Quality management for DTM production by Airborne Laser Scanning (ALS)
For Remote Sensing Centre (RSC)
Vietnam Ministry of Natural Resource and Environment (MoNRE)

Nguyen Thi Thuc Anh
March, 2007
Quality management for DTM production by Airborne Laser Scanning (ALS)  
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By

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Thesis submitted to the International Institute for Geo-information Science and Earth Observation in partial fulfillment of the requirements for the degree of Master of Science in Geo-information Science and Earth Observation, Specialization: Geo-Information Management

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Abstract

Airborne Laser Scanning (ALS) is increasingly used for the generation of Digital Terrain Model (DTM). While the technique of data acquisition, the accuracy and the applications of ALS data have been extensively described in literature, the experience of quality management in ALS DTM production is rather limited in the public domain.

The general experience of quality management has outlined two main approaches that an organization can use to manage quality in the production: the hard, standards-based and the soft, culture-based approaches. For both approaches, significant attention is required from those National Mapping Agencies (NMA) organizations which are new to the ALD technology and which have not paid much attention on the quality culture issue. The Remote Sensing Center (RSC), Vietnam Ministry of Natural Resource and Environment (MoNRE) is such an organization. Being aware of the new possibilities of ALS technology, a pilot project was conducted by RSC as first step to establish RSC ALS DTM production. RSC have faced problems dealing with quality management in this pilot project.

Given this situation, the thesis objective is to develop a framework for implementing a quality management system for ALS DTM production at RSC, MoNRE. The eight principles of ISO 9000 standards that cover both the hard and soft aspects of an organization is quality management were selected to form a theoretical quality management framework for this research. It was used to identify the critical points which the QMS of the future RSC ALS DTM production should take care of by combining the experience of the existing topographic map production and the ALS pilot project. While the topographic map production will reveal the bottlenecks mainly in the soft aspects of QMS in RSC, the ALS pilot project will set light more on the hard aspect that are related to the production with ALS technology. The finding is that both the quality culture and the process standardization need significant improvement to assure the quality of the production.

The quality management practice with ALS in the Netherlands was used as benchmark and adapted to identify the “desired future” for the Vietnam situation. A SWOT analysis was used to generate feasible strategies for implementing QMS to bridge the gaps between the identified “as is” and “to be” situations of RSC ALS DTM production. The synthesis of the strategies was checked for completeness against the critical success factors from the ISO theoretical quality management framework.

Finally the research came up with a proposed framework for implementing QMS for RSC ALS DTM production. It consists of seven main points: (1) the QMS implementation initiation; (2) an organizational structure and its working mechanism; (3) the quality manual development; (4) education and training; (5) the development of employee motivation and commitment to quality; (6) performance management system; (7) the communication system.

Keywords: Airborne laser scanning; Quality management system, ISO 9000, RSC, MoNRE, Vietnam.
Acknowledgements

With deep gratitude, I would like to take this opportunity to thank various persons who have contributed to this research which would not have been possible without them.

First and foremost, I wish to express my sincere gratitude to my supervisors: Ir.C.H.J. Lemmen and Dr. K. Tempfli for their constant help, guidance and encouragement throughout my research.

Similarly, I would like to thank C.M.J. Paresi, Ir. W.T. de Vries, Dr. J.M. Morales, Ir. S.J. Oude Elberink and Dr. D. van der Zee for their critical comments and their continuous support that greatly helped to improve my thesis.

My sincere gratitude goes to the Netherlands Fellowship Programme (NFP) and ITC for the learning opportunity in this exquisite, multi-cultural and friendly environment characterized by its international atmosphere.

Likewise, I would also like to extend my appreciation to Mr. Kees Bronsveld, GIM Program Director, and all staff members of GIM program including former secretary Ms. Ilona van der Schoor and Ms. Jacqueline Mol for their support throughout the study period at ITC.

I would like to express special thanks and appreciation to the AGI AHN and to Ms. Ir. I. Alkemade, for providing me valuable documents and in-depth information about the organization which serves as one of the foundations for my research.

The credit is extended to the personnel of MoNRE and RSC, especially Dr Le Minh for their support during my study in ITC and the fieldwork in Vietnam.

I would also like to thank my country-mates at ITC: Tuan, Nga, Quan, Cuong, Quang, Hoa for nice moments we shared. Thanks to fellow students at ITC: Cesito, Tannita, Lydita, Furito, Bai, Sumito just to name few, for their unforgettable company during my study period at ITC.

Finally, I am indebted to my family for always being there for me whenever I need.

Nguyen Thi Thuc Anh
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<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>3D</td>
<td>3 Dimensions</td>
</tr>
<tr>
<td>AGI</td>
<td>Adviesdienst Geo-Informatie en ICT, Ministerie van Verkeer en Waterstaat</td>
</tr>
<tr>
<td>AGPS</td>
<td>Airborne Global Positioning System</td>
</tr>
<tr>
<td>AHN</td>
<td>Actueel Hoogtebestand Nederland</td>
</tr>
<tr>
<td>ALS</td>
<td>Airborne Laser Scanning</td>
</tr>
<tr>
<td>CERCO</td>
<td>Comité Européan des Responsables de la Cartographie Officielle</td>
</tr>
<tr>
<td>CSF</td>
<td>Critical Success Factor</td>
</tr>
<tr>
<td>DGPS</td>
<td>Deferential Global Positioning System</td>
</tr>
<tr>
<td>DSM</td>
<td>Digital Surface Model</td>
</tr>
<tr>
<td>DTM</td>
<td>Digital Terrain Model</td>
</tr>
<tr>
<td>FEMA</td>
<td>Federal Emergency Management Agency</td>
</tr>
<tr>
<td>GIS</td>
<td>Geographic Information System</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>IMU</td>
<td>Inertial Measurement Unit</td>
</tr>
<tr>
<td>ISO</td>
<td>International Standards Association</td>
</tr>
<tr>
<td>LIDAR</td>
<td>Light Detection and Ranging</td>
</tr>
<tr>
<td>MoNRE</td>
<td>Ministry of Natural Resources and Environment, Vietnam</td>
</tr>
<tr>
<td>NMA</td>
<td>National Mapping Agency</td>
</tr>
<tr>
<td>QMS</td>
<td>Quality Management System</td>
</tr>
<tr>
<td>RMSE</td>
<td>Root Mean Squared Error</td>
</tr>
<tr>
<td>RSC</td>
<td>Remote Sensing Centre</td>
</tr>
<tr>
<td>SMA</td>
<td>State Mapping Agency of Bavaria, Germany</td>
</tr>
<tr>
<td>SPC</td>
<td>Statistical Process Control</td>
</tr>
<tr>
<td>SWOT</td>
<td>Strengths, Weaknesses, Opportunities, Threats</td>
</tr>
<tr>
<td>TIN</td>
<td>Triangulated Irregular Network</td>
</tr>
<tr>
<td>TLS</td>
<td>Terrestrial Laser Scanning</td>
</tr>
<tr>
<td>TQM</td>
<td>Total Quality Management</td>
</tr>
</tbody>
</table>
1. Introduction

1.1. Background

The Mekong delta is a region in the most southern part of Vietnam that consists of 12 provinces with a total area of about 40,000 km$^2$. It is a quite flat area with some similarities to the Dutch terrain, with prevailing elevation ranges from -1m to 3m, and a dense hydro-network without flood control dykes. The main types of land cover are paddy, vegetable and aquaculture field, orchard, secondary and mangrove forest with no leaf-off season. The tropical climate of the area leads to difficulties to acquire cloud free aerial photographs. The area is flooded for about three months each year by water from the Mekong river which causes a lot of damage.

The Mekong delta is a very important region for the Vietnamese economy, especially in agriculture and aquaculture production. A proper development plan is needed to make better use of the region’s advantages and to minimize the loss due to flood, including the reallocation of villages to high ground areas, and the construction of new irrigation and transportation infrastructure. In 2004, the Ministry of Natural Resource and Environment (MoNRE), being the main topographic data provider in Vietnam, took the responsibility to launch a project to establish an “Integrated GIS for regional development”. The GIS should contain a high accuracy Digital Terrain Model (DTM), large scale basemaps, orthophotos, cross-sections at critical points in the hydro-network, and social economic information. Because of the flatness of the area, the accuracy of the DTM was broadly identified as 20cm for areas highly sensitive to flood, and 40cm for the rest, based on a flood map from the previous year. Data acquisition is designed mainly based on field survey and large scale digital photogrammetry.

RSC is an organization directly under MoNRE with a long experience in surveying, mapping and remote sensing. It is also largely in charge with the implementation of the Mekong delta project. Recently, with the new possibility of using Airborne Laser Scanning (ALS) to generate a very high resolution DTM, the executive committee of the Mekong delta project has appointed the Remote Sensing Center (RSC) to launch a pilot project to acquire DTM using ALS. This pilot project was designed to cover an area of 1,800 km$^2$, which is highly sensitive to flooding, in the Cantho province. RSC outsourced it to a foreign contractor. The data acquisition took place in June 2006 and the contractor delivered the result for evaluation in August 2006. The RSC pilot project team performed quality control on the delivered dataset, and accepted it.

MoNRE has appointed RSC to establish the first ALS DTM production for Vietnam. In the near future, this production aims to contribute to the completion of the high resolution DTM acquisition for the Mekong Delta project. In the long term, it targets to other government projects from MoNRE, as well as to other ordinary customers in the GI market.

1.2. Problem definition

On one hand, the RSC is a typical National Mapping Agency (NMA) involved in survey and mapping
for a long time, and has not changed much towards the market orientation. The organization’s quality management and quality culture need significant improvement. On the other hand, ALS technology combines complicated techniques using expensive equipment for data acquisition. ALS has not been practiced in Vietnam, so there is little experience dealing with acquisition, data handling, data validation, DTM generation etc. in RSC itself as well as in other organizations.

Therefore, setting up the production of an ALS DTM is a big task for the RSC, but ensuring the quality of products in the long term, the satisfaction of customers and the efficiency of the organization is an even bigger issue to consider. The solution for the RSC is a comprehensive quality management system (QMS) embedded within the ALS DTM production. Looking further, a successfully implemented QMS in the ALS DTM production could easily be expanded to other activities of the RSC, in order to improve the overall organization performance.

There are different ways an organization may choose to implement a QMS: to adopt the ISO standard and seek an ISO 9001 certificate, to use the principles and concepts within the ISO 9000 standard, or to implement a QMS based on other principles. Each NMA has to make this decision and develop strategies based on its specific situation.

1.3. Prior works

A number of articles addressed the topic of QMS for both the industry and public sector organizations (Kim and Wolff 1994) (Ravichandran and Rai 2000). Documentation of the ISO 9000 family of standards are (ISO9000 2000; ISO9001 2000; ISO9004 2000). Experiences with QMS in several European NMAs, focusing on ISO 9000, were also summarized by the Comité Européan des Responsables de la Cartographie Officielle (CERCO), Working Group on Quality (Cerco 1999; Cerco 2000).

Specifically, changes in mapping and cadastre organizations under pressure from the market were discussed by (Molen 2003), with examples from the Dutch Cadastre.

Regarding the technical aspects of ALS acquisition, a number of articles were published from researches on the accuracy of an ALS DTM and its applications in flooding, road construction, etc (Ackermann 1999; Gomes Pereira and Wicherson 1999; Cobby, Mason et al. 2001; Brügelmann and Bollweg 2004).

Problems concerning quality control, quality assurance, and quality management of ALS projects were addressed to different degrees in other articles based on the experience from program Actueel Hoogtebestand Nederland (AHN) in Adviesdienst Geo-Informatie en ICT (AGI), Ministerie van Verkeer en Waterstaat, the Netherlands; State Mapping Agency of Bavaria, Germany; and Swiss Federal Office of Topography (Crombaghs, Elberink et al. 2002; Ahokas, Kaartinen et al. 2003; Luethy and Ingensand 2003; Alharthy, Bethel et al. 2004).

There are also a few ITC MSc research efforts on the quality aspect in NMA production. Two of them focus on the development of a QMS: one for digital topographic map production of the Mapping Agency of Taiwan (Weng 1997); and the other for topographic database production (Fathia 1998).

Finally, there is the material from the program modules: Structural approach to the management of optimization of geoinformation processes (Radwan, Onchaga et al. 2001); Planning and management tools (Groenendijk and Dopheide 2003), Lecture handout on Total Quality Management (TQM) (Paresi 2006).

A literature review will accompany all the phases of this research and this list will be extended with more applicable documents to answer research questions.
1.4. **Research objective:**

The objective of this research is to: *Develop a framework for implementing a quality management system for ALS DTM production for RSC, MoNRE.*

1.5. **Research questions**

Having this objective to achieve, the following research questions are posed:

1. What are the requirements of a quality management system for an organization?
2. What are the experiences related to introducing/using a quality management system in NMAs in Europe?
3. What are the experiences in quality management of the ALS projects in AGI AHN?
4. What are the bottlenecks in current RSC, MoNRE quality management system?
5. What are the similarities and differences of the conditions for ALS production between AGI AHN and RSC? What is the “desired future” of QMS for RSC ALS DTM production?
6. What is the framework for implementing QMS for ALS DTM production at the RSC?

1.6. **Research approach and the thesis structure**

The research methodology is illustrated below.

![Diagram of research methodology]

*Figure 1.1: Research methodology*
The thesis structure is derived from the main points of the research methodology. The thesis contains six chapters.

Chapter 1: Introduction
This is the current chapter, and presents the framework of the research. It gives a short overview of the current quality management and background about the ALS DTM development at the RSC, defines the problems, the objective to be achieved and the research question to be answered. The research methodology and the thesis structure will follow indicating where each research question is expected to be answered.

Chapter 2: Literature review
This chapter explored two main topics:

1. ALS DTM production
   This topic focused on the ALS DTM production, and on techniques and tools for accuracy improvement and quality control. This contributed to answering research questions No 5 and 6.

2. Quality management experiences
   This topic first reviewed the QM theory, the ISO 9000 standards and the experiences of implementing a QMS at NMAs. This contributed to answering research questions No 1 and 2.
   Then, the experience in quality management at the AGI AHN has been investigated, in order to acquire information to answer research questions No 3, 5 and 6.
   From the theory and the experience, a quality management framework has been designed to be used for assessing the current quality management at the RSC, and later on to formulate the strategies to implement QMS for RSC ALS DTM production. It will give the final answer to research question No 1.

Chapter 3: Current quality management at RSC, MoNRE
This chapter reviewed the current quality management at the RSC, by reviewing the MoNRE quality management framework, and investigating problems related to quality in topographic map production and to the ALS DTM pilot project. The review is based on information gathered from the fieldwork. From analysis of these findings, conclusions have been drawn to answer research question No 4.

Chapter 4: ALS DTM production for RSC, MoNRE
This chapter starts by reviewing the user’s interests and the user requirements toward ALS DTM product. The findings will contribute to answering question No 5.

Next, the conditions of the ALS projects at the AGI and the RSC are analyzed and compared. This will contribute to answering research question No 5 and 6.

Finally, Strength, Opportunity, Weakness and Threat (SWOT) analysis will be used as a tool to generate strategies for implementing a QMS for the RSC ALS DTM production, following the principles of the quality management as identified in chapter 2. The result will be checked against the critical success factors (CSF) from the quality management framework for completeness. The findings will contribute to answering research question No 6.
Chapter 5: Framework for implementing quality management system for ALS DTM production for RSC, MoNRE

Based on the strategies from the SWOT analysis and other findings, the framework for implementing a QMS for the RSC ALS DTM production has been developed. As parts of the quality manual, the quality policy and the work process model will be worked out in details. This will finally answer research question No 6.

Chapter 6: Conclusions and recommendations

Finally, a summary of the findings and the results has been outlined as well as recommendations for further research.
2. Literature review

2.1. Introduction

The laser scanning technology provides a new tool for acquisition of topographic data. It has been used to establish high resolution datasets for several organizations. Many researchers have put their efforts on developing tools to improve data accuracy as well as techniques to carry out quality control of a dataset. This chapter will begin with a short review on technical aspects of ALS technology and ALS DTM production.

Quality is always an important issue in a production. The next step, the study will focus on the quality management theory and practice, the experience with standards from ISO 9000 series in different industries and specifically for NMAs. A framework for quality management system will be drawn from this literature review.

These two aspects in combination are shown in the case of AGI AHN: deploying the ALS technology for production and implementing QMS to ensure its performance goals. This example of success practice can be used as reference for similar case.

2.2. ALS DTM production

2.2.1. ALS technology

Light detection and ranging (LIDAR) over recent years has become widely accepted as an extremely accurate tool for acquiring 3D geographic data. It is able to deliver coordinates on a reflecting surface based on an accurate measurement of the position and orientation of a sensor platform and the elapse time of a laser pulse. Depending on the sensor carriers, LIDAR can be divided into two main groups: Terrestrial Laser Scanning (TLS) and Airborne Laser Scanning (ALS). This research focuses on ALS technology.

![Figure 2.1: Principle components of ALS system](image)

GPS base station

GPS

IMU

Laser scanner

Figure 2.1: Principle components of ALS system
An ALS system uses a powerful laser sensor comprised of a transmitter and a receiver, a geodetic-quality Global Positioning System (GPS) receiver (for x, y, z sensor location), and an Inertial Measurement Unit (IMU) (for measuring the angular orientation of the sensor to the ground), a highly accurate clock, substantial onboard computer support, reliable electronics and robust storage (Lillesand and Kiefer 2000).

The technology resembles radar sensors by which a device emits laser light and then measures the time it takes to travel to a target and to return to a collector and at the same time compensates for the movement of the aircraft and the sensor. The laser sensor is precision-mounted to the underside of an aircraft, the sensor emits rapid pulses of infrared laser light that are used to determine ranges to points on the terrain below as shown in figure 2.1.

Most ALS systems use a scanning mirror to generate a swath of light pulses. The swath width depends on the mirror’s angle of oscillation and the ground point density depends on such factors as aircraft speed, system capability for emitting pulses of light, and mirror oscillation rate. Ranges are determined by computing the amount of time it takes light to leave its source, travel to the ground, and return to the sensor. The sensing unit’s precise position and attitude, instantaneous mirror angle, and the collected ranges are used to calculate 3D positions of terrain points. As many as 50,000 positions, or “mass points,” can be captured every second (Raber 2005).

ALS data acquisition requires a surveyed GPS ground base station to be established in the project area as well as differential post-processing corrections. In addition, a calibrated alignment process for the GPS position of the sensor and the orientation parameter is required to assure and verify the accuracy of ALS dataset (Lillesand and Kiefer 2000).

ALS systems operate regardless to sun angle, but they do not penetrate cloud cover. It is recommended that some forms of data exist over the area such as ALS intensity return, simultaneous taken video or digital imagery or digital orthophotos taken at different time. These help to identify features during ALS data post-processing.

Flight-path planning is an important factor in the ALS. Depending on the mission purpose, weather conditions, desired point density and spacing, and other factors, the flight path should be designed with suitable scan widths that cover the study area satisfactorily including both parallel and enough cross flight lines to eliminate shadowing and allow for proper quality control.

