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Logistics in the Royal Thai Air Force

Case Study: Preventing Problems in Logistics Support for the 4.5 Generation Fighter Aircraft

Master Thesis within Military Logistics

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Abstract

The implementation of complex equipment as fighter aircraft with a long supply line in logistics support is an interesting subject for study. The Royal Thai Air Force has just purchased Gripen 39 C/D, 4.5 generation fighter aircraft, which have new technology and will need to come together with a new platform in logistics support to supercede the existing system for the F-16 A/B. The lessons learned and experience regarding logistics problems with the F-16 A/B are set to prevent problems in the new system related to four logistics functions that are important to the support of fighter aircraft: supply, logistics information management, maintenance, and transportation.

The purpose of this thesis is to find out which of the main four logistics functions is considered the most appropriate for preventing problems systematically and hence to study how these four functions support the Gripen 39 C/D. Two methods are used in this thesis together with the lessons learned from the existing system to discover this information.

The results of the analysis show that supply is the main logistics function that will cause possible future logistics problems in supporting the new-generation fighter aircraft, and it is also inclined to outsource most of the logistics functions. The pooling programme is the main process in outsourcing, whereas maintenance is the only function that is not outsourced, due to the fact that it is the core function.

The main conclusion from the analysis conducted is that the stock level of supply and the budgets for the pooling programme should be increased to help prevent problems in the main area that is expected to create future possible problems. Moreover, planning is one of the important processes that can help mitigate any problems that may occur.

Acronyms and Abbreviations

3PL	Third-Party Logistics
4PL	Fourth-Party Logistics
AEA	Aerial Equipment Assemblers
AFMO	Air Fleet Management Office
ALMS	Automated Logistics Management System
AMP	Aircraft Maintenance Publication
ARM	Analyse and Report Module
BVR	Beyond Visual Range
C^4I	Command, Control, Communications, Computer, and Intelligence
CONUS	Contiguous United States
COTS	Commercial-off-the-Shelf
DA	Directorate of Armament
DAE	Directorate of Aeronautical Engineering
DC&E	Directorate of Communications and Electronics
DL	Directorate of Logistics
DP	Direct Purchase
DT	Directorate of Transportation
DTU	Data Transfer Unit
EOD	Explosive Ordnance Disposal
EWS	Electronic Warfare System
FMC	Full Mission Capability
FMS	Foreign Military Sale
FMTS	Armed Forces Technical School
FOB	Forward Operation Base
GSE	Ground Support Equipment
GTCC	Gripen Technician Conversion Course
GPS	Global Positioning System
G-to-G	Government to Government
GUG	Gripen User Group

HMS	Helmet-Mounted Sights
HNS	Host Nation Support
ICT	Information and Communication Technology
IEL	Infrastructure Engineering for Logistics
LMIS	Logistics Management Information System
LP	Local Purchase
LRUs	Line Replacement Units
LSP	Logistics Service Provider
M&T	Movement and Transportation
MGSS	Maintenance Ground Support System
MOB	Main Operating Base
MRO	Maintenance, Repair, and Overhaul
NPO	National Program Office
OEM	Original Equipment Manufacturer
OJT	On-the-Job Training
RSOM	Reception, Staging, and Onward Movement
RTAF	Royal Thai Air Force
SCM	Supply Chain Management
SSG	Swedish Support Group
SwAF	Swedish Air Force
TOs	Technical Publications
TR	Technical Report
USA	United States of America

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1 Introduction

1.1 Background

Nowadays, there are many types of equipment on the market with different requirements for logistics support to sustain their availability, reliability, and maintainability. Moreover, there are two terms that have to be classified when purchasing equipment or items: profit impact and supply risk (Kraljic, 1983). Complex equipment always involves a high profit impact and high supply risk when the customers reside in locations far from the original equipment manufacturer (OEM). Logistics support for fighter aircraft is a good example of this issue since fighter aircraft are complex equipment and are sold all over the world to military customers such as air forces. In this thesis, the case of the Royal Thai Air Force (RTAF), which has just purchased new-generation fighter aircraft from Sweden, will be studied in terms of how to support these new-generation fighter aircraft in a long supply line from Sweden to Thailand and vice versa when repairing and maintenance are needed.

Fighter aircraft generate high profits, because they provide the air power to prohibit threats that may aim to obtain the national interest and balance the power in the region. Only the noise of their engines can make the ground forces fear to breach the country's borders. In addition, the latest generation is necessary in air battles between fighter aircraft. Their purchase needs to take into consideration not only the quantity but also the quality of modern technology, which are important factors. From the 1990s until now; the 4.5 generation fighter aircraft are the latest generation in the military markets. Every country that has purchased this type of aircraft has either a defensive or an offensive purpose, depending on its situation. The 4.5 generation fighter aircraft are a group of fighter aircraft that have been developed from the fourth-generation ones following thirty years of improvements (Hebert, 2008). The characteristics of these aircraft are the application of advanced digital avionics and aerospace materials, and highly integrated systems and weapons. These fighters have been designed to operate in a "network-centric" battlefield environment and are principally multirole aircraft. The key weapons technologies introduced include beyond visual range (BVR) missiles, helmet-mounted sights (HMSs), and improved secure, jamming-resistant data links. The designs are based either on existing airframes or on new airframes following similar design theory to the previous generations; however, these modifications have introduced the structural use of composite materials to reduce the weight and greater fuel fractions to increase the range. The group of 4.5 generation fighter aircraft consists of the Boeing F-18E/F Super Hornet, Sukhoi Su-30, Sukhoi Su-33, Sukhoi Su-35, Eurofighter Typhoon, Saab Gripen, and Dassault Rafale (Wikipedia, 2011).

The challenge for countries purchasing the 4.5 generation fighter aircraft with new technology that differs from that of the fourth-generation ones is not only to create the capability of the aircraft to achieve their characteristics and performance, but also to support them in logistics functions that ensure their availability for operational requirements. With regard to the RTAF's fighter purchasing of aircraft, there are more challenges concerning the supply risk from a long supply chain. Because of the long supply chain, the logistics need efficient supply chain management and an effective supply strategy to maintain a sufficient stock level of supplies and to ensure they are available when required.

Logistics support is divided into thirteen logistic functions in the NATO *Logistics Handbook* (2007), whereas there are four logistics functions that are important to and related to supporting the fighter aircraft since they were the problem areas when the RTAF operated fourth-generation fighter aircraft. The four logistics functions are: *supply*, which indicates material and items that are constantly replenished in the aircraft to meet the availability requirement and also to support maintenance, *logistics information management*, which uses information and communication technology (ICT) to record and manage the supply and maintenance data, and it is also used for logistics planning, *maintenance* sustains the availability of items in the aircraft by repairing, and requires four resources – personnel, materials, documentation, and management information systems (Pintelon, Preez, & Puyvelde, 1999), and *transportation* moves supplies from suppliers to customers and carries out other logistics functions when the aircraft are in deployment.

Before the Kingdom of Thailand purchased the new 4.5 generation fighter aircraft, it had also been operating the fourth-generation fighter aircraft. Hence, the gaps between the two generations of fighter aircraft regarding logistics support constitute an interesting topic to study. In addition, they are from different regions. The new aircraft are from Europe and the others are from North America. All the fighter aircraft in Thailand are managed by the Royal Thai Air Force (RTAF). The RTAF has operated fourth-generation fighter aircraft, Lockheed Martin F-16 A/Bs from the United States of America (USA), since 1988 and has a great deal of experience in both operations and logistics with these fourth-generation fighter aircraft. Also, it has a great deal of experience in solving problems from the viewpoint of the four logistics functions mentioned above.

Figure 1-1 RTAF F-16 A/B (Source: www.rtaf.mi.th, 2011)

At present, technology is developing very quickly, and the fourth-generation fighter aircraft lack sufficient technology to defend Thailand and balance the power in the region of Southeast Asia. Moreover, the RTAF needs capability at sea and network-centric operations following the RTAF's vision. Thus, the acquisition of the new 4.5 generation fighter aircraft was instigated and the Gripen 39 C/D from the Kingdom of Sweden was selected as a suitable 4.5 generation fighter.

In 2008, after the selection of the Gripen 39 C/D as the RTAF's new-generation fighter aircraft, a purchase agreement was signed between the RTAF, authorized by the Government of the Kingdom of Thailand, and the Swedish Defence Material Administration (FMV), authorized by the Government of the Kingdom of Sweden, to purchase six Saab Gripen 39 C/Ds that would be delivered in 2011. Moreover, the RTAF aims to operate these aircraft for more than 20 years after their delivery to the southern part of Thailand.

After delivery, the RTAF Gripen 39 C/Ds were to be commissioned in Wing 7, Suratthani. They are the main air defence system in the southern area of Thailand to protect and defend the national interests at sea, covering both sides of the sea to the east (the Gulf of Thailand) and to the west (the Andaman Sea).

Figure 1-2 RTAF Gripen 39 C/D (Source: www.saabgroup.com, 2011)

1.2 Specification of the problem

Nowadays, there are forces that drive the rate of change and shape our economic and political landscape: globalization, technology, organizational consolidation, the empowered consumer, and government policy and regulation (Langley, Coyle, Gibson, Novack, & Bardi, 2009). Complex equipment as a system, with new technology and a global supply chain, challenges the owner organizations in terms of how to maintain capability and availability that will be unlike those of the existing system. However, new platforms in logistics support are being developed and provided by the suppliers that will be able to reduce complexity. These platforms also need an adequate understanding of how to process them. In addition, at the beginning of implementation of the new system and transition from the existing system to the new system, there will be gaps between the two systems that will cause problems to occur related to the problem area in the existing system, especially in logistics support. It is preferable to identify and be aware of logistics problems in advance and find preventive ways to solve them since this method is less time-consuming. Moreover, using the preventive method, the lessons learned from the existing system can be used as guidelines in solving the problems.

1.3 Purpose

The purpose of this thesis is to find out how to support the new 4.5 generation fighter aircraft in four logistics functions and prevent future possible problems related to the problems encountered when the RTAF operated the Lockheed Martin F-16 A/Bs. This purpose dominates the following research questions:

- *What has been the main problem area in logistics support for fighter aircraft?*
- *How can the lessons learned from logistics support in the existing systems be incorporated into the new system?*
- *How can we support the new-generation fighter aircraft in four logistics functions?*

1.4 Delimitation

As the four logistics functions to support the fighter aircraft involve each other, determining the preventable problems from each logistics function separately is better than examining all the four functions at the same time. Thus, in this thesis, the author will only be examining one logistics function and not all four, considering the fact that they are all important. Moreover, the survey conducted will identify the most important logistics function of the four. After the author has gathered all the data, business and military theories are used to deal with the problems that could possibly occur to new-generation fighter aircrafts in the future. The time frame for this thesis will extend from the beginning of March 2011 (which is the first flight month of the RTAF Gripen 39 C/Ds in Thailand) to March 2012, which will mark the conclusion of the data collection by survey and interviews.

There are five classes of supply in the NATO system. In this thesis, only Class II supply is expected to be studied and only that related to supporting fighter aircraft. Class II supply consists of supplies for which allowances are established by tables of organization and equipment, e.g. clothing, weapons, tools, spare parts, and vehicles (NATO, 2007).

1.5 Organization of the thesis

Chapter 2 – Methodology. To gain a clearer understanding of this thesis, the overall picture of the research study is described. Moreover, two research approaches and two data collection methods are used in this thesis. The survey method is used first to collect the data and then interviews are conducted to gain more and clearer data. The data collection process and guidelines are presented to explain how to obtain the data, select the mode of collection, choose the sampling frame, and create the questionnaire standard. In addition, the plans to implement the data collection without unit non-response are presented. The last part of this chapter discusses the validity and reliability of the data.

Chapter 3 – Frame of reference. This chapter presents all the theory and knowledge from business and military logistics, supply chain management, and other interesting theories. The solutions to preventable problems in logistics functions will overarch the trend of supply chain management and logistics today. They are covered by the topics of third-party logistics, performance measurement, strategy, and postponement and speculation. Moreover, the definitions of the logistics functions mentioned previously are given.

Chapter 4 – Presentation of the Royal Thai Air Force. This chapter aims to provide some background information about the RTAF's vision, missions, core values, and organizations. Moreover, the reader will understand how logistics proceeds in the RTAF and which RTAF organizations cooperate to support fighter aircraft in logistics functions. The presentation includes many figures to facilitate a clearer understanding.

Chapter 5 – Empirical findings. The lessons learned when the RTAF operated Lockheed Martin F-16 A/Bs are presented in this chapter. Many problems occurred in the four logistics functions that support the fighter aircraft. The problems were solved by many methods, and created many experiences for the RTAF. Moreover, the data from the survey and interviews are presented. These data are collected from RTAF officers and the Swedish Support Group (SSG) in Thailand. There are many figures and tables in this chapter to illustrate the data.

Chapter 6 – Analysis. The interpretation of the data in the empirical findings combined with the frame of reference are presented and analyzed to answer the research questions. The focus in this chapter is on establishing which area of the logistics functions is the main problem, how to incorporate the lessons learned from the existing system into the new system, and the thoughts of Thai officers in different fields about logistics support for the 4.5 generation fighter aircraft in the four logistics functions.

Chapter 7 – Conclusions. This chapter provides the main results from the analysis and the tendency of military logistics, thus answering the research questions mentioned previously, as well as examining whether the research has succeeded in answering the purpose and questions of the thesis.

Chapter 8 – Discussion. This final chapter discusses the lessons learned from the thesis study in general and the theoretical part, especially the methodology. In addition, future research suggestions are offered.

2 Methodology

This chapter presents the method used to conduct this study from the beginning to the end in order to answer the research questions and achieve the purpose. For a clearer understanding of the overall structure and methodology of this thesis, Figure 2-1 illustrates its outline.

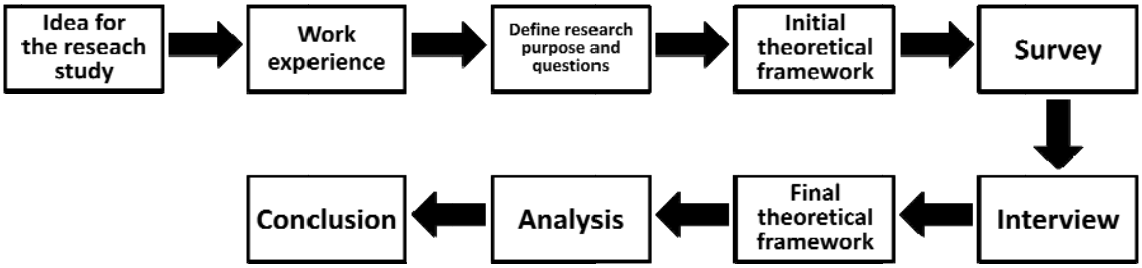

Figure 2-1 Research study diagram (Source: constructed by the author, 2012)

The implementation of Gripen 39 C/Ds in Thailand and how to support them logistically generated *the idea for the research study*. Moreover, according to NATO's definition of logistics, there are thirteen logistics functions in logistics support for military forces. This idea, combined with the author's *work experience* in logistics support with F-16 A/Bs reduced the thirteen logistics functions to four (supply, logistics information management, maintenance, and transportation) that are important to supporting fighter aircraft, and *defined the research purpose and questions*. To support the research purpose and questions academically, the *initial theoretical framework* was established and framed as the reference. In addition, to answer research questions, some data are necessary and data collection methods need to be conducted. The methods for data collection that follow the purpose of this thesis are surveys and interviews. *Surveys* are the first method used in order to find out which logistics function is considered to be the main problem area and the most important function that could cause possible problems in the future. The second method is *interviews*, which are used to determine how to support the 4.5 generation fighter aircraft in four logistics functions. These two methods were conducted during February–March 2012, eleven months after the first flight of Gripen 39 C/Ds in Thailand.

After data collection, some theories are added to make concrete the frame of reference and combined with the initial one as the *final theoretical framework*. Since there are two steps in the frame of reference, this research study can be classed as inductive. Inductive research is a process whereby the exploitation and analysis of related observations leads to the construction of a theory that systematically links such observations in a meaningful way (Dorn, 2008). When there are sufficient data and the frame of reference is complete, the empirical findings and theories are interpreted together as an *analysis* that aims to answer the research questions. Finally, in the *conclusion*, the data analyses are accumulated to answer the research questions directly in order to achieve the research purpose of this thesis.

The next topics in this chapter present respectively the research approaches that concur with the data collection methods, the survey method with the data collection process and a plan for avoiding non-response, the interview method with guidelines for the interview process, secondary information from the author's work experience, and the quality of the study concerning validity and reliability.

2.1 Quantitative vs. qualitative approach

There are two distinctive approaches to study that are mainly based on the kind of information used to study a phenomenon (Blumberg, Cooper, & Schindler, 2008): quantitative and qualitative. *Quantitative* research frequently studies people's attitudes towards various facets of an organization, tends to pay little attention to the context and deals less well with the processual aspects of organizational reality, entails the rigorous preparation of a framework within which the data are to be collected, and presents the organizational reality as an inert amalgam of facts waiting to be unravelled by an investigator (Bryman, 1989). Quantitative data are numbers and figures, so it can be concluded that a survey is a quantitative approach. A *qualitative approach* is a research design that reveals many different emphases from a quantitative approach and there are significant differences in the priority accorded to the perspectives of those being studied rather than the prior concerns of the researcher, along with a related emphasis on the interpretation of observation in accordance with subjects' own understanding. Qualitative data are words, sentences, and narrative, leading us to conclude that interviews are a qualitative approach. Moreover, Blumberg et al. (2008) stated that qualitative refers to the meaning, the definition or analogy, or the model or metaphor characterizing something, while quantitative assumes the meaning and refers to a measure.

Both quantitative and qualitative approaches are used in this thesis since the author would like them to be appropriate for obtaining useful data and being able to answer the research questions perfectly. The quantitative approach would be suitable for a research question that asks *what* since it needs numbers of respondents to decide on the exact answers and many attitudes from many people that can be transcribed in figures. In addition, the qualitative approach would be appropriate for a question that asks *how* since sentences and narrative are needed to answer the question. In this study, the quantitative approach was conducted in the methodology to explore the data, followed by the qualitative approach in order to obtain more data in detail and fill the gaps in the data that the survey method could not achieve. This process is not similar to a new investigation that often starts with a qualitative approach exploring new phenomena and, later on, quantitative studies that follow to test the validity of the propositions formulated in the previous qualitative research (Blumberg et al., 2008). Consequently, using both approaches would make this thesis quite strong regarding data collection and acceptable for interpreting an analysis with many theories.

