# IMPROVEMENT OF GPRS INTERNATIONAL ROAMING PROCESS USING LEAN SIX SIGMA APPROACH

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A Thesis Submitted in Partial Fulfillment of the Requirements

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# การปรับปรุงกระบวนการให้บริการรับส่งข้อมูลข้ามแดนอัตโนมัติโดยวิธีการของลีนซิกซ์ซิกมา

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ระรินทิพย์ ศิริสุขโภคา : การปรับปรุงกระบวนการให้บริการรับส่งข้อมูลข้ามแดนอัตโนมัติโดยวิธีการของลีนซิกซ์ซิกมา. (IMPROVEMENT OF GPRS INTERNATIONAL ROAMING PROCESS USING LEAN SIX SIGMA APPROACH) อ. ที่ปรึกษาวิทยานิพนธ์หลัก : ผศ. ประเสริฐ อัครประถมพงศ์ , 132 หน้า.

งานวิจัยนี้มีวัตถุประสงค์เพื่อปรับปรุงกระบวนการให้บริการรับส่งข้อมูลข้ามแดนอัตโนมัติโดยวิธีการของลีนซิกซ์ซิกมา ตามขั้นตอนการพัฒนาโครงการ DMAIC โดยเน้นปรับลดระยะเวลาในการทำงานอย่างมีประสิทธิภาพในขั้นตอนการเปิดบริการใหม่ก่อนให้ลูกค้าใช้งานจริง ขอบข่ายของการวิจัยจะเน้นกระบวนการเปิดบริการข้ามแดนอัตโนมัติเฉพาะบริการรับส่งข้อมูลที่เป็นโครงข่าย GPRS (General Packet Radio Service) ตั้งแต่การเตรียมข้อมูลของส่วนงานธุรกิจระหว่างประเทศไปจนถึงการดำเนินงานในส่วนงานทางวิศวกรรม

การวิเคราะห์ผังงาน (Flow Chart Analysis) ,กระบวนการ SIPOC และ แผนภูมิการวิเคราะห์เหตุและผล (Cause and Effect diagram) ได้ถูกนำมาใช้ในการวิเคราะห์และระบุถึงปัญหาในกระบวนการเปิดบริการรับส่งข้อมูลข้ามแดนอัตโนมัติ จากการศึกษาพบว่าปัญหาหลักๆเกิดจาก คน วัสดุ และขั้นตอนการทำงานที่ไม่มีการวางแผนที่ดี ปัญหาเหล่านี้ทำให้เกิดปัญหาความล่าช้าในการเปิดให้บริการ รวมไปถึงการใช้ทรัพยากรอย่างไม่มีประสิทธิภาพ ซึ่งส่งผลกระทบต่อการสร้างโอกาสในการเพิ่มรายได้ของบริษัท และยังทำให้เกิดการเสียเปรียบคู่แข่งทางการค้าในเชิงธุรกิจอีกด้วย จากผลการวิเคราะห์นำไปสู่การจัดทำขั้นตอนมาตรฐานในการเปิดให้บริการรับส่งข้อมูลข้ามแดนอัตโนมัติเพื่อปรับลดระยะเวลาการทำงาน ขั้นตอนการทำงานของพนักงานให้มีประสิทธิภาพยิ่งขึ้น โดยการปรับปรุงนี้ได้ลดค่าเฉลี่ยระยะเวลาการทำงานจาก 203.6 วัน เป็น 84.6 วัน ซึ่งคิดเป็น 58.45%

ศูนย์ระดับภูมิภาคทางวิศวกรรมระบบการผลิต.....ลายมือชื่อนิสิต.....
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The purpose of this research is to improve GPRS International Roaming process by using Lean Six Sigma approach. The selected methodology of this research is DMAIC. It is applied to efficiently reduce the average set-up time before commercial launch to customer. The scope of this research covers only the International Roaming services in data communication network, namely GPRS from preparing documents by international business division to processing by engineering division.

Flow Chart analysis, SIPOC and Cause and Effect diagram are applied as quality tools for problem identification and analysis in pre-launch phase of GPRS International Roaming process. Based on the study, it is found that the main causes are from Man, Material, and Method which have inefficiency in planning and designing. These causes lead to the delay problem in launching new GPRS International Roaming service, and inefficient resource management. These problems led to losing opportunity to increase revenue of the company and low competition to competitors. With results of analysis, the new process of GPRS International Roaming service is conducted as a standard process to improve resource managements, especially time management. It can reduce the average set-up time from 203.6 days to 84.6 days which is 58.45% time reduction.

The Regional Centre for Manufacturing Systems Engineering....Student's Signature.....
Field of Study :...Engineering Management.....Advisor's Signature.....
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# CHAPTER I

# INTRODUCTION

## 1.1 Background of the Research

XYZ is a mobile service provider in Thailand. Nowadays, Thailand has had a rather strong competition market of wireless network services. There are five mobile operators playing in Thai telecom market, namely, Advanced Info Service PLC (AIS), TrueMove, Hutch, Thai Mobile, and Total Access communication PLC. (DTAC). XYZ's position in Thai mobile market today is as one of leading mobile operator. XYZ provides both voice and non-voice services with the main objective to drive the growth in the Thai Telecom market. The basic services of XYZ are voice, Short Message Service (SMS), Multimedia Message Service (MMS), and General Packet Radio Service (GPRS). In addition, International Roaming Service is a special service to allow XYZ's Customers call back home and connect the internet wherever they go in the world. Meanwhile, subscribers of roaming partners travel in Thailand can call back their home country and connect the internet by using XYZ's network.

Other operators which XYZ agrees to share revenue and benefit with are called roaming partners. The roaming partners are mobile service providers in own countries same as XYZ company providing mobile services in Thailand. After the concept of no barrier in communication combining to advances in telecom technology, the networks of many operators around the world are easily connected. So, the International Roaming service has been established after there are voices of customers regarding the requirements of using mobile services in everywhere. XYZ company has also received these requirements. Thus, XYZ has been finding chances in establishing connection between other mobile service providers to share benefits together. The XYZ company and each roaming partner have to get trials of own services before having commercial agreement. These tasks are in scopes of implementation phase and related to many units in the company. If commercial group of both mobile service providers accept in test results, agreement will be created. That service will be opened for customers. If there is no agreement, those services will be blocked. Subscribers of that operator are not

allowed to use voice, GPRS or SMS services via XYZ's networks. In the same manner, XYZ's customers are not allowed to temporarily use voice and non-voice, SMS, MMS and GPRS, services when they roam in other networks. Thus, the International Roaming service is the extra service to offer comfort in communication to their customers for traveling outside their own countries.

To achieve this concept, the process is one of the key success factors in providing services. Figure 1.1 shows organization chart; it is divided into five groups which are People group, Technology group, Commercial group, Customer group, and Financial group. All the services in XYZ company are initiated by the Commercial group including the International Roaming service. Technology group is the group of engineering team supporting in technique of telecom services.

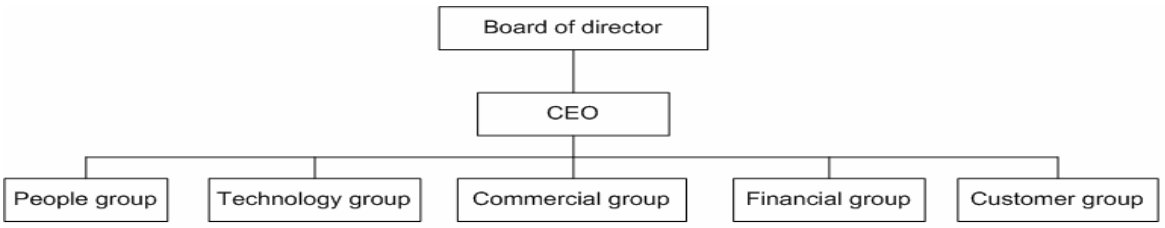



Figure 1.1: XYZ organization chart
(XYZ intranet, 2008)

## 1.2 Statement of the problem

As previously informed, the International Roaming service consists of voice, SMS, MMS and GPRS services. This service relates to International Business unit in the Commercial group and engineering teams in the Technology group which are DSN and IS teams. This research focuses on GPRS International Roaming service in the implementation period. The International Business unit sends the request form to the engineering team in every quarter. This request details list of target operator names which XYZ company needs to share benefit with. The related teams work on setting up their own systems in order to allow connection between network elements of that operator and XYZ company. If there is delay in some works in a team, the other tasks cannot be run. It not only consumed too much time and man powers, but also made

revenue loss in the International Roaming service by the cause of delay in time to market. XYZ company has lost opportunity for launching the International Roaming service with some big operators in the world for many times. Table 1.1 shows the statistic of actual implementation periods of launched operators in GPRS roaming service since 2006. The International Business unit sets 120 days as the target time frame for completion of the whole tasks in a quarter. However, the average of set-up period is 203 days calculated by the statistic during 2006 until July 2008.

| No. | Country | Network operator | Launched date | Set-up time (Both sites) (days) |
|---|---|---|---|---|
| 1 | Pakistan | Telenor Pakistan | 27-Jan-06 | 87 |
| 2 | United Kingdom | T-Mobile UK | 14-Feb-06 | 75 |
| 3 | Maldives | Wataniya Telecom Maldives | 08-Mar-06 | 154 |
| 4 | Austria | Hutchison 3G Austria | 07-Apr-06 | 75 |
| 5 | Finland | Elisa Corporation | 11-Apr-06 | 82 |
| 6 | Isle of Man | Manx Telecom | 12-Apr-06 | 209 |
| 7 | Australia | Hutchison 3G Australia | 19-Apr-06 | 60 |
| 8 | Iceland | Siminn/Iceland Telecom Ltd | 19-May-06 | 83 |
| 9 | Lithuania | Omnitel Lituania | 07-Jun-06 | 241 |
| 10 | France | Orange /France Telecom | 12-Jun-06 | 142 |
| 11 | Taiwan | VIBO Telecom | 04-Jul-06 | 322 |
| 12 | Indonesia | PT Telekomunikasi Selular | 07-Jul-06 | 134 |
| 13 | Ukraine | Astelit LLC | 20-Jul-06 | 375 |
| 14 | Bahrain | Bahrain Telecom | 31-Jul-06 | 381 |
| 15 | Pakistan | Warid Telecom | 04-Aug-06 | 104 |
| 16 | Denmark | Hi3G Denmark | 11-Aug-06 | 110 |
| 17 | Latvia | Tele2 Latvia | 11-Aug-06 | 401 |
| 18 | Qatar | Q-Tel | 15-Aug-06 | 384 |
| 19 | Cambodia | CamGSM | 19-Sep-06 | 103 |
| 20 | Korea | SK Telecom (3G) | 20-Sep-06 | 92 |
| 21 | South Africa | Vodacom | 10-Oct-06 | 392 |
| 22 | China | China Mobile | 18-Oct-06 | 57 |
| 23 | Turkey | Vodafone Telekomunikasyon | 09-Nov-06 | 131 |
| 24 | Bangladesh | Aktel | 30-Nov-06 | 65 |
| 25 | Bermuda | Mobility /M3 Wirelesss | 07-Dec-06 | 49 |
| 26 | Anguilla | Digicel Anguilla | 20-Dec-06 | 228 |
| 27 | Brazil | TNL PCS (Oi) | 20-Dec-06 | 62 |
| 28 | Cayman Island | Digicel Cayman | 20-Dec-06 | 98 |
| 29 | Dominican | Digicel Dominican | 20-Dec-06 | 267 |
| 30 | Grenada | Digicel Grenada | 20-Dec-06 | 263 |
| 31 | Haiti | Digicel Haiti | 20-Dec-06 | 278 |
| 32 | Jamaica | Digicel Jamaica | 20-Dec-06 | 97 |
| 33 | Moldova | Moldcell | 20-Dec-06 | 187 |
| 34 | St. Kitts & Nevis | Digicel St. Kitts | 20-Dec-06 | 234 |
| 35 | St. Lucia | Digicel St.Lucia | 20-Dec-06 | 241 |
| 36 | St. Vincent | Digicel St.Vincent | 20-Dec-06 | 237 |
| 37 | Turks & Caicos | Digicel Turks & Caicos | 20-Dec-06 | 242 |
| 38 | Saudi Arabia | Etihad Etisalat Company | 05-Apr-07 | 97 |
| 39 | Peru | Claro/TIM | 11-Apr-07 | 131 |
| 40 | Canada | Fido Solutions/Microcell | 03-May-07 | 210 |
| 41 | Canada | Rogers Wireless | 03-May-07 | 210 |
| 42 | Kazakhstan | Kar-Tel LLC | 24-May-07 | 154 |
| 43 | Sri Lanka | Mobitel | 05-Jun-07 | 207 |
| 44 | Croatia | Vip-Net | 27-Jun-07 | 237 |
| 45 | Trinidad & Tobago | Telecommunications Services of Trinidad and Tobago Limited | 11-Jul-07 | 241 |
| 46 | Brazil | Claro | 27-Sep-07 | 39 |
| 47 | Bulgaria | Cosmo Bulgaria Mobile | 07-Nov-07 | 365 |
| 48 | India | IDEA Cellular | 08-Nov-07 | 43 |
| 49 | Brunei | DataStream Technology | 04-Dec-07 | 64 |
| 50 | Congo | Vodacom Congo | 10-Apr-08 | 395 |
| 51 | Macau | SmarTone Mobile Communications | 10-Apr-08 | 130 |
| 52 | Cyprus | Cyprus Telecommunications | 21-Apr-08 | 545 |
| 53 | United Arab Emirates | Emirates Integrated Telecommunications | 26-May-08 | 236 |
| 54 | Vietnam | Viettel | 02-Jun-08 | 242 |
| 55 | Denmark | Telia Danmark | 01-Jul-08 | 470 |
| 56 | Saudi Arabia | AL JAWAL- Saudi Telecom Company | 07-Jul-08 | 422 |
| 57 | Vietnam | VMS Vietnam Mobile Telecommunication Services | 08-Jul-08 | 423 |

Table 1.1: Implementation days of GPRS service in each operator during 2006 and 2008

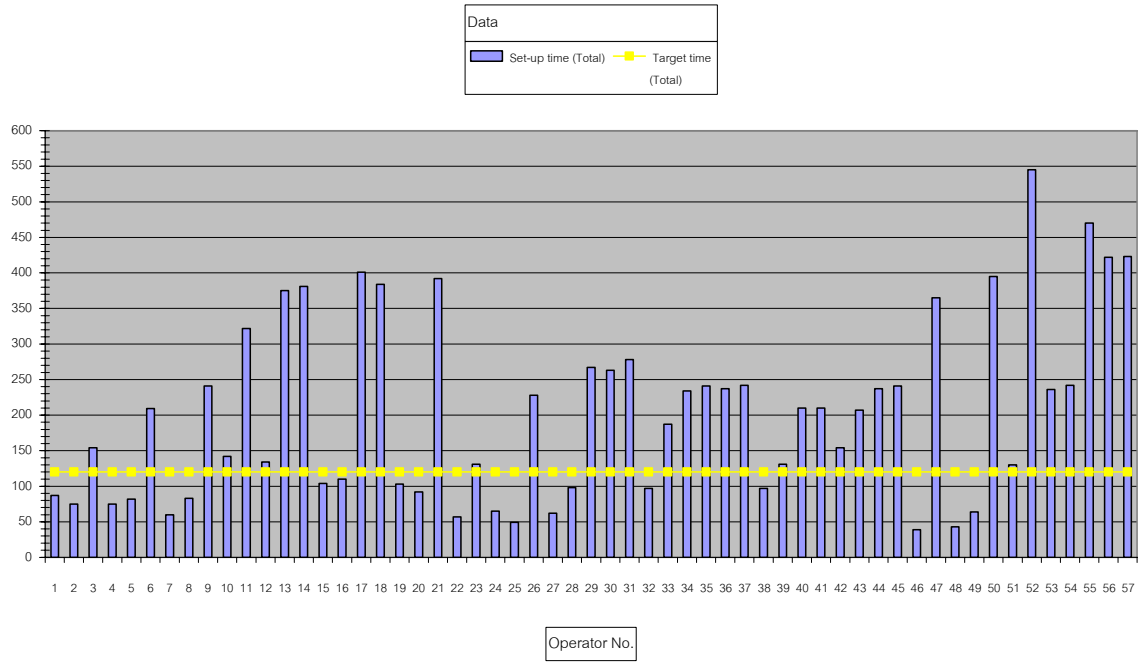



Figure 1.2: Actual implementation day of each operator comparing to the target set-up time, 120 days

Figure 1.2 shows actual implementation days for implementing and verifying GPRS service during the implementation period and target set-up time, 120 days, showing in line. Thus, the percentage of failure is 64.9% on average which is calculated from ratio of numbers of the operators that XYZ company cannot launch the GPRS service within the limitation of time, 120 days, and total requested operators. Presently, the International Business unit has set the target that they can launch GPRS service with other mobile service providers 10 operators per quarter. So, the target implementation time frame is 120 days for 10 operators after the request is opened until launching GPRS service. The variation of implementation time shows in Figure 1.3.

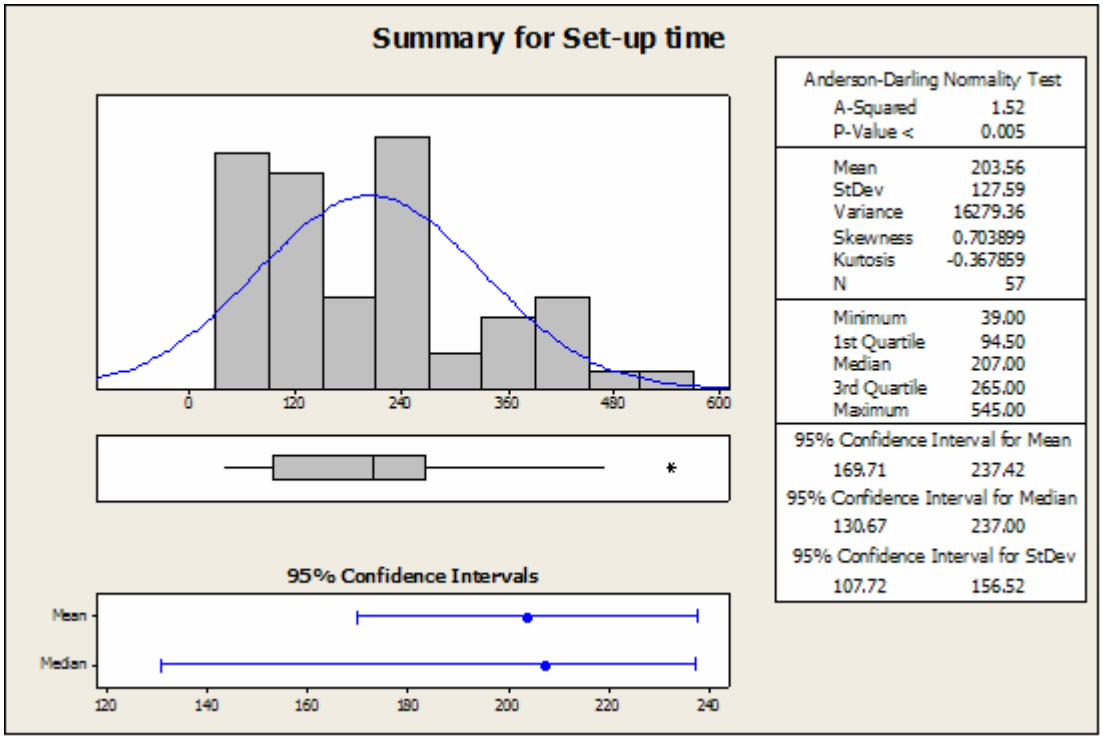



Figure 1.3: Summary for set-up time of implementing GPRS International Roaming 57 operators in XYZ company

Another waste which can be cost of doing nothing is working hours of each man power in terms of man hours. The related staff in XYZ company have lost their working hours in waiting period.

- International Business Unit ( 3 man powers )
    - Manager: 1 man power : 20-40% allocation a day for GPRS roaming service
    - Staff : 2 man powers :
        - Staff 1: 30-60% allocation a day for GPRS roaming service
        - Staff 2 : 10-25% allocation a day for GPRS roaming service
- Technology group ( 7 man powers for 3 teams )
        - Manager: 2 man powers : 15-20% allocation for GPRS roaming service
        - Staff : 5 man powers :

- 2 man powers in DSN team : 70-90% allocation for GPRS roaming service
- 2 man powers in IS team : 35-65% allocation for GPRS roaming service
- 1 man powers in Security team : 10-15% allocation for GPRS roaming service

Normal working hour is 8 hours per day. If total working day for a month is 20 days, the capacity of each staff is 480 man hours for a quarter. The utilization of each staff shows for implementing an operator in Table 1.2 based on assumption of 10 operators required per a quarter. The percentage of resource allocation for GPRS service is calculated from total tasks and weighting of each staff.

| No. | Resource | Max. Capacity/Quarter (man hours) | % allocation (min) | % allocation (max) | % allocation (average) | Utilization/Quarter (man hours) | Utilization / operator (man hours) |
|---|---|---|---|---|---|---|---|
| 1 | International Business manager | 480 | 20% | 40% | 30% | 144 | 14.4 |
| 2 | International Business staff #1 | 480 | 30% | 60% | 45% | 216 | 21.6 |
| 3 | International Business staff #2 | 480 | 10% | 25% | 18% | 84 | 8.4 |
| 4 | DSN manager | 480 | 15% | 20% | 18% | 84 | 8.4 |
| 5 | DSN staff #1 | 480 | 70% | 90% | 80% | 384 | 38.4 |
| 6 | DSN staff #2 | 480 | 70% | 90% | 80% | 384 | 38.4 |
| 7 | IS manager | 480 | 15% | 20% | 18% | 84 | 8.4 |
| 8 | IS staff #1 | 480 | 35% | 60% | 48% | 228 | 22.8 |
| 9 | IS staff #2 | 480 | 35% | 60% | 48% | 228 | 22.8 |
| 10 | Security staff #1 | 480 | 10% | 15% | 13% | 60 | 6 |

Table 1.2: Resource utilization

## 1.3 Objective of the Research

To reduce the average set-up time and variation of GPRS international roaming service.

## 1.4 Scope of the Research

This research focuses on improvement of internal GPRS International Roaming process in XYZ company. It includes only activities of International Business unit and Engineering planning units which are DSN, IS and Security units in the period of implementing GPRS service. The activities are from sending a job request form by

International Business unit to transferring task to operation support division by DSN unit. The activities responded by GRX provider and roaming partners are out of the scope of this research. The statistical data is based on quarter 1/ 2009 which has 10 operators.

## 1.5 Expected benefit

This research is expected to increase the opportunity for revenue increasing of GPRS International Roaming service. Moreover, it can be applied for other internal processes of XYZ company.

## 1.6 Methodology

The research methodology is applied the DMAIC methodology of Six Sigma as follows:

1. Study applied theories and other researches involving in this research such as ECRS, work flow analysis, process improvement, fish bone diagram, Why-Why tree diagram, How-How tree diagram, internal benchmarking, 7 waste reduction, lean six sigma, Poka-Yoke, Knowledge Management (KM), FMEA, and SPC.
2. Define the problems and process improvement goals that are consistent with company strategy especially in the GPRS roaming service by collecting historical data and current data from related teams in each process.
3. Measure data to identify the key measures and conclude the quantified evaluation of any given characteristics of operation based on the observed data which is separately collected in terms of internal set-up time and the whole set-up time.
4. Analyze the data to find the causes of problems by applying work flow analysis, man-hour capacity, fish bone diagram, Why-Why, and internal benchmarking/KM techniques.
5. Improve the whole GPRS International process by defining the potential solutions and evaluation.
6. Control the outputs after applying the selected solution by using Poka-Yoke technique.

7. Evaluate and conclude the results based on the initiate objective of the research.
8. Write up the research and submission.

## 1.7 Research schedule

| Procedure | 2008 | | | | 2009 | | | |
|---|---|---|---|---|---|---|---|---|
| | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr |
| 1. Study applied theories and other researches | | | | | | | | |
| 2. Define the problems and process improvement goals | | | | | | | | |
| 3. Measure data to identify the key measures | | | | | | | | |
| 4. Analyze the data to find the causes of problems | | | | | | | | |
| 5. Improve the whole GPRS International process | | | | | | | | |
| 6. Control the outputs after applying the selected solution | | | | | | | | |
| 7. Evaluate and conclude the results in terms of success rate and variation | | | | | | | | |
| 8. Write up the research and submission | | | | | | | | |

Table 1.3: Research schedule

# CHAPTER II

# THEORIES AND LETERATURE REVIEW

## 2.1 Lean Six Sigma

Lean Six Sigma (LSS) is the methodology for business transformation to improve business performance. It requires more than the projects. It takes transforming organizations to process-based and service-oriented organizations. Several authors describe that Lean Six Sigma is a powerful methodology which integrates between Lean and Six Sigma concepts. Lean focuses on elimination by flow, and Six Sigma focuses on quality problem solving by statistics. As lean does not make a process stable or under statistical control and Six Sigma does not improve the flow of information though a process, combination of Lean and Six Sigma should be the better way to make quality faster and the reduction in cost and complexity. So, Lean Six sigma focuses by speed of flow and quality.

Considering to Lean concept, there is a research in the topic “The integration of Lean management and Six Sigma” written by Arnheiter and Maleyeff (Arnheiter, D. E., Maleyeff, J., 2005) in the TQM Magazine Volume. 17 No.1, 2005. This research explains that Six Sigma was founded by Motorola Corporation and subsequently adopted by many US companies, including GE and Allied Signal. Lean Management originated at Toyota in Japan and has been implemented by many major US firms, including Danaher Corporation and Herley-Davidson.

As previously introduced, the concept of Lean Management can be traced to the Toyota Production System (TPS), a manufacturing philosophy pioneered by the Japanese Engineers Taiichi Ohno and Shigeo Shingo. The TPS is credited with being the birthplace of just-in-time (JIT) production methods which is key element of lean production. So, the TPS remains a model of excellence for advocates of lean management. Another side, Henry Ford achieves high throughput and low inventories, and practiced short-cycle manufacturing as early as the late 1910s. The traditional US production system was based on the batch-and-queue concept. It generates high production volumes, large batch sizes, and long non-value added queue times. Batch-

and-queue techniques developed from economy of scale principles which implicitly assumed that setup and changeover penalties make small batch sizes uneconomical. So, Lean Management emphasizes on small batch sizes and single-piece flow. Its goal is to eliminate waste, muda in Japanese. Efforts focused on the reduction of waste are followed through continuous improvement or kaizen events, as well as redical improvement activities, or kaikaku. Both of these reduce muda, although the term kaikaku is generally reserved for the initial rethinking of a process.

Moreover, element of Lean Management is the reduction of variability at every opportunity, including demand variability, manufacturing variability, and supplier variability. Manufacturing variability includes not only variation of production quality characteristics, but also variation of task time such as downtime, absenteeism, and operator skill levels. Lean Management attempts to reduce task time variation by establishing standardized work procedures. Quality management practices in lean production emphasize on the concept of zero quality control (ZQC). A ZQC system includes mistake proofing (poka-yoke), source inspection, normally use go-no go gages rather than more time consuming variable measurement methods.

There are many tools for achieving lean manufacturing published in “A business process change framework for examining lean manufacturing: a case study” written by Motwani (Motwani, J., 2003) in Industrial Management & Data Systems journal. These include:

- “Takt time
- Line balancing
- One-piece flow
- Self-directed terms
- U-shaped cells
- Constraint management
- Value stream mapping”

In addition, five initiatives that are necessary for a successful implementation of LM include: (Motwani, J., 2003)

- “Supplier programs
- Continuous improvement
- Flexibility

- Eliminate waste
- Zero defects”

On another hand of Six Sigma concept, the Business Process Management Journal, Volume 14 No. 13, 2008 publishes a research in topic “Lean, six sigma and lean sigma: fads or real process improvement methods?” written by Naslund (Naslund, D, 2008), working in University of North Florida, USA that purpose of Six Sigma is to reduce cost by reducing the variability in the processes which leads to decreased defects. Six Sigma is a method to improve capability and enhance process throughput. It is also hailed as a method to reduce waste, increase customer satisfaction, and improve financial results. By using statistical methods, organizations are able to understand fluctuations in a process. The Six Sigma methodology is based on DMAIC cycle. The author describes that it is difficult to identify what difference between Six Sigma and TQM if statistical process control was included in TQM. Both TQM and Six Sigma also rely on a plethora of tools. There are many quality tools exist that “ In her book, Tague (2005) discuss 148 different tools divided into six categories (project planning and implementing tools, idea creation, process analysis, data collection and analysis, cause analysis and finally evaluation and decision-making tools) with many tools belonging to more than one category. Some of the more commonly mentioned quality tools are often described as QC7 or the seven basic quality tools (McConnell, 1989; Bamford and Greatbanks, 2005; Tauge,2005) These are cause-and-effect diagrams (fishbone and ishikawa) control charts, check sheets, pareto charts and histogram, scatter diagrams and graphs or flow charts (McConnell, 1989; Koehler and Pankowski,1996; Dale and McQuater,1998).”

A sentence concluded by NasLund (Naslund, D, 2008) in Lean, six sigma and lean six sigma:fads or real process improvement methods research in Business Process Management Journal that Lean and Six Sigma essentially share same fundamental approach to change with JIT and TQM. George publishes in book “Lean Six Sigma Pocket toolbook” (George, M. L., Rowlands, D. T., Kastle, B., 2004) that Lean Six Sigma is new coming concept integrated Lean and Six Sigma. The foundations of below four keys to Lean Six Sigma as shown in Figure 2.1. It focuses on delighting customers and improving process. This case study has been successful due to participation of among the staff and management team as a team work.


Figure 2.1: Key to Lean Six Sigma
(George, M. L., Rowlands, D. T., Kastle, B., 2004)

## 2.2 Brainstorming

Brainstorming is a basic guideline for holding an idea-generating discussion. It is a process where an individual or team develops as many ideas concerning a topic as "They can use various creativity techniques or methods." (Munro, R. A.et al, 2007) The purpose of this activity is to provide a group with range of ideas in any topics. Why brainstorming is needed are:
(George, M. L. et. al, 2005)

- "Brainstorming produces many ideas or solutions in a short time.
- Brainstorming stimulates the creative thinking process.
- Brainstorming helps make sure that all group members' ideas are considered."

When to use brainstorming is whenever team want to make sure a range of ideas whether they should be considered. It includes:
(George, M. L. et. al, 2005)

- "Completing elements in a project charter.
- Identifying customers to include in research.
- Identifying potential causes to investigate.
- Identifying types of data to collect.

- Identifying solution ideas.

How to brainstorm, the steps are defined as:

- Review the problem definition
- Clarify everyone a few minutes of silence to think about the question and individually write down some ideas
- Gather ideas
- Consolidate similar ideas and discuss the complete set of ideas."

## 2.3 Deployment flowchart (Swim-lane flowchart)

The deployment flowchart emphasizes on the "who" in "who does what". This tool can make easily to study handoffs between people and/or work groups in a process. The deployment flowchart can be done step by step as:
(George, M. L. et. al, 2005)

1. Identify the different people or job functions involved in the process. Then, list them down from the left side or across the top of a flip chart or whiteboard.
2. Brainstorm the steps in the process and write them on self-stick notes.
3. Work through each step in order, placing the notes in the appropriate swim-lane.
4. Use the result to make discussions on how to improve workflow.

## 2.4 SIPOC

SIPOC represents Supplier, Input, Process, Output and Customer. SIPOC is a process snapshot that helps capturing the information critical to a project. Moreover, SIPOC helps teams verify that process inputs match outputs of the upstream processes and inputs/expectations of downstream processes. The steps of how to create SIPOC are: (George, M. L. et. al, 2005)

1. Identify process boundaries and key activities.
2. Identify the key outputs (Ys) and customers of those outputs
    - Brainstorming outputs and customers.
    - If you have a lot of different outputs and customers, focus on a critical few.
3. Identify inputs (Xs) and suppliers.
    - Brainstorming inputs and suppliers.

- If you have a lot of different inputs and suppliers, focus on a critical few.

4. Identify critical-to-quality requirements for the inputs, process steps, and outputs.
    - These critical-to-quality requirements have to be verified with data collection.

## 2.5 Workflow analysis

Work flow analysis or process mapping or process flow diagram. It is a structured system to improve or to understand a work process. One of the major advantages of constructing a work flow analysis (WFA) diagram is that one can identify and remove no-value-added activities to streamline the work flow into an effective and efficient operation. WFA identifies and eliminates unnecessary process steps by analyzing functions, activities, and tasks. (Stamatis, D.H., 2003)

The purpose of workflow detail is to:

(Kruchten, P., 2003)

- ‘Provide the natural transition from analysis activities to design activities, identifying.
    - Appropriate design elements from analysis elements and
    - Appropriate design mechanisms from related analysis mechanisms.
- Maintain the consistency and integrity of the architecture, ensuring that
    - New design elements identified for the current iteration are integrated with preexisting design element and
    - Maximal reuse of available components and design elements in achieved as early as possible in the design effort.
- Describe the organization of the system’s runtime and deployment architecture.
- Organize the implementation model to make the transition between design and implementation seamless.’

## 2.6 Fish bone diagram

Fish bone diagram or Cause-and-effect diagram or Ishikawa diagram is initially developed in the 1940s by Kaoru Ishikawa in Japan. Cause-and-effect diagram is a graphical analysis tool that allows the user to display the factors involved in a given situation. Cause-and-effect diagrams are drawn to visibly point up the a variety of causes (x) affecting the item being investigated. A good cause-and-effect diagram is one that fits the purpose, and there is no one exact form. These causes can be any item or occurrence that it related to the effect (Y) that is being studied. Thus, the effect of a situation is the result of the function of the causes [Y= f(x)]. Asking the five W's and one H (what, why, when, where, who, and how) can be effected in developing the elements of the cause-and-effect diagram. Besides using the five W's and one H in creating the cause-and-effect diagram, consider starting with the six M's:
(Munro, R. A.et al, 2007)

- Man (people/operator)
- Machine (equipment)
- Methods (operating procedures)
- Materials
- Measurement
- Mother Nature (environment)
- Money (optional, but an important consideration)
- Management (optional)

This tool is relatively simple to use and it is very powerful. Once it is completed, it is able to show graphically the factors of the system or process to management and other teams.

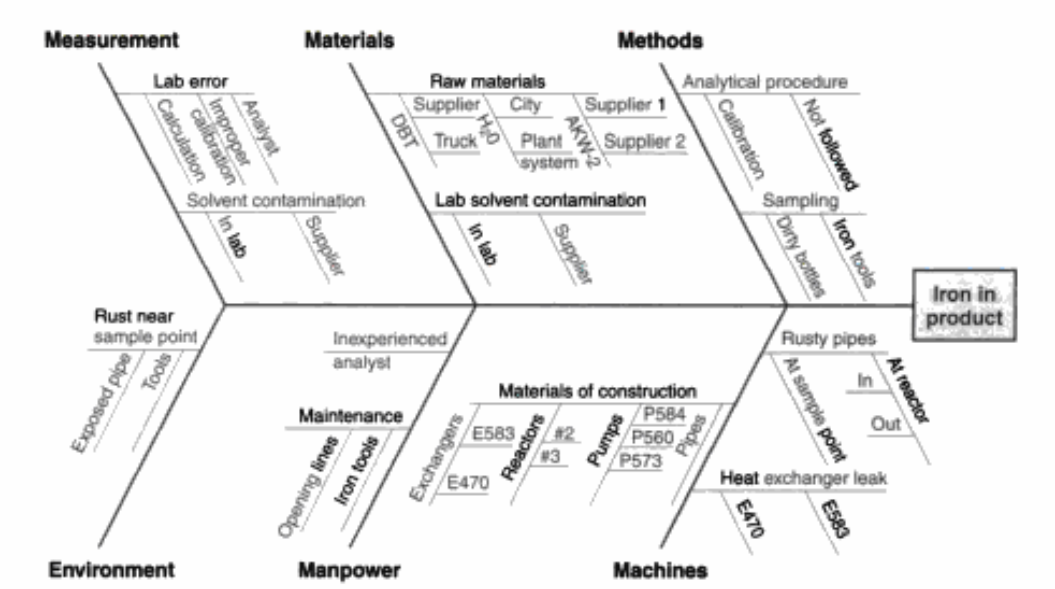



Figure 2.2: Example of cause-and-effect diagram
(Tague, N.R., 2005)

## 2.7 Five Whys Analysis

Five whys analysis is known as the why-why chart and root cause analysis. As these names imply, the purpose is to find the true root cause of a problem. The technique can very well be used in connection with a cause-and-effect chart to analyze each identified cause to ensure that it really is the root cause of the problem and not only a symptom of another and more deeply rooted cause. This can in fact be compared to peeling an onion, where each layer is removed to reveal another layer, until the center of the onion is reached.

The procedure for conducting the five whys analysis is as follows:

1. Determine the starting point, either a problem or a high-level cause that should be further analyzed.
2. Use brainstorming to find causes at the level below the starting point.
3. For each identified cause, pose the question, why is this a cause for the original problem?
4. For each new answer to the question, ask the question again and again until no new answers results. This will probably be one of the root causes of the

problem. As a rule of thumb, this often requires five rounds of the question why.

If the question is slightly altered to ask “how’ instead of “why”, the technique can be used to find the root means for reaching a desired state or effect. The analysis can be conducted in different ways. A graphically visible way of keeping track of the different levels of causes is listing them below one another, as shown in Figure 2.3. In this example, a manufacturing company is attempting to reduce the amount of work in progress. The result of analysis is that the key to reducing the work in progress is to develop good relationships with the suppliers. If this analysis had not been undertaken, the company might be led to believe that the answer was simply to remove the finished goods inventory, which could have serious consequences. Alternatively, a diagram might be used to portray and entire network of causes at different levels. The example of using five whys analysis is Figure 2.4.

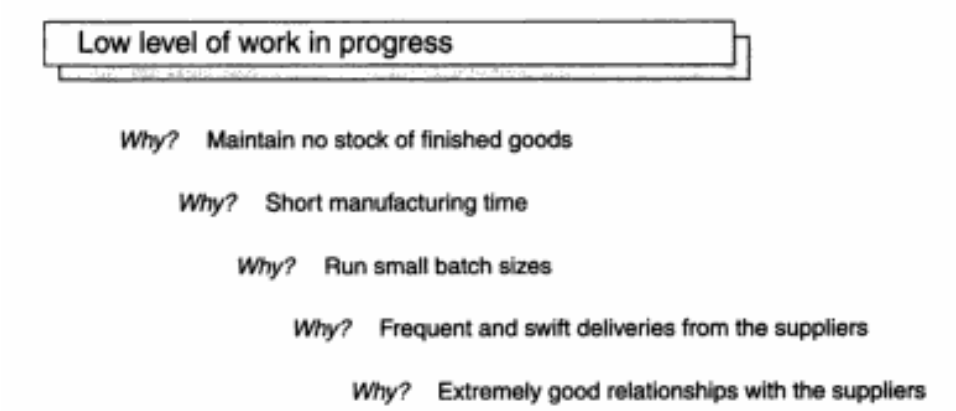



Figure 2.3: List representative of five why
(Andersen, B., 2007)

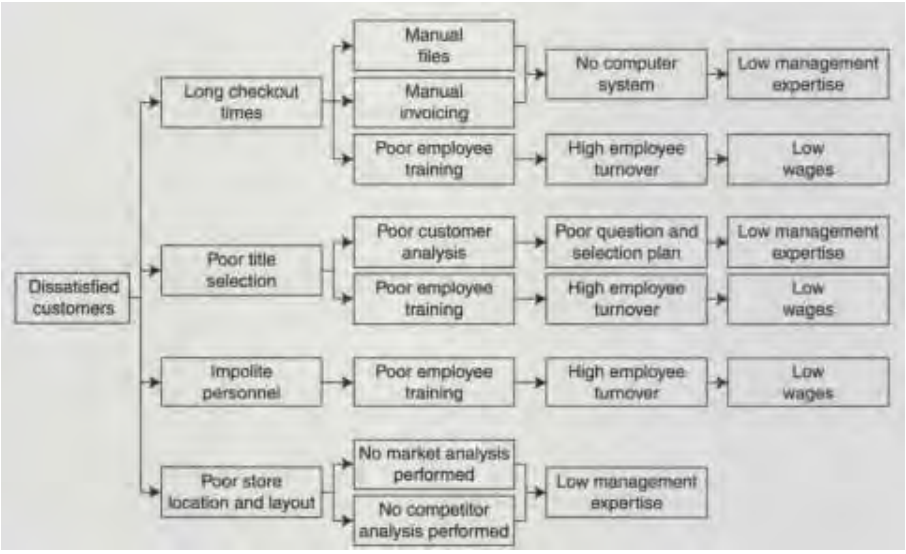



Figure 2.4: Example of five whys analysis chart
(Andersen, B., 2007)

## 2.8 How-How diagram

How-How diagram (Spenley, P., 1995) is a technique to creatively explore and consider numerous solution alternatives instead of jumping to the obvious solution. It helps members determine the specific steps that should be taken to implement a solution and hence formulate a specific action plan. The method is following. Figure 2.5 is an example of How-How diagram.

- Begin with a solution statement and explore possible ways of accomplishing the action at each stage by asking “how?”
- At each stage of the chain a convergent process can be used to narrow the list of alternatives before the next divergent step is taken.
- Advantages and disadvantages change of success, and relative cost of each alternative can be established to get a more objective selection process.

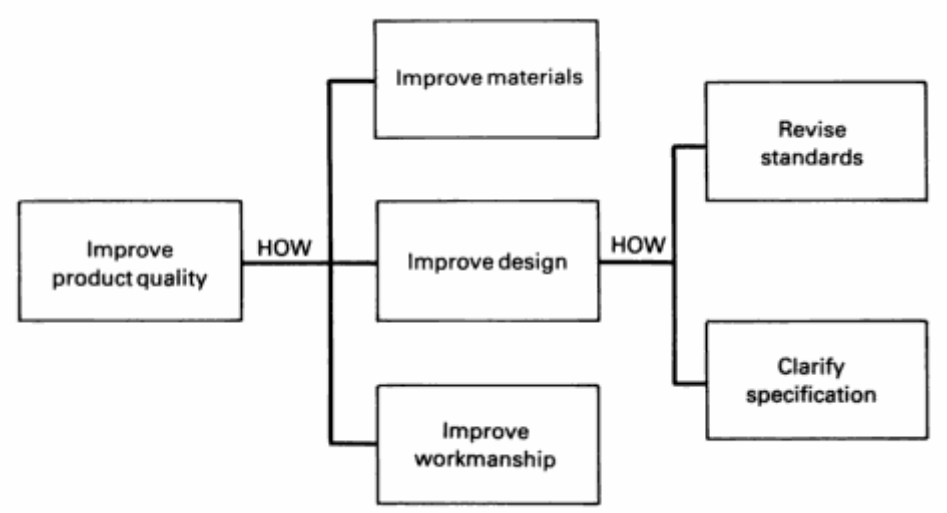



Figure 2.5: Example of How-How diagram
(Spenley, P., 1995)

## 2.9 Eliminate-Combine-Rearrange-Simplify (ECRS technique)

With the Equalized and Synchronized Production: The High-mix Manufacturing System that Moves Beyond JIT (Naruse, T., et al., 2003), the ECRS is detailed as the four steps for archiving the manufacturing process improvements that will renovate current manufacturing processes into a dream come true. The ECRS is and acronym that stands for Eliminate-Combine-Rearrange-Simplify. It is also used to describe the most common options to streamline processes (and eliminate waste). (Thompson, J., 1997) Figure 2.6 shows ECRS worksheet, for example.

ECRS Worksheet

| | Process Name: | Ideas or Observations |
|---|---|---|
| Eliminate | How much value added work results from this motion? | |
| | How can motions of searching, placing, arranging, selecting, be reduced through workplace organization & 5S? | |
| | How can tools and parts be arranged to make motion more natural? | |
| | How much work surface or work area is needed for the process? | |
| | What barriers can be removed to make motion safer and more natural? | |
| Combine | How can both hands be used effectively to perform this process? | |
| | How could another motion be performed simultaneously? | |
| | How can both hands work in smooth and natural motions without interference? | |
| | How could a spring mechanism be used to hold and position the part? | |
| | How could a lever mechanism be used to perform multiple tasks simultaneously? | |
| | What operations could be done on the return path of this process? | |
| | What other parts of the body could be used (feet, etc.)? | |
| Rearrange | What is the proper sequence of motions for better safety, efficiency, flow? | |
| | What changes in work sequence would improve the process? | |
| | What elements of motion could be rearranged to simplify them? | |
| | What are some other ways to perform the same process? | |
| | How could steps or motions be reduced by rearranging the workplace? | |
| | What other parts of the body could perform this same motion? | |
| | What would happen if the other hand was used instead (left instead of right, right instead of left) to perform this motion? | |
| Simplify | How can natural forces (gravity, inertia, reaction force, etc.) be used to simplify the motion? | |
| | How can multiple motions be simplified using special tools or devices? | |
| | What devices can be used to make rotating or turning motions easier? | |
| | What adjustments are needed to improve the working height and work posture? | |

Figure 2.6: ECRS worksheet
(GEMBA RESEARCH, 2003-2009)

## 2.10 DMAIC Methodology

DMAIC is a structured problem-solving methodology. It applies for improving speed, quality and cost. DMAIC stands for Define-Measure-Analyze-Improve-Control. (George, M. L., et al., 2005) These phases can lead a team logically from defining a problem through implementing solutions linked to underlying causes, and establishing the best practices to make sure the solutions stay in a good place. Furthermore, DMAIC can encourage creative thinking within boundaries such as keeping the basic process, product, or service. Each phase of DMAIC is detailed in Figure 2.7.


Figure 2.7: DMAIC methodology
(George M. L. et al., 2005)

### *2.10.1 Implementation Options for DMAIC*

There are two primary options for implementing DMAIC.
(George M. L. et al., 2005)

"1. Project-team-approach

- Black Belts deployed full-time to projects.
- Team members work on the project part-time which work on the project is interspersed with regular work.
- Full involvement by all team members in all phases of DMAIC.
- Duration can be one to four months depending on scope.

2. Kaizen approach

- Rapid (1 week or less), intense progress through all of DMAIC except full-scale implementation.
- Preparatory work on Define, and sometimes on Measure which is done by a subgroup. (team leader and a Black Belt, for instance)
- Rest of the work done by the full group during several days or a week when they work only on the project. (Participants are pulled off their regular jobs)"

### *2.10.2 Define (D)*

(George M. L. et al., 2005)

"Define phase is to have the team and its sponsor reach agreement on the scope, goals, and financial and performance targets for the project. Key steps in Define phase is showed in Figure 2.8.

- Review project charter
- Validate problem statement and goals
- Validate financial benefits
- Create/validate process map and scope
- Create communication plan
- Develop project plans
- Complete the Define gate review"

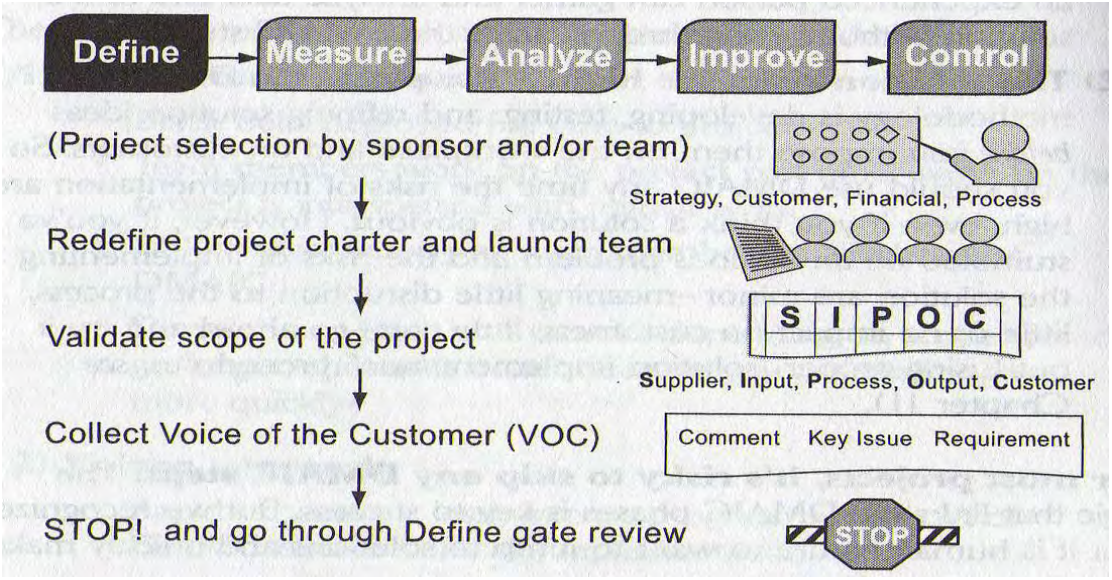



Figure 2.8: DMAIC: Define phase
(George M. L. et al., 2005)

### *2.10.3 Measure (M)*

(George M. L. et al., 2005)

"Measure phase is to thoroughly understand the current state of the process and collect reliable data on process speed, quality, and costs that you will use to expose the underlying causes of problems. Key steps in Measure phase is showed in Figure 2.9.

- Create/Validate a value steam map to confirm current process flow.
- Identify the outputs, inputs, and process variables relevant to project.
- Create a data collection plan including operational definitions for all measures.
- Create a data analysis plan.
- Use Measurement System Analysis and Gage R&R.
- Collect data to establish baselines.
- Update value steam map with data.
- Use Little's law to calculate lead time.
- Perform process capability evaluation.
- Make quick-hit improvements.
- Prepare for Measure gate review."