2.2.2. ALS DTM production

A Digital Terrain Model (DTM) is defined as surface of bare-earth terrain, devoid of vegetation and manmade structure (FEMA 2002). DTM datasets can have one or more of the following data models: digital contours, mass points, breaklines, Triangulated Irregular Network (TIN) and GRID, each of these models has its own advantages and weaknesses in earth surface description and each of these models are suitable for different applications. ALS directly produces relatively dense, irregularly spaced mass points without breaklines.

DTM have been mainly compiled photogrammetrically from aerial photography. The vertical accuracy of photogrammetrically measured points is a function of the flying height, image quality, instrument used, etc. DTM accuracy depends on the measuring accuracy of elevation and above all on point spacing. Static GPS or conventional survey equipments can also be used to survey terrain for digital terrain modeling. In mid-nineteenth, ALS began to be used for data acquisition to generate high resolution DTM. Calculations by State Mapping Agency of Bavaria, Germany (SMA) showed that laser scanning requires only 25% to 33% of the budget that was needed for photogrammetric
compilation. One of the most money-saving factors is the reduced field measurement for former “cut-out”, mostly in forest areas (Petzold, Reiss et al. 1999).

An ALS DTM production project usually divided in two main parts (Raber 2005):

1. **ALS acquisition**: The acquisition phase contains of the following steps:

   **Flight planning**: The key parameters addressed in flight planning are the accuracy requirements and the area of coverage. Flight planning parameters also include flying height, amount of overlap, and planning for cross strips to verify accuracy. Other parameters include aircraft speed and swath width. As part of the flight planning process, all necessary flight clearances are obtained

   **Mobilization**: This includes mobilization of aircraft, sensor and field operations staff to the project site. Mobilization usually begins at an airport close to the project area. Other mobilization activities include establishing Airborne Global Positioning System (AGPS) base stations and checkpoints, and surveying a data validation test or calibration site

   **Instrument installation**: This involves installing the ALS system in the aircraft

   **System calibration/test flight**: System calibration should be performed each time an ALS system is installed in an aircraft. This essentially involves calibrating the sensor using survey techniques to define the geometric relationship between the sensor, aircraft with AGPS, and inertial measurement system components

   **Flight mission**: A flight mission includes actual flying and initialization of the ALS and AGPS sensors. Data is typically flown in strips, with each strip or group of strips making up a flight mission

   **Field survey**: It surveying of control points for validation or accuracy evaluation using conventional leveling technique or GPS. It should be done in open and flat terrain with vertical accuracy from two to three times better than the accuracy of ALS DTM to be produced

   **Acquisition reporting**: In addition to the flying parameters described previously, other acquisition conditions should be described namely: Cloud cover, flight clearance issues, safety issues, tidal conditions, time of day, weather conditions.

2. **Post-processing and data classification**: The post-acquisition phase contains of the following steps:

   **Post-processing**: It involves processing the ALS data along with the AGPS information and IMU data to derive the x, y z value of mass points of surface model and intensity image

   **Filtering**: Filtering activities involve classification and filtering out the vegetation and aboveground features

   **Accuracy check and accuracy improvement**: It involves accuracy assessment using the data redundancy in strip overlap, cross trips and surveyed control points and if necessary techniques for accuracy improvement are applied

   **Generation of surface products in required formats**: Depending on product requirements, complement the acquired dataset with additional features such as breaklines if necessary.

2.2.3. **ALS DTM quality**

According to (ISO19113 2002) the quality of Geo-information can be described using the following data quality elements:

- **Completeness**: presence and absence of features, their attributes and relationships
Logical consistency: degree of adherence to logical rules of data structure, attribution and relationships (data structure can be conceptual, logical or physical)

Positional accuracy: accuracy of the position of features

Temporal accuracy: accuracy of the temporal attributes and temporal relationships of features

Thematic accuracy: accuracy of quantitative attributes and the correctness of non-quantitative attributes and of the classifications of features and their relationships.

These, where applicable, shall be used to describe how well a dataset meets the product specification.

For the case of DTM quality, the completeness, positional accuracy and thematic accuracy receives significant attention. The positional accuracy usually it is depicted using vertical and horizontal accuracy calculated in Root Mean Squared Error (RMSE) using a number of control points. According to (FEMA 2002), assuming that errors have a normal distribution, the metadata will state: DTM is tested for 1.96 x RMSE (vertical or horizontal) accuracy at 95% confidence level. On the other hand, qualitative assessment of DTM quality can also be done through visual inspection of DTM appearance. Visualization is an efficient tool to identify the error caused by internal inconsistency in the dataset.

Due to complicated acquisition technology and filtering technique, the completeness and the thematic accuracy of the output data also are focus of the quality check.

ALS technology has been widely used for high accuracy DTM generation during the last decade. Researches tried to get a complete list of technical aspects describing ALS DTM quality and identify the error sources to develop methods to eliminate it. (FEMA 2002; Luethy and Ingensand 2003) suggest the six following technical aspects to look at when talking about quality of ALS DTM:

1. Horizontal and vertical accuracy
2. Point density
3. Data voids - areas with no points, where multiple returns should have been measured, according to the requirements. Data voids can be caused by malfunction of the system or non-reflective surface (e.g. water, dark soil)
4. Artifacts - regions of anomalous elevations or oscillations and ripples within the DTM data resulting from systematic errors, environmental conditions, or incomplete post-processing
5. Outliers often occur as a result of the failure to achieve a true bare-earth surface from the filtering process. A single outlier can override dozens or hundreds of accurate checkpoints, making the entire RMSE value appear to be poor
6. Steps - areas with an abrupt change of height. Steps are typically seen between adjacent flight lines and are therefore caused by navigational data or poor calibration.

2.2.4. Errors sources of ALS DTM and accuracy improvement techniques

Efforts have been put to identify the factors affecting horizontal and vertical accuracy of ALS DTM and develop techniques to eliminate them to improve the products quality. (Crombaghs, Brügelmann et al. 2000) identified four main components that contribute to the geometrical errors of ALS data. They are illustrated in figure 2.2.

1. Error per point

Due to the measuring uncertainty of the laser scanner each point is affected with a random error or so called point noise of about 10-15cm. It can be decreased by averaging heights of a number of
points of an area in order to compute mean height values for the area. The differences in point height for strip adjustment or for accuracy assessment must not be computed for individual points because the point noise will affect the result.

If differences are computed as mean differences for groups of minimal 100 points in areas of flat 50x50m² this random error can be minimized. A point noise of 12cm results in \((12\sqrt{2})/\sqrt{100}=1.7cm\) for the averaged height differences. In this way, an offset of for example 6cm can be found in spite of the original point noise of 12cm.

![Error components of ALS acquisition](image)

**Figure 2.2: Error components of ALS acquisition**

2. **Error per GPS observation**

The GPS observation interval usually is set to one second. Every GPS observation is affected with a random error as well. This GPS error, however, is constant for all laser points measured during this second. Usually, these points are lying in a strip-wide area of about 100m length (depending on flying speed).

3. **Error per strip**

GPS and IMU sensors are needed to measure the position and orientation of the aircraft along the flight path. This GPS/IMU system introduces a vertical offset for every strip as well as an along- and across-track tilt. Sometimes even other systematic effects are caused by GPS/IMU namely cross strip parabolic effects, strip torsions and periodic effects in along-track direction.

4. **Error per block**

Terrestrial reference measurements (ground control “points”) are used to correct blocks of laser measurements. Thus, errors in these reference measurements affect whole blocks of laser altimetry data.

Strip adjustment and correction for strip deformation techniques (Crombaghs, Brügelmann et al. 2000), were developed to minimize error components 3 and 4.

2.2.5. **Applications of ALS technology**

Nowadays, ALS DTM has been proved to be useful as input data for several applications (Wehr and Lohr 1999; Cobby, Mason et al. 2001; Raber 2005; AHN 2007) such as:
• Civil engineering
• Corridor mapping
• Spatial planning
• Flood monitoring
• Irrigation management
• Coastline analysis and protection
• Volumetric studies
• Landslide analysis
• Geomorphology
• Archeology.

On the other hand, the ALS surface model has been used successfully for: Vegetation mapping, Transmission-line studies, Cellular networks, 3D mapping, 3D perspective analysis, Noise scattering, etc.

Research efforts have been put in improvement of these applications and the development new fields of ALS exploration (Raber 2005; AHN 2007).

2.2.6. Summary

New technology means new possibilities with promising applications that were not feasible earlier. Effectively handling it requires a lot of efforts. The literature about technical aspects of ALS DTM technology and production gives general information about production workflow, the technical components of ALS DTM, the errors sources and the technical approaches to deal with them.

2.3. Quality management principles

A QMS can be seen as a complex system consisting of all the parts of an organization dealing with the quality of processes and products. A QMS can be defined as the managing structure, the responsibilities, procedures, processes, and management resources to implement the principles and action lines needed to achieve the quality objectives of an organization (Cerco 2000).

Figure 2.3: Organization framework in changing environment
Adopted from (Huxhold and Levinsohn 1995)
This definition shows that, talking about quality management, all the internal components of an organization and also the external aspects that effect the business should be taken under consideration (see figure 2.3).

2.3.1. General quality management experience

The quality concept has changed a lot during the last decades, especially in the industry. Its development can be shown in three main steps as shown in figure 2.4.

In the mid-eighties, the focus was put on the quality control of product quality (i.e. compare final product with the specification), but the practical experience showed that the best guarantee for error free products are well-proven and stable processes. Besides quality control, the quality assurance focusing on integrity, validity and efficiency of processes leading to the product becomes more important in production. And in the mid-nineties, the focus was shifted to TQM with as main points: the involvement of stakeholders, and the continuous improvement process. This means that the interests of the people involved need to be considered, and that processes don not follow a linear flow but must also include a feedback loop according to the Deming’s idea of “Plan-Do-Check-Act” (Luethy and Ingensand 2003).

![Figure 2.4: The road to quality](image)

Figure 2.4: The road to quality
Adopted from (Duller 1995)

As quality management is an organization-wide function, (Montgomery 1995) and (Spencer 1994) studied the different organization models from quality management perspectives. They noticed that traditional values specific for public sectors are also moving towards new values under the driving force of competition (see table 2.1). NMAs have always been in public sector, and therefore are not an exception. They are also in this transition period but at a lower pace, due to special characteristics of Geo-information organization, especially in developing countries.

Many researchers try to identify the components of quality management that contribute to an organization’s quality outcome, from the practices in industrial as well as governmental organizations, and they come up with different conclusions:

- (Dow, Samson et al. 1999) start their research by surveying a large, random sample of manufacturing sites, and come up with nine dimensions of quality practice that correlated highly in quality implementation. In the end they extracted three dimensions that contribute significantly to superior quality outcome. These are: Employee commitment, Shared vision and Customer focus
- (Kim and Wolff 1994) in their research addressing the performance of the public sector, concluded that good performance of government organizations need the synergy of a proper blend of: Organization culture and structure, Leadership, Employee relation, Teamwork, Quality improvement program, Advanced technology and The changing demography of the
workforce. But they also mentioned that main constraints are the fiscal stress on an organization, and that implementation of new ideas is restricted.

- (Benson, Saraph et al. 1991) investigate the perception of over 150 managers in different manufacturing and service companies, regarding eight critical quality factors: management leadership for quality, role of quality department, training, product design, supplier quality management, process management, quality data and reporting, and employee relations. They came to conclusion that there are two outstanding factors for successful implementation of quality management. The first factor is Top management leadership and the second is Training and education in quality for all organization members, particularly management.

- (Ravichandran and Rai 2000) have performed a significant effort in integrating literature about quality management and quality performance factors. The authors evaluated the influence of quality management factors on quality performance using an empirical survey of a large number of software development companies. As a result, this study proved that the 5 most critical factors for a quality-oriented organizational system are: Top management commitment, Quality goal, Management infrastructure, Process improvement, and Stakeholders participation.

<table>
<thead>
<tr>
<th>Aspects</th>
<th>Traditional value</th>
<th>New value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Macro-level</td>
<td>Monopoly</td>
<td>Competition</td>
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<tr>
<td></td>
<td>Regulation</td>
<td>Market incentives</td>
</tr>
<tr>
<td></td>
<td>(Organization for control)</td>
<td>(Organization around mission)</td>
</tr>
<tr>
<td></td>
<td>Reduction vs. growth</td>
<td>Continuous improvement</td>
</tr>
<tr>
<td></td>
<td>Adding program</td>
<td>Changing programs</td>
</tr>
<tr>
<td>Organizational structure</td>
<td>Centralized</td>
<td>Decentralized</td>
</tr>
<tr>
<td></td>
<td>Supervisor as controller</td>
<td>Supervisor as helper</td>
</tr>
<tr>
<td></td>
<td>Non-democratic</td>
<td>Participative</td>
</tr>
<tr>
<td></td>
<td>Individual work</td>
<td>Teamwork</td>
</tr>
<tr>
<td></td>
<td>Hierarchical organization</td>
<td>Flat organization</td>
</tr>
<tr>
<td></td>
<td>Simple jobs</td>
<td>Multi-dimensional jobs</td>
</tr>
<tr>
<td></td>
<td>Single service</td>
<td>Multiple versions of service</td>
</tr>
<tr>
<td>Value about work</td>
<td>Expert focus (internally driven)</td>
<td>Customer focus (externally driven)</td>
</tr>
<tr>
<td></td>
<td>Focus on tradition (status quo)</td>
<td>Focus on innovation (change)</td>
</tr>
<tr>
<td></td>
<td>Problem analysis</td>
<td>Seeing possibilities</td>
</tr>
<tr>
<td></td>
<td>Measurement is feared</td>
<td>Measurement is opportunity</td>
</tr>
<tr>
<td></td>
<td>Protective</td>
<td>Productive</td>
</tr>
<tr>
<td></td>
<td>Performance</td>
<td>Ability</td>
</tr>
<tr>
<td></td>
<td>Inspection and control</td>
<td>Prevention</td>
</tr>
<tr>
<td>Value about employees</td>
<td>System indifference</td>
<td>Employee needs</td>
</tr>
<tr>
<td></td>
<td>Employees as expense</td>
<td>Employee as asset</td>
</tr>
<tr>
<td></td>
<td>Manager focus</td>
<td>Employee focus</td>
</tr>
<tr>
<td></td>
<td>Appraisal/sanction/ranking</td>
<td>Development/learning/recognition</td>
</tr>
</tbody>
</table>

Table 2.1: A comparison of traditional public sector values with new values (Montgomery 1995)

2.3.2. ISO 9000:2000 standards

The ISO 9000 series is different from ISO 19113 (see section 2.2.3), in the sense that it is not concerned with products, but processes, thus the way an organization goes about its work. It states the
requirements for an organization in order to manage processes influencing quality. Nevertheless, the way in which the organization manages its processes is obviously going to affect its final product.

ISO 9000:2000 has identified the “quality management system” as a management system to direct and control an organization with regard to quality and “TQM” is a management approach for an organization, centered on quality, based on the participation of all its members and aiming at long-term success through customer satisfaction, and benefits to all members of the organization and to society. The ISO 9000:2000 series of standards contain functional embodiments of TQM concepts within their requirements (elements). It suggests eight quality management principles:

1. Customer focus
2. Leadership
3. Involvement of people
4. Process approach
5. System approach to management
6. Continuous improvement
7. Factual approach to decision making
8. Mutually beneficial supplier relationships.

These principles were also proved to have the most significant influence on quality outcome by researches reviewed in section 2.3.1.

Table 2.2 shows the comparison of the factors used in the (Benson, Saraph et al. 1991; Flynn, Schroeder et al. 1994; Ahire, Golhar et al. 1996; Ravichandran and Rai 2000) studies conducted within the period from late eighties to late nineties, with the ISO principles. The researches were carried out using different techniques in many fields: manufacturing, service, or software industry. They focused on the time of significant change in quality management practices, especially when ISO 9000:2000 was issued. In this way, the difference in the terms used, the common points, the overlaps and the missing factors in earlier studies can be clearly recognized. The main principles of ISO 9000:2000 cover all aspects in the six above mentioned studies in a complete and systematic structure.
### Table 2.2: Summary of quality management factors

Adopted from (Ravichandran and Rai 2000)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Top management leadership</td>
<td>Top management support</td>
<td>Top management support</td>
<td>Top management support</td>
<td>IS management support for quality</td>
<td>Leadership</td>
</tr>
<tr>
<td>Management infrastructure sophistication</td>
<td>Quality policy not explicitly considered</td>
<td>Not considered</td>
<td>Quality policy and goals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Training</td>
<td>Included under workforce management</td>
<td>Employee training</td>
<td>Commitment to skill development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nature of reward schemes included under employee relations</td>
<td>Considered under top management support</td>
<td>Considered under employee involvement but dropped from the validation scale</td>
<td>Quality orientation of reward schemes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process management efficacy</td>
<td>Product/service design</td>
<td>Product design</td>
<td>Design quality management</td>
<td>Formulation of analysis and design</td>
<td>Process approach</td>
</tr>
<tr>
<td></td>
<td>Process management</td>
<td>Process management</td>
<td>SPC usage</td>
<td>Formalization of reusability in system development</td>
<td>Continuous improvement</td>
</tr>
<tr>
<td></td>
<td>Quality data and reporting</td>
<td>Quality information</td>
<td>Internal quality information usage</td>
<td>Fact based management</td>
<td>Factual approach to decision making</td>
</tr>
<tr>
<td></td>
<td>Benchmarking</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stakeholder participation</td>
<td>Employee relation</td>
<td>Workforce management</td>
<td>Employee empowerment</td>
<td>Employee empowerment of programmer/analyst</td>
<td>People involvement</td>
</tr>
<tr>
<td></td>
<td>Supplier management</td>
<td>Supplier involvement</td>
<td>Supplier performance</td>
<td>Vendor/consultant participation</td>
<td>Mutually beneficial supplier relationships</td>
</tr>
<tr>
<td></td>
<td>Customer involvement not explicitly considered</td>
<td>Customer involvement</td>
<td>Customer focus</td>
<td>User participation</td>
<td>Customer focus</td>
</tr>
</tbody>
</table>

#### 2.3.3. Implementing ISO 9000:2000 QMS, quality manual

The ISO 9000:2000 series also suggest an approach to develop and to implement a quality management system consisting of the following steps (Schlickman 2003):

1. Determining the needs and expectations of customers and other interested parties
2. Establishing the quality policy and quality objectives of the organization
3. Determining the processes and responsibilities necessary to attain the quality objectives
4. Determining and providing the resources necessary to attain quality objectives
5. Establishing methods to measure the effectiveness and efficiency of each process
6. Applying these measures to determine the effectiveness and efficiency of each process
7. Determining the means of preventing nonconformities and eliminating their causes
8. Establishing and applying a process for continual improvement of the quality management system.
To follow this approach, a quality organization could follow the structure shown in figure 2.5 in order to form required QMS processes.

Operationally, a QMS rests upon three pillars (see figure 2.6) which are:

- Documentation that accurately describes the organization’s core competencies and provides the necessary policies, processes, procedures, forms, and records to support the organization’s QMS
- Implementation based on the operational use of the documents on a daily basis
- Demonstration of effectiveness based on the monitoring, measuring, and analyzing of operational data and the corresponding corrective and preventive action programs.