In other words, the quality of any approach does not so much depend on whether it is qualitative or quantitative, but rather on the quality of its design and how well it is conducted (Blumberg et al., 2008), which will be presented separately in the next sections on the survey method and interviews.

2.2 Survey

The survey method consists of structured questionnaires given to respondents and designed to elicit specific information; the questionnaires may be administered by telephone, person, mail, or electronically (Frankel, Naslund, & Bolumole, 2005). To implement the survey method, the design and selection of the data collection method is important. The data collection process according to Groves et al. (2004) is presented in Figure 2-2.

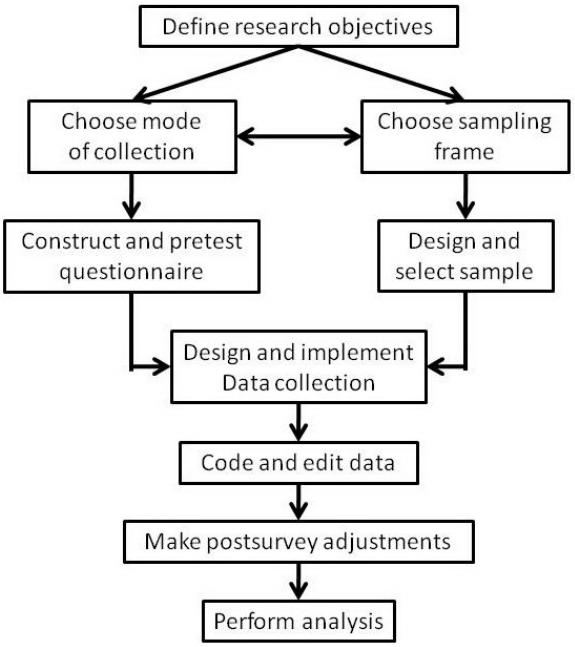

Figure 2-2 Data collection process (Source: Groves et al., 2004)

Following the data collection process, the research objectives have already been defined for the purpose of this thesis. Then, the choice of the mode of collection and sampling frame will be explained. The alternative modes of collection considered included web surveys, in which a computer administers the questions on a web page (Groves et al., 2004), after which the author sends the web link to the questionnaire directly to the respondents' e-mail. The security of the web page is important to keep the data confidential. Thus, finding a web page that has suitable protection is the first process that the author has to undergo.

Google Docs was used to put the questionnaires on the web page since the form can be created easily and it can be sent to respondents via an e-mail address. Moreover, it shows automatically the number of responses, provides a summary of the data in graph form with percentages, and puts all the respondents' answers in an Excel file. In addition to the site's security, a username and password have to be filled in when the author wants to see the data. A web link is sent to the respondents for the questionnaires[1] to be answered.

2.2.1 Respondents

The sampling frame or respondents in the survey are the RTAF officers who work in the RTAF Gripen programme from the top management level in the RTAF Headquarters and Support Section to the technicians in Squadron 701 who repair and maintain these fighter aircraft. The number of eligible respondents is about 130 officers, divided between 3 fields in the Gripen programme: the Program Management Committee, Train-

[1] https://docs.google.com/spreadsheet/viewform?formkey=dGYxb3dBVk0zMW9Dbkc3SU5fTHRUVUE6MQ

ing, and Technology Transfer. In addition, there are officers of any rank and education level who have been involved in this programme since 2008.

The reason why only RTAF officers were selected to respond to the survey and answer the questionnaires is because they understand the intended questions of the researcher, have the necessary information, and are able and willing to provide an answer (Czaja & Blair, 1996). Moreover, there is the question of why some respondents are not Swedish people who have worked with Gripen C/Ds for many years and have a lot of experience in logistics support for these aircraft. The answer to this question should be, firstly, that the different climates in the two countries may cause new problems for the aircraft; secondly, that the culture and attitude towards work of Thai and Swedish people are different; thirdly, that the RTAF Gripen 39 C/D will have a longer supply line; and finally, that the RTAF Gripen logistics aim is to be able to support the aircraft singlehandedly without any advice from Sweden and only to need the Swedish supply support.

After sending the questionnaires to the respondents via a web link during February–March 2012, 64 actual respondents from the 130 eligible respondents answered the survey questions and this information is reported in the Google Docs summary. The response rate is the number of actual respondents (numerator) divided by the number of eligible respondents (denominator) (Fink, 2003a). For this survey, the response rate is 49%. This percentage is reasonable and adequate for giving ideas to this research study. Moreover, it is hard to find basic information to compare with these data since the survey was conducted in military organizations and Fink (2003b) stated that no single rate is considered standard. Additionally, the data are followed by interviews, making all the data more reliable.

2.2.2 Questionnaire

After considering the alternative modes of collection and sampling frame, the questionnaire was constructed. The design of the questionnaire considers not only the implementation of the new system as Gripen 39 C/D, but also the many experiences from the existing system as F-16 A/B and the lessons learned from the problem areas of the logistics function. Moreover, the objective in designing the questionnaire was to convince the potential respondents that this study is important enough for them to devote their personal resources of time and effort to it (Czaja & Blair, 1996). In addition to the questionnaire standard, there are three distinct standards that all survey questions should meet: *content* means the questions will ask the right things, *cognitive* means the respondents understand the questions' consistency and have the information required to answer them, and *usability* means the respondents can complete the questionnaire easily and intend to answer the questions (Groves et al., 2004). Moreover, after constructing the questionnaire, there are different methods to evaluate draft survey questions. In this thesis, the method used was expert reviews. Expert reviews allow experts to review the questions, to assess whether their content is appropriate for measuring the intended concepts, or the questionnaire design, to assess whether the questions meet the three standards mentioned above (Groves et al., 2004).

The author translated the questionnaires from English to Thai since this translation would make it more convenient for Thai respondents to answer the survey questions. Before that, the English version of the questionnaire was reviewed by the author's supervisor. The Thai version was reviewed by the RTAF logistics expert.

The English version of the questionnaire for this thesis is presented in Appendix 1 and consists of four sections that follow the logic of the sampling plan, the data collection procedure, and the question administration: the introduction, respondent selection, background questions, and substantive questions address each aspect of the research goals. Moreover, this questionnaire considers the need to be completely self-explanatory because no one will be present to assist if something is confusing or complex, so the words used in the questions are simpler than the scientific intentions and closed questions are used as much as possible for clarity purposes (Czaja & Blair, 1996).

In addition to the closed questions, the response choices are used and categorized into three scales: categorical or nominal, ordinal, and numerical response choices. *Categorical and nominal response choices* have no numerical or preferential value but simply correct or incorrect, or true or false, such as male or female, *ordinal response choices* let the respondents rate or order the items in a list from very positive to very negative, and *numerical response choices* call for numbers such as age or height (Fink, 2003c). Moreover, as ordinal response choices, bipolar ordinal scales measuring gradation along two opposite dimensions with the zero point falling in the middle of the scale are used instead of unipolar ordinal scales measuring gradation along one dimension on which the zero point falls at one end of the scale (Dillman, Smyth, & Christian, 2009), for instance definitely important–important–probably important–probably not important.

2.2.3 Implementation

After the questionnaire was completed and put onto the appropriate web page, the survey was implemented by sending the web link to the respondents and allowing them to answer the questions. There is a barrier regarding insufficient data from surveys, which is non-response. Thus, the non-response in a survey should be considered. There are three types of unit non-response that cause distinctive effects on the quality of the survey statistics: failure to deliver the survey request, refusal to participate, and the inability to participate (Groves et al., 2004). To solve the non-response in the survey, the plans to implement the data collection were as follows:

- Send the web link to the questionnaire directly to the official RTAF personal e-mail address of respondents, to prevent failure in delivering the survey request.
- Use the top-down strategy by writing an official letter to the Gripen 39 C/D purchase management office to obtain the authorization for the survey in the RTAF and command the respondents to answer the questionnaire, preventing the refusal to participate.
- The use of the Thai language would help the respondents to understand and answer the questionnaire more clearly, since the use of English would result in the inability to participate.

The survey data achieved will be presented in Chapter 5 on the empirical findings; the author obtained a large amount of data from the survey, especially the most important logistics function out of the four that may cause future possible problems in logistics support for the new-generation fighters. Moreover, the survey data provided come from RTAF officers who work in different offices, such as the RTAF Headquarters and Support Group in Bangkok through Wing 7 and Squadron 701 in Suratthani.

Moreover, for clearer data and guidelines to deal with the problems, interviews are another method of data collection that was implemented after the survey had finished so as to gain an additional perspective from people who have worked with the Gripen system more than the RTAF officers and senior RTAF officers who planned all the logistics issues in the RTAF Gripen programme.

2.3 Interviews

Interviewing is a research method that always involves a conversation between people, in which one person has the role of the researcher (Arksey & Knight, 1999), and can be used at any stage of the research process: during the initial phases, to identify areas for more detailed exploration and/or to generate hypotheses; as part of the piloting or validation of other instruments; as the main mechanism for data collection; and as a sanity check by referring back to the original members of a sample to ensure the interpretations made from the data are representative and accurate (Brewerton & Millward, 2001).

In this thesis, interviews are the main focus to obtain more in-depth data about the main topics. Thus, face-to-face interviews were conducted at the RTAF Headquarters in Bangkok and Wing 7 in Suratthani. However, before conducting the interviews, the interview guidelines mentioned below were used as a suggestion, which contained twelve topics and these topics were utilized to present numerous examples of how not to conduct a research interview (Brewerton & Millward, 2001). The guidelines are presented in Table 2-1.

Table 2-1 Guidelines for the interview process (Source: adapted from Brewerton & Millward, 2001)

Topics	**Descriptions**
Design for consistency	Use the same interviewer for all the interviews so that all the data will be from the same source and can be controlled for error.
Obtain as much background information as possible	On the sample interviewees, the setting as the organization or institution, and the area being researched.
Prepare and pilot the interview in advance	In terms of estimated the running time, subject areas to cover, question content, contingency for difficult interviewees, and difficult subject areas.
Ensure privacy and avoid interruptions	Anonymity is a key issue in much research, particularly organizational, so a private office is often a necessity; explains to others that interviews are being conducted.
Put the interviewee at ease	Inquire as to the level of knowledge the interviewee already has; explain the purpose of the interview/research as far as possible; explain the anonymous nature of the research.
Establish rapport	Avoid technical language/jargon; start slowly; establish the level of the interviewee and adapt to him or her.

Topics	Descriptions
Maintain control	Keep to the core areas/questions; remain relevant and directed; if necessary, steer the interviewee back to the point and avoid long discussions of peripheral material.
Avoid bias as far as possible	Bias may arise in terms of leading questions. If interviewers plan to use them, ensure that they are aware of possible biases in the interview situation and are capable of minimizing them.
Be objective	Never make value judgments about interviewees; apply the same standards to each interviewee when classifying information, even at the interview stage.
Obtain the maximum response from each question	Be a good listener and follow up questions with additional probing and exploration when an interviewee appears to have more to say; this also allow the flow of the interview to be maintained to avoid disjointed questioning.
Be sensitive	To the feelings and attitude of the interviewee; avoid antagonizing the interviewee or making him/her defensive; use neutral, non-emotive language; approach sensitive issues with qualifiers.
Give yourself a chance	Allow extra time than expected for each interview as a contingency; leave 10–15 minutes following each interview to revisit, write up, and expand the notes.

The author followed most of the topics in these guidelines; for instance, appointments were made for the meetings with the interviewees before the author's travel to Suratthani. The interviews were conducted individually in a private meeting room. When the interview began, the author gave a short introduction to the thesis and how the data would be used. During the interview, data were recorded by notes and voice recorder to ensure that all the data to be transcribed later were accurate. To provide a better explanation of the four logistics functions used, the interviewees were given a description of the four logistics functions that made it easier for them to answer the questions. Before the end of the interview, the interviewees were allowed to elaborate on any topics they felt were important. The interviews took about an hour the first time and this reduced to 40 minutes later on.

2.3.1 Interviewees

The interviewees are divided into two groups. One is the RTAF logistics team in the National Program Office (NPO), which takes care of all the logistics issues in the RTAF Gripen programme. The team consists of a logistics manager and two assistant logistics managers. The other group is the Swedish Support Group (SSG), which has experience of Gripen 39 C/D operations and logistics support in Sweden and is currently working together with RTAF officers at Wing 7. They have worked in Thailand since these fighter aircraft arrived in Suratthani on 22 February 2011. Their provision to the RTAF is included in the Gripen purchase agreement. They were recruited by people who have

worked with these fighter aircraft and will be in Thailand for two years as advisors to the RTAF officers. There are twelve Swedish people from the Swedish Air Force (SwAF) and Saab Company in the SSG, consisting of commander, engineers, technicians, and pilots.

During the interview planning stage, the author planned to interview the three members of the RTAF logistics team but only one person was available at that time: the logistics manager. The interview with the RTAF logistics manager was conducted at the RTAF Headquarters in Bangkok. For the SSG, six of the twelve people who are involved in Gripen logistics support were selected; however, because of the Gripen deployment to Wing 1 for exercise, only three people were available when the author was in Wing 7, Suratthani. Thus, four interviewees participated in the interviews: one is the logistics manager in the RTAF Gripen programme and the others are Swedish people in the SSG.

2.3.2 Questions

The interview questions were constructed by the author during the survey period and were reviewed by the author's supervisor before being used for conducting the interviews. The reviewed interview questions are shown in Appendix 2. These interview questions are semi-structured in that the main questions and script are fixed, but the interviewer is able to improvise follow-up questions and to explore meanings and areas of interest that emerge (Arksey & Knight, 1999). Moreover, Blumberg et al. (2008) stated that a semi-structured interview usually starts with rather specific questions but allows the interviewer to follow his or her own thoughts later on.

After the interviews, the data from each interviewee were transcribed and combined from two sources: notes and voice recorder. Then, they were sent back to the interviewees for reviewing, correcting, adding, and approving for release in public.

2.4 Secondary data

Viewing information that has been documented before, not with the purpose of collecting information for this specific study, is called viewing secondary data (Dorn, 2008). The secondary data in this thesis come from a literature review of documents in the RTAF Headquarters to support the author's own experience of logistics support for the F-16 A/B. The documents consist of presentations and minutes from meetings among directorates in the RTAF. These data were prepared and collected before the author went to study in Sweden, and an additional review was performed when the author was in Bangkok, Thailand, during February–March 2012. The data are related to the lessons learned after the RTAF faced problems and solved them in F-16 logistics support, especially in four logistics functions to support fighter aircraft: supply, logistics information system, maintenance, and transportation. The problems in the F-16 logistics support indicate the problem areas that may occur for the Gripen 39 C/D in the future and can be used as a qualitative data argument for this research study.

2.5 Validity and reliability

To ensure the quality of the data, validity and reliability are two components that have to be considered. Arksey and Knight (1999) stated that these issues require the researchers to demonstrate the fact that what they are doing is fit for their research purpose. *Validity* raises the question of whether you are actually investigating what you claim to be investigating (Arksey & Knight, 1999), for example whether the questionnaires in the

survey method constrain the respondents. Moreover, Bryman (1989) stated that validity raises the issue of whether the research really relates to the concept that it is claimed to measure. In the survey, the data were ensured to be valid by forming a questionnaire that was reviewed by experts before being sent out to the respondents, and the ordinal response choices were bipolar ordinal scales measuring gradation along two opposite dimensions with the zero point falling in the middle of the scale (Dillman et al., 2009). As a web-based survey, the web link was sent to the respondents' individual e-mail address, which would be more valid for data collection than posting the link in a public social network that cannot limit the respondents' answers.

In addition to the interviews, validity was also constructed by the expert review of the interview questions before conducting the interviews and the interview data that were sent back to the interviewees for correction and the addition of more information if needed. There is a weakness regarding validity in that some interviewees did not answer some questions since they work specifically in logistics functions and the questions were outside their work scope. On the other hand, the validity is acceptable in that the motive of this thesis is that applying a business theory to a governmental/military organization that has political and budget restrictions is not strictly fair due to the different conditions that exist (Dorn, 2008).

Reliability refers to the consistency of a measure that can be taken to comprise two elements: external reliability is the degree to which a measure is consistent over time and internal reliability is the degree of internal consistency of a measure and is particularly important in the context of multiple-item measures in which the question may arise of whether the constituent indicators cohere to form a single dimension (Bryman, 1989). Moreover, the reliability provides the researcher with an indication of the level of consistency across scale items (Brewerton & Millward, 2001) and a discussion in terms of the trustworthiness and authenticity of the research (Arksey & Knight, 1999).

According to the survey and interview method, the reliability was constructed by selecting the respondents and interviewees who have work experience with the Gripen 39 C/D, although it is a new system in Thailand. This selection also ensures all the data are reliable. Moreover, the respondents received a definition of the four logistics functions when answering the questionnaires in the survey and interviews to give them a better understanding of logistics support for fighter aircraft. Also, referring to the number of actual respondents and interviewees, a 49% response rate was achieved in the survey and 4 interviewees participated. This response rate is sufficient to obtain the data to answer the research questions and no single rate is considered the standard (Fink, 2003b). It depends on the situation and the research purpose. The 4 interviewees are also enough to gain more data for answering the research questions since they are high-quality interviews with people who have a lot of experience related to the research purpose.

During the interviews, data were recorded electronically to ensure that everything that was said throughout the interviews was correctly noted (Dorn, 2008), and to make sure that all the informants were asked exactly the same questions and given similar sorts of clarification (Arksey & Knight, 1999). For the survey, the questionnaire was made available on the Google Docs website, which ensures secure analysis of the data since it requires a username and password to view the data. In conclusion, using two methods, the survey and interview, is more reliable than using only one method.

