of implementation.
4. A cost-benefit ratio needs to be prepared for reaching each Maturity level so that the release of funds to execute the project can be motivated against the benefits it can provide.

5. An economical method of implementation could be to implement the prerequisites identified under [41]. This can be followed by prioritising the process areas that have the least current compliance in the GTDO based on the health check in GTDO under chapter 8.3 Health of GTDO with respect to CMMI Maturity
## 12.3 Checklist of the results of the research and identified activities for the future

<table>
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<tr>
<th>#</th>
<th>Major activity</th>
<th>Complete (Yes/No)</th>
<th>Main reference</th>
</tr>
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<tr>
<td>1</td>
<td>Comparison of CMMI to similar standards and practices and their summarization</td>
<td>Yes</td>
<td>8.2 Comparison of CMM with ISO 9001:2000</td>
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<td>2</td>
<td>Definition of scope of the research project, entry and exit criteria</td>
<td>Yes</td>
<td>4 Scope</td>
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<tr>
<td>3</td>
<td>Performing Gap analysis of the GTDO’s processes against CMMI maturity levels</td>
<td>Yes</td>
<td>[40]</td>
</tr>
<tr>
<td>4</td>
<td>Measuring the compliance of GTDO and providing an insight on the health of GTDO</td>
<td>Yes</td>
<td>8.3 Health of GTDO with respect to CMMI Maturity</td>
</tr>
<tr>
<td>5</td>
<td>Devising the different phases of implementation for CMMI Maturity level 5 appraisal as solution</td>
<td>Yes</td>
<td>9 Results</td>
</tr>
<tr>
<td>6</td>
<td>Providing checklists for addressing the gaps and providing examples of templates and tools for implementing the different phases</td>
<td>Yes</td>
<td>9 Results Appendix A - Templates and Essential Elements</td>
</tr>
<tr>
<td>7</td>
<td>Performing Verification and Validation of the results of the research work</td>
<td>Yes</td>
<td>9.3.2.1 Checklist for bridging gap in Requirements Management</td>
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<tr>
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<td>(a) Through Verification in Ground/Sea Travel and services for Requirement Management and Measurement and Analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(b) Through Validation from process improvement department responsible</td>
<td></td>
<td>9.3.8.1 Checklist for bridging gap in Measurement and Analysis (MA)</td>
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<td></td>
<td></td>
<td></td>
<td>Validation was done by the process improvement department responsible who will be also leading the SEPG under the CMMI initiative.</td>
</tr>
<tr>
<td>7</td>
<td>Estimating the budget needed for performing the different Maturity level implementation in the different phases.</td>
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<td>Part of future work</td>
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<tr>
<td>8</td>
<td>Analysis of activities and strategies that needs to be implemented in different phases to secure the social and political aspect</td>
<td>No</td>
<td>Part of future work</td>
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regarding the change of mind-set and the way of working for the employees.

<table>
<thead>
<tr>
<th></th>
<th>The identified activities in the checklist for each phase needs to be implemented in a sustainable manner. If the order of implementation is made different, dependencies between the different process areas needs to be considered.</th>
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<th>Part of future work</th>
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<tr>
<td>9</td>
<td>There might be differences and developments in the business and IT infrastructure from the time the How to reach CMMI 5 for GTDO research work is delivered compared to when it will be implemented. Such changes need to be considered if they will have an impact on the implementation</td>
<td>No</td>
<td>Part of future work</td>
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<tr>
<td>10</td>
<td>Reach the additional capability levels in selected process areas as envisaged in the Figure 11: How to reach CMMI 5 and beyond: Phases of Implementation</td>
<td>No</td>
<td>Part of future work</td>
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</table>
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Additional material by the authors


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43. Shankar Gopinath, Mardin Nickrad (2014), Requirements Management in depth- Bridging gap for maturity level 2
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45. Shankar Gopinath, Mardin Nickrad (2014), Pilot Study – Capability and Maturity Levels Comparison