Quality manual plays the role of the first pillar in the operational QMS. (ISO9001 2000) has defined a quality manual as a *document that specifies an organization’s QMS*. A quality manual should include:

- The scope of the QMS
- The documented procedures as established for the QMS - or reference to them
- A description of the interactions between the processes of the QMS.

On the one hand, the quality manual should address all quality system elements (ISO10013 1995):

- Describe and explain how each of the quality system requirements is being satisfied, and how each of the resulting quality system elements will be monitored and controlled
- Demonstrate that the quality system is complete, well organized, and thoroughly integrated.

On the other hand, the quality manual should contain or should refer to procedures of an organization’s QMS processes (ISO10013 1995). Procedures can be very general or very detailed, or anywhere in between. While a general procedure could take the form of a simple flow diagram, a detailed procedure could be a one page form or it could be several pages of text. A detailed procedure defines the work to be done, and explains how it should be done, who should do it, and under what conditions. In addition, it explains what authority and what responsibility has been allocated for this
work, which supplies and materials should be used, and which documents and records must be used to carry out the work.

Quality procedures need to be documented according to ISO 9000:2000 requirements (ISO9001 2000).

A quality manual can serve several purposes (ISO10013 1995):

- Description of the quality system
- Description of the quality policy and procedures
- Definition of the quality standards
- Explanation how quality requirements will be met
- Documenting the QMS according to the requirements
- Controlling quality work practices and activities
- Educating of people about quality requirements
- Guidelines for the implementation of the quality system
- Serving as a stable definition of the quality system
- Showing that the quality system meets requirements.

The following structure of a quality manual is recommended for a Geo-information organization (Paresi 2006):

- Quality policy
- Quality system
- Quality organization
- Quality procedures (work processes)
- Quality work instructions
- Quality reports
- Quality manual update.

2.3.4. Experience of QMS in NMA in Europe

The principles of ISO 9000:2000 are applicable to any organization. However, the way to implement these principles is different from one to another case. It is especially difficult for organizations like NMAs due to organization characteristics (Cerco 2000):

- Most of the NMAs are huge organizations with large number of employees
- NMA operations are usually defined and prescribed by the government, mainly in performing public services. Funding comes also mainly from the governmental budget
- In most of NMAs, the organizational structure is still hierarchical, based on function (e.g. survey, cartography, printing) rather than project based
- NMAs are more technology driven than business driven, with standardized products (geodetic, network, data, model etc.). In NMAs, a lot of knowledge and expertise is held in the heads of “experts”.

These characteristics have to be taken under consideration when a NMA decides to set up a QMS.

QMS concepts and applicability in a mapping environment in the late nineties were investigated by looking at experiences from national and local mapping agencies in Europe (Cerco 1999). In this study, most of NMAs adopted the ISO 9000:2000 standards as a reference for introducing and
implementing a QMS for the whole organization as well as just for a part of it. The results show that in the long term, financially, the benefit/cost ratio is good for an NMA when implementing a QMS.

The most important benefits of implementing QMS are:

- Improved customer satisfaction
- Improved quality of products and services
- Workers’ satisfaction and more commitment to the organization
- Better management and a more effective organization
- Improved relations with suppliers
- Improved promotion of corporate image.

Besides implementing a QMS also creates opportunities (Cerco 2000) to:

- Review business goals, and assess how well the organization is meeting those goals
- Identify processes that are unnecessary or inefficient, and remove them
- Review the organizational structure, clarifying managerial responsibilities
- Improve internal communication, and business and process interfaces
- Improve staff morale by identifying the importance of their output to the business, and by involving them in the review and improvement of their work.

However, it also involves risks (Cerco 2000) namely:

- Short-term increase in production costs during training and implementation of the QMS
- Dissatisfaction of staff because of new methodology - Resistance to change and perceived risk of “exposure”
- Another set of rules and papers without actual results
- Additional bureaucratic effort with no gain.

These risks of implementing and maintaining a QMS need to be managed to reduce the negative impacts on the organization.

The study of CERCO shows that, establishing a QMS in NMA is not a simple process. It needs a systematic approach and special attention to deal with the difficulties characterized for NMA.

2.3.5. Quality management framework

For the purpose of this study, a quality management framework was developed based on eight ISO 9000:2000 principles owing to its completeness and worldwide recognition. The resulting framework can be used for assessing or setting up a QMS for an organization. The eight principles are reflected in a number of characteristics of an organization (ISO9000:2000 2006):

1. Customer focus: Organizations depend on their customers and therefore should understand current and future customer needs, should meet customer requirements and strive to exceed customer expectations.
   1.1. Researching and understanding customer needs and expectations
   1.2. Ensuring that the objectives of the organization are linked to customer needs and expectations
   1.3. Communicating customer needs and expectations throughout the organization
1.4. Measuring customer satisfaction and acting on the results
1.5. Systematically managing customer relationships
1.6. Ensuring a balanced approach between satisfying customers and other interested parties
    (such as owners, employees, suppliers, financiers, local communities and society as a whole).

2. **Leadership:** Leaders establish unity of purpose and direction of the organization. They should create and maintain the internal environment in which people can become fully involved in achieving the organization's objectives.

   2.1. Considering the needs of all interested parties including customers, owners, employees, suppliers, financiers, local communities and society as a whole
   2.2. Establishing a clear vision of the organization's future
   2.3. Setting challenging goals and targets
   2.4. Creating and sustaining shared values, fairness and ethical role models at all levels of the organization
   2.5. Establishing trust and eliminating fear
   2.6. Providing people with the required resources, training and freedom to act with responsibility and accountability
   2.7. Inspiring, encouraging and recognizing people's contributions.

3. **Involvement of people:** People at all levels are the essence of an organization and their full involvement enables their abilities to be used for the organization's benefit.

   3.1. People understanding the importance of their contribution and role in the organization
   3.2. People identifying constraints to their performance
   3.3. People accepting ownership of problems and their responsibility for solving them
   3.4. People evaluating their performance against their personal goals and objectives
   3.5. People actively seeking opportunities to enhance their competence, knowledge and experience
   3.6. People freely sharing knowledge and experience
   3.7. People openly discussing problems and issues.

4. **Process approach:** A desired result is achieved more efficiently when activities and related resources are managed as a process.

   4.1. Systematically defining the activities necessary to obtain a desired result
   4.2. Establishing clear responsibility and accountability for managing key activities
   4.3. Analyzing and measuring the capability of key activities
   4.4. Identifying the interfaces of key activities within and between the functions of the organization
   4.5. Focusing on the factors such as resources, methods, and materials that will improve key activities of the organization
   4.6. Evaluating risks, consequences and impacts of activities on customers, suppliers and other interested parties.

5. **System approach to management:** Identifying, understanding and managing interrelated processes as a system contributes to the organization's effectiveness and efficiency in achieving its objectives.
5.1. Structuring a system to achieve the organization's objectives in the most effective and efficient way
5.2. Understanding the interdependencies between the processes of the system
5.3. Structured approaches that harmonize and integrate processes
5.4. Providing a better understanding of the roles and responsibilities necessary for achieving common objectives and thereby reducing cross-functional barriers
5.5. Understanding organizational capabilities and establishing resources constraints prior to action
5.6. Targeting and defining how specific activities within a system should operate
5.7. Continually improving the system through measurement and evaluation.

6. Continuous improvement: Continual improvement of the organization's overall performance should be a permanent objective of the organization.
6.1. Employing a consistent organization-wide approach to continual improvement of the organization's performance
6.2. Providing people with training in the methods and tools of continual improvement
6.3. Making continual improvement of products, processes and systems an objective for every individual in the organization
6.4. Establishing goals to guide, and measures to track, continual improvement
6.5. Recognizing and acknowledging improvements.

7. Factual approach to decision making: Effective decisions are based on the analysis of data and information
7.1. Ensuring that data and information are sufficiently accurate and reliable
7.2. Making data accessible to those who need it
7.3. Analyzing data and information using valid methods
7.4. Making decisions and taking action based on factual analysis, balanced with experience and intuition.

8. Mutually beneficial supplier relationships: An organization and its suppliers are interdependent and a mutually beneficial relationship enhances the ability of both to create value
8.1. Establishing relationships that balance short-term gains with long-term considerations
8.2. Pooling of expertise and resources with partners
8.3. Identifying and selecting key suppliers
8.4. Clear and open communication
8.5. Sharing information and future plans
8.6. Establishing joint development and improvement activities
8.7. Inspiring, encouraging and recognizing improvements and achievements by suppliers.

This framework for quality management also supports to achieving the new values (see table 2.1) that public sector organizations in the transition period would go for.
2.3.6. Conclusion

In this section, a literature review was performed related to general quality management issues during the last decades, with a comparison to the ISO principles. The experiences of setting up and maintaining a QMS in organizations and specifically for NMAs with reference to the ISO 9000 standards were reviewed.

At the end, a quality management framework with detailed requirements based on ISO 9000 principles was chosen for reviewing the AGI AHN experience, assessing the current quality management in the RSC and developing a QMS for the RSC ALS DTM production.

2.4. Experience with QMS from AGI AHN project

An interview with the ALS project manager of the AGI AHN was carried out about the general activities of the AGI AHN and with specific focus on the quality management system that has been developed and implemented in the AGI AHN project.

The AHN program is a division under the AGI. AGI AHN has dealt with several ALS projects every year since 1996, and in 2003 has completed a country-wide dataset of laser data. Laser scanning was always done by ALS contractors. The task of the AGI AHN was to perform the quality control process using its expertise and experiences to guarantee that the quality of the dataset satisfies the requirements of their main customers.

There is an increasing tendency of outsourcing in the AGI AHN. There will be more focus on project management, and AGI AHN is considering also outsourcing the quality control process.

2.4.1. Customer involvement and process improvement

There are three main customers of the AGI AHN program: Water Boards, Provincial Government and "Rijkswaterstaat" (Ministry of Transport, Public Works and Water Management) (Crombaghs, Elberink et al. 2002). The customers set the requirements of each project and they practically share the costs of data production (AHN 2007).

These users have specific requirements about data quality. In special projects they require very high accuracy. Together with contractors, the AGI AHN tried to find a way to meet these requirements or to discuss with customers to come to feasible options for projects.

AGI was doing research on how to improve the data accuracy based on the faults that were found in previous projects. The strip adjustment is a good example of that. During quality checks of earlier projects, the AGI discovered that the height differences in strip-overlaps were sometimes very big, up to 1 meter. AGI researchers developed a method to adjust the strips in the same way as adjustments in "regular" surveying projects took place. The result was the strip-adjustment program that AGI AHN contractors are using up till now (Crombaghs, Brügelmann et al. 2000). The research and development department of the AGI developed several techniques to carry out quality control. These are described in detail in their quality plan.

Working with contractors, the AGI AHN gradually increases the quality demands when they are enabled by technology. On the other hand, ALS companies also improved their products, so there was a constant update on quality demands and technical possibilities.
2.4.2. Work process and quality control procedure

The ALS acquisition in the AGI AHN is project-based. Contractors should pass a pre-qualification test to be in the tender shortlist. Now four ALS companies are listed and provide their services to the AGI AHN from time to time. They are all ISO 9001 certified. The selection of a contractor for a project is based not only on price but also on the quality they may deliver for specific product requirements.

The AGI AHN itself is not ISO certified, but they maintain a QMS with ISO 9000:2000 principles as a reference. In contracts, the AGI AHN and contractors both refer to their quality plan.

The research and development department of the AGI developed a quality plan for ALS projects in order to facilitate the outsourcing process and communicating with contractors and customers. This quality plan has been improved frequently during the first years of ALS deployment in the AGI AHN. The last three years it has not changed much, and has been used in all projects.

The output products of AHN ALS projects are both the Digital Surface Model (DSM) and DTM. These projects consist of the following processes: project planning, flight, ground control survey and accuracy assessment, and filtering (see appendix A.8). Each of the processes is described in detail with respect to: process organization, process description, process planning, assurance, reporting and quality control. The quality plan gives clear answers to the questions: what has to be done, when, how, and by whom. It also states what has to be done if something goes wrong.

Especially, the quality control process is specified in detail so that contractors know how the AGI AHN will check the result. On the other hand, AGI AHN customers also know how data delivered to them have been checked.

This quality plan of AGI AHN covers all the procedural part of the quality manual for an ALS production.

2.4.3. Human resources

The AGI AHN project team consists of four staff members. Two are technicians that carry out the quality control of the ALS data delivered by contractors. The other two are project managers. One of them is in charge with contractors and the other is responsible for customer’s relations. It was observed that AGI AHN employees have a good working environment, they are motivated and competent to their work.

2.4.4. Conclusion

The quality management experience from the AGI AHN in their projects is a successful practice that follows the principles of the ISO 9000 family. It is characterized by:

- A clear vision and a quality culture that is well spread throughout the organization
- A strong outsourcing policy focusing on long term mutual beneficial relationships with contractors
- Knowledgeable customer groups with clear product requirements
- A flat organizational structure with good support from the AGI research and development activities
- Good working environment
- Motivated and competent human resources.
Technically, the quality plan and technical specification and techniques for accuracy enhancement have been improved several times and used sufficiently in a large number of projects. This quality plan of AGI AHN covers all the procedural part of the quality manual for an ALS production.

These experiences can be used as benchmark for similar projects.
3. Current quality management in RSC, MoNRE

3.1. Introduction

The objective of this chapter is to review the current situation of the RSC’s quality management system, and to obtain a better picture of the environment in which the ALS DTM production is going to be launched. This objective will be achieved by: (i) reviewing the general quality management framework of the MoNRE, that the RSC, being its sub-organization, should follow; (ii) identifying the problems on quality management that the RSC is facing in the topographic map production (where RSC has long experience); (iii) reviewing the experiences from the ALS DTM pilot project.

For this purpose, the quality management framework based on the ISO 9000:2000 series (see section 2.3.5) was used, combined with the experiences from the AGI AHN project, to evaluate the RSC organizational structure, and in particular quality policy, quality culture, quality control procedure, standards and documentation, human resources and education, and supplier relations and outsourcing.

The idea was to use the topographic map production, which was in place in the RSC for years, as an example to identify the quality culture of the organization. It will reveal the characteristics of the main components in the quality management system in the RSC that have a negative influence on the quality of the output products. The main components are: the general organizational structure and its financial mechanism, the production and quality control, the management commitment to quality and human resources.

On the other hand, the experience from the pilot project will highlight the problems to be aware of when organizations like the RSC apply a new technology for the first time in production, in terms of quality management.

Combination of the findings will give a complete picture of the RSC QMS components that need consideration for improvements to assure success for the future ALS DTM production.

3.2. MoNRE quality management framework

The MoNRE quality management framework was investigated through interviews and by reviewing collected documents that focus on the quality control procedures and standards that organizations under the MoNRE should follow. Interviewees were selected by purposive sampling. They are senior staff working in different organizations under the MoNRE, directly in charge with standards, project planning, production, quality control and quality audit. The list of interviewees and related documents can be found in appendix A.3.1.

MoNRE is responsible for managing natural resources and environment in Vietnam, appendix A.1 shows its organizational structure. Survey and mapping activities is one of the fields under control of the MoNRE. The Surveying and Mapping Department sets standards, technical regulations, and technical specifications for all surveying and mapping activities in Vietnam. The organizations under
the MoNRE, carry out most of these activities, especially in topographic mapping. The MoNRE assigns these projects to its operational organizations, distributes budgets based on established norms, and sets the quality management framework for the implementation of the projects.

The main actors in term of quality management in surveying and mapping activities in the MoNRE are shown in figure 3.1.

![MoNRE organization chart in quality management domain](image)

Figure 3.1: MoNRE organization chart in quality management domain

In the MoNRE, operational organizations prepare a technical-economical design for each surveying and mapping project, which is then submitted to the Survey and Mapping Department for approval. The Quality Audit Centre, which is placed directly under the Survey and Mapping Department, is responsible for the quality audit for all the deliverables of these projects based on all the standards, regulations, technical specifications, and the project design.

There are five operational organizations involved in topographic mapping projects in the MoNRE. The Remote Sensing Centre is one of them. For topographic map production, usually every operational organization has a quality control unit and three independent production units: a survey, a photogrammetry and a map editing division that exchange the intermediate output with each other through the Quality Control Unit.

### 3.2.1. MoNRE quality control procedure

According to the “Regulation on quality control of mapping and surveying products”, published in 1997 by the MoNRE, product quality control takes place at 3 levels. At level 1, production units should check 100% of all intermediate and final products they produce. At level 2, the quality control unit will check from 30% to 100% of the output from each production unit, depending on the specific type of process. Finally, at level 3 the Quality Audit Centre will check 3% of the outdoor output, like the ground controls points for aerial triangulation, and 30% of the indoor products. At each level, a...
A simple quality check form is used. When all deliverables of projects pass the final quality control in level 3, it will be archived together with the final quality report. At that moment, the operational organization will receive a statement for project clearance from the Survey and Mapping Department.

If the products fail to pass quality control, they should be redone until they satisfy the requirements. Because of this, the operational organization may miss the delivery deadline.

However, a quality manual does not exist for topographic map production in the sense as defined in section 2.3.3.

### 3.2.2. Standard and technical specification

Appendix A.4 shows the list of the technical documents in force for processes in large scale topographic map production using digital photogrammetry, and the project design of two recent large scale topographic mapping projects. This information was collected during the fieldwork. Interviews were conducted with specialists in the MoNRE that are directly in charge of planning, production, quality control, and quality audit. They were asked to share their experience in applying current standards and technical specification in survey and mapping activities. The interviews show a common opinion that current technical documents needed to be complemented and updated. In more detail:

- There is lack of standards and technical specification, especially with survey activities. These specifications can be found in some researches or projects reports, but are not yet summarized into legal documents
- The existing technical legal documents are not detailed or clear enough, and sometimes contradict each other. It leaves room for arguments in production as well as in the quality control and quality audit processes
- The operational organizations try to clarify and legalize the technical details through the approval of the project design. They try to include in the project design as much as possible technical details from the hardware user manual, and previous research and project reports to make it a legal document for production as well as for the quality audit process. However the more detail the project design is prepared, the more difficult it gets approved by Survey and Mapping Department. This causes delay in the project design approval and puts more time pressure for the production
- The existing legal technical documents are not up-to-date in terms of technology: equipment/software and user requirements. For example, standards for topographic map production are still mainly based on traditional cartography that focuses on hardcopy appearance. Advantages of new technology that could better meet new user requirements, such as an intermediate DTM, orthophoto products, the possibility of attaching features and attributes in digital maps, are not yet considered
- There is no standard and technical specification for a DTM product set by the MoNRE.

However, there is a rule to introduce new technology into Vietnam. The technical specification of a world recognized professional association can be considered for use in a special or pilot project. It has to be reported beforehand and be approved by the Ministry in charge.
3.3. **Quality management system for topographic map production in RSC**

In this study, interviews were conducted with top and middle managers of the RSC; senior staff in the technical department, which is the quality control unit of the RSC; team leaders of production units; and some operators which have been involved in topographic map production for a long time. The list of interviewees and the documents collected can be found in appendix A.3.2. Some general information about the RSC was taken from the RSC website (RSC 2007).