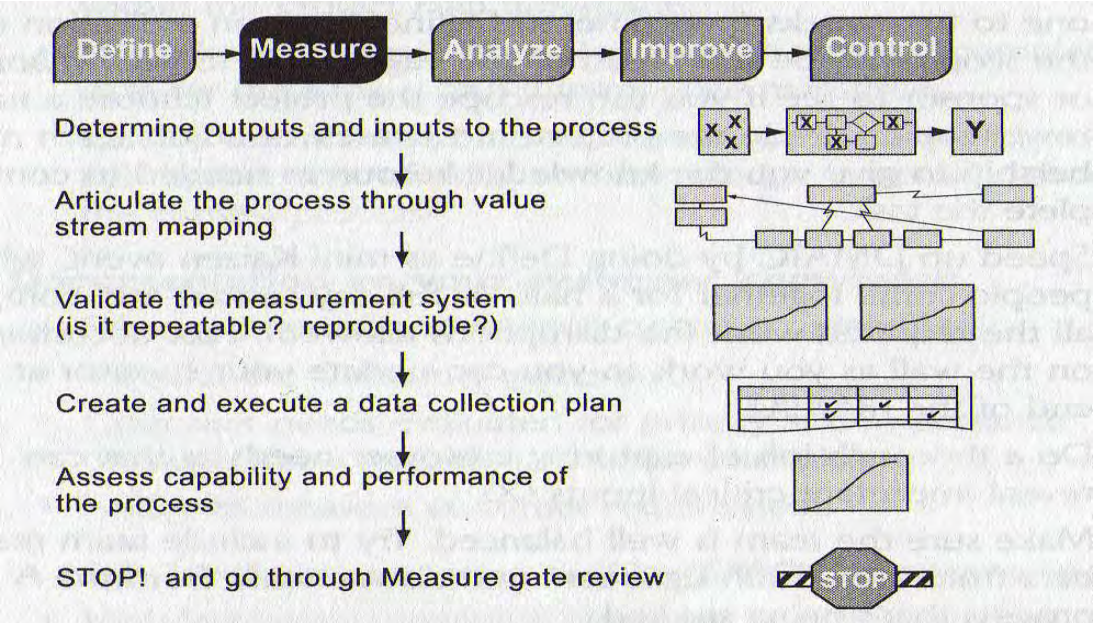



Figure 2.9: DMAIC: Measure phase
(George M. L. et al., 2005)

### *2.10.4 Analyze (A)*

(George M. L. et al., 2005)

"Analysis phase is to pinpoint and verify causes affecting the key input and output variables tied to project goals. Key steps in Analysis phase is showed in Figure 2.10.

- Conduct value analysis.
- Calculate Process Cycle Efficiency (PCE)
- Analysis the process flow.
- Analysis data collected in Measure.
- Generate theories to explain potential causes.
- Narrow the search.
- Collect additional data to verify root causes.
- Prepare for Analysis gate review."

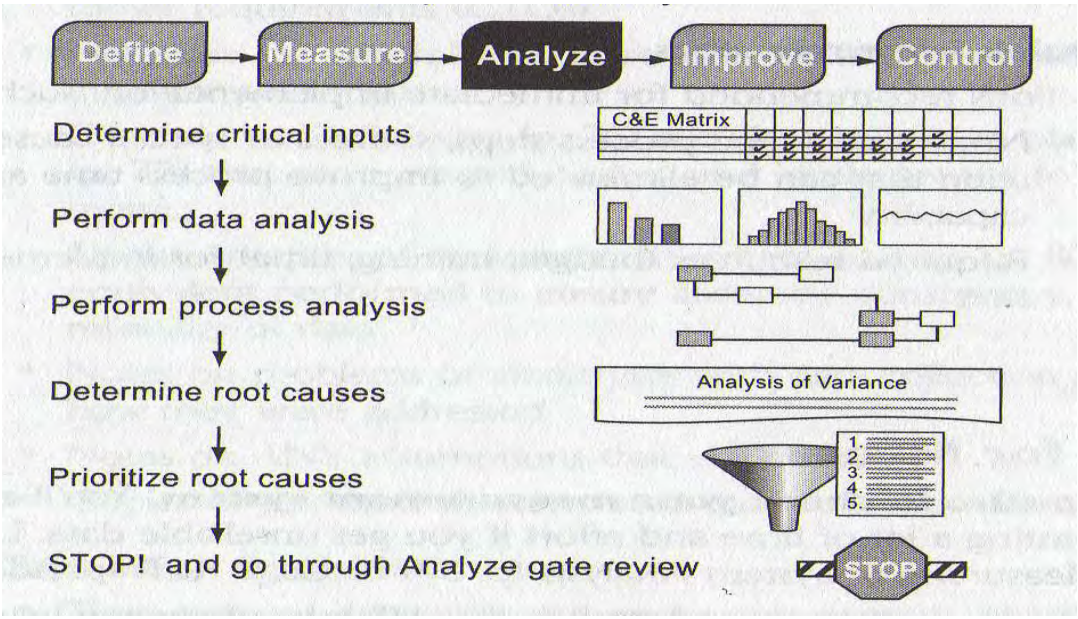



Figure 2.10: DMAIC: Analyze phase
(George M. L. et al., 2005)

### *2.10.5 Improve (I)*

(George M. L. et al., 2005)

'Improve phase is to learn from pilots of the selected solution and execute full-scale implementation. Key steps in Improve phase is showed in Figure 2.11. Develop potential solutions.

- Evaluate, select, and optimize best solutions.
- Develop "To Be" value steam map.
- Develop and implement pilot solution.
- Confirm attainment of project goals.
- Develop and execute full-scale implementation plan.
- Prepare for Improve gate review.'

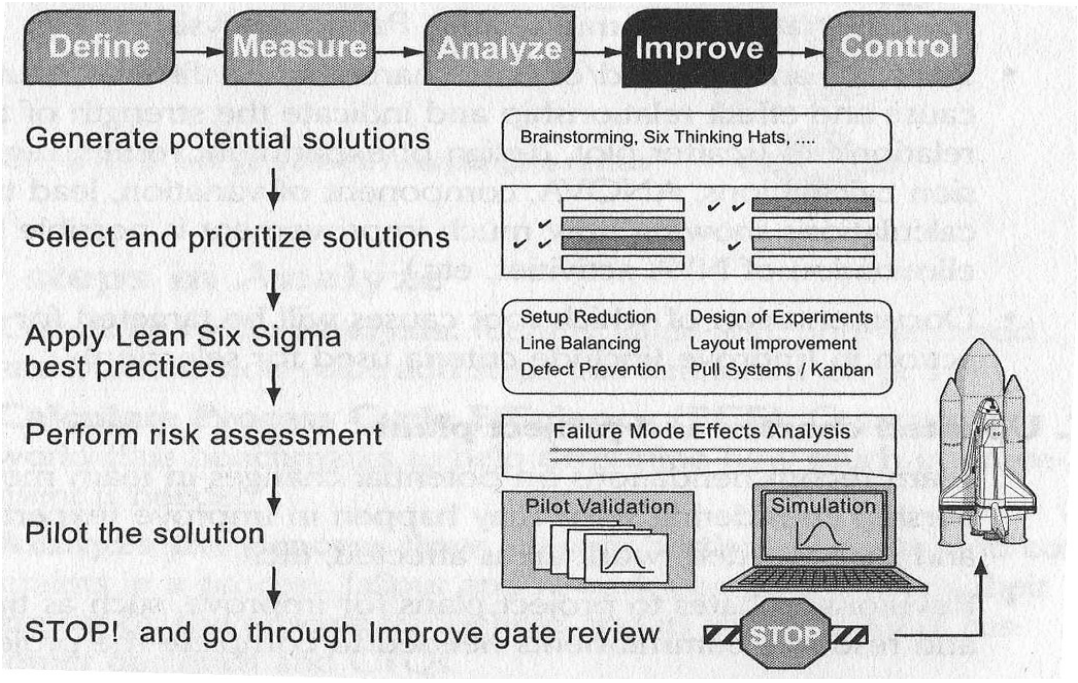



Figure 2.11: DMAIC: Improve phase
(George M. L. et al., 2005)

### *2.10.6 Control (C)*

(George M. L. et al., 2005)

"Control phase is to complete project work and hand off improved process to process owner, with procedures for maintaining the gains. Key steps in Control phase is in Figure 2.12. Develop supporting methods and documentation to sustain full-scale implementation.

- Launch implementation.
- Lock in performance gains.
- Monitor implementation.
- Develop Process Control Plans and hand off control to process owner.
- Audit the results.
- Finalize project.
- Validate performance."

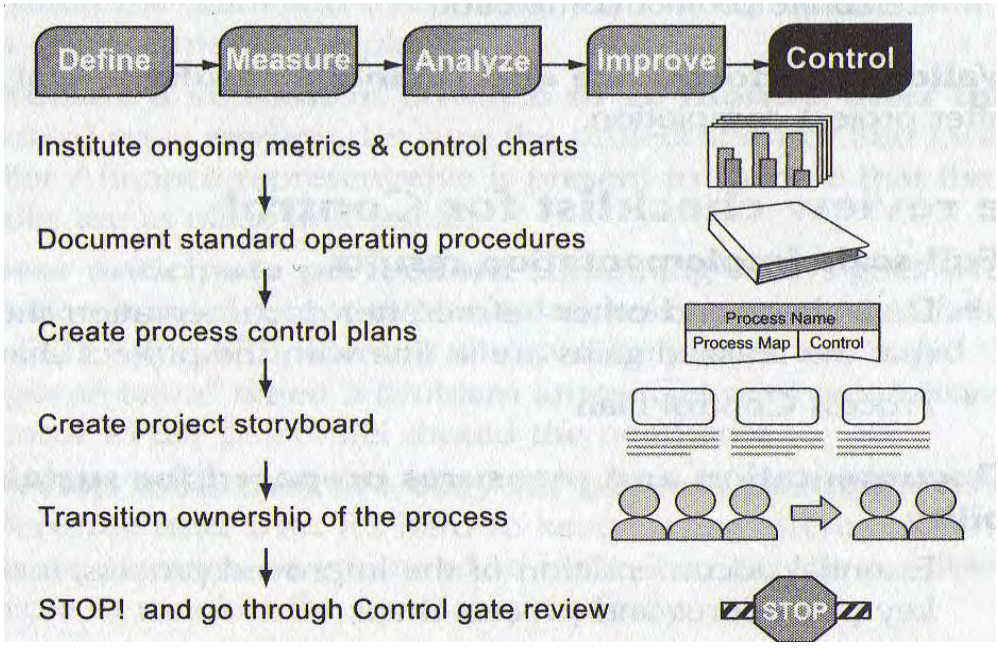



Figure 2.12: DMAIC: Control phase
(George M. L. et al., 2005)

## 2.11 Literature reviews

As previously introduced the Lean Six Sigma concept, the Lean Six Sigma can be applied to the service as George L. Michael publishes Lean Six Sigma for Service : How to Use Lean Speed and Six Sigma Quality to Improve Services and Transactions in year 2003 (George, M, L., 2003). This book explains that Lean Six Sigma for services is a business improvement methodology that can help maximize shareholder value by achieving the faster rate of improvement in customer satisfaction, cost, quality, process speed, and invested capital.

There is a paper regarding the basic concepts of Lean Six Sigma written by Beven, Westwood, Crowe, and O'Connor (Beven, H., et al., 2007) who work for Institute for Innovation and Improvement of Warwick University and NHS. The NHS is the English National Health Service, the largest healthcare system in the world. It is in the transformational change which needs to provide a health and healthcare service to meet the life-long needs of the citizens of England. They have tested a wide range of improvement strategies in their quest to create faster, more effective change. So, the Lean, Six Sigma and Lean Six Sigma are included. In conclusion, "the NHS has found Lean Six Sigma is a promising improvement methodology that incorporates the best of Lean and the best of Six Sigma. It is very rare that two approaches to enhancing value, eliminating waste and reduce variation can be used in a complementary rather than in a competing way. A pragmatic approach is required; use Lean and Six Sigma where necessary, or use Lean where Lean is necessary or Six Sigma where Six Sigma is necessary. Combining common sense (Lean) and common science (Six Sigma) offers the potential to achieve uncommon results." Figure 2.13 shows the relative strengths of the two approaches. The strength of Lean approach is getting higher from analyze phase to control phase. Meanwhile, the Six Sigma is getting higher from Define phase to Analyze phase. The conclusion from this paper regarding Lean, Six Sigma, and Lean Six Sigma is that "as Lean provides the strategy and creates the environment for improving flow and eliminating waste. Empowered staff are encouraged to continuously improve to create value adding opportunities that otherwise would not be identified. Six Sigma helps to quantify problems, makes evidence based decisions (this prevents wasting time on anecdotal evidence), helps to understand and reduce variation and identifies root causes of variation to find sustainable solutions. Furthermore, it

quantifies the financial benefits and savings. This helps to focus efforts in the areas that offer the most potential for improvement. A combination of both can provide the philosophy and the effective tools to solve problems and create rapid transformational improvement at lower cost. Potentially, this could increase productivity, improve quality, reduce costs, improve speed, create a safer environment for patients and staff and exceed customer expectations." Figure 2.14 shows the integrating the two improvement approaches.

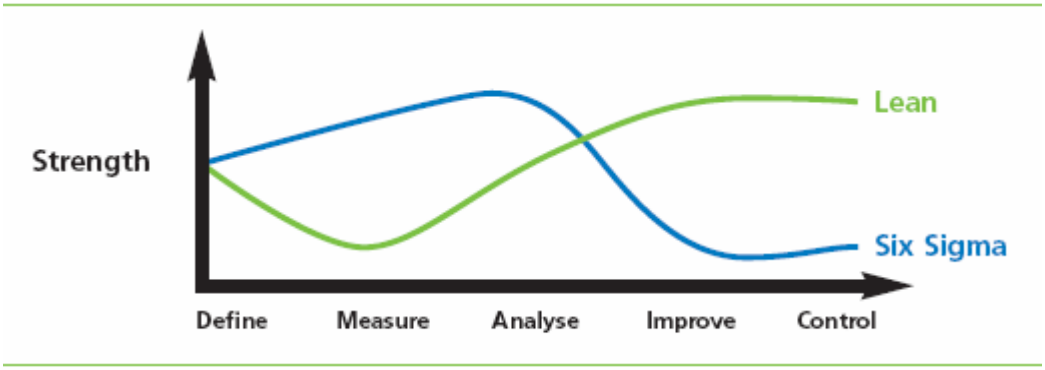



Figure 2.13: The relative strengths of the two approaches
(Beven, H., et al., 2007)

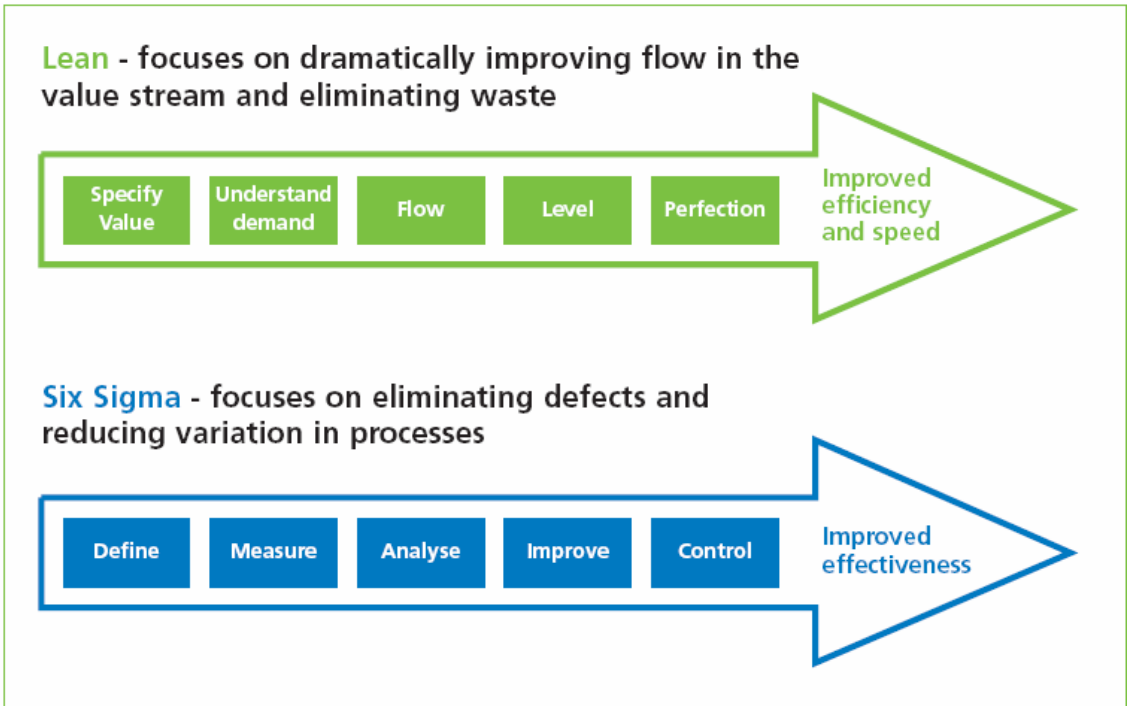



Figure 2.14: The integrating the two improvement approaches
(Beven, H., et al., 2007)

A case study shown in the book is in the Lockheed Martin company. Initially, Lockheed Martin (LM) in 1999 set a goal of eliminating $3.7 billion in costs. At that time, Lockheed Martin was a relatively young organization. It had been formed by a series of mergers and consolidations in the aerospace industry in 1995. There were almost 20 separate companies, cultures, and processes in Lockheed Martin. After Lockheed Martin developed a clear goal that they want Lean processes with 6δ capability by the concept of Lean Six Sigma. They have succeeded in their business. A few years since starting introducing Lean Six Sigma, they have had better financial statement. Their debt is down, revenues are healthy. Moreover, they have won the Joint Strike Fighter contract which has an estimated value of over $100 billion. Mike Joyce, a vice president at Lockheed Martin, has said his organizational effectiveness initiative is based on Lean Six Sigma.

Another case study applied Lean Six Sigma is published in iSix Sigma healthcare website which topic is “Creating a Lean Six Sigma Hospital Discharge process” written by Chuck and Rangel (Chuck ,D.B., Rangel, A. Jr., unknown). This project was to reduce the time between when a discharge order for a patient was entered into the computer and when the room was ready for the next patient of Valley Baptist Medical Center in Harlingen, Texas, USA. This project team led by a Black Belt included nursing staff, case managers, an information technology Green Belt, and the chief medical officer, a Green Belt. During the initial scope of this project, the team divided the process into four components:

1. From discharge order entry to discharge instructions signed.
2. From discharge instructions signed to patient leaving.
3. From patient leaving to room cleaned.
4. From room cleaned to discharge entered in the computer (thus indicating the bed was ready for another patient)

Due to the commitment to customer service, the team was asked to concentrate on the first two components. The goal was for this first sub-process to be completed in less than 45 minutes. Firstly, they used the Lean concepts, they revised the map by identifying rework steps, communication flows and staff movements and adding key metrics. After, they analyzed and improved and controlled their process. The results show that the from-discharge-order-entry-to-patient-leaving sub-process showed a

mean improvement of 74 percent with a 70 percent decrease in the standard deviation. The second sub-process, from patient-leaving-to-discharge-in-computer, showed an improvement of 90 percent in the mean and 58 percent in the standard deviation. The result is show in Figure 2.15.

| | From Discharge Order Entry to Patient Leaving<br>Upper Specification Limit: 45 Minutes | | From Patient Leaving to Discharge in Computer<br>Upper Specification Limit: 5 Minutes | |
|---|---|---|---|---|
| | Baseline | Current | Baseline | Current |
| Mean | 184.8 | 47.8 | 36.6 | 3.47 |
| St.Dev. | 128.7 | 37.2 | 36.1 | 16.9 |
| Yield | 6.9% | 61.7% | 24.6% | 95.4% |

Figure 2.15: Summary of process improvement after applied Lean Six Sigma to Hospital discharge process
(Chuck ,D.B., Rangel, A. Jr., unknown)

With the literature review for lean concept, a case study is in healthcare described in Improving Healthcare Using Toyota Lean Production Methods written by Robert. This book presents a simple recipe of 46 lean steps for healthcare providers to reduce cost and improve quality. The healthcare providers can adopt the same lean methods that have enabled companies like Toyota to become so successful. This book presents the advice of lean advocates and quality experts such as W. Edwards Deming, Peter Drucker, Joseph Juran, Philip Crosby, Taiichi Ohno, Shigeo Shingo, Iwao Kobayashi, James Womack, Don Berwick, and author who has 30 years of experience with process improvement in healthcare. “The 46 steps are: (Chalice, R., 2007)

1. Define value from the perspective of the patient. (customer)
2. Map the patient’s value stream.
3. Walk through all your core processes, and observe how they work in detail.
4. Implement Toyota-style lean production.
5. Train administrators, managers, and supervisors to be lean leaders.
6. Provide empathetic ‘change management” to ease the transition to lean.
7. Change the name “quality improvement manual” to “quality and cost improvement department”.

8. Change the name “quality improvement manual” to “quality and cost improvement manual”
9. Educate every employee about the basic strategic plan of the organization.
10. Establish an improvement plan with goals to be accomplished by specific people and dates.
11. Implement a simple scorecard for the entire healthcare organization.
12. Use a simple scorecard to monitor each department.
13. The board of directors initiates selected strategic quality and cost improvement goals.
14. Publish an annual quality report for simultaneous review with the annual financial report.
15. Create a rapid improvement team (RIT) to make quick cost and quality improvements.
16. Encourage RIT members to implement Toyota-style work teams.
17. Implement rapid improvement circles of employees. (RICs)
18. Implement a permanent organizational structure for quality and cost improvement.
19. Set a goal for each RIC member to produce one to four new suggestions per month.
20. Have a clear reward and recognition program, and communicate negative consequences.
21. Adopt and teach continuous improvement to as many people as possible in the organization.
22. The rapid improvement team quickly implements a 5S program.
23. Identify unnecessary items using red tags.
24. Promote visual control throughout the workplace and organization.
25. Eliminate all forms of waste.
26. Reduce specific examples of potential waste.
27. Sequence work and standardize it.
28. Eliminate bottlenecks to improve continuous flow.
29. Document all important processes in the organization or department.
30. Implement and maintain continuous improvement.
31. Consider radical improvement where appropriate.

32. Videotape each step of entire work processes.
33. Use flowcharts to improve core processes.
34. Use spaghetti diagrams to trace the path of a patient, employee, or product.
35. Measure process cycle times.
36. Implement quick changeovers within a process.
37. Complement nursing care delivery models with lean.
38. Challenge and work with your extended network of suppliers and partners.
39. Automatic processes to further improve quality and cost.
40. Learn from benchmark nonhealthcare organizations.
41. Learn from other benchmark healthcare organization.
42. Learn from the institute for healthcare improvement.
43. Hold on to the gains you've archived.
44. Reduce administrative overhead costs.
45. Avoid insurance company overhead costs.
46. Take a total systems view of healthcare for lean improvement."

These steps would provide the product meaningful cost and quality improvement, achieve strategic advantage, quell growing business and public clamoring about healthcare costs, earn greater prestige, generate greater profit, provide funds for uninsured intervention, cost control and nationalized healthcare, and better use increasingly scarce healthcare workers.

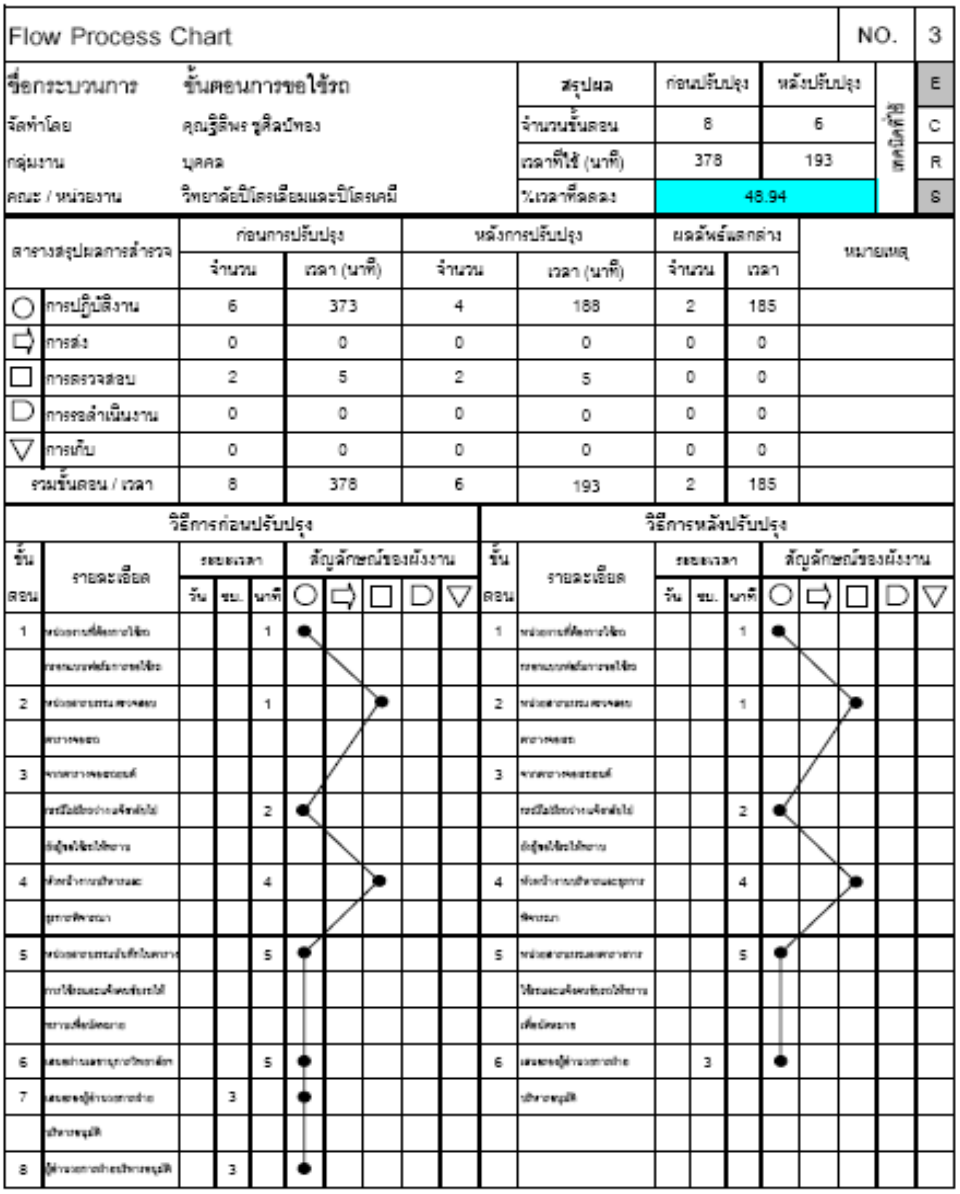
With After Lean Production book written by Thomas, Russell and Macduffie (Thomas, K. A., Russell, L. D., Macduffie, P. J. (ed), 1997), a part of this book exemplified the lean production methods by Japanese automakers which are Mazda and Toyota. The key element affecting plant performance has been management by objectives by division. At Mazda, a significant index for implementing such management has been cost; at Toyota, it has been efficiency. Mazda sets and allocates per-car cost targets for each subsection within its plants. The semiannual results of subsections and larger units of organization are identified by comparing actual costs with cost targets and are expressed as lack or extremes Costs and results are compared with the targets every month at the section, department, and plant levels. The monthly report meeting is an occasion to exert considerable control over line managers, including subsections. The achievements of each division are directly reflected in the performance evaluations of section managers and their superiors. Individual evaluations

of workers are also indirectly affected by the results of cost performance. If a subsection's costs are above the cost target, it is unlikely that the individuals in the subsection will receive favorable performance evaluations. Toyota's management by division is essentially the same. Whereas Mazda uses a monetary index of costs per car in monitoring performance, Toyota uses two indexes simultaneously which are production efficiency and costs for each section within a plant. Production efficiency is standard time multiplied by the volume of production, the results being divided by total works hours. The production efficiency results of each section are circulated among all departments and sections every month and attract strong interest from line managers. Efficiency meetings and cost meetings are held systematically at company, plant, department, and section levels, and progress with respect to objectives is monitored monthly. The processes at section and lower levels are the same at Mazda.

With the literature review for six sigma concept, there is a Master thesis written by Yamolyong. (Yamolyong, S., 2007) This thesis uses the six sigma philosophy to be a road map for implementation. The DMAIC and DMADV methodologies are the guideline for improvement. The first phase, define phase is used to find out the root cause of high scrap cost per unit problem. The Pareto and process flow are applied. The secondary phase, measure phase, the Fused Biconic Taper Coupler is broken down in details by concept of measure phase. To reduce the scrap of fiber, draw process is the main point that needs to be improved. The piece of fiber which is torn for accurate length, specification is collected for process capability calculation. The result shows that the existing draw process has low process capability. Thus, to improve product reliability with higher cost, the draw process capability needs to be improved. The mind mapping is applied to list the factors in draw process. Next, analyze phase, they have found that to take a simple action following the mind mapping makes the new problem in the opposite site. So, they change the design new draw process to DMADV model. In design phase, the new feeding machine is designed to prevent human error problem and improve process capability of draw process. The concept to design feeding machine is applied by Kano model and QFD. They use the information both internal and external to make this project shift to the exciting quality in Kano model. Reducing excess usage in draw process, the feature of machine can help to improve inventory management. The verify phase, this phase is applied to confirm the capability or efficiency of the machine before full implementing in the production line. To verify the

machine, some parameters in technical term need to be proved by standard quality procedure and statistical testing. Finally, the control phase, the feeding machine can improve the draw process capability. It can reduce fiber scrap from more accurate length about 97% from manual. Expected reduce scrap cost per unit after full implementation is 20% reduction. In conclusion, this improvement project is proposed to customer and they receive the good feedback from customer. Thus, the six sigma can provide the real time continuous improvement if they can adopt it to suitable project to company.

A case applied ECRS technique by a good practice from www.cu-gp.chula.ac.th (Quality assurance Chulongkorn university, 2008), as topic “Rearrangement of process and cycle time for using cars in faculty of the Petroleum and Petrochemical college, Chulalongkorn University”. The results show that the procedure has been reduced from 8 steps to 6 steps. Moreover, the cycle time has been reduced from 6 hours and 18 minutes to 3 hours 13 minutes. The percentage of reduced time is 48.94 %. The applied techniques based on ECRS that they used are Eliminate and Simplify. Figure 2.16 shows flow process chart which is applied for data analysis of both before and after improvement with eliminate and simplify techniques.



Flow Process Chart — NO. 3

| | | สรุปผล | ก่อนปรับปรุง | หลังปรับปรุง | เทคนิคที่ใช้ |
|---|---|---|---|---|---|
| ชื่อกระบวนการ | ขั้นตอนการขอใช้รถ | จำนวนขั้นตอน | 8 | 6 | E |
| จัดทำโดย | คุณฐิติพร ชูศิลป์พงษ์ | เวลาที่ใช้ (นาที) | 378 | 193 | C |
| กลุ่มงาน | บุคคล | %เวลาที่ลดลง | 48.94 | | R |
| คณะ / หน่วยงาน | วิทยาลัยปิโตรเลียมและปิโตรเคมี | | | | S |

| ตารางสรุปผลการสำรวจ | ก่อนการปรับปรุง | | หลังการปรับปรุง | | ผลลัพธ์ผลกล่าง | | หมายเหตุ |
|---|---|---|---|---|---|---|---|
| | จำนวน | เวลา (นาที) | จำนวน | เวลา (นาที) | จำนวน | เวลา | |
| การปฏิบัติงาน | 6 | 373 | 4 | 188 | 2 | 185 | |
| การส่ง | 0 | 0 | 0 | 0 | 0 | 0 | |
| การตรวจสอบ | 2 | 5 | 2 | 5 | 0 | 0 | |
| การรอดำเนินงาน | 0 | 0 | 0 | 0 | 0 | 0 | |
| การเก็บ | 0 | 0 | 0 | 0 | 0 | 0 | |
| รวมขั้นตอน / เวลา | 8 | 378 | 6 | 193 | 2 | 185 | |

| วิธีการก่อนปรับปรุง | | | | | | | | | | วิธีการหลังปรับปรุง | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ขั้นตอน | รายละเอียด | ระยะเวลา | | | สัญลักษณ์ของผังงาน | | | | | ขั้นตอน | รายละเอียด | ระยะเวลา | | | สัญลักษณ์ของผังงาน | | | | |
| | | วัน | ชม. | นาที | | | | | | | | วัน | ชม. | นาที | | | | | |
| 1 | [illegible] | | | 1 | | | | | | 1 | [illegible] | | | 1 | | | | | |
| | [illegible] | | | | | | | | | | [illegible] | | | | | | | | |
| 2 | [illegible] | | | 1 | | | | | | 2 | [illegible] | | | 1 | | | | | |
| | [illegible] | | | | | | | | | | [illegible] | | | | | | | | |
| 3 | [illegible] | | | | | | | | | 3 | [illegible] | | | | | | | | |
| | [illegible] | | | 2 | | | | | | | [illegible] | | | 2 | | | | | |
| | [illegible] | | | | | | | | | | [illegible] | | | | | | | | |
| 4 | [illegible] | | | 4 | | | | | | 4 | [illegible] | | | 4 | | | | | |
| | [illegible] | | | | | | | | | | [illegible] | | | | | | | | |
| 5 | [illegible] | | | 5 | | | | | | 5 | [illegible] | | | 5 | | | | | |
| | [illegible] | | | | | | | | | | [illegible] | | | | | | | | |
| | [illegible] | | | | | | | | | | [illegible] | | | | | | | | |
| 6 | [illegible] | | | 5 | | | | | | 6 | [illegible] | | 3 | | | | | | |
| 7 | [illegible] | | 3 | | | | | | | | [illegible] | | | | | | | | |
| | [illegible] | | | | | | | | | | | | | | | | | | |
| 8 | [illegible] | | 3 | | | | | | | | | | | | | | | | |

Figure 2.16: Flow Process Chart applied Eliminate and Simplify techniques of ECRS (QUALITY ASSURANCE CHULALONGKORN UNIVERSITY, 2008)

# CHAPTER III
# DMAIC METHODOLOGY IN THE EXISTING PROCESS

## 3.1 Define phase

As define phase of DMAIC methodology is set to identify selected project for scope, benefits, goal and target. Most of these are detailed previously as in chapter 1. To implement this project in the XYZ company, draft of project charter is initially set and proposed to top managers of business and engineering teams. Then, the first meeting is arranged to brainstorm for completing project plan including team set-up. The project charter is shown in Figure 3.1.

**Project Charter**

**Project name :** **Improvement of GPRS international Roaming Process**

**Project Leader :** **Rarintip Sirisukpoca**

**Team member :**

| | | Position |
|---|---|---|
| 1. | "A" | Senior manager / IB |
| 2. | "B" | Senior coordinator / IB |
| 3. | "C" | Coordinator / IB |
| 4. | "D" | Manager / DSN |
| 5. | "E" | Specialist / DSN |
| 6. | "F" | Engineer / DSN |
| 7. | "G" | Senior Manager / IS |
| 8. | "H" | Engineer / IS |
| 9. | "I" | Engineer / IS |
| 10. | "J" | Engineer / Network security |

**Significance of project :** Engineering and Business teams need to set-up the standard process for GPRS international roaming service in XYZ in order to reduce average set-up time.

**Statement of problem :**
Average set-up time of new GPRS international roaming service is high.

**Target :**
The maximum of set-up time is 120 days and the failure rate is acceptable at 5% within 30 April 2009.

**Scope :** The improvement covers the processes in IB, DSN, IS teams for set-up new GPRS international roaming service in XYZ company

**Resource and time frame :** Existing resource in XYZ company

28 October 2008 – 30 April 2009

Figure 3.1: Project charter of improvement of GPRS international roaming process in XYZ

### *3.1.1 Statement of problem for GPRS international Roaming process*

The average actual set-up time during the set-up GPRS international roaming service period is 203 days for an operator where the target set-up is 120 days. So, the percentage of failure is 64.9%. Figure 3.2 shows historical failure rate. So, this project is set up to reduce the average set-up time for GPRS international roaming in order to be the standard process of international roaming between business team and engineering team.

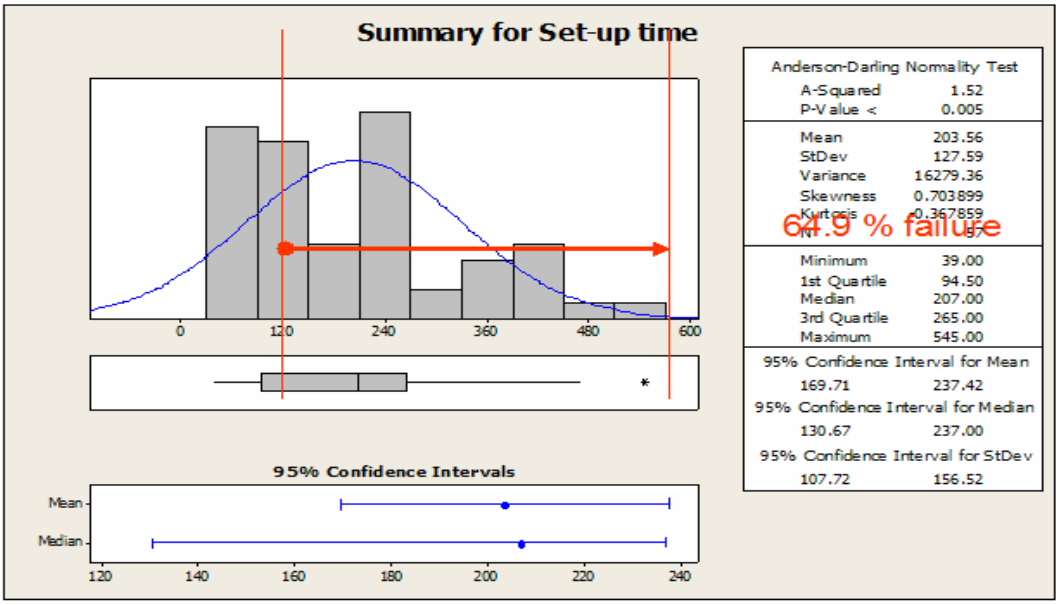



Figure 3.2: Failure rate of set-up time in GPRS international roaming service Improvement objective and benefits

### *3.1.2 Team members and roles*

In this improvement of GPRS International roaming service, the team members and roles are detailed as:

- *International Business (IB/Commercial Group)*

IB team is the user who responsible for providing target operators and send job request forms to other teams. There are three people in team following:

“A” is a senior manager responsible for roaming agreement process and contract. Working experience is 17 years.

“B” is a senior coordinator responsible for cooperation among related teams both internal and external. Working experience is 10 years.

“C” is a coordinator responsible for cooperation among related teams both internal and external. Working experience is 7 years.

- *Data and Supplementary Network team (DSN/Technology Group)*

DSN team is the main team in engineering team to implement GPRS service to create connection and test the services between XYZ company and Roaming partners. This team consists of:

“D” is a manager responsible for job approval and deployment to team. Working experience is 11 years.

“E” is an engineering specialist responsible for creation of GPRS service. Working experience is 8 years.

“F” is an engineer responsible for creation of GPRS service. Working experience is 4 years.

- *Information System team (IS/Technology Group)*

IS team is responsible for call detail record validation. This team consists of:

“G” is a senior manager responsible for job approval and deployment to team. Working experience is 14 years.

“H” is a senior engineer responsible for inspection of call detail record (CDR). Working experience is 6 years.

“I” is an engineer responsible for inspection of CDR. Working experience is 3 years.

- *Network Security team (Security/Technology Group)*

Network Security team is responsible for a part of implementing in connection permission between XYZ company and other networks. This team consists of:

“J” is an engineer responsible for creating the network connection permission between XYZ and others. Working experience is 3 years.

### *3.1.3 Project target and project time frame*

The improvement of GPRS international roaming project is defined the project target that the maximum of set-up time is 120 days as business unit has set the target time frame and the failure rate is acceptable at 5% calculated by the Service Level Agreement (SLA) between Business and Engineering teams in the common service enabling of the XYZ company. The SLA is 95%. The failed job is the job which the set-up time is over 120 days or rejected by any problems. The pilot implementation period starts at the beginning of Q1/2009 and ends at the end of April 2009. So, the whole period of this project is approximately 6 months starting from 28 October 2008 to 30 April 2009. Figure 3.3 is Gantt chart of GPRS International Roaming process improvement which is proposed to management level. The list of selected jobs is prepared by Business unit which has 10 operators. To meet the target that the failure rate is acceptable at 5%, the success jobs are 9.5 or 10 from 10 job requests.

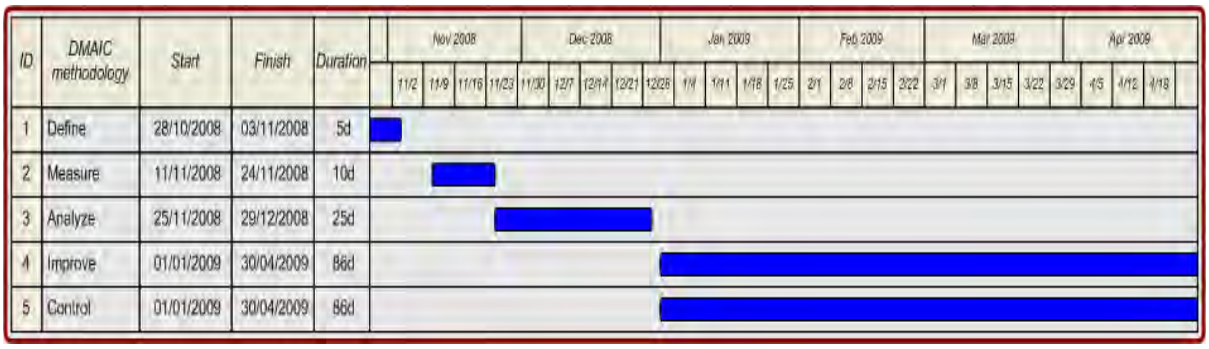



Figure 3.3: Gantt chart of DMAIC methodology for GPRS international roaming process

## 3.2 Measure phase

In this Measure phase of DMAIC, the expected outcomes are the key measures identified, data collection planned and executed. This phase, deployment flowchart or swim-lane flowchart of XYZ company in Figure 3.4 is the first study of how to analysis movement in each activity among teams in the whole GPRS international roaming service. Then, the whole process is classified into five main processes, and related teams in each main process are listed in order to be captured time consumption. Later on, to find out which process makes delay, deep analysis of each main process is

necessary to capture the involved information. SIPOC and process flow analysis are applied. Finally, the process or area should be focused specially are detailed from this measure phase. Figure 3.5 is five main processes and Figure 3.6 is list of related teams in each process.

As the process of GPRS International Roaming are classified as five main processes as in Figure 3.6, these processes will be started after International Business team (IB) decide to establish agreement with roaming partner (RP). IB team creates internal job requests to related teams for implementation step. When the network systems are ready, the test phase and validation phases will be started respectively. The commercial launch confirmation is announced afterwards. Creating new service of GPRS roaming is completely done by all of these processes which are Document preparation, Implementation, Test, Validation and Commercial launch announcement.

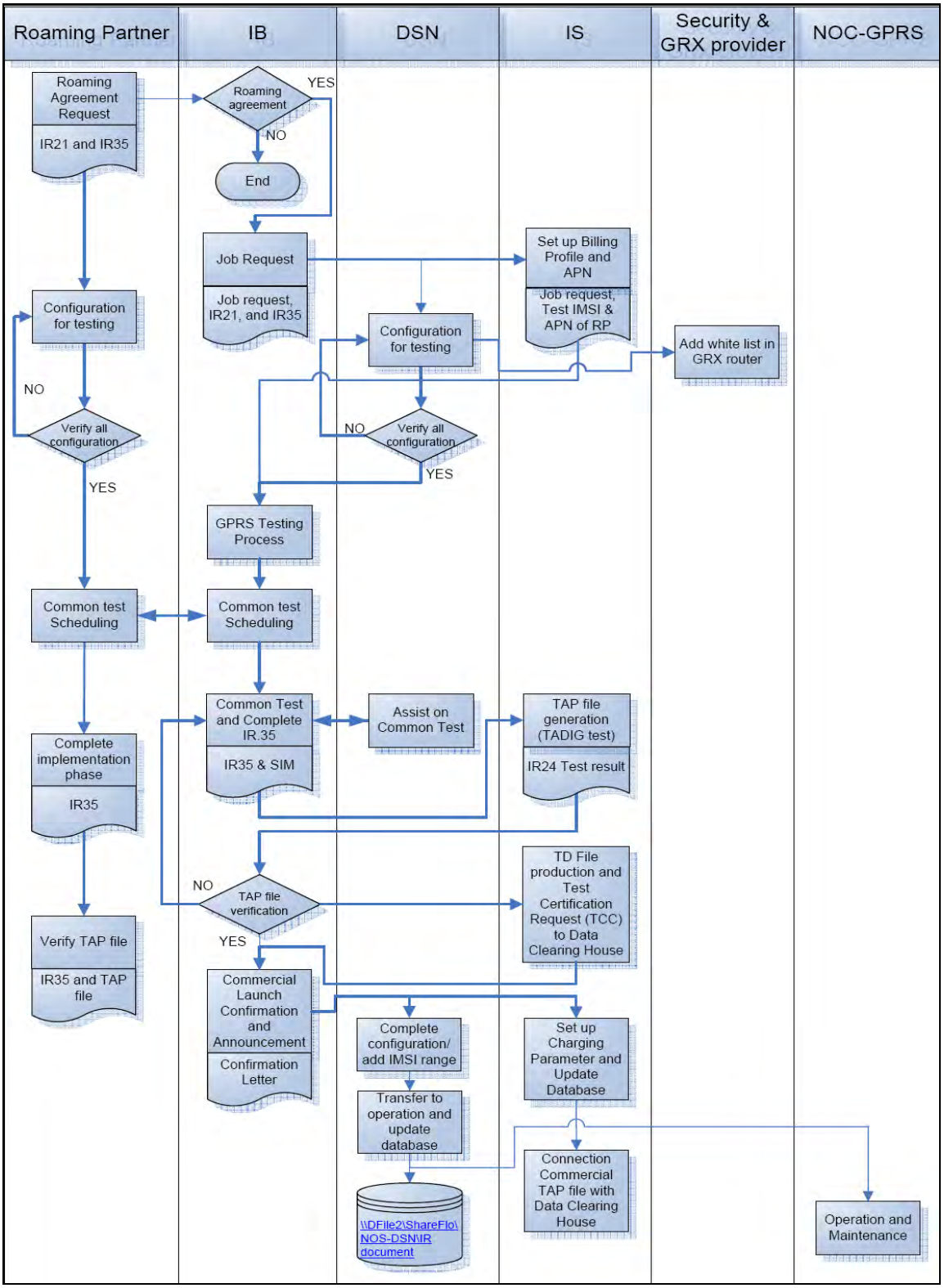



Figure 3.4: Deployment flowchart of GPRS International Roaming process
(Source: XYZ intranet)

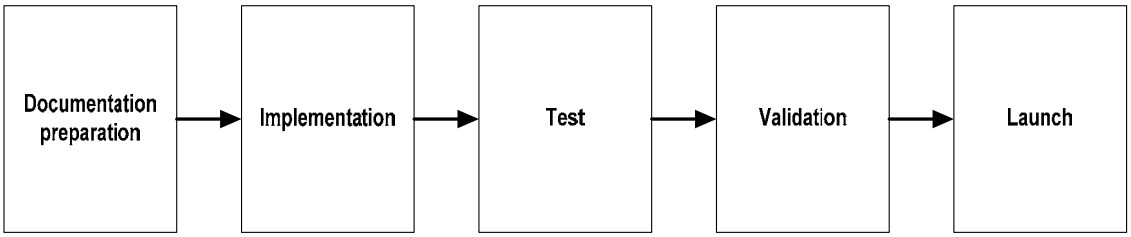



Figure 3.5: Main process flow of GPRS International Roaming service

After five main processes are identified, teams who involve in each main process are specified as Figure 3.6. The involved teams are detailed following:

1. Documentation preparation: IB, Roaming partner
2. Implementation: DSN, IS, IB, Roaming partner
3. Test: DSN, IB, Roaming partner
4. Validation: IB, IS, Roaming partner
5. Launch: IB, Roaming partner

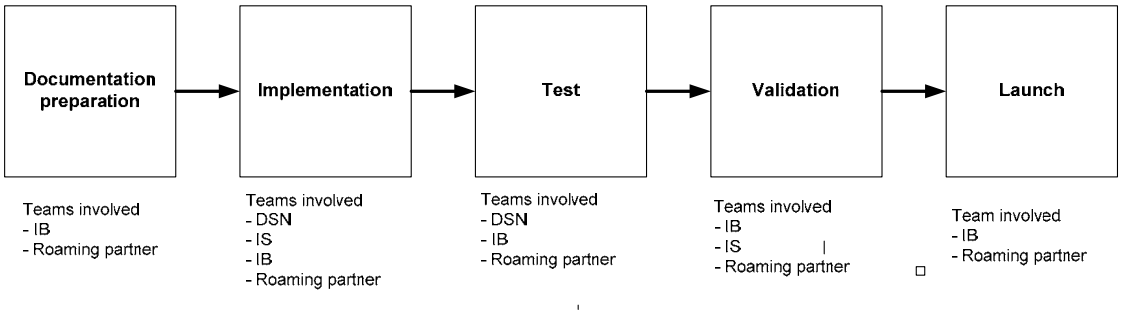



Figure 3.6: Main processes of GPRS International Roaming service and identification of teams involved

To measure the results from historical data, the total 57 jobs cannot be detailed because of the limitation of database. Then, jobs of four best cases and five worse cases are listed in Table 1.1 for initial practice in this measure phase of this research. The four best cases are jobs no. 22 (China Mobile/China), 25 (Mobility/Bermuda), 27 (TNL

PCS/Brazil) and 46 (Claro/Brazil). The worse cases are jobs no. 48 (IDEA Cellular/India), 52 (Cyprus Telecommunication/Cyprus), 55(Telia Denmark/Denmark), 56 (AL JAWALSaudi Telecom Company/ Saudi Arabia), and 57 (VMS Veitnam Mobile Telecommunication Services/Veitnam). All of 9 jobs are discussed in team and selected by the sufficient data which started from Q4/2006, and variety of problem by experience of team. Table 3.1 shows the summarization of processing time in each process of selected nine samples. Then, all collected datum are plotted as histogram in Figure 3.7. The result shows that documentation preparation process consumes 12-22 days, implementation process consumes 5-10 days, the test process consumes 14-480 days, the validation process consumes 4-28 days, and launch process consume 3-5 days. Figure 3.8 shows the statistical results of 9 samples which are grouped as two groups, best practice and worse practice. Mean of best practice is 51.75 days and mean of worst practice is 445 days.