46. Shankar Gopinath, Mardin Nickrad (2014), Project Planning - Bridging gap for maturity level 2
## Appendix A - Templates and Essential Elements

<table>
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<tr>
<th>#</th>
<th>Req No</th>
<th>Has the SOR followed SOR Formulation Guidelines? (See table SOR Writing Guidelines in [42])</th>
<th>Does the SOR have all the Required Elements? (See Table 23: Essential Elements in SOR)</th>
<th>Is the Requirement Correct? If Not, State, the incorrectness (E.g. Wrong Classification)</th>
<th>Is the Requirement Consistent? If Not, state the requirement # that causes conflict.</th>
<th>Appropriate to Implement? If Not, State why</th>
<th>Is the requirement Complete? If Not State missing component</th>
<th>Is the requirement verifiable (testable)?</th>
<th>Is the requirement Clear and Unambiguous?</th>
<th>Is the requirement Inside Scope of responsibility of an Identifiable Team? (Specify Team)</th>
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</thead>
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</tbody>
</table>

*Table 20: SOR High Level Acceptance Guideline Evaluation*

<table>
<thead>
<tr>
<th>#</th>
<th>Page #</th>
<th>Include SOR High Level Acceptance Guideline Results table</th>
<th>Foreseen Limitations of implementing this requirement if present</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
</tbody>
</table>

*Table 21: SOR Review Template - Functional Analyst*

**SOR Review = SOR Review Template(Functional Analyst) + SOR Review Template(Customer) + Feasibility Study**

*Equation 1: Composition of an SOR Review*
Table 22: Essential Elements in Feasibility Study

### GENERIC SOR HISTORY INFORMATION

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<tr>
<th>#</th>
<th>Date of Release</th>
<th>Version No</th>
<th>Review Date</th>
<th>Reviewer</th>
<th>Approver</th>
<th>Short description of the change made</th>
</tr>
</thead>
</table>
| 1 | 12-09-2008       | 1.0        | 10-09-2008  | Mark Jones| Shankar Gopinath | Package Ticketing  
120TIK Ticket Status Requirement  
The Client Reference should always be the key to check the status of the ticket. |

### RATIONALE AND TRACKING OF SOR

<table>
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<tr>
<th>Req #</th>
<th>List all the versions in which this requirement number appeared before</th>
<th>Nature of Action (Addition/Deletion/Modification)</th>
<th>Rationale Behind Action (Justify)</th>
<th>Reference to SOW (Statement of Work) / from Client</th>
<th>Change Request Open regarding the subject</th>
<th>Nature of Action (Addition/Deletion/Modification)</th>
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<td>Change of Market Regulation requirement</td>
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### REQUIREMENTS CONTENTS

Table 23: Essential Elements in SOR
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<td>120TIK</td>
<td>UK Software Usability Watch Board</td>
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<td>High</td>
<td>RFP19458</td>
<td>Accreditation Requirement</td>
<td>CR78934</td>
<td>CP39483</td>
<td>None</td>
<td>Accreditation Req Doc stored at Link</td>
<td>None</td>
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<td>Active</td>
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<td>The Client Reference should be retrieved from the Ticket Acknowledge message receipt in checking for the Ticket Status</td>
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</table>