The interviews were conducted based on the quality management framework (see section 2.3.5). A fishbone diagram (Heller 2002) was used during interviews to encourage discussions around specific aspects, such as management commitment, human resources, the organization, and production and quality control, to identify the factors that have a negative influence on the quality of the output product. (It should be noted that it is not very common in Vietnamese government organizations to talk about negative points. It has to be observed that, of course, there are also positive points. Those positive points are presented in the SWOT in chapter 4). A cross check technique (Kumar 2005) was applied during the interviews and results is summarized and shown in figure 3.2 and described in more detailed in the next subsections.

![Fishbone Diagram]

**Figure 3.2: Aspects which need improvement in quality management of RSC topographic map production**

Most of the interviewees agreed on two problems in the current productions: a high waste of resources and project delays, and a low satisfaction of the topographic map end-user.

### 3.3.1. **Organization of RSC**

The RSC organization chart and its missions are shown in appendix A.2.

The RSC is an administrative - non profit organization directly under the MoNRE. It must accomplish the missions assigned by the MoNRE, and MoNRE will distribute an annual budget for
implementation of all the activities, based on established norms that cover the production cost. This budget should be spent according to a rule applied to government offices. By law, being a non-profit organization, the RSC should not create any fund out of the annual budget for any purpose.

The RSC mainly performs mapping and surveying projects given by the MoNRE, using governmental budget. This budget is the main financial source for the RSC.

This financial constraint limits the organization’s motivation to take initiatives and make changes for improvement. All the expenses of an organization such as the salary schema, comment and reward fund, employee’s benefits as well as employee development program are set by common rules for government offices that the RSC management has to follow. Training and education is usually organized by the MoNRE. The RSC can just send its employees to attend. RSC has no budget to arrange its own employee training program that would better fit the organization’s needs.

RSC has no department dealing with customer and there have not been any efforts to identify topographic map end-user requirements. The topographic map production is carried out by request from MoNRE and follows the current MoNRE standards. As mentioned in section 3.2.2, the product standard needs to be improved and updated to better address the end-user requirements of topographic map.

The RSC carries out researches ordered by the MoNRE. Usually the manager of each of the divisions of the RSC is the one, personally responsible for the research. There is no department that is specifically responsible for research and development. So far no research was done to improve the production processes, nor have any quality control tools been developed.

The Science and Technology Department is responsible for the planning and quality control of common surveying and mapping projects at the RSC. It should prepare the project design and get approval from the Survey and Mapping Department, MoNRE. It also has to check the intermediate and final products, and solve technical problems during the production and the quality audit period. At data delivery, they are responsible for the final quality report. It is a very important unit in the production process; nevertheless its capacity needs significant improvement.

### 3.3.2. Commitment to quality

The RSC managers percept the importance of time and cost in production is higher than that of quality. They are aware of the TQM concepts, but have not yet considered applying it into the organization and its production.

The top manager has a vision of the organization’s future, but this vision is not clearly stated, hence it just penetrates to the middle managers, and there is no shared vision communicated within the organization.

There is no quality policy, and no quality objectives are identified and communicated within the organization.

### 3.3.3. Human resources

There are 240 employees at the RSC, 90% of whom are university graduates or post graduates. However, most employees do not understand the importance of their roles and their contribution within the organization. In some cases, operators do not follow the specification strictly.

Interviewees agreed that low employee motivation is one of aspects that strongly affects the quality of products. Employees have low income. Generally, the RSC follows a salary schema
according to rules applied for all governmental offices, which is based mainly on service-time. This does not encourage productivity, neither the contribution of the young employees. The formalistic comment and reward schema and the *uncomfortable working environment* also have a negative impact on the quality of the work.

Another problem is the *employee’s work competence*, which on average is low (even if employees have an university degree). It depends mainly on the on-job kind of training where new comer is simply shown the way to do the job by other operators without proper understanding about complete workflow of the production. The instruction the newcomer receives depends very much on the willingness of the colleagues. The employee development at the RSC is ineffective: usually the training that the MoNRE organizes does not meet the RSC needs. The RSC does not have any resources to arrange training that meets their needs. There have only been a few suitable training courses, but the participants were not the ones directly in charge with the work. The ineffective communication between employees and departments limits knowledge and experience sharing and the fact that employees do not feel the need for continuous improvement also limits their working competence.

### 3.3.4. Production

All of interviewed agreed that the lack of comprehensive standardization in the production processes and the quality control is the biggest problem in the production. In each of the processes, the units in charge create some type of working specifications based on their previous experience in working with the Quality Audit Centre. These specifications are used internally within the units and are *not documented* in the final project reporting. In general, production and quality reporting has a formalistic character.

Another factor that affects product quality is the late project design approval by the Survey and Mapping Department, which leads to time pressure on production (see section 3.2.1), under which the processes specification is not followed strictly by operators.

There is no appraisal meeting to evaluate the success of the projects, or to measure the quality performance, which could lead to some improvement actions, therefore problems keep coming.

### 3.3.5. Quality control

There is no quality manual for RSC topographic map production.

The lack of legalized, comprehensive standards in the production processes and the quality control, and the formalistic nature of reporting in the production are obstacles in quality control.

Quality control is carried out mainly by visual inspection. No tools or techniques were developed to improve quality and efficiency of the quality control.

The lack of comprehensive standards and consistent technical specifications for a product also causes difficulties in carrying out the quality control, and negatively influences the quality of the output product.

### 3.3.6. Summary

In the RSC, many components of the organization and their combination influence the quality management of the production. The findings about the problems in the current quality management of
the RSC can be summarized to the following main points:

- The lack of a quality culture in organization
- The lack of the management’s commitment to quality
- The need to standardize the production and quality control processes by means of legal documents, such as standards, technical specifications and quality manuals
- The need for a change in the organization’s structure, a mechanism towards customer orientation and continuous improvement.

However, there are no crisp boundaries between these components and often they strongly interact with each other. Thus these problems should be considered all together while looking for measures to improve the situation.

Finally, the RSC could consider solving the problems related to the human resources aspects. Further RSC could consider taking measures to improve staff motivation and commitment to quality, and plan an employee development program that effectively and efficiently improves employees’ working competence.

### 3.4. ALS pilot project in RSC

This pilot project is the first experience with ALS technology and it is also the first time that the RSC has outsourced a project. The RSC manager created a project team with experienced senior staff to cooperate closely with the contractor, and made all the resources needed for the project available.

For the purpose of this research, the focus was on identification of the constraints and difficulties in the pilot project. First, the author attended a workshop, that was co-organized by the RSC and the contractor for reporting about the results of the pilot project. After that, in-depth interviews of all people in the RSC pilot project team were conducted, and available documents were collected. These documents were: the outsourcing contract, the contractor’s project report, the RSC final project report with the production workflow generated based on the experience from the pilot project. It was not possible to interview the experts from the contractor-company. The list of interviewees, the role they played in the pilot project and the documents collected are shown in appendix A.3.2. The quality management framework (see section 2.3.5) and the experience from the AGI AHN (see section 2.4) were also used to guide through the interviews when applicable.

![Figure 3.3: Aspects which need improvement in the RSC ALS pilot project](image-url)
The pilot project was implemented in the framework of the “Integrated GIS for regional development of the Mekong Delta project, 2004-2007”, and the accuracy requirement for the DTM was taken from this mother project, it was 20cm. In practice, the delivered and accepted data from the ALS pilot project needed improvement, before this data can be used for DTM generation for the Mekong project. A fishbone diagram (Heller 2002) was used during interviews to find out the factors leading to this problem in specific aspects of contracting, human resources, product delivery, and quality control. Cross checking (Kumar 2005) the opinions of interviewees helped to finalize the findings that are briefly summarized in figure 3.3.

A dataset was collected from the pilot project to perform some quality check techniques. The description of the dataset and the check results are shown in appendix A.6 and A.7 respectively.

3.4.1. Human resources
The people working for the RSC pilot project have got no experience in dealing with ALS technology and the quality control of the ALS DTM product, or hands-on experience with ALS data.

3.4.2. Contracting
The contractor in the pilot project is not ISO 9000 certified, so it does not have an official quality manual that the RSC could refer to. The contractor also did not provide any production workflow, technical specifications or a quality plan that was followed in this project.

   In the contract, there is no agreement on the quality plan and the reporting. The requirements were not clearly stated. Only the vertical accuracy of 20cm was mentioned in the contract.

3.4.3. Product delivery
The contractor did not deliver the path of the flight strips. Laser points were delivered in fixed square tiles, and not in flying strips. This limits the possibility of checking for systematic errors in the overlapping area of parallel and cross strips.

   The contractor’s project report is not complete. It only describes shortly the final product and the list of delivered files, without mentioning the production process. It was not clear what was done and how.

3.4.4. Quality control
There is no quality manual used for the ALS DTM project. Only an ad-hoc quality control was conducted by the RSC project team. It included a simple vertical accuracy check using a small number of control points, and a check on the quality of filtering. However, because of time pressure to meet the deadline of the project, the quality control of filtering was not complete. RSC accepted the dataset from contractor and tried to improve the filtering further.

3.4.5. Summary
The pilot project gives the RSC the first experience in dealing with a contractor and with ALS
technology. It also stretches the importance of having a quality manual and a quality plan on which the parties should agree. Moreover, the competence and the commitment of the staff involved, and also their good teamwork skill and cooperation, are crucial issues for the success of an ALS DTM project. RSC could consider implementing QMS for ALS DTM production to ensure the long term success of the production.

3.5. Conclusion

RSC has several production lines in places for many years such as topographic mapping, cadastral mapping, small scale topographic map updating, land inventory mapping, etc. that follow the same framework and facing similar problems in quality management. Topographic map production was selected for assessment the current QMS of RSC as it is the largest production for RSC and technically, it is the one closest to the large scale DTM production. The quality management framework developed in section 2.3.5 was used. The current quality management in RSC reveals the critical points that need improvement namely:

- Customer orientation
- Management commitment to quality
- Organization
- Standardization of processes and legalization of technical document for quality control process; development of a quality manual (which is currently lacking)
- Quality culture of the organization
- Employee motivation and working competency
- Communication within organization.

The experience from the pilot project again stresses the need for improvement in processes standardization and employee’s competence especially as it concerns this relatively new field of technology for RSC.

The combination of the findings from these assessments underlines the need to implement QMS for the RSC ALS DTM production and provides the concrete information to develop a suitable framework for QMS for RSC ALS DTM production.
4. ALS DTM production in RSC, MoNRE

This chapter will combine the factors that strongly influence RSC quality management system based on the conclusions from chapter 3 with preliminary findings about potential customer’s requirements. It will create an overview of the conditions of the environment in which RSC ALS DTM production is going to be launched. Afterward, it is compared with experiences from AGI AHN and the “desired future” of QMS for RSC ALS DTM production will be identified following the ISO 9000:2000 principles and experiences of AGI AHN as a benchmark.

The Strength, Weakness, Opportunities and Threats (SWOT) of RSC in for QMS implementation are identified through interviews with key informants. SWOT analysis will be conducted to generate feasible implementation strategies to bridge the gaps between the “as is” and the “to be” situation in the case of RSC. The initiatives synthesized from the SWOT matrix will be validated for completeness against critical success factors from the quality management framework (see section 2.3.5).

4.1. ALS DTM potential user requirements

As mentioned in many researches (see section 2.2.5), potential users of ALS DTM are in the sectors of:

- Water resource management
- Flood monitoring
- Infrastructure engineering
- Urban planning and development
- Public work department
- Agriculture and aquaculture management
- Forestry
- Telecom
- Petroleum
- Electricity industry
- Survey and mapping
- Academic institutions.

In this study, however, only thirteen persons from five main sectors were interviewed because of limited time. They are senior staff in charge with technical project design and to some degree involved in organization cooperation and management aspects. The list of interviewees and the organization main activities are shown in appendix A.3.3.

The interviews were conducted in three steps. First, semi-structured interviews (Kumar 2005) were conducted with short introduction of ALS DTM products and the applications. In these interviews, the focus was on: the interviewee’s organization missions, their awareness, interests, and possible requirements toward the product. Next, the focus was on the way they carry out the daily work and the possibility of cooperation to develop applications with ALS DTM product.
Normally, a project is started from preliminary project planning using any available small scale topographic map. Then a detailed survey is conducted in the project area that is resulting in large scale topographic maps, i.e. 1:500, 1:2000, and 1:5000. These maps also have to follow the technical specifications issued by MoNRE, according to that positional accuracy of terrain objects can be derived (see table 4.1). ALS DTM could very well replace the detail survey part in these projects by providing the high resolution DTM for large scale topographic map production and speed up the whole project.

<table>
<thead>
<tr>
<th>No</th>
<th>Sector</th>
<th>Expected requirements</th>
<th>Detail survey map scale</th>
<th>Derived requirement:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Infrastructure development related to water management</td>
<td>Not clear</td>
<td>1:500-1:1000</td>
<td>0.2m 0.2m - 0.5m</td>
</tr>
<tr>
<td>2</td>
<td>Natural resource and environment management</td>
<td>Not clear</td>
<td>1:5000</td>
<td>1.0m 2.5m</td>
</tr>
<tr>
<td>3</td>
<td>Hydropower station construction</td>
<td>Not clear</td>
<td>1:2000-1:5000</td>
<td>0.5 - 1.0m 1.0 - 2.5m</td>
</tr>
<tr>
<td>4</td>
<td>Geological survey and mapping</td>
<td>Not clear</td>
<td>1:2000-1:5000</td>
<td>0.5 - 1.0 m 1.0 - 2.5m</td>
</tr>
<tr>
<td>5</td>
<td>Urban planning</td>
<td>Not clear</td>
<td>1:500-1:1000</td>
<td>0.2m 0.2m - 0.5m</td>
</tr>
<tr>
<td>6</td>
<td>Public work department</td>
<td>Not clear</td>
<td>1:500-1:1000</td>
<td>0.2m 0.2m - 0.5m</td>
</tr>
</tbody>
</table>

Table 4.1: Possible user requirements toward ALS DTM product

Beside it, other findings can be drawn from the interviews with customers for strategic planning of ALS DTM production in RSC:

- The customer’s project area is not big (less than 100km²), therefore the customer’s budget for surveying would not cover the whole cost of an ALS acquisition project. A cost-sharing mechanism is needed for these cases
- Customers are well equipped with technology (modern hardware and software) in their professional domain, but it has not been used efficiently. One of the reasons is the lack of suitable high resolution DTM as input data. The applications of ALS DTM are promising and users are ready to put expertise in cooperation for application development in their domain.

4.2. The desired future for the RSC ALS DTM production

RSC ALS DTM production is going to be launched in the same organizational environment as topographic map production and pilot ALS DTM project. To have a good framework for implementing QMS for ALS DTM production, it is necessary to be aware of the situation and the problems that current topographic map production and pilot ALS DTM project are facing. From the findings of section 3.3 and 3.4 the main problems that will have negative influences on the future ALS DTM production were selected and shown in table 4.2. The content of table 4.2 is partly derived from the fishbone diagrams (see figures 3.2 and 3.3). These will point out the weaknesses and threats that need to be considered in SWOT analysis when strategies are developed.

However, the interviews with top manager of RSC and management of MoNRE show that there are some predefined organizational conditions for the future ALS DTM production that gives RSC
more opportunity and freedom to act differently compare to the case of topographic map production.

There are two favorable conditions that will strongly contribute to make QMS implementation for ALS DTM production viable:

- The department that will be in charge of ALS DTM production will have profit finance status (see section 3.3.1). It has strong support from MoNRE and RSC management
- RSC management has a clear vision about the desired future of the production. They also stress that there will not be outsourcing and the human resources for the ALS DTM production are mainly within RSC.

In table 4.2, these aspects are compared with the situation and experience of AGI AHN for defining the “to be” situation of RSC ALS DTM production in term of QMS. The main points describing its “desired future” are proposed to be:

- ALS DTM production with established and well maintained QMS that adopted ISO 9000 family standards as reference. RSC will consider to apply for ISO 9001:2000 certificate on long term
- Top management of RSC recognizes the needs and is committed to implement QMS in the production
- Standardized and legalized production processes with a comprehensive quality plan and technical specification for ALS DTM production with no outsourcing (could be the form of a quality manual)
- Effective customer relation activities that can ensure both the promotion of ALS DTM products and cooperation in application development in customer domain
- Satisfied customers with applications newly developed in close cooperation with RSC using ALS DTM data
- ALS DTM production within a flat organizational structure that works in flexible and efficient way
- Mechanism for research and development to create suitable tools and techniques for quality improvement and quality control
- Quality culture is well spread through out ALS DTM production
- Effective internal and external communication
- Employees are motivated, competent to their works and committed to quality.
Table 4.2: Starting point for RSC ALS DTM production versus AGI AHN experiences

<table>
<thead>
<tr>
<th>From topographic map production (1)</th>
<th>From the pilot project(2)</th>
<th>RSC ALS DTM production</th>
<th>AGI AHN situation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Leadership</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No vision</td>
<td>Not applicable</td>
<td>Clear Vision for RSC ALS DTM production</td>
<td>Clear vision Whole organization is committed to quality</td>
</tr>
<tr>
<td>No commitment to quality</td>
<td></td>
<td>Inherit from (1)</td>
<td></td>
</tr>
<tr>
<td><strong>Customer</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not applicable</td>
<td>Requirements based on design of Mekong delta project, no requirements from direct users</td>
<td>Customers are not aware of product or have no clear requirement</td>
<td>Users have clear requirements that AGI AHN need to fulfill</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Their current application have data requirement that can be translate into ALS DTM product requirement</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>They are ready to cooperate to develop application in their domain</td>
<td></td>
</tr>
<tr>
<td><strong>Product</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not applicable</td>
<td>Targeting at ALS DTM</td>
<td>Currently targeting in DTM production</td>
<td>Both DTM and DSM products</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inherit from (1) + (2)</td>
<td></td>
</tr>
<tr>
<td><strong>Standardized process</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technical specifications for survey activities related to ground survey measurement in ALS DTM production needs significant update and needs to be legalized</td>
<td>No quality manual, no quality plan, no technical specification Ad hoc quality control There is production workflow followed in pilot project</td>
<td>Comprehensive quality plan for ALS project Have comprehensive quality manual for related survey activity</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inherit from (1) + (2)</td>
<td></td>
</tr>
<tr>
<td><strong>ALS technology</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not applicable</td>
<td>Lack of experience of ALS technology No tool and technique for quality control and quality improvement</td>
<td>Inherit from (2) Tools and techniques for quality control and quality improvement</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Organization</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No outsourcing</td>
<td>Outsourcing</td>
<td>No outsourcing</td>
<td>Outsourcing</td>
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<tr>
<td></td>
<td></td>
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</tr>
<tr>
<td>QMS needs significant improvement</td>
<td>Contractor has no ISO 9001:2000 certification</td>
<td>Inherit from (1) + (2)</td>
<td>Contractors have ISO 9001 certification AGI AHN adopted ISO 9000 as reference</td>
</tr>
<tr>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hierarchy structure</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small and flat structure of the project team</td>
<td>Inherit from (1) + (2)</td>
<td>Flat organization</td>
<td></td>
</tr>
<tr>
<td><strong>No customer department, No customer focus</strong></td>
<td>Not applicable</td>
<td>Inherit from (1)</td>
<td>Active user group crossing organization boundary</td>
</tr>
<tr>
<td><strong>No research and development department</strong></td>
<td>Not applicable</td>
<td>Inherit from (1)</td>
<td>Strong support from research and development department</td>
</tr>
<tr>
<td><strong>Low capacity of planning department</strong></td>
<td>Not applicable</td>
<td>Inherit from (1)</td>
<td>Capable employees for planning</td>
</tr>
<tr>
<td><strong>Human resources</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Need for improved employee motivation and competence improvement</td>
<td>Employee eager for new technology and but have low competence due to lack of experience</td>
<td>Human resources are selected mainly within RSC Inherit from (1) + (2)</td>
<td>Staff is motivated and competent to the work</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Quality culture</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No quality culture: No management commitment to quality; no quality policy communicated; Non-optimal people involvement and continuous improvement; Many activities related to quality performance are carried in formalistic manner.</td>
<td>Not applicable</td>
<td>Inherit from (1)</td>
<td>Quality culture well spread in organization, effective internal and external communication</td>
</tr>
</tbody>
</table>
4.3. SWOT analysis in implementation QMS for ALS DTM production in RSC, MoNRE