Referring to the secondary data from experiences in F-16 logistics support, those data are considered as a limited resource. In contrast, they do not form the main study in this thesis, but only give an idea of the research study and are used for minimizing the logistics functions scope from thirteen to four by considering the problems and solutions in each function that have been solved in the past to support fighter aircraft.

After the completion of the data collection by survey, interview, and secondary data, all the data are interpreted in Chapter 5 and then the analysis of the data will transform the data into information. The analysis will bring the information together to answer the research questions with business logistics and supply chain theory. In addition, the military logistics and lessons learned from F-16 A/B operations will also be used together with the business theory and knowledge. This process will be interpreted in the analysis in Chapter 6. Prior to that, the frame of reference is discussed in the next chapter and the Royal Thai Air Force is presented in Chapter 4.

3 Frame of reference

To analyse the empirical data from the methodology, the frame of reference has to be studied to discover the appropriate theory and knowledge. This chapter will present logistics theory and other interesting study topics: supply chain management, third-party logistics, performance measurement, strategy, and postponement and speculation.

In addition to logistics, this chapter begins by defining logistics, which includes the four logistics functions that support the fighter aircraft, and the logistics planning process. The chapter proceeds by describing the business theory that involves the method used to solve problems in the past; hence the same theory will be used to prevent potential problems in the future for a different generation of fighter aircraft.

3.1 Logistics

Logistics is the knowledge about managing items from one place to another and supporting the operations or production. In the twenty-first century, logistics should be viewed as part of management and has four subdivisions: business logistics, military logistics, event logistics, and service logistics (Langley et al., 2009). In this thesis, only two subdivisions will be described: business and military logistics.

Business logistics is defined as the process of anticipating customer needs and wants by acquiring the capital, materials, people, technologies, and information necessary to meet those needs and wants; optimizing the goods- or service-producing network to fulfil customer requests; and utilizing the network to fulfil customer requests in a timely manner (Langley et al., 2009). In addition, logistics is the process whereby a commodity or services move from the initial customer order to the final consumption of the commodity or services by the customer (Voortman, 2004).

Military logistics is defined as the science of planning and carrying out the movement and maintenance of forces that are comprised of the various logistic functions that come together to form the totality of logistics support (NATO, 2007). Moreover, Hunt (1956) defined military logistics as the process of planning and providing goods and services for the support of the military forces. Military logistics is divided into peacetime logistics and wartime logistics.

Peacetime logistics, which is expected more than wartime logistics in this thesis, has the role of supporting the creation and sustaining of the military capability for readiness for wartime. In addition, it aims to increase the efficiency in the capability process, depending on the military strategy.

3.1.1 Logistics functions

Regarding business logistics, Jonsson (2008) gave examples of common logistics-related functions as forecasting, customer order management, production and materials management, transport planning, procurement, materials handling and internal transport, production, storage, and freight transport. Each logistics function is described as a functional system and defined by its results, for instance the production system is a system that produces products, a storage system stores components, a transport system transports goods, and a forecast system produces forecasts (Jonsson, 2008).

Moreover, function means a special activity or purpose of a person or thing (*Oxford Advanced Learner's Dictionary of Current English*, 1995), so logistics functions would be assumed to have the same meaning as logistics activities. Voortman (2004) stated that logistics activities are:

- Order processing
- Purchasing and procurement
- Total quality management
- Production scheduling
- Protective packaging
- Stores and warehousing
- Transportation
- Inventory management
- Materials management
- Information management
- Customer service

Each logistics activity is related to each of the others, and they are almost performed step by step in the manufacturing or production of goods that starts with a customer order and is followed by order processing. *Order processing* involves the accurate collecting, processing, and storage of information, which is then passed on to the next link in the supply chain and distribution (Voortman, 2004). In addition, companies have to have their products in storage when customers order them. Thus, *purchasing and procurement* of raw materials and component parts for manufacturing needs should be carried out first in the production. This activity also relates to the transportation cost as procurement decisions need to be made in consideration of the total logistics costs (Langley et al., 2009).

In production, *total quality management* commences with buying the material in the right quantity and making it the right quality, which is the starting block for competing in the global economy (Voortman, 2004). Then, *production scheduling* is the next activity that is closely related to forecasting in terms of effective inventory control (Langley et al., 2009) and involves a careful analysis of the production process (Voortman, 2004) to consider whether the company has enough skilled people to produce the products by using the right tools in order to deliver the products to the customers in time. When the production is complete, the products need protection during transportation and storage by packaging. *Protective packaging* includes materials such as corrugated packaging (cardboard boxes), stretch wrap, banding, and bags (Langley et al., 2009). Moreover, Voortman (2004) stated that packaging performs a number of key tasks in logistics, namely providing information, protection, handling considerations, and storage and transportation considerations. The modes of transportation selected also affect the packaging requirements both for moving the finish goods to the market and for inbound materials (Coyle, Bardi, & Langely, 2003).

After production, products are kept in a warehouse and wait for delivery following the customers' orders. *Stores and warehousing* consider the size and owner of the space for storage, layout and stock placement by handling equipment, location close to the marketplace, and a transportation connection. In addition, this activity has a trade-off relationship with transportation, for instance, companies have to keep a high level of stores and have more warehousing space if they use a relatively slow mode of transport (Coyle et al., 2003). When the destination of the customer is set, transportation is the next activity to consider. *Transportation* is a very important activity in logistics and often generates the largest variable logistics cost (Langley et al., 2009) depending on the modes of transportation. There are five basic modes of transportation: air, rail, road, shipping, and pipeline (Voortman, 2004).

When customers receive and use the products, there is likely to be some feedback that the company should manage itself in some logistics activities such as inventory management, material management, information management, and customer service.

Inventory management involves inventory calculations and inventory control and has two dimensions: assuring adequate inventory levels and certifying inventory accuracy (Langley et al., 2009). Many techniques are used for inventory management: forecasting, reordering, and planning methods. Moreover, Coyle et al. (2003) stated that accurate forecasting of inventory requirements and materials and parts is essential for effective inventory control.

Material management is the activity that projects how to handle raw material and work with process components and finished goods throughout the supply chain, especially in transportation and warehousing. Moreover, material handling is important for efficient warehouse operations and usually concerns mechanical equipment for short-distance movement, including forklift trucks, and overhead cranes (Coyle et al., 2003).

Information management is critical in the supply and distribution of the right product to the right customer at the right time, and assists in determining exactly the customer's current needs and the data that must be supplied to the customer, controlling and monitoring payments automatically, forecasting the required stock level and identifying the most popular stock items, and tracking items (Voortman, 2004).

The last logistics activity in business logistics is *customer service*, which is important because of two dimensions: the process of interacting directly with the customer to influence or take the order and the levels of service an organization offers to its customers (Langley et al., 2009). Moreover, Voortman (2004) stated that customer service is the most critical aspect of the whole supply chain and distribution since, indeed, without customers no business will take place.

In comparison, in the military logistics in NATO, thirteen logistics functions come together to form the totality of logistics support (NATO, 2007) for military forces. They overarch both wartime and peacetime and both national and international operations. They are described in Appendix 3 and are as follows:

- *Supply*
- Materiel
- Services
- *Logistics Information Management*
- *Equipment Maintenance and Repair*
- *Movement and Transportation (M&T)*
- Reception, Staging, and Onward Movement (RSOM)
- Petroleum Logistics
- Explosive Ordnance Disposal (EOD)
- Infrastructure Engineering for Logistics (IEL)
- Medical Support
- Contracting
- Host Nation Support (HNS)

Logistics functions in the military context are expected in the activities that logisticians have to carry out and coordinate with other people in different organizations. In this re-

search, the author sets the situation in peacetime and national operations since this time is the first period in which to implement the complex equipment of the Gripen 39 C/D. Moreover, these logistics functions are concerned specifically with supporting only the fighter aircraft sourced from abroad.

To promote the secondary data and the author's work experience in F-16 A/B logistics support indicating that there are four important logistics functions for supporting fighter aircraft, the decision to reduce NATO's logistics functions from thirteen to four refers to the situation in the thesis. Nine logistics functions are out of the scope of this thesis: materiel, services, RSOM, petroleum logistics, EOD, IEL, medical support, contracting, and HNS. With regard to materiel, this function is covered by supply. Supply covers all the materiel and items used in the equipment, support, and maintenance of military forces (NATO, 2007). Moreover, materiel is one of the four maintenance resources. Thus, *materiel* can be combined in both supply and equipment maintenance and repair functions. In addition, *services* is the provision of manpower and skills in support of combat troops or logistics activities (NATO, 2007), which can be assumed to be personnel in maintenance resources and can also be combined with the equipment maintenance and repair function.

RSOM and *HNS* are not of relevance to this research since the situation is set up in the national operations of the Gripen C/D or only homeland defence. These fighter aircraft are not being deployed abroad, which would need HNS, and are not being operated by large forces such as people and equipment that need RSOM. Moreover, *medical support* is not relevant since this function supports only military troops and humans, not equipment. *Petroleum logistics*, *EOD*, and *IEL* are general logistics support for military forces and not specific to fighter aircraft. Logisticians have to coordinate with other military organizations to provide the support from these functions. Finally, *contracting* has already been undertaken before the operation of these fighter aircraft and thus is also beyond the scope of this thesis.

From the above description, there are five parameters for reducing the thirteen logistics functions to four important functions in logistics support for fighter aircraft. They are the combined function, homeland defence, human support, general logistics support, and prior function, as presented in Table 3-1.

Table 3-1 Parameters for the reduction of the NATO logistics functions to support fighter aircraft (Source: constructed by the author, 2012)

Parameter	**NATO logistics functions**			
Combined function	Materiel	Services		
Homeland defence	RSOM	HNS		
Human support	Medical support			
General function	Petroleum logistics	EOD	IEL	
Prior function	Contracting			
Specific functions for fighter aircraft	Supply	Logistics information management	Equipment maintenance and repair	Movement and transportation

According to the specific functions for fighter aircraft, there are four logistics functions that are related to the NATO logistics functions and the author's work experience in F-16 logistics support when working in the RTAF. They are supply, logistics information management, maintenance, and transportation. Descriptions of each logistics function are provided below:

Supply – this involves raw materiel, commodities, manufactured articles, component parts, assemblies, and units or equipment that have been procured and stored but have not become real property or been installed, and are classified and coded to indicate expendability, recoverability, reparability, and category (United States Air Force, 2012). This function is also one of the fundamental types of core processes of the business logistics system and defines from the identified material the need to receive and approve delivery (Jonsson, 2008). In NATO logistics, supply is divided into classes. The NATO classes of supply are established in the five-class system of identification as shown in Appendix 4 and this function includes the determination of stock levels, provisioning, distribution, and replenishment (NATO, 2007).

Logistics information management – this logistics function couples the available information technology with the logistics processes and practices to meet the logistics information requirements. To be effective, logistics information systems must facilitate the delivery of the right information to the right people at the right time with the right information security protection. They should cover all the logistics functions and interfaces between these functions and other functional areas as required. Interfaces with industrial systems should also be considered where practical and cost-effective (NATO, 2007).

Equipment maintenance and repair – Maintenance means all the actions, including repair, to retain the material in or restore it to a specified condition (NATO, 2007). This function is divided into two types: *corrective maintenance*, which restores the equipment to its desired operating condition after a breakdown or failure, and *preventive maintenance*, which is carried out in order to decrease the failure probability (Pintelon et al., 1999). Repair includes all the measures taken to restore material to a serviceable condition in the shortest possible time (NATO, 2007).

Nowadays, information and communication technology (ICT) is evolving extremely quickly. Moreover, this technology blends to produce almost human behavior and is also used in maintenance. Management information systems are used for integration among maintenance resources at present. This process involves many factors and activities requiring support within the new platform of maintenance in complex equipment such as fighter aircraft: this process is called eMaintenance. eMaintenance is a structured and coherent application of ICT throughout the whole life cycle of the support system, coordinated with technical solutions in the aircraft system (Candell, Karim, & Söderholm, 2009a). In addition, the main objective of eMaintenance is to enhance and support the maintenance process by establishing a content-sharing process based on ICT that provides the right information at the right time, of the right quality, to the right actor (Candell, Karim, & Söderholm, 2009b).

Movement and transportation – It is a requirement that a flexible capability exists to move forces in a timely manner within and between theatres to undertake the full spectrum of the Alliance's roles and missions. It also applies to the logistic support necessary to mount and sustain operations. It also means the transportation of the supply from

one place to another place (NATO, 2007). Presently, commercial transport companies are used, if the mission and items in military organizations are not classified, since it is more cost-efficient, frequent, and allows a larger cargo than using military capability.

The fact that there are thirteen logistics functions to process in logistics support means a lot of tasks and activities need to be carried out, otherwise they will accumulate, thus causing problems in operations. Eccles (1959) defined this phenomenon as a *logistics snowball*, as logistics activities tend to grow to an inordinate size like a snowball, they tend to become rigid, and they tend to acquire a very physical momentum.

Moreover, the logistics snowball is caused by three major factors: *the effect of the industrial revolution* since the new military equipment demands more logistics support in both supply and maintenance to make tactical units more efficient, *a very high standard of modern living* is required to enhance the morale of the troops in operations, as the standard of living should be similar to the one at home and more modern, causing more logistics support for them, and *the failure of many commanders and staff planners to understand the nature of the snowball and its full implications*, causing an understanding of the logistics support to be very important in the planning process since it would be too late and take time when logistics problems occur during operations (Eccles, 1959).

Thus, the logistics snowball is a phenomenon whereby logistics activities tend to grow out of all proportion to the tactical forces that they support, and evidently occur when there is inadequate planning in the logistics functions to support the military forces. When the logistics support is insufficient, it affects the military operations more and more since the troops and military equipment always need support, so small problems accumulate to become bigger ones that affect the efficiency of military operations.

3.1.2 Logistics planning process

To minimize the logistics snowball, planning is very important. According to the military logistics, planning consists of three levels: the strategic level, operational level, and tactical level. To describe the logistics planning levels more clearly, using an analogy from the restaurant business, at the strategic level the plans concern the design of the kitchen, the pantry, and the dining hall, the operational-level plan determines the monthly work schedule and menu, and the tactical-level plan is concerned with planning today's menu (Kress, 2002).

Moreover, the logistics planning process in the operation comprises two stages. The first stage is macro-logistics planning and the second is micro-logistics planning. The whole process with the two stages is shown in Figure 3-1.

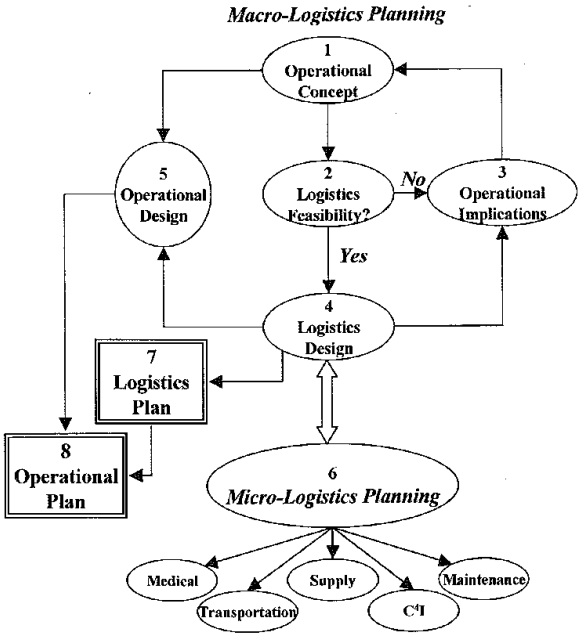

Figure 3-1 Macro/micro-logistics planning (Source: Kress, 2002)

The macro-logistics planning begins with the operational concept that characterizes the basic properties of a military operation and also embodies the logistics concept (Kress, 2002). Then, it is the role of the logistics part to screen and determine the feasibility, providing the responsiveness to the operation concept. If the answer is Yes, the next step of the logistics design continues with the detailed analysis at the micro-planning stage of all the logistics functions: supply, maintenance, transportation, C^4I (command, control, communication, computer, and intelligence), and medical. When the logistics design is complete, it is declared to be the logistics plan.

Besides, this micro-logistics planning promotes the importance of the four logistics functions to support the fighter aircraft mentioned previously and logistics information management can be assumed to be the C^4I in logistics.

3.2 Supply chain management

Supply to support the operations in military logistics is very important to respond to the demands from the operational unit. According to the business situation nowadays, globalization, and complex equipment from other countries, supply is not only sourced from local suppliers but also from the global chain. Thus, to deliver the supply to the customers in time, supply chain management is created to help firms achieve customer satisfaction and competitive advantage.

Supply chain management (SCM) is defined as the art and science of integrating the flows of products, information, and finance through the entire supply pipeline from the supplier's supplier to the customer's customer (Langley et al., 2009). In addition, SCM is defined as the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole (Mentzer et al., 2001). There are many actors in the business supply chain, as shown in Figure 3-2.

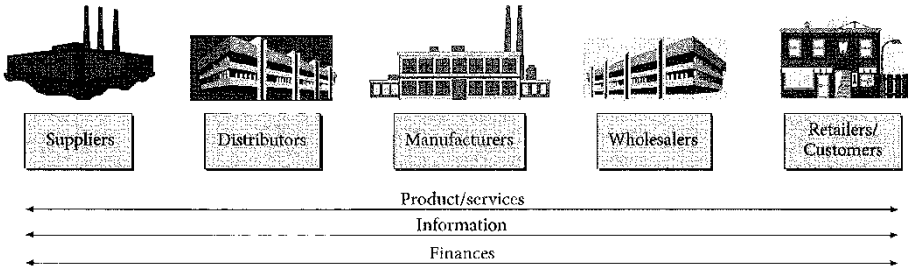

Figure 3-2 Actors in supply chains (Source: Langley et al., 2009)

As shown in Figure 3.2, there are three flows that are very important to the success of supply chain management (Langley et al., 2009): the *product/services flow* is the top flow that has traditionally been an important focus of logisticians and it is a two-way flow in today's environment because of the growing importance of reverse logistics systems for returning products, the *information flow* has traditionally been viewed in the opposite direction to that of products but it is shared along the supply chain at present with less uncertainly and less safe stock, and the *finance flow* is more specifically cash and has been viewed as one-directional-backward in the supply chain or, in other words, payment for goods, services, and orders received (Coyle et al., 2003).