| No. | Country | Network Operator | Set-up time (days) | Documentation preparation (days) | Implement ation (days) | Test (days) | Validation (days) | Launch (days) |
|---|---|---|---|---|---|---|---|---|
| 46 | Brazil | Claro | 39 | 12 | 6 | 14 | 4 | 3 |
| 25 | Bermuda | Mobility / M3 wireless | 49 | 13 | 5 | 23 | 5 | 3 |
| 22 | China | China mobile | 57 | 14 | 6 | 29 | 4 | 4 |
| 27 | Brazil | TNL PCS (Oi) | 62 | 14 | 7 | 32 | 5 | 4 |
| 48 | India | IDEA Cellular | 365 | 20 | 7 | 326 | 7 | 5 |
| 56 | Saudi Arabia | AL JAWAL - Saudi Telecom | 422 | 14 | 7 | 391 | 6 | 4 |
| 57 | Vietnam | VMS Vietnam Mobile Telecom | 423 | 17 | 8 | 380 | 13 | 5 |
| 55 | Denmark | Telia Denmark | 470 | 18 | 9 | 431 | 8 | 4 |
| 52 | Cyprus | Cyprus Telecom. | 545 | 22 | 10 | 480 | 28 | 5 |

Table 3.1: Time consumption analysis in each process of observed jobs

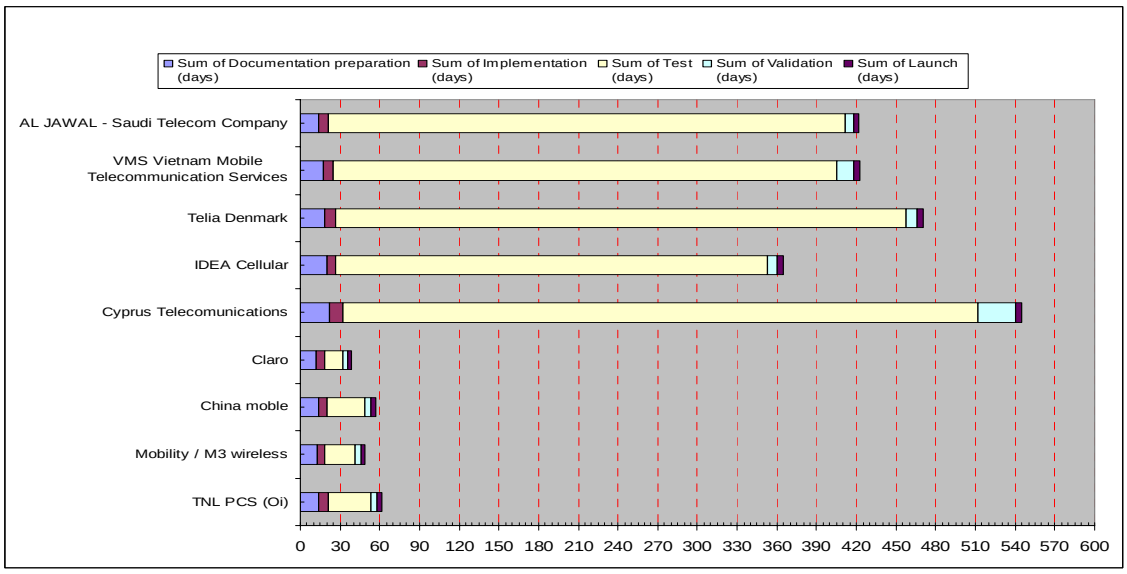



Figure 3.7: Histogram of time consumption analysis in each step of four best jobs and five worse jobs

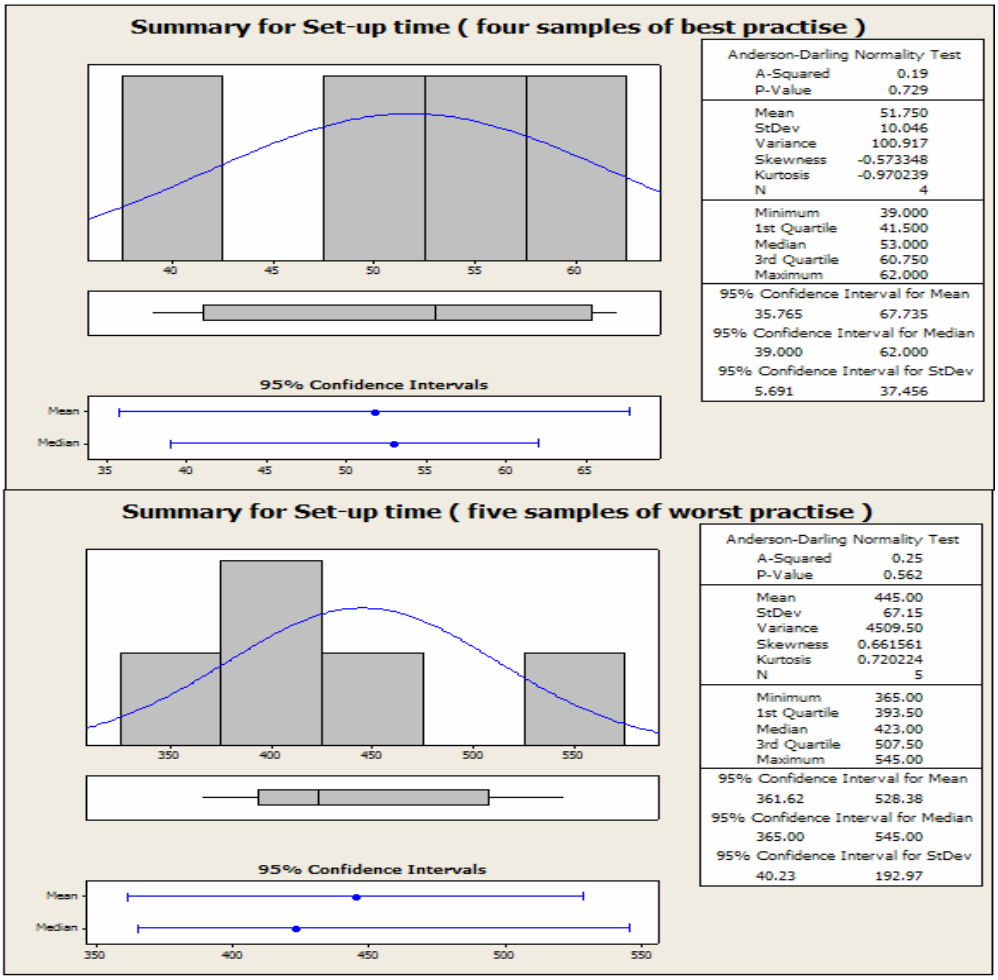



Figure 3.8: Statistical results of set-up time of best and worse practices

Based on collected data of observation jobs, the key measures to improve GPRS international roaming process to reduce the average of the whole set-up time is the reducing processing time in the test and validation processes respectively. The test phase consumes the longest period of the whole process. The secondary process is validation. However, each process relates each others, especially test and validation. If validation shows the results is failure, that job has to be retested. Thus, to meet the goal of this improvement, the whole process should be captured and controlled in terms of time and resource consumptions. As this result, SIPOC is the tool to support analysis in each process for defining, measuring and capturing time consumption. Table 3.2, 3.3, 3.4, 3.5, and 3.6 are SIPOC of documentation preparation, implementation, test, validation and launch processes respectively. Tables 3.7, 3.8, 3.9, 3.10 and 3.11 show time consumption in each sub-process of main process.

| Supplier | Input | Process | Output | Customer |
|---|---|---|---|---|
| IB | Email invitation, IR.21 (XYZ) | 1. Roaming agreement request | Roaming agreement, IR.21 (RP) | RP |
| RP | Roaming agreement, IR.21 (RP), Email approval (RP) | 2. Agreement approval | Confirmation agreement for test | IB |
| IB | Confirmation agreement for test | 3. Agreement confirmation | Approval form, Configuration document (IR.21, IR.35, Tariff plan) | RP |
| RP | Approval form, Configuration document (IR.21, IR.35, Tariff plan) | 4. Get documentation for implementation (RI.21,IR.35, Tariff plan) | IREG contact point for test (XYZ) | IB |
| IB, RP | Approval form, Simcard | 5. Simcard deployment (Logistics) | Simcard shipment | RP, IB |
| IB | Job request form, IR.21, IR.35, Simcard | 6. Create job request forms | Job Ticket | DSN, IS |

Table 3.2: SIPOC analysis in “documentation preparation” process

| Supplier | Input | Process | Output | Customer |
|---|---|---|---|---|
| IB | Job request, IR.21,IR.35(RP) | 1. Set parameters on SGSN, BG | Parameters set up | DSN |
| IB | Job request, Test IMSI, APN list | 2. Set up billing profile and APN | New billing profile, APN list | IS |
| DSN | Job request, IR.21(RP) | 3. Create jobs to Network security and GRX provider | Job ticket, Network routing permission | Network security, GRX provider |
| Network security, GRX provider | Job ticket, IR.21(RP) | 4. Add routing permission on GRX routers | Network routing allowed | DSN |
| Network security | Result of new network routing allowed | 5. Close job from network security | Results verified | DSN |
| GRX provider | Result of new network routing allowed | 6. Close job from GRX provider | Results verified | DSN |
| DSN | IR.35, network verification ( ready to test) | 7. Verify connection and feed back ( Set-up complete) | Network systems ready | IB, RP |

Table 3.3: SIPOC analysis in “Implementation” process

| Supplier | Input | Process | Output | Customer |
|---|---|---|---|---|
| Data warehouse, RP | Job request, email | 1. Order simcard and IR.35 form | Simcard, IR.35 | IB,DSN, NOC |
| IB | IR.35 | 2. Test Mobility Management test case and fill in | Completed test 1 in IR.35 | IB |
| IB | IR.35 | 3. Test WAP test case and fill in | Completed test 2 in IR.35 | IB |
| IB | IR.35 | 4. Test Internet test case and fill in | Completed test 3 in IR.35 | IB |
| IB | IR.35 | 5. Test MMS test case and fill in | Completed test 4 in IR.35 | IB |
| DSN, RP | IR.35, Call | 6. Test ODB test case and fill in | Completed test 5 in IR.35 | RP, DSN |
| IB | Completed IR.35 | 7. Verify completed IR.35 | Verified IR.35 | DSN |
| DSN | Revised IR.35 | 8. Send mail to IB with completed form. (IR.35) | Email, Job close | IB |

Table 3.4: SIPOC analysis in “Test” process

| Supplier | Input | Process | Output | Customer |
|---|---|---|---|---|
| IB | Completed IR.35, Job request | 1. TAP file generation | Job ticket | IS |
| IS | Job ticket, Completed IR.35 | 2. Get call detail record (CDR) from systems | CDRs, validation results | IB |
| IB | IR.35, All CDRs | 3. Validate TAP file between "IR.35" and CDRs | TD file | IS |
| IB | Validated IR.35, Validated TAP files, Agreement form | 4. Send mail to RP. | Validated IR.35, Validated TAP files, Agreement approved | RP |
| RP | Validated IR.35, Validated TAP files, Agreement form | 5. Validate results from RP. | Validated IR.35, Validated TAP files, Agreement approved | IB |
| IB | TD file, Test certification request (TCC) | 6. Test Certification to data clearing house | Certification, Contract | IS |
| IB,RP | Agreement approval (Scanned file), Contract, rate/price agreement, Test results | 7. Propose agreement on rate/price and sign contract | Contract,AA.14 | IB,RP |

Table 3.5: SIPOC analysis in “Validation” process

| Supplier | Input | Process | Output | Customer |
|---|---|---|---|---|
| IB | IR.21, IR.35, APN list, IMSI range, contract | 1. Commercial launch announcement | Email - announcement | DSN, IS, NOC |
| DSN | IR.21, IR.35, Email announcement | 2. Delete and recreate parameters with full IMSI range | Full parameter set-up | IB |
| IS | IR.21, APN list, IMSI range | 3. Set up charging parameter, update database, and announce commercial launch TAP file | Full parameter set-up | IB, data clearing house |
| DSN | IR.21, IR.35 and new configuration | 4. Update Information to database | Document collected in database | NOC, DSN |
| DSN | IR.21, IR.35 and new configuration | 5. Final verification and transfer to operation team | Job transfer | NOC |

Table 3.6: SIPOC analysis in “Commercial launch” process

| | | | | | Time consumed | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Supplier** | **Input** | **Process** | **Output** | **Customer** | **Brazil/Claro** | **Bermuda/M3** | **China/China Mobile** | **Brazil/Oi** | **India/IDEA** | **Saudi/Saudi Telecom.** | **Vietnam/VMS** | **Denmark/Telia** | **Cyprus/Cyprus telecom** |
| IB | Email invitation, IR.21 (XYZ) | 1. Roaming agreement request | Roaming agreement, IR.21 (RP) | RP | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| RP | Roaming agreement, IR.21 (RP), Email approval (RP) | 2. Agreement approval | Confirmation agreement for test | IB | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| IB | Confirmation agreement for test | 3. Agreement confirmation | Approval form, Configuration document (IR.21, IR.35, Tariff plan) | RP | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| RP | Approval form, Configuration document (IR.21, IR.35, Tariff plan) | 4. Get documentation for implementation (RI.21,IR.35, Tariff plan) | IREG contact point for test (XYZ) | IB | 5 | 6 | 6 | 6 | 12 | 4 | 8 | 10 | 11 |
| IB, RP | Approval form, Simcard | 5. Simcard deployment (Logistics) | Simcard shipment | RP, IB | 3 | 3 | 4 | 4 | 4 | 6 | 5 | 4 | 7 |
| IB | Job request form, IR.21, IR.35, Simcard | 6. Create job request forms | Job Ticket | DSN, IS | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |

Table 3.7: SIPOC and time consumption in “Documentation preparation” process

| | | | | | Time consumed | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Supplier** | **Input** | **Process** | **Output** | **Customer** | **Brazil/Claro** | **Bermuda/ M3** | **China/China Mobile** | **Brazil /Oi** | **India/ IDEA** | **Saudi/ Saudi Telecom.** | **Vietnam/VMS** | **Denmark/Telia** | **Cyprus/ Cyprus telecom** |
| IB | Job request, IR.21,IR.35(RP) | 1. Set parameters on SGSN, BG | Parameters set up | DSN | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| IB | Job request, Test IMSI, APN list | 2. Set up billing profile and APN | New billing profile, APN list | IS | 1.5 | 1.5 | 1.5 | 1 | 2 | 1 | 1.5 | 2 | 2 |
| DSN | Job request, IR.21(RP) | 3. Create jobs to Network security and GRX provider | Job ticket, Network routing permission | Network security, GRX provider | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| Network security, GRX provider | Job ticket, IR.21(RP) | 4. Add routing permission on GRX routers | Network routing allowed | DSN | 1.5 | 1 | 2 | 3 | 2 | 3 | 2.5 | 1.5 | 1.5 |
| Network security | Result of new network routing allowed | 5. Close job from network security | Results verified | DSN | 1 | 0.5 | 0.5 | 1 | 1 | 0.5 | 0.5 | 0.5 | 0.5 |
| GRX provider | Result of new network routing allowed | 6. Close job from GRX provider | Results verified | DSN | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 1 |
| DSN | IR.35, network verification ( ready to test) | 7. Verify connection and feed back ( Set-up complete) | Network systems ready | IB, RP | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 1 | 2 | 3.5 | 4 |

Table 3.8: SIPOC and time consumption in “Implementation” process

| | | | | | Time consumed | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Supplier** | **Input** | **Process** | **Output** | **Customer** | **Brazil/Claro** | **Bermuda/M3** | **China/China Mobile** | **Brazil/Oi** | **India/IDEA** | **Saudi/Saudi Telecom.** | **Vietnam/VMS** | **Denmark/Telia** | **Cyprus/Cyprus telecom** |
| Data warehouse, RP | Job request, email | 1. Order simcard and IR.35 form | Simcard, IR.35 | IB,DSN, NOC | 4 | 7 | 11 | 15 | 13 | 9 | 8 | 22 | 42 |
| IB | IR.35 | 2. Test Mobility Management test case and fill in | Completed test 1 in IR.35 | IB | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 1 | 0.5 | 0.5 |
| IB | IR.35 | 3. Test WAP test case and fill in | Completed test 2 in IR.35 | IB | 1 | 1 | 1 | 1 | 15 | 5 | 1 | 0.5 | 7 |
| IB | IR.35 | 4. Test Internet test case and fill in | Completed test 3 in IR.35 | IB | 0.5 | 1 | 1 | 0.5 | 1 | 2 | 1 | 1 | 1 |
| IB | IR.35 | 5. Test MMS test case and fill in | Completed test 4 in IR.35 | IB | 2 | 1 | 1 | 3 | 15 | 4 | 3 | 3 | 7 |
| DSN, RP | IR.35, Call | 6. Test ODB test case and fill in | Completed test 5 in IR.35 | RP, DSN | 4 | 10 | 12 | 9 | 279 | 368 | 362 | 402 | 420 |
| IB | Completed IR.35 | 7. Verify completed IR.35 | Verified IR.35 | DSN | 1 | 1.5 | 1.5 | 2 | 1.5 | 1.5 | 2 | 1 | 1.5 |
| DSN | Revised IR.35 | 8. Send mail to IB with completed form. (IR.35) | Email, Job close | IB | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |

Table 3.9: SIPOC and time consumption in “Test” process

| | | | | | Time consumed | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Supplier** | **Input** | **Process** | **Output** | **Customer** | **Brazil /Claro** | **Bermuda/ M3** | **China/China Mobile** | **Brazil/Oi** | **India/ IDEA** | **Saudi/ Saudi Telecom.** | **Vietnam/VMS** | **Denmark/Telia** | **Cyprus/ Cyprus telecom** |
| IB | Completed IR.35, Job request | 1. TAP file generation | Job ticket | IS | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 |
| IS | Job ticket, Completed IR.35 | 2. Get call detail record (CDR) from systems | CDRs, validation results | IB | 1 | 2 | 1 | 0.5 | 1 | 1 | 4 | 3 | 15 |
| IB | IR.35, All CDRs | 3. Validate TAP file between "IR.35" and CDRs | TD file | IS | 1 | 1 | 1 | 2 | 3 | 2 | 4 | 2 | 6 |
| IB | Validated IR.35, Validated TAP files, Agreement form | 4. Send mail to RP. | Validated IR.35, Validated TAP files, Agreement approved | RP | 0.25 | 0.25 | 0.5 | 0.25 | 0.25 | 0.5 | 0.5 | 0.25 | 0.25 |
| RP | Validated IR.35, Validated TAP files, Agreement form | 5. Validate results from RP. | Validated IR.35, Validated TAP files, Agreement approved | IB | 1 | 1 | 0.5 | 1.5 | 2 | 1.5 | 3 | 2 | 6 |
| IB | TD file, Test certification request (TCC) | 6. Test Certification to data clearing house | Certification, Contract | IS | 0.25 | 0.25 | 0.25 | 0.25 | 0.25 | 0.5 | 0.25 | 0.25 | 0.25 |
| IB,RP | Agreement approval (Scanned file), Contract, rate/price agreement, Test results | 7. Propose agreement on rate/price and sign contract | Contract,AA.14 | IB,RP | 0.25 | 0.25 | 0.5 | 0.25 | 0.25 | 0.25 | 1 | 0.25 | 0.25 |

Table 3.10: SIPOC and time consumption in “Validation” process

| | | | | | Time consumed | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Supplier** | **Input** | **Process** | **Output** | **Customer** | **Brazil/Claro** | **Bermuda/M3** | **China/China Mobile** | **Brazil/Oi** | **India/IDEA** | **Saudi/Saudi Telecom.** | **Vietnam/VMS** | **Denmark/Telia** | **Cyprus/Cyprus telecom** |
| IB | IR.21, IR.35, APN list, IMSI range, contract | 1. Commercial launch announcement | Email - announcement | DSN, IS, NOC | 0.25 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 |
| DSN | IR.21, IR.35, Email announcement | 2. Delete and recreate parameters with full IMSI range | Full parameter set-up | IB | 1 | 0.5 | 1 | 1 | 2 | 1 | 2 | 1 | 2 |
| IS | IR.21, APN list, IMSI range | 3. Set up charging parameter, update database, and announce commercial launch TAP file | Full parameter set-up | IB, data clearing house | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| DSN | IR.21, IR.35 and new configuration | 4. Update Information to database | Document collected in database | NOC, DSN | 0.5 | 0.5 | 0.5 | 0.5 | 1 | 0.5 | 0.5 | 0.5 | 1 |
| DSN | IR.21, IR.35 and new configuration | 5. Final verification and transfer to operation team | Job transfer | NOC | 0.25 | 0.5 | 1 | 1 | 0.5 | 1 | 1 | 1 | 0.5 |

Table 3.11: SIPOC and time consumption in “Launch” process

With measure phase, the test and validation processes are the keys to make the request jobs of GPRS international roaming service whether is successful within limitation of time. Historically, range of time consumption in the test process is from 14 to 480 days, by the best case to the worst case of observed jobs. Meanwhile, the range of time consumption in validation phase is from 4 to 28 days, by the best case to the worst case of observed jobs. Then, fish-bone diagram is a useful tool to deeply identify causes of problems which effect to high consumption of time in the test and validation periods. It is shown in next phase of DMAIC, the analysis phase.

## 3.3 Analysis phase

From the measure phase, the delay in the test and validation processes impact to the whole GPRS international roaming process in set-up new service. This phase, analysis phase, there are many tools and techniques applied to find the root cause of delay problem in test and validation processes. The steps are detailed as follows:

### *3.3.1 Work flow analysis*

Work flow analysis or process mapping or process analysis is an applied to in this phase to identify activities and actions in the test process and validation process. This tool helps clarify the activities that can help next identify causes and effects by fish bone diagram. This analysis is done by brainstorming between teams related to the test and validation processes. In test process, the main team responded for testing is in IB team. They also need support from engineering team when problem occurs. Occasionally, they need support from roaming partners if that is the network problem of roaming partner. When test is done completely, IB team will send job request with test results to IS team. Then, validation process starts. This validation phase begins from IS checks whether there are CDRs that they want in systems. If there are the needed CDRs, they will export and send to IB for validation of CDRs or TAP files case by case. If there are no CDRs, they have to return IB to retest. So, the contract will be accepted and will move to launch process when validations of all test cases are acceptable for both sites between roaming partner and XYZ. If there is one case failed, the agreement cannot be done. Team has to retest until that case is passed. Figure 3.9 is

process mapping of the test process. Figure 3.10 is process mapping of the validation phase. They are created by SIPOC by Table 3.9, 3.10. After the activities are detailed as flowchart, the movement of the main process can be displayed to show causes of delay problem which effect to the whole process. Then, fish bone diagram is applied to specify causes and effects in delay time.

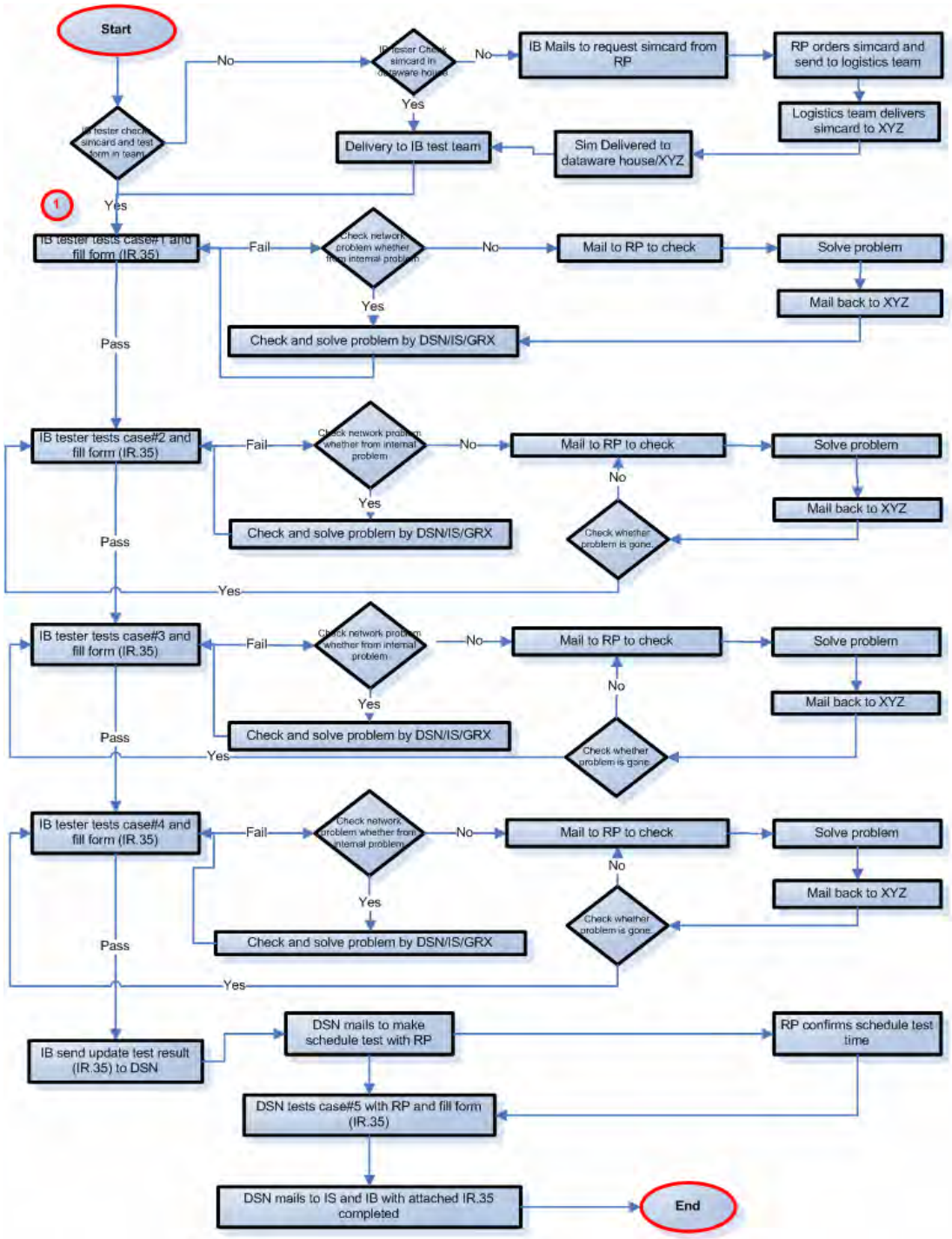



Figure 3.9: Process mapping of test process

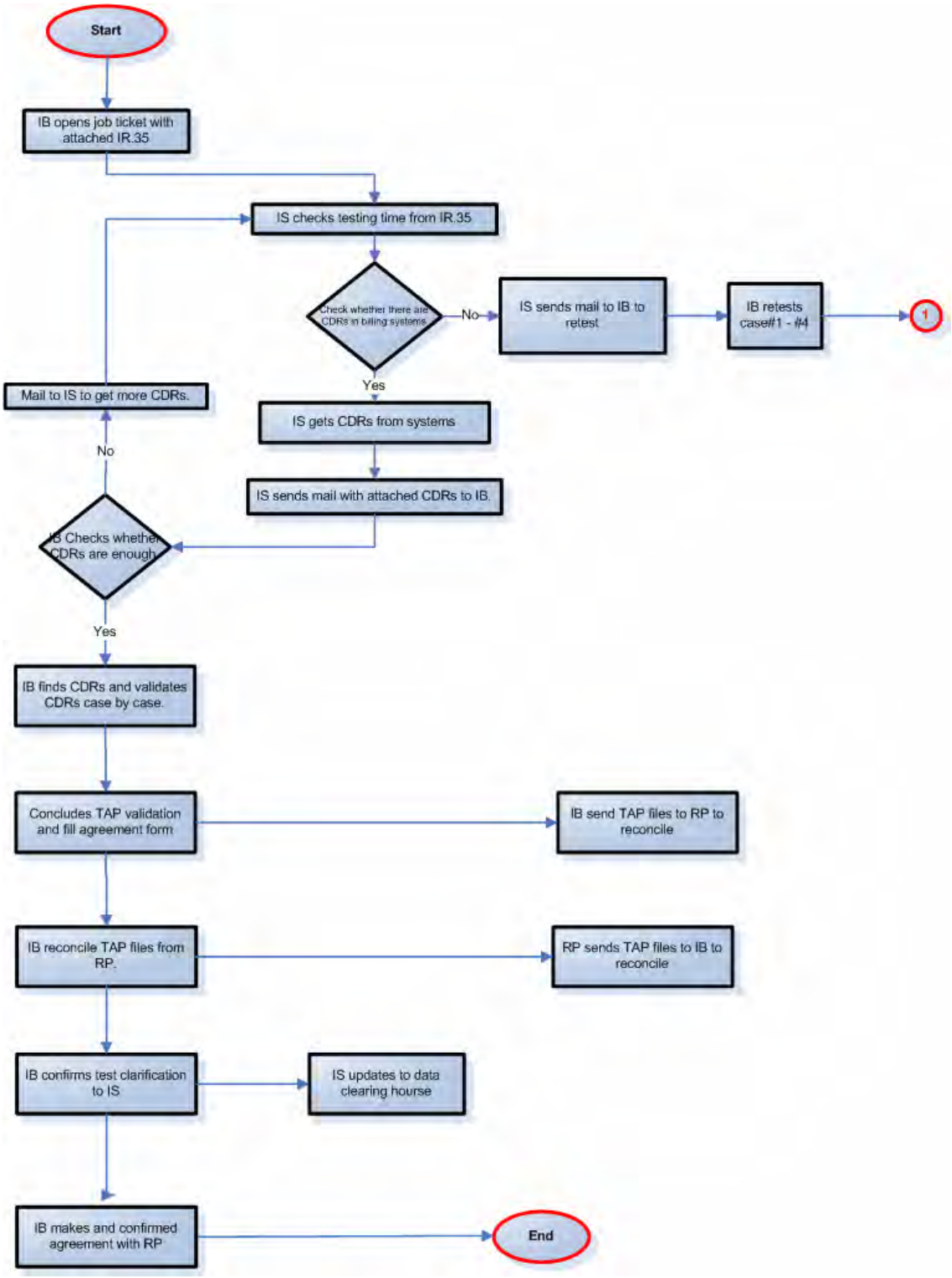



Figure 3.10: Process mapping of validation process

### *3.3.2 Fish bone diagram or cause-and-effect diagram*

When the workflow analysis displays the activities in sub-processes of the test and validation processes, the delay can be identified where it can happen. Then, the fish bone diagram is playing role in this phase.

In the test process, cause of making delay can be detailed as classifying by 5 M's and 1 E or Figure 3.11.

- Methods
  - Process is not clear.
  - Communication between the related teams is not well enough both internal and external.
  - There is no simcard management.
- Machines
  - Systems fail.
    - Internal XYZ company.
    - External XYZ: roaming partner's , GRX provider, Data clearing house.
  - Systems are not ready such as policy to freezing network during festival.
- Materials
  - Information is lost.
    - No test phone.
    - No IR.35 (test form).
    - No simcard.
    - No IR.21 or out-of-date.
  - Simcard is inactivated or expired.
- Man powers
  - No skills.
  - Lack of man power.
  - Lack of time.
- Measurement
  - Out of record: The test information is lost from systems due to long period testing.

- Environment
    - Local time is different to make test case no.5 incomplete, because it needs to test in real-time as call conference with roaming partner.
    - There are many offices in XYZ company located in different areas, so it makes delay time in simcard transferring.
    - There are many data warehouse for storing simcards. Managing and deploying simcards for several teams is limited by limited amount of simcards from roaming partner.

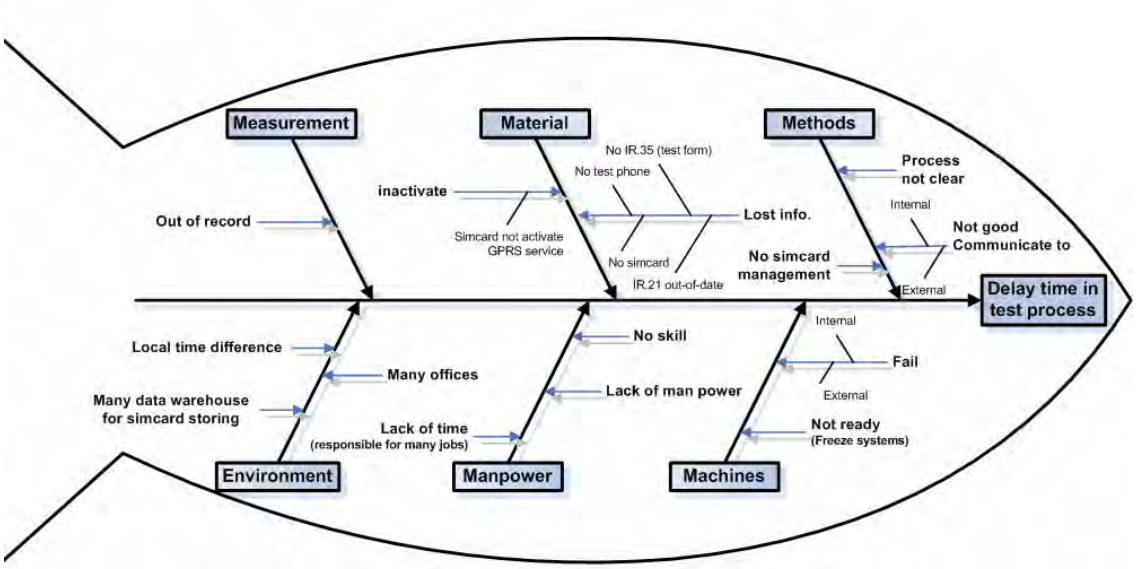



Figure 3.11: Fish bone diagram to specify delay in the test process

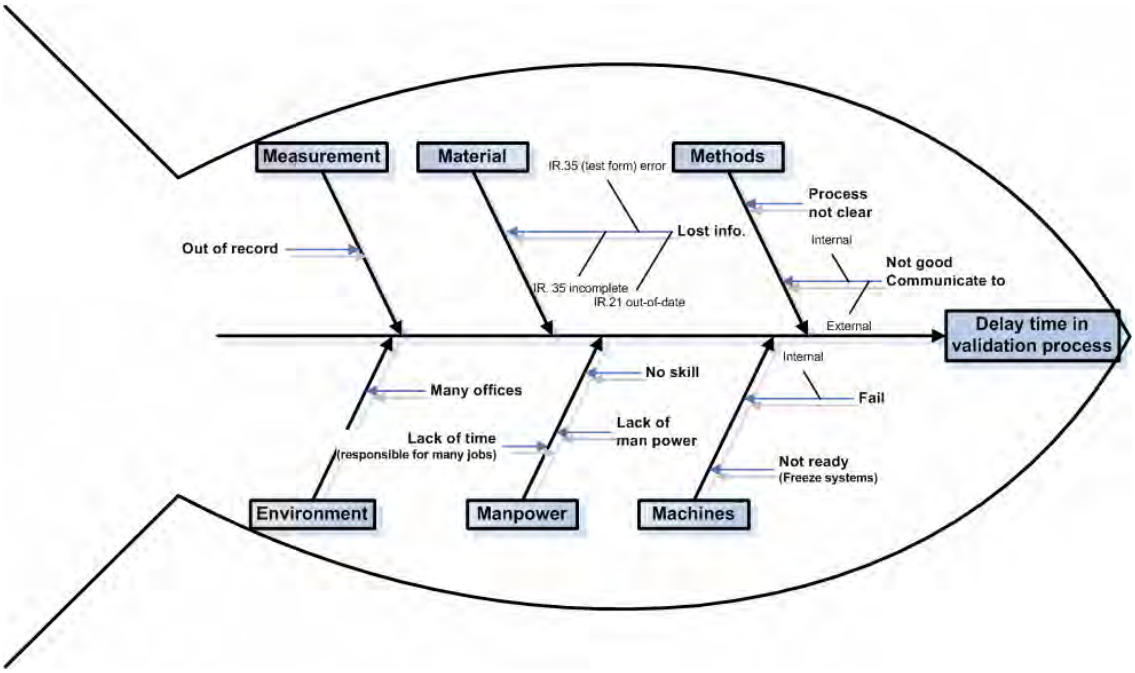



Figure 3.12: Fish bone diagram to specify delay in the validation process

In the validation process, cause of making delay can be detailed as classifying by 5M's and 1 E as follows or as shown in Figure 3.12.

- Methods
  - Process is not clear.
  - Communication between the related teams is not well enough both internal and external.
- Machines
  - Systems fail.
    - Internal XYZ company.
  - Systems are not ready such as policy to freezing network during festival.
- Materials
  - Information is lost.
    - IR.35 (test form) is error.
    - IR. 35 is incomplete. Some mandatory data is not recorded.
    - No IR.21 or out-of-date.

- Man powers
    - No skills.
    - Lack of man power.
    - Lack of time.
- Measurement
    - Out of record: The test information is lost from systems due to long period testing.
- Environment
    - There are many offices in XYZ company located in different areas, so it makes delay time in simcard transferring.

From the cause-and-effect diagram, the list of causes which can affect to delay time of GPRS international roaming process can be inputs, cause, for relationship matrix.

### 3.3.3 Relationship matrix

After causes of delay problem are detailed by cause-and-effect diagram as shown previously, team decides to apply relationship matrix to prioritize the causes which should be considered specially. So, the involved teams in the test process and validation process brainstorm to fill criteria and score. The criteria are considered from what makes the whole process inefficiency. Thus, three criteria are voted as time consumption in each activity, effect to rework, and effect to failure. The conclusions of each process are illustrated as following Tables. The score used in evaluating relationship matrix rates from 1- the lowest score, to 5-the highest score.

- "5" refers to the highest correlation level of the cause and selection criteria.
- "4' refers to a high correlation between the cause and selection criteria.
- "3" refers to a fair correlation between the cause and selection criteria.
- "2" refers to a low correlation between the cause and selection criteria.
- "1" refers to none correlation between the cause and selection criteria.

Table 3.12 and 3.13 are relationship matrix between cause and criteria in the test process and validity process respectively.

| Cause / Criteria | Time consumed | Effect to rework | Effect to failure | Total | Category | Summary |
|---|---|---|---|---|---|---|
| Process not clear. | 4 | 2 | 4 | 10 | Method | 7.3 |
| Communication not well enough. | 3 | 2 | 2 | 7 | | |
| No simcard management. | 2 | 1 | 2 | 5 | | |
| Systems failed. (XYZ) | 3 | 1 | 2 | 6 | Machines | 5.7 |
| Systems failed. (external-RP, GRX, Data clearing house) | 3 | 1 | 2 | 6 | | |
| Systems not ready | 3 | 1 | 1 | 5 | | |
| Information net ready | 3 | 2 | 4 | 9 | Materials | 8 |
| Simcard inactivated or expired. | 3 | 1 | 3 | 7 | | |
| No skills. | 5 | 3 | 3 | 11 | Man powers | 8.7 |
| Lack of man power. | 3 | 2 | 2 | 7 | | |
| Lack of time. | 4 | 2 | 2 | 8 | | |
| No record. | 3 | 3 | 1 | 7 | Measurement | 7 |
| Local time different | 4 | 2 | 2 | 8 | Environment | 6 |
| Many offices in XYZ | 3 | 1 | 1 | 5 | | |
| Many data warehouse for storing simcards. | 3 | 1 | 1 | 5 | | |

Table 3.12: Relationship matrix of the test process

| Causes / Criteria | Time consumed | Effect to rework | Effect to failure | Total | Category | Summary |
|---|---|---|---|---|---|---|
| Process not clear. | 4 | 2 | 4 | 10 | Method | 8.5 |
| Communication not well enough. | 3 | 2 | 2 | 7 | | |
| Systems failed. (XYZ) | 3 | 1 | 2 | 6 | Machines | 5.5 |
| Systems not ready | 3 | 1 | 1 | 5 | | |
| Information net ready | 3 | 2 | 4 | 9 | Materials | 9 |
| No skills. | 5 | 3 | 3 | 11 | Man powers | 8.7 |
| Lack of man power. | 3 | 2 | 2 | 7 | | |
| Lack of time. | 4 | 2 | 2 | 8 | | |
| No record. | 3 | 3 | 1 | 8 | Measurement | 7 |
| Many offices in XYZ | 3 | 1 | 1 | 5 | Environment | 5 |

Table 3.13: Relationship matrix of the validity process

In order to make decision to cut off some causes which make low impact to delay time in the test process, in summary from Table 3.12, man powers has the highest point, 8.7 and the secondary high point, is 8, is material. The third one is method, 7.3. The fourth one is measurement, 7. The fifth one is environment, 6. The last one of causes affected to time delay in GPRS international roaming process is machine, 5.7. So, this improvement is focusing on the root causes which are from man powers, material and method. The last three causes are cut off.

With Table 3.13, in validity process the highest point is material, 9. The secondary high point is man powers, 8.7. The third high point is method, 8.5. The fourth one is measurement, 7. The fifth one is machine, 5.5. The last one is environment, 5. So, the three highest points which are material, man power and method are concentrated on for next improvement action. The last three causes are ignored for this improvement due to low impact to the whole process of delay time in GPRS international roaming service.

### *3.3.4 Why-why analysis*

Referred to Relationship matrix previously applied during team brainstorming, the root causes of delay problem in GPRS international process which happens during the test process and validation process can be specified. In the test process, the categories of causes of problems are man powers, material and method. The root causes of delay problem in test process are listed by team as following. Figure 3.13 shows the why-why analysis chart to deeply analyze the root causes of problems.

- No skills
- Lack of time
- Lack of man power
- Information not ready
- Simcard not active
- Process not clear
- Communication not well enough
- No simcard management

Then, the root causes of delay problem in validation process are listed as following. Figure 3.14 is the why-why analysis chart for this validation process.

- No skills
- Lack of time
- Lack of man power
- Information not ready
- Process not clear
- Communication not well enough

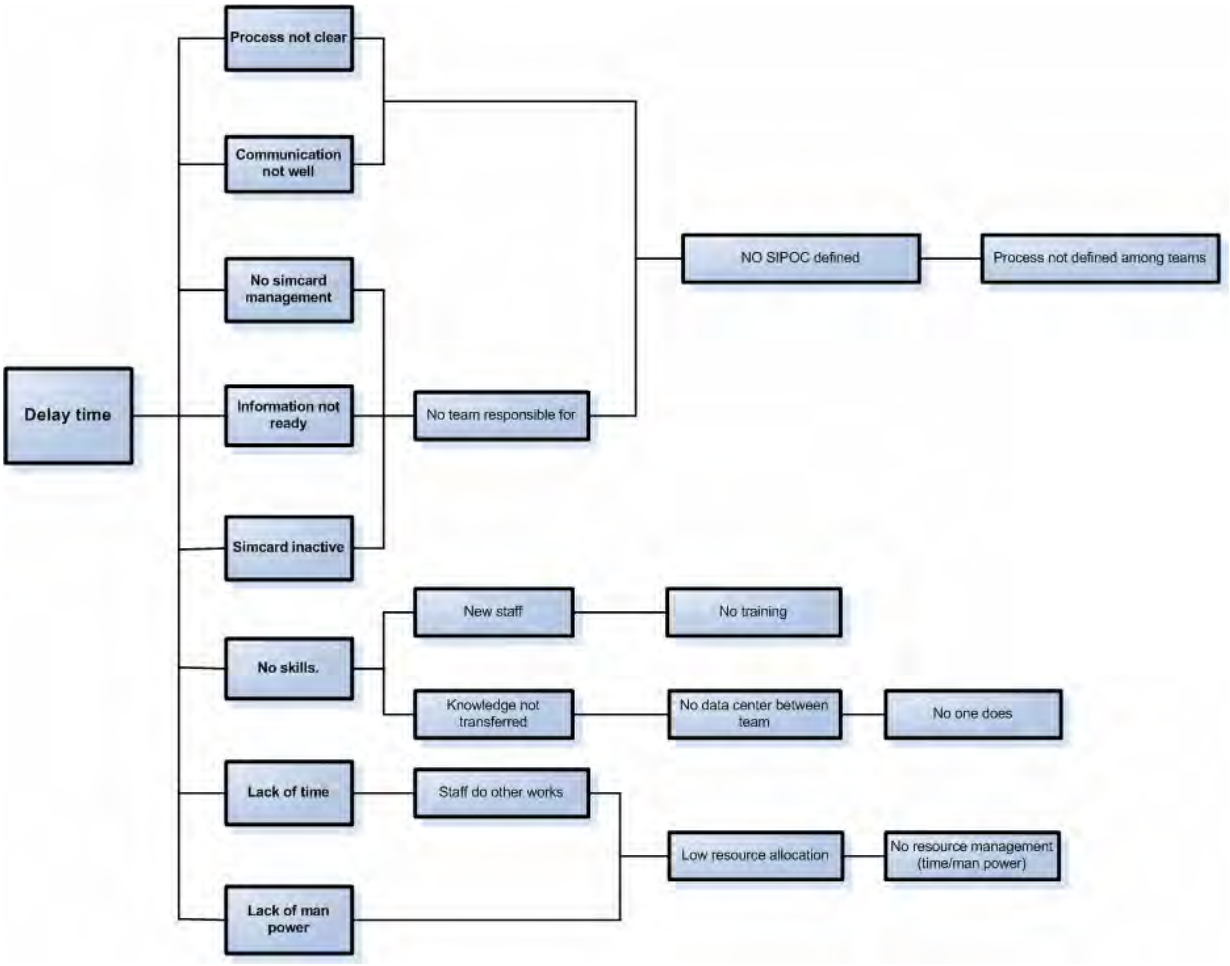



Figure 3.13: Why-why analysis for test process

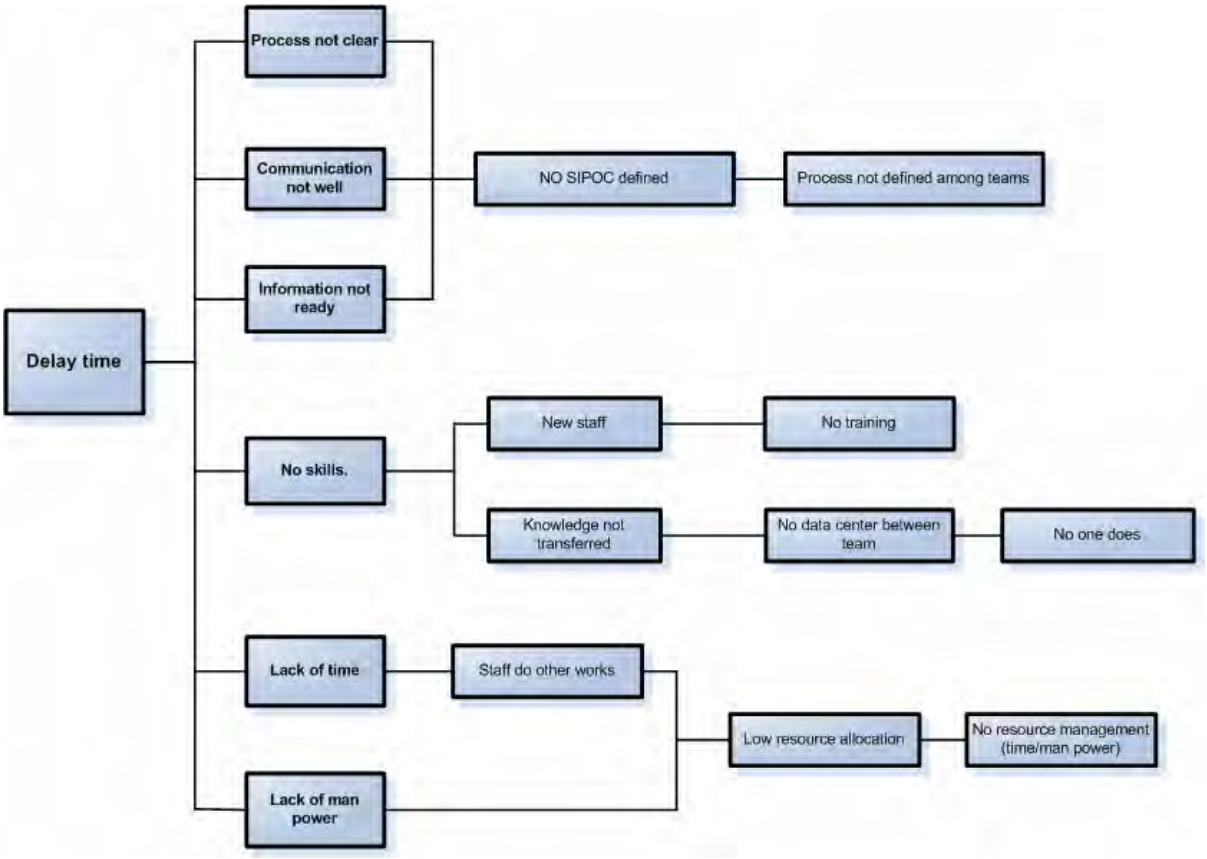



Figure 3.14: Why-why analysis for validity process

With why-why analysis for both processes, most of problems could be attributed to no process defined, no knowledge management, and no resource management. Firstly, from the cause of no process defined, problem is from no process set-up among teams. Each team does not understand which information that other teams really need. Secondly, from the cause of man power, problem is from insufficiency on resources and skills of staffs. Finally, from no resource management, this is because staffs in engineering team have many works to do in the same time. It is difficult to allocate time for GPRS international roaming service. In addition to no skill problem, the knowledge among team has never transferred. The relationship among teams is low. So, the transition of process does not good. All of these causes can bring to the result which is insufficient information due to missing information and misunderstanding the SIPOC of the whole GPRS international roaming process.