Table 24: Template for SOR upload into MultiApproach tool by Product Manager/Business Analyst
<table>
<thead>
<tr>
<th>ID</th>
<th>Req #</th>
<th>Current Version of SOR/List of all previous SOR versions where this requirement appeared</th>
<th>Overall Impact (High, Medium, Low)</th>
<th>Impact in the Development team of the product (Justify and specify sizing)</th>
<th>Impact in Other Teams (Specify Team Name and Impact) (Justify and specify sizing)</th>
<th>Impact on Current Commitments and tasks (Specify which Tasks will have a direct impact and which have a shift in dates)</th>
<th>CR#</th>
<th>Commitment (Team, Date and Minutes Document Version /Mail Confirmation with link to DB)</th>
<th>Client Approval (Specify Date of Approval)</th>
<th>Additional Comments (Specify the Logger Name)</th>
<th>Example</th>
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<td>UI1 0</td>
<td>Aris SORv1.3/ Aris-SORv1.0</td>
<td>Medium (27 if Linear) (37 if Queued)</td>
<td>UI Dev. Team needs to introduce a new page for accommodating the change to this requirement. Booking Engine needs to be connected to this page and will impact integration. The new page as stated in requirements must be supported with Flash Plug in player and Goggle Coordinates selection for choosing location and update the PNR at the same time. Has impact on other functionalities - 17 Person Days</td>
<td>UI Funct Analysts – Design of new page - 3 Person Days Update in Specifications - 3 Person Days Development - 15 Person Days Testing - 4 Person Days</td>
<td>Won’t be able to meet Functional Walkthrough deadline – Shift in date by mentioned sizing if performed linear. If U10 is to be performed at the end of Functional Walkthrough and prototyping of Solution, more rework will be required by extra 10 days. Cannot commit to satisfying U18 to U27 to function correctly in provided deadline if U10 takes precedence.</td>
<td>0263 7436</td>
<td>UI Dev. Team – Jean Paul Barter UI Funct Team – Shane Bond Booking Engine – Ravi Kumar Delivery Dates Renegotiated. Minutes070508_CR02637436.doc Link to DB provided</td>
<td>Yes 21-06-2008</td>
<td>This date affects the Accreditation date which is set up already with external party.</td>
<td></td>
</tr>
</tbody>
</table>

Table 25: Essential Elements in Impact Analysis with an example
Explanation of Terms in Table 25: Essential Elements in Impact Analysis
The Req No will follow SOR (Statement of Requirement) naming convention
The SOR will identify the different types of requirements through prefixes
UI10 – Requirement 10 under User Interface
BD10 – Business Domain Requirement corresponding to UI10
Aris – Name of the product
Funct analysis- Functional Analysis

Appeared first in SOR Version/ Current Version of SOR
This specifies the version of SOR first time this requirement was presented in a different form. The Current Version Number is also presented here.
No modification of Requirement numbering shall be allowed. When a particular requirement is de-scoped or removed, the rest of the requirements retain their numbering. Therefore a requirement cannot have a particular number in one version and another number in another version. This is specified under the SOR Preparation guideline under the table SOR Writing Guidelines in [42]

Overall Impact
This is described under equation 1 (Overall Impact Index Calculation) under [43]

Impact in the Development team of the product (Justify and specify sizing)
The impact of implementing this requirement in the Development team is documented and sizing specified here along with justification

Impact in Other Teams (Specify Team Name and Impact) (Justify and specify sizing)
When the requirement impacts other teams, their names and sizing is provided along with justification.

Impact on Current Commitments and tasks (Specify which Tasks will have a direct impact)
When implementing this requirement can impact another requirement which is currently under development (Other than shift in dates specified under (4) and (5), it has to be specified if performed Linear or if Queued)

Linear – When a Requirement is accommodated immediately into the software,
Queued – If Requirement is not implemented now, but at the end of rest of the requirements delivery
The Change Request the requirement is associated to is mentioned here

**Commitment**
The Team contact points who have provided their Commitments on performing this requirement is provided under this column. A database link is also provided

<table>
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<th>Inconsistency</th>
<th>Source of Inconsistency (Document, Person, Process etc.)</th>
<th>Affected Artefacts (Deliverables such as Test Plan, Deployment Procedures, Roll Out Strategy)</th>
<th>Corrective Action (Action required to address the inconsistency)</th>
<th>Responsible (Assigned Person)</th>
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*Table 26: Gap Analysis Report Template*
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<td>ABC783 Implementation Collection in Release XYZ 1.7.9</td>
<td>&lt;UName&gt;</td>
<td>TCK898 DeliveryPacket in Release XYZ 1.7.9</td>
<td>UT79380 &lt;UName&gt;</td>
<td>TCTKB10898 978 &lt;UName&gt;</td>
<td>None &lt;UName&gt;</td>
<td>08478923 [Master]</td>
<td>Active</td>
<td>IA9829 879.doc in DB Link</td>
</tr>
</tbody>
</table>

**Table 27: Requirement Traceability Matrix Populated by MultiApproach Tool**

**Note:**
The <UName> should be added by MultiApproach tool as it has information of which user logs in and who adds information.