To adapt the business theory to military logistics, we compared and defined the actors between the business supply chain and the defence supply chain. An example of a defence supply chain is shown in Figure 3-3.

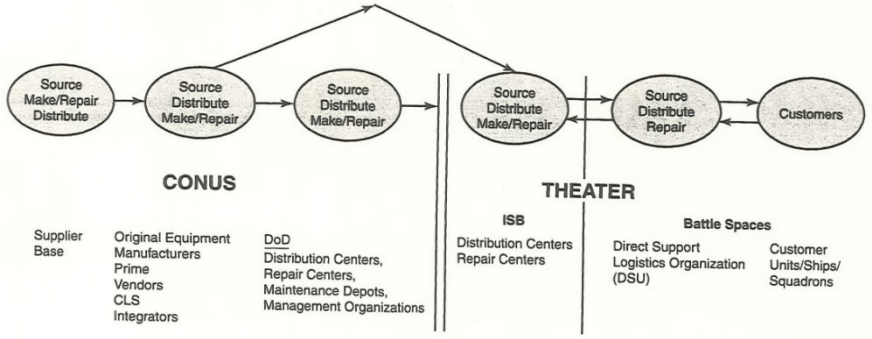

Figure 3-3 US defence supply chain (Source: Tuttle, 2005)

In Figure 3-3, the schematic is divided into two regions: *Contiguous United States* (*CONUS*), which includes for the purpose bases abroad where forces are normally stationed, and *theatre*, the geographic combatant command areas (Tuttle, 2005) that force deployment from the mainland to these areas. There are primary flows of goods and services from left to right and critical flows from right to left in the form of the return of disfuntional equipment and components needing repair.

After consideration of the role of actors in the business supply chain compared with that in the defence supply chain, the actors from the two supply chains that are similar are: supplier – Defence/commercial industries, distributer – distribution centre/TPL, manufacturer – procurement agency/depot, wholesaler – maintenance and support unit, and customer – operation unit.

3.3 Third-party logistics and fourth-party logistics

Rising customer service expectations, increased attention to costs, widespread application of the marketing orientation, and increasing international competition have all increased businesses' need to perform (Bloomberg, LeMay, & Hanna, 2002). These factors urge companies to outsource some logistics functions to a more professional company as third-party logistics. Moreover, the investment in the assets related to logistics functions in the company is costly and would not have an efficient and professional production process. The new alternative way to achieve cost reductions and service improvements in logistics functions and attain greater efficiency in a company is to outsource these functions by hiring third-party logistics firms that are more professional and have scale. Also, using the third-party logistics firms shares the risk involved in logistics functions.

A third-party logistics firm (3PL) is defined as an external supplier that performs all or part of a company's logistics functions (Coyle et al., 2003), such as transportation, warehousing, distribution, and financial services. Moreover, Christopher (2005) defined this firm as a company that provides a range of logistics activities for its clients and might operate distribution centres, manage the delivery of the product through its transport fleets, or undertake value-adding services such as repacking. According to Langley et al. (2009), the terms contract logistics and outsourcing are sometimes used in place of 3PL.

The evolution of 3PL stems from the effort of logistics service providers (LSPs), which tend to position themselves in the third-party market by focusing on a need-based position that satisfies a specific customer and requires a high degree of coordination and integration of the process to be competitive (Persson & Virum, 2001). Moreover, LSPs not only need to focus on the need-based position, but also to have their own physical assets to perform specific logistics functions related to these assets when they want to be third-party logistics operators. Persson and Virum (2001) defined third-party logistics operators as LSPs that have become more needs-based, respond to the small but growing third-party logistics market, have established departments or more independent business units to cover the target segment, and find customers who are consistent with their asset bases.

Regarding the types of 3PL, Langley et al. (2009) categorize them into five types based on their logistics activities: transportation-based, warehouse/distribution-based, forwarder-based, financial-based, and information-based firms. Financial-based firms provide services such as freight payment and auditing, cost accounting and control, and logistics management tools for monitoring, booking, tracking, tracing, and managing inventory. In addition to forms of 3PL, they are, for example, freight forwarders, international freight forwarders, property brokers, non-vessel operating common carriers, shippers' associations, and shipping agents (Bloomberg et al., 2002).

Furthermore, the strategic reasons for outsourcing are cost reduction, service improvement, strategic flexibility, focus on the core, and change implementation (Laarhoven, Berglund, & Peters, 2000), which can be assumed to be the benefits of outsourcing. Although there are many benefits to outsourcing some functions in the company to 3PL, companies should consider carefully not outsourcing the core functions to other firms. Otherwise, the competitive advantages in the company will be reduced and may be transferred to the competitors. In addition to the success with 3PL, the key success fac-

tors are considered, which are well-defined requirements, procedures and systems, close and dedicated working relationships, top management involvement, clear separation of responsibility, a tiered provider structure, and strong performance orientation (Laarhoven et al., 2000).

From the underpinning principle that modern supply networks are becoming increasingly global, and certainly more complex, and the capabilities to manage the network probably do not exist in any one organization (Chirstopher, 2005), the idea of fourth-party logistics (4PL) originated. 4PL is developed from 3PL in services and customer relationships involving the coordination of a few customers, customer adaptation, and a focus on specific niches of a few customers whereby both the knowledge development and the adaptation can be high and can still be used for coordinating the customers' activities (Hertz & Alfredsson, 2003). Christopher (2005) stated that there are four key components that must be in place and assembled by 4PL, which are:

- Systems architecture and integration skills
- A supply chain control room
- The ability to capture and utilize information and knowledge across the network
- Access to best-of-breed asset providers

The evolution of 4PL comes from the development of specific and important issues of 3PL. These issues are organizing and neutrality of the TPL business, internationalization, and the effects of strategic alliances, mergers, and acquisitions (Hertz & Alfredsson, 2003). 4PL is similar to the classification of 3PL firms, related to the abilities of customer adaptation and problem solving as a customer developer. A *customer developer* is the most advanced and difficult form, involving a high level of integration with the customer, often in the form of taking over its whole logistics operations (Hertz & Alfredsson, 2003). To develop a clearer understanding of 4PL, an example of 4PL is presented by the LINC firm in Figure 3-4.

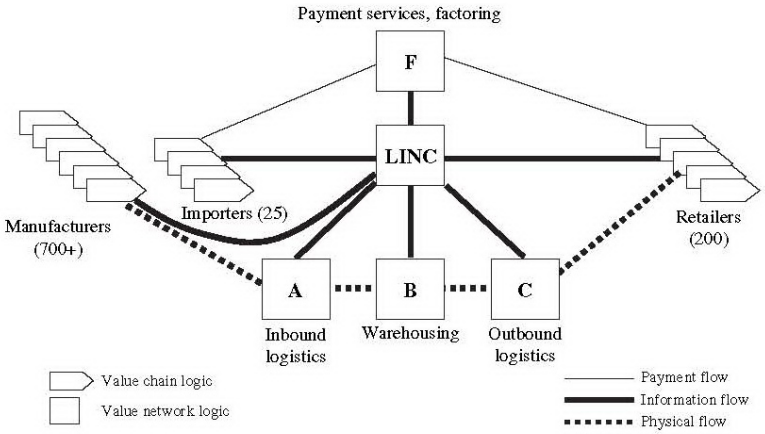

Figure 3-4 Example of 4PL – LINC firm (Source: Huemer, 2006)

LINC provides and integrates services for customers in four types of 3PL. Transportation-based is outsourced to A, warehouse/distribution-based to B and C, financial-based to F, and information-based to LINC's own infrastructure. The core of LINC's own infrastructure is its integrated logistics governance system, which controls the network's flow of goods, including purchasing, transportation, warehousing, ordering of sales, and invoicing (Huemer, 2006).

3.4 Performance measurement

To achieve efficiency in the production process and effectiveness to achieve the goal, performance measurement is carried out in organizations. According to Mentzer and Konrad (1991), performance measurement is the analysis of both effectiveness and efficiency in accomplishing a given task, where effectiveness is defined as the degree to which a goal is achieved and efficiency is defined as the ratio of resources utilized against the results derived. Moreover, in logistics performance measurement, the measurement characteristics should be realistic, representative, related to other criteria, acceptable to management, consistent from one situation to another, inexpensive, and understandable.

Logistics performance measurement is categorized into hard measures, such as net income or accounting figures, and soft measures, such as customer satisfaction ratings (Chow, Hever, & Henriksson, 1994). Moreover, Bloomberg et al. (2002) stated that these measurement techniques revolve around cost, productivity, and service. According to military logistics, soft measures are a good method for performance measurement and measuring productivity and services since military organizations are non-profit organizations and the aim in military logistics is responsiveness in the operations.

According to Chow et al. (1994), the logistics performance in the business that needs to be measured and achieved consists of sales growth, job security and working conditions, customer satisfaction, product availability, cost-efficiency, profitability, social responsibility, on-time delivery, keeping promises, low loss and damage, fair prices for inputs, and flexibility. A selection of some of the logistics performances above would also apply in the military context.

3.5 Strategy

The goal will not achieve effectiveness if a guideline or plan is not constructed beforehand. Thus, a strategy is needed. A strategy is a construct that has evolved to signify an identifiable behaviour in humans (Grattan, 2002). Moreover, in the business context, strategy is the pattern of objectives, purpose or goals, and the major policies and plans for achieving these goals, stated in such a way as to define the business the company operates in or that it is to operate in the future (Hofer & Schendel, 1978). Also, in the military context, strategy is the art of distributing and applying military means to fulfil the ends of the policy (Freedman, 1981).

To achieve a goal successfully in business, the strategy has to fit. A strategic fit means that both the competitive and the supply chain strategies have aligned goals that refer to consistency between the customer priorities and the competitive strategy hopes to satisfy the supply chain capabilities that the supply chain strategy aims to build (Chopra & Meindl, 2001).

Conversely, strategic change should be undertaken when the strategy does not fit. This change is caused by the factors that more and more managers have to deal with today: new government regulations, new products, growth, increased competition, technological developments, and a changing workforce (Kotter & Schlesinger, 2008). Moreover, the strategic change decision should be made from the strategic level and needs an implementation process to avoid any resistance. Bruch, Gerber, and Maier (2005) stated in regard to strategic change that top executives must systematically make two decisions:

first, they need to decide what the right change is for their company and second, they need to decide how to implement the change correctly.

3.6 Postponement and speculation

Customer satisfaction is the aim of many companies, which in turn will increase their economies of scale, profits, and long customer relationships, thus maintaining their position in the market, requiring large amounts of investment in business. On the other hand, these companies also need to achieve cost reductions and efficiency in their production and distribution by avoiding establishing warehouses near the customers' location and also avoiding keeping a dead stock of products. Thus, of the reasons mentioned above, the concept of speculation and postponement strategies originates to respond to customer requirements. This concept offers opportunities to achieve the delivery of products in a timely and cost-effective manner by rearranging the conventional production and logistics structure (Pagh & Cooper, 1998).

Speculation is the concept that permits goods to be ordered in large quantities, reducing the cost of sourcing and transportation; moreover, it limits goods from being lost due to stock outs and it also permits the reduction of uncertainly in a variety of ways (Bucklin, 1965). In addition, Pagh and Cooper (1998) state that this concept makes it possible to gain economies of scale in manufacturing and logistics operations, and limit the number of stock outs. According to the context of supply chains, speculation means that value-adding or material-moving activities are carried out without any commitment from a customer in the form of an order (Jonsson, 2008). Referring to military logistics, speculation is assumed to be stockpiling to react faster in operations than the capability of a supply chain in production, inventory, and lead time.

On the other hand, the market at present is in high competition, leading to high investment, which in speculation is not good for the company. Cost-efficiency is a more important aim to maintain in the market, which means decreased costs but increased effective services to the customer. This situation alters the speculation concept to postponement. *Postponement* is the concept of delaying activities until the latest possible point in time when the exact attributes of the demand can be identified (Yang, Burns, & Backhouse, 2004) and extends the manufacturing and logistics operations until final customer commitments have been obtained and the risk and uncertainly of those operations can be reduced or fully eliminated (Pagh & Cooper, 1998). Moreover, this concept is shown as a comprehensive strategy, capable of driving changes in the structure of the supply chain (Boone, Craighead, & Hanna, 2007). The main advantages of using the postponement concept are a better fit with customer demands (Jensen, 2009) and the reduction of wrong manufacturing or incorrect inventory deployment when the working arrangement in companies allows the postponement of the final manufacturing, customization, or distribution of a product until the receipt of a customer order (Bowersox, Closs, & Cooper, 2010). In addition to the benefits of postponement, they include reducing inventory levels across the supply chain while improving customer responsiveness (Yang et al., 2004).

Not only do the benefits of postponement reduce costs and uncertainty in the company, but the establishment of third-party logistics (3PL) with high capabilities in services also makes the postponement concept more relevant, especially in logistics postponement. Logistics postponement aims to maintain a full time of anticipatory inventory at one or a few strategic locations, postponing changes in the inventory location down-

stream in the supply chain to the latest possible point (Pagh & Cooper, 1998). Moreover, this concept presents an opportunity to shift the risk of owning goods from one position in a supply chain to another (Boone et al., 2007), for instance in transportation. When companies use 3PL to deliver goods, the risks moves from the company to the 3PL. An attempt to minimize the risk is achieved by reducing the safety stock level of the inventories and relying more upon speedy delivery from 3PL (Bucklin, 1965).

Focusing on the downstream part of the supply chain from factory to end customer, Pagh and Cooper (1998) identified four generic supply chain postponement and speculation (P/S) strategies in a 2×2 matrix, which can be referred to as the P/S matrix. This matrix is presented in Figure 3-5.

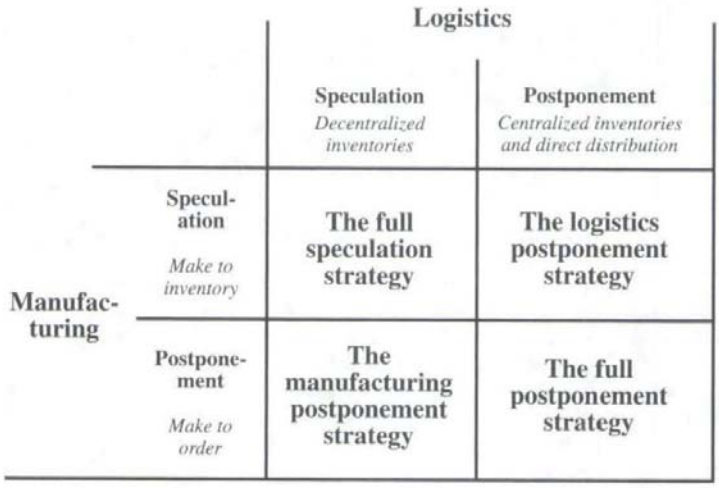

Figure 3-5 The P/S matrix and generic supply chain P/S strategies (Source: Pagh & Cooper, 1998)

The four generic supply chain P/S strategies are the full speculation strategy, the logistics postponement strategy, the manufacturing postponement strategy, and the full postponement strategy. To support fighter aircraft, there are two interesting P/S strategies from the P/S matrix that are involved in logistics support: the full speculation strategy and the logistics postponement strategy.

The *full speculation strategy* is based on forecasts with mass manufacturing, mass distribution, and producing to stock, which is most often the traditional set-up (Jensen, 2009) of the companies. In this strategy, the product is stocked close to customers, and distributed through a decentralized distribution system so that the inventory investment will be high (Pagh & Cooper, 1998). To understand this strategy more clearly, an illustration of the full speculation strategy is presented in Figure 3-6.

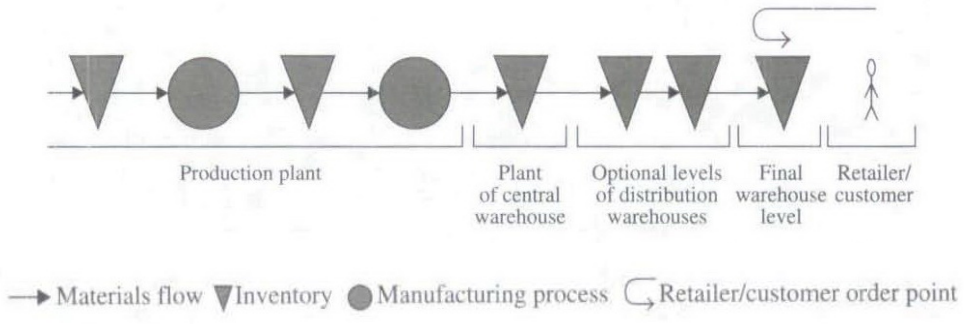

Figure 3-6 Illustration of the full speculation strategy (Source: Pagh & Cooper, 1998)

The *logistics postponement strategy* is based on manufacturing in advance to forecasts, but not moving goods to their final destinations until the demand for a particular area is known (Jensen, 2009); the basic notion is to build and stock a full-line inventory at a limited number of strategic locations (Bowersox et al., 2010). Similarly, this strategy of make to inventory but centralized inventories and direct distribution results in increased on-time deliveries of complete orders, shorter and more reliable lead times, reductions in inventory costs, constant transportation costs, and faster introduction of new products into the assortment (Pagh & Cooper, 1998). For a clearer understanding, an illustration of this strategy is presented in Figure 3-7.