After applied these analysis tools which are the fish bone diagram, the relationship matrix and the why-why chart, overall picture of root causes of problems is

identified. However, the improvement cannot be defined because this improvement project has limitation of time. Team decide to specific more details on sub process of test and validation processes in order to focus on main causes of problems. Thus, the measurement data from SIPOC is reconsidered. Table 3.14 shows the average data which is collected in each sub process in the test process. This Table can illustrate the average set-up time of the whole test process from best practice jobs is 23.5 days. Meanwhile, from another side of the worse practice is 400.4 days. The fifth sub process which is the ODB (Operator Determine Barring) test case shows high time consumption as shown in Figure 3.15. So, this sub process is needed to be improved first. Considered to the validation process from the SIPOC in Table 3.15, the average set-up time from the best practice jobs is 4.3 days. Meanwhile, the average set-up time of the worse practice is 7.8 days. The third sub process is needed to be improved first as shown in Figure 3.16. This process is validation of TAP file and IR.35 test results. The why-why and how-how analysis are applied to find the root causes of problem in the test process by interviewing DSN team and validation process by IS team.

| Supplier | Input | Process | Output | Customer | Average of best practice | Average of worse practice |
|---|---|---|---|---|---|---|
| Data warehouse, RP | Job request, email | 1. Order simcard and IR.35 form | Simcard, IR.35 | IB, DSN, NOC | 9.3 | 18.8 |
| IB | IR.35 | 2. Test Mobility Management test case and fill in | Completed test 1 in IR.35 | IB | 0.5 | 0.6 |
| IB | IR.35 | 3. Test WAP test case and fill in | Completed test 2 in IR.35 | IB | 1.0 | 5.7 |
| IB | IR.35 | 4. Test Internet test case and fill in | Completed test 3 in IR.35 | IB | 0.8 | 1.2 |
| IB | IR.35 | 5. Test MMS test case and fill in | Completed test 4 in IR.35 | IB | 1.8 | 6.4 |
| DSN, RP | IR.35, Call | 6. Test ODB test case and fill in | Completed test 5 in IR.35 | RP, DSN | 8.8 | 366.2 |
| IB | Completed IR.35 | 7. Verify completed IR.35 | Verified IR.35 | DSN | 1.5 | 1.5 |
| | | | | | **23.5** | **400.4** |

Table 3.14: Average time in test process comparison between the best practice and the worse practice from data collection

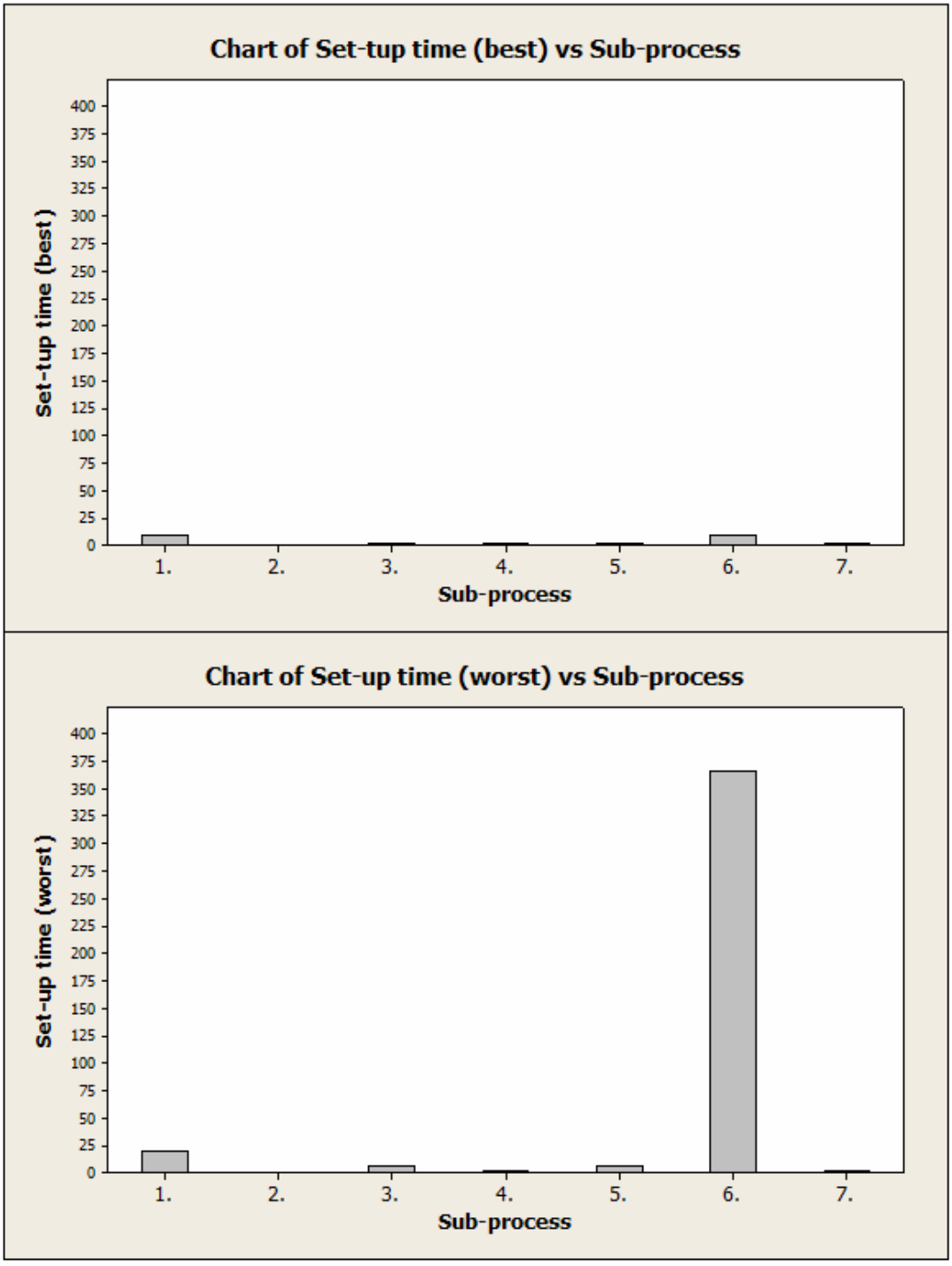



Figure 3.15: Set-up time of each sub process in test process

| Supplier | Input | Process | Output | Customer | Average of best practice | Average of worse practice |
|---|---|---|---|---|---|---|
| IB | Completed IR.35, Job request | 1. TAP file generation | Job ticket | IS | 0.3 | 0.3 |
| IS | Job ticket, Completed IR.35 | 2. Get call detail record (CDR) from systems | CDRs, validation results | IB | 1.3 | 1.9 |
| IB | IR.35, All CDRs | 3. Validate TAP file between "IR.35" and CDRs | TD file | IS | 1.0 | 2.6 |
| IB | Validated IR.35, Validated TAP files, Agreement form | 4. Send mail to RP. | Validated IR.35, Validated TAP files, Agreement approved | RP | 0.3 | 0.4 |
| RP | Validated IR.35, Validated TAP files, Agreement form | 5. Validate results from RP. | Validated IR.35, Validated TAP files, Agreement approved | IB | 0.8 | 2.0 |
| IB | TD file, Test certification request (TCC) | 6. Test Certification to data clearing house | Certification, Contract | IS | 0.3 | 0.3 |
| IB,RP | Agreement approval (Scanned file), Contract, rate/price agreement, Test results | 7. Propose agreement on rate/price and sign contract | Contract,AA.14 | IB,RP | 0.3 | 0.4 |
| | | | | | 4.3 | 7.8 |

Table 3.15: Average time in validity process comparison between the best practice and the worse practice from data collection

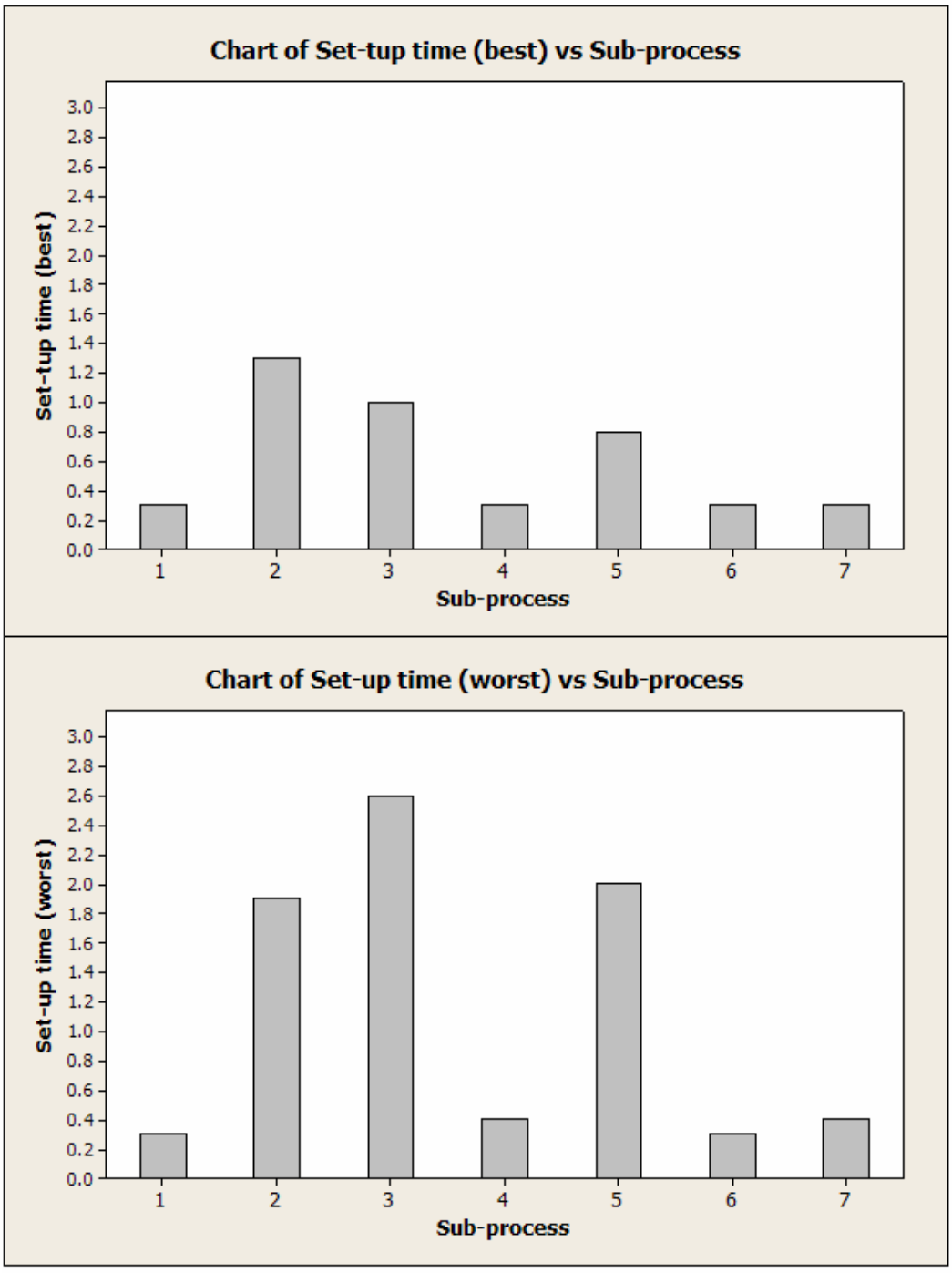



Figure 3.16: Set-up time of each sub process in validation process

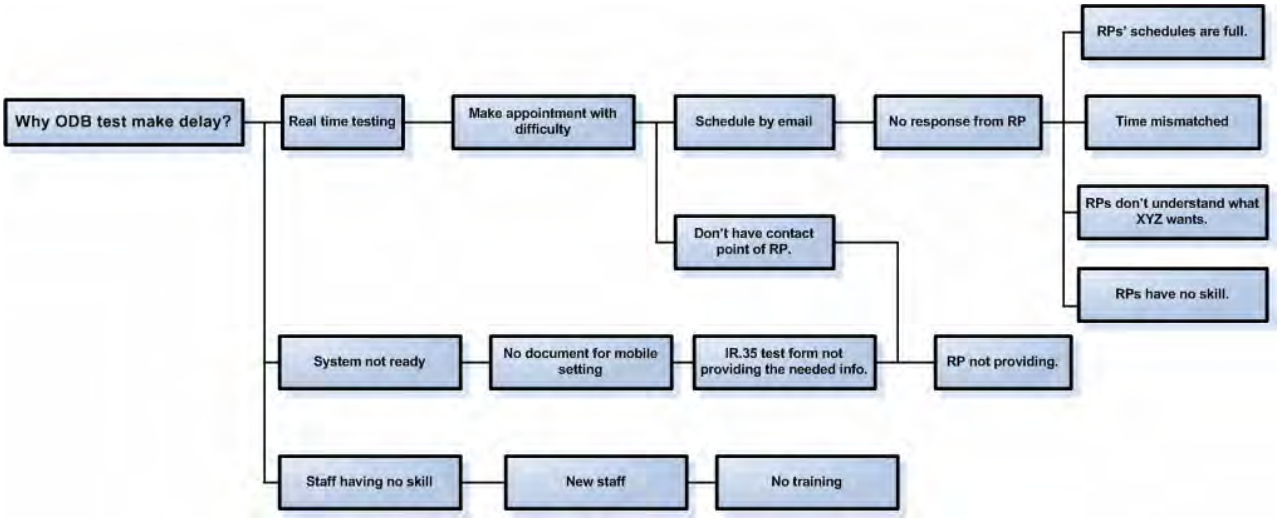



Figure 3.17: Why-why analysis of test process of ODB sub-test case

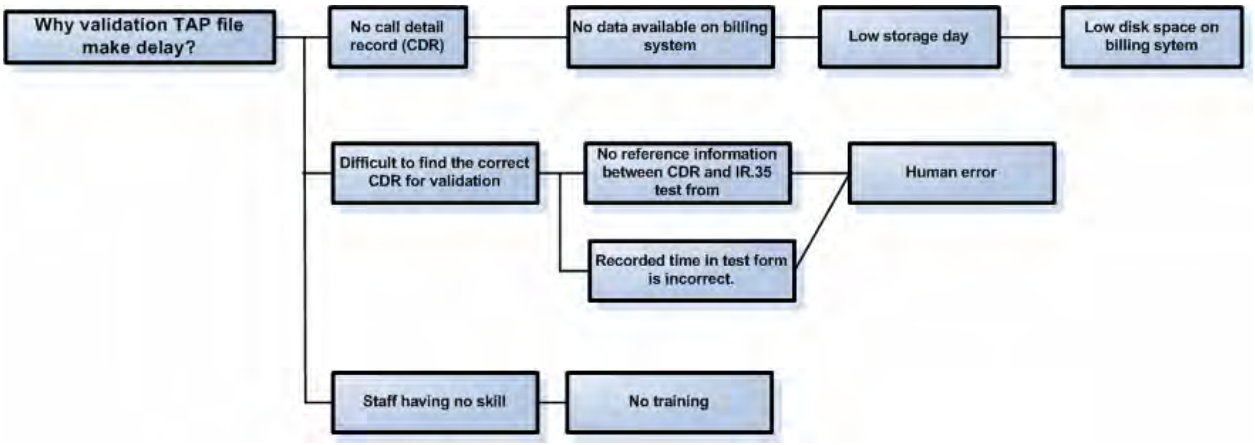



Figure 3.18: Why-why analysis of validation process of validating TAP file and IR.35 test form

After why-why diagram is reapplied as in Figure 3.17 and Figure 3.18 to find the root cause of problem deeply in each process, the root cause of problem in ODB testing process of the test process could be:

- Schedules of roaming partners are full.

- Cannot make appointment with roaming partners due to time mismatched.

- Roaming partners do not understand what XYZ really needs.

- Some mandatory information is missing due to no providing from roaming partners.

- Staffs have no skills.

Meanwhile, the root causes of delay problem in validation process are from:

- No record on billing systems,
- Difficulty to find CDR due to insufficient recorded information,
- No skills of staffs due to no training.

### *3.3.5 How-How diagram*

Based on the best practice in implementing the GPRS international service, the how-how diagram is applied to be the guideline of this improvement by brainstorming in team. The ODB testing in test process and TAP file validation in validation process are the focused processes. Figure 3.19 is how-how diagram for ODB testing. Figure 3.20 is how-how diagram for TAP file validation.

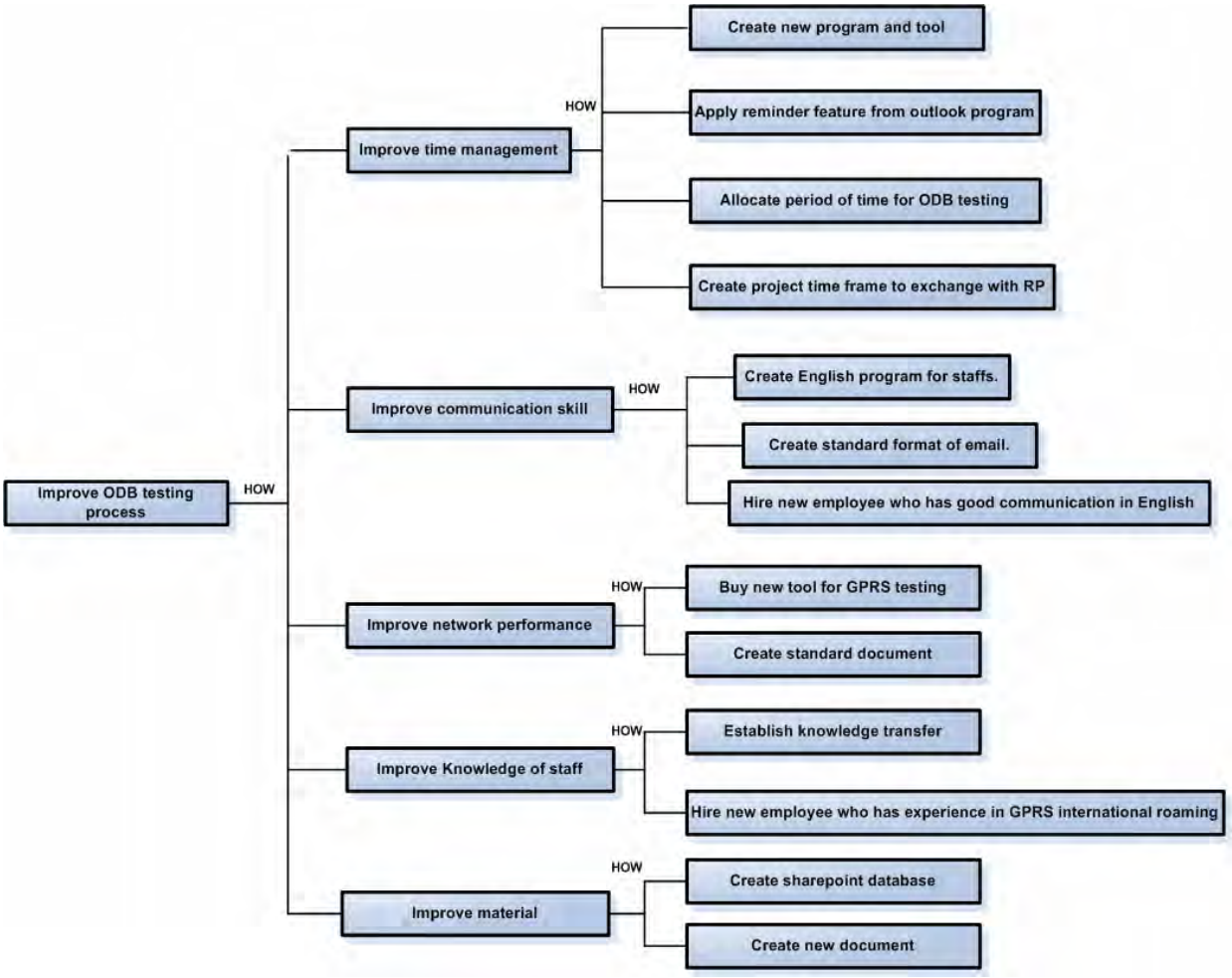



Figure 3.19: How-how diagram to find potential solutions for ODB testing process

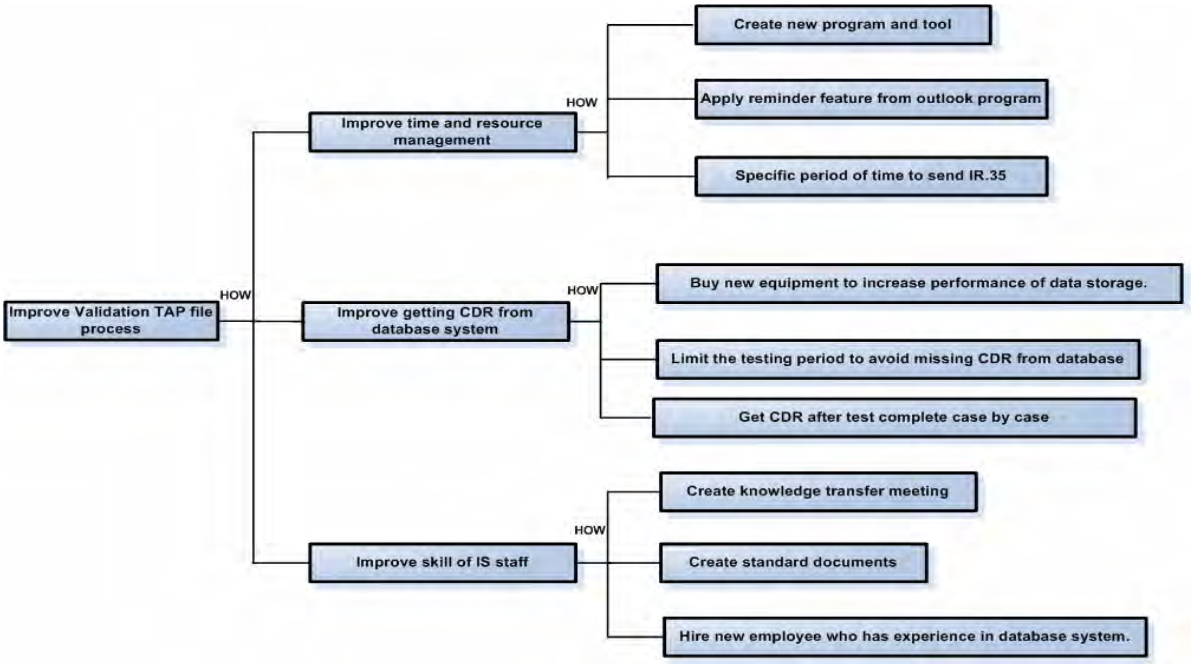



Figure 3.20: How-how diagram to find potential solutions for validation TAP file in validation process

In analysis phase, the root causes of problem have been defined. These root causes identified by the why-why and potential solutions by how-how techniques are considered in the next phase to find potential solutions for improvement of GPRS international roaming process accordingly.

## 3.4 Improve phase

This phase, the potential solution is the target output. So, tree diagram is selected to find the good solution for real implementing in pilot test. The inputs of tree diagram are from how-how diagram as previously detailed. These solutions are considered by mapping the why-why analysis whether they can react the causes of problem. Figure 3.21 shows analysis of ODB testing in testing process. Figure 3.22 shows analysis of TAP file validation in validation process. The score used in evaluating tree diagram rates from 1- the lowest score, to 5-the highest score.

- “5” refers to the highest correlation level of the cause and selection criteria.
- “4’ refers to a high correlation between the cause and selection criteria.
- “3” refers to a fair correlation between the cause and selection criteria.
- “2” refers to a low correlation between the cause and selection criteria.
- “1” refers to none correlation between the cause and selection criteria

| | | Low Impact | Possibility | Low cost | Total score | Rank | Continue? | Responsibility | Time period | Operating plan |
|---|---|---|---|---|---|---|---|---|---|---|
| Improve time management | Create new program and tool. | 1 | 1 | 1 | 3 | 6 | × | | | |
| | Apply reminder feature from outlook program | 5 | 5 | 5 | 15 | 1 | ✓ | All | 1/12/208-12/12/2008 | create standard format among teams |
| | Allocate period of time for ODB testing | 2 | 4 | 5 | 11 | 4 | × | | | |
| | Create project time frame to exchange with RP | 4 | 3 | 5 | 12 | 3 | ✓ | IB | 1/12/208-12/12/2008 | create document |
| Improve communi cation skill | Create English program for staffs. | 2 | 1 | 2 | 5 | 5 | × | | | |
| | Create standard format of email. | 5 | 5 | 5 | 15 | 1 | ✓ | All | 1/12/208-12/12/2008 | create standard format among teams |
| | Hire new employee | 1 | 1 | 1 | 3 | 6 | × | | | |
| Improve network performance | Buy new tool for GPRS testing | 1 | 1 | 1 | 3 | 6 | × | | | |
| | Create standard document | 3 | 4 | 5 | 12 | 3 | ✓ | DSN, IS | 1/12/208-19/12/2008 | Create standard documents |
| Improve knowledge of staff | Establish knowledge transfer | 5 | 5 | 4 | 14 | 2 | ✓ | DSN, IS | 1/12/208-19/12/2008 | Create material and meeting |
| | Hire new employee | 1 | 1 | 1 | 3 | 6 | × | | | |
| Improve material | Create shartpoint database | 4 | 5 | 5 | 14 | 2 | ✓ | IB | 1/12/208-19/12/2008 | Request database from helpdesk |
| | Create new document | 4 | 4 | 4 | 12 | 3 | ✓ | DSN,IS | 1/12/208-12/12/2008 | Create materials |

Figure 3.21: Tree diagram to find potential solution of improvement of ODB testing process

| | | Low Impact | Possibility | Low cost | Total score | Rank | Continue? | Responsibility | Time period | Operating plan |
|---|---|---|---|---|---|---|---|---|---|---|
| Improve time and resource management | Create new program and tool. | 1 | 1 | 1 | 3 | 4 | × | | | |
| | Apply reminder feature from outlook program | 5 | 5 | 5 | 15 | 1 | ✓ | All | 1/12/208-12/12/2008 | create standard format among teams |
| | Specific period of time to send IR.35 | 2 | 2 | 5 | 9 | 3 | × | | | |
| | | | | | | | | | | |
| Improve getting CDR from database | Buy new equipments to increase performance of data storage. | 1 | 1 | 1 | 3 | 4 | × | | | |
| | Limit the testing period to avoid missing CDR | 2 | 2 | 5 | 9 | 3 | × | | | |
| | Get CDR after test complete case by case | 5 | 5 | 5 | 15 | 1 | ✓ | DSN,IS | 1/12/208-12/12/2008 | define solution |
| | | | | | | | | | | |
| Improve skill of staff | Create knowledge transfer meeting | 5 | 5 | 3 | 13 | 2 | ✓ | DSN, IS | 1/12/208-19/12/2008 | Create standard documents |
| | Create standard documents | 5 | 4 | 4 | 13 | 2 | ✓ | DSN, IS | 1/12/208-19/12/2008 | Create material |
| | Hire new staff. | 1 | 1 | 1 | 3 | 4 | × | | | |
| | | | | | | | | | | |

Figure 3.22: Tree diagram to find potential solution of improvement of TAB file validation

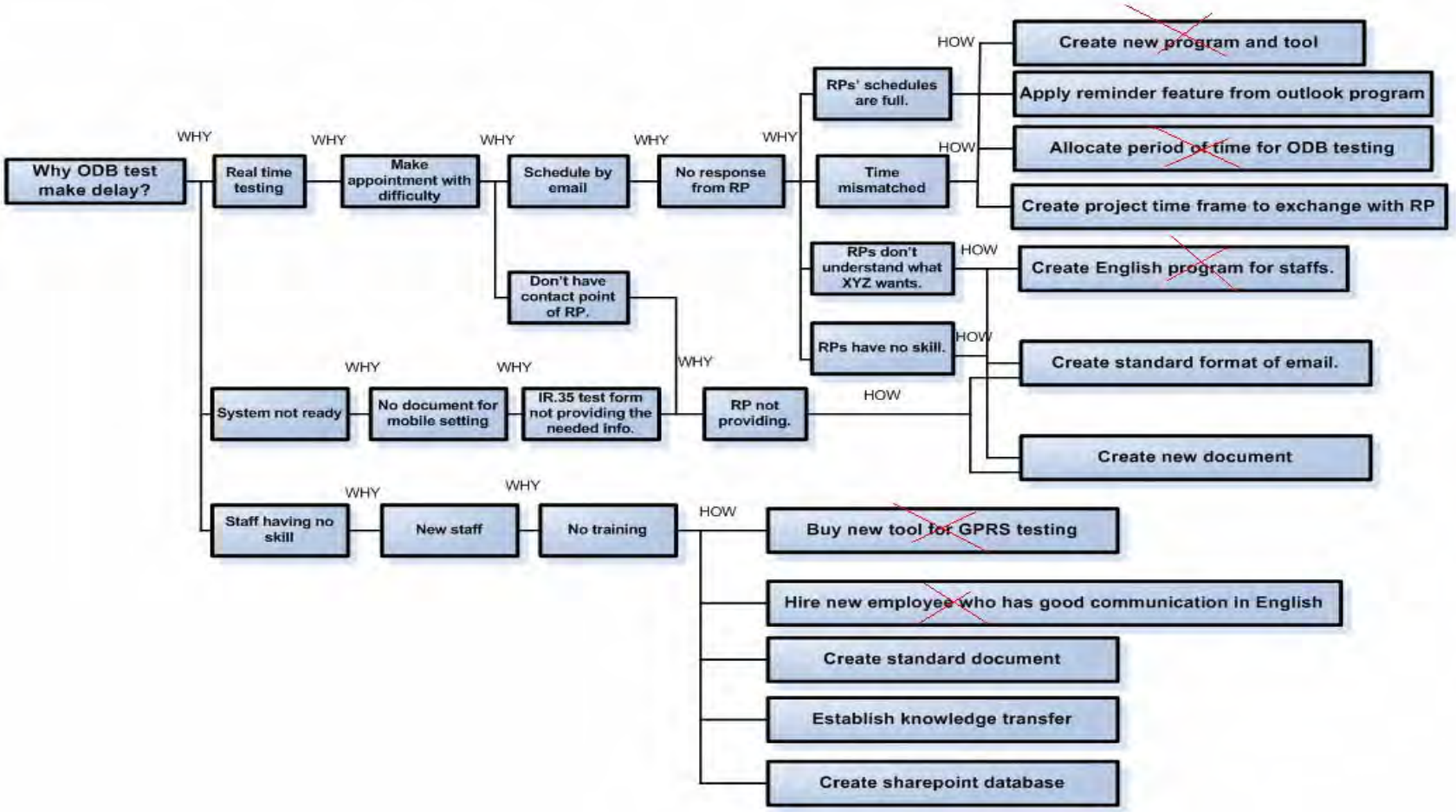



Figure 3.23: Why-why analysis and how-how analysis of improvement of ODB testing

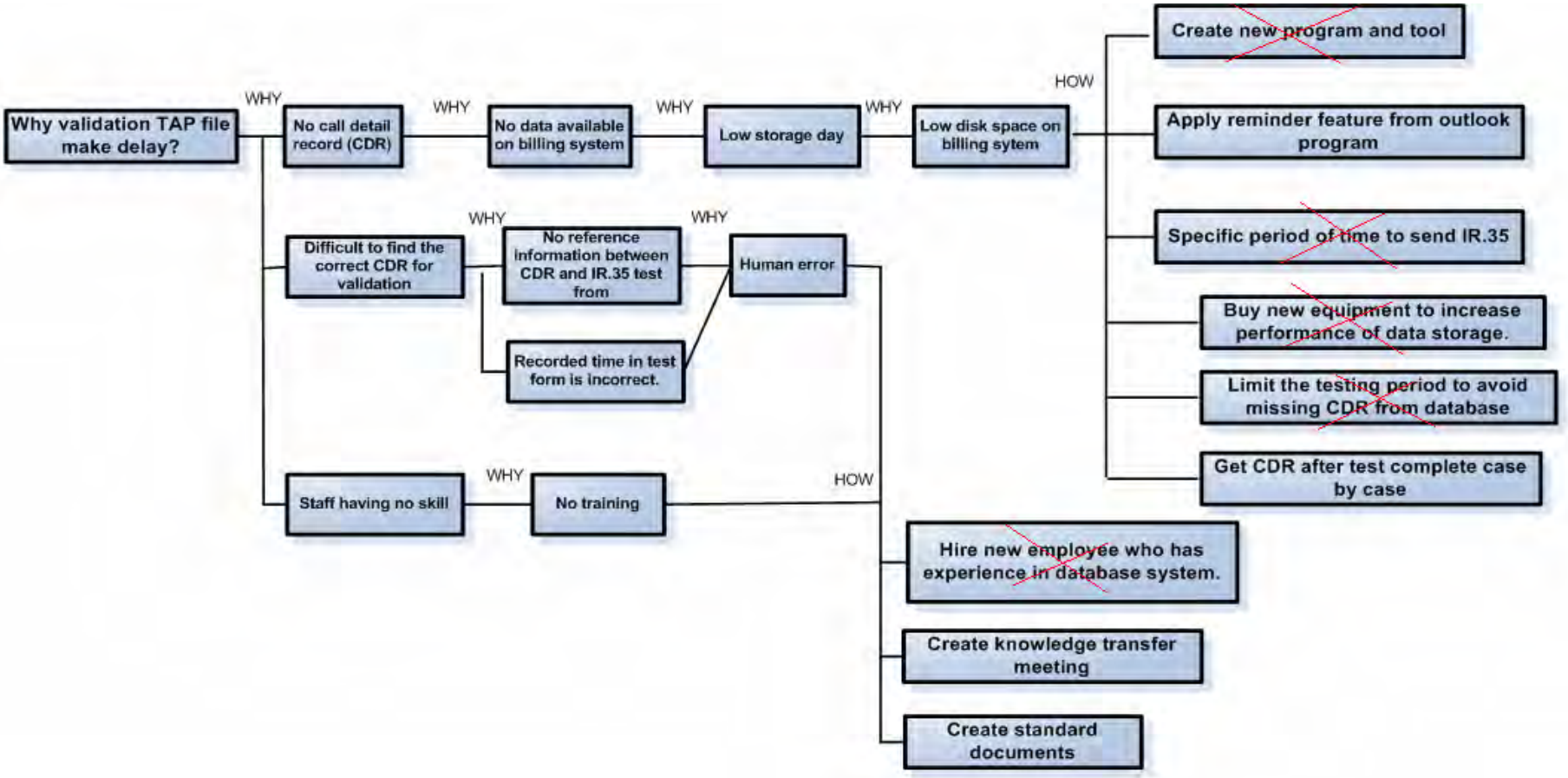



Figure 3.24: Why-why analysis and how-how analysis of improvement of TAP file validation

Considering to the why-why and how-how analysis as showing in Figure 3.23, the ODB testing case can be solved by

- Applying reminder feature from outlook program.
- Creating project time frame to exchange with the roaming partners.
- Create standard format of email.
- Create new document.
- Create standard document.
- Establish knowledge transfer.
- Create sharepoint database.

In Figure 3.24 for why-why and how-how analysis of TAP file validation, the solution can be:

- Applying reminder feature from outlook program.
- Getting CDR after test complete case by case.
- Creating knowledge transfer meeting.
- Creating standard document.

From these solutions, to meet the target that the average set-up time of overall GPRS international roaming process should be reduced, working these sub potential solutions case by case cannot be efficiently improved. As these results, the potential solutions in next topic are come from integration of sub potential solutions. They are the whole picture of improvement of GPRS international roaming process.

### *3.4.1 Potential solutions*

The potential solutions of improvement in GPRS international roaming process are proposed as three solutions. The first solution is applied the R-rearrange technique of ECRS. The secondary solution is applied the C-combine technique of ECRS. The last potential solution is applied the C-combine, R-rearrange, and S-simplify techniques of ECRS.

***Solution1:*** **Applying R-rearrange of ECRS technique**

From Figure 3.25, after International Business (IB) and roaming partner (RP) agree to verify GPRS service before establishing commercial launch to customers, IB

team have to make tentative schedule ODB testing three weeks forward or more depended on readiness of systems between both sites. If ODB testing is done completely, the other test cases are continued afterwards. So, the test process is in responsible of IB tester. Then, the validation is done after all test cases are completed and sent to IS team.

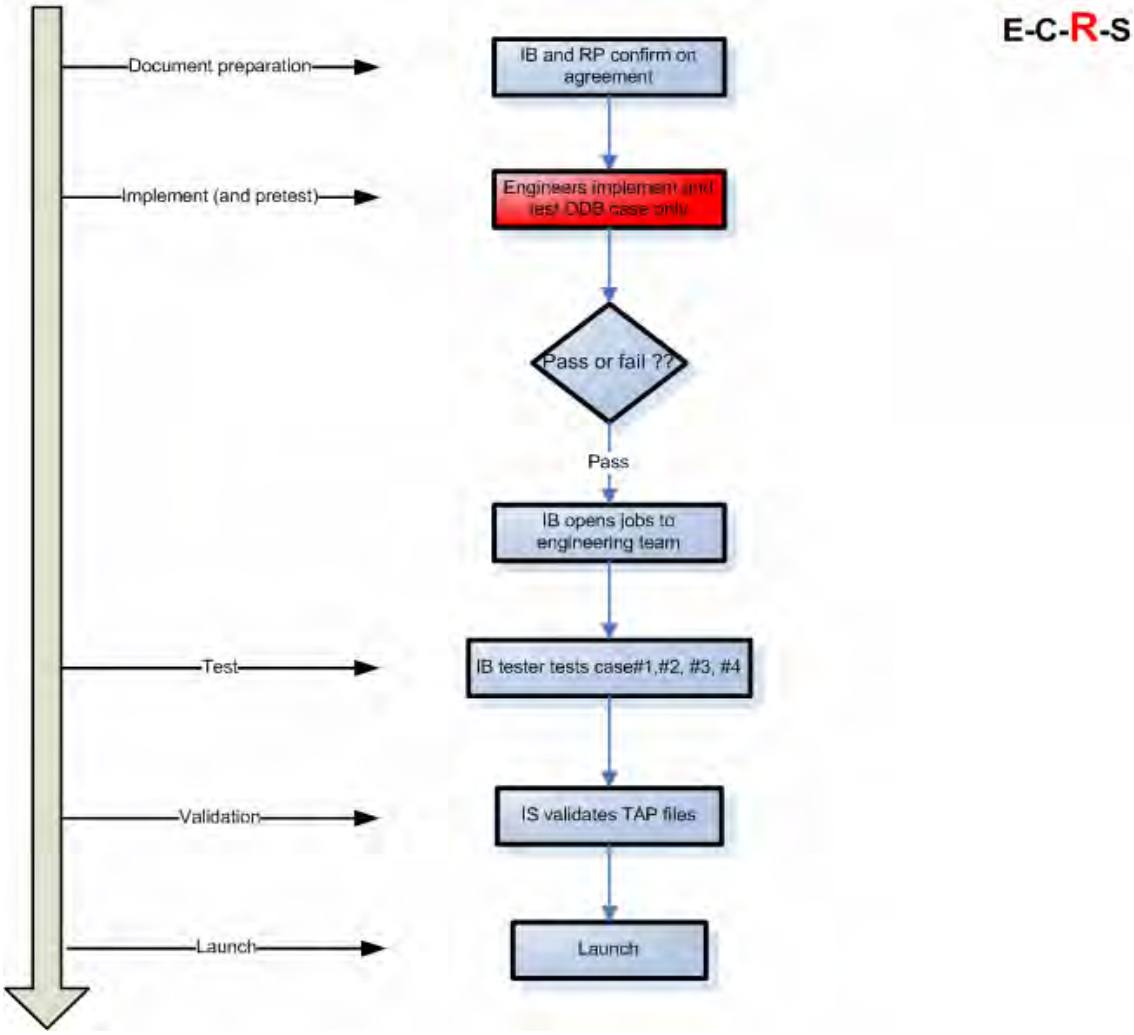



Figure 3.25: Potential solution 1, applied rearrange technique of ECRS

***Solution2*: Applying C-combine of ECRS technique**

The C-combine technique of ECRS is applied between test and validation processes as in Figure 3.26 to reduce the lead time and improve in missing CDR file from databases of IS team. The test and validation is separately done by IB tester, DSN and IS team. DSN also make appointment with roaming partner's engineer by

themselves after IB tester completes all test cases except ODB case. When ODB case is done, DSN has to inform IB for ending test phase.

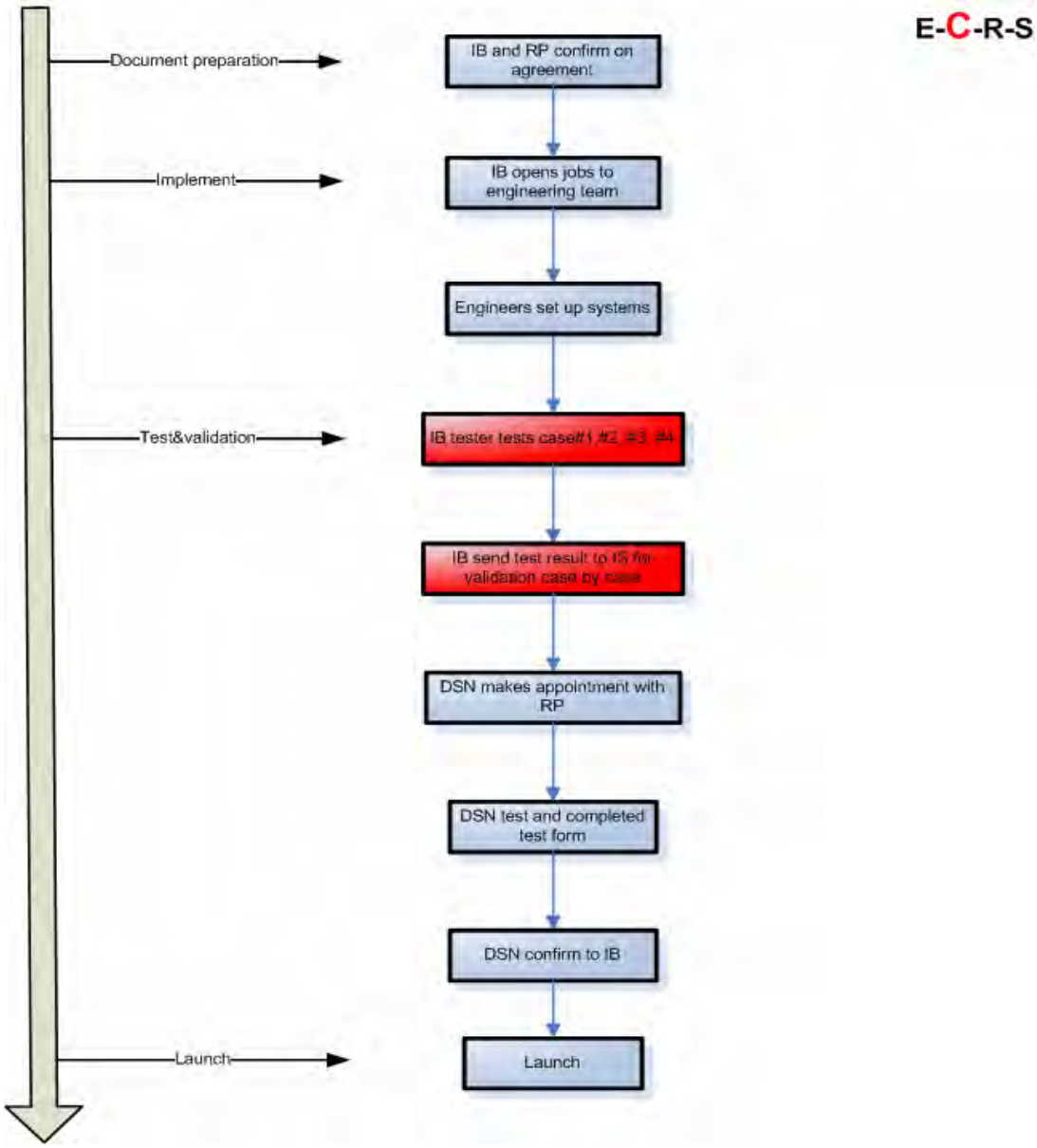



Figure 3.26: Potential solution 2, applied combine technique of ECRS

***Solution 3*: Applying C-combine, R-rearrange, and S-simplify of ECRS technique**

This solution is integration between solution 1 and 2. The C-combine technique is applied to merge test and validation processes together to reduce lead time and avoid missing of CDR file from database. The R-rearrange technique is applied for solving

the problem of ODB scheduling time. The ODB scheduling time is done by IB in the document preparation process after agreement is committed. The last technique which is S-simplify technique is applied for making process easier. The job request is not opened by paper or hard copy. It is opened by mailing among team. All job requests are collected into sharepoint of database. This database is for collecting and sharing all documents and information such as the job request, IR.21 or network configuration, IR.35 or test results and other related information. Figure 3.27 shows uncomplicated flow chart of solution 3.

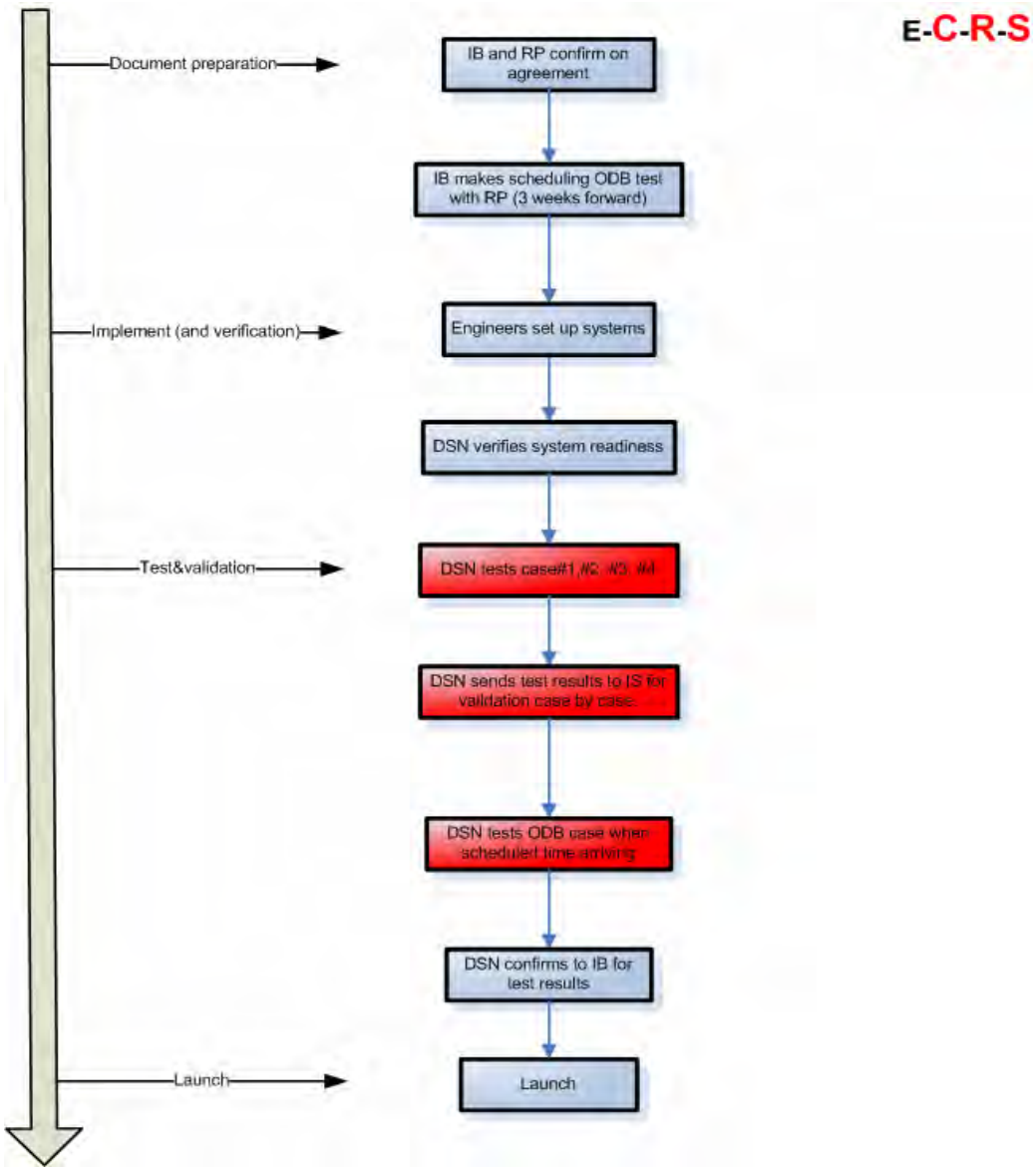



Figure 3.27: Potential solution 3, applied combine, rearrange and simplify technique of ECRS

### *3.4.2 Evaluation and selection*

After the potential solutions are defined as flow charts previously, evaluation and selection is the next step to find the best fit solution for improving the GPRS international roaming process. Then, the criterions are listed for evaluating and finding the best fit solution before the new suitable process is deployed to XYZ company. Parewise ranking is selected to weight criteria and the solution selection matrix is chosen to find only one solution for implementing afterwards.

Prospective criterions for new process improvement of GPRS international roaming are listed from brainstorming among teams.

1. Easy to implement
2. Clear picture for the whole process and job responsibility
3. Reduce lead-time
4. Good resource management
5. Low risk to failure
6. Good practice for other processes
7. Easy to control
8. Easy to understand and trace progress
9. Cost and benefit relationship
10. Low impact to others (process, team, job function)

#### 1. Pairwise ranking to weight criteria

Applying the pairwise ranking technique is to weight the criteria for next solution selection matrix. From the list of prospective criteria, voting among team is done as results in Table 3.16, and Table 3.17 shows total score and ranking after vote by pairing the criteria one by one.

| Criteria | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| 1. Easy to implement | | 2 | 3 | 4 | 5 | 1 | 7 | 8 | 9 | 10 |
| 2. Clear picture for the whole process and job responsibility | | | 3 | 4 | 5 | 2 | 7 | 2 | 9 | 2 |
| 3. Reduce lead-time | | | | 3 | 5 | 3 | 3 | 3 | 9 | 3 |
| 4. Good resource management | | | | | 5 | 4 | 7 | 4 | 9 | 4 |
| 5. Low risk to failure | | | | | | 5 | 5 | 5 | 9 | 5 |
| 6. Good practice for other processes | | | | | | | 7 | 8 | 9 | 10 |
| 7. Easy to control time | | | | | | | | 7 | 9 | 7 |
| 8. Easy to understand and trace job progress | | | | | | | | | 9 | 8 |
| 9. Cost and benefit relationship | | | | | | | | | | 9 |
| 10. Low Impact to others (process, team, job function) | | | | | | | | | | |
| | | | | | | | | | | |
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| Total score | 1 | 4 | 7 | 5 | 8 | 0 | 6 | 3 | 9 | 2 |

Table 3.16: Pairwise ranking to weight criteria

| Criteria | Score | Ranking |
|---|---|---|
| 1. Easy to implement | 1 | 9 |
| 2. Clear picture for the whole process and job responsibility | 4 | 6 |
| 3. Reduce lead-time | 7 | 3 |
| 4. Good resource management | 5 | 5 |
| 5. Low risk to failure | 8 | 2 |
| 6. Good practice for other processes | 0 | 10 |
| 7. Easy to control time | 6 | 4 |
| 8. Easy to understand and trace job progress | 3 | 7 |
| 9. Cost and benefit relationship | 9 | 1 |
| 10. Impact to others (process, team, job function) | 2 | 8 |

Table 3.17: Total score and ranking the criteria after applied the pairwise ranking

In summary in weighting criteria, the results from ranking from Table 3.17 are:

1. Cost and benefit relationship
2. Low risk to failure
3. Reduce lead-time
4. Easy to control time
5. Good resource management
6. Clear picture for the whole process and job responsibility
7. Easy to understand and trace job progress
8. Low impact to others (process, team, job function)
9. Easy to implement
10. Good practice for other processes

## 2. Solution selection matrix

After identified the rank of how important each criteria is, these criterions are given the weight for the solution selection matrix from 1 to 3 as defined in weight row in Table 3.18. The solution 1 to solution 3 are put for voting the point based on each criterion. Then the total scores are calculated by raw score (1-10) multiplied by weight. The total scores of all are ranked again for selecting the best solution for implementation. The result from solution selection matrix shows that the best solution that should be the best fit for improvement of the GPRS international roaming process is solution 3.

| Criteria | #1 (1. Easy to implement) | #2 (2. Clear picture for the whole process and job responsibility) | #3 (3. Reduce lead-time) | #4 (4. Good resource management) | #5 (5. Low risk to fail use) | #6 (6. Good practice for other processes) | #7 (7. Easy to control time) | #8 (8. Easy to understand and trace job progress) | #9 (9. Cost and benefit relationship) | #10 (10. Low impact to others (process, team, job function)) | Total Score | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Weight | 1 | 2 | 2.5 | 2 | 3 | 1 | 2.5 | 1.5 | 3 | 1.5 | | |
| 1. solution #1 | 9 | 16 | 16 | 13 | 18 | 6 | 15 | 11 | 20 | 13.5 | 136.75 | 3 |
| 2. solution #2 | 8 | 14 | 18 | 16 | 18 | 6 | 15 | 9.8 | 21 | 12.8 | 138 | 2 |
| 3. solution #3 | 7 | 14 | 21 | 17 | 26 | 7.5 | 20 | 11 | 26 | 12.8 | 161.75 | 1 |

Table 3.18: Solution selection matrix

### *3.4.3 Best solution and "to be"*

After the best solution is selected by solution selection matrix, the overall new flow chart for implementing in pilot test is considered based on why-why and how-how analysis.