SWOT analysis is a management tool for strategic planning and management. Its basic principle is that a good planning means ensuring a fit between planned activities and the environment (Groenendijk and Dopheide 2003). It can also be used for development implementation plan for quality management system in this case. A SWOT analysis contains four basic steps:

1. **External analysis:** takes into account the actual situation (existing threats and non exploited opportunities as well as possible trends and developments. An opportunity is the external fact or development that if take advantage of can substantially contribute to the realization of the organization’s objective. A threat can be identified as external factor development that has or can a substantial negative effect on an organization performance

2. **Internal analysis:** discusses the existing situation and explores strengths and weaknesses that critically determine organization performance. Strength is an existing internal asset (management, knowledge, resources, business links, etc.) that contribute substantially to the realization of organization mission. A weakness is an internal characteristic that threatens the functioning of the organization

3. **Generating alternatives:** Strengths, weaknesses, opportunities and threats are matched into SWOT matrix, based on particular combination of these factor a set of alternative strategies can be formulated. It is illustrated in the following table:

<table>
<thead>
<tr>
<th>Internal factor</th>
<th>Strengths</th>
<th>Weaknesses</th>
<th>TO strategies: Generate strategies that use opportunities to combat threats</th>
</tr>
</thead>
<tbody>
<tr>
<td>External factor</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opportunities</td>
<td><strong>SO strategies:</strong> Generate strategies that use strengths to take advantage of opportunities</td>
<td><strong>WO strategies:</strong> Generate strategies that take advantage of opportunities by overcoming the weaknesses</td>
<td></td>
</tr>
<tr>
<td>Threats</td>
<td><strong>ST strategies:</strong> Generate strategies that consider strength as a way of avoiding threat</td>
<td><strong>WT strategies:</strong> Generate defensive strategies that minimize weakness and avoid threat</td>
<td></td>
</tr>
<tr>
<td></td>
<td><strong>SW strategies:</strong> Generate strategies that use strength to mitigate weaknesses</td>
<td></td>
<td><strong>Synthesis</strong></td>
</tr>
</tbody>
</table>

Table 4.3: Principle of SWOT analysis
(Groenendijk and Dopheide 2003)

4. **Selection of alternatives strategies:** Alternative strategies are summarized from SWOT matrix and further discussed to come to final decision (synthesis) on the strategy to follow. Synthesis of strategies is followed up by an action plan for implementation.

In this research, a SWOT analyses was done to develop strategies for QMS implementation. Strengths, Opportunities, Weaknesses and Threats for RSC in setting up QMS for its ALS DTM production were identified in detail through in depth interviews using table 4.3 as a guideline. The key informants are people directly involved in pilot project, the top manager of RSC and a deputy director.
of Survey and Mapping Department of MoNRE. Their opinions were cross checked and findings were sent back to them for approval.

As shown in chapter 3, there were a number of weak points in the current quality management of RSC that have to be overcome by taking advantages of opportunities and the internal strength of RSC. Some defensive measures should be applied to avoid dangerous failures caused by combination of threats and weaknesses.

On the other hand, RSC should bring into play its strong points, such as resources, management commitments, and external support from MoNRE related to implementation of ALS DTM production, to overcome the weaknesses and threats.

Table 4.4 shows the results of SWOT analysis in quality management domain for ALS DTM production implementation in RSC. The supporting documentation from ISO for implementing ISO 9001 standards in organization, the experiences of NMAs in Europe as well as from AGI AHN were used as the guidelines for generating the strategies in the SWOT matrix. Several points appeared repeatedly as strategies in SO, WO, TO, ST, WT and SW such as quality manual development, education and training in quality, development of commitment to quality. These strategies should be mentioned with higher priority in the framework for implementation (see chapter 5).

### 4.4. Synthesis of the strategies

The results from the SWOT matrix were synthesized into 25 strategies for implementation of QMS for RSC ALS DTM production:

1. Develop business strategies, mission and vision for RSC ALS DTM production
2. Develop a comprehensive quality manual for RSC ALS DTM production based on ISO 9000 principles taking advantage of:
   - The support from RSC and MoNRE management and available financial resources
   - The cooperation and consultancy from international professional institutions with successful experiences in ALS DTM production. First by introduction of quality manual used successfully in their production
   - The experience from pilot project and in-house knowledge.
3. Fill up the gap of survey and mapping technical specifications and standards of MoNRE in this quality manual in the ALS DTM production
4. Have the quality manual legalized by MoNRE for ALS DTM production and approved as standards for ALS DTM products for Vietnam
5. Launch researches to improve ALS DTM quality in RSC beginning with extensive literature review on experiences in developed countries. Consider a possible cooperation with universities
6. Implement coming ALS DTM projects according to quality manual and maintain well documented procedures to gain the customers trust in product and accumulate experiences in order to keep ALS DTM production stable against possible personnel change and to ease the legalization of the quality manual
7. Communicate the contents of the RSC ALS DTM production quality manual with strategy, mission and vision, quality policy, quality objective of to MoNRE and potential customers to assure them about the RSC quality commitment
8. Communicate RSC ALS DTM production strategy, quality policy, quality objective quality manual throughout RSC
9. Develop criteria to evaluate the performance of ALS DTM production in each project against the set objectives. Measure it systematically and take action based on these facts for performance improvement
10. Set up a customer relation office with capable personnel to manage systematically customer relations for ALS DTM production and begin to advertise about ALS DTM product
11. Develop mechanisms for mutual benefits cooperation (“win-win” situation) in research in application development with customers to better identify their requirements and promote use ALS DTM. Begin with using financial resources from Mekong delta project to facilitate the initial application development with selected customers taking advantage of the available dataset from pilot project
12. Identify customer needs and expectations and communicate it throughout the RSC
13. Develop a mechanism to balance satisfying customers and other interested parties (such as employee, supplier, RSC management and MoNRE)
14. Develop a training program on quality to introduce a quality culture into RSC - first for management and then for all employees. This can begin with adapting the management to new quality concepts by interaction with good practices in quality management (available through RSC international relation)
15. Plan and implement an employee development program in ALS technology to build in-house expertise with all processes of ALS technology as they can not be outsourced. The pilot project dataset can be used as training dataset
16. Select the staffs directly in charge with work for technical training program
17. Improve vertical and horizontal communication between departments, employees and management for sharing vision and knowledge
18. Improve the teamwork skills of employees
19. Encourage people reporting problems and express their ideas to improve production processes
20. Create cross-functional teams for problem solving and improvement
21. Encourage employees to improve English and self-update with new technology especially in the ALS techniques and applications
22. Using the change from non-profit to profit finance for the ALS DTM production in RSC to set up new salary schema and to establish a good working environment for the ALS DTM production; to increase employee motivation and to avoid brain drain
23. Improve commend and reward schema to reflect the real employee’s contribution, encourage the high quality work to stop the brain drain
24. Plan the project long before hand, being aware of the lengthy project design approval and flight arrangement procedure. Base the project design on the developed quality manual
25. Ensure a mutually beneficial partnership with the ALS equipment supplier based on performance and not the price. Put significant focus on the details of training and after-sell services.

The synthesis of strategies derived from SWOT analysis was checked for completeness against the critical success factors in quality framework (see section 2.3.5) by the author. The results (see table 4.5) show that the 25 developed strategies have covered all the critical success factors in the developed framework to different degrees.
4.5. Conclusion

As ALS DTM technology and the principles of ISO 9000 series are new for RSC, therefore, the “desired future” for QMS for ALS DTM production in RSC was defined based on the experiences from AGI AHN. However, the conditions to implement QMS are different among organizations so the experiences from AGI AHN should be modified before these can be applied for RSC and a number of additional strategies are proposed to bridge the gaps between the current situations of QMS in RSC to reach the defined “desired future”.

The common points and the differences between RSC and AGI AHN are shown in detail in table 4.2. The largest differences are: the lacks of customer orientation, the lack of quality culture, the lack of standardized processes and employee motivation and work competence in RSC.

Technically, due to the differences in outsourcing policy and the final products, the work process model from AGI AHN needs a significant change before it can be used for production in RSC. However, the techniques and tools related to the quality control and quality improvement from AGI AHN could be used for RSC if the project conditions are the same.

How to bridge the defined gaps between the “as is” and the “to be” situation that contain both the hard and soft aspects of quality management from standardization process to development of quality culture and employee motivation? To come up with feasible strategies for implementation of QMS, the SWOT matrix was developed and the synthesis of the strategies was checked for completeness by bringing the strategies into matrix and linking them to the critical success factors from the quality management framework (based on ISO 9000:2000 principles), see table 4.5. The clear vision about the future of the production of RSC top management and the availability of resources are seen as the strong driving forces for implementing QMS in RSC ALS DTM production.
### Table 4.4: SWOT analysis for implementation QMS for RSC ALS DTM production

<table>
<thead>
<tr>
<th>Strength</th>
<th>Weakness</th>
<th>Strength / Weakness</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Strong management commitment to the production</td>
<td>• RSC has no quality policy, no quality objective and no quality manual, in general as well as for ALS DTM production</td>
<td>• Develop vision, mission, quality policy and quality objective for ALS DTM production and communicated it throughout the organization</td>
</tr>
<tr>
<td>• There is a high accuracy Geoid model and well maintained geodetic network for Vietnam in national reference system VN2000</td>
<td>• Importance related to cost and time exceeds the importance related to product quality as perceived by management and all employees</td>
<td>• Develop business strategies for ALS DTM production</td>
</tr>
<tr>
<td>• Clear quality control mechanism for all products in RSC</td>
<td>• RSC has no customer relation department as well as personnel trained professionally to deal with customer relation</td>
<td>• Build up quality manual for ALS DTM production and communicate it throughout RSC and to potential customers</td>
</tr>
<tr>
<td>• RSC has in house experts in airphoto acquisition, surveying and digital photogrammetry</td>
<td>• No effort have been done officially by RSC to identify customers, to get in touch with them and understand their needs</td>
<td>• Set up customer relation office with capable personnel to start systematic customer relation for ALS DTM production</td>
</tr>
<tr>
<td>• High accuracy DGPS equipment, hardware and software in digital photogrammetry technology are available</td>
<td>• RSC has no research and development department</td>
<td>• Develop marketing mechanisms to better identify user requirements and expectations and communicate it throughout the organization</td>
</tr>
<tr>
<td>• Staff with experience in large scale mapping, high resolution DTM production</td>
<td>• The inflexible hierarchy structure of RSC can not give quick respond to solve problems</td>
<td>• Develop mechanism to balance satisfying customers and other interested parties (such as employee, supplier, RSC management and MoNRE)</td>
</tr>
<tr>
<td>• Relatively young staff, willing to learn.</td>
<td>• RSC every year has difficulty to deliver product timely due to late approval of project design, technical problems in production and lack of detail products specification</td>
<td>• Develop training program on quality to introduce quality culture into RSC, first for management and then for all employees</td>
</tr>
<tr>
<td>• Internet connection is available for all employees in RSC</td>
<td>• There are no criteria to evaluate performance of mapping and surveying projects in RSC. No appraisal meeting is conducted to draw lessons from these projects for improvement</td>
<td>• Develop training program on ALS technology to assure the employee’s work competence for all production processes. The pilot project dataset can be used for practice</td>
</tr>
<tr>
<td>• Top and middle management accept quality responsibility</td>
<td>• Horizontal communication and cooperation between departments are sluggish due to bureaucratic nature of organization and lacking of shared vision</td>
<td>• Make sure to train the staffs who directly in charge with work</td>
</tr>
<tr>
<td></td>
<td>• The bottom up communication in RSC is not always effective.</td>
<td>• Set up research and development department with focus on ALS technology and develop tools for accuracy improvement and quality control</td>
</tr>
<tr>
<td></td>
<td>• Commend and reward schema has formalistic characteristic and become counter-productive</td>
<td>• Improve commend, reward schema to reflect the real employee’s contribution and to encourage the high quality work</td>
</tr>
<tr>
<td></td>
<td>• Employee motivation are low concerning income and working environment</td>
<td></td>
</tr>
</tbody>
</table>
Table 4.5: SWOT analysis (continue 1)

<table>
<thead>
<tr>
<th><strong>Strength</strong></th>
<th><strong>Weakness</strong></th>
<th><strong>Strength / Weakness</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>• RSC has good international cooperation with GI institutions and organizations, which ready to share experiences</td>
<td>• General reporting and quality reporting have formalistic characteristic</td>
<td>• Improve salary schema to increase employee motivation</td>
</tr>
<tr>
<td>• Related departments are involved in project design review</td>
<td>• Operators are passive, they do not participate in quality decision neither in continuous improvement</td>
<td>• Improve vertical and horizontal communication between departments, employees and management</td>
</tr>
<tr>
<td>• RSC has the first experience and hand on real ALS dataset</td>
<td>• Lack of effective training and employee development program that meet the need of organization</td>
<td>• Improve the teamwork skill of employees</td>
</tr>
<tr>
<td>• RSC employees are eager to get experience on ALS DTM technology through pilot project</td>
<td>• Participants selected for trainings are not always the one, directly in charge with work. It reduces the benefit from training for organization.</td>
<td>• Encourage people reporting problem and express their ideas for process improvement</td>
</tr>
<tr>
<td>• RSC have good cooperation with Air-service company for decades in airphoto acquisition.</td>
<td>• Employee limitation in English slowdown the self-update in technology</td>
<td>• Create cross-functional teams for problem solving and improvement</td>
</tr>
<tr>
<td></td>
<td>• Employees are specialized in one process, they do not have multi-skills</td>
<td>• Develop criteria to measure performance of ALS DTM production systematically and take action based on these facts for performance improvement</td>
</tr>
<tr>
<td></td>
<td>• In RSC as well as in MoNRE there are little experiences in dealing with ALS equipment, software, data</td>
<td>• Encourage employee to improve English and self-update though Internet focusing on the ALS technology and applications.</td>
</tr>
</tbody>
</table>

- Pilot project have poor reporting from the contractor
- The frequent personnel change in middle and top level of management in RSC may influence continuity in commitment of management.
Table 4.6: SWOT analysis (continue 2)

<table>
<thead>
<tr>
<th>Opportunities</th>
<th>Strength/ Opportunity</th>
<th>Weakness / Opportunity</th>
</tr>
</thead>
<tbody>
<tr>
<td>· Support by MoNRE policy in modernization for survey and mapping technology</td>
<td>· Speed up the ALS deployment taking advantage of current support by MoNRE; available resources: financial, human, supporting data; good cooperation with air-service company</td>
<td>· Develop clear strategy, quality policy, quality objective for RSC ALS DTM production and convey them to MoNRE and potential customers to assure them about RSC quality commitment</td>
</tr>
<tr>
<td>· Available financial resources for ASL deployment in alignment with Mekong delta project</td>
<td>· Develop business strategy, specific goal and objective for ALS DTM production with customer orientation direction</td>
<td>· Launch researches to improve ALS DTM quality and develop quality control techniques in RSC begin with extensive review on experiences from international pioneering organization in ALS technology. Consider the possible cooperation with universities</td>
</tr>
<tr>
<td>· Shifting from non-profit finance into profit finance for ALS DTM production. It enables funding for activities required for success of the production</td>
<td>· Introduce proved quality plan and technical specification from professional organization to apply and test in other ALS projects</td>
<td>· Start changing the quality culture of organization toward new quality concept</td>
</tr>
<tr>
<td>· New data acquisition tools emerged using the latest technologies open new fields of application</td>
<td>· Using support from international cooperation step by step to develop comprehensive quality manual for ALS DTM production for RSC</td>
<td>· Adopt customer focus approach for ALS DTM production</td>
</tr>
<tr>
<td>· Customer growing need of digital high accuracy / large scale data /DTM that so far acquired by slow and expensive field survey technique</td>
<td>· Initiate cross-organization cooperation to develop application of ALS DTM by using the available dataset of Cantho pilot project in alignment with objective of Mekong delta project</td>
<td>· Set up customer department with capable personnel to start systematic customer relation for ALS DTM production</td>
</tr>
<tr>
<td>· Customer’s capacity in term of technology has been improved rapidly</td>
<td>· Adapt the management to new quality management concept by interaction with good practice using international relation</td>
<td>· Develop mechanisms for mutual benefit cooperation with customers to better identify their requirements and promote use ALS DTM</td>
</tr>
<tr>
<td>· Some users in private sectors already have experience working with ALS data with their foreign counterparts</td>
<td>· Using the change from non-profit to profit finance in RSC to create funding mechanism for training, education and research development.</td>
<td>· Set up new salary schema for ALS DTM production for MoNRE and for all potential users to follow</td>
</tr>
<tr>
<td>· All users follow technical regulations and standards of MoNRE for mapping and surveying products</td>
<td>· Set up the standard for high resolution DTM product for MoNRE and for all potential users to follow</td>
<td>· Ensure a mutually beneficial partnership with ALS equipment supplier based on performance not the price. Put significant focus on the details of training and after-sell services.</td>
</tr>
<tr>
<td>· Increasing trend of cooperation cross-organization</td>
<td></td>
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</tr>
<tr>
<td>· ALS technology has been deployed extensively for last decade in developed countries, comprehensive quality plan and technical specification and quality improvement techniques were developed and tested successfully in their projects</td>
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<tr>
<td>· New rule allowing adopting technical specification from proved professional authority for special projects</td>
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<tr>
<td>· ALS equipment suppliers are eager to introduce their product for the first time into Vietnam especially in the mapping authority like RSC, MoNRE.</td>
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</table>
### Table 4.7: SWOT analysis (continue 3)