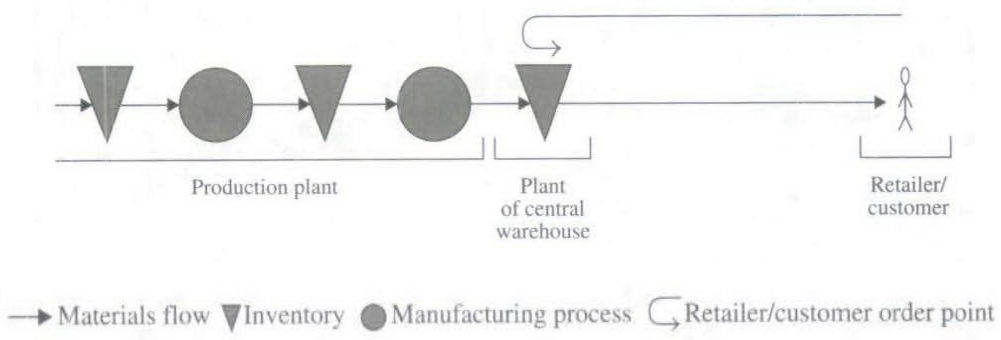

Figure 3-7 Illustration of the logistics postponement strategy (Source: Pagh & Cooper, 1998)

In a real business situation, the postponement cannot occur everywhere (Boone et al., 2007). A hybrid strategy between postponement and speculation would be applied to respond to customer requirements. According to the military context, the relevance of the P/S strategies from the commercial side can be questioned due to the different purpose of the commercial side, which is to increase revenue, while the military organization focuses on value for money.

Following the frame of reference, the Royal Thai Air Force is presented in the next chapter, Chapter 4, in order to provide the reader with an in-depth understanding and clearer vision of the empirical data, which are described in Chapter 5.

4 Presentation of the Royal Thai Air Force

The Royal Thai Air Force (RTAF) is one of three military branches in Thailand and was founded in 1937 and separated from the Royal Thai Army (RTA). The first three pilots were trained in France and the first batch of aeroplanes was imported after they graduated; the RTAF increased its capability by procuring materiel and manufacturing various types of aircraft after the First World War. Until 1951, the United States of America (USA) provided military assistance to Thailand with various types of air trainers and fighters, which caused the shutdown of the Thai aircraft manufacturing factory. On the other hand, the depot maintenance of aircraft capabilities has been retained in the RTAF. The current high-performance jet fighters of the RTAF are Gripen 39 C/Ds from the Kingdom of Sweden since 2011, and F-16A/Bs from the USA since 1988.

The *mission* of the RTAF is to prepare the air power and capabilities of the Air Force, defend the kingdom, and operate the air power and follow the authority and function of the Ministry of Defence. The Commander-in-Chief of the RTAF is the supreme commander and has overall responsibility (Royal Thai Air Force, 2012).

The *vision* of the RTAF is to be "One of the Best Air Forces in ASEAN" in 2019, and the RTAF strategy is specified in three phases:

- *Digital* Air Force during 2008 to 2011
- *Wisdom* during 2012 to 2015
- *Never Lose* with network-centric operations (NCO) during 2016 to 2019.

The *core values* of the RTAF are the path for the RTAF personnel commonly to uphold in order to represent their identity and to create air-mindedness, abbreviated hereby to "AIR", and are divided into three concepts (Royal Thai Air Force, 2012):

- *Airmanship* implies that the RTAF personnel are to be disciplined and knowledgeable about the principles, steps, and operational skills. They are to perform their tasks professionally, be self-aware, be capable of making proper decisions in critical situations, and be able to work together effectively as a good team.
- *Integrity and allegiance* imply that the RTAF personnel are to uphold the honor system and be loyal to the nation, religion, and monarchy. They are to have moral courage, as well as being ethical, honest, equitable, professional, and open-minded towards any comments.
- *Responsibility* implies that the RTAF personnel are to be responsible for themselves, the organization, the society, and the country in order to perform their duties successfully and efficiently by aiming to achieve the common interests to benefit the country as a whole.

4.1 Organizations

The current number of RTAF personnel is approximately 45,000, with approximately 300 aircraft in service. The RTAF has just accomplished reorganization in 2010 to create greater efficiency in the working process.

The RTAF organization consists of five major components: the *General Staff Section* (9 directorates and 5 offices), *Combat Section* (a directorate, a force command, 11 wings, and a school), *Support Section* (7 directorates), *Training and Education Section* (a directorate and an academy), and *Special Affairs Section* (a directorate, an office, an institute, and a centre). All the organizations are presented in Figure 3-1.

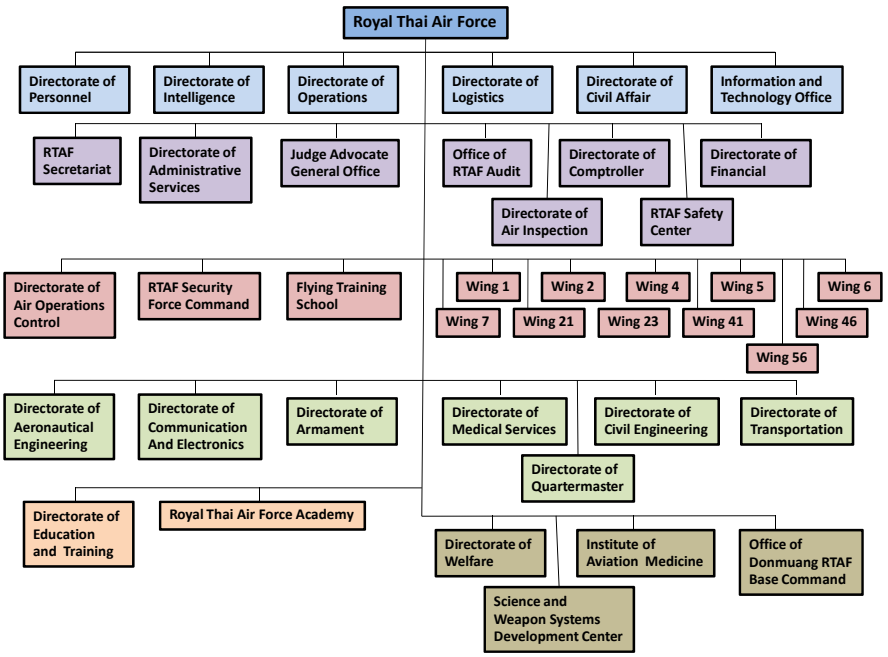

Figure 4-1 The Royal Thai Air Force (RTAF) organizations (Source: constructed by the author, 2012)

In the Combat Section, each wing consists of operational units called *squadrons*. The number of squadrons in a wing is dependent on the type of wing, which is a Main Operating Base (MOB) or Forward Operating Base (FOB), for example Wing 7 is the MOB in the southern part of Thailand and has two squadrons: the 701 and 702 squadrons. A squadron is the smallest unit that operates and maintains the aircraft.

Logistics support for the fighter aircraft is involved in five directorates: a directorate in the General Staff Section and four directorates in the Support Section. The mission and activities of each directorate are as follows:

- *Directorate of Logistics* (*DL*): the mission of the DL is to consider, bring up policy, plan, direct, coordinate, control, develop, and process logistics issues. Refer to procurement, the DL takes care of government-to-government (G-to-G).
- *Directorate of Aeronautical Engineering* (*DAE*): the mission of the DAE is to plan the action, direct, coordinate, follow, control, develop, and process aeronautical issues relating to equipment and supply management, production, maintenance, and technical standardization.
- *Directorate of Communications and Electronics* (*DC&E*): the mission of the DC&E is to plan the action, direct, coordinate, follow, control, develop, and process the communications and electronics issues regarding equipment and supply procurement, supply management, calibration, maintenance, and technical standardization.
- *Directorate of Armament* (*DA*): the mission of the DA is to plan the action, direct, coordinate, follow, control, develop, and process armament issues relating to equipment and supply procurement, supply management, explosive ordnance disposal (EOD), production, maintenance, and technical standardization.
- *Directorate of Transportation* (*DT*): the mission of the DT is plan the action, direct, coordinate, follow, control, develop, and process transportation issues concerning equipment and supply procurement, supply management, repair, maintenance, technical standardization, transport services, and custom clearance.

From the description of directorates, it is apparent that they conduct similar activities in logistics functions to support fighter aircraft and that there are three sources of supply, maintenance, and technical responsibility in an aircraft: the DAE, DC&E, and DA.

4.2 Logistics and supply chain

Logistics in the RTAF is divided into four branches: supply, maintenance, real estate, and services. Only three of them are involved in logistics support for fighter aircraft according to the secondary data as well as the NATO *Logistics Handbook* (2007).

Supply is the first branch for which the directorates in the Support Section have their own warehouse and inventory of supply since they have their own budget for procurement and maintenance. There are three types of procurement in the RTAF: *direct purchase* (*DP*) is procurement from foreign commercial companies, *local purchase* (*LP*) is procurement from in-country commercial companies, and *government-to-government* (*G-to-G*) is procurement from another nation's government, for instance from the USA in Foreign Military Sale (FMS), Germany in purchasing the Alpha jet aircraft, and Sweden in purchasing the Gripen 39 C/D aircraft.

Three directorates are involved in the supply management of aircrafts as well as three types of procurement; the RTAF supply chain to support the fighter aircraft is presented in Figure 3-2.

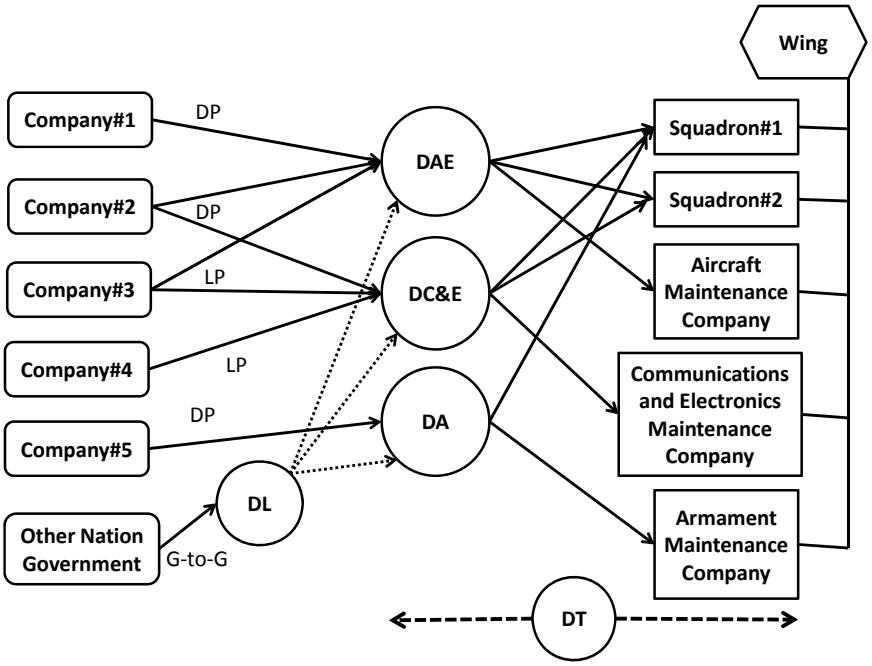

Figure 4-2 The Royal Thai Air Force (RTAF) supply chain (Source: constructed by the author, 2012)

Secondly, *maintenance* in the RTAF for aircraft is divided into three levels: the organizational (O) level operated by the squadron, the intermediate (I) level operated by the maintenance company in the wing, and the depot (D) level operated by directorates in the Support Section for which squadrons have to fly their aircrafts to the workshop for doing the maintenance. Finally, *services* for the aircraft are expected to be transported for service by the DT from the directorate to the units in the wing, whereas transportation from suppliers to directorate is usually the responsibility of the suppliers. The DT only helps in custom clearance, thus the military is exempt from paying taxes.

5 Empirical findings

From the introduction through to the methodology, there are many data to be presented in this chapter, which is divided into three parts. Firstly, the data from the experience in F-16 A/B logistics support by the RTAF are presented in relation to why four logistics functions are important to support fighter aircraft, instead of the thirteen logistics functions stated in the NATO *Logistics Handbook*. Secondly, the data from the survey method are presented from the perspective of the RTAF personnel. Lastly, the data from the interviews are presented in the area of the RTAF logistics planning to support the Gripen 39 C/D in Thailand, and also from a Swedish personnel perspective.

5.1 Experiences and lessons learned from the F-16 A/B

The RTAF has operated Lockheed Martin F-16 A/Bs for more than 20 years. During the operations, there have been many problems in logistics support related to four logistics functions: supply, logistics information management, maintenance, and transportation. Since these four logistics functions caused the problems to the F-16 A/B, it is important for the RTAF to be aware of them when supporting the Gripen 39 C/D in the same logistics functions, and these functions are more important than nine of the thirteen logistics functions in the NATO logistics system, as mentioned before. In addition, the problems occurring in the past have already been solved and collected as lessons learned and experience for fighter aircraft in the future. The problems and solutions are presented in each logistics function as follows:

Supply – the problems are out of stock, long lead-time restocking, and budget support. For the solutions, the RTAF is trying to make new calculations for restocking and supply priority: which supply should be prepared in the warehouse to support the fighter aircraft in time. Moreover, in the Foreign Military Sale (FMS) system, a tracking process has been created since the supply is distributed from the US warehouse to the ports in Thailand. If it is a necessary and valuable supply, air transportation would be used to deliver it, which will cut down the lead time. Due to the limited budget, it is crucial to manage a lean process in order to purchase more supplies.

Logistics information management – the RTAF just changed the logistics information system from an Automated Logistics Management System (ALMS) to a Logistics Management Information System (LMIS); the transition period causes a problem with user satisfaction and new system compatibility, and it took a long time for RTAF officers to become familiar with the new system. This problem affected the operations and logistics, which were slower than before. The problem was solved by teaching the team how to run the new system and receiving immediate comments from users, as well as creating the guideline book and a web board for Q&A.

Maintenance – spare parts, manuals/technical publications, equipment, and technicians are the important factors in complete and efficient maintenance. Conversely, these factors can also be the problems in maintenance, such as skill transferability from the repositioning and promotion of technicians, obsolete technical publications from the long process to obtain the information, and equipment readiness from old equipment not being replaced when unavailable. These problems are the most difficult to solve since they involve human beings; however, we attempted to solve those issues by transferring the military technicians to civilians, thus forming a company to take over the maintenance tasks. For the manuals/technical publications, we signed up more accounts for the tech-

nicians to access the website directly so as to obtain the information earlier. In addition, there is a lack of equipment due to the limited budget. Thus, we arranged for a larger budget and purchased new items or repaired them to be ready for maintenance.

Transportation – the problems in transportation are limited to means of transportation, as well as being subjected to old regulations and lack of innovation. They hardly affect the supply that is to be delivered through land; however, the effect is on the supply that has to be delivered by air, examples of which are jet engines. Because of the road conditions in the past, the regulations state that jet engines have to be delivered only by air; moreover, the limited number of airlifts in the fleet has a more significant mission than delivering spare parts. We tried to find solutions by checking the road condition and regulations, then found that the regulations were too old and had to be improved. In addition, the road condition is better today than in the past. Thus, we have improved the regulations to allow jet engines to be delivered by land and hired a transport firm to innovate a normal truck to carry a jet engine, which comprises air bags and vibration warning indicators to absorb and warn about over the limit vibrations when the truck run on the road. The experiment with the trucks has already passed the standard of vibration stated in the technical publication. Thus, the truck has been used to deliver jet engines instead of military airlifts. The truck is presented in Figure 5-1.

Figure 5-1 Jet engine in land transportation (Source: The RTAF presentation, 2010)

Although all the problems had already been solved to make the F-16 A/B reach its full mission capability (FMC) that the RTAF requires, some problems took a long time to solve. Thus, it will be better for all four logistics functions to have preventive methods in logistics support for the new-generation fighters.

5.2 Survey data

After sending the web-based questionnaire by e-mail, 64 responses were received. As a result, this number of responses gives enough data to answer the research question.

5.2.1 Actors

The 64 respondents are from 3 fields that are involved in the RTAF Gripen programme: the Program Management Committee, Training, and Technology Transfer. On the other hand, their task fields in the programme will not give a proper result for analysis, since these tasks are their special responsibility in their normal work according to their position. When the programme is accomplished, these responsibilities will consequently be finished. Thus, to perform the analysis in a proper way as they are the important actors, the respondents were divided into three groups according to their office. Referring to the

RTAF organizations and supply chain, three sections are involved in supporting fighter aircraft related to the respondents and the author compared these sections with the answers in the questionnaires: the General Staff Section as *the RTAF Headquarters*, the Support Section as the *Support Group (DAE, DCE, DA,...)*, and the Combat Section as *Wing 7 and Squadron 701*.

The number of respondents from the RTAF Headquarters is 24 (37.5%) and this amount is the same as the respondents from Wing 7 and Squadron 701. The smallest number of respondents by office is from the Support Group with 16 responses (25%). The percentage of all the respondents' offices is presented in a graph in Figure 5-1.

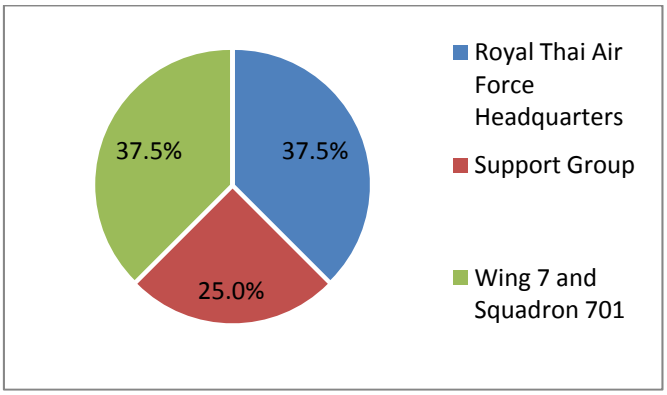

Figure 5-2 Respondents' office (Source: constructed by the author, 2012)

Thus, the actors in the RTAF to support fighter aircraft in logistics functions are from three offices. Subsequently, the actors are represented by their office names to be clearer about their works and perspectives.

In addition to the background of actors, their rank and highest level of education is mostly at the operational level. The highest rank is Squadron Leader (Sqn.Ldr.) to Group Captain (Gp.Capt.) with 43 responses (67%). Their highest educational level is Master's degree with 26 responses (41%), and the second highest is Bachelor's degree with 35 responses (55%). Moreover, Bachelor's degree received the highest amount of responses only in the RTAF Headquarters and Wing 7 when the actors are separated into their offices. The highest amount of the highest education in the Support Group is Master's degree. This solution is presented in Figure 5-3.