## 1. New flow chart of the GPRS international roaming process

With Figure 3.28, the details of input and output are identified in each process in order to provide clear picture what information is needed among teams. Then, the full new flow chart of the GPRS international roaming process is detailed by Figure 3.29. There are three main points modified which are:

1. In the documentation preparation phase, IB has to collect all mandatory information which is needed for implementation, test and validation phases.

Additionally, IB has to commit with roaming partner for the time frame including the contact point name, mobile number and mobile setting document for ODB test before opening job request to engineering team.

2. The all tests are in the responsibilities of engineering team which are DSN and IS for test and validation phase.
3. Validation process is combined in the test phase, and validation is done case by case until all test cases in IR.35 test form is done completely.

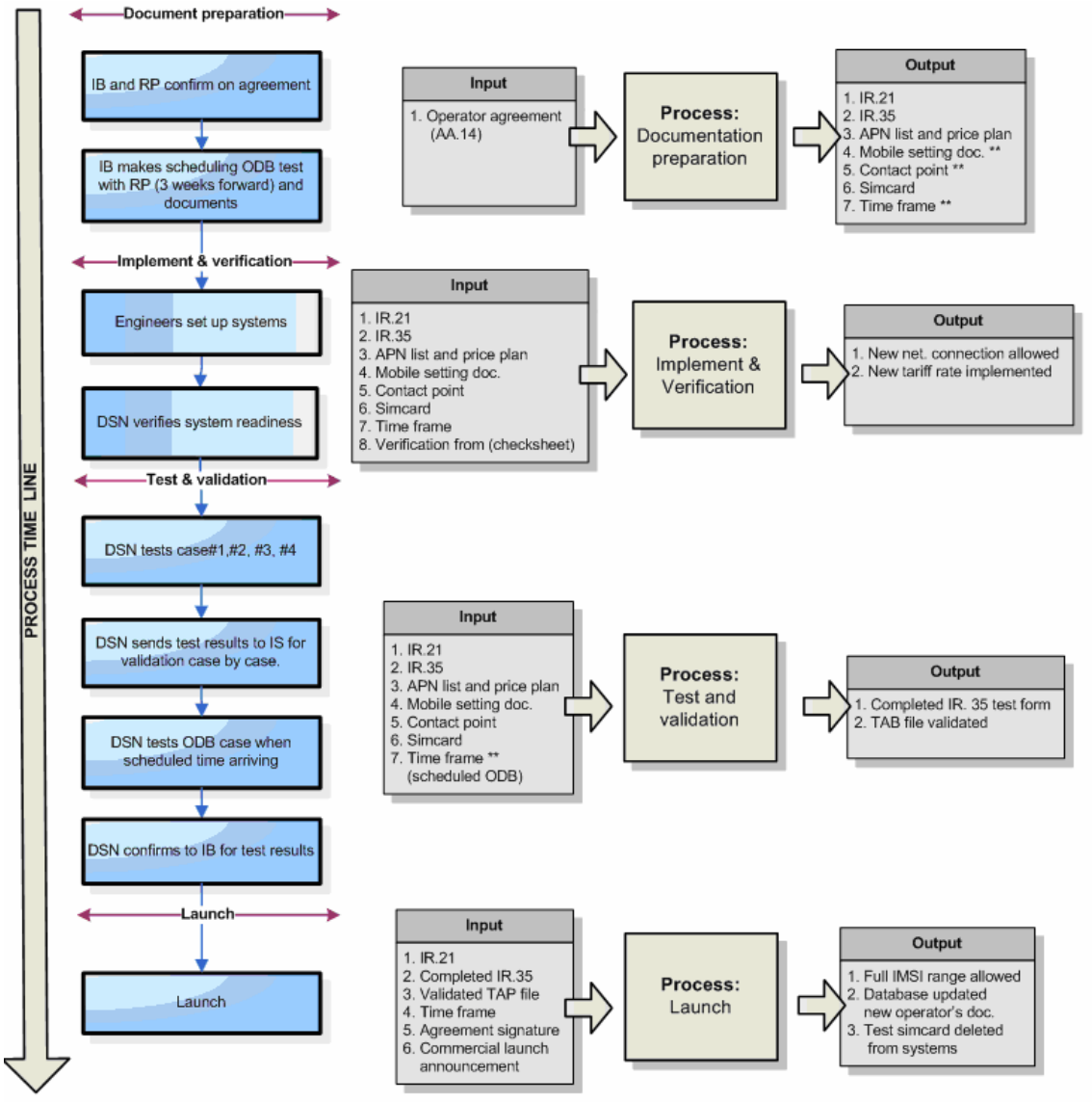



Figure 3.28: Input and output in each process

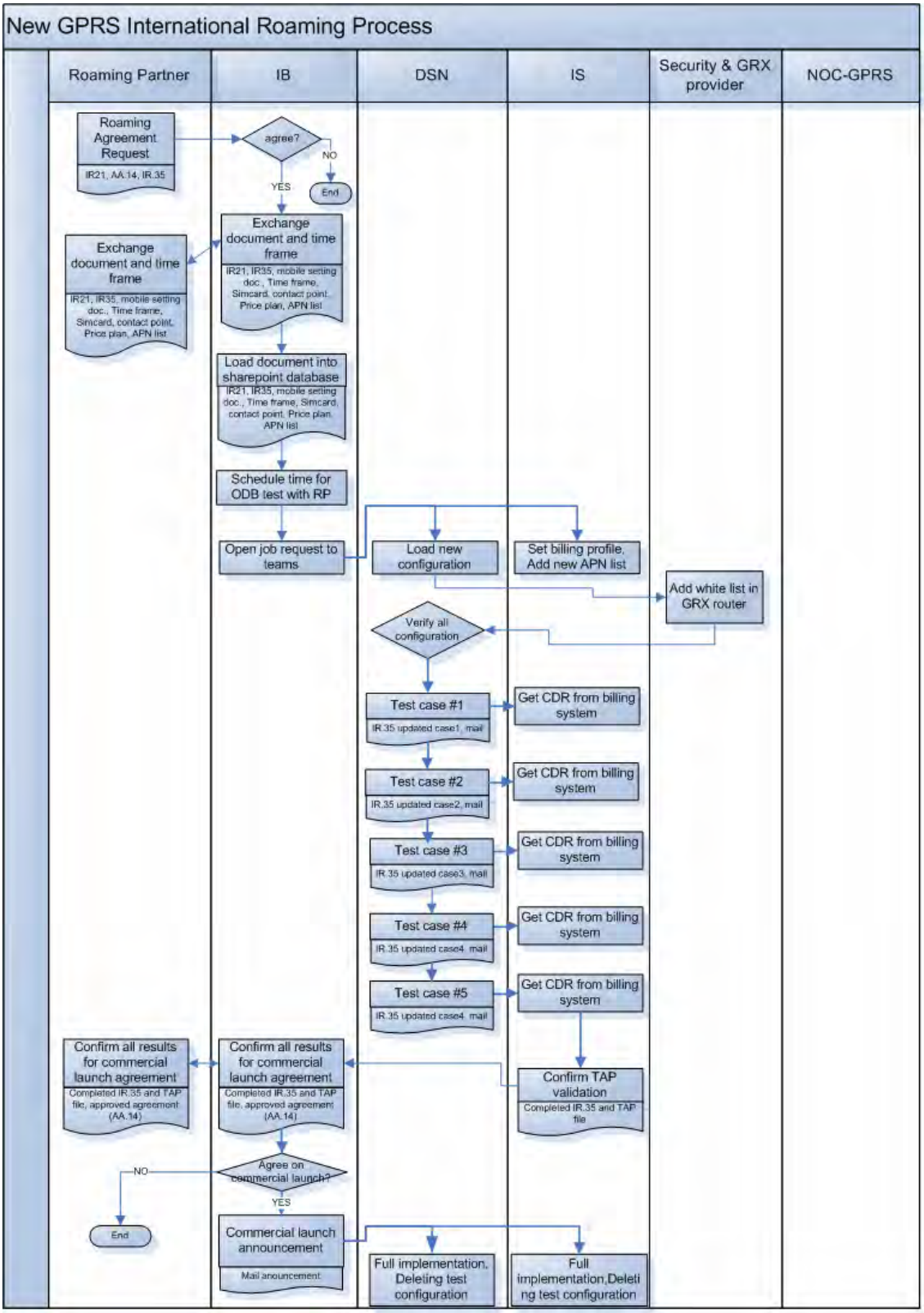



Figure 3.29: Full new process flow chart

## 2. New SIPOC for the GPRS international roaming process

With the new process flow chart proposed previously, the SIPOC is one of the most important things which can make the GPRS international roaming process complete and make the process run smoothly. The SIPOC is a key to make the whole process of GPRS international roaming service fit in the process time line. It is committed among teams in brainstorming meeting.

| Supplier | Input | Process | Output | Customer |
|---|---|---|---|---|
| IB, RP | AA. 14 (roaming agreement) | 1. Documentation preparation | IR.21, IR.35, APN list and price plan, Mobile setting document, Contact point, Simcard, Time frame | IB, Engineering team (DSN, IS) |
| IB | Job request, all document loaded into database | 2. Implementation and verification | System readiness and verification results | Engineering team (DSN, IS) |
| Engineering team (DSN, IS) | Validated IR.35, Validated TAP files | 3. Test and validation | Test results and approved agreement | IB |
| IB, RP | Validated IR.35, Validated TAP files, Test results and approved agreement | 4. Launch | Commercial launch announcement | Engineering team (DSN, IS) |

Table 3.19: SIPOC of new GPRS international roaming process

### *3.4.4 Pilot test and Full-scale implementation plan*

Before the new GPRS international roaming process is distributed into XYZ company, the pilot testing is verified whether the new process can meet the objective which is the reducing of the set-up time for new GPRS international roaming service. The pilot time frame starts from 5 January 2009 until 30 April 2009 based on new base line. In addition, before the process starts, there are some tasks to prepare first. The pre-kick off meeting is required to distribute these tasks. All activities are concluded in project plan. The details for running the pilot test are:

- Number of operators : 10 operators
- Main resources : IB, DSN, and IS
- Pilot test time line : 5 January – 30 April 2009
- List of tasks and documents which should be prepared :

- Database (sharepoint), it is used for sharing all documents among teams for GPRS international roaming service.
- Standard documents, these documents are needed for exchanging mandatory information between XYZ company and roaming partners for implementing and testing.
    - Time frame
    - Verification checksheet
    - Mobile setting document
    - Simcard management database
    - Training documents
        - Basic GPRS international roaming service
        - Implementation GPRS international roaming service
        - GPRS CDR
        - CDR validation

The full scale implementation plan is identified by Microsoft project in Figure 3.30. This project plan is used for collecting and tracing the time line, resource usage and project progress of the 10 sample operators.

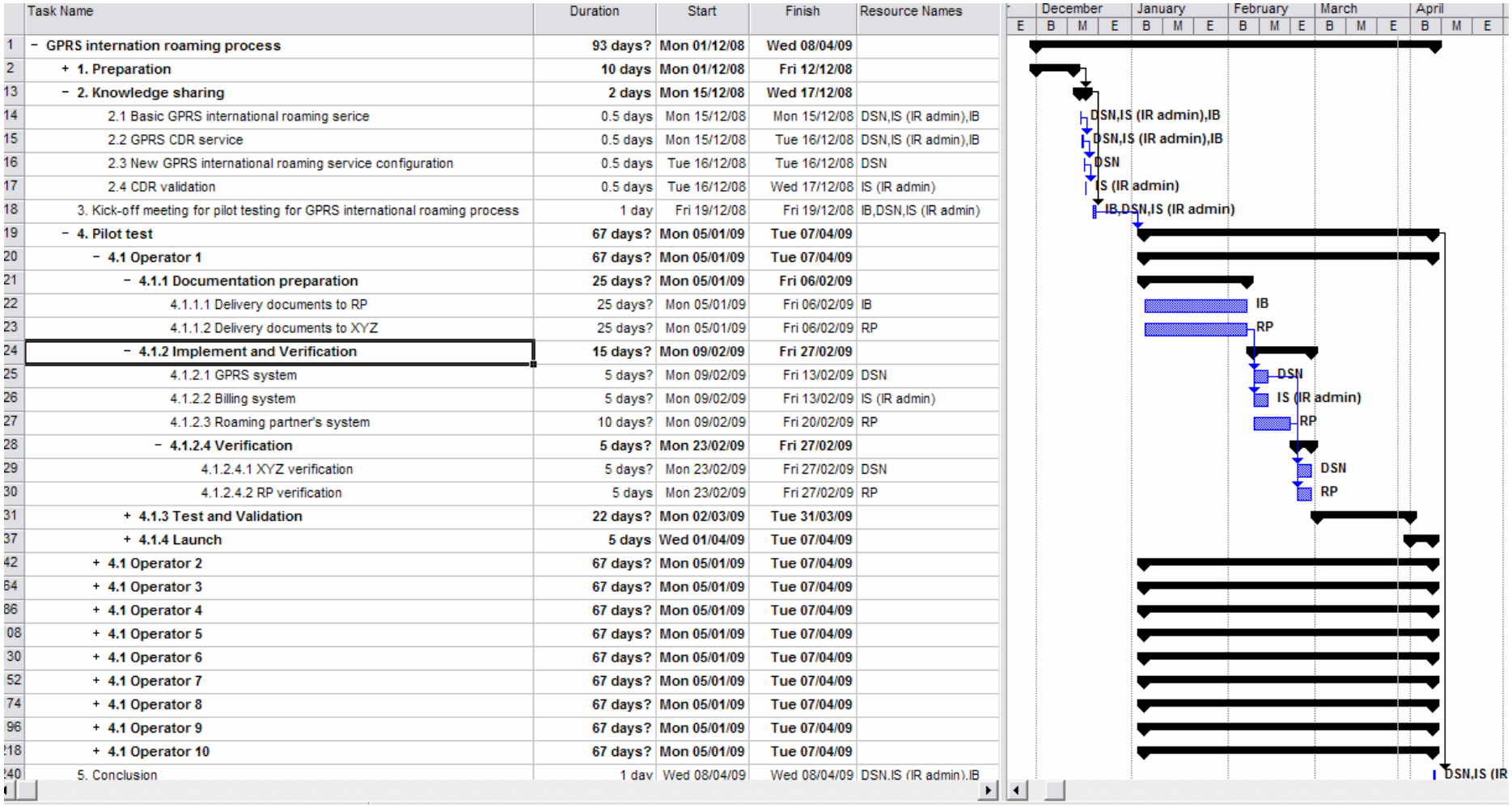



Figure 3.30: Full scale implementation plan

## 3.5 Control phase

In the control phase, the implementation of each task has been running following the full-scale implementation plan. It starts from the documentation preparation phase to launch phase. In the documentation preparation, the SIPOC in Table 3.19 details that the necessary output to support implementation is the schedule time frame. It uses for synchronization between XYZ company and other operators to manage the time line. Table 3.20 details the tentative time frame for each significant process, especially the ODB case scheduling and target commercial launch. Subsequently, the actual implementation time frame of each task is summarized by Table 3.19. Figure 3.31 to 3.40 show the whole time frame of each operator. The actual work hour of each team for implementing each task is illustrated separately in Appendix A, because work hour analysis cannot be calculated in actual details. The allocated work hour of each person is not same and has no pattern. So, the resource management is ignored.

### *3.5.1 Tentative implementation time frame*

| No. | Tentative dead line | Operator#1 | Operator#2 | Operator#3 | Operator#4 | Operator#5 | Operator#6 | Operator#7 | Operator#8 | Operator#9 | Operator#10 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Document and simcard delivery (IR.21, IR.35, Mobile setting, APN list, Simcard) | 06/02/2009 | 30/01/2009 | 26/01/2009 | 20/01/2009 | 26/01/2009 | 30/01/2009 | 30/01/2009 | 18/01/2009 | 20/01/2009 | 23/01/2009 |
| 2 | Implement & verification | 16/02/2009 | 13/02/2009 | 26/02/2009 | 27/01/2009 | 20/02/2009 | 16/02/2009 | 02/03/2009 | 30/01/2009 | 02/02/2009 | 27/02/2009 |
| 3 | Verification confirmation | 20/02/2009 | 16/02/2009 | 26/02/2009 | 28/01/2009 | 20/02/2009 | 17/02/2009 | 18/03/2009 | 02/02/2009 | 03/02/2009 | 02/03/2009 |
| 4 | ODB case scheduling | 25/02/2009 | 19/02/2009 | 26/02/2009 | 29/01/2009 | 04/03/2009 | 18/02/2009 | 18/03/2009 | 11/02/2009 | 05/02/2009 | 05/03/2009 |
| 5 | Complete IR.35 | 23/03/2009 | 25/02/2009 | 16/03/2009 | 19/02/2009 | 16/03/2009 | 04/03/2009 | 31/03/2009 | 06/03/2009 | 27/02/2009 | 25/03/2009 |
| 6 | Send TAP out | 26/03/2009 | 04/03/2009 | 23/03/2009 | 18/03/2009 | 27/03/2009 | 06/03/2009 | 31/03/2009 | 13/03/2009 | 03/02/2009 | 27/03/2009 |
| 7 | Target commercial launch | 01/04/2009 | 30/03/2009 | 06/04/2009 | 01/04/2009 | 01/04/2009 | 01/04/2009 | 04/04/2009 | 31/03/2009 | 16/03/2009 | 05/04/2009 |

Table 3.20: Tentative implementation time frame of each operator

### *3.5.2 The actual implementation time frame of each operator*

| | Operator#1 | | Operator#2 | | Operator#3 | | Operator#4 | | Operator#5 | | Operator#6 | | Operator#7 | | Operator#8 | | Operator#9 | | Operator#10 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Start time | End time | Start time | End time | Start time | End time | Start time | End time | Start time | End time | Start time | End time | Start time | End time | Start time | End time | Start time | End time | Start time | End time |
| **4.1 Documentation preparation** | 05/01/2009 | 03/02/2009 | 05/01/2009 | 20/01/2009 | 05/01/2009 | 19/01/2009 | 05/01/2009 | 20/01/2009 | 05/01/2009 | 28/01/2009 | 05/01/2009 | 28/01/2009 | 05/01/2009 | 20/01/2009 | 05/01/2009 | 19/01/2009 | 05/01/2009 | 28/01/2009 | 05/01/2009 | 22/01/2009 |
| 4.1.1 Delivery documents to RP (IR doc. + Sim) | 05/01/2009 | 23/01/2009 | 05/01/2009 | 13/01/2009 | 05/01/2009 | 19/01/2009 | 05/01/2009 | 12/01/2009 | 05/01/2009 | 14/01/2009 | 05/01/2009 | 14/01/2009 | 05/01/2009 | 15/01/2009 | 05/01/2009 | 13/01/2009 | 05/01/2009 | 16/01/2009 | 05/01/2009 | 13/01/2009 |
| 4.1.1.2 Delivery documents to XYZ | 06/01/2009 | 03/02/2009 | 07/01/2009 | 20/01/2009 | 05/01/2009 | 14/01/2009 | 06/01/2009 | 20/01/2009 | 07/01/2009 | 28/01/2009 | 13/01/2009 | 28/01/2009 | 07/01/2009 | 20/01/2009 | 08/01/2009 | 19/01/2009 | 05/01/2009 | 28/01/2009 | 06/01/2009 | 22/01/2009 |
| **4.2 Implement and Verification** | 23/01/2009 | 04/02/2009 | 13/01/2009 | 27/01/2009 | 14/01/2009 | 27/01/2009 | 12/01/2009 | 23/01/2009 | 14/01/2009 | 04/02/2009 | 14/01/2009 | 06/02/2009 | 15/01/2009 | 26/01/2009 | 13/01/2009 | 27/01/2009 | 16/01/2009 | 04/02/2009 | 13/01/2009 | 27/01/2009 |
| 4.2.1 GPRS system | 23/01/2009 | 28/01/2009 | 20/01/2009 | 23/01/2009 | 14/01/2009 | 19/01/2009 | 20/01/2009 | 23/01/2009 | 28/01/2009 | 04/02/2009 | 28/01/2009 | 04/02/2009 | 20/01/2009 | 26/01/2009 | 19/01/2009 | 23/01/2009 | 28/01/2009 | 04/02/2009 | 22/01/2009 | 26/01/2009 |
| 4.2.2 Billing system | 23/01/2009 | 27/01/2009 | 20/01/2009 | 23/01/2009 | 14/01/2009 | 16/01/2009 | 20/01/2009 | 23/01/2009 | 28/01/2009 | 02/02/2009 | 28/01/2009 | 02/02/2009 | 20/01/2009 | 23/01/2009 | 19/01/2009 | 22/01/2009 | 28/01/2009 | 02/02/2009 | 22/01/2009 | 26/01/2009 |
| 4.2.3 Roaming partner's system | 23/01/2009 | 04/02/2009 | 13/01/2009 | 26/01/2009 | 19/01/2009 | 27/01/2009 | 12/01/2009 | 23/01/2009 | 14/01/2009 | 20/01/2009 | 14/01/2009 | 06/02/2009 | 15/01/2009 | 23/01/2009 | 13/01/2009 | 26/01/2009 | 16/01/2009 | 27/01/2009 | 13/01/2009 | 20/01/2009 |
| **4.1.2.4 Verification** | 02/02/2009 | 04/02/009 | 23/01/2009 | 27/01/2009 | 19/01/2009 | 27/01/2009 | 23/01/2009 | 23/01/2009 | 20/01/2009 | 04/02/2009 | 04/02/2009 | 06/02/2009 | 23/01/2009 | 26/01/2009 | 23/01/2009 | 27/01/2009 | 27/01/2009 | 04/02/2009 | 20/01/2009 | 27/01/2009 |
| 4.2.4.1 XYZ verification | 02/02/2009 | 04/02/2009 | 23/01/2009 | 27/01/2009 | 19/01/2009 | 19/01/2009 | 23/01/2009 | 23/01/2009 | 04/02/2009 | 04/02/2009 | 04/02/2009 | 06/02/2009 | 26/01/2009 | 26/01/2009 | 23/01/2009 | 27/01/2009 | 04/02/2009 | 04/02/2009 | 26/01/2009 | 27/01/2009 |
| 4.2.4.2 RP verification | 04/02/2009 | 04/02/009 | 26/01/2009 | 26/01/2009 | 27/01/2009 | 27/01/2009 | 23/01/2009 | 23/01/2009 | 20/01/2009 | 04/02/2009 | 06/02/2009 | 06/02/2009 | 23/01/2009 | 23/01/2009 | 26/01/2009 | 26/01/2009 | 27/01/2009 | 04/02/2009 | 20/01/2009 | 26/01/2009 |
| **4.3 Test and Validation** | 04/02/2009 | 02/03/2009 | 28/01/2009 | 23/02/2009 | 21/01/2009 | 02/03/2009 | 04/02/2009 | 25/02/2009 | 06/02/2009 | 06/03/2009 | 18/02/2009 | 20/03/2009 | 04/03/2009 | 19/03/2009 | 11/02/2009 | 19/03/2009 | 05/02/2009 | 19/02/2009 | 05/03/2009 | 23/03/2009 |
| 4.3.1 Case 1 | 04/02/2009 | 09/02/2009 | 28/01/2009 | 05/02/2009 | 26/01/2009 | 06/02/2009 | 04/02/2009 | 09/02/2009 | 06/02/2009 | 12/02/2009 | 19/02/2009 | 02/03/2009 | 04/03/2009 | 10/03/2009 | 11/02/2009 | 27/02/2009 | 05/02/2009 | 05/02/2009 | 05/03/2009 | 09/03/2009 |
| 4.3.2 Case 2 | 04/02/2009 | 09/02/2009 | 03/02/2009 | 05/02/2009 | 26/01/2009 | 06/02/2009 | 04/02/2009 | 09/02/2009 | 06/02/2009 | 12/02/2009 | 20/02/2009 | 02/03/2009 | 04/03/2009 | 10/03/2009 | 18/02/2009 | 27/02/2009 | 05/02/2009 | 13/02/2009 | 05/03/2009 | 09/03/2009 |
| 4.3.3 Case 3 | 05/02/2009 | 16/02/2009 | 03/02/2009 | 05/02/2009 | 29/01/2009 | 06/02/2009 | 04/02/2009 | 25/02/2009 | 09/02/2009 | 12/02/2009 | 25/02/2009 | 20/03/2009 | 09/03/2009 | 12/03/2009 | 24/02/2009 | 12/03/2009 | 13/02/2009 | 17/02/2009 | 11/03/2009 | 23/03/2009 |
| 4.3.4 Case 4 | 05/02/2009 | 25/02/2009 | 03/02/2009 | 05/02/2009 | 30/012009 | 12/02/009 | 17/02/2009 | 25/02/2009 | 09/02/2009 | 12/02/2009 | 25/02/2009 | 20/03/2009 | 10/03/2009 | 19/03/2009 | 23/02/2009 | 19/03/2009 | 13/02/2009 | 17/02/2009 | 11/03/2009 | 23/03/2009 |
| 4.3.5 Case 5 | 25/02/2009 | 25/02/2009 | 19/02/2009 | 19/02/2009 | 26/02/2009 | 26/02/2009 | 29/01/2009 | 02/02/2009 | 04/03/2009 | 04/03/2009 | 18/02/2009 | 18/02/2009 | 04/03/2009 | 04/03/2009 | 11/02/2009 | 18/02/2009 | 05/02/2009 | 05/02/2009 | 05/03/2009 | 05/03/2009 |
| **4.4 Launch** | 16/03/2009 | 25/03/2009 | 18/03/2009 | 30/03/2009 | 25/03/2009 | 03/04/2009 | 27/03/2009 | 01/04/2009 | 23/03/2009 | 07/04/2009 | 27/03/2009 | 01/04/2009 | 30/03/2009 | 07/04/2009 | 05/03/2009 | 11/03/2009 | 09/03/2009 | 17/03/2009 | 31/03/2009 | 08/04/2009 |
| 4.4.1 Commercial launch announcement | 16/03/2009 | 16/03/2009 | 18/03/2009 | 18/03/2009 | 25/03/2009 | 25/03/2009 | 27/03/2009 | 27/03/2009 | 23/03/2009 | 23/03/2009 | 27/03/2009 | 27/03/2009 | 30/03/2009 | 30/03/2009 | 05/03/2009 | 05/03/2009 | 09/03/2009 | 09/03/2009 | 31/03/2009 | 31/03/2009 |
| **4.4.2 Full configuration** | 19/03/2009 | 25/03/2009 | 25/03/2009 | 30/03/2009 | 31/03/2009 | 03/04/2009 | 30/03/2009 | 01/04/2009 | 30/03/2009 | 07/04/2009 | 30/03/2009 | 01/04/2009 | 01/04/2009 | 07/04/2009 | 09/03/2009 | 11/03/2009 | 13/03/2009 | 17/03/2009 | 07/04/2009 | 08/04/2009 |
| 4.4.2.1 Full IMSI range allowance | 25/03/2009 | 25/03/2009 | 30/03/2009 | 30/03/2009 | 03/04/2009 | 03/04/2009 | 01/04/2009 | 01/04/2009 | 07/04/2009 | 07/04/2009 | 01/04/2009 | 01/04/2009 | 07/04/2009 | 07/04/2009 | 11/03/2009 | 11/03/2009 | 17/03/2009 | 17/03/2009 | 08/04/2009 | 08/04/2009 |
| 4.4.2.2 TAP file update | 19/03/2009 | 20/03/2009 | 25/03/2009 | 27/03/2009 | 31/03/2009 | 02/04/2009 | 30/03/2009 | 31/03/2009 | 30/03/2009 | 01/04/2009 | 30/03/2009 | 31/03/2009 | 01/04/2009 | 03/04/2009 | 09/03/2009 | 11/03/2009 | 13/03/2009 | 16/03/2009 | 07/04/2009 | 07/04/2009 |
| **Commercial launch** | 25/03/2009 | | 30/03/2009 | | 03/04/2009 | | 01/04/2009 | | 07/04/2009 | | 01/04/2009 | | 07/04/2009 | | 11/03/2009 | | 17/03/2009 | | 08/04/2009 | |

Table 3.21: Actual implementation time frame of each operator

| Task Name | Baseline Duration | Duration | Start | Finish | % Work complete | Resource Names |
|---|---|---|---|---|---|---|
| − GPRS internation roaming process | 93 days | 93 days? | Mon 01/12/08 | Wed 08/04/09 | 100% | |
| + 1. Preparation | 10 days | 11 days | Mon 01/12/08 | Mon 15/12/08 | 100% | |
| + 2. Knowledge sharing | 2 days | 2 days | Mon 15/12/08 | Wed 17/12/08 | 100% | |
| 3. Kick-off meeting for pilot testing for GPRS interna | 1 day | 0.5 days | Fri 19/12/08 | Fri 19/12/08 | 100% | IB,DSN,IS (IR admin) |
| − 4. Pilot test | 67 days | 68 days? | Mon 05/01/09 | Wed 08/04/09 | 100% | |
| − 4.1 Operator 1 | 67 days | 57.5 days | Mon 05/01/09 | Wed 25/03/09 | 100% | |
| − 4.1.1 Documentation preparation | 25 days | 21 days | Mon 05/01/09 | Tue 03/02/09 | 100% | |
| 4.1.1.1 Delivery documents to RP | 25 days | 14 days | Mon 05/01/09 | Fri 23/01/09 | 100% | IB |
| 4.1.1.2 Delivery documents to XYZ | 25 days | 20 days | Tue 06/01/09 | Tue 03/02/09 | 100% | RP |
| − 4.1.2 Implement and Verification | 15 days | 17.56 days | Mon 12/01/09 | Wed 04/02/09 | 100% | |
| 4.1.2.1 GPRS system | 5 days | 3 days | Fri 23/01/09 | Wed 28/01/09 | 100% | DSN |
| 4.1.2.2 Billing system | 5 days | 2 days | Mon 12/01/09 | Mon 02/02/09 | 100% | IS (IR admin) |
| 4.1.2.3 Roaming partner's system | 10 days | 8 days | Fri 23/01/09 | Wed 04/02/09 | 100% | RP |
| − 4.1.2.4 Verification | 5 days | 2.5 days | Mon 02/02/09 | Wed 04/02/09 | 100% | |
| 4.1.2.4.1 XYZ verification | 5 days | 2.5 days | Mon 02/02/09 | Wed 04/02/09 | 100% | DSN |
| 4.1.2.4.2 RP verification | 5 days | 0 days | Wed 04/02/09 | Wed 04/02/09 | 100% | RP |
| − 4.1.3 Test and Validation | 22 days | 15.5 days | Wed 04/02/09 | Wed 25/02/09 | 100% | |
| 4.1.3.1 Case 1 | 22 days | 3.5 days | Wed 04/02/09 | Mon 09/02/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.2 Case 2 | 22 days | 3.5 days | Wed 04/02/09 | Mon 09/02/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.3 Case 3 | 22 days | 7 days | Thu 05/02/09 | Mon 16/02/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.4 Case 4 | 22 days | 14 days | Thu 05/02/09 | Wed 25/02/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.5 Case 5 | 22 days | 0.5 days | Wed 25/02/09 | Wed 25/02/09 | 100% | DSN,IS (IR admin) |
| − 4.1.4 Launch | 5 days | 7.5 days | Mon 16/03/09 | Wed 25/03/09 | 100% | |
| 4.1.4.1 Commercial launch announc | 1 day | 0.5 days | Mon 16/03/09 | Mon 16/03/09 | 100% | IB |
| − 4.1.4.2 Full configuration | 4 days | 4.5 days | Thu 19/03/09 | Wed 25/03/09 | 100% | |
| 4.1.4.3 Full IMSI range allowan | 3 days | 0.5 days | Wed 25/03/09 | Wed 25/03/09 | 0% | |
| 4.1.4.2.2 TAP file update | 1 day | 1 day | Thu 19/03/09 | Fri 20/03/09 | 100% | IS (IR admin) |

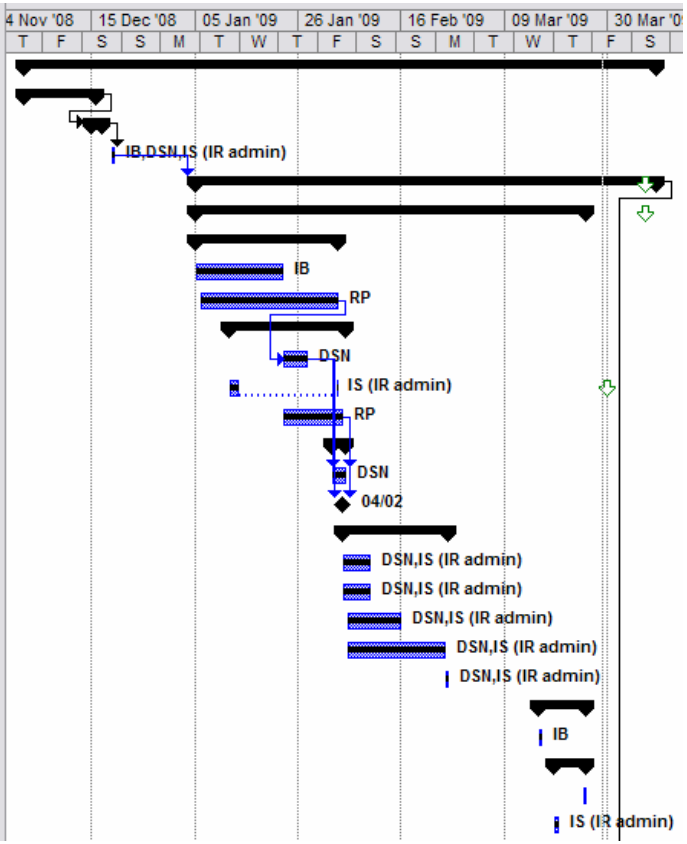



Figure 3.31: Actual implementation time frame of operator 1

| Task Name | Baseline Duration | Duration | Start | Finish | % Work complete | Resource Names |
|---|---|---|---|---|---|---|
| − GPRS internation roaming process | 93 days | 93 days? | Mon 01/12/08 | Wed 08/04/09 | 100% | |
| + 1. Preparation | 10 days | 11 days | Mon 01/12/08 | Mon 15/12/08 | 100% | |
| + 2. Knowledge sharing | 2 days | 2 days | Mon 15/12/08 | Wed 17/12/08 | 100% | |
| 3. Kick-off meeting for pilot testing for GPRS interna | 1 day | 0.5 days | Fri 19/12/08 | Fri 19/12/08 | 100% | IB,DSN,IS (IR admin) |
| − 4. Pilot test | 67 days | 68 days? | Mon 05/01/09 | Wed 08/04/09 | 100% | |
| + 4.1 Operator 1 | 67 days | 57.5 days | Mon 05/01/09 | Wed 25/03/09 | 100% | |
| − 4.2 Operator 2 | 67 days | 60.5 days | Mon 05/01/09 | Mon 30/03/09 | 100% | |
| − 4.2.1 Documentation preparation | 25 days | 11 days | Mon 05/01/09 | Tue 20/01/09 | 100% | |
| 4.2.1.1 Delivery documents to RP | 25 days | 6 days | Mon 05/01/09 | Tue 13/01/09 | 100% | IB |
| 4.2.1.2 Delivery documents to XYZ | 25 days | 9 days | Wed 07/01/09 | Tue 20/01/09 | 100% | RP |
| − 4.2.2 Implement and Verification | 15 days | 10 days | Tue 13/01/09 | Tue 27/01/09 | 100% | |
| 4.2.2.1 GPRS system | 5 days | 3.5 days | Tue 20/01/09 | Fri 23/01/09 | 100% | DSN |
| 4.2.2.2 Billing system | 5 days | 3.5 days | Tue 20/01/09 | Fri 23/01/09 | 100% | IS (IR admin) |
| 4.2.2.3 Roaming partner's system | 10 days | 9 days | Tue 13/01/09 | Mon 26/01/09 | 100% | RP |
| + 4.2.2.4 Verification | 5 days | 2 days | Fri 23/01/09 | Tue 27/01/09 | 100% | |
| − 4.2.3 Test and Validation | 22 days | 16.5 days | Wed 28/01/09 | Thu 19/02/09 | 100% | |
| 4.2.3.1 Case 1 | 22 days | 6 days | Wed 28/01/09 | Thu 05/02/09 | 100% | DSN,IS (IR admin) |
| 4.2.3.2 Case 2 | 22 days | 2.5 days | Tue 03/02/09 | Thu 05/02/09 | 100% | DSN,IS (IR admin) |
| 4.2.3.3 Case 3 | 22 days | 2.5 days | Tue 03/02/09 | Thu 05/02/09 | 100% | DSN,IS (IR admin) |
| 4.2.3.4 Case 4 | 22 days | 2.5 days | Tue 03/02/09 | Thu 05/02/09 | 100% | DSN,IS (IR admin) |
| 4.2.3.5 Case 5 | 22 days | 0.5 days | Thu 19/02/09 | Thu 19/02/09 | 100% | DSN,IS (IR admin) |
| − 4.2.4 Launch | 5 days | 8.5 days | Wed 18/03/09 | Mon 30/03/09 | 100% | |
| 4.2.4.1 Commercial launch announc | 1 day | 0.5 days | Wed 18/03/09 | Wed 18/03/09 | 100% | IB |
| − 4.2.4.2 Full configuration | 4 days | 3.5 days | Wed 25/03/09 | Mon 30/03/09 | 100% | |
| 4.2.4.2.1 Full IMSI range allowa | 3 days | 0.5 days | Mon 30/03/09 | Mon 30/03/09 | 100% | DSN |
| 4.2.4.2.2 TAP file update | 1 day | 2 days | Wed 25/03/09 | Fri 27/03/09 | 100% | IS (IR admin) |

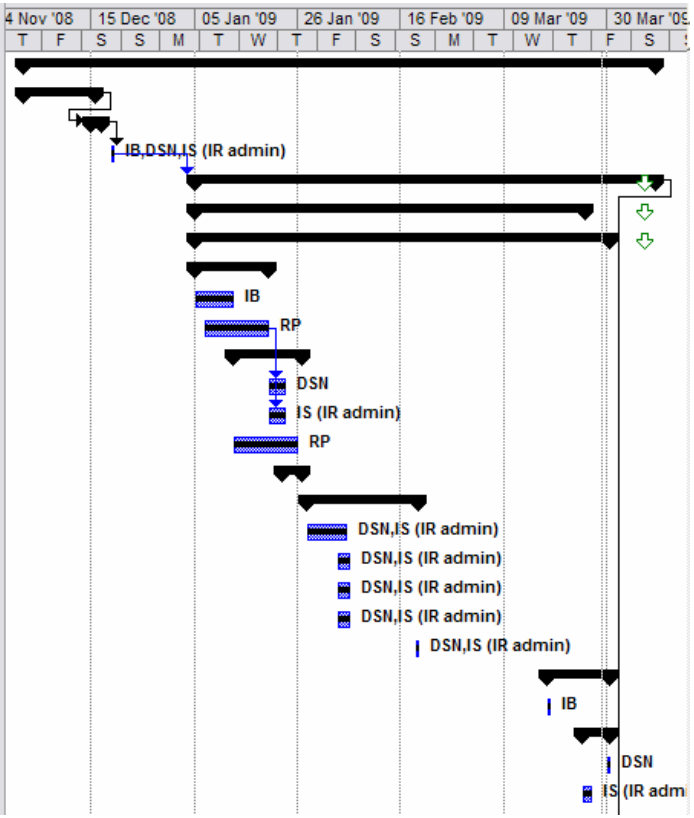



Figure 3.32: Actual implementation time frame of operator 2

| Task Name | Baseline Duration | Duration | Start | Finish | % Work complete | Resource Names |
|---|---|---|---|---|---|---|
| − GPRS internation roaming process | 93 days | 93 days? | Mon 01/12/08 | Wed 08/04/09 | 100% | |
| + 1. Preparation | 10 days | 11 days | Mon 01/12/08 | Mon 15/12/08 | 100% | |
| + 2. Knowledge sharing | 2 days | 2 days | Mon 15/12/08 | Wed 17/12/08 | 100% | |
| 3. Kick-off meeting for pilot testing for GPRS interna | 1 day | 0.5 days | Fri 19/12/08 | Fri 19/12/08 | 100% | IB,DSN,IS (IR admin) |
| − 4. Pilot test | 67 days | 68 days? | Mon 05/01/09 | Wed 08/04/09 | 100% | |
| + 4.1 Operator 1 | 67 days | 57.5 days | Mon 05/01/09 | Wed 25/03/09 | 100% | |
| + 4.2 Operator 2 | 67 days | 60.5 days | Mon 05/01/09 | Mon 30/03/09 | 100% | |
| − 4.3 Operator 3 | 67 days | 64.56 days | Mon 05/01/09 | Fri 03/04/09 | 100% | |
| − 4.1.1 Documentation preparation | 25 days | 11 days | Mon 05/01/09 | Mon 19/01/09 | 100% | |
| 4.1.1.1 Delivery documents to RP | 25 days | 11 days | Mon 05/01/09 | Mon 19/01/09 | 100% | IB |
| 4.1.1.2 Delivery documents to XYZ | 25 days | 8 days | Mon 05/01/09 | Wed 14/01/09 | 100% | RP |
| − 4.1.2 Implement and Verification | 15 days | 9 days | Wed 14/01/09 | Tue 27/01/09 | 100% | |
| 4.1.2.1 GPRS system | 5 days | 3 days | Wed 14/01/09 | Mon 19/01/09 | 100% | DSN |
| 4.1.2.2 Billing system | 5 days | 2 days | Wed 14/01/09 | Fri 16/01/09 | 100% | IS (IR admin) |
| 4.1.2.3 Roaming partner's system | 10 days | 6 days | Mon 19/01/09 | Tue 27/01/09 | 100% | RP |
| − 4.1.2.4 Verification | 5 days | 6 days | Mon 19/01/09 | Tue 27/01/09 | 100% | |
| 4.1.2.4.1 XYZ verification | 5 days | 1 day | Mon 19/01/09 | Tue 20/01/09 | 100% | DSN |
| 4.1.2.4.2 RP verification | 5 days | 0 days | Tue 27/01/09 | Tue 27/01/09 | 100% | RP |
| − 4.1.3 Test and Validation | 22 days | 23.5 days | Mon 26/01/09 | Thu 26/02/09 | 100% | |
| 4.1.3.1 Case 1 | 22 days | 9 days | Mon 26/01/09 | Fri 06/02/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.2 Case 2 | 22 days | 9 days | Mon 26/01/09 | Fri 06/02/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.3 Case 3 | 22 days | 6 days | Thu 29/01/09 | Fri 06/02/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.4 Case 4 | 22 days | 9 days | Fri 30/01/09 | Thu 12/02/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.5 Case 5 | 22 days | 0.5 days | Thu 26/02/09 | Thu 26/02/09 | 100% | DSN,IS (IR admin) |
| − 4.1.4 Launch | 5 days | 7.5 days | Wed 25/03/09 | Fri 03/04/09 | 100% | |
| 4.1.4.1 Commercial launch announc | 1 day | 0.5 days | Wed 25/03/09 | Wed 25/03/09 | 100% | IB |
| − 4.1.4.2 Full configuration | 4 days | 3.5 days | Tue 31/03/09 | Fri 03/04/09 | 100% | |
| 4.1.4.2.1 Full IMSI range allowa | 3 days | 0.5 days | Fri 03/04/09 | Fri 03/04/09 | 100% | DSN |
| 4.1.4.2.2 TAP file update | 1 day | 2 days | Tue 31/03/09 | Thu 02/04/09 | 100% | IS (IR admin) |

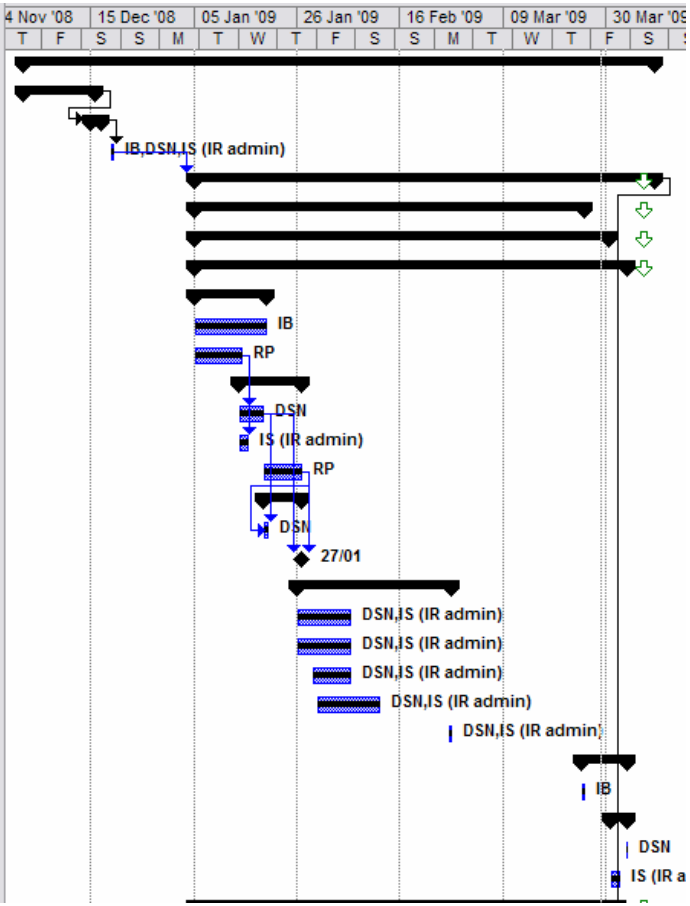



Figure 3.33: Actual implementation time frame of operator 3

| Task Name | Baseline Duration | Duration | Start | Finish | % Work complete | Resource Names |
|---|---|---|---|---|---|---|
| − GPRS internation roaming process | 93 days | 93 days? | Mon 01/12/08 | Wed 08/04/09 | 100% | |
| + 1. Preparation | 10 days | 11 days | Mon 01/12/08 | Mon 15/12/08 | 100% | |
| + 2. Knowledge sharing | 2 days | 2 days | Mon 15/12/08 | Wed 17/12/08 | 100% | |
| 3. Kick-off meeting for pilot testing for GPRS interna | 1 day | 0.5 days | Fri 19/12/08 | Fri 19/12/08 | 100% | IB,DSN,IS (IR admin) |
| − 4. Pilot test | 67 days | 68 days? | Mon 05/01/09 | Wed 08/04/09 | 100% | |
| + 4.1 Operator 1 | 67 days | 57.5 days | Mon 05/01/09 | Wed 25/03/09 | 100% | |
| + 4.2 Operator 2 | 67 days | 60.5 days | Mon 05/01/09 | Mon 30/03/09 | 100% | |
| + 4.3 Operator 3 | 67 days | 64.56 days | Mon 05/01/09 | Fri 03/04/09 | 100% | |
| − 4.1 Operator 4 | 67 days | 62.56 days | Mon 05/01/09 | Wed 01/04/09 | 100% | |
| − 4.1.1 Documentation preparation | 25 days | 11.06 days | Mon 05/01/09 | Tue 20/01/09 | 100% | |
| 4.1.1.1 Delivery documents to RP | 25 days | 6 days | Mon 05/01/09 | Mon 12/01/09 | 100% | IB |
| 4.1.1.2 Delivery documents to XYZ | 25 days | 10 days | Tue 06/01/09 | Tue 20/01/09 | 100% | RP |
| − 4.1.2 Implement and Verification | 15 days | 10 days | Mon 12/01/09 | Mon 26/01/09 | 100% | |
| 4.1.2.1 GPRS system | 5 days | 3 days | Tue 20/01/09 | Fri 23/01/09 | 100% | DSN |
| 4.1.2.2 Billing system | 5 days | 3 days | Tue 20/01/09 | Fri 23/01/09 | 100% | IS (IR admin) |
| 4.1.2.3 Roaming partner's system | 10 days | 9 days | Mon 12/01/09 | Fri 23/01/09 | 100% | RP |
| − 4.1.2.4 Verification | 5 days | 1 day | Fri 23/01/09 | Mon 26/01/09 | 100% | |
| 4.1.2.4.1 XYZ verification | 5 days | 1 day | Fri 23/01/09 | Mon 26/01/09 | 100% | DSN |
| 4.1.2.4.2 RP verification | 5 days | 0 days | Fri 23/01/09 | Fri 23/01/09 | 100% | RP |
| − 4.1.3 Test and Validation | 22 days | 39 days | Thu 29/01/09 | Wed 25/03/09 | 100% | |
| 4.1.3.1 Case 1 | 22 days | 3.5 days | Wed 04/02/09 | Mon 09/02/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.2 Case 2 | 22 days | 3.5 days | Wed 04/02/09 | Mon 09/02/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.3 Case 3 | 22 days | 35 days | Wed 04/02/09 | Wed 25/03/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.4 Case 4 | 22 days | 6 days | Tue 17/02/09 | Wed 25/02/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.5 Case 5 | 22 days | 2 days | Thu 29/01/09 | Mon 02/02/09 | 100% | DSN,IS (IR admin) |
| − 4.1.4 Launch | 5 days | 3.5 days | Fri 27/03/09 | Wed 01/04/09 | 100% | |
| 4.1.4.1 Commercial launch announc | 1 day | 1 day | Fri 27/03/09 | Mon 30/03/09 | 100% | IB |
| − 4.1.4.2 Full configuration | 4 days | 2.5 days | Mon 30/03/09 | Wed 01/04/09 | 100% | |
| 4.1.4.2.1 Full IMSI range allowa | 3 days | 0.5 days | Wed 01/04/09 | Wed 01/04/09 | 100% | DSN |
| 4.1.4.2.2 TAP file update | 1 day | 1 day | Mon 30/03/09 | Tue 31/03/09 | 100% | IS (IR admin) |