<table>
<thead>
<tr>
<th>Threat</th>
<th>Strength / Threat</th>
<th>Weakness / Threat</th>
</tr>
</thead>
</table>
| • Lengthy project design approval through Survey and Mapping Department due to the lack of comprehensive legal technical specification in MoNRE  
• Stricter regulation / and longer procedure to get flight permission from Ministry of defense for ALS project compare to traditional airphoto acquisition  
• Brain drain of skilled staff to private sector/NGO/other organization with higher income  
• Frequent personnel change in middle and top level of management in RSC and MoNRE  
• Decreasing budget for ALS deployment when Mekong delta project finishing in 2008  
• Customers are not aware of possibility of ALS technology  
• Customers do not have clear requirements on high accuracy DTM  
• Low user’s confidence about data quality from public sector  
• ALS DTM production is combination of different latest technologies that not understand or practiced by most of customers. In most of the case, they do not have means to check the product quality  
• Small budget available from potential users for developing applications using ALS data  
• Technical specifications of MoNRE are not comprehensive/up-to-date with technology in survey and mapping. It leaves room for argument in production  
• Outsourcing culture is not commonly accepted in MoNRE  
• The private surveying are not reliable in term of quality, they do not follow strictly the technical regulations. | • Develop detail quality manual by putting together in house knowledge and first experience of pilot project and cooperation with supplier  
• Update technical specification for survey activity related ground survey measurement in ALS DTM production and get it legalized  
• Implement the project according to quality plan to gain the customer trust in ALS product  
• Plan training for employee to build in house expertise with all processes of ALS technology as they can not be outsourced  
• Establish good working environment for ALS DTM production to prevent brain drain experienced employees  
• Take advantage of current support and management commitment to obtain resources needed for education and training; quality manual development; cooperation with customers in application development. | • Plan the project long before hand, being aware of the lengthy project design approval and flight arrangement procedure. Based the project design on the developed quality manual  
• Select the staffs directly in charge with work for training; improve commend and reward schema to reflect the real employee’s contribution, encourage the high quality work to limit the brain drain of good employee  
• Develop quality manual and maintain well documented procedures to keep stable ALS DTM production against possible personnel change  
• Convey organization strategy, quality policy, quality objective of ALS DTM production together with quality plan to potential customers to assure them about RSC quality commitment. |

### Threat / Opportunity

- Using financial resource available from Mekong delta project to facilitate the initial cooperation in application development with selected customer. It can begin with the Cantho municipality using the pilot projects dataset.
- Develop quality manual based on successful practices and set up standard for ALS DTM products. Then have it approved by MoNRE as regulation for ALS DTM production and standards for ALS DTM products in Vietnam.
### Table 4.8: Critical success factors matrix

<table>
<thead>
<tr>
<th>Customer focus</th>
<th>Leadership</th>
<th>Involvement of people</th>
<th>Process approach</th>
<th>System approach to management</th>
<th>Continual improvement</th>
<th>Factual decision making</th>
<th>Mutually beneficial supplier relationships</th>
<th>Σ</th>
</tr>
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<tbody>
<tr>
<td>S 1.1</td>
<td>1.2</td>
<td>1.3</td>
<td>1.4</td>
<td>1.5</td>
<td>2.1</td>
<td>2.2</td>
<td>2.3</td>
<td>2.4</td>
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The first column shows the number correspondent to the strategies synthesized in section 4.4.
The second row shows the number of the critical success factors based on quality management framework under the eight ISO 9000 principles (see section 2.3.5).
5. Framework for implementing QMS for ALS DTM production in RSC, MoNRE

Implementing a QMS is not a simple process. It concerns every component of an organization, and is closely related to each of the production processes. It implies changes, and in an organization like RSC, most people are resistant to change. In particular, it means more work in the short term just to get started (Cerco 2000). In the case of the RSC ALS DTM production, the starting points for implementation the QMS are even more difficult compared to other NMAs. Because it is necessary to change the quality culture in organization, and the comprehensive standards of common survey and mapping activities are not yet in place.

This chapter will propose a framework to implement a QMS for the RSC ALS DTM production, based on the synthesis of strategies from the SWOT matrix (see section 4.4). The activities are grouped in four main focus points: the organizational structure and working mechanism, the quality manual with the technical process model, human resources and quality culture development.

(Shadur 1995) has outlined two different approaches to quality management. The standards-based approach is the hard approach that should be first implemented in the production process. The culture-based approach is more fragile and difficult to implement, especially for NMA, but it will provide efficient support for the standards-based system to ensure the long term success of the business. Both approaches contain elements which are considered to be relevant to RSC ALS DTM production.

For the RSC ALS DTM production, besides getting the equipments in place, the quality manual is the first document that needs to be developed. This will put strong grounds for all production processes in the standards-based approach, and at the same time give guidelines to introduce a quality culture into the production.

The RSC has several missions, and ALS DTM production will be just one of the production lines that have been established in the RSC. However, in this case, the QMS and its components that the author of this document proposes will fit inside the structure of ALS DTM production and will be focusing only on the needs of ALS DTM production, apart from other productions.

The issues like: tender and purchasing, recruitment, pricing and copyright are not included in this framework, but they are closely related to the quality management and they need appropriate attention.

5.1. Initiate the QMS implementation for the RSC ALS DTM production

According to experience introducing QMS into NMAs, it is a long process involving investments and resources and concerning all the components of an organization (Cerco 2000). It is a strategic decision for RSC ALS DTM production that the top manager of RSC has to be convinced to make. To initiate the awareness of the needs of QMS in the production, the findings from this thesis can be introduced to the top and middle managers of RSC in a seminar follow by a discussion about its business advantages (see section 2.3.4) for RSC ALS DTM production. After that, to further develop the top management commitment to the implementation of QMS, RSC management can:
• Visit to a “Sister” organizations that have implemented a QMS according to ISO 9000 principles for 3 to 5 years for similar high-tech production
• Discuss the benefits of implementing a QMS from the professional point of view as a proof of the quality of the ALS DTM product, which is an aspect that customers have difficulty to check systematically due to the complexity of the acquisition technology
• Discuss the risk of failure in production without proper quality management, and the associated costs: financial and political.

Once the management endorsed the principles, a broad implementation plan with a business case showing milestones, required resources, costs, benefits and possible savings over 3-5 years is proposed to be prepared. Based on that, the RSC management can make the final decision to go for the QMS implementation for RSC ALS DTM production.

When top management of RSC is committed to the implementation of QMS, the next step in implementation is to get a quality manager in place and to work out a detailed implementation plan for both the production and the QMS. A taskforce need to be assigned for the activities in this transition period when QMS is introduced in to the production. Of course this has to be formalised by the top manager and to be communicated throughout RSC.

The milestones in the QMS implementation plan are:
• Assign task force for QMS implementation
• Set up an organizational structure centered on quality for ALS DTM production
• Develop and legalize a quality manual
• Educate and train human resources
• Develop a quality culture in the organization.

These steps will be worked out into more details in the next sections.

5.2. Organizational structure and working mechanism

There are many successful cases and the AGI AHN is an example, of a flat organizational structure that applies self-managed groups that can function efficiently, without frequent involvement of management in day to day decisions. With a simple flat structure, the organization is more flexible, so that it can promptly respond to customer needs and solve problems that occur during production (Heller 2002). It also reduces the cost for several middle layers in the organizational structure. Furthermore, an ALS DTM is not a rigid product. Its specifications may greatly vary, and technological complexity of the production also requires a high flexibility in the organizational structure. A flattened structure is also efficient in reducing production costs, which is an important issue when the RSC ALS DTM has the “profit finance” status.

The classic organization with a pyramidal structure establishes a hard boundary between the “inside” and the “outside” world. It focuses only “inside the organization”. The customer, the reason for the organization’s existence is excluded. Moreover, this boundary also limits the possibilities to learn from the outside world. A dynamic learning organization with a blurred boundary and a flattened inverted pyramid structure with the customer firmly on top, shows many advantages in the changing environment and rapid technology development era (Heller 2002).
Figure 5.1 shows the proposed organizational structure for ALS DTM production for RSC. It consists of four units that cover all the core competencies of a quality organization (see section 2.3.2 and figure 2.5).

In the management unit, the executive manager of the production at the same time will play role of the quality manager. Together with top manager of RSC, (s)he has to develop a strategic business plan for RSC ALS DTM production. This arrangement will assure the alignment between the business objectives and the quality objectives of the production as well as the implementation of QMS in parallel with the production line. A secretary/assistant is needed to assist the manager. A financial manager is in charge with financial management of the production.

The customer relation office is responsible for setting up and managing customer relations systematically. The technical management unit is on one hand responsible for planning and quality control of the production, and on the other hand in charge of cooperation with customers in application development. The customer relation office and the technical management together with customers will create a triangle needed to promote the ALS DTM product as well as to push up the development of its applications. This development is critical for long term success of the production in this case, as the applications of ALS DTM products are still limited in the customer’s domain. This triangle will blur the boundary between the organization and the customers.

Beside the involvement in the production, the technical management unit is also responsible for research activities to develop or adapt techniques for accuracy improvement and quality control for RSC ALS DTM production.

Experience from the literature review shows that although ALS was used for DTM production for a long time, there is little literature available in the public domain that goes into details about the
production process and the quality procedure, or a quality manual. To implement the ALS DTM production and the QMS in short time, the RSC would greatly benefit from external consultants with expertise in ALS production, developing quality manuals, developing applications etc. Following the model of the “learning organization” (Heller 2002), the RSC ALS DTM production boundary needs to be opened for consultancy or cooperation from the outside world in order to learn from experienced international partners.

The production unit carries out three main tasks: field survey, acquisition flight and data post-processing, based on the project plan prepared by the technical management unit. The final data will be checked by the technical management unit before being delivered to the customers.

For projects coming from the MoNRE, the final product, after being approved by technical management unit, will have to follow the general quality control procedure of the MoNRE. The legalized quality manual and well documented production processes will streamline, and speed up this process.

Last but not least is managing the finances of the production. It should take advantage of the current support of the RSC and MoNRE management, of the available resources from the Mekong delta project and of the “profit finance” status of the RSC ALS DTM production to finance the activities needed to implement and maintain the production as well as the QMS, namely:

- Develop quality manual
- Tailor-made education and training
- Research and development within the RSC ALS DTM production
- Cooperation with customer in application development
- External consultancy
- Establish an encouraging salary and reward schema
- Establish good working conditions.

However, this compact structure of the organization requires competent and motivated human resources with multiple skills and highly committed to the quality. A function matrix needs to be developed in the production implementation plan. It should describe the details required for each working position: the responsibilities, knowledge, and competence. An employee development plan will be developed based on this function matrix.

5.3. Develop quality manual for RSC ALS DTM production

The quality manual is the most important document supporting QMS in a quality organization (see section 2.3.4). It is also the first document required when an organization wants to register for the ISO 9001:2000 certificate. It should be written in clear and simple way. There are two steps related to quality manual: developing the quality manual (including decision making on implementation) and living the quality manual.

Developing quality manual contains the following steps:

- Develop manual structure
- Assemble existing materials
- Document the procedures
- Develop work instructions.
For RSC, the development of a quality manual for ALS DTM production is a crucial task as the technology is new to the organization and there is no in-house expertise yet. Existing technical documentation is outdated and leads to problems in production (see Section 3.2.2). To achieve the development of a quality manual in short time, there should be efficient cooperation between the ALS hardware suppliers and RSC production team in charge. In purchasing, the detail of training and after sale service and maintenance are important issues in agreement to reach for long term win-win situation.

During the quality manual development, the RSC may need external consultants who have been involved in developing and living the quality manual in organizations with long experience in ALS technology (such as AGI AHN). When the first version of the quality manual is ready, RSC is recommended to get critical review - the “second opinion” from other experienced organizations to finalize it.

A quality manual is a living document in a production environment. After development, the quality manual for the RSC ALS DTM production should be put in use. It needs to be communicated through the production, understood by all, and used consistently in the next acquisition projects. From the quality manual user’s (employees) opinions, the quality manual needs to be reviewed by key people in the production and made more practical and convenient, complete and accurate.

The legalization of the technical parts of quality manual by MoNRE is a milestone in the implementation phase of QMS. It will streamline the quality control procedure of the MonRE for the production and speed up the project life cycle. The well documented processes in each RSC ALS project during the period quality manual improvement will ease the quality manual legalization process.

The quality manual for RSC ALS DTM production is proposed to follow structure recommended by (Paresi 2006):

- Quality policy
- Quality system
- Quality organization
- Quality procedures (work processes)
- Quality work instructions
- Quality reports
- Quality manual update.

For the purpose of the thesis, the quality policy and work process model will be developed in detail based on the experience of NMA, quality plan from AGI AHN and the pilot project at RSC.

### 5.4. Quality policy for ALS DTM production

The vision of RSC top manager for the ALS DTM production can be stated as follows:

**Vision statement:**

*Excellence in providing high resolution DTM by ALS technology in Vietnam and South East Asia region.*

To reach the vision, in the situation of the RSC, there are two main points that ALS DTM production should target: customer satisfaction and efficiency of the production processes that optimize the resources and ensure survival of the production in the long term.
Mission statement:

To meet the customer requirements for high resolution DTM using ALS technology, and to do so at lowest possible costs.

Quality policy:

A policy is basically a rule of the house set up by top management. Quality policy is the first point in quality manual that should be identified and reviewed periodically by the management. For RSC ALS DTM production, the proposed quality policy statement should directly address the main principles of quality management (Schlickman 2003) and as proof of commitment to quality, it is necessary to mention the accountability on product quality. Here is the proposed Quality Policy Statement for RSC ALS DTM production (adopted from (Schlickman 2003)):

The business of quality

RSC ALS DTM is committed to total customer satisfaction.

To meet this commitment, we cooperate with our customers to develop high resolution DTM applications to support customer's goals and to provide products and services that fulfill customer expectations.

Our quality management system is based on the principles of ISO 9001:2000, and we are fully committed to continually improve the effectiveness of our system by means of constant top management review and oversight. It is complemented by formal management reviews, internal audits, extensive training, and an aggressive corrective and preventive action program that includes cross-functional teams for root-cause analysis and problem resolution.

To ensure the integrity of our system, quantitative quality objectives based are established, monitored, measured, and reviewed by managers periodically. On behalf of RSC, they hold accountability on our products quality.

In addition, all of our employees are thoroughly trained and motivated in quality management methods and are supplied with the resources required to ensure that such methods are effective.

At RSC ALS DTM, business objectives and quality objectives are synonymous.
5.5. Production process model

The process model is the skeleton of the production. Based on the experience from AGI AHN (see appendix A.8) and the pilot project in RSC (see appendix A.5), the following process model is proposed (see figure 5.2). In AGI AHN, the customers are interested in both the DSM and the DTM products so the production workflow divided into two parallel main tasks. One of them produces a 3D point cloud represent the DSM and the other produces the filtered mass points representing DTM.

Figure 5.2: Proposed production process model for RSC ALS DTM
In the RSC pilot project, according to the report of RSC project team (see appendix A.5) first the recoded laser points was processed to get the 3D point cloud in the required referenced system and then filtering was conducted.

The future RSC ALS DTM production is targeting at DTM product thus the adopted workflow from AGI AHN can be modified to be used in RSC. After the acquisition, geometric post-processing and accuracy improvement of 3D mass points is done first. After the geometric accuracy of 3D mass points is checked and accepted, it will be filtered to get the DTM, the final products.

The quality control is designed for each step in the workflow with a feedback loop as (Luethy and Ingensand 2003) suggested. If the output of the previous process is not accepted in the quality control, it has to come back again for improvement until it meets the requirements stipulated for each quality check point. The quality control for intermediate products will be conducted mainly by the staff in the production unit. The final product will be checked by the technical management unit. After that, the product is ready to be delivered to customer or to follow the quality control procedure of MoNRE if the project is assigned by MoNRE (see section 3.2.1). In case, the production process and its quality control are carried out by the same unit, these two tasks should be assigned to different teams or individuals.

For ALS DTM production, the reporting is important. Each process in each project has to be well documented and the quality check will begin with checking the process report before checking the process outputs. Proper reporting will speed up the quality control and quality audit process and as well make the production process transparent for the customers.

5.6. Education and training

Human resources training and development follows three steps (Heller 2002):

1. Assessing the training needs

   The function matrix shows the detailed requirements for human resources. The next question for RSC is which of the required knowledge and skills for the intended position does the individual have and which are still missing. The training and education program need to be developed to fill up these gaps.

2. Choose the training methods

   There are different training methods which have its own advantages and disadvantages.
   - On job training
   - In house training
   - External training
   - Self-learning.

   Which method to chose depends on a number of factors: How many people need training; the skill or knowledge required and the level to be attained; how urgent is the training need; and what is the available budget for training.

3. Evaluation and follow up

   After each training, there is a need to carry out some kind of evaluation with trainees to see whether the desired improvement has been achieved. This will give guidance for decision about the follow up action and other future training.
From the strategies synthesized in the SWOT matrix (see section 4.4), to implement QMS for RSC ALS DTM production the education and training program should aim at two main targets:

- **The training in the ALS technology** to ensure that employees are competent to carry out the assigned works in the production
- **The education on quality concepts** to ensure that all the people in RSC ALS DTM production understand quality concepts of ISO 9000 series and are committed to the implementation of QMS in the production.

1. **The training in the ALS technology**
   This training should be conducted in cooperation with the equipment supplier. The content of the training program should be discussed already in the purchasing phase as well as the details about maintenance and update. An On-the-job or In-house training is most likely suitable for this. External training methods can be considered for a few key people in the period of quality manual development.

2. **The education on quality concepts**
   RSC ALS DTM production is inheriting the lack of a quality culture in the general in RSC (see section 4.2) so the quality concepts of ISO 9000 series should be introduced to everybody involved in the organization.

   The introduction of a QMS is more complex than, say, the introduction of a new production line (Cerco 2000). It is the introduction of principles of continuous improvement and customer focus which enables the whole organization to break through old patterns and create new ones. Education and training are significant stimulating factors for changing an organization’s culture and achieving the benefits of a QMS.

   The quality manager and quality trainer can be trained first and then they can reproduce the course and train the rest of the staff. The quality trainer can be the key person in each unit in the production. The quality manager and trainer can be sent to take an external training course. This is also an opportunity to meet quality managers from other organizations and to visit other sites where QMS already implemented.

   Beside this, it is good idea to invite all the staff to a one-day in-house training for quality and in the end of the day, the top management of RSC and the manager of ALS DTM production can express the commitment to the new quality concepts as well as the implementation of QMS into the production.

   The training program can be developed consulting the list of the common courses related to QMS (see appendix A.9).

5.7. **Developing employee motivation and commitment to quality**
A motivated employee is energetic and enthusiastic. Such an individual performs consistently well, actively seeks for greater responsibility and is not afraid for change (Heller 2002). The motivation of the staff in ASL DTM production and their commitment to the quality of work is crucial factor for the success of its implementation.

People involved in topographic map production have the following opinion (see section 3.3): income is low and government salary schema is discouraging; the commend and reward schema is
formalistic; the working conditions are bad and deadline-time pressure is high. These are the main reasons for employee’s demotivation. This has a great negative impact on the quality performance of the organization. With the new possibility for change in financial as well as organization management, RSC ALS DTM production can take measures to motivate its employees.

According to Herzberg’s theory (Heller 2002), these measures should focus on both the “hygiene factors” and the “motivators”.