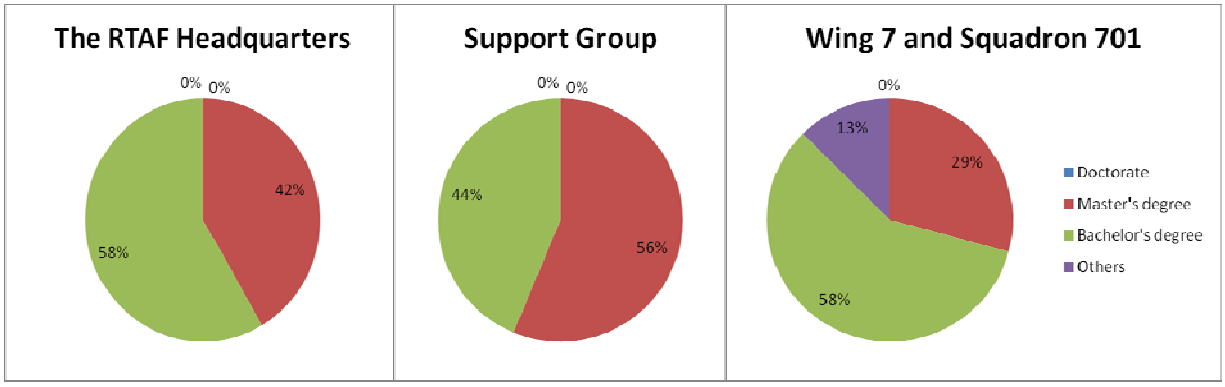

Figure 5-3 Actors' highest education (Source: constructed by the author, 2012)

Figure 5-3 shows other educational achievements, with 13% in Wing 7 and Squadron 701 of the technicians who have the rank of Leading Aircraftman (LAC) to Flight Sergeant 1st class (FS1) having vocational certificates. In contrast, their skills and work experiences are often higher than those of officers who have just graduated with a Bachelor's degree.

5.2.2 Logistics involvement and problems

The questionnaire includes not only questions, but also the definitions of the four logistics functions that are involved in logistics support for fighter aircraft. These function definitions are included to ensure that the respondents understand all four logistics functions before answering the next questions.

After the questions about the respondents' background, questions about logistics were asked. Firstly, the questionnaire covered the logistics involvement in their work; this question allowed actors to answer more than one logistics function because all logistics functions concern each other so that actors are absolutely involved in more than one. The highest number of responses for logistics function involvement is *maintenance* with 48 responses and then a lower number of responses in sequence for logistics information management, supply, and lastly transportation. On the other hand, when separating the actors by offices, the result for the RTAF Headquarters is different from that of the other actors in that the most involvement is in *supply* and *logistics information management*. The distribution of logistics involvement in each office is presented in Figure 5-4.

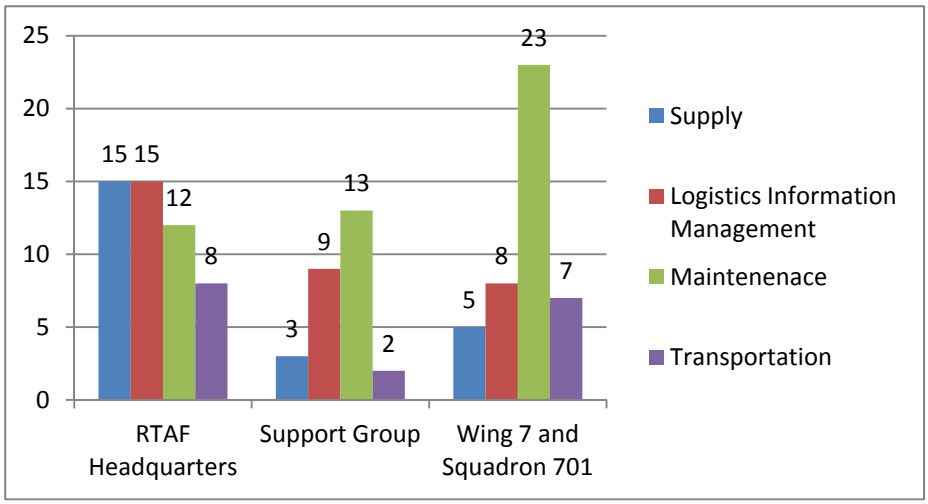

Figure 5-4 Logistics involvement by actors' office (Source: constructed by the author, 2012)

Secondly, from their work experience, the questionnaire asked the respondents to scale the four logistics functions according to their importance to supporting the Gripen 39 C/D, 4.5 generation fighter aircraft. When looking only at the definitely important scale, the most important logistics function is *logistics information management* with 47 responses (73%), whereas, when looking at each actor, the Support Group and Wing 7 scaled differently from the total 64 actual respondents. The Support Group scaled maintenance as the most important to support their responsibility in logistics with 14 out of 16 respondents (88%). Wing scaled supply as the most important, showing some problems they faced in their experience, with 19 out of 24 respondents (74%). The result of the logistics functions' importance is presented in Figure 5-5.

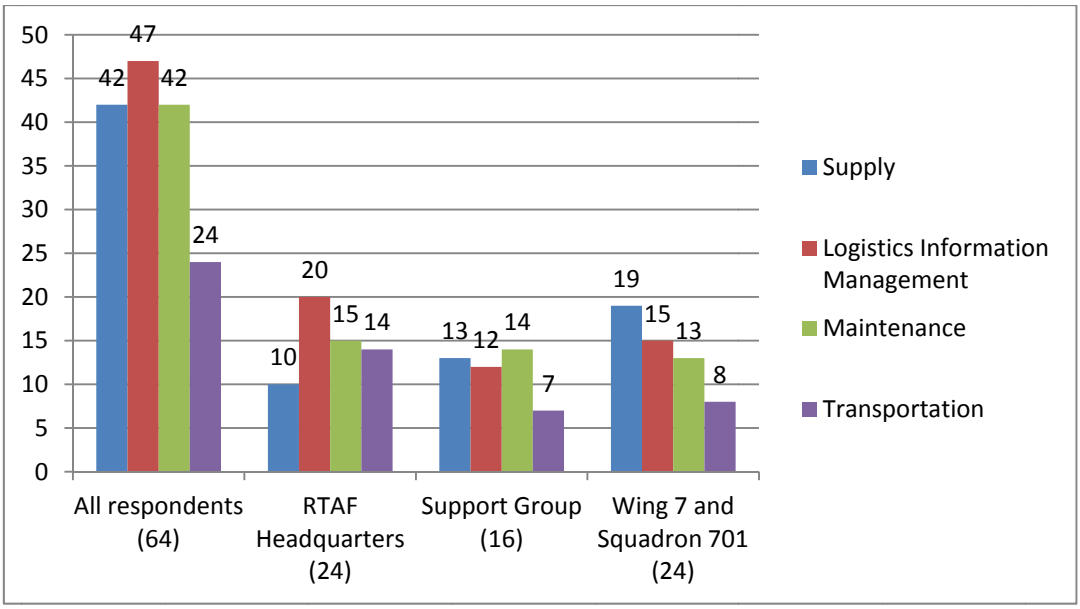

Figure 5-5 The importance of logistics functions by actors (Source: constructed by the author, 2012)

From Figure 5-5, it is apparent that the scales of importance are quite variable, that is to say that all the logistics functions are important to supporting fighter aircraft and their importance definitely depends on actors' perspective from their work experience. Moreover, transportation seems to be the least important according to the graph.

This result affects the next question about the problems that occurred in logistics support for fighter aircraft. There are sixteen problems that the RTAF faced when supporting fighter aircraft in the past. Each problem is measured by how frequently it occurred. The result from actors in relation to the problems that often occurred in their work is presented in Figure 5-6.

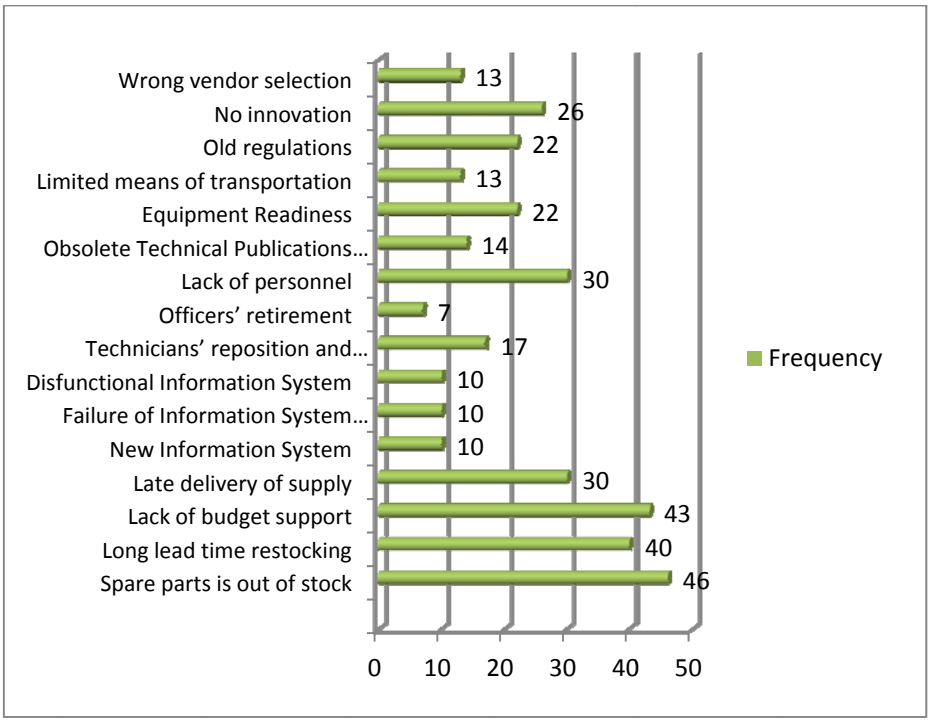

Figure 5-6 The frequency of problems in logistics support (Source: constructed by the author, 2012)

From the graph, it can be seen that the most frequent problem that occurred is *spare parts are out of stock or shortage* with 46 responses (72%). The following problems in sequence that have more than 30 responses (47%) are lack of budget support, long lead-time restocking, late delivery of supply, and lack of personnel. In addition to each actor, the RTAF Headquarters considers another problem of no innovation with 42% of responses. The Support Group reports more problems with more than 42% of responses: technicians' repositioning and promotion, obsolete technical publications (TOs), equipment readiness, old regulations, and no innovation. Some of these problems the Support Group could not solve by itself and they needed solving at the strategic level.

Moreover, regarding involvement and solving problems, 16 actors (25%) are always involves and have opportunities to solve the logistics problems when they occur in their work. In contrast, 15 actors (23%) are involved fairly often and sometimes in the same amount, as presented in Figure 5-7.

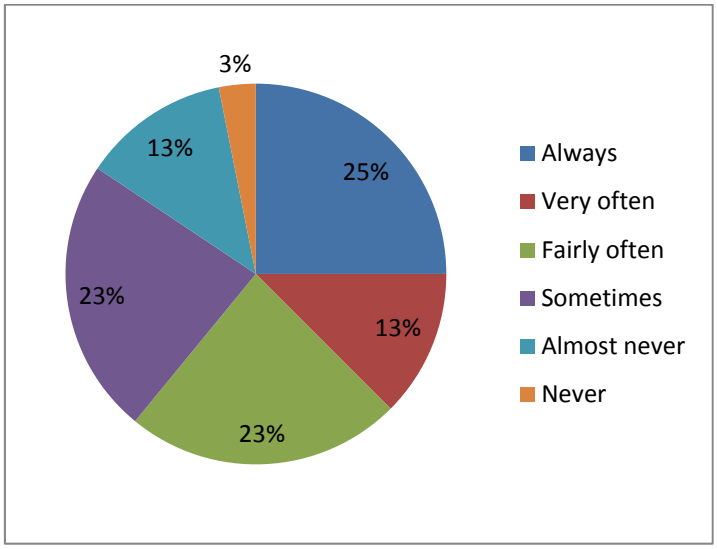

Figure 5-7 The percentage of involvement and solving logistics problems
(Source: constructed by the author, 2012)

The figure shows that the involvement and opportunities to solve logistics problems are quite various and would depend on the actors' background as their rank and responsibility. Especially, in a military organization, the lower the rank, the less responsibility. The sixteen logistics problems need to be solved at the strategic level and operational level. The tactical level just waits for the order from their commander to tell them what they have to do.

In addition to the most frequent and following problems with more than 30 responses from all actors, they generate the answer tendency in the next question, which asks which logistics function the respondents expect to create the most possible problems in the future by ranking them from 1 to 4. The result is *supply* with 34 responses (53%) in the first rank. This is followed by maintenance in the second rank with 24 responses (38%), logistics information management in the third rank with 22 responses (34%), and transportation in the fourth rank with 24 responses (38%). The results are presented in Figure 5-8.

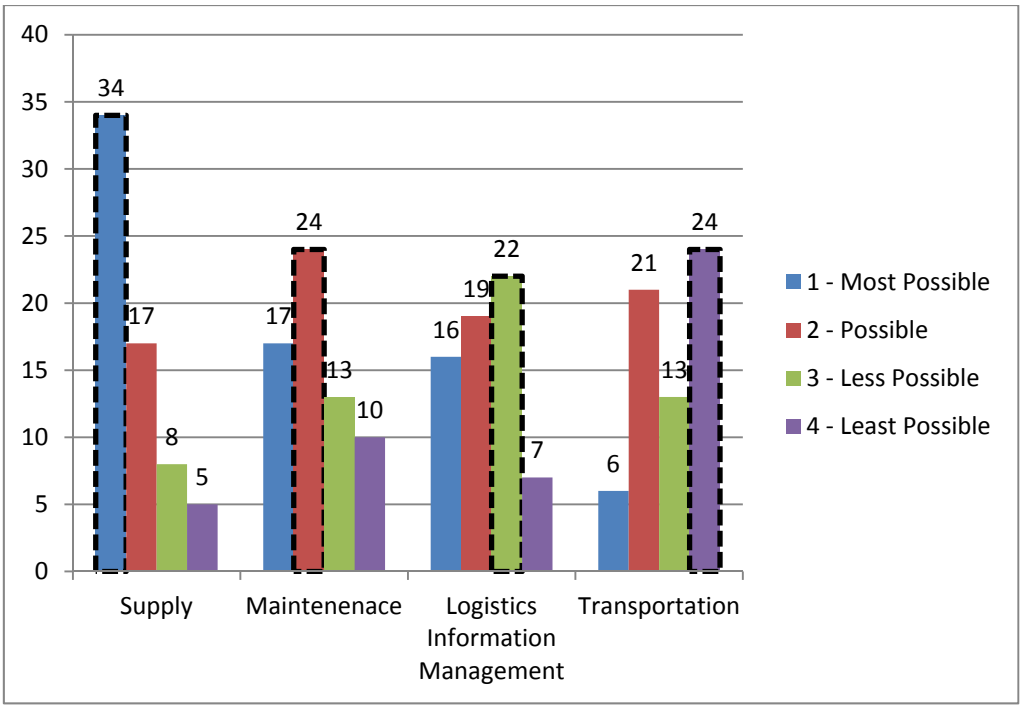

Figure 5-8 The possibility in the rank of logistics functions to be problems in the future
(Source: constructed by the author, 2012)

In contrast, when looking each actor, the most important logistics function in the RTAF Headquarters is maintenance, then supply, logistics information management, and transportation. For the Support Group, the result is the same as for all the actors. For Wing, the most important logistics function is the same as for all the actors but they are different in the following important logistics functions that start with transportation, then logistics information management, and maintenance with the same amount of responses. All the results for each actor are presented in Table 5-1.

Table 5-1 Rank of logistics functions that could cause possible problems in the future
(Source: constructed by the author, 2012)

Rank	Actors		
	RTAF Headquarters	Support Group (All actors)	Wing 7 and Squadron 701
1 – Most Possible	Maintenance	Supply	Supply
2 – Possible	Supply	Maintenance	Transportation
3 – Less Possible	Logistics Information Management	Logistics Information Management	Logistics Information Management
4 – Least Possible	Transportation	Transportation	Maintenance

5.2.3 Suggestions for dealing with problems

In the questionnaire, there are spaces in some questions for noting comments from the respondents. Some respondents answered the questions with comments but most of them answered without any comments. As *supply* is the logistics function that respondents expect to create the most possible problems in the future and would be the most

important function for prevention, there are some comments from them regarding dealing with this logistics function and these can be used as advice to create ideas. The comments are summarized as follows:

> "Assign a supply officer who has knowledge and skills in supply management and supply information to respond to the requirements in time."
>
> "To procure and stock supply according to the operational requirements."
>
> "Record and analyse the data from using supply in name, amount, value, and suppliers for planning and alternative choices in supply acquisition."
>
> "Outsource the supply management to commercial organizations increasingly."
>
> "Adding more budgets and using a contract service is the most appropriate way in logistics support right now. This way should not be changed to others."
>
> "Combine supply acquisition to increase economics of scale and decrease the price as in Gripen User Group (GUG)."
>
> "Create statistics in using each item and include the aircraft problems to prepare the necessary supply in maintenance."

5.3 Interview data

To obtain more data more clearly from the comments in the survey, interviews were conducted in Thailand. There were four interviewees from the Swedish Support Group (SSG) and the RTAF logistics team in the Gripen programme. From the SSG, they were three respondents and they were interviewed individually at Wing 7, Suratthani. For the logistics team, there was only one person, the logistics manager, who was interviewed at the RTAF Headquarters in Bangkok. According to the data from the interview, two main topics will be presented: the logistics planning in the Gripen programme and the Swedish perspective of Gripen logistics support in Thailand.

5.3.1 Logistics planning

In the Gripen purchase agreement, logistics planning is offered from the Swedish side but it is adapted to the RTAF requirements. This adaptation is the RTAF's opportunity to change and develop some issues in logistics support. The logistics planning is divided into four parts: supply definition, pooling programme, technician training, and logistics information system.

5.3.1.1 Supply definition

Supply to support fighter aircraft in the Swedish system is different from that in the US system in the meaning of words. In the US system, spare parts means supply that is reusable by repairing, such as line replacement units (LRUs), and consumables are supply that is not reusable, for example, o-rings, screws, glue, and sealing compound. Conversely, in the Swedish system, *spare parts* means o-rings and screws, *consumables* means general materiel such as glue and sealing compound, and *LRUs*. Hence, the planning to give this information is important in the beginning of logistics support.