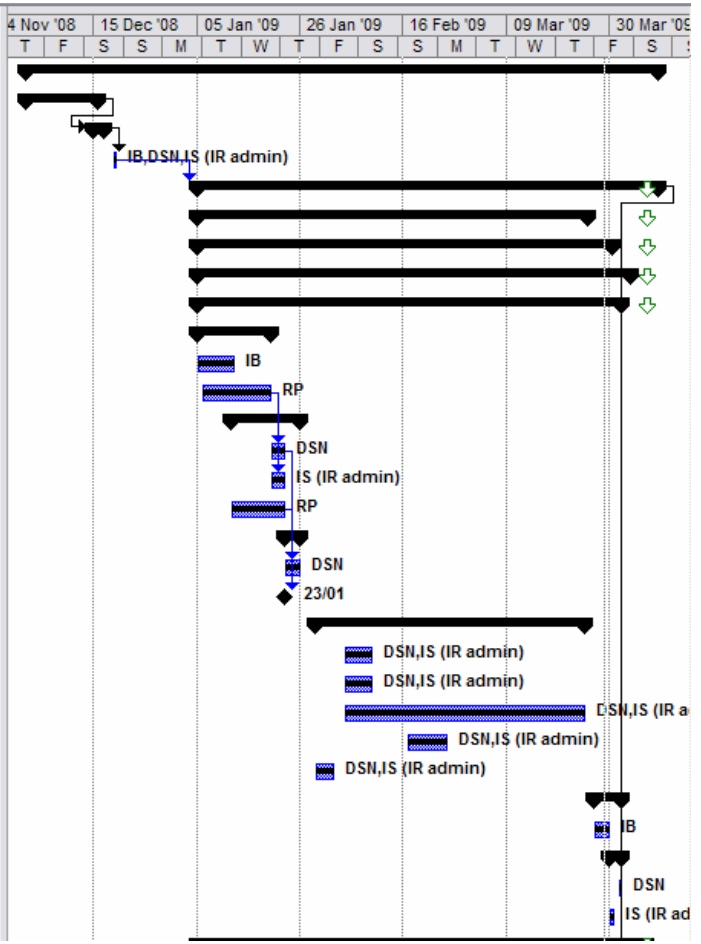



Figure 3.34: Actual implementation time frame of operator 4

| Task Name | Baseline Duration | Duration | Start | Finish | % Work complete | Resource Names |
|---|---|---|---|---|---|---|
| − GPRS internation roaming process | 93 days | 93 days | Mon 01/12/08 | Wed 08/04/09 | 100% | |
| + 1. Preparation | 10 days | 11 days | Mon 01/12/08 | Mon 15/12/08 | 100% | |
| + 2. Knowledge sharing | 2 days | 2 days | Mon 15/12/08 | Wed 17/12/08 | 100% | |
| 3. Kick-off meeting for pilot testing for GPRS inter | 1 day | 0.5 days | Fri 19/12/08 | Fri 19/12/08 | 100% | IB,DSN,IS (IR admin) |
| − 4. Pilot test | 67 days | 68 days | Mon 05/01/09 | Wed 08/04/09 | 100% | |
| + 4.1 Operator 1 | 67 days | 57.5 days | Mon 05/01/09 | Wed 25/03/09 | 100% | |
| + 4.2 Operator 2 | 67 days | 60.5 days | Mon 05/01/09 | Mon 30/03/09 | 100% | |
| + 4.3 Operator 3 | 67 days | 64.56 days | Mon 05/01/09 | Fri 03/04/09 | 100% | |
| + 4.1 Operator 4 | 67 days | 62.56 days | Mon 05/01/09 | Wed 01/04/09 | 100% | |
| − 4.1 Operator 5 | 67 days | 66.56 days | Mon 05/01/09 | Tue 07/04/09 | 100% | |
| + 4.1.1 Documentation preparation | 25 days | 17.06 days | Mon 05/01/09 | Wed 28/01/09 | 100% | |
| − 4.1.2 Implement and Verification | 15 days | 16 days | Wed 14/01/09 | Thu 05/02/09 | 100% | |
| 4.1.2.1 GPRS system | 5 days | 5 days | Wed 28/01/09 | Wed 04/02/09 | 100% | DSN |
| 4.1.2.2 Billing system | 5 days | 3 days | Wed 28/01/09 | Mon 02/02/09 | 100% | IS (IR admin) |
| 4.1.2.3 Roaming partner's system | 10 days | 4 days | Wed 14/01/09 | Tue 20/01/09 | 100% | RP |
| − 4.1.2.4 Verification | 5 days | 12 days | Tue 20/01/09 | Thu 05/02/09 | 100% | |
| 4.1.2.4.1 XYZ verification | 5 days | 1 day | Wed 04/02/09 | Thu 05/02/09 | 100% | DSN |
| 4.1.2.4.2 RP verification | 5 days | 11 days | Tue 20/01/09 | Wed 04/02/09 | 100% | RP |
| − 4.1.3 Test and Validation | 22 days | 18.5 days | Fri 06/02/09 | Wed 04/03/09 | 100% | |
| 4.1.3.1 Case 1 | 22 days | 4 days | Fri 06/02/09 | Thu 12/02/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.2 Case 2 | 22 days | 4 days | Fri 06/02/09 | Thu 12/02/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.3 Case 3 | 22 days | 3 days | Mon 09/02/09 | Thu 12/02/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.4 Case 4 | 22 days | 3 days | Mon 09/02/09 | Thu 12/02/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.5 Case 5 | 22 days | 0.5 days | Wed 04/03/09 | Wed 04/03/09 | 100% | DSN,IS (IR admin) |
| − 4.1.4 Launch | 5 days | 11.5 days | Mon 23/03/09 | Tue 07/04/09 | 100% | |
| 4.1.4.1 Commercial launch annou | 1 day | 0.5 days | Mon 23/03/09 | Mon 23/03/09 | 100% | IB |
| − 4.1.4.2 Full configuration | 4 days | 6.5 days | Mon 30/03/09 | Tue 07/04/09 | 100% | |
| 4.1.4.2.1 Full IMSI range allo | 3 days | 0.5 days | Tue 07/04/09 | Tue 07/04/09 | 100% | DSN |
| 4.1.4.2.2 TAP file update | 1 day | 2 days | Mon 30/03/09 | Wed 01/04/09 | 100% | IS (IR admin) |

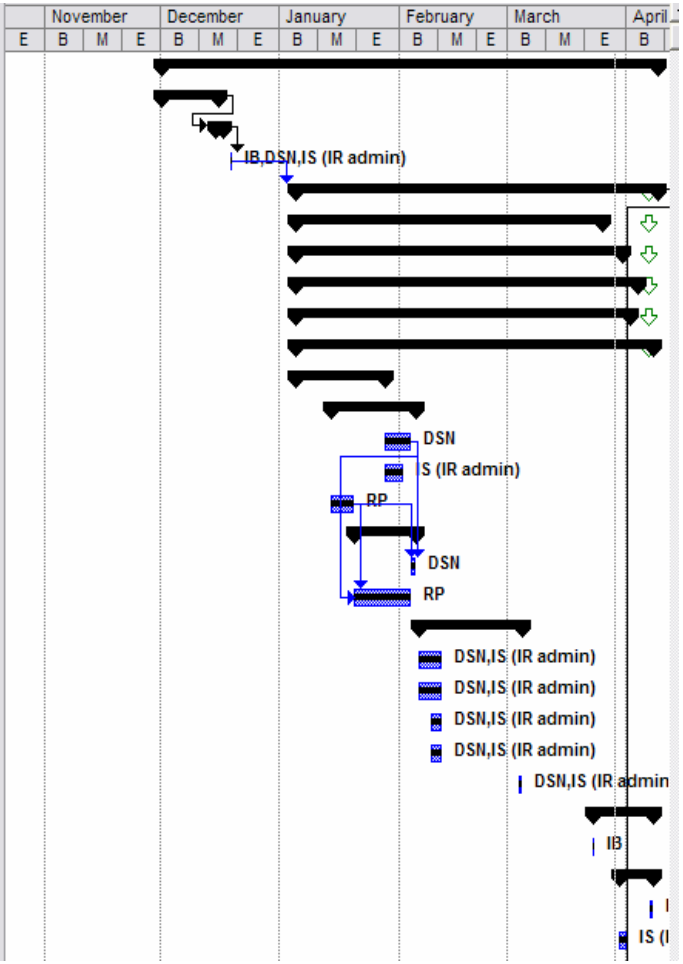



Figure 3.35: Actual implementation time frame of operator 5

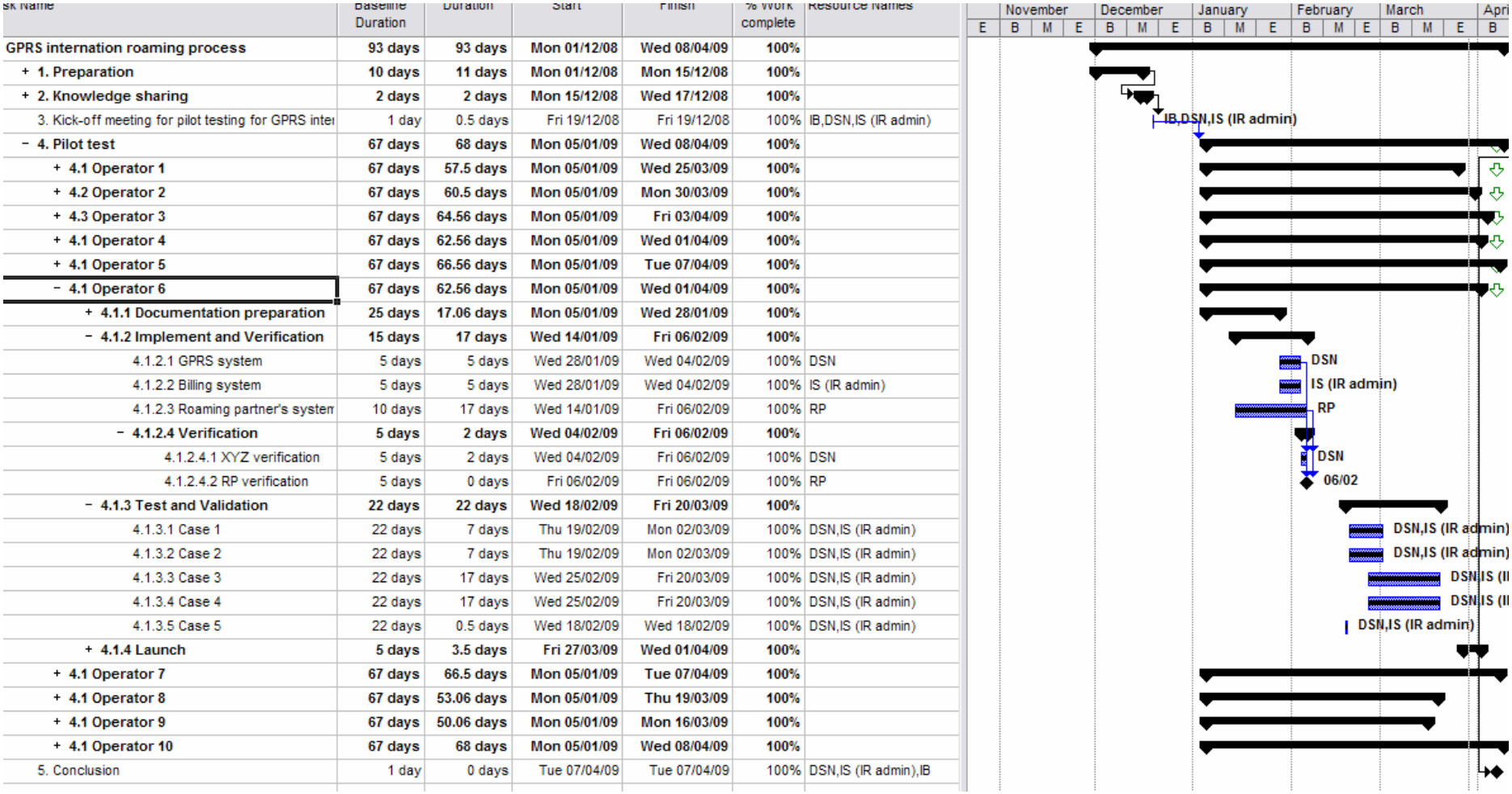
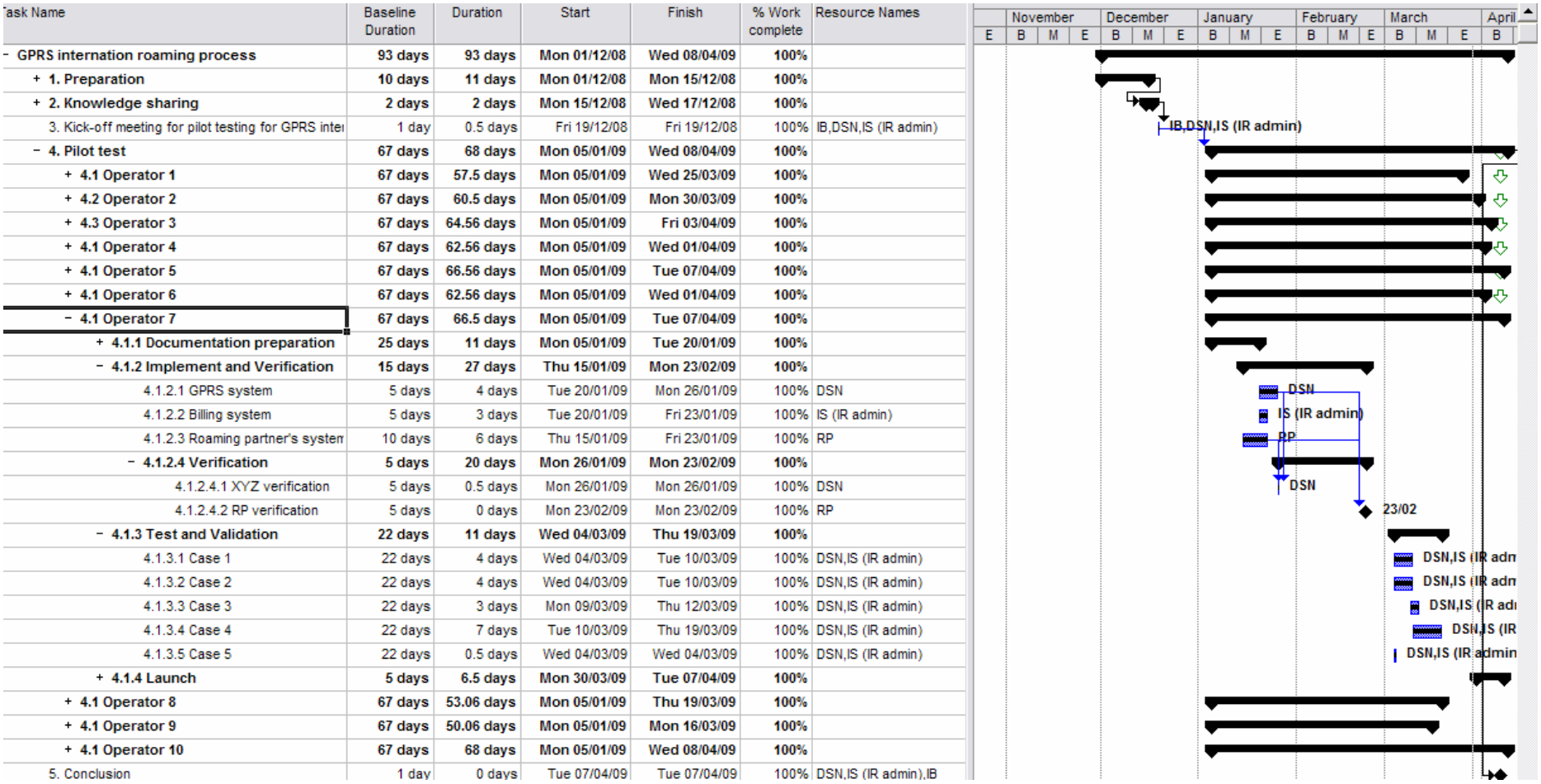



Figure 3.36: Actual implementation time frame of operator 6



| Task Name | Baseline Duration | Duration | Start | Finish | % Work complete | Resource Names |
|---|---|---|---|---|---|---|
| GPRS internation roaming process | 93 days | 93 days | Mon 01/12/08 | Wed 08/04/09 | 100% | |
| 1. Preparation | 10 days | 11 days | Mon 01/12/08 | Mon 15/12/08 | 100% | |
| 2. Knowledge sharing | 2 days | 2 days | Mon 15/12/08 | Wed 17/12/08 | 100% | |
| 3. Kick-off meeting for pilot testing for GPRS inter | 1 day | 0.5 days | Fri 19/12/08 | Fri 19/12/08 | 100% | IB,DSN,IS (IR admin) |
| 4. Pilot test | 67 days | 68 days | Mon 05/01/09 | Wed 08/04/09 | 100% | |
| 4.1 Operator 1 | 67 days | 57.5 days | Mon 05/01/09 | Wed 25/03/09 | 100% | |
| 4.2 Operator 2 | 67 days | 60.5 days | Mon 05/01/09 | Mon 30/03/09 | 100% | |
| 4.3 Operator 3 | 67 days | 64.56 days | Mon 05/01/09 | Fri 03/04/09 | 100% | |
| 4.1 Operator 4 | 67 days | 62.56 days | Mon 05/01/09 | Wed 01/04/09 | 100% | |
| 4.1 Operator 5 | 67 days | 66.56 days | Mon 05/01/09 | Tue 07/04/09 | 100% | |
| 4.1 Operator 6 | 67 days | 62.56 days | Mon 05/01/09 | Wed 01/04/09 | 100% | |
| 4.1 Operator 7 | 67 days | 66.5 days | Mon 05/01/09 | Tue 07/04/09 | 100% | |
| 4.1.1 Documentation preparation | 25 days | 11 days | Mon 05/01/09 | Tue 20/01/09 | 100% | |
| 4.1.2 Implement and Verification | 15 days | 27 days | Thu 15/01/09 | Mon 23/02/09 | 100% | |
| 4.1.2.1 GPRS system | 5 days | 4 days | Tue 20/01/09 | Mon 26/01/09 | 100% | DSN |
| 4.1.2.2 Billing system | 5 days | 3 days | Tue 20/01/09 | Fri 23/01/09 | 100% | IS (IR admin) |
| 4.1.2.3 Roaming partner's systen | 10 days | 6 days | Thu 15/01/09 | Fri 23/01/09 | 100% | RP |
| 4.1.2.4 Verification | 5 days | 20 days | Mon 26/01/09 | Mon 23/02/09 | 100% | |
| 4.1.2.4.1 XYZ verification | 5 days | 0.5 days | Mon 26/01/09 | Mon 26/01/09 | 100% | DSN |
| 4.1.2.4.2 RP verification | 5 days | 0 days | Mon 23/02/09 | Mon 23/02/09 | 100% | RP |
| 4.1.3 Test and Validation | 22 days | 11 days | Wed 04/03/09 | Thu 19/03/09 | 100% | |
| 4.1.3.1 Case 1 | 22 days | 4 days | Wed 04/03/09 | Tue 10/03/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.2 Case 2 | 22 days | 4 days | Wed 04/03/09 | Tue 10/03/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.3 Case 3 | 22 days | 3 days | Mon 09/03/09 | Thu 12/03/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.4 Case 4 | 22 days | 7 days | Tue 10/03/09 | Thu 19/03/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.5 Case 5 | 22 days | 0.5 days | Wed 04/03/09 | Wed 04/03/09 | 100% | DSN,IS (IR admin) |
| 4.1.4 Launch | 5 days | 6.5 days | Mon 30/03/09 | Tue 07/04/09 | 100% | |
| 4.1 Operator 8 | 67 days | 53.06 days | Mon 05/01/09 | Thu 19/03/09 | 100% | |
| 4.1 Operator 9 | 67 days | 50.06 days | Mon 05/01/09 | Mon 16/03/09 | 100% | |
| 4.1 Operator 10 | 67 days | 68 days | Mon 05/01/09 | Wed 08/04/09 | 100% | |
| 5. Conclusion | 1 day | 0 days | Tue 07/04/09 | Tue 07/04/09 | 100% | DSN,IS (IR admin),IB |



Figure 3.37: Actual implementation time frame of operator 7

| Task Name | Baseline Duration | Duration | Start | Finish | % Work complete | Resource Names |
|---|---|---|---|---|---|---|
| − GPRS internation roaming process | 93 days | 93 days | Mon 01/12/08 | Wed 08/04/09 | 100% | |
| + 1. Preparation | 10 days | 11 days | Mon 01/12/08 | Mon 15/12/08 | 100% | |
| + 2. Knowledge sharing | 2 days | 2 days | Mon 15/12/08 | Wed 17/12/08 | 100% | |
| 3. Kick-off meeting for pilot testing for GPRS inter | 1 day | 0.5 days | Fri 19/12/08 | Fri 19/12/08 | 100% | IB,DSN,IS (IR admin) |
| − 4. Pilot test | 67 days | 68 days | Mon 05/01/09 | Wed 08/04/09 | 100% | |
| + 4.1 Operator 1 | 67 days | 57.5 days | Mon 05/01/09 | Wed 25/03/09 | 100% | |
| + 4.2 Operator 2 | 67 days | 60.5 days | Mon 05/01/09 | Mon 30/03/09 | 100% | |
| + 4.3 Operator 3 | 67 days | 64.56 days | Mon 05/01/09 | Fri 03/04/09 | 100% | |
| + 4.1 Operator 4 | 67 days | 62.56 days | Mon 05/01/09 | Wed 01/04/09 | 100% | |
| + 4.1 Operator 5 | 67 days | 66.56 days | Mon 05/01/09 | Tue 07/04/09 | 100% | |
| + 4.1 Operator 6 | 67 days | 62.56 days | Mon 05/01/09 | Wed 01/04/09 | 100% | |
| + 4.1 Operator 7 | 67 days | 66.5 days | Mon 05/01/09 | Tue 07/04/09 | 100% | |
| − 4.1 Operator 8 | 67 days | 53.06 days | Mon 05/01/09 | Thu 19/03/09 | 100% | |
| + 4.1.1 Documentation preparation | 25 days | 10.06 days | Mon 05/01/09 | Mon 19/01/09 | 100% | |
| − 4.1.2 Implement and Verification | 15 days | 32 days | Tue 13/01/09 | Thu 26/02/09 | 100% | |
| 4.1.2.1 GPRS system | 5 days | 4 days | Mon 19/01/09 | Fri 23/01/09 | 100% | DSN |
| 4.1.2.2 Billing system | 5 days | 3 days | Mon 19/01/09 | Thu 22/01/09 | 100% | IS (IR admin) |
| 4.1.2.3 Roaming partner's system | 10 days | 9 days | Tue 13/01/09 | Mon 26/01/09 | 100% | RP |
| − 4.1.2.4 Verification | 5 days | 24 days | Fri 23/01/09 | Thu 26/02/09 | 100% | |
| 4.1.2.4.1 XYZ verification | 5 days | 2 days | Fri 23/01/09 | Tue 27/01/09 | 100% | DSN |
| 4.1.2.4.2 RP verification | 5 days | 0 days | Thu 26/02/09 | Thu 26/02/09 | 100% | RP |
| − 4.1.3 Test and Validation | 22 days | 26 days | Wed 11/02/09 | Thu 19/03/09 | 100% | |
| 4.1.3.1 Case 1 | 22 days | 12 days | Wed 11/02/09 | Fri 27/02/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.2 Case 2 | 22 days | 7 days | Wed 18/02/09 | Fri 27/02/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.3 Case 3 | 22 days | 12 days | Tue 24/02/09 | Thu 12/03/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.4 Case 4 | 22 days | 18 days | Mon 23/02/09 | Thu 19/03/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.5 Case 5 | 22 days | 5 days | Wed 11/02/09 | Wed 18/02/09 | 100% | DSN,IS (IR admin) |
| − 4.1.4 Launch | 5 days | 4.5 days | Thu 05/03/09 | Wed 11/03/09 | 100% | |
| 4.1.4.1 Commercial launch annou | 1 day | 0.5 days | Thu 05/03/09 | Thu 05/03/09 | 100% | IB |
| − 4.1.4.2 Full configuration | 4 days | 2.5 days | Mon 09/03/09 | Wed 11/03/09 | 100% | |
| 4.1.4.2.1 Full IMSI range allo | 3 days | 0.5 days | Wed 11/03/09 | Wed 11/03/09 | 100% | DSN |
| 4.1.4.2.2 TAP file update | 1 day | 2 days | Mon 09/03/09 | Wed 11/03/09 | 100% | IS (IR admin) |

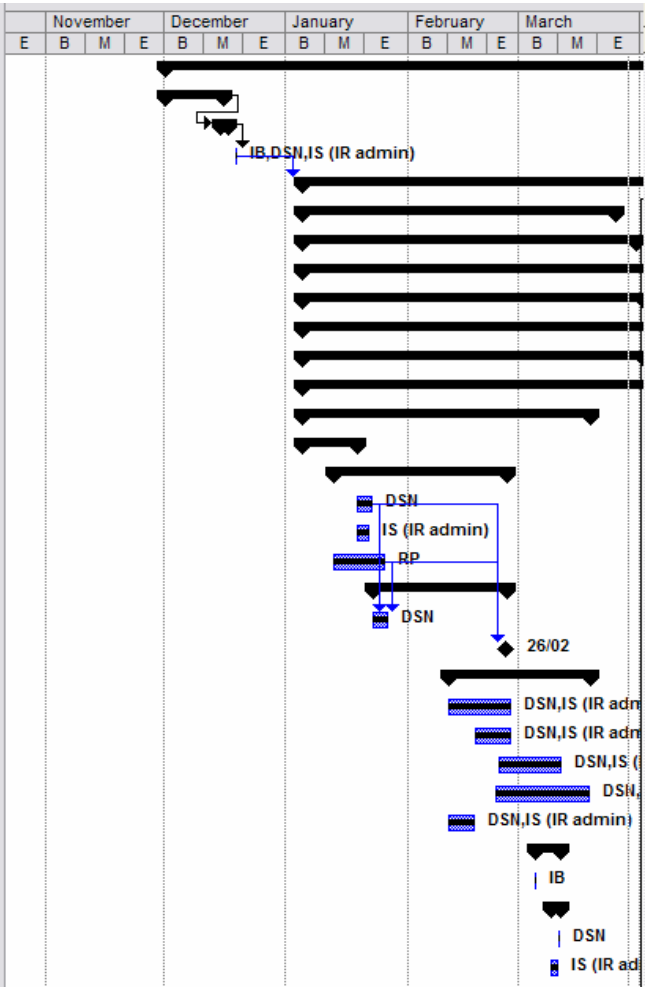



Figure 3.38: Actual implementation time frame of operator 8

| Task Name | Baseline Duration | Duration | Start | Finish | % Work complete | Resource Names |
|---|---|---|---|---|---|---|
| + **4.1 Operator 5** | **67 days** | **66.56 days** | **Mon 05/01/09** | **Tue 07/04/09** | **100%** | |
| + **4.1 Operator 6** | **67 days** | **62.56 days** | **Mon 05/01/09** | **Wed 01/04/09** | **100%** | |
| + **4.1 Operator 7** | **67 days** | **66.5 days** | **Mon 05/01/09** | **Tue 07/04/09** | **100%** | |
| + **4.1 Operator 8** | **67 days** | **53.06 days** | **Mon 05/01/09** | **Thu 19/03/09** | **100%** | |
| − **4.1 Operator 9** | **67 days** | **50.06 days** | **Mon 05/01/09** | **Mon 16/03/09** | **100%** | |
| − **4.1.1 Documentation preparation** | **25 days** | **17.06 days** | **Mon 05/01/09** | **Wed 28/01/09** | **100%** | |
| 4.1.1.1 Delivery documents to RP | 25 days | 10 days | Mon 05/01/09 | Fri 16/01/09 | 100% | IB |
| 4.1.1.2 Delivery documents to XY | 25 days | 17 days | Mon 05/01/09 | Wed 28/01/09 | 100% | RP |
| − **4.1.2 Implement and Verification** | **15 days** | **17.5 days** | **Fri 16/01/09** | **Tue 10/02/09** | **100%** | |
| 4.1.2.1 GPRS system | 5 days | 5 days | Wed 28/01/09 | Wed 04/02/09 | 100% | DSN |
| 4.1.2.2 Billing system | 5 days | 3 days | Wed 28/01/09 | Mon 02/02/09 | 100% | IS (IR admin) |
| 4.1.2.3 Roaming partner's system | 10 days | 7 days | Fri 16/01/09 | Tue 27/01/09 | 100% | RP |
| − **4.1.2.4 Verification** | **5 days** | **10.5 days** | **Tue 27/01/09** | **Tue 10/02/09** | **100%** | |
| 4.1.2.4.1 XYZ verification | 5 days | 0.5 days | Tue 10/02/09 | Tue 10/02/09 | 100% | DSN |
| 4.1.2.4.2 RP verification | 5 days | 6 days | Tue 27/01/09 | Wed 04/02/09 | 100% | RP |
| − **4.1.3 Test and Validation** | **22 days** | **8 days** | **Thu 05/02/09** | **Tue 17/02/09** | **100%** | |
| 4.1.3.1 Case 1 | 22 days | 0.5 days | Thu 05/02/09 | Thu 05/02/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.2 Case 2 | 22 days | 6 days | Thu 05/02/09 | Fri 13/02/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.3 Case 3 | 22 days | 2 days | Fri 13/02/09 | Tue 17/02/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.4 Case 4 | 22 days | 2 days | Fri 13/02/09 | Tue 17/02/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.5 Case 5 | 22 days | 0.5 days | Thu 05/02/09 | Thu 05/02/09 | 100% | DSN,IS (IR admin) |
| − **4.1.4 Launch** | **5 days** | **19 days** | **Tue 17/02/09** | **Mon 16/03/09** | **100%** | |
| 4.1.4.1 Commercial launch annou | 1 day | 0.5 days | Mon 09/03/09 | Mon 09/03/09 | 100% | IB |
| − **4.1.4.2 Full configuration** | **4 days** | **19 days** | **Tue 17/02/09** | **Mon 16/03/09** | **100%** | |
| 4.1.4.2.1 Full IMSI range allo | 3 days | 0.5 days | Tue 17/02/09 | Tue 17/02/09 | 100% | DSN |
| 4.1.4.2.2 TAP file update | 1 day | 1 day | Fri 13/03/09 | Mon 16/03/09 | 100% | IS (IR admin) |
| + **4.1 Operator 10** | **67 days** | **68 days** | **Mon 05/01/09** | **Wed 08/04/09** | **100%** | |
| 5. Conclusion | 1 day | 0 days | Tue 07/04/09 | Tue 07/04/09 | 100% | DSN,IS (IR admin),IB |

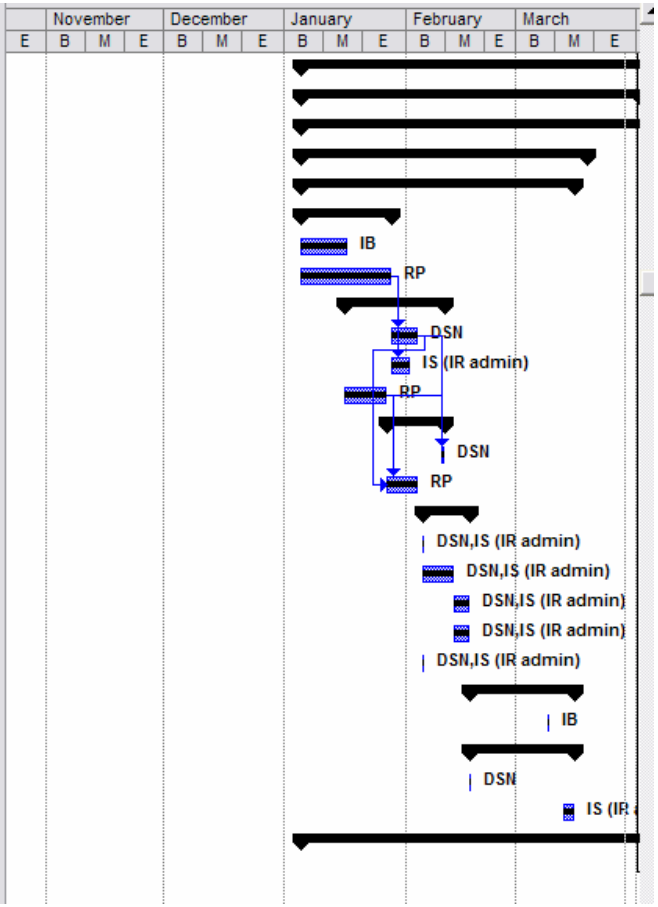



Figure 3.39: Actual implementation time frame of operator 9

| Task Name | Baseline Duration | Duration | Start | Finish | % Work complete | Resource Names |
|---|---|---|---|---|---|---|
| + **4.1 Operator 5** | **67 days** | **66.56 days** | **Mon 05/01/09** | **Tue 07/04/09** | **100%** | |
| + **4.1 Operator 6** | **67 days** | **62.56 days** | **Mon 05/01/09** | **Wed 01/04/09** | **100%** | |
| + **4.1 Operator 7** | **67 days** | **66.5 days** | **Mon 05/01/09** | **Tue 07/04/09** | **100%** | |
| + **4.1 Operator 8** | **67 days** | **53.06 days** | **Mon 05/01/09** | **Thu 19/03/09** | **100%** | |
| + **4.1 Operator 9** | **67 days** | **50.06 days** | **Mon 05/01/09** | **Mon 16/03/09** | **100%** | |
| − **4.1 Operator 10** | **67 days** | **68 days** | **Mon 05/01/09** | **Wed 08/04/09** | **100%** | |
| − **4.1.1 Documentation preparation** | **25 days** | **13.06 days** | **Mon 05/01/09** | **Thu 22/01/09** | **100%** | |
| 4.1.1.1 Delivery documents to RP | 25 days | 7 days | Mon 05/01/09 | Tue 13/01/09 | 100% | IB |
| 4.1.1.2 Delivery documents to XY | 25 days | 12 days | Tue 06/01/09 | Thu 22/01/09 | 100% | RP |
| − **4.1.2 Implement and Verification** | **15 days** | **10 days** | **Tue 13/01/09** | **Tue 27/01/09** | **100%** | |
| 4.1.2.1 GPRS system | 5 days | 2 days | Thu 22/01/09 | Mon 26/01/09 | 100% | DSN |
| 4.1.2.2 Billing system | 5 days | 2 days | Thu 22/01/09 | Mon 26/01/09 | 100% | IS (IR admin) |
| 4.1.2.3 Roaming partner's system | 10 days | 5 days | Tue 13/01/09 | Tue 20/01/09 | 100% | RP |
| − **4.1.2.4 Verification** | **5 days** | **5 days** | **Tue 20/01/09** | **Tue 27/01/09** | **100%** | |
| 4.1.2.4.1 XYZ verification | 5 days | 1 day | Mon 26/01/09 | Tue 27/01/09 | 100% | DSN |
| 4.1.2.4.2 RP verification | 5 days | 4 days | Tue 20/01/09 | Mon 26/01/09 | 100% | RP |
| − **4.1.3 Test and Validation** | **22 days** | **18.94 days** | **Thu 05/03/09** | **Tue 31/03/09** | **100%** | |
| 4.1.3.1 Case 1 | 22 days | 2 days | Thu 05/03/09 | Mon 09/03/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.2 Case 2 | 22 days | 2 days | Thu 05/03/09 | Mon 09/03/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.3 Case 3 | 22 days | 8 days | Wed 11/03/09 | Mon 23/03/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.4 Case 4 | 22 days | 8.13 days | Wed 11/03/09 | Tue 31/03/09 | 100% | DSN,IS (IR admin) |
| 4.1.3.5 Case 5 | 22 days | 0.5 days | Thu 05/03/09 | Thu 05/03/09 | 100% | DSN,IS (IR admin) |
| + **4.1.4 Launch** | **5 days** | **6.94 days** | **Tue 31/03/09** | **Wed 08/04/09** | **100%** | |
| 5. Conclusion | 1 day | 0 days | Tue 07/04/09 | Tue 07/04/09 | 100% | DSN,IS (IR admin),IB |

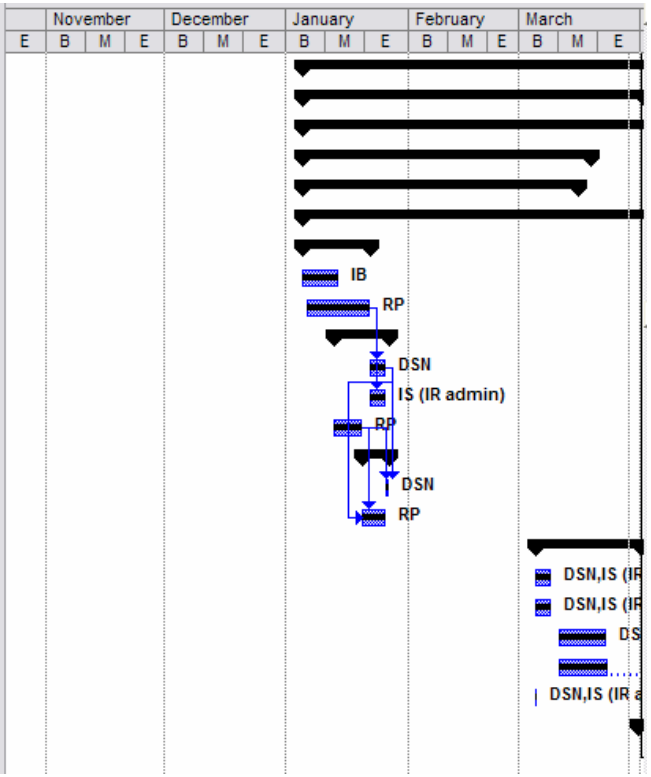



Figure 3.40: Actual implementation time frame of operator 10

### *3.5.3 Controlling problem method*

In improvement of the GPRS international roaming process, controlling problem is also the important thing to reduce any mistakes which used to occur in the past. The methods from brainstorming are:

- Establishing database for teams during working in GPRS international roaming services.
- Establishing checksheet for XYZ and roaming partners which are standard documents such as process time frame, verification checksheet and mobile setting documents. These documents are used in test phase.
- Establishing knowledge management by establishing instruction documents and transferring knowledge among teams before running the pilot test.
- Controlling lead-time of each operator is done by IB to inform coordinator of roaming partner when there is any delay in process. This controlling time is based on time-frame agreement which is sent to roaming partner before any implementing by engineering team.

1. Sharepoint database

The purpose of establishing the sharepoint database is to help exchange and manage all documents among team easier as in Figure 3.41. This sharepoint database is one of the important key improvements for implementing the GPRS international roaming service. It can manage necessary information internally. This sharepoint collects the IR.21, IR.35, Simcard management and other related documents.


Figure 3.41: Sharepoint database for internal XYZ

## 2. Standard documents

Standard documents are established for improving in GPRS international roaming services. The time frame document, verification checksheet and mobile setting documents are for exchanging mandatory information between XYZ and other operators. These documents help reduce time line in testing process because roaming partners can verify and check the problems before completing the IR.35 test form instead of asking by mail time to time. The simcard management document and training documents are for internal XYZ company.

- Process time frame (Appendix B)
- Verification checksheet (Appendix C)
- Mobile setting document (Appendix D)
- Simcard management document (Appendix E)
- Training documents

## 3. Mistake proofing and prevention

As errors or defects occurring during running process, applying mistake proofing and prevention technique or Poka-yoke technique can help reduce lead time of the whole process. From analysis, the delay often occurs by postponement of ODB testing which is required real-time testing between engineers of XYZ and roaming partner. So, the key in improvement is how to make related people ready for work and run working smoothly. Moreover, email is the most way of communication among team especially to roaming partners who work in different place and time. One of improvement in control phase is applying mistake prevention to email to make it clearer and make notification to who related.

- *Email heading format*

From brainstorming during running pilot test, the problem sometimes occurs by missing reading email in suitable time. So, making standard of email heading format can make notification to destination person to pay attention to easier. It moreover helps trace progress, update contents and information among teams during working. This improvement is useful to inform objective of mailing. Figure 3.42 shows an example of creating email heading following the standard format.
The email heading standard format is:

**[*operator name/country # PROCESS*] - To *objective***

Example:
[Operator C /Bulgaria # DOCUMENT PRE] – To request your documents
[Operator C /Bulgaria # IMPLEMENT] – To exchange verification test form
[Operator C /Bulgaria # TEST] – To confirm scheduled ODB testing time
[Operator C /Bulgaria# TEST] – To validate TAP-out
[Operator C / Bulgaria # TEST] – To check problem on simcard activation
[Operator C / Bulgaria # TEST] – To check problem on network connection
[Operator C / Bulgaria # TEST] – To check problem on DNS reservation
[Operator C / Bulgaria # LAUNCH] – To inform commercial launch date/time

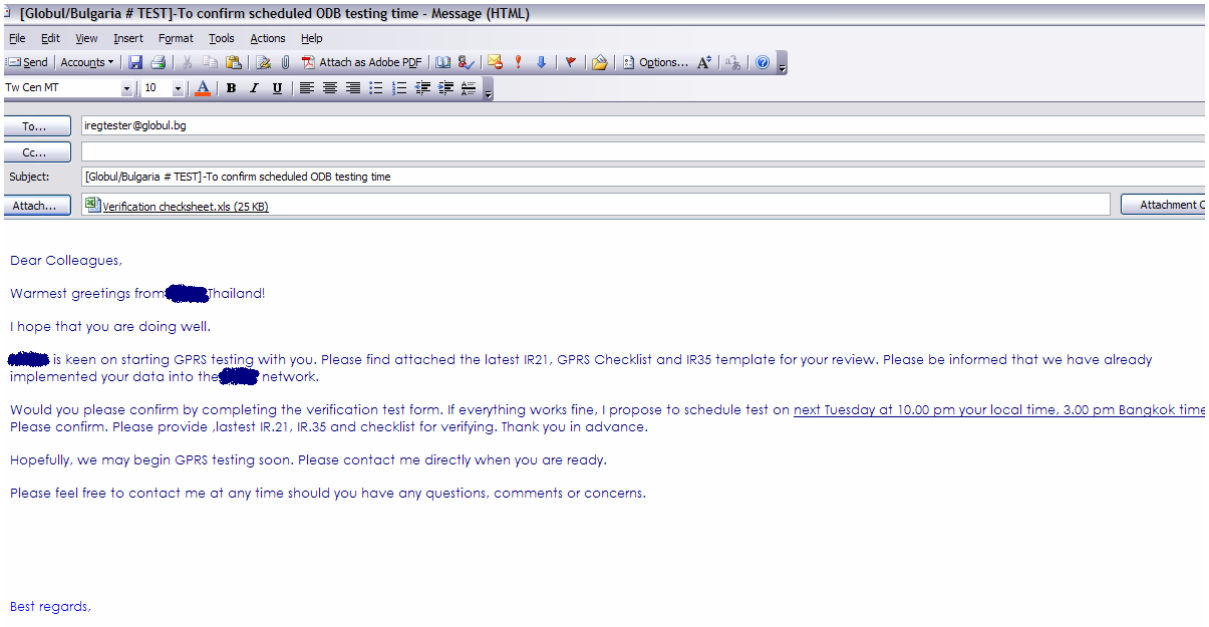



Figure 3.42: Mistake prevention: email heading format

- Calendar alert

To avoid missing appointment for ODB testing between XYZ company and roaming partners, the calendar alert is a technique for poka-yoke from brainstorming among teams. This way also helps improving in reducing lead-time, because this alert message will pop-up before the actual scheduling time 30 minutes. Person who responses for ODB test can prepare simcard, test phone and IR.35 test form before conference by phone call. Figure 3.43 shows an example of applying calendar alert.