Legend:
The Requirement Traceability Matrix is version controlled.

<table>
<thead>
<tr>
<th>#</th>
<th>Inconsistency Description</th>
<th>Reason/ Rationale</th>
<th>Affected Documents/ Deliverables</th>
<th>Action Initiated</th>
<th>References to Other Documents (E.g. Reference to Id in Requirements Traceability Matrix Id/Impact Analysis Item Id)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Deployment of Version 1.0 of Aristocratic Rail has been delayed to 2010 December</td>
<td>Quality Target has not been met. (Too many defects present in core functionalities)</td>
<td>Test Plan</td>
<td>Initiated action with Test Responsible</td>
<td>Requirement Traceability Matrix Version 5.2 (With System Test Cases Updated)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Deployment Plan</td>
<td>Updated (New version)</td>
<td>Deployment Plan V6.0</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Development Plan (For Fixing of bugs)</td>
<td>Escalated action with Developers and Functional Analysts.</td>
<td>--</td>
</tr>
</tbody>
</table>

*Table 28: Inconsistency - Corrective Action - Traceability Document*
<table>
<thead>
<tr>
<th>Test Case ID</th>
<th>Description of the test case</th>
<th>Test Steps</th>
<th>Precondition</th>
<th>Expected Result</th>
<th>Test Scripts ID</th>
<th>UC ID Reference</th>
<th>Req Traceability Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Case ID (A logical numbering system is recommended)</td>
<td>Steps that needs to be performed for this Use Case. (Note that this does not include Other Test Cases included under Preconditions)</td>
<td>Other Test Case IDs (Test Cases which needs to be executed prior to this test case in order to achieve expected result)</td>
<td>The result expected from the Test Case.</td>
<td>The list of different Test Case scripts which are made from the Test Case.</td>
<td>The reference to the Use Case that is tested against</td>
<td>The reference to the requirements traceability matrix.</td>
<td></td>
</tr>
</tbody>
</table>

Table 29: Test Plan Template

<table>
<thead>
<tr>
<th>#</th>
<th>Skill</th>
<th>Employees Matching Criteria</th>
<th>Currently Engaged in Project?, Project Id, Project Manager</th>
<th>Consultants Matching Criteria</th>
<th>Consultants Currently Engaged in Project?, Project Id, Project Manager</th>
<th>Training/Courses that can provide the skill</th>
<th>Demanding Project</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CMMI Expert Level</td>
<td>A</td>
<td>No, NA, NA</td>
<td>-</td>
<td>-</td>
<td>SEI CMMI Training</td>
<td>ABC Cruising</td>
</tr>
<tr>
<td></td>
<td></td>
<td>B</td>
<td>Yes, Dominican Rail, Samuel Johan</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Linux Server Advanced Expertise</td>
<td>E</td>
<td>No</td>
<td>Q</td>
<td>No</td>
<td>Advanced Linux Training for Unix Specialists</td>
<td>EFG Infrastructure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>H</td>
<td>Yes, Cloud Nine Airlines</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>J</td>
<td>Yes, Beech Airlines</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>K</td>
<td>Yes, Flotilla Cruise</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 30: Skill set worksheet
Aristocratic Rail Travel
Distribution Service with
features better than
competitors

ARISTOCATIC RAIL IMPLEMENTATION IN GTDO

Requirements and
Functionalities needed
according to Market Needs

Marketing Manager –
Aristocratic Rail

Aristocratic Rail Travel
Distribution Service with
features better than
competitors

External Service Company
providing rail booking data

Get the reference of
GTDO as a Customer
and increase
Customer Base

Provide Rail Data to
the GTDO and enable
booking of travel

Fast and efficient
booking system with
seamless integration
with relevant existing
systems