5.3.1.2 Pooling programme

This programme is separated from the Gripen purchase agreement in that the payment for this programme is an additional cost to support the Gripen 39 C/D in logistics. The concept of the pooling programme is the RTAF signing another agreement with the FMV to allow it to acquire and manage all the LRUs. This agreement also includes transportation from the central warehouse in Sweden to the local store in Wing 7, Suratthani, and vice versa. Regarding spare parts and consumables, they are included in the purchase agreement that the FMV has initially supported for two years.

The LRUs in this programme are divided into pooling items and non-pooling items. *Pooling items* do not need a repair workshop in Thailand. When these items are disfunctional, they will be exchanged with new ones from the warehouse and the disfunctional ones will be packed and sent back to the workshop in Sweden for repair, which speeds up the repair time, transportation lead time, and workshop investment. According to *non-pooling items*, for instance, the radio and electronic warfare system (EWS), there are no new ones in the warehouse at Wing 7 when they are disfunctional. They have to be packed and sent back to Sweden for repair, so the RTAF has to wait until they return in a functional condition. Non-pooling items are also high-technology and expensive items and careful consideration should be given to purchasing more for reserves or investment in the workshop in the country. On the other hand, all transportation and repair costs of non-pooling items are included in the pooling agreement. The pooling process after Gripen 39 C/D landing from an operational or training flight is presented in Figure 5-9.

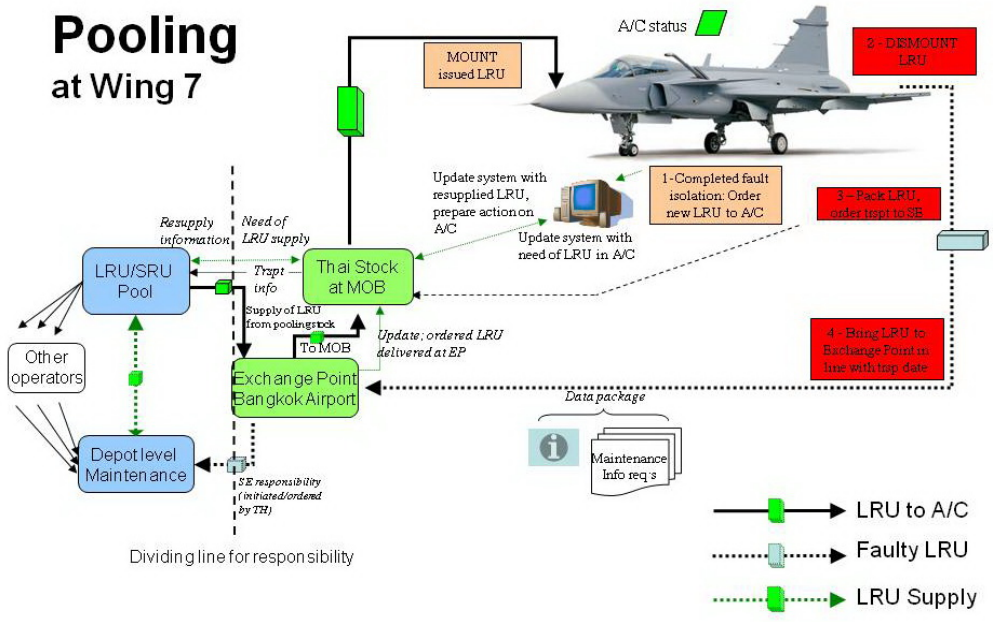

Figure 5-9 The pooling process (Source: FMV presentation, 2008)

When the result of trouble shooting shows that the LRU is disfunctional, this information will be put into the logistics information system that transfers to Sweden. In Sweden, the pool owner will see whether this LRU is in the local store at Wing 7 or not. If yes, the LRU will be brought from there to the maintenance unit in the squadron and the local store will have another LRU sent from Sweden to restock at the same time. If no,

the pool owner will send this LRU directly from Sweden. Not all LRUs are kept in the local store at Wing 7.

It is the RTAF's responsibility to change the LRUs in the aircraft, carry out the packaging, call the transportation company to bring the disfunctional LRU, and ensure customs clearance. The FMV responds with the LRU procurement, inventory, and hiring a transportation company both in Thailand and in Sweden to deliver LRUs from the central warehouse in Arbåga and Linköping, Sweden to the local store at Wing 7 in Suratthani, Thailand, and vice versa.

The stock level of LRUs in the local store is calculated from the RTAF operational requirements, which are 200 flight hours per aircraft per year and a full mission capability (FMC) of 70% as the indicator of aircraft availability on average per month. The FMC means the number of available aircraft from the total in the squadron at a specific time. For example, there are 6 Gripen 39 C/Ds in 701 squadron, so 70% FMC means that about 4 of the 6 aircraft have to be available for operations on average per month. These operational requirements are also stated in the pooling agreement to guarantee supportability for the customer from the supplier.

5.3.1.3 Technician training

As maintenance needs four resources – personnel, materials, documentation, and management information systems (Pintelon et al., 1999) – but three of them are included in the Gripen purchase agreement, the only resource that the RTAF has to provide itself is personnel. The members of personnel who perform the maintenance are called *technicians*. Forty technicians were recruited to train for logistics support for the Gripen 39 C/D and they are from both the Support Group and Wing 7. Before training, the Gripen technicians were from three groups of career fields and skills: aeronautical, communication and electronics, and armament.

The technicians' capability in maintenance was created in Sweden by training for 11 months. They were in a mixed career field and divided into 3 batches: 20 people in Batch 1 and 10 people in Batch 2 and Batch 3 each. For Batch 1, the training began in the Armed Forces Technical School (FMTS) located in Halmstad with the Gripen Technician Conversion Course (GTCC) for 5 months. The GTCC is the course that combines all the systems in the Gripen 39 C/D to study as a single system that is different from the RTAF's technical responsibility. The RTAF accepted the training like this since it gave more knowledge and skills to all the Gripen technicians so that they can replace each other in this combined system. Moreover, there are not only lectures and practice with presentations and textbooks in the GTCC, but also an examination in each topic to measure the knowledge of the Gripen technicians. After that, they moved from Halmstad to two Swedish wings and divided into two groups: 10 people for each wing. In the Swedish wing, they received on-the-job training (OJT) with real Swedish Gripen 39 C/Ds to let them apply their knowledge from the FMTS to operating and maintaining real aircraft for 6 months. Thus, the OJT gave them more skills and experiences to create their capabilities. During the OJT, there were many special trainings in specific skills to which they were assigned to train separately depending on their career field and old skills. Batch 2 and Batch 3 studied the GTCC together but undertook separate OJT: Batch 2 in Sweden and Batch 3 in Thailand.

On the other hand, this capability is insufficient to maintain and repair these fighter aircraft in Thailand since the climate is dramatically different. So, there are two Swedish

Gripen technicians in the SSG to help and advise in solving maintenance and repair problems during the first two years of aircraft commission.

5.3.1.4 Logistics information system

Two systems are provided that are included in the Gripen purchase agreement: FENIX E and the Maintenance Ground Support System (MGSS). These two systems are not connected to each other since FENIX E is a web-based program and the MGSS is a stand-alone program with confidential information from the aircraft. All Gripen technicians from the RTAF were trained to use these two systems during the GTCC and OJT in Sweden.

FENIX is a new maintenance, repair, and overhaul (MRO) system for the Swedish Air Force (SwAF) and basically a commercial-off-the-shelf (COTS) product that has many users all around the world. The use of a COTS product means that operations must be adapted to the product in almost all parts of the system. The SwAF created add-on modules that are missed functions in the COTS product to satisfy some interests from the customer. This system was developed for the reason that new types of missions and products lead to new requirements for the information systems. The purpose of this system is to replace old technology to meet new requirements and support international missions; it needs to be deployable and support the leasing and export business. This project started in 2003 and was implemented to support the Gripen 39 C/D in 2008. Four nations use this system now: the Swedish Armed Forces, the Czech Republic Air Force, the Hungarian Air Force, and the Royal Thai Air Force.

To ensure that all the processes are step by step in the system, FENIX is designed for the chronological input of all information in respect of usage, for instance, preventive or corrective maintenance and installation or removal. Another reason for this is to guarantee that the correct usage and parameters are attributed to all inventory and units. The authorization of information in FENIX is individual, to determine what a particular user can access in the system concerning aircraft, equipment, or stores. Consequently, FENIX gives a user access only to whatever is necessary for carrying out the user's functions.

The concept of FENIX consists of basic concepts and more concepts. Basic concepts are the *baseline*, which is basic data that are the permitted configuration defined concerning the slot structure, positions, and modifications, *assembly* is to make a change from the baseline in one step according to the change notified, and the *slot structure* represents a position for an inventory in the aircraft that is connected to a number of conditions and those conditions determine what is permitted to install and demand for maintenance. More concepts are *task* to perform preventive maintenance according to the maintenance plan, a *fault* arises when an aircraft or component does not satisfactorily fulfill its intended purpose, such as cracks, dents, corrosion, and breakdowns that will be taken care of with corrective maintenance, a *check* is created for each occasion when one or more tasks/faults must be taken care of and used when preventive and/or corrective maintenance is carried out on the aircraft to be completed in order to make them serviceable, a *work order* is created for each occasion when one or more tasks/faults must be taken care of and has to be completed in order to make an inventory serviceable, a *schedule* is the planning when a check or a work order is to start and to finish and where the work is to be carried out, *commit scope* means the contents of the check/work order in FENIX will be approved, *convert to component replacement* is used in cases in which

a removed unit needs to be replaced with a serviceable unit to convert the fault to a replacement task that has two subtasks, removal and installation, *shipment* involves sending a part to an external recipient who is not within the local, official organization, and *transfer* involves sending a part within the same location/airport.

The functions in FENIX are presented in Figure 5-10. From the top right, they are operational and control, line maintenance, external maintenance, materials management, crew, FENIX backbone, special features, and others.

Figure 5-10 The functions in FENIX (Source: FMV presentation, 2012)

FENIX E is the new FENIX Export version implemented in 2010 and developed from the FENIX system that the Swedish Air Force has used since 2008. The RTAF is the first customer and user of this developed system. The function of FENIX E is the same as that of FENIX, to follow up aircraft, LRUs, and spare parts information, record all supply consumption, aircraft and component maintenance, and reorder supplies. However, there is an additional analysis module in FENIX E called the ARM (Analyse and Report Module) that is able to count the consumption of each supply and report how many spare parts and line replacement units (LRU) are used during a period of time. This module will help the RTAF to order spare parts and consumables when the initial support finishes after two years and also when the pooling programme is cancelled.

For the MGSS, this system will help to analyse the trouble shooting that cannot be solved easily with the *Aircraft Maintenance Publication* (AMP) by following up the situation in flight from the aircraft system and flight data and presenting the value of data in graphs and many figures second by second. Moreover, this program presents data that are recorded by the data transfer unit (DTU) in the aircraft to help technicians analyse the faults in the technical report (TR) that pilots fill in after landing.

5.3.2 Swedish perspective

More interview data come from the Swedish Support Group (SSG) that works in Wing 7, Suratthani. The three Swedish interviewees are a logistics engineer, an aircraft system engineer for the JAS 39 Gripen, and a technician for the JAS 39 Gripen.

5.3.2.1 Background

The responsibilities of the logistics engineer are logistics, spare parts, LRU, supporting FENIX E, updating ground support equipment (GSE), and maintenance supply. He also stated in relation to his responsibility:

> "To support Squadron 701 and 702 logistics in aircraft maintenance that specifically are aircraft logistics and mainly support spare parts and LRU. When I support spare parts and LRUs, I have to deal with the information system that is FENIX E. Moreover, my responsibility is GSE as quality engineer and to help the aircraft and GSE engineer, and also take care of aerial equipment assemblers (AEA) for pilots in following up their status, maintenance, and technical issues." (Johan, personal communication, 2012-03-13).

The responsibilities of the aircraft system engineer JAS 39 Gripen are aircraft technical support in airworthiness and trouble shooting, helping the contact between the FMV and the Air Fleet Management Office (AFMO), which is the pool owner and responsible for pool services and SAAB services in the SwAF and SAAB company, and suggesting using the MGSS. He made an important statement:

> "I do not make any decision in maintenance; I just help to do an action plan or suggest decision by making more and transfer experiences to RTAF technicians." (Lars-Åke, personal communication, 2012-03-14)

The responsibilities of the technician for the JAS 39 Gripen are to support aircraft maintenance, GSE support, aircraft technical support, and flight line. That is to say, he helps to make these aircraft take off again.

5.3.2.2 Four logistics functions

According to the four logistics functions to support the fighter aircraft – supply, logistics information management, maintenance, and transportation – three SSG representatives as interviewees described each function in the same way:

Supply for aircraft is divided into three groups: spare parts, consumables, and LRUs. Depending on the pooling programme, LRUs are divided into pooling and non-pooling items that are handled differently in the FENIX E system regarding the routines for maintenance and shipping. The important process in supply is ordering new items from Sweden.

Logistics information management uses two systems in logistics support: FENIX E is for maintenance records and materiel orders and the MGSS is an analysis tool for maintenance. FENIX E cannot order material automatically; this system only generates the order form in a PDF file that the RTAF technicians have to send to the AFMO. It is a gap in this system that some information is not connected between FENIX E and FENIX in the SwAF and it has to be transferred manually. Regarding the ARM in FENIX E, Thailand is the first place to use this module. It has never been used in Sweden before; so far the functionality of the ARM has not been fully tried out and there is little experience of the system. Moreover, e-mail is mainly used for communication and exchanging information when functions in FENIX E are not covered, for instance, materiel order.

Maintenance concerns planning, which is important in this function. To ensure that enough aircraft are available when some of them are undergoing an overhaul period, long-term planning is very important. The corrective maintenance process begins with a technical report (TR) from the pilot and if there are small faults, FENIX E is used for repairs, recording, and materiel order. If there are big faults, MGSS is used to analyze first before using FENIX E. The preventive maintenance is generated from FENIX E when the materiel records reach the condition.

Transportation is outsourced to a commercial company named DSV. DSV is a transportation-based, warehouse/distribution-based, and forwarder-based firm that has offices in more than 60 countries all over the world and an international network of partners and agents, which makes it a truly global player offering services worldwide (DSV, 2012). The responsibilities of DSV are to transport supplies from the central warehouse and repair workshop in Sweden through local and international means of transportation to the local store in Wing 7, Thailand, and vice versa. Since this function is included in the pooling agreement, the organization that hires this company is the FMV. The issues that should be taken into consideration in this function are the time difference between Sweden and Thailand, distance, administrative work in Sweden before sending items to Thailand and in Thailand after the items arrive as this process cannot avoid customs clearance, and dangerous goods, for example, ejection seats and gad bottles.

5.3.2.3 The RTAF technicians

Although the RTAF technicians were trained in Sweden for 11 months, they do not have sufficient experience in maintenance, especially in reading graphs and parameters in the beginning in the MGSS. They have been becoming more confident in using the MGSS and better at maintenance. It will take about 3–5 years for the RTAF technicians to be able to handle Gripen logistics support by themselves since there are many new systems and new functions in this programme. Regarding the number of technicians, 35 people work in Wing 7 and the SSG thinks this amount is enough to maintain 6 Gripen 39 C/Ds. For the evolution of RTAF technicians, one of the SSG stated:

> "I think RTAF technicians have been improving a lot, and they need time to improve more and think in the same way in the Gripen system." (Lars-Göran, personal communication, 2012-03-14)

5.3.2.4 Logistics problems and important logistics function

The SSG faced some big problems when it supported Gripen 39 C/Ds in Thailand, but they are not big deals since the FMC has always been 70% on average each month. Examples of the problems are the stock level of LRUs being lower than the requirements, a lack of items need, and sometimes waiting for items. These problems are caused by the long lead time in transportation, the operations of the Gripen 39 C/D being in high demand and expectations in the first year of implementation, but there are only six aircraft in the fleet, and planning cannot be planned and sometimes changed. On this issue, one of the SSG stated concerning the operational awareness:

> "The RTAF Gripen 39 C/D have flown more than other aircraft operators compared to the numbers of aircraft that consumed a lot of spare parts and LRUs in both preventive and corrective maintenance, this act will affect the overhaul period of aircrafts that they will be on the ground be-

tween 6 and 10 weeks and FMC will be down at that time." (Lars-Åke, personal communication, 2012-03-14)

Moreover, regarding the logistics function related to the problems, two logistics functions are important from the SSG perspective: *supply* and *transportation*. For supply, the lack of supply is due to a lack of planning. Transportation is connected to distance, in that Sweden is on the other side of the world, and administrative work, for example customs clearance.

5.3.2.5 Help and suggestions

Because the main task of the SSG is to help and make suggestions to the RTAF officers until they are able to maintain the Gripen system by themselves, the SSG has helped and made suggestions in relation to many issues, for instance:

- Making understanding that maintenance needs integration among the MGSS, maintenance skills, and materiel planner in this system.
- Contacting Swedish people by phone and e-mail when the RTAF officers did not know them to speed up the process of obtaining needed items, for example, sending the faults and history of these faults to the workshop in the AFMO to speed up and ensure the right method of repair when the items are non-pooling.
- Finding and preventing problems before they occur.
- Trying to change LRUs from another aircraft with the problem one when no one knew the exact problems in troubleshooting to save more time and transportation cost than sending them directly back to Sweden. This method may be called *change by chance*.
- Asking Swedish people from the FMV or SAAB Company to bring some items, for example non-pooling items, from Sweden to Thailand when they were planning visits to speed up the transportation lead time.
- Finding the process in the transportation of secret LRUs since there will be fewer Thailand visits by Swedish people in the near future.

In addition to suggestions for improvement, the SSG has suggested some topics that the RTAF should improve with the aim of being able to support the Gripen 39 C/D by itself after two years of commission. The topics are:

- More planning in the form of a year plan or two-year plan caused by joining in big exercises and changes of plan.
- Airworthiness decisions in Bangkok should be faster.
- The understanding that the Gripen 39 C/D is a combined system aircraft and different from the RTAF support system with four directorates is the key function to generate faster decisions and to find the right people to solve problems.