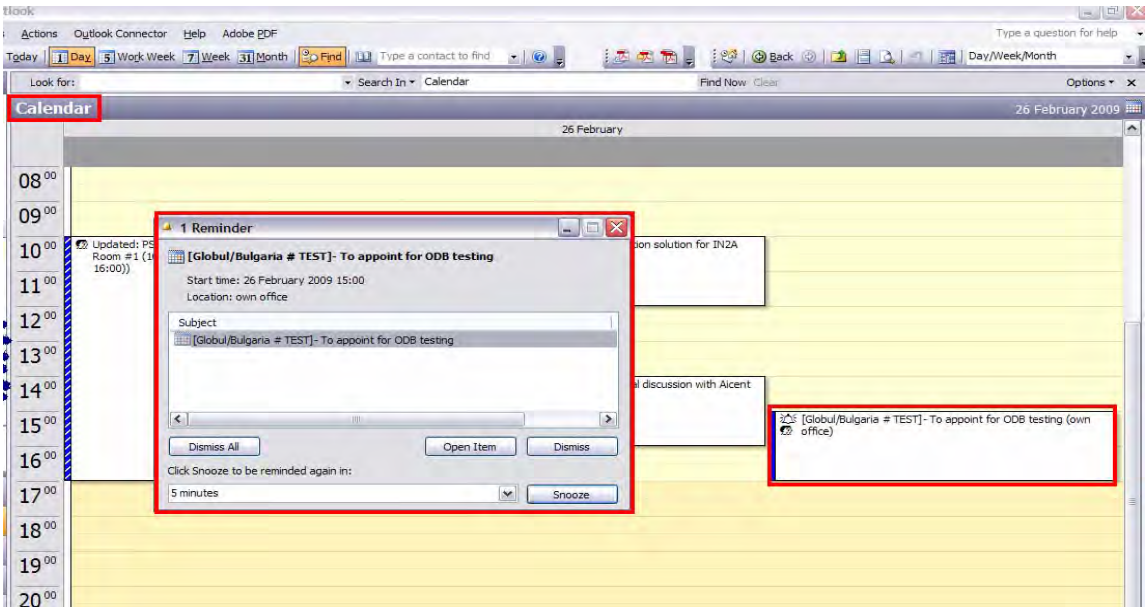



Figure 3.43: Mistake prevention: calendar alert

### *3.5.4 Statistical results*

To evaluate the details of lead-time in the same unit between statistical data at the initial project and after applied DMAIC to improve GPRS international roaming process, the time consumption is recalculated by ignoring weekend. Table 3.22 shows time consumption from pilot test's results previously. Figure 3.44 and 3.45 show the control charts of each of ten operators from the pilot test. Figure 3.46 and 3.51 show total lead-time of ten sample tasks. However, the statistical results are collected in terms of accumulated time and all of them are independent. These results in next topic are basically analyzed to analyze the variation by mean tendency.

| Name | Start-time | End-time | Total lead-time |
|---|---|---|---|
| Operator 1 | 05/01/2009 | 25/03/2009 | 80 |
| Operator 2 | 05/01/2009 | 30/03/2009 | 85 |
| Operator 3 | 05/01/2009 | 03/04/2009 | 89 |
| Operator 4 | 05/01/2009 | 01/04/2009 | 87 |
| Operator 5 | 05/01/2009 | 07/04/2009 | 93 |
| Operator 6 | 05/01/2009 | 01/04/2009 | 87 |
| Operator 7 | 05/01/2009 | 07/04/2009 | 93 |
| Operator 8 | 05/01/2009 | 11/03/2009 | 66 |
| Operator 9 | 05/01/2009 | 17/03/2009 | 72 |
| Operator 10 | 05/01/2009 | 08/04/2009 | 94 |

Table 3.22: Results of total time consumption from pilot test

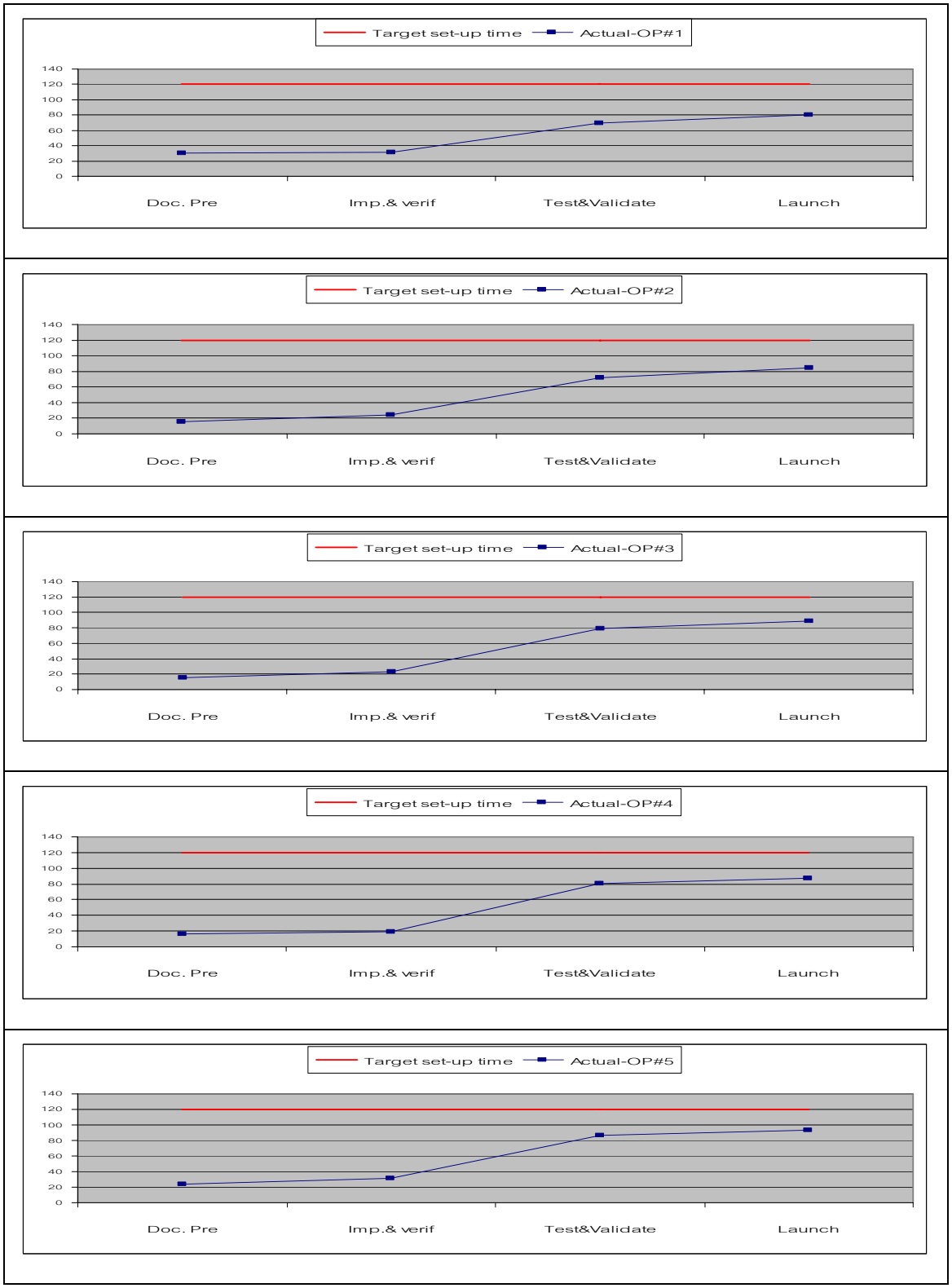



Figure 3.44: Control chart of lead time of operator 1-5 comparing to target time

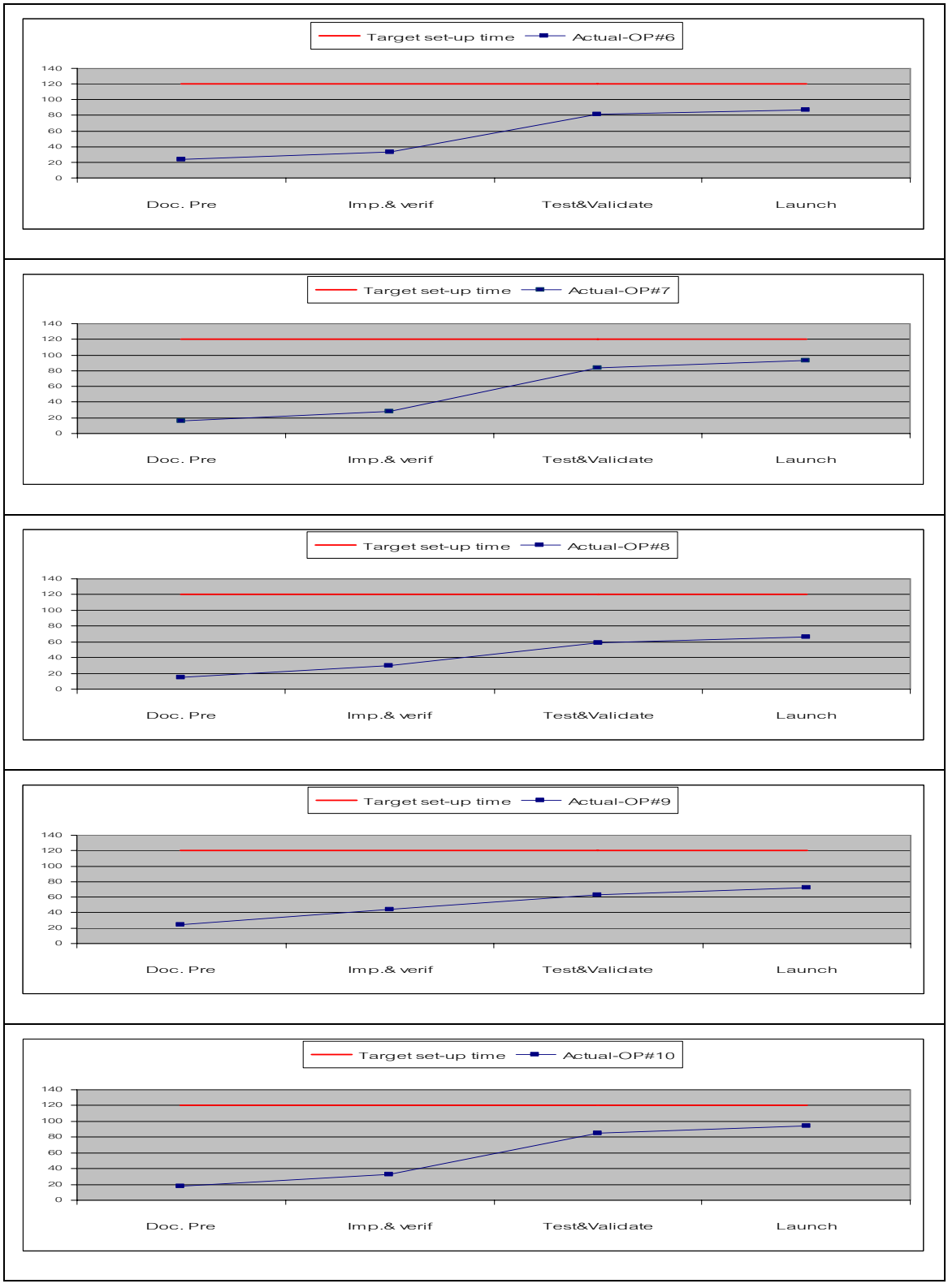



Figure 3.45: Control chart of lead time of operator 6-10 comparing to target time

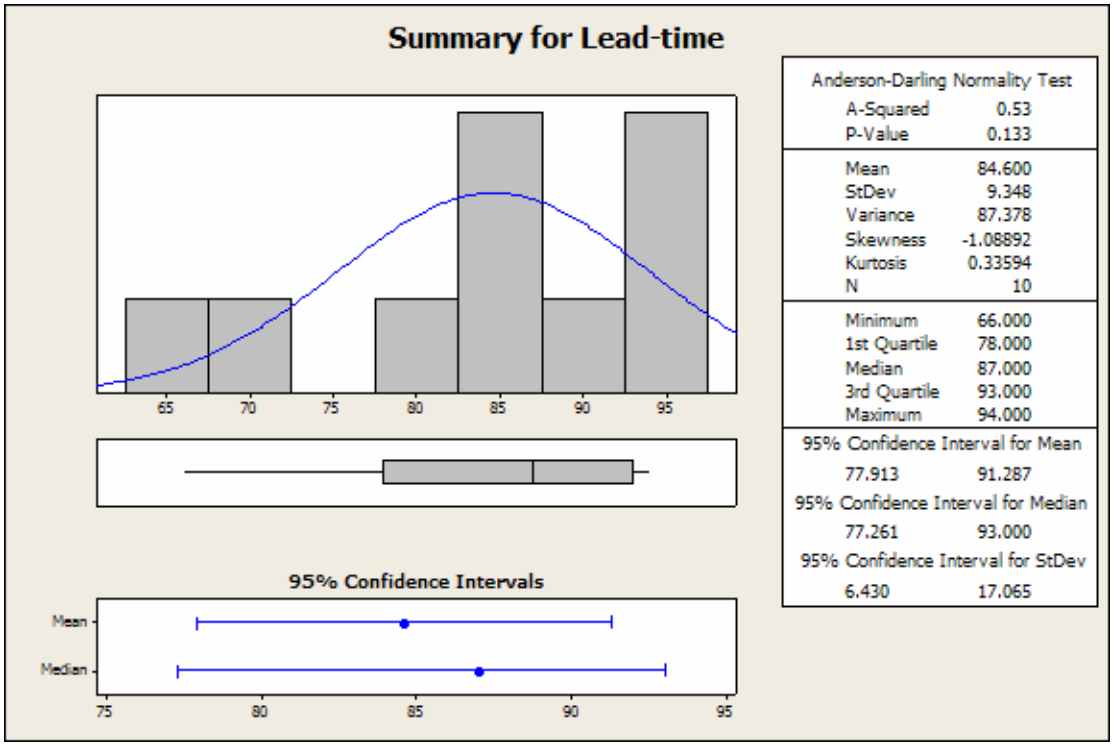



Figure 3.46: Summary of lead time

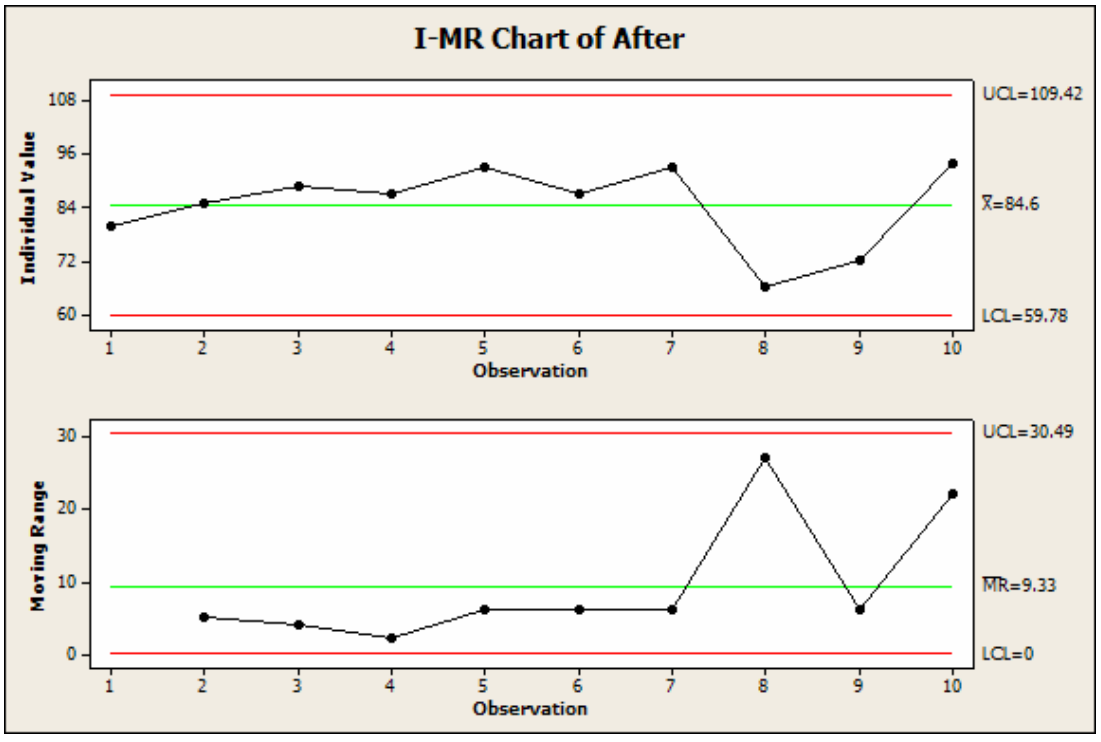



Figure 3.47: I-MR chart of results after implementation

Figure 3.46 illustrates measures of central tendency, measures of spread, box plot, frequency plot and distribution. The graph shows mean value equal to 84.6 and the S.D. is 9.348. Range can be calculated by minimum value and maximum value. So, the range is 28. Figure 3.44 and Figure 3.45 show that all of ten tasks are in the control which is not over 120 days. Figure 3.47 shows I-MR chart of results after implementation. The data has only 10 plots due to limitation of time and job request during pilot test. This chart plots individual data on one chart and moving ranges which the differences between each two adjacent points on the second chart. Individual chart shows that all of data are not over the upper control limit, 109.42. Average of moving range is 9.33. The I-MR chart is applied to evaluate set-up time in order to control all tasks implemented during pilot test period and it will be used for future when the data is collected more.

### *3.5.5 Hypothesis testing*

Figure 3.48 is the box plot of hypothesis testing by two-sample t-test for analyzing lead-time of before and after improvement of the GPRS international roaming process. So, we reject null hypothesis when null hypothesis is mean is equal. It means that the means of before and after improvement is statistically different.

**Two-Sample T-Test and CI: Before, After**

```
Two-sample T for Before vs After

         N   Mean  StDev  SE Mean
Before  57    204    128       17
After   10  84.60   9.35      3.0

Difference = mu (Before) - mu (After)
Estimate for difference:  118.961
95% lower bound for difference:  90.292
T-Test of difference = 0 (vs >): T-Value = 6.93  P-Value = 0.000  DF = 59
```

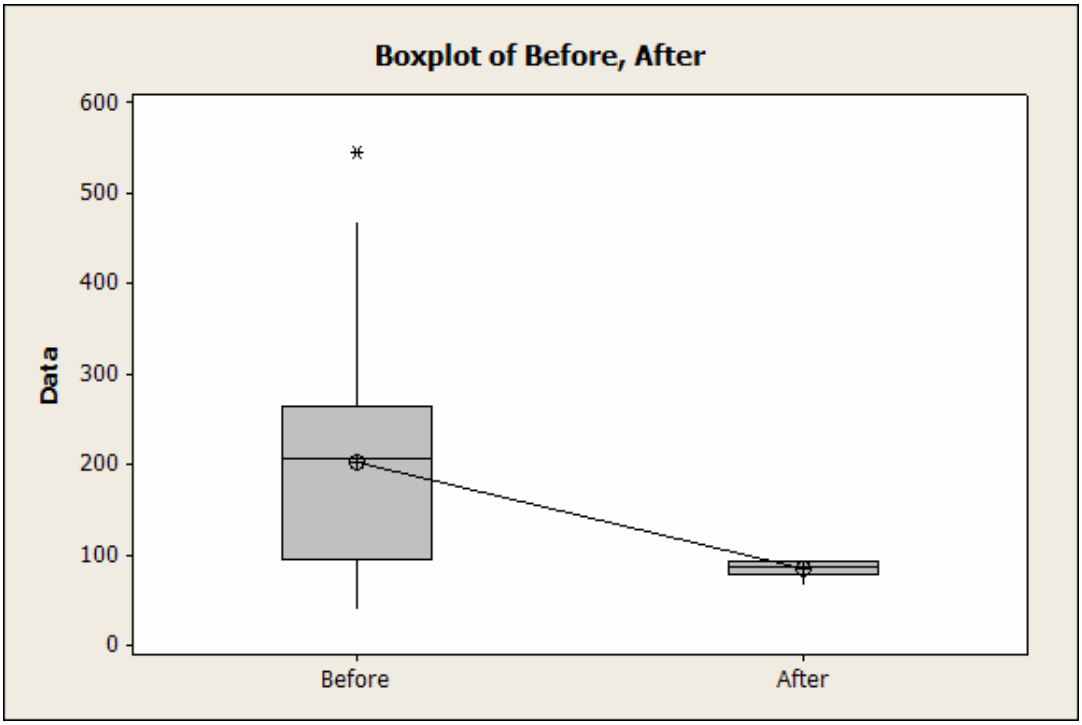



Figure 3.48: Box plot of hypothesis testing by two-sample t-test of before and after improvement

The one-sample t-test is applied to check whether mean after implementation is less than target value, 120 as shown in figure 3.49. The result shows that p-value is less than 0.0005 which is less than alpha of 0.05. It means that sample of mean of after implementation is less than target value 120 days. Then, re-applying the one-sample T test by hypothesis testing again when changed the target value to 90 and 91. Figure 3.50 when target value is 90, the p-value is 0.051 which is higher than 0.05, so accept the hypothesis which mean is equal target value, 90. Figure 3.51 when target value is 91, the p-value is 0.029 which is lower than 0.05. So, the conclusion is the average set-up time is less than 91 with significance at 95% confidence.

**One-Sample T: After**

```
Test of mu = 120 vs < 120

                                                  95%
                                                Upper
Variable   N     Mean   StDev  SE Mean    Bound       T      P
After     10  84.6000  9.3476   2.9560  90.0186  -11.98  0.000
```

**One-Sample T: After**

```
Test of mu = 90 vs < 90

                                                    95%
                                                  Upper
Variable   N     Mean   StDev  SE Mean    Bound      T      P
After     10  84.6000  9.3476   2.9560  90.0186  -1.83  0.051
```

**One-Sample T: After**

```
Test of mu = 91 vs < 91

                                                    95%
                                                  Upper
Variable   N     Mean   StDev  SE Mean    Bound      T      P
After     10  84.6000  9.3476   2.9560  90.0186  -2.17  0.029
```

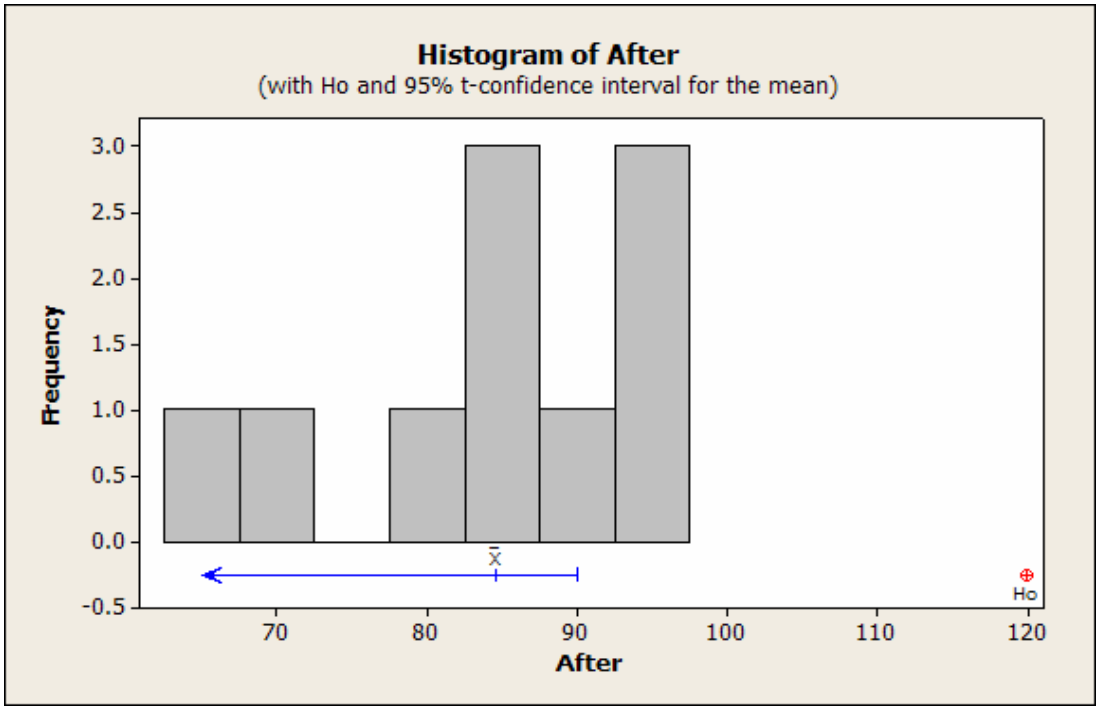



Figure 3.49: Histogram of hypothesis testing by one-sample t-test of after improvement when target value = 120

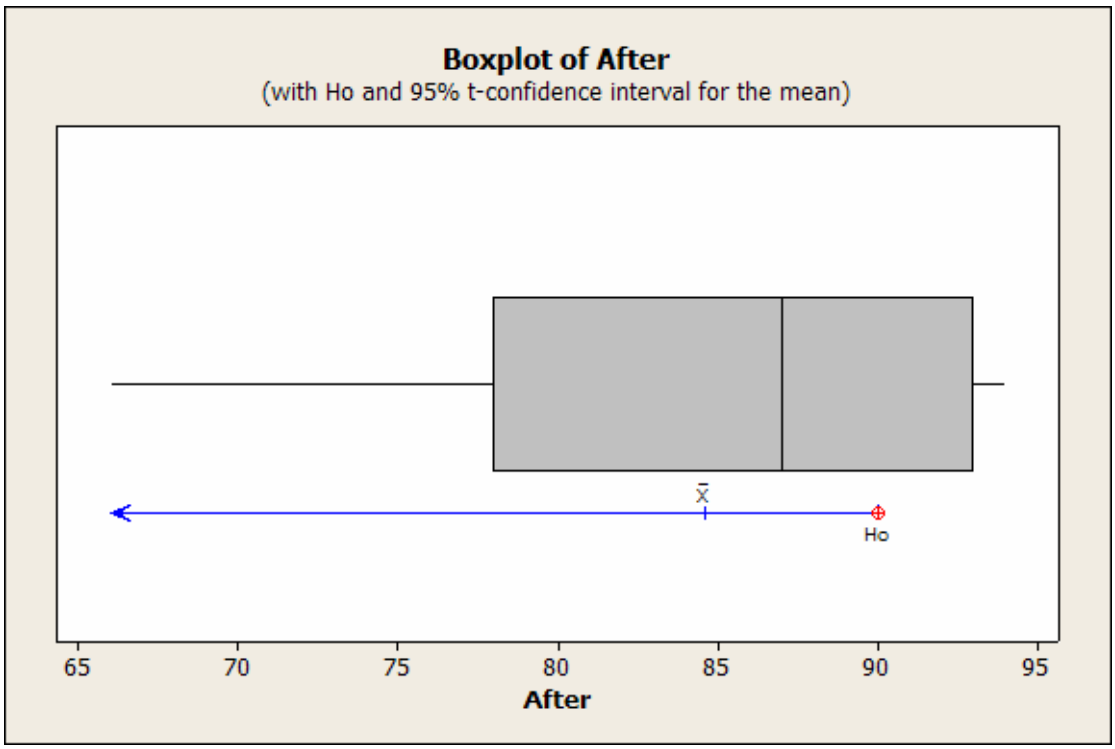



Figure 3.50: Box plot of hypothesis testing by one-sample t-test of after improvement when target value = 90

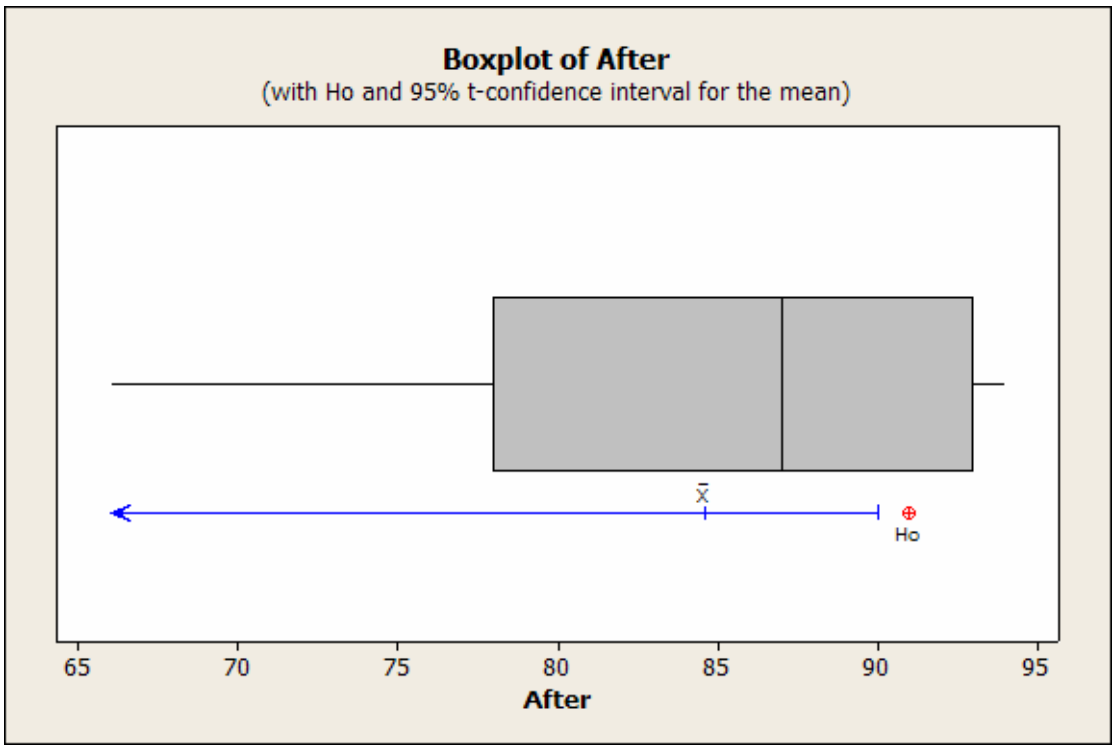



Figure 3.51: Box plot of hypothesis testing by one-sample t-test of after improvement when target value = 91

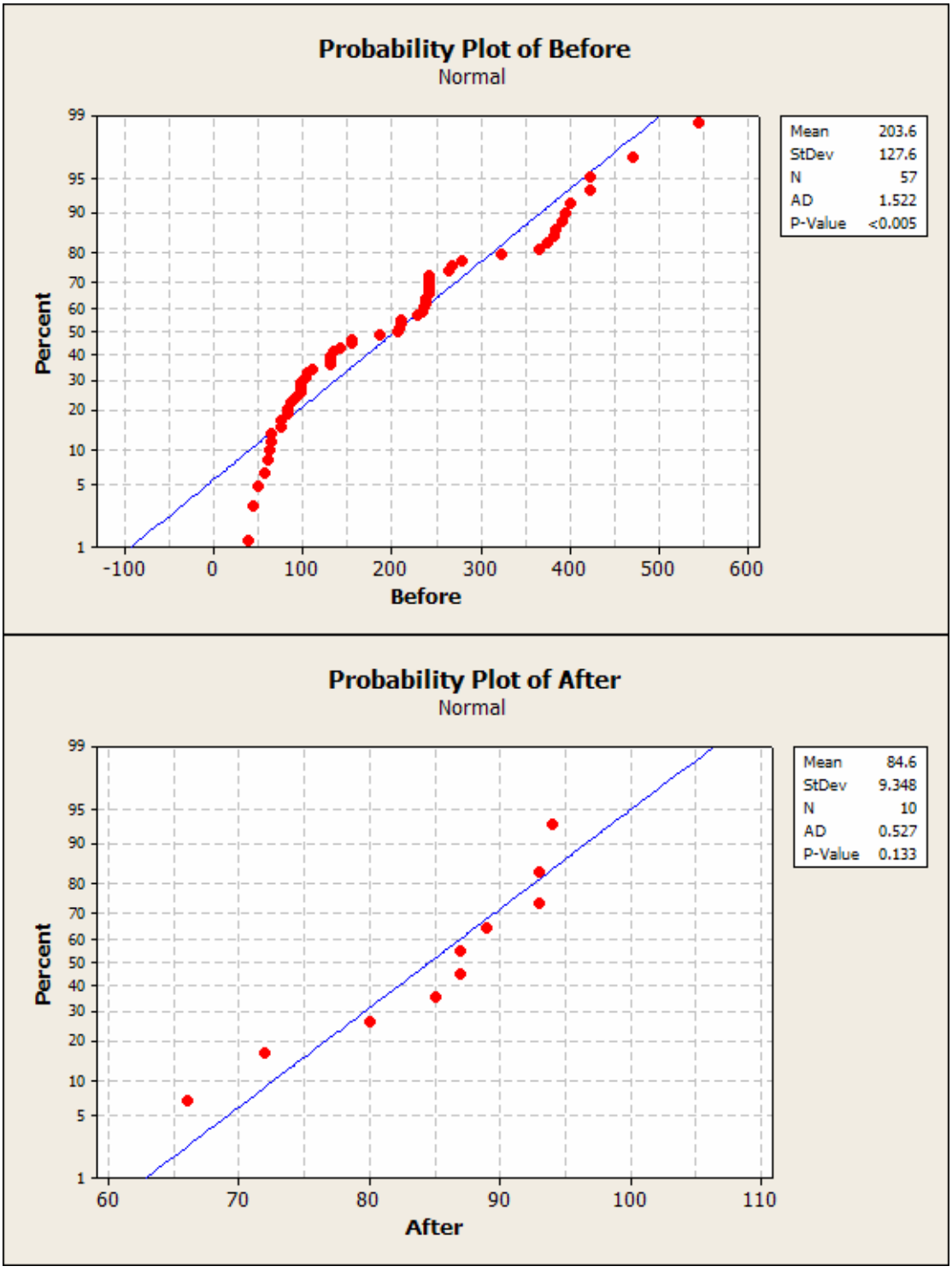



Figure 3.52: Normality test of before and after

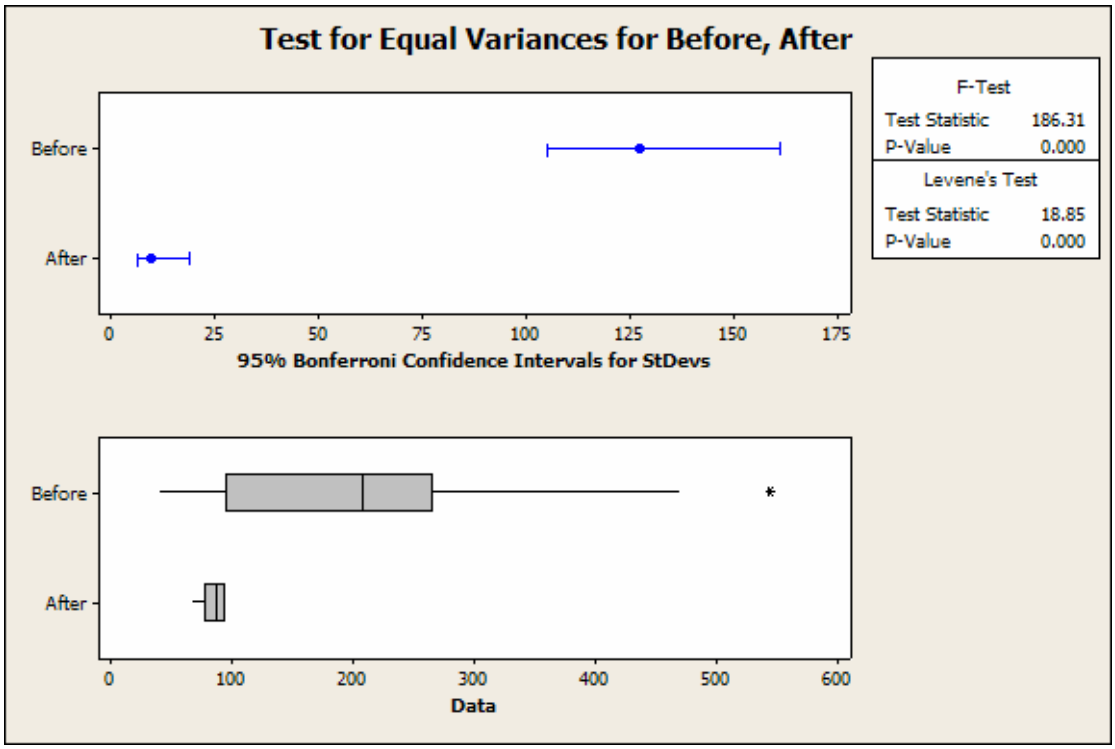



Figure 3.53: Test for equal variances for before, after

Following the normality test to check whether data is normal distribution as shown in figure 3.52, the p-value of sample data in the first graph is less than 0.0005, so reject null hypothesis, when null hypothesis is data distribution is normal. It means that the distribution of data plots is non-normal. Based on figure 3.53, test for equal variances for two groups of data which are before and after implementation. The p-value of Levene's Test is less than 0.0005. So, reject null hypothesis which null hypothesis is variances of two groups are equal. It means that variances of before and after is not equal. The variance of after implementation is less than the variance of before implementation.

# CHAPTER IV

# THE IMPORTANT FACTOR OF LEAN SIX SIGMA APPROACH FOR IMPROVEMENT OF GPRS ROAMING PROCESS

## 4.1 Factors for Lean Six Sigma project

There are many books detail the critical success factors which are required for successful implementation of Lean Six Sigma. As “The executive Guide to understanding and implementing Lean Six Sigma: The financial Impact” written by Meisel (Meisel, R.M., 2007) has been detailed that the “The first and foremost of these factors in the need for executive-level engagement. Senior management must be visibly in charge, consistently supportive, and willing to play and active role in communication and reward. Senior management must assure linkage of Lean Six Sigma to corporate strategies by utilizing effective goal deployment and performance tracking methods. They must provide clear prioritization relative to other initiatives, programs and priorities. Senior management will be responsible for conducting and participating in regularly scheduled reviews to assure and verify progress of the Lean Six Sigma projects”

The secondary critical success factor detailed in this book is communication. As Meisel (Meisel, R.M., 2007) put it that “Communication aids are developed and disseminated by and for management. A common language is created and advocated based on Lean Six Sigma. Lean Six Sigma is visibly promoted in every company meeting and communication. Another element of successful programs that is easily overlooked is the need for creating and communicating a human resources plan to support the various roles for Lean Six Sigma.”

The third critical success factor is the project itself. (Meisel, R.M., 2007) “A project pipeline spanning at least one year must be created and continually refreshed. The project must be linked to critical business and customer needs. The project’s scope and size must be defined in such a way as to produce significant saving and still be achievable. A Champion and Black Belt must be assigned to each project and held accountable. Other key resources also need to be assigned. It has also been found

helpful to implement a project-tracking system that will help keep projects on track by making their progress (or lack thereof) visible. The tracking system can also be used to communicate project results so that the knowledge grained from one project can be applied in other areas."

In addition to critical success factor, "Lean Six Sigma is the need for core knowledge and abilities in a variety of areas, including:

- *Knowledge of systems and value streams.* How interdependent components work toward a common aim. The goal is to optimize value-added components while reducing variation so that customers always get what they want.
- *Knowledge of various tools.* Statistics, data analysis, quality methods, root cause analysis, lean tools, and so on. Teams need to be able to distinguish signal from noise, define true root causes, propose countermeasures, develop improvement plans, and drive the project to completion following structured methods.
- *Knowledge of psychology.* The interpersonal and management skills to sell ideas, motivate teams, make data-based decisions, deal with conflict, and build trust."

## 4.2 Important factors in running project

In running Lean Six Sigma project in improvement of GPRS international roaming process, the important factors to bring this project succeed are concluded as mind map in Figure 4.1

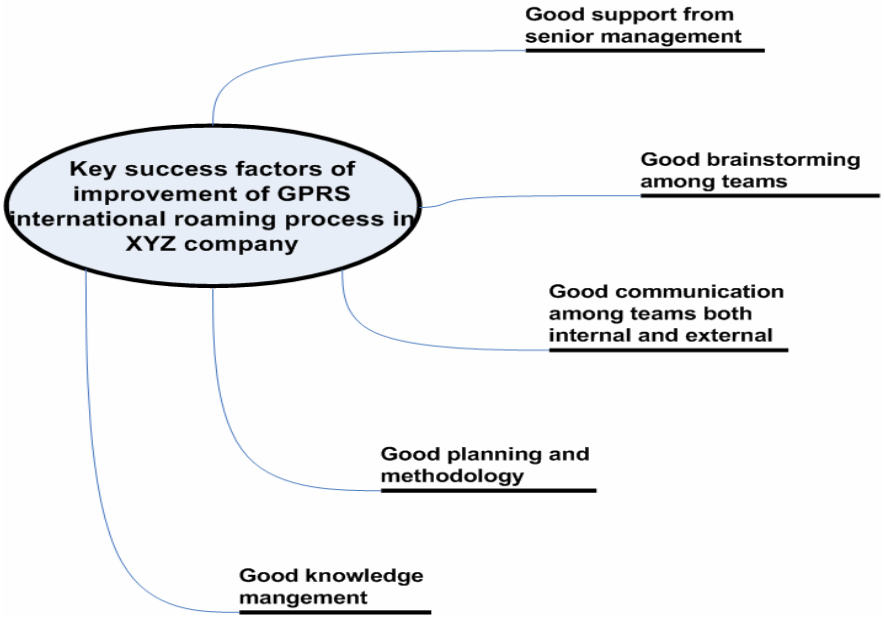



Figure 4.1: Key success factors of implementing process improvement of GPRS international roaming process in XYZ company

- Good support from senior management

In implementing new process to verify whether the concept can improve GPRS international roaming process following target objective, the support from senior management is the main key success, because to run any changes in company is required involvement of many teams related in that process. If there is no support from the senior management, this project cannot be run smoothly until the project is complete.

- Good brainstorming among teams

During running project in every phase, brainstorming is the most technique applied to find, analyze, and create any ideas. This project cannot be run by only person. Brainstorming moreover makes more understanding among teams to share what they want and they think to any topic. Many people in team have faced the different problems, so they can share each others for their ideas. The best solution can come out easier.

- Good communication among teams both internal and external

In GPRS roaming process, communication is the way to run and transfer works to related teams. Clear communication helps project run efficiently.

- Good planning and methodology

In running project, the time period is from December 2008 to April 2009. It runs long period, so the good planning and selected methodology is the key to success. The DMAIC methodology helps running project in caution. It provides step to step to find the best solution in improvement of GPRS international roaming process in XYZ company.

- Good knowledge management

As implementing GPRS international roaming service requires technical knowledge in telecommunication skill, the knowledge management can support in setting up and share information. Each team requires different information and document for own responsibility. So, the knowledge management technique helps in solving the mismatch information among teams. The documents and mandatory information are collected into sharepoint database to be references for any details in each activity.

From all of these key success factors for running process improvement of GPRS international roaming process in XYZ company, these factors just drive this project to have a good result. Nevertheless, implementing the new process cannot control external factors which are from roaming partners' sites or network problem. This new process improvement can efficiently improve internal GPRS international roaming process of XYZ company only. It additionally helps reducing any problems from XYZ company to roaming partners. The SIPOC is useful to reduce misunderstanding among teams.

# CHAPTER V

# CONCLUSION AND RECOMMENDATION

The improvement of GPRS international roaming process using Lean Six Sigma approach is initiated from the problem of delay in time-to-market which is cause of missing opportunity to launch new roaming services with operators around the world. The selected methodology is DMAIC to find the root cause of problems and create new process afterwards. The whole of basic methodology implemented in this project can be illustrated as Figure 5.1.

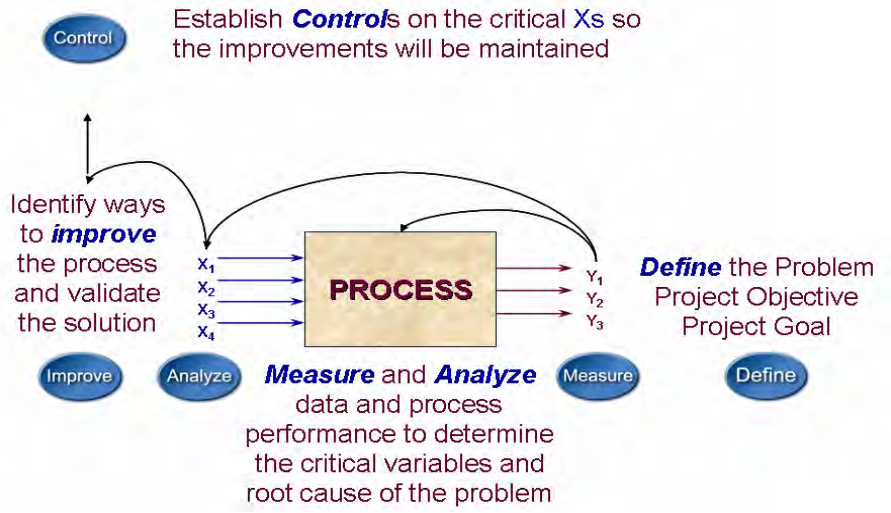



Figure 5.1: Key success factors of implementing process improvement of GPRS international roaming process in XYZ company

The first phase, define phase, it is basically applied in order to identify the selected project in details of objective, benefits, goal and target. It is also used to report to senior management. It details what the scope of work is, how long project take time, and the team members are. It is also the direction for team in implementing during running project in process improvement of GPRS international roaming service. The main technique implemented in this phase is brainstorming, project charter, grant chart, project target and time frame.

The secondary phase, measure phase, this phase is to collect information from historical data to be input in next phase. With the initial historical data in statement of problem, the total collected jobs are 57. This phase, those jobs are cut to 9 jobs due to limitation of tracking information from database. Subsequently, the process is defined as 5 main processes which are document preparation, implementation, test, validation and launch processes. These main processes are concluded from flowchart of initial GPRS international roaming process. The tools and techniques applied into this phase are deployment flowchart diagram, SIPOC of each phase, and histogram to illustrate the time consumptions of 9 selected jobs in each process. This phase requires many supports from involved people to detail the required information. At the final of this phase, the main phases which make the whole process delay can be specified easier. Furthermore, the draft time frame and involved team in each 5 main processes is detailed to fit in 120 days as target time frame.

The third phase, analyze phase, this phase is to find root cause of problem from input information in pervious phase. There are many tools and techniques applied into this phase. Those tools and techniques are the work flow analysis, the fish-bone diagram or cause and effect diagram, the relationship matrix, the Why-Why, How-How analysis, initial benchmarking and the SIPOC. From results of analyze phase, the Test and Validation phases are the root cause of problem in delay of time-to-market of GPRS international roaming service.

The fourth phase, improve phase, at this phase can scope down to find the best fit solution from the root cause of problems. The improvement solution focuses on how to solve the problems in test and validation phases from analysis results. The Tree diagram of How-How and Why-Why are the tools during brainstorming to generate ideas in improvement. The ECRS technique is the principle technique in improvement of the whole process based on Lean Six Sigma way. The potential solutions can be come up as 3 solutions. So, the pairewise ranking and the solution selection matrix are the techniques to find the best suit solution in implementing in pilot test. The best fit solution is solution 3 which is the applying Combine, Re-arrange and Simplify principles together. Finally, the new process based on the best solution is detailed as 4 main processes which are document preparation, implement and verification, test and validation, and commercial launch respectively. It combines test and validation processes into one process. Then, the details for pilot test are created among teams by brainstorming technique. The selected operators for

implementing in pilot test are 10 operators which are selected by business team. Then, the implementation plan is defined by Microsoft project software. The materials such as database establishment, training documents, schedule time frame document, simcard management document and checksheet for verification phase are prepared before starting the pilot test at 5th January 2009.

The last phase, control phase, this phase is to prevent any errors during running pilot test. So, the techniques and tools applied are mistake proofing and prevention by creating standard documents, standard heading of email format, and applying calendar alert to send notification to related team work. Moreover, control chart, Hypothesis testing, test for two variances from minitab program are applied to prove the pilot test whether it can be relied on before being concluded and reported to senior management.

The summary is in Table 5.1. The mean after applying DMAIC methodology based on new GPRS international roaming process is 84.6 days. So, it means that the new average set-up time in average is 84.6 days. This result can show the reduction of set-up time is equal to 119 days which is 58.45 % improvement. The hypothesis testing results of one sample T-Test is applied to show that the average set-up time is less than 91 days with significance at 95% confidence. The results of two variance test show that the average set-up time of after implement based on new process is lower than before implementing the new process. So, this new process can help reduce waste which are waiting time, and rework, Moreover, new process has quality which can provide improvement of time and resource management.

| **Info.** | **Before (improvement)** | **After (improvement)** |
|---|---|---|
| Mean of Lead-time | 203.6 days | 84.6 days |
| Variance | 16279.36 | 87.378 |

Table 5.1: Summary of result of before and after improvement

In conclusion, as XYZ company is the mobile network operator, the DMAIC methodology approach can be applied to the GPRS international roaming process. The new process by the way of Lean Six Sigma is the suitable concept for this improvement. As the lean is an approach that seeks to improve flow in the value stream and eliminate waste. The waste reduction in this research are mainly from

waiting time from exchanging information among teams in each process, it is about doing things quickly. Meanwhile, Six Sigma uses a powerful framework (DMAIC) and statistical tools to uncover root causes to understand and reduce variation. It is about doing things right. To prove the concept of quality by Six Sigma concept in this research, it is done by checking the variation of the results of 10 sample tasks whether total set-up time is acceptable by statistical analysis. A combination of both provides an over-arching improvement philosophy that incorporates powerful data-driven tools to solve problems and create rapid transformational improvement as integrating these concepts into new process of GPRS international roaming service. The new standard flowchart and SIPOC are detailed as previously illustrated in Chapter 3, Figure 3.29 and Table 3.19. The flowchart is helpful for overall picture of how to proceed the GPRS international roaming service from International Business (IB) team to Engineering teams that are Data and Supplementary Network (DSN), Information System (IS) and Network security team. The SIPOC is used to support the flowchart to detail who are supplier and customer of each process and what information is needed. This information is helpful to reduce the waiting time by improving communication system among teams. It can make the implementation of this GPRS international roaming service faster. The improvement from this research might be come from willing of team members working in this project, so the percentage of successful cases might not be the main improvement. However, the DMAIC methodology as applied to this service can be the guideline of other processes in XYZ company or other processes of other companies in the same telecom market sector. It is based on environment of that company.