Ideas to integrate
Aristocratic Rail service with
other services to maximize
booking numbers

DISTRIBUTION SPECIALIST - GTDO

LEGEND

Expected input from the
Stakeholder into the project
Expected result from the
Project for a stakeholder

STAKEHOLDER MODEL EXAMPLE: ARISTOCRATIC RAIL

Figure 20: Example of a Stakeholder Model
<table>
<thead>
<tr>
<th>#</th>
<th>Functionality / Capability</th>
<th>Make</th>
<th>Buy</th>
<th>Reuse</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Match to desired Functionality/ Capability %</td>
<td>Cost in EUR</td>
<td>Match to desired Functionality/ Capability %</td>
<td>Cost in EUR</td>
</tr>
<tr>
<td>1</td>
<td>The functionality or capability desired is specified here. Example: Reservation Web Services for Rail to handle Ticket less travel</td>
<td>Maximum % of Match to the requested functionality that can be developed in house at reasonable cost</td>
<td>Cost of developing in-house</td>
<td>Maximum % of Match to the requested functionality that can be bought at reasonable cost</td>
</tr>
</tbody>
</table>

**Table 31: MBR Analysis Matrix**

**Legend:**

MBR Analysis – Make, Buy, Reuse analysis
<table>
<thead>
<tr>
<th>#</th>
<th>Area</th>
<th>Subject</th>
<th>Person responsible</th>
<th>Decision</th>
<th>Decision taken by</th>
<th>Date</th>
<th>Rationale and Parameters Used in decision making</th>
<th>Process Capability Baseline references</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The area of decision making is specified here</td>
<td>The actual issue is described here. It may be a question, a subject that needs investigation</td>
<td>The person assigned responsibility for investigation of the issue.</td>
<td>The decision that is actually made</td>
<td>Self-descriptive</td>
<td>Date</td>
<td>Rationale behind the decision</td>
<td>Reference to collected data in the Process Capability Baseline</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Design</td>
<td>Should there be a customized portal with standard functions or standard portal with customized functions or some other design for the customer log-in?</td>
<td>Fredric Mougin</td>
<td>Standard portal with standard functions with a maximum 2 customizations with documented consequences. Customizations need to be approved by Product management.</td>
<td>Julie Langart</td>
<td>2008-03-03</td>
<td>Complexity and high number of defects were discovered in another project in the Ferry sector where customized portals were built and tested.</td>
<td>Record 2787 (Links to record 2787 in the PCB Web view) The record 2787 describes the no. of defects for functional point Webb portal and also describes the defect detection rate.</td>
</tr>
</tbody>
</table>