Here are the measures proposed to improve the “hygiene factors”, they aim to avoid the dissatisfaction of the employees:

- Develop a salary and benefit schema that cover the needs of employees and encourage their contributions with focus on the work quality
- Improve working conditions for employees in the production. Arrange an ergonomic working place, and necessary facilities and equipments
- People who are confident in their job will be more satisfied than those who feel overloaded so the employees needed to be trained to have the skills that match the work requirements
- The executive manager of the production needs to review and to re-assess the work load where necessary and to use training to improve ability.

To improve the “motivation factors” the following activities are proposed:

- Give employees clear responsibilities but at the same time give them as much as possible freedom in how they carry out their tasks
- Make employees understand the importance of their role and quality of their work for the success of the organization
- Improve the current commend and reward schema to reflect the real contribution of individual and their work quality. It can be used as an efficient tool for individual’s achievement recognition. The non-monetary reward such as: positive feedback, increasing responsibility in recognition of ability, taking an active interest in the individual’s career or giving them the opportunities for development is an effective motivator too.

The employee commitment to the quality is one of indicators of quality culture in the organisation. As a culture, it largely depends on the education and communication in the organisation. Education can help to develop employee’s awareness and good communication will create a shared-vision of the quality organisation that the employee can absorb. The commitment to quality will develop gradually. These issues are addressed in section 5.6 and 5.9. On the other hand, the employee’s commitment to quality is closely related to motivation. If emphasis is put on the work quality aspects when taking measures to improve the employee’s motivation it will practically increase the employee’s commitment to quality too.

5.8. Develop a performance management system

A factual approach and continuous improvement are important principles of management of a quality organization. A performance management system is the tool to support these principles. It also follows of the “Plan-Do-Check-Act” circle where first the goal is set, and then people are supported by organization to reach the set goals, the achievements are regularly reviewed in appraisal meeting. In the end, based on the findings from appraisals, the manager and the individual will plan training
and development or revisit the goals that have set. The performance management system provides reliable information to take action and to improve the employee’s motivation and assure fairness within the organization.

It is important to make sure that the individual’s goals and objectives are aligned with the ones of working team and of the organization. If employees take part in defining the goals and objectives they will be more satisfied when they achieve them.

For the RSC ALS DTM production, the appraisal meeting in project-bases also helps to identify the problems and find out the improvement solutions.

5.9. Establishing a communication system

Communication is a two way process which is considered as an integral part of an organization. It is the responsibility of the management to set up the communication system. It needs to contain both the internal and external communication channels.

1. The internal communication

Inside the organization, communication is a key factor for efficiency and success of all the processes. For RSC ALS DTM production, it is an important tool for the quality culture development especially in the period of implementation of QMS.

The organization must be as transparent as possible and information must be visible and for whom may need it. To ensure commitment to quality and to remove possible barriers in both implementations of production and of QMS there should be a good communication about:

- The business strategy, the quality policy and quality objective
- The product requirements
- The technical specifications and standards
- The work progress
- The financial situation
- Performance improvement.

If the people involved in the production are kept fully informed on these issues, both organization efficiency and employee satisfaction will increase. After the quality manual has been developed it should be well communicated to all staffs and then put into use. A quality manual is a living document so it also needs to be reviewed and updated based on the communication-feedback from its users.

For internal communication, the conventional means of communication like interactive meetings, workshops, seminars, bulletins, newsletters can be used. Taking advantage of the good IT infrastructure of RSC, the use of organization website and intranet are more convenient tools for RSC ALS DTM production, especially to communicate non-static information such as the work progress or updating technical work details.

The proposed flat and compact organizational structure of RSC ALS DTM production significantly simplifies the vertical communication within the production. However, the management still needs to support a good horizontal communication between the four units (see section 5.2) and between the operators which will encourage the sharing of knowledge and opinions. This helps operators to gain the working competence speedy and gives clues for process improvement.
2. The external communication

Communication with customer is an important component in the customer relation management. Besides the cooperation with customer in research and application development (see section 5.2), it is necessary to make organization activities transparent to the customer. For newly established RSC ALS DTM production, the quality manual that contains of all the main points describing the way organization carries out its work, should be well communicated to customer to gain customer’s trust.

Other objectives of communication with customers are:
- To identify the customer requirements
- To find out information to improve product quality and customer satisfaction
- To handle customer complaints efficiently.

The communication with the external organizations and professionals to share experiences with ALS technology and QMS implementation also needs to be established and maintained. Sending the key staff to participate in relevant international conferences also increases the knowledge exchange with outside world.

5.10. Conclusion

In this chapter a framework for implementing QMS for the specific case of RSC ALS DTM production was proposed based on the result of SWOT analysis, the experience of NMAs and the general organization management rules. The main points are:
- Initiate the QMS implementation
- Propose a suitable organizational structure and its working mechanism
- The guideline to develop a quality manual where the quality policy and the technical production process model are developed in detail
- Education and training
- Develop employee motivation and commitment to quality
- Develop a performance management system
- Establish a communication system.

These should be developed in more detail into a proper implementation plan being aware of the high correlation and interaction between these components. The implementation plan of QMS for ALS DTM production has to fit well with the production implementation plan.
6. Conclusions and recommendations

This study identified a list of problems which RSC is facing while setting up the ALS DTM production. Required activities have been undertaken for successful completion of the research and achievement of the research objectives.

This chapter presents the conclusions and recommendations. Section 6.1 presents the conclusions and the outcomes that have been achieved and section 6.2 gives recommendations for RSC in the implementation QMS and suggests areas for further research.

6.1. Conclusions

The objective of this research is: Develop a framework for implementing a quality management system for ALS DTM production for RSC, MoNRE.

The objective was achieved by answering the research questions. The conclusions are structured in line with the six research questions as stipulated in chapter 1 of this thesis.

Research question No 1: What are the requirements of a quality management system for an organization?

The quality concept has changed a lot during the last decades from product focus to process focus. The quality management also developed from quality control to quality assurance and then to TQM. From late eighties, researchers recommended different key factors of TQM but ISO 9000:2000 series has combined these into eight fundamental principles for QMS in a modern organization. This is used and accepted widely by the product and the service provider as well as the customer. The eight ISO 9000:2000 principles, (each is reflected in a number of indicators), are proposed as a quality management framework. It can be used for assessing the current QMS or planning the implementation of QMS for an organization.

Research question No 2: What are the experiences related to introducing/using a quality management system in NMAs in Europe?

Many NMAs began implementing QMS in nineties. Most of them adopted the ISO 9000 standards as reference and considered registering for ISO 9001 later if the business increasingly requires the certificate. It is more efficient not to implement QMS for the whole organization at once but to choose one department as pilot and to put efforts to show the benefits for that department. It will be convincing evidence to decide to enlarge QMS to the whole organization.

Implementing QMS for NMAs is more difficult than for other organizations due to their specific characteristics. The CERCO handbook pointed out the risks that an organization will be facing when first implementing the QMS, mainly related to the employee resistance to change and to the problem of investment in QMS without direct visible benefit. Practical guidelines are given to overcome these risks focusing in the following key factors: top management commitment; good communication that
encourages people involvement and continuous improvement; introduction for efficient monitoring system that allows identifying the bottlenecks; staff development program and the development of supporting documentation.

**Research question No 3: What are the experiences in quality management of the ALS projects in AGI AHN?**

AGI AHN has been doing ALS projects since 1996. Quality management experiences from AGI AHN are a successful practice that also adopted principles of ISO 9000 family. It is characterized by:

- Clear vision and quality culture is well spread throughout the organization
- Strong outsourcing policy, focusing on long term mutual beneficial relationships with contractors
- Knowledgeable customers groups with clear products requirements
- Flat organizational structure with good support by AGI research activities
- Good working condition
- Motivated human resources, competent to the work.

Technically, the quality plan and technical specifications and techniques for accuracy improvement have been improved several times and used sufficiently in a large number of projects. This quality plan of AGI AHN covers all the procedural part of the quality manual for an ALS production. These experiences can be used as benchmarking for similar projects.

However, the documents about AGI AHN activities are mainly in Dutch and some of them are not in the public domain. These have been obstacles for the research to extract more information from AGI AHN experience and documentation that would be valuable as benchmark for RSC ALS DTM production.

**Research question No 4: What are the bottlenecks in current RSC, MoNRE quality management system?**

The quality management framework based on ISO principles was used to assess the current quality management in RSC. The interviews were conducted with the key staffs involved in topographic map production and ALS DTM pilot project. The developed fishbone diagram reveals the critical points that need improvement as follows:

- Customer orientation
- Management commitment to quality
- Organization
- Standardization of processes and legalization of technical document for quality control process; development of a quality manual (which is currently lacking)
- Quality culture of the organization
- Employee motivation and working competency
- Communication within organization.

The experience from the pilot project again stresses the need for improvement in processes standardization and employee’s competence dealing with ALS technology.

These points needed special consideration while RSC begin the ALS DTM production and implementing the QMS for it.
**Research question No 5:** What are the similarities and differences of the conditions for ALS production between AGI AHN and RSC? What is the “desired future” of QMS for RSC ALS DTM production?

The environments to run ALS production are not identical in AGI AHN and RSC organizations. The main differences are the lack of customer orientation, the lack of quality culture, the lack of standardized processes and employee motivation and work competence in RSC. RSC needs to implement the QMS to ensure the success of the production in the changing environment.

The desired future for QMS for RSC ALS DTM production was formulated following the principles of ISO 9000:2000 series and using the experiences from AGI AHN as benchmark. It covers all the issues which have been identified as bottlenecks related to QMS in RSC ALS DTM production.

Technically, due to the difference in outsourcing policy and the final products, the work process model from quality plan of AGI AHN needs adaptation before it can be used for production in RSC. However, the techniques and tools related to the quality control and quality improvement from AGI AHN can be tested then used for RSC if the project conditions are the same.

**Research question No 6:** What is the framework for implementing QMS for ALS DTM production at the RSC?

To bridge the gaps between the defined “as is” and the “to be” situation in QMS for ALS DTM production, a SWOT analysis was used to identify suitable strategies for implementing QMS for RSC ALS DTM production. The Strengths, Weaknesses, Opportunities and Threats were identified by the key informants in MoNRE and RSC. The synthesis of the strategies was checked on completeness again the critical success factors based on the developed quality framework with the eight main principles of ISO 9000:2000 standards.

The SWOT matrix shows that, the clear vision of the top management of RSC on the future of the production and the availability of resources are the strong driving forces for implementing QMS in RSC ALS DTM production. The change to the profit-finance status of RSC ALS DTM production will be provide resources to update and maintain the QMS after it has been established.

The framework for implementing QMS for RSC ALS DTM production was proposed based on the developed strategies. It consists of eight main points:

- Initiate the QMS implementation
- Propose a suitable organizational structure and its working mechanism
- Develop guidelines for develop quality manual where the quality policy and the technical production process model are developed in detail
- Education and training
- Develop employee motivation and commitment to quality
- Develop a performance management system
- Establish a communication system.
6.2. Recommendations

Some recommendations are drawn from this study for implementation in the organization and future researches are proposed:

Recommendations for RSC

- Recommend RSC to implement QMS for the ALS DTM production following the proposed framework in the chapter 5. It is a learning process for RSC and for ALS DTM production thus during the QMS implementation, the progress and effects of activity need to be reviewed frequently and the framework and the implementation plan need to be fine-tuned.

- Due to time limits, this research just focuses on the analysis of the current situation and development of the framework for implementation of QMS for RSC ALS DTM production in the technical and the quality culture aspects. The issues of resources management; cost management, pricing and copyright that influence on the production quality and customer satisfaction also need to be addressed.

- In this research, the user requirements study regarding the high resolution DTM just covers a limited number of organizations due to time limits and the available contacts. In the implementation phase, the customer relation office should conduct wider investigation with potential users to better identify the user current and future needs and concerns and improves the strategy toward customers.

- The finding about the bottlenecks in RSC topographic map production in this research, after being refined, could be used for developing QMS for topographic map production for RSC.

- The CSF checking was conducted by only the author therefore the result may be subjective and conclusion can be drawn about the completeness of the proposed strategies. RSC is recommended to conduct CSF check again by number of participants with NMA management experience. Then strategies can be cluster by importance for better strategic plan.

Recommendations for future research

The thesis has illustrated several fields where further research is recommended:

- In developing countries, the customer’s capacity is often limited when it is about discovering the new possibilities that technology brings. In these cases, NMA’s new production is more policy and technology driven than market driven and user requirements are difficult to identify. Further research is recommended to develop model for customer management in these situations that can accelerate the application of technology and to generate win-win solution for NMA, customer and society.

- Based on the finding of this thesis, further research is recommended to develop a common framework for QMS implementation for other NMA in the developing countries who want to bring a new technology into the production.
References


Paresi (2006). "Lecture handout on TQM."


Appendices

Appendix A. 1: MoNRE organization chart
Appendix A. 2: RSC organization chart and missions

The Remote Sensing Centre is a public agency under MoNRE, responsible for supervising the natural resources and environment by the remote sensing technology in order to facilitate the state management and the national economic industries. Its missions are:

- Application of remote sensing technology for investigation, monitoring of natural resources and environment such as land resource, water resource, mineral resource, natural resources exploitation, environmental phenomenon, hydro-meteorological phenomenon, calamity, geological accidents
- Building up and submitting to the MoNRE the long term plan, 5-year plan and annual plan for remote sensing technology development
- Receiving, processing, archiving, managing and providing of remote sensing images and products information for natural resources and environment management
- Establishing and updating national topographic map system by remote sensing technology for territorial planning and management
- Establishment of remote sensing database and GIS for economic development and management
- Research, application and development of remote sensing technology for natural resources and environment monitoring
- Creating technical standards, regulations and procedures contribution to creation of technical economic norms for remote sensing activities
- Implementation of scientific researches, projects, programs in cooperation with international organizations, countries in remote sensing fields research and application of remote sensing technology in combination with geomatic for determination of crust changes and for calamity monitoring prediction
- Application of remote sensing technology and other advanced technologies for creation of DTM, Atlas and thematic maps
- Supply of satellite images and value added products, services of consultancy, remote sensing and GIS technology transfer to other organizations domestic and oversea in compliance with legislations
- Making statistics and reports on tasks assigned by Ministry periodically and at request
- Management and organization of staffs, finance, property of RSC
- Carrying out other tasks assigned by the Minister.
## Appendix A. 3: List of interviewees and documents collected during the fieldwork

### Appendix A. 3.1: List of interviewees and documents collected about quality management in RSC, MoNRE

<table>
<thead>
<tr>
<th>Name</th>
<th>Working position</th>
<th>The role played</th>
<th>Documents collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Vu Tien Quang</td>
<td>Manager of Surveying division, Quality Audit Center, Survey and Mapping Department, MoNRE</td>
<td>Manage all auditing of surveying and mapping product</td>
<td>Processes of controlling and quality check upon products delivery in topographic mapping project, Quality Audit Center, 2005</td>
</tr>
<tr>
<td>2 Le Minh Tam</td>
<td>Deputy director general, Department of Survey and Mapping, MoNRE.</td>
<td>Editor of technical regulation published by MoNRE</td>
<td>Regulations on setting up, assessment, approval, management and implementation projects under MoNRE, 2004, Regulation on quality control of mapping and surveying products, MoNRE, 1997, Guideline on technical inspection and quality check upon mapping and surveying products delivery MoNRE, 1997, Forms using in quality control processes MoNRE, 1997, Regulation in airphoto acquisition MoNRE, 2005</td>
</tr>
<tr>
<td>3 Nguyen Thi Ngoc</td>
<td>Quality Control Unit, Aerial Photo - Topography Company, MoNRE.</td>
<td>In charge with project design, quality control, data delivery through the quality audit centre. Some of projects are with foreign partners with standards other than MoNRE.</td>
<td>Some documentation about design and quality control in projects with foreign partners</td>
</tr>
<tr>
<td>4 Nguyen Phi Son</td>
<td>Manager of Technical Department Centre of LA development, Research Institute of Land Admin, MoNRE</td>
<td>In charge with project design, quality control, data delivery through the quality audit center</td>
<td>Report and documentation on final quality control and product delivery of project: Building topographic basemap, Camau province. VIRILA, 2005</td>
</tr>
<tr>
<td>5 Le Hong Son</td>
<td>Vice director of Technical Department, Remote Sensing Centre, MoNRE.</td>
<td>In charge with project design, quality control, data delivery through the quality audit centre</td>
<td>Regulation on quality control by RSC, 2005</td>
</tr>
<tr>
<td>6 Vo Anh Tuan</td>
<td>The Information Centre of Natural Resources and Environment, MoNRE.</td>
<td>In charge with project design, quality control, data delivery through the quality audit centre</td>
<td>Report on current situation of Reference system, geodetic and leveling network for Vietnam, 2000, List of regulations currently applied in MoNRE</td>
</tr>
<tr>
<td>7 Nguyen Thu Hang</td>
<td>Head in Map Editing Unit, Remote Sensing Centre, MoNRE.</td>
<td>In charge with managing map editing, review project design, working with quality audit centre in data delivery period.</td>
<td></td>
</tr>
<tr>
<td>8 Nguyen Ha Phu</td>
<td>Head in Photogrametry Unit Remote Sensing Centre, MoNRE.</td>
<td>In charge with managing photogrametry process, review project design, working with quality audit centre in data delivery period.</td>
<td></td>
</tr>
<tr>
<td>9 Nguyen Thi Hanh</td>
<td>Operator in Photogrametry Unit Remote Sensing Centre, MoNRE.</td>
<td>Carry out daily work with digital photogrammetry</td>
<td></td>
</tr>
<tr>
<td>10 Tran Thu Ha</td>
<td>Operator in Map Editing Unit Remote Sensing Centre, MoNRE.</td>
<td>Carry out daily work on digitizing on orthophoto and map editing</td>
<td></td>
</tr>
</tbody>
</table>
**Appendix A. 3. 2: List of interviewees and documents collected about management of the ALS pilot project in RSC**

<table>
<thead>
<tr>
<th>No</th>
<th>Name</th>
<th>Working position</th>
<th>The role played</th>
<th>Documents collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Le Minh, PhD in Geodesy</td>
<td>Director, Remote Sensing Centre, MoNRE.</td>
<td>General management</td>
<td>Technical design of Cantho ALS pilot project</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Contract and appendixes of Cantho ALS pilot project between RSC and Credent</td>
</tr>
<tr>
<td>2</td>
<td>Hoang Ngoc Lam, PhD in Geodesy</td>
<td>Director of Centre of Science - Technology Application &amp; Development, Remote Sensing Centre, MoNRE.</td>
<td>In charge with setting base station from existing leveling network, Ground Control points survey</td>
<td>Reports ALS pilot project by Credent</td>
</tr>
<tr>
<td>3</td>
<td>Nguyen Tuan Anh, Engineer in Geodesy</td>
<td>Vice director of Centre of Science - Technology Application &amp; Development Remote Sensing Centre, MoNRE.</td>
<td>In charge with GPS base station during the flight Cooperate with Credent during post-processing</td>
<td>Reports of ALS pilot project by RSC project team</td>
</tr>
<tr>
<td>4</td>
<td>Dang Thai Hung, Engineer in Geodesy</td>
<td>Office manager, Leader of aerial photo acquisition team, Remote Sensing Centre, MoNRE.</td>
<td>In charge with admin arrangements Cooperate with Credent and pilot during the flight planning and flight</td>
<td>Procedures of fly and administrative arrangement</td>
</tr>
<tr>
<td>5</td>
<td>Dinh Hong Phong, Engineer in IT</td>
<td>Director of IT Centre, Remote Sensing Centre, MoNRE.</td>
<td>In charge with the setting up project of establishment whole country DTM coverage</td>
<td>Proposal of establishment whole country DTM coverage</td>
</tr>
<tr>
<td>6</td>
<td>Nguyen Dai Dong, PhD in Geodesy</td>
<td>Technical and Technology Department, Aerial Photo - Topography Company, MoNRE.</td>
<td>Project team leader</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Dinh Thi Lan Anh, Engineer in Cartography</td>
<td>Credent project team</td>
<td>Filtrering operator</td>
<td></td>
</tr>
</tbody>
</table>
### Appendix A. 3. 3: List of interviewees as RSC ALS DTM potential users