**Abbreviations**

1. IR = International Roaming
2. IB = International Business
3. IS = Information System
4. IR.21 = Internet Registry. 21 (document of configuration)
5. IR.35 = Internet Registry. 35 (document of test form)
6. DSN = Data and Supplementary Network
7. AA14 = GSM Association Permanent Reference Document
8. GRX = GPRS international roaming exchange
9. TAP = Transfer Account Procedure
10. WAP = Wireless Application Protocol
11. MMS = Multimedia Message Service
12. GPRS = General Packet Radio Service
13. CDR = Call Detail Record
14. SGSN = Served GPRS Support Node
15. BG = Border Gateway
16. NOC = Network Operation Center

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# APPENDIXES

## A. Actual man hours of 10 samples in pilot test

| | | Task Name | Work | Duration | Start | Finish |
|---|---|---|---|---|---|---|
| 18 | ✓ | + 3. Kick-off meeting for pilot testing for GPRS international roaming process | 12 hrs | 0.5 days | Fri 19/12/08 | Fri 19/12/08 |
| 19 | ◆ | − **4. Pilot test** | **7,975.67 hrs** | **68 days?** | **Mon 05/01/09** | **Wed 08/04/09** |
| 20 | | − **4.1 Operator 1** | **858.67 hrs** | **57.5 days** | **Mon 05/01/09** | **Wed 25/03/09** |
| 21 | ✓ | + **4.1.1 Documentation preparation** | **272 hrs** | **21 days** | **Mon 05/01/09** | **Tue 03/02/09** |
| 24 | ✓ | − **4.1.2 Implement and Verification** | **118.67 hrs** | **17.56 days** | **Mon 12/01/09** | **Wed 04/02/09** |
| 25 | ✓ | − 4.1.2.1 GPRS system | 24 hrs | 3 days | Fri 23/01/09 | Wed 28/01/09 |
| | | *DSN* | *24 hrs* | | *Fri 23/01/09* | *Wed 28/01/09* |
| 26 | ✓ | − 4.1.2.2 Billing system | 10.67 hrs | 2 days | Mon 12/01/09 | Mon 02/02/09 |
| | | *IS (IR admin)* | *10.67 hrs* | | *Mon 12/01/09* | *Mon 02/02/09* |
| 27 | ✓ | − 4.1.2.3 Roaming partner's system | 64 hrs | 8 days | Fri 23/01/09 | Wed 04/02/09 |
| | | *RP* | *64 hrs* | | *Fri 23/01/09* | *Wed 04/02/09* |
| 28 | ✓ | − **4.1.2.4 Verification** | **20 hrs** | **2.5 days** | **Mon 02/02/09** | **Wed 04/02/09** |
| 29 | ✓ | − 4.1.2.4.1 XYZ verification | 20 hrs | 2.5 days | Mon 02/02/09 | Wed 04/02/09 |
| | | *DSN* | *20 hrs* | | *Mon 02/02/09* | *Wed 04/02/09* |
| 30 | ✓ | − 4.1.2.4.2 RP verification | 0 hrs | 0 days | Wed 04/02/09 | Wed 04/02/09 |
| | | *RP* | *0 hrs* | | *Wed 04/02/09* | *Wed 04/02/09* |
| 31 | ✓ | − **4.1.3 Test and Validation** | **456 hrs** | **15.5 days** | **Wed 04/02/09** | **Wed 25/02/09** |
| 32 | ✓ | − 4.1.3.1 Case 1 | 56 hrs | 3.5 days | Wed 04/02/09 | Mon 09/02/09 |
| | | *DSN* | *28 hrs* | | *Wed 04/02/09* | *Mon 09/02/09* |
| | | *IS (IR admin)* | *28 hrs* | | *Wed 04/02/09* | *Mon 09/02/09* |
| 33 | ✓ | − 4.1.3.2 Case 2 | 56 hrs | 3.5 days | Wed 04/02/09 | Mon 09/02/09 |
| | | *DSN* | *28 hrs* | | *Wed 04/02/09* | *Mon 09/02/09* |
| | | *IS (IR admin)* | *28 hrs* | | *Wed 04/02/09* | *Mon 09/02/09* |
| 34 | ✓ | − 4.1.3.3 Case 3 | 112 hrs | 7 days | Thu 05/02/09 | Mon 16/02/09 |
| | | *DSN* | *56 hrs* | | *Thu 05/02/09* | *Mon 16/02/09* |
| | | *IS (IR admin)* | *56 hrs* | | *Thu 05/02/09* | *Mon 16/02/09* |
| 35 | ✓ | − 4.1.3.4 Case 4 | 224 hrs | 14 days | Thu 05/02/09 | Wed 25/02/09 |
| | | *DSN* | *112 hrs* | | *Thu 05/02/09* | *Wed 25/02/09* |
| | | *IS (IR admin)* | *112 hrs* | | *Thu 05/02/09* | *Wed 25/02/09* |
| 36 | ✓ | − 4.1.3.5 Case 5 | 8 hrs | 0.5 days | Wed 25/02/09 | Wed 25/02/09 |
| | | *DSN* | *4 hrs* | | *Wed 25/02/09* | *Wed 25/02/09* |
| | | *IS (IR admin)* | *4 hrs* | | *Wed 25/02/09* | *Wed 25/02/09* |
| 37 | | + **4.1.4 Launch** | **12 hrs** | **7.5 days** | **Mon 16/03/09** | **Wed 25/03/09** |

Figure A.1: Actual work hour of each unit for implementing operator 1

| | Task Name | Work | Duration | Start | Finish |
|---|---|---|---|---|---|
| 18 | + 3. Kick-off meeting for pilot testing for GPRS international roaming process | 12 hrs | 0.5 days | Fri 19/12/08 | Fri 19/12/08 |
| 19 | **− 4. Pilot test** | **7,975.67 hrs** | **68 days?** | **Mon 05/01/09** | **Wed 08/04/09** |
| 20 | **+ 4.1 Operator 1** | **858.67 hrs** | **57.5 days** | **Mon 05/01/09** | **Wed 25/03/09** |
| 42 | **− 4.2 Operator 2** | **512 hrs** | **60.5 days** | **Mon 05/01/09** | **Mon 30/03/09** |
| 43 | **+ 4.2.1 Documentation preparation** | **120 hrs** | **11 days** | **Mon 05/01/09** | **Tue 20/01/09** |
| 46 | **− 4.2.2 Implement and Verification** | **144 hrs** | **10 days** | **Tue 13/01/09** | **Tue 27/01/09** |
| 47 | − 4.2.2.1 GPRS system | 28 hrs | 3.5 days | Tue 20/01/09 | Fri 23/01/09 |
| | *DSN* | *28 hrs* | | *Tue 20/01/09* | *Fri 23/01/09* |
| 48 | − 4.2.2.2 Billing system | 28 hrs | 3.5 days | Tue 20/01/09 | Fri 23/01/09 |
| | *IS (IR admin)* | *28 hrs* | | *Tue 20/01/09* | *Fri 23/01/09* |
| 49 | − 4.2.2.3 Roaming partner's system | 72 hrs | 9 days | Tue 13/01/09 | Mon 26/01/09 |
| | *RP* | *72 hrs* | | *Tue 13/01/09* | *Mon 26/01/09* |
| 50 | **− 4.2.2.4 Verification** | **16 hrs** | **2 days** | **Fri 23/01/09** | **Tue 27/01/09** |
| 51 | − 4.1.2.4.1 XYZ verification | 16 hrs | 2 days | Fri 23/01/09 | Tue 27/01/09 |
| | *DSN* | *16 hrs* | | *Fri 23/01/09* | *Tue 27/01/09* |
| 52 | − 4.1.2.4.2 RP verification | 0 hrs | 0 days | Mon 26/01/09 | Mon 26/01/09 |
| | *RP* | *0 hrs* | | *Mon 26/01/09* | *Mon 26/01/09* |
| 53 | **− 4.2.3 Test and Validation** | **224 hrs** | **16.5 days** | **Wed 28/01/09** | **Thu 19/02/09** |
| 54 | − 4.2.3.1 Case 1 | 96 hrs | 6 days | Wed 28/01/09 | Thu 05/02/09 |
| | *DSN* | *48 hrs* | | *Wed 28/01/09* | *Thu 05/02/09* |
| | *IS (IR admin)* | *48 hrs* | | *Wed 28/01/09* | *Thu 05/02/09* |
| 55 | − 4.2.3.2 Case 2 | 40 hrs | 2.5 days | Tue 03/02/09 | Thu 05/02/09 |
| | *DSN* | *20 hrs* | | *Tue 03/02/09* | *Thu 05/02/09* |
| | *IS (IR admin)* | *20 hrs* | | *Tue 03/02/09* | *Thu 05/02/09* |
| 56 | − 4.2.3.3 Case 3 | 40 hrs | 2.5 days | Tue 03/02/09 | Thu 05/02/09 |
| | *DSN* | *20 hrs* | | *Tue 03/02/09* | *Thu 05/02/09* |
| | *IS (IR admin)* | *20 hrs* | | *Tue 03/02/09* | *Thu 05/02/09* |
| 57 | − 4.2.3.4 Case 4 | 40 hrs | 2.5 days | Tue 03/02/09 | Thu 05/02/09 |
| | *DSN* | *20 hrs* | | *Tue 03/02/09* | *Thu 05/02/09* |
| | *IS (IR admin)* | *20 hrs* | | *Tue 03/02/09* | *Thu 05/02/09* |
| 58 | − 4.2.3.5 Case 5 | 8 hrs | 0.5 days | Thu 19/02/09 | Thu 19/02/09 |
| | *DSN* | *4 hrs* | | *Thu 19/02/09* | *Thu 19/02/09* |
| | *IS (IR admin)* | *4 hrs* | | *Thu 19/02/09* | *Thu 19/02/09* |
| 59 | **+ 4.2.4 Launch** | **24 hrs** | **8.5 days** | **Wed 18/03/09** | **Mon 30/03/09** |

Figure A.2: Actual work hour of each unit for implementing operator 2

| | Task Name | Work | Duration | Start | Finish |
|---|---|---|---|---|---|
| 42 | **+ 4.2 Operator 2** | **512 hrs** | **60.5 days** | **Mon 05/01/09** | **Mon 30/03/09** |
| 64 | **− 4.3 Operator 3** | **808 hrs** | **64.56 days** | **Mon 05/01/09** | **Fri 03/04/09** |
| 65 | **+ 4.1.1 Documentation preparation** | **152 hrs** | **11 days** | **Mon 05/01/09** | **Mon 19/01/09** |
| 68 | **− 4.1.2 Implement and Verification** | **96 hrs** | **9 days** | **Wed 14/01/09** | **Tue 27/01/09** |
| 69 | − 4.1.2.1 GPRS system | 24 hrs | 3 days | Wed 14/01/09 | Mon 19/01/09 |
| | *DSN* | *24 hrs* | | *Wed 14/01/09* | *Mon 19/01/09* |
| 70 | − 4.1.2.2 Billing system | 16 hrs | 2 days | Wed 14/01/09 | Fri 16/01/09 |
| | *IS (IR admin)* | *16 hrs* | | *Wed 14/01/09* | *Fri 16/01/09* |
| 71 | − 4.1.2.3 Roaming partner's system | 48 hrs | 6 days | Mon 19/01/09 | Tue 27/01/09 |
| | *RP* | *48 hrs* | | *Mon 19/01/09* | *Tue 27/01/09* |
| 72 | **− 4.1.2.4 Verification** | **8 hrs** | **6 days** | **Mon 19/01/09** | **Tue 27/01/09** |
| 73 | − 4.1.2.4.1 XYZ verification | 8 hrs | 1 day | Mon 19/01/09 | Tue 20/01/09 |
| | *DSN* | *8 hrs* | | *Mon 19/01/09* | *Tue 20/01/09* |
| 74 | − 4.1.2.4.2 RP verification | 0 hrs | 0 days | Tue 27/01/09 | Tue 27/01/09 |
| | *RP* | *0 hrs* | | *Tue 27/01/09* | *Tue 27/01/09* |
| 75 | **− 4.1.3 Test and Validation** | **536 hrs** | **23.5 days** | **Mon 26/01/09** | **Thu 26/02/09** |
| 76 | − 4.1.3.1 Case 1 | 144 hrs | 9 days | Mon 26/01/09 | Fri 06/02/09 |
| | *DSN* | *72 hrs* | | *Mon 26/01/09* | *Fri 06/02/09* |
| | *IS (IR admin)* | *72 hrs* | | *Mon 26/01/09* | *Fri 06/02/09* |
| 77 | − 4.1.3.2 Case 2 | 144 hrs | 9 days | Mon 26/01/09 | Fri 06/02/09 |
| | *DSN* | *72 hrs* | | *Mon 26/01/09* | *Fri 06/02/09* |
| | *IS (IR admin)* | *72 hrs* | | *Mon 26/01/09* | *Fri 06/02/09* |
| 78 | − 4.1.3.3 Case 3 | 96 hrs | 6 days | Thu 29/01/09 | Fri 06/02/09 |
| | *DSN* | *48 hrs* | | *Thu 29/01/09* | *Fri 06/02/09* |
| | *IS (IR admin)* | *48 hrs* | | *Thu 29/01/09* | *Fri 06/02/09* |
| 79 | − 4.1.3.4 Case 4 | 144 hrs | 9 days | Fri 30/01/09 | Thu 12/02/09 |
| | *DSN* | *72 hrs* | | *Fri 30/01/09* | *Thu 12/02/09* |
| | *IS (IR admin)* | *72 hrs* | | *Fri 30/01/09* | *Thu 12/02/09* |
| 80 | − 4.1.3.5 Case 5 | 8 hrs | 0.5 days | Thu 26/02/09 | Thu 26/02/09 |
| | *DSN* | *4 hrs* | | *Thu 26/02/09* | *Thu 26/02/09* |
| | *IS (IR admin)* | *4 hrs* | | *Thu 26/02/09* | *Thu 26/02/09* |
| 81 | **+ 4.1.4 Launch** | **24 hrs** | **7.5 days** | **Wed 25/03/09** | **Fri 03/04/09** |

Figure A.3: Actual work hour of each unit for implementing operator 3

| | | Task Name | Work | Duration | Start | Finish |
|---|---|---|---|---|---|---|
| 42 | ✓ | + **4.2 Operator 2** | **512 hrs** | **60.5 days** | **Mon 05/01/09** | **Mon 30/03/09** |
| 64 | ✓ | + **4.3 Operator 3** | **808 hrs** | **64.56 days** | **Mon 05/01/09** | **Fri 03/04/09** |
| 86 | ✓ | − **4.1 Operator 4** | **1,076 hrs** | **62.56 days** | **Mon 05/01/09** | **Wed 01/04/09** |
| 87 | ✓ | + **4.1.1 Documentation preparation** | **128 hrs** | **11.06 days** | **Mon 05/01/09** | **Tue 20/01/09** |
| 90 | ✓ | − **4.1.2 Implement and Verification** | **128 hrs** | **10 days** | **Mon 12/01/09** | **Mon 26/01/09** |
| 91 | ✓ | − 4.1.2.1 GPRS system | 24 hrs | 3 days | Tue 20/01/09 | Fri 23/01/09 |
| | | *DSN* | *24 hrs* | | *Tue 20/01/09* | *Fri 23/01/09* |
| 92 | ✓ | − 4.1.2.2 Billing system | 24 hrs | 3 days | Tue 20/01/09 | Fri 23/01/09 |
| | | *IS (IR admin)* | *24 hrs* | | *Tue 20/01/09* | *Fri 23/01/09* |
| 93 | ✓ | − 4.1.2.3 Roaming partner's system | 72 hrs | 9 days | Mon 12/01/09 | Fri 23/01/09 |
| | | *RP* | *72 hrs* | | *Mon 12/01/09* | *Fri 23/01/09* |
| 94 | ✓ | − **4.1.2.4 Verification** | **8 hrs** | **1 day** | **Fri 23/01/09** | **Mon 26/01/09** |
| 95 | ✓ | − 4.1.2.4.1 XYZ verification | 8 hrs | 1 day | Fri 23/01/09 | Mon 26/01/09 |
| | | *DSN* | *8 hrs* | | *Fri 23/01/09* | *Mon 26/01/09* |
| 96 | ✓ | − 4.1.2.4.2 RP verification | 0 hrs | 0 days | Fri 23/01/09 | Fri 23/01/09 |
| | | *RP* | *0 hrs* | | *Fri 23/01/09* | *Fri 23/01/09* |
| 97 | ✓ | − **4.1.3 Test and Validation** | **800 hrs** | **39 days** | **Thu 29/01/09** | **Wed 25/03/09** |
| 98 | ✓ | − 4.1.3.1 Case 1 | 56 hrs | 3.5 days | Wed 04/02/09 | Mon 09/02/09 |
| | | *DSN* | *28 hrs* | | *Wed 04/02/09* | *Mon 09/02/09* |
| | | *IS (IR admin)* | *28 hrs* | | *Wed 04/02/09* | *Mon 09/02/09* |
| 99 | ✓ | − 4.1.3.2 Case 2 | 56 hrs | 3.5 days | Wed 04/02/09 | Mon 09/02/09 |
| | | *DSN* | *28 hrs* | | *Wed 04/02/09* | *Mon 09/02/09* |
| | | *IS (IR admin)* | *28 hrs* | | *Wed 04/02/09* | *Mon 09/02/09* |
| 100 | ✓ | − 4.1.3.3 Case 3 | 560 hrs | 35 days | Wed 04/02/09 | Wed 25/03/09 |
| | | *DSN* | *280 hrs* | | *Wed 04/02/09* | *Wed 25/03/09* |
| | | *IS (IR admin)* | *280 hrs* | | *Wed 04/02/09* | *Wed 25/03/09* |
| 101 | ✓ | − 4.1.3.4 Case 4 | 96 hrs | 6 days | Tue 17/02/09 | Wed 25/02/09 |
| | | *DSN* | *48 hrs* | | *Tue 17/02/09* | *Wed 25/02/09* |
| | | *IS (IR admin)* | *48 hrs* | | *Tue 17/02/09* | *Wed 25/02/09* |
| 102 | ✓ | − 4.1.3.5 Case 5 | 32 hrs | 2 days | Thu 29/01/09 | Mon 02/02/09 |
| | | *DSN* | *16 hrs* | | *Thu 29/01/09* | *Mon 02/02/09* |
| | | *IS (IR admin)* | *16 hrs* | | *Thu 29/01/09* | *Mon 02/02/09* |
| 103 | ✓ | + **4.1.4 Launch** | **20 hrs** | **3.5 days** | **Fri 27/03/09** | **Wed 01/04/09** |

Figure A.4: Actual work hour of each unit for implementing operator 4

| | | Task Name | Work | Duration | Start | Finish |
|---|---|---|---|---|---|---|
| 108 | ✓ | − **4.1 Operator 5** | **632 hrs** | **66.56 days** | **Mon 05/01/09** | **Tue 07/04/09** |
| 109 | ✓ | + **4.1.1 Documentation preparation** | **184 hrs** | **17.06 days** | **Mon 05/01/09** | **Wed 28/01/09** |
| 112 | ✓ | − **4.1.2 Implement and Verification** | **192 hrs** | **16 days** | **Wed 14/01/09** | **Thu 05/02/09** |
| 113 | ✓ | − 4.1.2.1 GPRS system | 40 hrs | 5 days | Wed 28/01/09 | Wed 04/02/09 |
| | | *DSN* | *40 hrs* | | *Wed 28/01/09* | *Wed 04/02/09* |
| 114 | ✓ | − 4.1.2.2 Billing system | 24 hrs | 3 days | Wed 28/01/09 | Mon 02/02/09 |
| | | *IS (IR admin)* | *24 hrs* | | *Wed 28/01/09* | *Mon 02/02/09* |
| 115 | ✓ | − 4.1.2.3 Roaming partner's system | 32 hrs | 4 days | Wed 14/01/09 | Tue 20/01/09 |
| | | *RP* | *32 hrs* | | *Wed 14/01/09* | *Tue 20/01/09* |
| 116 | ✓ | − **4.1.2.4 Verification** | **96 hrs** | **12 days** | **Tue 20/01/09** | **Thu 05/02/09** |
| 117 | ✓ | − 4.1.2.4.1 XYZ verification | 8 hrs | 1 day | Wed 04/02/09 | Thu 05/02/09 |
| | | *DSN* | *8 hrs* | | *Wed 04/02/09* | *Thu 05/02/09* |
| 118 | ✓ | − 4.1.2.4.2 RP verification | 88 hrs | 11 days | Tue 20/01/09 | Wed 04/02/09 |
| | | *RP* | *88 hrs* | | *Tue 20/01/09* | *Wed 04/02/09* |
| 119 | ✓ | − **4.1.3 Test and Validation** | **232 hrs** | **18.5 days** | **Fri 06/02/09** | **Wed 04/03/09** |
| 120 | ✓ | − 4.1.3.1 Case 1 | 64 hrs | 4 days | Fri 06/02/09 | Thu 12/02/09 |
| | | *DSN* | *32 hrs* | | *Fri 06/02/09* | *Thu 12/02/09* |
| | | *IS (IR admin)* | *32 hrs* | | *Fri 06/02/09* | *Thu 12/02/09* |
| 121 | ✓ | − 4.1.3.2 Case 2 | 64 hrs | 4 days | Fri 06/02/09 | Thu 12/02/09 |
| | | *DSN* | *32 hrs* | | *Fri 06/02/09* | *Thu 12/02/09* |
| | | *IS (IR admin)* | *32 hrs* | | *Fri 06/02/09* | *Thu 12/02/09* |
| 122 | ✓ | − 4.1.3.3 Case 3 | 48 hrs | 3 days | Mon 09/02/09 | Thu 12/02/09 |
| | | *DSN* | *24 hrs* | | *Mon 09/02/09* | *Thu 12/02/09* |
| | | *IS (IR admin)* | *24 hrs* | | *Mon 09/02/09* | *Thu 12/02/09* |
| 123 | ✓ | − 4.1.3.4 Case 4 | 48 hrs | 3 days | Mon 09/02/09 | Thu 12/02/09 |
| | | *DSN* | *24 hrs* | | *Mon 09/02/09* | *Thu 12/02/09* |
| | | *IS (IR admin)* | *24 hrs* | | *Mon 09/02/09* | *Thu 12/02/09* |
| 124 | ✓ | − 4.1.3.5 Case 5 | 8 hrs | 0.5 days | Wed 04/03/09 | Wed 04/03/09 |
| | | *DSN* | *4 hrs* | | *Wed 04/03/09* | *Wed 04/03/09* |
| | | *IS (IR admin)* | *4 hrs* | | *Wed 04/03/09* | *Wed 04/03/09* |
| 125 | ✓ | + **4.1.4 Launch** | **24 hrs** | **11.5 days** | **Mon 23/03/09** | **Tue 07/04/09** |

Figure A.5: Actual work hour of each unit for implementing operator 5

| | Task Name | Work | Duration | Start | Finish |
|---|---|---|---|---|---|
| 108 | + **4.1 Operator 5** | **632 hrs** | **66.56 days** | **Mon 05/01/09** | **Tue 07/04/09** |
| 130 | − **4.1 Operator 6** | **1,176 hrs** | **62.56 days** | **Mon 05/01/09** | **Wed 01/04/09** |
| 131 | + **4.1.1 Documentation preparation** | **152 hrs** | **17.06 days** | **Mon 05/01/09** | **Wed 28/01/09** |
| 134 | − **4.1.2 Implement and Verification** | **232 hrs** | **17 days** | **Wed 14/01/09** | **Fri 06/02/09** |
| 135 | − 4.1.2.1 GPRS system | 40 hrs | 5 days | Wed 28/01/09 | Wed 04/02/09 |
| | *DSN* | *40 hrs* | | *Wed 28/01/09* | *Wed 04/02/09* |
| 136 | − 4.1.2.2 Billing system | 40 hrs | 5 days | Wed 28/01/09 | Wed 04/02/09 |
| | *IS (IR admin)* | *40 hrs* | | *Wed 28/01/09* | *Wed 04/02/09* |
| 137 | − 4.1.2.3 Roaming partner's system | 136 hrs | 17 days | Wed 14/01/09 | Fri 06/02/09 |
| | *RP* | *136 hrs* | | *Wed 14/01/09* | *Fri 06/02/09* |
| 138 | − **4.1.2.4 Verification** | **16 hrs** | **2 days** | **Wed 04/02/09** | **Fri 06/02/09** |
| 139 | − 4.1.2.4.1 XYZ verification | 16 hrs | 2 days | Wed 04/02/09 | Fri 06/02/09 |
| | *DSN* | *16 hrs* | | *Wed 04/02/09* | *Fri 06/02/09* |
| 140 | − 4.1.2.4.2 RP verification | 0 hrs | 0 days | Fri 06/02/09 | Fri 06/02/09 |
| | *RP* | *0 hrs* | | *Fri 06/02/09* | *Fri 06/02/09* |
| 141 | − **4.1.3 Test and Validation** | **776 hrs** | **22 days** | **Wed 18/02/09** | **Fri 20/03/09** |
| 142 | − 4.1.3.1 Case 1 | 112 hrs | 7 days | Thu 19/02/09 | Mon 02/03/09 |
| | *DSN* | *56 hrs* | | *Thu 19/02/09* | *Mon 02/03/09* |
| | *IS (IR admin)* | *56 hrs* | | *Thu 19/02/09* | *Mon 02/03/09* |
| 143 | − 4.1.3.2 Case 2 | 112 hrs | 7 days | Thu 19/02/09 | Mon 02/03/09 |
| | *DSN* | *56 hrs* | | *Thu 19/02/09* | *Mon 02/03/09* |
| | *IS (IR admin)* | *56 hrs* | | *Thu 19/02/09* | *Mon 02/03/09* |
| 144 | − 4.1.3.3 Case 3 | 272 hrs | 17 days | Wed 25/02/09 | Fri 20/03/09 |
| | *DSN* | *136 hrs* | | *Wed 25/02/09* | *Fri 20/03/09* |
| | *IS (IR admin)* | *136 hrs* | | *Wed 25/02/09* | *Fri 20/03/09* |
| 145 | − 4.1.3.4 Case 4 | 272 hrs | 17 days | Wed 25/02/09 | Fri 20/03/09 |
| | *DSN* | *136 hrs* | | *Wed 25/02/09* | *Fri 20/03/09* |
| | *IS (IR admin)* | *136 hrs* | | *Wed 25/02/09* | *Fri 20/03/09* |
| 146 | − 4.1.3.5 Case 5 | 8 hrs | 0.5 days | Wed 18/02/09 | Wed 18/02/09 |
| | *DSN* | *4 hrs* | | *Wed 18/02/09* | *Wed 18/02/09* |
| | *IS (IR admin)* | *4 hrs* | | *Wed 18/02/09* | *Wed 18/02/09* |
| 147 | + **4.1.4 Launch** | **16 hrs** | **3.5 days** | **Fri 27/03/09** | **Wed 01/04/09** |

Figure A.6: Actual work hour of each unit for implementing operator 6

| | Task Name | Work | Duration | Start | Finish |
|---|---|---|---|---|---|
| 108 | + **4.1 Operator 5** | **632 hrs** | **66.56 days** | **Mon 05/01/09** | **Tue 07/04/09** |
| 130 | + **4.1 Operator 6** | **1,176 hrs** | **62.56 days** | **Mon 05/01/09** | **Wed 01/04/09** |
| 152 | − **4.1 Operator 7** | **572 hrs** | **66.5 days** | **Mon 05/01/09** | **Tue 07/04/09** |
| 153 | + **4.1.1 Documentation preparation** | **144 hrs** | **11 days** | **Mon 05/01/09** | **Tue 20/01/09** |
| 156 | − **4.1.2 Implement and Verification** | **108 hrs** | **27 days** | **Thu 15/01/09** | **Mon 23/02/09** |
| 157 | − 4.1.2.1 GPRS system | 32 hrs | 4 days | Tue 20/01/09 | Mon 26/01/09 |
| | *DSN* | *32 hrs* | | *Tue 20/01/09* | *Mon 26/01/09* |
| 158 | − 4.1.2.2 Billing system | 24 hrs | 3 days | Tue 20/01/09 | Fri 23/01/09 |
| | *IS (IR admin)* | *24 hrs* | | *Tue 20/01/09* | *Fri 23/01/09* |
| 159 | − 4.1.2.3 Roaming partner's system | 48 hrs | 6 days | Thu 15/01/09 | Fri 23/01/09 |
| | *RP* | *48 hrs* | | *Thu 15/01/09* | *Fri 23/01/09* |
| 160 | − **4.1.2.4 Verification** | **4 hrs** | **20 days** | **Mon 26/01/09** | **Mon 23/02/09** |
| 161 | − 4.1.2.4.1 XYZ verification | 4 hrs | 0.5 days | Mon 26/01/09 | Mon 26/01/09 |
| | *DSN* | *4 hrs* | | *Mon 26/01/09* | *Mon 26/01/09* |
| 162 | − 4.1.2.4.2 RP verification | 0 hrs | 0 days | Mon 23/02/09 | Mon 23/02/09 |
| | *RP* | *0 hrs* | | *Mon 23/02/09* | *Mon 23/02/09* |
| 163 | − **4.1.3 Test and Validation** | **296 hrs** | **11 days** | **Wed 04/03/09** | **Thu 19/03/09** |
| 164 | − 4.1.3.1 Case 1 | 64 hrs | 4 days | Wed 04/03/09 | Tue 10/03/09 |
| | *DSN* | *32 hrs* | | *Wed 04/03/09* | *Tue 10/03/09* |
| | *IS (IR admin)* | *32 hrs* | | *Wed 04/03/09* | *Tue 10/03/09* |
| 165 | − 4.1.3.2 Case 2 | 64 hrs | 4 days | Wed 04/03/09 | Tue 10/03/09 |
| | *DSN* | *32 hrs* | | *Wed 04/03/09* | *Tue 10/03/09* |
| | *IS (IR admin)* | *32 hrs* | | *Wed 04/03/09* | *Tue 10/03/09* |
| 166 | − 4.1.3.3 Case 3 | 48 hrs | 3 days | Mon 09/03/09 | Thu 12/03/09 |
| | *DSN* | *24 hrs* | | *Mon 09/03/09* | *Thu 12/03/09* |
| | *IS (IR admin)* | *24 hrs* | | *Mon 09/03/09* | *Thu 12/03/09* |
| 167 | − 4.1.3.4 Case 4 | 112 hrs | 7 days | Tue 10/03/09 | Thu 19/03/09 |
| | *DSN* | *56 hrs* | | *Tue 10/03/09* | *Thu 19/03/09* |
| | *IS (IR admin)* | *56 hrs* | | *Tue 10/03/09* | *Thu 19/03/09* |
| 168 | − 4.1.3.5 Case 5 | 8 hrs | 0.5 days | Wed 04/03/09 | Wed 04/03/09 |
| | *DSN* | *4 hrs* | | *Wed 04/03/09* | *Wed 04/03/09* |
| | *IS (IR admin)* | *4 hrs* | | *Wed 04/03/09* | *Wed 04/03/09* |
| 169 | + **4.1.4 Launch** | **24 hrs** | **6.5 days** | **Mon 30/03/09** | **Tue 07/04/09** |

Figure A.7: Actual work hour of each unit for implementing operator 7

| | | Task Name | Work | Duration | Start | Finish |
|---|---|---|---|---|---|---|
| 174 | ✓ | **− 4.1 Operator 8** | **1,144 hrs** | **53.06 days** | **Mon 05/01/09** | **Thu 19/03/09** |
| 175 | ✓ | **+ 4.1.1 Documentation preparation** | **112 hrs** | **10.06 days** | **Mon 05/01/09** | **Mon 19/01/09** |
| 178 | ✓ | **− 4.1.2 Implement and Verification** | **144 hrs** | **32 days** | **Tue 13/01/09** | **Thu 26/02/09** |
| 179 | ✓ | − 4.1.2.1 GPRS system | 32 hrs | 4 days | Mon 19/01/09 | Fri 23/01/09 |
| | | *DSN* | *32 hrs* | | *Mon 19/01/09* | *Fri 23/01/09* |
| 180 | ✓ | − 4.1.2.2 Billing system | 24 hrs | 3 days | Mon 19/01/09 | Thu 22/01/09 |
| | | *IS (IR admin)* | *24 hrs* | | *Mon 19/01/09* | *Thu 22/01/09* |
| 181 | ✓ | − 4.1.2.3 Roaming partner's system | 72 hrs | 9 days | Tue 13/01/09 | Mon 26/01/09 |
| | | *RP* | *72 hrs* | | *Tue 13/01/09* | *Mon 26/01/09* |
| 182 | ✓ | **− 4.1.2.4 Verification** | **16 hrs** | **24 days** | **Fri 23/01/09** | **Thu 26/02/09** |
| 183 | ✓ | − 4.1.2.4.1 XYZ verification | 16 hrs | 2 days | Fri 23/01/09 | Tue 27/01/09 |
| | | *DSN* | *16 hrs* | | *Fri 23/01/09* | *Tue 27/01/09* |
| 184 | ✓ | − 4.1.2.4.2 RP verification | 0 hrs | 0 days | Thu 26/02/09 | Thu 26/02/09 |
| | | *RP* | *0 hrs* | | *Thu 26/02/09* | *Thu 26/02/09* |
| 185 | ✓ | **− 4.1.3 Test and Validation** | **864 hrs** | **26 days** | **Wed 11/02/09** | **Thu 19/03/09** |
| 186 | ✓ | − 4.1.3.1 Case 1 | 192 hrs | 12 days | Wed 11/02/09 | Fri 27/02/09 |
| | | *DSN* | *96 hrs* | | *Wed 11/02/09* | *Fri 27/02/09* |
| | | *IS (IR admin)* | *96 hrs* | | *Wed 11/02/09* | *Fri 27/02/09* |
| 187 | ✓ | − 4.1.3.2 Case 2 | 112 hrs | 7 days | Wed 18/02/09 | Fri 27/02/09 |
| | | *DSN* | *56 hrs* | | *Wed 18/02/09* | *Fri 27/02/09* |
| | | *IS (IR admin)* | *56 hrs* | | *Wed 18/02/09* | *Fri 27/02/09* |
| 188 | ✓ | − 4.1.3.3 Case 3 | 192 hrs | 12 days | Tue 24/02/09 | Thu 12/03/09 |
| | | *DSN* | *96 hrs* | | *Tue 24/02/09* | *Thu 12/03/09* |
| | | *IS (IR admin)* | *96 hrs* | | *Tue 24/02/09* | *Thu 12/03/09* |
| 189 | ✓ | − 4.1.3.4 Case 4 | 288 hrs | 18 days | Mon 23/02/09 | Thu 19/03/09 |
| | | *DSN* | *144 hrs* | | *Mon 23/02/09* | *Thu 19/03/09* |
| | | *IS (IR admin)* | *144 hrs* | | *Mon 23/02/09* | *Thu 19/03/09* |
| 190 | ✓ | − 4.1.3.5 Case 5 | 80 hrs | 5 days | Wed 11/02/09 | Wed 18/02/09 |
| | | *DSN* | *40 hrs* | | *Wed 11/02/09* | *Wed 18/02/09* |
| | | *IS (IR admin)* | *40 hrs* | | *Wed 11/02/09* | *Wed 18/02/09* |
| 191 | ✓ | **+ 4.1.4 Launch** | **24 hrs** | **4.5 days** | **Thu 05/03/09** | **Wed 11/03/09** |

Figure A.8: Actual work hour of each unit for implementing operator 8

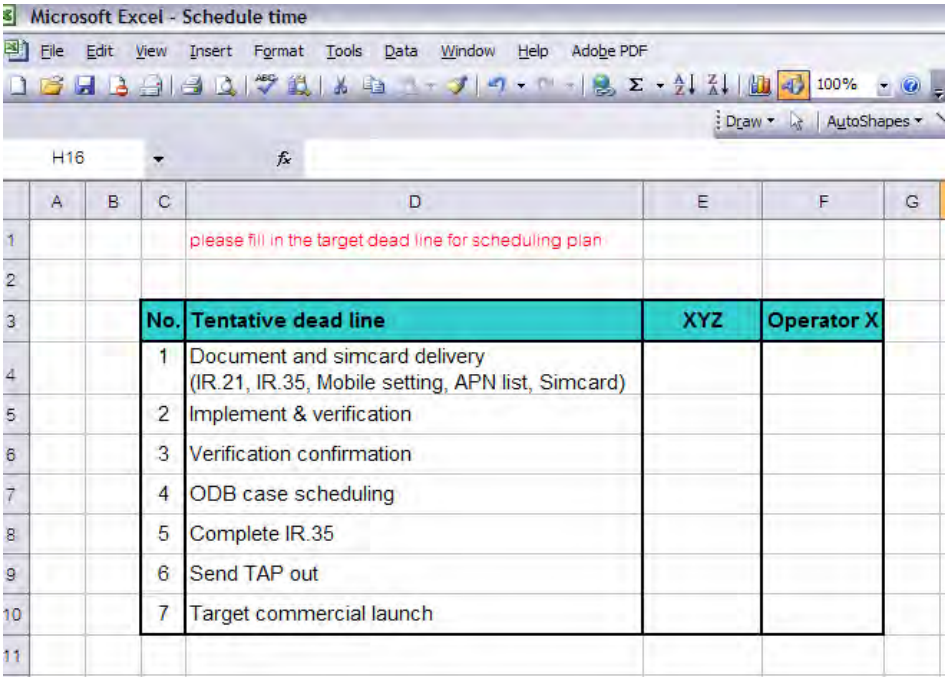
| | | Task Name | Work | Duration | Start | Finish |
|---|---|---|---|---|---|---|
| 174 | ✓ | **+ 4.1 Operator 8** | **1,144 hrs** | **53.06 days** | **Mon 05/01/09** | **Thu 19/03/09** |
| 196 | ✓ | **− 4.1 Operator 9** | **580 hrs** | **50.06 days** | **Mon 05/01/09** | **Mon 16/03/09** |
| 197 | ✓ | **+ 4.1.1 Documentation preparation** | **216 hrs** | **17.06 days** | **Mon 05/01/09** | **Wed 28/01/09** |
| 200 | ✓ | **− 4.1.2 Implement and Verification** | **172 hrs** | **17.5 days** | **Fri 16/01/09** | **Tue 10/02/09** |
| 201 | ✓ | − 4.1.2.1 GPRS system | 40 hrs | 5 days | Wed 28/01/09 | Wed 04/02/09 |
| | | *DSN* | *40 hrs* | | *Wed 28/01/09* | *Wed 04/02/09* |
| 202 | ✓ | − 4.1.2.2 Billing system | 24 hrs | 3 days | Wed 28/01/09 | Mon 02/02/09 |
| | | *IS (IR admin)* | *24 hrs* | | *Wed 28/01/09* | *Mon 02/02/09* |
| 203 | ✓ | − 4.1.2.3 Roaming partner's system | 56 hrs | 7 days | Fri 16/01/09 | Tue 27/01/09 |
| | | *RP* | *56 hrs* | | *Fri 16/01/09* | *Tue 27/01/09* |
| 204 | ✓ | **− 4.1.2.4 Verification** | **52 hrs** | **10.5 days** | **Tue 27/01/09** | **Tue 10/02/09** |
| 205 | ✓ | − 4.1.2.4.1 XYZ verification | 4 hrs | 0.5 days | Tue 10/02/09 | Tue 10/02/09 |
| | | *DSN* | *4 hrs* | | *Tue 10/02/09* | *Tue 10/02/09* |
| 206 | ✓ | − 4.1.2.4.2 RP verification | 48 hrs | 6 days | Tue 27/01/09 | Wed 04/02/09 |
| | | *RP* | *48 hrs* | | *Tue 27/01/09* | *Wed 04/02/09* |
| 207 | ✓ | **− 4.1.3 Test and Validation** | **176 hrs** | **8 days** | **Thu 05/02/09** | **Tue 17/02/09** |
| 208 | ✓ | − 4.1.3.1 Case 1 | 8 hrs | 0.5 days | Thu 05/02/09 | Thu 05/02/09 |
| | | *DSN* | *4 hrs* | | *Thu 05/02/09* | *Thu 05/02/09* |
| | | *IS (IR admin)* | *4 hrs* | | *Thu 05/02/09* | *Thu 05/02/09* |
| 209 | ✓ | − 4.1.3.2 Case 2 | 96 hrs | 6 days | Thu 05/02/09 | Fri 13/02/09 |
| | | *DSN* | *48 hrs* | | *Thu 05/02/09* | *Fri 13/02/09* |
| | | *IS (IR admin)* | *48 hrs* | | *Thu 05/02/09* | *Fri 13/02/09* |
| 210 | ✓ | − 4.1.3.3 Case 3 | 32 hrs | 2 days | Fri 13/02/09 | Tue 17/02/09 |
| | | *DSN* | *16 hrs* | | *Fri 13/02/09* | *Tue 17/02/09* |
| | | *IS (IR admin)* | *16 hrs* | | *Fri 13/02/09* | *Tue 17/02/09* |
| 211 | ✓ | − 4.1.3.4 Case 4 | 32 hrs | 2 days | Fri 13/02/09 | Tue 17/02/09 |
| | | *DSN* | *16 hrs* | | *Fri 13/02/09* | *Tue 17/02/09* |
| | | *IS (IR admin)* | *16 hrs* | | *Fri 13/02/09* | *Tue 17/02/09* |
| 212 | ✓ | − 4.1.3.5 Case 5 | 8 hrs | 0.5 days | Thu 05/02/09 | Thu 05/02/09 |
| | | *DSN* | *4 hrs* | | *Thu 05/02/09* | *Thu 05/02/09* |
| | | *IS (IR admin)* | *4 hrs* | | *Thu 05/02/09* | *Thu 05/02/09* |
| 213 | ✓ | **+ 4.1.4 Launch** | **16 hrs** | **19 days** | **Tue 17/02/09** | **Mon 16/03/09** |

Figure A.9: Actual work hour of each unit for implementing operator 9

| | | Task Name | Work | Duration | Start | Finish |
|---|---|---|---|---|---|---|
| 174 | ✓ | + **4.1 Operator 8** | **1,144 hrs** | **53.06 days** | **Mon 05/01/09** | **Thu 19/03/09** |
| 196 | ✓ | + **4.1 Operator 9** | **580 hrs** | **50.06 days** | **Mon 05/01/09** | **Mon 16/03/09** |
| 218 | | − **4.1 Operator 10** | **617 hrs** | **68 days?** | **Mon 05/01/09** | **Wed 08/04/09** |
| 219 | ✓ | + **4.1.1 Documentation preparation** | **152 hrs** | **#########** | **Mon 05/01/09** | **Thu 22/01/09** |
| 222 | ✓ | − **4.1.2 Implement and Verification** | **112 hrs** | **10 days** | **Tue 13/01/09** | **Tue 27/01/09** |
| 223 | ✓ | − 4.1.2.1 GPRS system | 16 hrs | 2 days | Thu 22/01/09 | Mon 26/01/09 |
| | | *DSN* | *16 hrs* | | *Thu 22/01/09* | *Mon 26/01/09* |
| 224 | ✓ | − 4.1.2.2 Billing system | 16 hrs | 2 days | Thu 22/01/09 | Mon 26/01/09 |
| | | *IS (IR admin)* | *16 hrs* | | *Thu 22/01/09* | *Mon 26/01/09* |
| 225 | ✓ | − 4.1.2.3 Roaming partner's system | 40 hrs | 5 days | Tue 13/01/09 | Tue 20/01/09 |
| | | *RP* | *40 hrs* | | *Tue 13/01/09* | *Tue 20/01/09* |
| 226 | ✓ | − **4.1.2.4 Verification** | **40 hrs** | **5 days** | **Tue 20/01/09** | **Tue 27/01/09** |
| 227 | ✓ | − 4.1.2.4.1 XYZ verification | 8 hrs | 1 day | Mon 26/01/09 | Tue 27/01/09 |
| | | *DSN* | *8 hrs* | | *Mon 26/01/09* | *Tue 27/01/09* |
| 228 | ✓ | − 4.1.2.4.2 RP verification | 32 hrs | 4 days | Tue 20/01/09 | Mon 26/01/09 |
| | | *RP* | *32 hrs* | | *Tue 20/01/09* | *Mon 26/01/09* |
| 229 | | − **4.1.3 Test and Validation** | **329 hrs** | **18.94 days** | **Thu 05/03/09** | **Tue 31/03/09** |
| 230 | ✓ | − 4.1.3.1 Case 1 | 32 hrs | 2 days | Thu 05/03/09 | Mon 09/03/09 |
| | | *DSN* | *16 hrs* | | *Thu 05/03/09* | *Mon 09/03/09* |
| | | *IS (IR admin)* | *16 hrs* | | *Thu 05/03/09* | *Mon 09/03/09* |
| 231 | ✓ | − 4.1.3.2 Case 2 | 32 hrs | 2 days | Thu 05/03/09 | Mon 09/03/09 |
| | | *DSN* | *16 hrs* | | *Thu 05/03/09* | *Mon 09/03/09* |
| | | *IS (IR admin)* | *16 hrs* | | *Thu 05/03/09* | *Mon 09/03/09* |
| 232 | ✓ | − 4.1.3.3 Case 3 | 128 hrs | 8 days | Wed 11/03/09 | Mon 23/03/09 |
| | | *DSN* | *64 hrs* | | *Wed 11/03/09* | *Mon 23/03/09* |
| | | *IS (IR admin)* | *64 hrs* | | *Wed 11/03/09* | *Mon 23/03/09* |
| 233 | | − 4.1.3.4 Case 4 | 129 hrs | 8.13 days | Wed 11/03/09 | Tue 31/03/09 |
| | | *DSN* | *65 hrs* | | *Wed 11/03/09* | *Mon 23/03/09* |
| | | *IS (IR admin)* | *64 hrs* | | *Wed 11/03/09* | *Mon 23/03/09* |
| 234 | ✓ | − 4.1.3.5 Case 5 | 8 hrs | 0.5 days | Thu 05/03/09 | Thu 05/03/09 |
| | | *DSN* | *4 hrs* | | *Thu 05/03/09* | *Thu 05/03/09* |
| | | *IS (IR admin)* | *4 hrs* | | *Thu 05/03/09* | *Thu 05/03/09* |
| 235 | ✓ | + **4.1.4 Launch** | **24 hrs** | **6.94 days** | **Tue 31/03/09** | **Wed 08/04/09** |

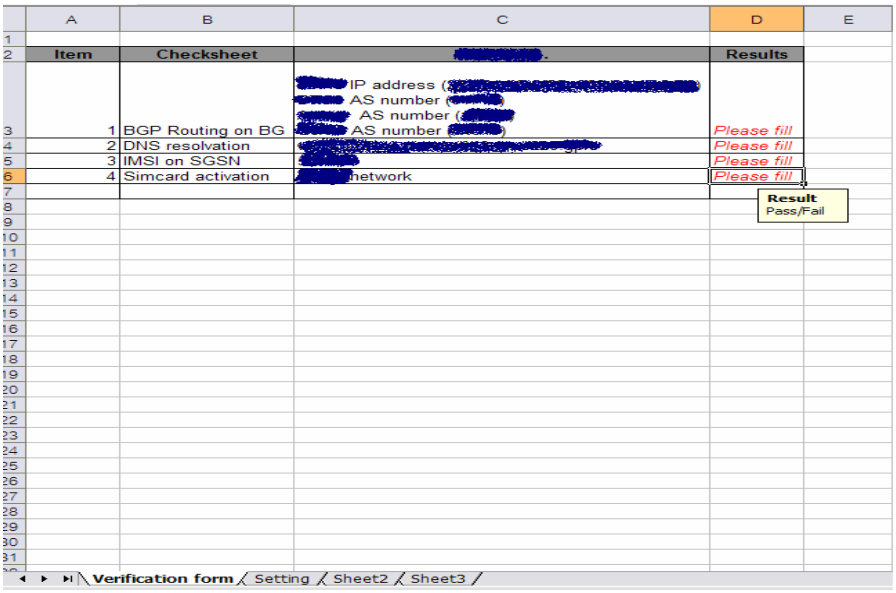
Figure A.10: Actual work hour of each unit for implementing operator 10

# B. Time frame document




B.1: Time frame document

# C. Verification document



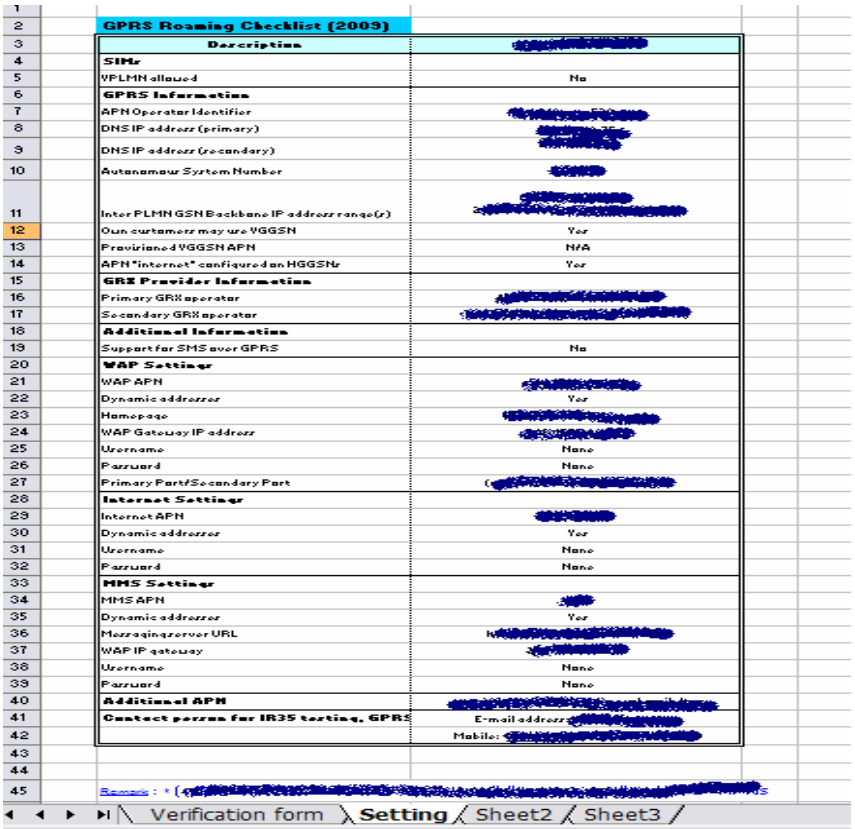
| Item | Checksheet | [redacted] | Results |
|---|---|---|---|
| | | [redacted] IP address ([redacted]<br>[redacted] AS number ([redacted]<br>[redacted] AS number ([redacted] | |
| 1 | BGP Routing on BG | [redacted] AS number [redacted] | Please fill |
| 2 | DNS resolvation | [redacted] | Please fill |
| 3 | IMSI on SGSN | [redacted] | Please fill |
| 4 | Simcard activation | [redacted]network | Please fill |

Result
Pass/Fail

Verification form | Setting | Sheet2 | Sheet3

C.1: Verification doument

# D. Mobile setting document



| GPRS Roaming Checklist (2009) | |
|---|---|
| **Description** | [redacted] |
| **SIMs** | |
| VPLMN allowed | No |
| **GPRS Information** | |
| APN Operator Identifier | [redacted] |
| DNS IP address (primary) | [redacted] |
| DNS IP address (secondary) | [redacted] |
| Autonomous System Number | [redacted] |
| Inter PLMN GSN Backbone IP address range(s) | [redacted] |
| Own customers may use VGGSN | Yes |
| Provisioned VGGSN APN | N/A |
| APN "internet" configured on HGGSNs | Yes |
| **GRX Provider Information** | |
| Primary GRX operator | [redacted] |
| Secondary GRX operator | [redacted] |
| **Additional Information** | |
| Support for SMS over GPRS | No |
| **WAP Settings** | |
| WAP APN | [redacted] |
| Dynamic addresses | Yes |
| Homepage | [redacted] |
| WAP Gateway IP address | [redacted] |
| Username | None |
| Password | None |
| Primary Port/Secondary Port | [redacted] |
| **Internet Settings** | |
| Internet APN | [redacted] |
| Dynamic addresses | Yes |
| Username | None |
| Password | None |
| **MMS Settings** | |
| MMS APN | [redacted] |
| Dynamic addresses | Yes |
| Messaging server URL | [redacted] |
| WAP IP gateway | [redacted] |
| Username | None |
| Password | None |
| **Additional APN** | [redacted] |
| **Contact person for IR35 testing, GPRS** | E-mail address: [redacted] |
| | Mobile: [redacted] |

Remark : * [redacted]

Verification form | Setting | Sheet2 | Sheet3

D.1: Mobile setting doument

# E. Simcard management document

Sim data for postpaid ,Prepaid : Camel and USIM , GPRS for DSN

| no. | Div. | ype of servic | COUNTRY | OPERATOR | ICCID | IMSI | MSISDN | PUK1 |
|---|---|---|---|---|---|---|---|---|
| 1 | dsn | voice | Afghanistan | AWCC | 8993017100002723846 | 412012200115374 | 9370090812 | 54362912 |
| 2 | dsn | | Afghanistan | AWCC | 8993017100002723820 | 412012200115372 | 9370090810 | 97241645 |
| 3 | dsn/ ภานุวิทย์ | | Australia | H3G | 8961060300015038090 | 505060000006021 | 61433104757 | |
| 4 | dsn/ ภานุวิทย์ | | Australia | H3G | 8961060300015038116 | 505060000006023 | 61433104753 | |
| 5 | dsn | | Australia | Optus | 8961020603539040602 | 505020602200430 | 61411072298 | 10125332 |
| 6 | dsn | | Australia | Optus | 8961020603539040610 | 505020602200431 | 61411072297 | 82561226 |
| 7 | DSN | | Australia | Telstra | 126111921 | 505010077012232 | 61417701451 | 13041100 |
| 8 | dsn | | Australia | Vodafone | 8961030000420779818 | 505037002607981 | 61404024896 | 73132071 |
| 9 | dsn | | Australia | Vodafone | 8961030000420779842 | 505037002607984 | 61404024912 | 46543518 |
| 10 | dsn/ ภานุวิทย์ | | Austria | H3G | 8943101000035004481 | 232106902099486 | 436608793160 | 88912358 |
| 11 | dsn/ ภานุวิทย์ | | Austria | H3G | 8943101000035004499 | 232106902099487 | 436608793161 | 61563461 |
| 12 | dsn/ ภานุวิทย์ | | Austria | Mobilkom | 8943015502355562647 | 232011120081984 | 436641170066 | 35245437 |
| 13 | dsn/ ภานุวิทย์ | | Austria | Mobilkom | 8943015502355562654 | 232011120081985 | 436641170067 | 28016675 |
| 14 | DSN | | Bahrain | MTC Vadafone | 8997302100000004764 | 426022100000476 | 97336746150 | 71591530 |
| 15 | DSN | | Bangladesh | AKTEL | 89880020500000449 | 470020500000449 | 8801894144246 | 81037824 |
| 16 | dsn/ ภานุวิทย์ | | Bangladesh | Grameenphone | 8988017970806029131 | 470010000023162 | 88017501068 | |
| 17 | dsn/ ภานุวิทย์ | | Bangladesh | Grameenphone | 8988017970806029149 | 470010000023163 | 88017501069 | 35315282 |
| 18 | dsn | | Belgium | BASE | 8932030060015156676 | 206202700848109 | 32484696079 | 15441883 |
| 19 | dsn | | Belgium | BASE | 8932030060015156684 | 206202700848110 | 32484696080 | |
| 20 | dsn/ ภานุวิทย์ | | Belgium | Belgacom Mobile | 7304072007540 | 206013301073965 | 32473474468 | 64614962 |
| 21 | dsn/ ภานุวิทย์ | | Belgium | Belgacom Mobile | 7304292086894 | 206013301173405 | 32473474551 | 10522225 |
| 22 | dsn | | Belgium | Mobistar | 2250809009649 | 206102200169163 | 32495253769 | 75707124 |
| 23 | dsn | | Belgium | Mobistar | 2250809009797 | 206102200169168 | 32495254609 | 65213415 |
| 24 | DSN/GPRS | | Bermuda | Mobility | 8901441040600313351 | 350020000031335 | 14413310442 | 85540616 |

E.1: Simcard Management doument

# BIOGRAPHY

Rarintip Sirisukpoca was born on 13 October 1980 in Nakornpathom, Thailand. She graduated a Bachelor Degree in Electrical Engineering from Thammasat University in 2004. She has worked for a mobile network operator as Senior Engineer for 5 years until present. She continues her Master Degree in Engineering Management at Regional Centre for Manufacturing Systems Engineering (RCMSE), Chulalongkorn University (TH) and University of Warwick (UK).