*Table 32: Example of Decision Log with PCB reference*
## Appendix B – Major terms glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CMMI</strong></td>
<td>CMMI (Capability Maturity Model Integration) is an integrated framework of process and quality improvement which enables improving processes and quality procedures in selected product lines/departments in an organization or across the whole organisation by following a set of guided procedures. CMMI consists of quality procedures for sustained quality improvement with a major focus on Software Development and Systems Engineering. CMMI framework is developed and maintained by Carnegie Mellon University.</td>
</tr>
<tr>
<td><strong>GTDO</strong></td>
<td>Global Travel Distribution Organization. The organization where the Map to CMMI 5 research work was performed. The GTDO builds and maintain systems integrating core functionalities of booking related operations in Airlines, Rail, Cruise, Hotels, Cars and Ferry so as to provide a common platform to perform all travel booking related operations.</td>
</tr>
<tr>
<td><strong>LOE</strong></td>
<td>Level of Effort. A proposed classification of amount of work required to perform a task. The level of effort is divided into 5 different levels depending on the number of hours required to complete the task.</td>
</tr>
<tr>
<td>- 0-20 hours - Level 0</td>
<td></td>
</tr>
<tr>
<td>- 21-50 hours - Level 1</td>
<td></td>
</tr>
<tr>
<td>- 51-100 hours - Level 2</td>
<td></td>
</tr>
<tr>
<td>- 101-500 hours - Level 3</td>
<td></td>
</tr>
<tr>
<td>- 501-900 hours - Level 4</td>
<td></td>
</tr>
<tr>
<td>- 901-1300 hours - Level 5</td>
<td></td>
</tr>
<tr>
<td>- More than 1300 hours = Need to break down the task into smaller units.</td>
<td></td>
</tr>
<tr>
<td><strong>Multi Approach</strong></td>
<td>An in-house developed tool in the GTDO which handles the following:</td>
</tr>
<tr>
<td>- Defects in the form of PTR (Problem Tracking Records)</td>
<td></td>
</tr>
<tr>
<td>- Sub-activities to be performed to fix the PTR in the form of Tasks (Usually a part of a PTR)</td>
<td></td>
</tr>
<tr>
<td>- Performing a well-defined functionality such as adding a new customer through WO (Work Orders)</td>
<td></td>
</tr>
<tr>
<td>- Change Request (Any requirement should be associated to a CR. A CR can contain multiple requirements in it)</td>
<td></td>
</tr>
<tr>
<td>- Change Proposal (Optionally Created before a Change Request as a part of response for Request For Proposal)</td>
<td></td>
</tr>
<tr>
<td><strong>OPD</strong></td>
<td>Organisational Process Definition. OPD is a process area within CMMI which aims at advocating a usable set of organizational process assets, processes and work environment standards in independent and integrated teams. The ambition is to create organizational assets and making use of them in different projects across the organization.</td>
</tr>
<tr>
<td><strong>PCB</strong></td>
<td>Process Capability Baseline. A Process Capability Baseline is a baseline of critical parameters in a project that are presented through different reports or views to be able to make decisions based on past experience and results recorded in different projects.</td>
</tr>
</tbody>
</table>
### Process Database
A Process Database is a repository where the identified metrics are collected during the different phases of the project and fed into the Process Database at two different points:

(A) During Transition phase or Closure phase. This is when the Project is completed and is being transferred to Production.

(B) Checkpoints during Maintenance and subsequent Release projects of the Software produced from the Project.

### Project Document Management (PDB)
A system or a speciality for management of documents, their statuses and lifecycle within a project.

### Project Management Body of Knowledge (PMBOK)
A set of 10 different project management disciplines (viz. knowledge areas) which provides the framework for practicing project management. The different knowledge areas are the project management of Integration, Scope, Time, Cost, Quality, Human Resources, Procurement, Communication, Risk and Stakeholders.

### Project Monitoring and Control (PMC)
Project Monitoring and Control
 PMC is a process area within the CMMI framework whose purpose is to significantly improve the understanding of the progress of the project in such a way that corrective actions are taken when the project’s deliverables and performance deviates significantly from the plan.

### ReqTracer
A proposed view in MultiApproach tool (as part of the research work) to display the traceability of requirements.

### Standard CMMI Appraisal Method for Process Improvement (SCAMPI)
Standard CMMI Appraisal Method for Process Improvement
SCAMPI is the established appraisal method developed by SEI for appraising the organisation in the different levels according to the chosen CMMI model (staged model/maturity model and continuous/capability model).

### Software Engineering Process Group (SEPG)
Software Engineering Process Group.
SEPG is a department within the GTDO which is entrusted with the responsibility of defining and prioritising the process improvement activities, overseeing the implementation of process improvement and drive the process related changes in the organization to improve the quality of the delivered products and services to the customers.

### Statement of Requirements (SOR)
A formal document that states functional requirements and non-functional requirements for development of a software system.

### Statement of Work (SOW)
Statement of Work
An agreement between the two parties regarding the terms and conditions of an assignment such as scope of the project, financial compensation, time plan and penalties. SOW is usually signed before the start of work by a supplier in a project.

### Transaction Process Facility (TPF)
Transaction Process Facility
A large and powerful server with high-end processing and execution capabilities.

### Work Breakdown Structure (WBS)
Work Breakdown Structure
WBS is a decomposition of tasks structured in a hierarchy for usage in projects and to perform assignment to different resources.