<table>
<thead>
<tr>
<th>No</th>
<th>Name</th>
<th>Working position</th>
<th>Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dao Viet Dzung</td>
<td>Researcher in Institute for Water Resources Research, Ministry of Agriculture and Rural Development.</td>
<td>Infrastructure development related to water management</td>
</tr>
<tr>
<td>2</td>
<td>Nguyen Dang Vy</td>
<td>Deputy director of Center for Water Resources Software, Institute for Water Resources Research, Ministry of Agriculture and Rural Development.</td>
<td>Infrastructure development water management</td>
</tr>
<tr>
<td>3</td>
<td>Pham Van Cu</td>
<td>Vice director Center for Applied Research in Remote Sensing and GIS, Hanoi National University.</td>
<td>Academic institution</td>
</tr>
<tr>
<td>4</td>
<td>Nguyen Nhat Quang</td>
<td>Director, Hamony Co Ltd.</td>
<td>Service provider and software development related to 3D geo data applications</td>
</tr>
<tr>
<td>5</td>
<td>Pham Hung Thuan</td>
<td>Director of Photogrametry, Geodesy and Cartography Company, Ministry of Geology and Mineral.</td>
<td>Geology survey and mapping</td>
</tr>
<tr>
<td>6</td>
<td>Vu Huu Liem</td>
<td>Center of Natural Resource and Environment Management, Remote Sensing Center, MoNRE.</td>
<td>Natural resource and environment</td>
</tr>
<tr>
<td>7</td>
<td>Nguyen Dinh Phuong</td>
<td>Vice director, Songda - Ucrin Consulting Engineering Co Ltd. Songda Corporation.</td>
<td>Consulting in hydropower station construction and engineering</td>
</tr>
<tr>
<td>8</td>
<td>Tran Bach Dang</td>
<td>Chief of Surveying Department, Songda - Ucrin Consulting Engineering Co Ltd. Songda Corporation.</td>
<td>Consulting in hydropower station construction and engineering</td>
</tr>
<tr>
<td>9</td>
<td>Nguyen Kim Nga</td>
<td>Manager of Indoor division, Photogrametry, Geodesy and Cartography Company, Ministry of Geology and Mineral.</td>
<td>Geology survey and mapping</td>
</tr>
<tr>
<td>10</td>
<td>Nguyen Thanh Binh</td>
<td>Head Division of Electro-Technology, Faculty of Electronics Engineering, Posts and Telecommunications Institute of Technology, Technical Manager of Giakhang Telecom Ltd.</td>
<td>Telecom</td>
</tr>
<tr>
<td>11</td>
<td>Nguyen Hieu Trung</td>
<td>Vice Head of Department of Environment and Water Resources Engineering, Cantho University, College of Technology.</td>
<td>Academic institution</td>
</tr>
<tr>
<td>12</td>
<td>Nguyen Thi Ngoc Uyen</td>
<td>Institute of Architecture and planning, People's Committee of Cantho City.</td>
<td>Urban planning</td>
</tr>
<tr>
<td>13</td>
<td>Dang Thu Suong</td>
<td>Deputy director of PMU of Cantho Urban Upgrading Project, Cantho Public Work Department, People’s Committee of Cantho City.</td>
<td>Public work department</td>
</tr>
</tbody>
</table>
### Appendix A. 3.4: List of interviewees involved with SWOT analysis for implementing QMS for RSC ALS DTM production

<table>
<thead>
<tr>
<th>No</th>
<th>Name</th>
<th>Working position</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Le Minh</td>
<td>PhD in Geodesy, Director RSC, Remote Sensing Centre, MoNRE.</td>
</tr>
<tr>
<td>2</td>
<td>Hoang Ngoc Lam</td>
<td>PhD in Geodesy, Director, Centre of Science - Technology Application &amp; Development, Remote Sensing Centre, MoNRE.</td>
</tr>
<tr>
<td>3</td>
<td>Nguyen Tuan Anh</td>
<td>Engineer in Geodesy, Vice director, Centre of Science - Technology Application &amp; Development, Remote Sensing Centre, MoNRE.</td>
</tr>
<tr>
<td>4</td>
<td>Dang Thai Hung</td>
<td>Engineer in Geodesy, Office manager, Leader of aerial photo acquisition team, Remote Sensing Centre, MoNRE.</td>
</tr>
<tr>
<td>5</td>
<td>Dinh Hong Phong</td>
<td>Engineer in IT, Director of IT Centre, Remote Sensing Centre, MoNRE.</td>
</tr>
<tr>
<td>6</td>
<td>Le Minh Tam</td>
<td>PM in GIS, Deputy director general, Department of Survey and Mapping, MoNRE.</td>
</tr>
</tbody>
</table>
### Appendix A. 4: List of regulations used in production of large scale topographic map

<table>
<thead>
<tr>
<th>Name</th>
<th>Editor</th>
<th>Publication year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Technical regulation for outdoor activities in production topographic map scale 1:500, 1:1 000, 1:2 000, 1:5 000</td>
<td>MoNRE</td>
<td>1990</td>
</tr>
<tr>
<td>2 Technical regulation for indoor activities in production topographic map scale 1:500, 1:1 000, 1:2 000, 1:5 000</td>
<td>MoNRE</td>
<td>1990</td>
</tr>
<tr>
<td>3 Technical specification for production topographic map scale 1:2 000, 1:5 000 using digital photogrametry technology</td>
<td>MoNRE</td>
<td>2005</td>
</tr>
<tr>
<td>4 Map symbol for topographic map scale 1:500, 1:1 000, 1:2 000, 1:5 000</td>
<td>MoNRE</td>
<td>1995</td>
</tr>
<tr>
<td>5 Technical specification for digitization of topographic map scale 1:10 000, 1:25 000, 1:50 000, 1:100 000</td>
<td>Map Publishing House</td>
<td>2000</td>
</tr>
<tr>
<td>6 Technical specification for using Trimble Navigation 4000 St “Surveyor” to establish Geodetic network</td>
<td>MoNRE</td>
<td>1991</td>
</tr>
<tr>
<td>7 Guideline for VN2000 reference system application in mapping and surveying activities</td>
<td>MoNRE</td>
<td>2001</td>
</tr>
<tr>
<td>8 Regulations on setting up, assessment, approval, management and implementation projects</td>
<td>MoNRE</td>
<td>2004</td>
</tr>
<tr>
<td>9 Regulation on quality control of mapping and surveying products</td>
<td>MoNRE</td>
<td>1997</td>
</tr>
<tr>
<td>10 Guideline on technical inspection and quality check upon mapping and surveying products delivery</td>
<td>MoNRE</td>
<td>1997</td>
</tr>
<tr>
<td>11 Forms using in quality control processes</td>
<td>MoNRE</td>
<td>1997</td>
</tr>
<tr>
<td>12 Regulation in airphoto acquisition processes of controlling and quality check upon products delivery in topographic mapping project</td>
<td>Quality Audit Center</td>
<td>2005</td>
</tr>
<tr>
<td>13 Project design of topographic map production project scale 1:5000 for Dongthap, Tiengiang and Bentre provinces</td>
<td>RSC</td>
<td>2006</td>
</tr>
<tr>
<td>14 Project design of topographic map production project scale 1:5000 for Camau and Baclieu provinces</td>
<td>Vietnam Research Institute of Land Admin.</td>
<td>2005</td>
</tr>
</tbody>
</table>
**Appendix A. 5: ALS pilot project workflow by RSC project team**

From experience from pilot project, RSC project team generated a workflow for ALS DTM production containing 7 main processes:

1. **Project preparation**
   - Formulation of project economic and technical design
   - Project approval by MoNRE
   - Design flight plan
   - Flight arrangement: contracts with Vasco (Viet Nam Air Services Company) and the airport
   - Apply for flight and data acquisition permission
   - Staff and equipment mobilization to the site
   - Establish 2 base stations leading from leveling network second category.
   - Survey ground control points with accuracy equivalent to leveling points category 4 with accuracy 5cm compare to points of higher category.

2. **Calibration**
   - Mounting equipments
   - Test flight
   - Calibration

3. **Data acquisition**
   - Weather watch
   - Actual laser scanning
   - Simultaneous measurement on GPS base stations and on airplane

4. **Post processing**
   - **Enter the Geo Reference parameters**
     - Enter the parameter of coordinate system
     - Enter the parameter of GEOID
     - Enter the conversion parameters between WGS 84 and VN 2000 systems
   - **Download and process data in REALM**
     - Download and decompress the data each strips
     - Decode and check raw data
     - Combine the GPS data from the plan and from the base station by module POSGPS
     - Combine the GPS data and the data from IMU by module POSProc
     - Combine GPS, IMU and Laser data by REALM to produce XYZ and intensity image
     - Cut out the data outside of project area
     - Process the strips overlap area
     - Create intensity image
     - Divide dataset into tiles of 1x1km

5. **Filtering:** Ground and non ground by Terrascan
   - Automatic filtering
   - Manual check and re-filtering

6. **Accuracy check**

7. **Reporting**
Appendix A. 6: Description of the dataset collected from pilot project

The dataset collected from pilot project contains of:

1. **General data:**
   - Topographic data in vector format of the pilot area scale 1:50 000
   - Schema of flying path: JPG format
   - Schema distribution of the base station and control points surveyed

2. **Cai Von Area:**
   - Control points: 211 points
   - ALS Intensity image of 4x4km
   - Points cloud of 4x4km - Filtered to ground & non-ground

3. **Can Tho Area:**
   - Control points: 133 points
   - Intensity image of 5x5km
   - Point cloud of 5x5km - Filtered to ground & non-ground
   - Color Airphoto 1m resolution
Appendix A. 7: Result of demonstration some quality check techniques using Cantho dataset

Due to the limit of collected dataset, it is possible just to perform some quality control measures on the final products from the contractor which are laser points delivered in title of 1x1km.

1. Vertical accuracy check

A vertical accuracy check using 2 set of ground control points in Caivon and in Cantho town area were conducted and come up with the graph describing the error distribution, mean error and RMSE for each area.

The Figure A.1.1 and Figure A.2.1 show the location of available control points respectively for Caivon and Cantho area. They are located mainly along the main road. As mention in Section 2.2.4 they may suffer with random error of 10 to 15 cm. The Figure A.1.2 and Figure A.2.2 show the distribution of the computed vertical errors; while the Figure A.1.3 and Figure A.2.3 show the absolute value of vertical error of the DTM generated from laser points and the ground control points of the two check areas. The RMSEs are 0.097m for Caivon area and 0.179m for Cantho area.

![Figure A.1: Caivon check area](image)

**Figure A.1.1**

<table>
<thead>
<tr>
<th>Number of points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum: -7.465</td>
</tr>
<tr>
<td>Count: 211</td>
</tr>
<tr>
<td>Mean: -0.035</td>
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<tr>
<td>Maximum: 0.272</td>
</tr>
<tr>
<td>Minimum: -0.295</td>
</tr>
<tr>
<td>Range: 0.567</td>
</tr>
<tr>
<td>Variance: 0.008</td>
</tr>
<tr>
<td>Standard deviation: 0.091</td>
</tr>
</tbody>
</table>

**Figure A.1.2**

<table>
<thead>
<tr>
<th>Number of points</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sum: 14.959</td>
</tr>
<tr>
<td>Count: 211</td>
</tr>
<tr>
<td>Mean: 0.071</td>
</tr>
<tr>
<td>Maximum: 0.295</td>
</tr>
<tr>
<td>Minimum: 0.001</td>
</tr>
<tr>
<td>Range: 0.294</td>
</tr>
<tr>
<td>Variance: 0.004</td>
</tr>
<tr>
<td>Standard deviation: 0.067</td>
</tr>
</tbody>
</table>

**RMSE: 0.097**
Figure A.2.1

Figure A.2.2
Sum: 17.906  
Count: 133  
Mean: 0.135  
Maximum: 0.300  
Minimum: -0.254  
Range: 0.554  
Variance: 0.014  
Standard Deviation: 0.118

Figure A.2.3
Sum: 20.910  
Count: 133  
Mean: 0.157  
Maximum: 0.300  
Minimum: 0.001  
Range: 0.299  
Variance: 0.007  
Standard Deviation: 0.085  
RMSE: 0.179

Figure A.2. Cantho city check area

In the future, if the control points are collected according to the quality manual, the vertical accuracy check can be conducted in the same way. The RMSE will be compared with the specified pass/fail value, which leads to a conclusion about the vertical accuracy of the laser points.
2. Filtering error check

The filtering error check was conducted using the rectified color airphoto 1m resolution which is available for the area. Clearly recognized polygons of houses and water bodies were digitized for 1km² of the tile No 5841107 from the rectified color airphoto using Microstation and IrasC. Figure A.3 shows a snapshot of the tile.

These ALS points filtered as ground points that fall inside these polygons are considered filtering errors. They were detected by overlay the points with polygon of the house and water body in ArcGis.

Table A.1 shows the number of wrongly filtered points and the percentage over total number of ground points. It can be compared with the set tolerance in the quality manual to come up with conclusion about the quality of filtering.

<table>
<thead>
<tr>
<th>Number of ground points that fall inside polygons of house and water body</th>
</tr>
</thead>
<tbody>
<tr>
<td>House</td>
</tr>
<tr>
<td>3175 points</td>
</tr>
<tr>
<td>Water body</td>
</tr>
<tr>
<td>1306 points</td>
</tr>
<tr>
<td>Σ</td>
</tr>
<tr>
<td>4481 points</td>
</tr>
<tr>
<td>% over total number of laser point in the checked tile (61644 points)</td>
</tr>
<tr>
<td>7.3%</td>
</tr>
</tbody>
</table>
Appendix A. 8: Work process model in AGI AHN project

Symbols

- Activities done by contractor
- Activities done by AGI AHN

Flowchart:
- Flight planning
  - Flight plan
    - Accepted
    - Rejected
- Terrestrial survey
- Reference area
- Laser acquisition
- Reporting
- Laser points
- Filtering
- Data delivery
- Check form
  - Accepted
  - Rejected
  - Improve strip adjustment
- Strip adjusted data
- Height report
- Control cost for contractor
- Control cost for contractor
- Final report
- Quality document
- Back to contract
- Check form
  - Accepted
  - Rejected
**Appendix A. 9: List of training courses related to QMS**

Adopted from (Cerco 2000)

This list of the training courses in QMS can be used for training program development for RSC ALS DTM production.

<table>
<thead>
<tr>
<th>Title and period of training</th>
<th>Contents</th>
<th>Program participants</th>
</tr>
</thead>
</table>
| 3. Quality assurance system  | **3. Quality assurance system**  
4 days                       | • Terminology and concepts related with quality  
• Quality costs  
• Introduction of ISO 9000 series standards  
• Organizational structure of QMS  
• Management of papers and procedures  
• Sample studies | • Top level managers  
• People to be qualified on quality assurance |
| 4. Quality system documentation | **4. Quality system documentation**  
3 days                       | • Document structure of QMS  
• Quality manual (handbook)  
• Procedures  
• Support documents (specifications, forms, etc.)  
• Document control  
• Sample studies | • People who prepares the document for QMS  
• People who trained in topic (1) or who will manage the related work |
| 5. Internal quality audits   | **5. Internal quality audits**  
3 days                       | • Introduction of ISO 10011 standards  
• Types of audits  
• Advantages of audits  
• Planning and management of audits  
• Lists of questions  
• Report writing of audits  
• Responsibilities of auditor s  
• Sample studies | • Managers and workers responsible for Internal Quality Audits  
• People trained on the topics (1) and (2) |
| 6. Total quality management  | **6. Total quality management**  
2 days                       | • Concepts of TQM  
• Continuous improvement  
• Continuous improvement  
• Dependency  
• Participation of all people  
• Planning, training and measuring | • Top level managers  
• All managers |
| 7. Quality circles          | **7. Quality circles**  
4 days                       | • Introduction  
• Problem prevention techniques  
• Data acquisition techniques  
• Brainstorming techniques  
• Group works  
• Reason/Result analysis  
• Presentation to Administration | • Medium level managers  
• Workers |
<table>
<thead>
<tr>
<th></th>
<th>Problem solving techniques</th>
<th></th>
<th>All level workers/managers</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 days</td>
<td>• Concepts of quality and customer</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Continuous improvement</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Logic of statistics</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Flow diagrams</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Reason / Result diagrams</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Making decisions</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Planning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.</td>
<td>Suppliers and subcontractors relations</td>
<td></td>
<td>Managers and staff responsible for organization purchasing</td>
</tr>
<tr>
<td>2 days</td>
<td>• Evaluation of supplier quality system</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• including:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Process documents</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Purchasing document control</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• First sample (prototype) and approval</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Entrance control</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Non-conforming supplies</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Purchasing and approval procedures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10.</td>
<td>Statistical process control</td>
<td></td>
<td>Section workers who implement and evaluate the statistical activities</td>
</tr>
<tr>
<td>3 days</td>
<td>• Basic knowledge on Quality system and Quality control</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Requirement for statistical techniques</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Basic statistical concepts</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Process control by statistical methods</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Verifying and measuring of processes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Data acquisition methods</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Determination of critical processes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Analysis of processes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Improvement methods of processes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Sample studies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11.</td>
<td>Process management and improvement</td>
<td></td>
<td>All level managers</td>
</tr>
<tr>
<td>2 days</td>
<td>• Process management and functional management</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Definition of processes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Determination of process owners</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Determination of critical processes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Analysis of processes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Improvement methods for processes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Sample studies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12.</td>
<td>Benchmarking</td>
<td></td>
<td>Top level managers</td>
</tr>
<tr>
<td></td>
<td>• Benchmarking types</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Data acquisition and analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Implementation</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Review and improvement</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13.</td>
<td>Calibration</td>
<td></td>
<td>People responsible for calibration</td>
</tr>
<tr>
<td>1 day</td>
<td>• Implementation of calibration in ISO 9000</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• General information</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Documentation of calibration</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Determining calibration periods</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Introduction of calibration environment</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Appendix A. 10: Pictures of the pilot project area in the Mekong delta

The flooding reason in Mekong delta - From the space

The flood is coming in Mekong river