5.3.2.6 Pooling cancellation

As the pooling agreement is separate from the Gripen purchase agreement and the RTAF has to pay an additional cost, which is quite high compared with those of other aircraft in the RTAF, there are some thoughts about cancelling this agreement and try-

ing to acquire directly from the OEM. The discussion from the SSG on the issue is firstly to say that pooling is the best way to support these aircraft right now since many faults have occurred differently from faults in Sweden so that the RTAF cannot forecast the right amount of supplies needed. The reason for different faults may be the climate and humidity in Thailand.

Secondly, this issue will create a large flow of items and the RTAF has to invest in the component repair workshop. Thirdly, concerning the time, some items will take more time than with pooling if they are not repaired at a component repair shop in Thailand. The period of time will count in both repair and transportation lead time. Finally, Gripen logistics support will not be able to reach the operational requirement of having 200 flight hours per aircraft per year.

After all the empirical data from the secondary data, survey, and interviews have been interpreted in this chapter, in the next chapter, the combination between theories and empirical data will be analysed with the aim of answering the three research questions. This analysis will also follow the purpose of this thesis.

6 Analysis

The frame of reference and empirical findings show the same descriptions of four logistics functions – supply, logistics information management, maintenance, and transportation – that are important to supporting the Gripen 39 C/D, 4.5 generation fighter aircraft because of the parameters in NATO logistics support as shown in Chapter 3 and the lessons learned from the existing system for the F-16 A/B, the fourth-generation fighter aircraft, in Chapter 5. The descriptions as theories and empirical data from these two chapters are analysed systematically in this chapter.

The aim of this chapter is to answer the research questions by linking the data in the empirical findings with the established theories in the frame of reference. This chapter is divided into three parts that follow in sequence: the main problem area, logistics lessons learned incorporated from the existing system for the F-16 A/B into the new system for the Gripen 39 C/D, and logistics support in four logistics functions for new-generation fighter aircraft.

6.1 Main problem area

The first research question is: *What has been the main problem area in logistics support of fighter aircraft?* The answer to this question is found to relate to thirteen logistics functions in NATO logistics as problem areas. Moreover, the survey method was used to find the main problem area.

Referring to the thirteen logistics functions, they are reduced according to five parameters – combined function, homeland defence, human support, general function, and prior function – to fit them into the logistics support of fighter aircraft. Thus, there are four logistics functions left: *supply*, *logistics information management*, *maintenance*, *and transportation*, which are important and related to the logistics problems with the existing system as F-16 A/B.

After reducing the logistics functions to four, the selection of the main problem area was made by surveying the RTAF officers as actors in the empirical data. Firstly, to promote the quality of the data from the survey, the rank and highest education of actors guarantees this issue by empirical data with the highest number of ranks being Squadron Leader to Group Captain as operation-level officers and the highest education level of actors being Bachelor's and Master's degrees. Thus, they are high-quality actors and respondents to the survey.

Secondly, to allow the actors to select the logistics function as the main problem area, the survey questions reminded them step by step of their work, the problems they faced, and the problems in the future. As the empirical data show that maintenance is function involved most in their work, it is apparent that this function needs the integration of many actors and resources. On the other hand, the data change when separated into each office's actors in that the RTAF Headquarters is involved in supply and logistics information management more than maintenance. These data show that the RTAF Headquarters' work is more expected to be in these two logistics functions and the Support Group and Wing are mainly responsible for maintenance work. After involvement, the first selection was given to the actors using the importance of the logistics functions to support Gripen 39 C/D, 4.5 generation fighter aircraft; the result is logistics information management from all the actors, showing that information sharing is the most important

when supporting the new system from an overall perspective. However, this result does not ensure that this function is the main problem area since the actors may have forgotten the problems they have faced so far. So, sixteen problems are mentioned in the next question to help them realize the problem area. These problems are from the logistics problems that occurred when supporting the F-16 A/B.

The questionnaire asked how frequently each of the sixteen problems occurred. The answers with a high frequency are *spare parts are out of stock*, *lack of budget support*, *long lead-time restocking*, *late delivery of supply*, *and lack of personnel*. To compare these answers with the four logistics functions to support fighter aircraft, the results tend to show one of these logistics functions to be the main problem: it is *supply*. Moreover, the empirical data support this tendency that supply is expected to create the most possible problems in the future and it is important to act preventively to eliminate the problems since the RTAF know about them in advance.

There is a change in the selection of the logistics function from the importance issue the first time, when the result was logistics information management, to importance and creating the most future possible problems the second time, as the result was supply. This change shows that when the actors were given more data to realize their work, they gained awareness of which function is the most important and changed the data later on.

As supply is expected to create the most possible problems in the future by all the actors, in contrast to the RTAF Headquarters, the most important function is maintenance, then supply, logistics information management, and transportation. This different result shows that they are more worried about maintenance than supply since maintenance needs some integration from resources into the process. Moreover, there would be new logistics planning to solve the problems in supply but they do not trust the new planning enough since supply is the second most important function. For Wing, the most important logistics function is the same as for all the actors but they are different in the order of important logistics functions, starting with transportation, then logistics information management and maintenance with the same amount of responses. This result from Wing shows that they believe in their maintenance capability from training and the logistics information system that is included in the programme. The technicians in Wing were also trained on this information system. However, they mention transportation as the second most important function that would cause problems in a real situation as they face the long supply line from Sweden to Bangkok to Suratthani.

However, supply is the main problem area and an important logistics function for prevention. The preventive method of this function is analysed following the purpose of this research by adapting business theories and empirical data from the lessons learned in logistics support for the F-16 A/B. Referring to the existing system problems in supporting the F-16 A/B, fourth-generation fighter aircraft, supply is one of the problem areas that occurred and has already been solved by new calculations, efficient tracking systems, and changes in the means of transportation. It tends to be the main problem area in the new system since the RTAF has a pooling programme to take care of LRUs and this time is still in the period of two-year initial support for spare parts and consumables. In addition to supply management, FENIX E is able to record and count the consumption of supply. So, the problems would be caused by another side that is not the RTAF.

In fact, the problems are not only from the customer side but also from the supplier side and depend on the supplier's strategy. Since suppliers are commercial, their strategy will be to reduce their cost as much as they can by processing logistics activities as late as possible, for example, decreasing the investment cost for keeping the supply in a warehouse near the customer by using the efficiency of 3PL to deliver the products and respond to customer requirements that can define the supplier process inventory management activity late. In addition, they need customer satisfaction with the customer service by keeping critical and high-cost parts in a central inventory to ensure availability for all potential users (Bowersox et al., 2010). From these two issues with commercial organizations, the strategy can be called a *logistics postponement strategy*. In a logistics postponement strategy, the centralization of inventories reduces the amount of stock required to offer high in-stock availability but the shipment cost may increase due to smaller shipment sizes and faster modes (Pagh & Cooper, 1998). Moreover, Bucklin (1965) stated in relation to this strategy of the supplier that postponement increases and costs decline as the delivery time lengthens, which affects intermediate inventories that will tend to disappear and be replaced by distribution channels with a direct flow.

To compare the logistics postponement strategy with the suppliers' benefits in the RTAF Gripen purchase programme, the benefits are not only cost-efficiency and cost reduction but also the elimination of risk and uncertainly in supply, finding information to fit with the customer demand, and improving customer responsiveness since the region where the RTAF operates these fighter aircraft is a new market with a new climate and culture for the suppliers of this product. In addition, this strategy allows the suppliers to use more professional firms in some logistics activities in the form of 3PL to respond to the customer needs, increase on-time deliveries, obtain more reliable lead times, and have constant transportation costs. Thus, the logistics postponement strategy in the implementation period of the product helps the suppliers to forecast the supply needs of the customers and aim to achieve customer demand and responsiveness.

However, the supply strategy in this purchase programme is not only the logistics postponement strategy but combines the full speculation strategy in that there is a local store in Wing 7 to guarantee responsiveness to the customers in time and ensure the customers would not have to wait for the supply. In contrast, the stock level of the supply is too low in the local store so the RTAF has to wait for supplies that are not in the local store until they arrive in Wing 7. This waiting time did not affect the FMC of the Gripen 39 C/D, but this situation raised the RTAF's awareness of the possible future effect on the FMC. The supply strategy in the Gripen purchase programme is a combination of postponement and speculation (P/S); the hybrid P/S strategy in this programme is illustrated in Figure 6-1.

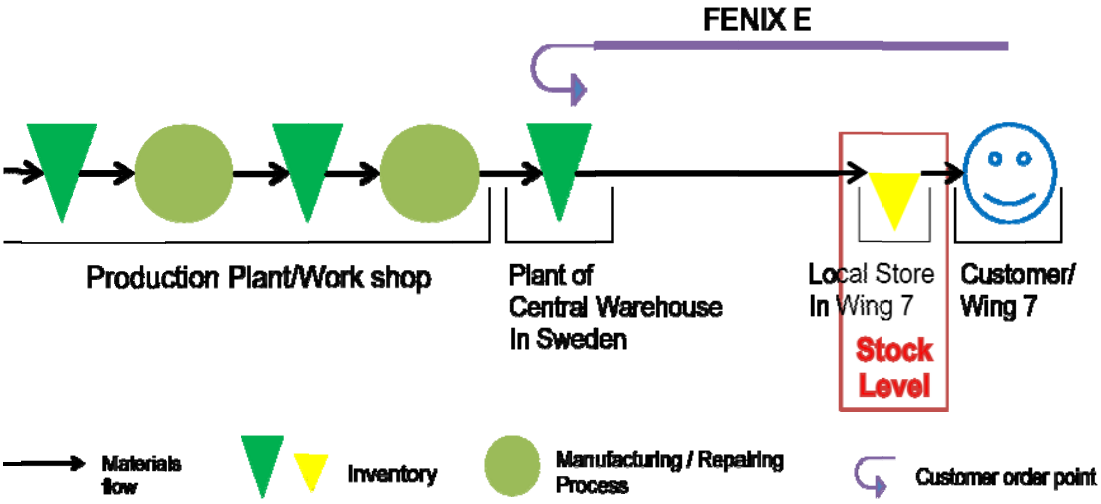

Figure 6-1 Illustration of the hybrid P/S strategy in the RTAF Gripen purchase programme (Source: adapted from Pagh & Cooper, 1998)

In Figure 6-1, the local store is the only warehouse to keep a supply with a low stock level and no inventory control. Supply chain management is organized from the central warehouse in Sweden by the AFMO, which is the pool owner. Moreover, supply reorders have to be requested in the FENIX E system back to Sweden and then permission obtained from there to take the supply to the local store; otherwise the RTAF cannot receive the supply locally. If the supply is not in the local store, the RTAF has to wait for supply delivery from the central warehouse. In addition, supplies are not transported from the central warehouse to the local warehouse until there is a customer order (Jonsson, 2008) if they are not kept in the local store.

Referring to the logistics postponement strategy in Figure 6-1, the supplier postpones some logistics activities: order processing, stores and warehousing, and transportation. Order processing is postponed by using ICT to order supplies from Thailand to Sweden as there are no offices to receive the order locally. Stores and warehousing are postponed by reducing the stock level in the local store so that most of the supplies are kept in the central warehouse to support other customers as well. Transportation is postponed by using appropriate means of transportation to deliver the supplies depending on the customer requirements.

From all the processes in Figure 6-1 and the supplier's strategy in logistics support, it can be said that *supply* is the main problem area in logistics support for new fighter aircraft.

To mitigate the main problem area of supply, there are many suggestions in the empirical data. The appropriate one is to increase the stock levels of supplies in the local store for the items that have been consumed a lot and are often on the waiting list; this can be achieved by using the ARM in FENIX E to obtain the information. Additionally, adding more budgets to the pooling programme is another way to prevent this problem because it will induce the supplier to increase the stock level as it will receive more money to invest and keep more supplies in the local store at Wing 7, Suratthani, and reduce the transportation cost.

Related to logistics activity, it is important for the supplier to give greater consideration to inventory management in the future. In addition, stores and warehousing should not be postponed since these activities are also important to supply.

Furthermore, spare parts and consumables have to be considered since the RTAF has to procure them in the future after two years of initial support. Using the ARM in FENIX E effectively will help to calculate an appropriate amount of them and the RTAF will be able to prepare the exact budget for procurement. Thus, preparing and planning are important activities for the future, especially using ICT effectively to decrease the supply problems and hope these problems will not occur in the future since they are preventable.

6.2 Incorporation of logistics lessons learned

The second research question is: *How can the lessons learned from logistics support in the existing system be incorporated into the new system?* The answer to this question is determined from the interview data and documentation as secondary data together with the military logistics theory.

Many lesson were learned from the RTAF's previous logistics support for fighter aircraft in the existing system for the F-16 A/B, the fourth-generation fighter aircraft, which give many experiences to prevent the logistics problems that may occur in the future with the Gripen 39 C/D as the 4.5 generation fighter aircraft and new system. The most important topic from the experiences to be incorporated into the new system is *planning*.

Logistics planning, as presented by Kress (2002), takes place in eight steps from the operational concept to the operational plan and involves logistics support within these steps. To apply it to the RTAF Gripen programme, the first step in the operational concept is the Gripen 39 C/D plan to achieve 200 flight hours per aircraft per year, operate at a main operating base (MOB), and have aircraft availability or FMC of 70% as a monthly average. The second step of planning is logistics feasibility from the operational concept; this can be approved depending on the company since the RTAF has a limited budget. If it is not approved, the step will turn back to the third one in operational implications and then start again with the operational concept. However, this operational concept is approved and then will meet the requirements of this programme. After this step, the fourth step is logistics design. With logistics design, there are three continued steps of operational design, logistics plan, and logistics planning in more detail for each logistics function. The last step is the operational plan, which combines the operational design and logistics plan.

The lessons learned from logistics support in the existing system should be incorporated into the new system by planning in four logistics functions with the solution of problems in the existing system. Firstly, supply planning is to use the pooling programme to cover supply calculation and means of transportation. Although this programme does not cover the tracking system when delivering supplies, it ensures that the customers will receive all the supplies they order to respond to their requirements in a timely manner. Secondly, logistics information management planning or C^4I in logistics is to use COTS product such as FENIX E, which is included in the programme. To guarantee the efficiency of the new system, the supplier offered FENIX E with the new module to help the RTAF technicians count the consumption of supplies and also be able to plan

supply and maintenance functions by themselves in the near future. Using FENIX E did not cause a lot of implementation problems since it is a stand-alone system that is used only with Gripen 39 C/D and Saab 340 aircraft in Wing 7, and the SSG, which has a great deal of experience in using this system, is available to help and give suggestions on site for two years. The challenge of logistics information management planning is to connect the information with the Logistics Management Information System (LMIS), which was implemented and used as the main ICT system throughout the RTAF with many aircraft before FENIX E.

According to maintenance planning, thirdly, the technicians are the most important maintenance resource to plan and prepare since they drive the other resources of materials, documentation, and the management information system from resources to the maintenance process. Moreover, these other resources are provided as part of the Gripen purchase programme and pooling programme. Materials such as LRUs are provided within the purchase programme but repaired by the pooling programme, and there are two years' initial support for spare parts and consumables. Two management information systems, FENIX E and the MGSS, are provided by the purchased programme. Documentation is initially provided by the purchased programme but is automatically updated within the pooling programme. In contrast, this function was not planned to be outsourced in the beginning period referring to the solution from the existing system since it is a new system with new people who will be not be promoted and moved from their position in maintenance. The challenge in maintenance planning is to gain more experience and be able to solve any faults by themselves with the resources they have when the SSG finishes its task in Thailand, and to keep the knowledge of Gripen 39 C/D maintenance to transfer to new technicians in the future. Finally, transportation planning is included in the pooling programme and is outsourced to a commercial company, outside any regulations in the RTAF.

Good planning, resulting from the lessons learned, decreases the logistics snowball with many logistics activities in logistics functions. To determine whether the planning is good or not, changing the requirements is one of the measurements for this issue in that the RTAF changes logistics plans with the MOB by deployment of the Gripen 39 C/D to others wings throughout Thailand and uses the wings as a forward operating base (FOB) that is beyond the scope in the first planning. From the empirical data in the interviews, there have been six deployments of Gripen 39 C/Ds until March 2012 and there have not been any huge problems that caused these aircrafts to be unable to fly back to the MOB. Thus, this operation in deployment proves that the logistics planning is good enough and caused the lessons learned from the existing system in logistics support to be incorporated into the new system.

6.3 Logistics support for new-generation fighter aircraft

The third research question is: *How can we support the new-generation fighter aircraft in four logistics functions?* The answer to this question comes mainly from the interview data and also follows the purpose of this thesis.

This purchasing of new-generation fighter aircraft of the 4.5 generation, the Gripen 39 C/D, follows the vision of the RTAF and involves many changes not only in operations, but also in logistics support. Some changes affect the strategy of the organizations since they have a new system with new technology development. The strategic change in lo-

gistics support will be interpreted separately in four logistics functions that are important to supporting fighter aircraft and how these functions support the Gripen 39 C/D.

6.3.1 Supply

Supply support to the Gripen 39 C/D is carried out by using the pooling programme that changes the supply strategy to combine supply procurement and supply chain management together from three directorates, the DAE, DCE, and DA. This change is appropriate for the Gripen C/D as a combined system aircraft. Concerning the flows in supply chain management, the product flow is shortened since the supply is delivered directly from the international airport in Bangkok to Suratthani where Wing 7 is located, differently from the previous-generation fighter aircraft and supply strategy in which all supplies had to move firstly to the directorate that belongs to the supply for checking and recording when they arrived in Thailand. Then they were sent to the military airport for loading into military cargo aircraft and sent to the wings or delivered by land transportation. The information flow is managed by the suppliers so that the RTAF only waits for the supplies and expedites the suppliers to deliver supplies as required in the proper period of time. The financial flow is not concerned during delivery since it is an annual payment in the pooling agreement.

Moreover, compared with business theory, the RTAF outsources supply chain management to third-party logistics (3PL) to manage the new supply chain by using their experiences, efficiency, and professionalism in this logistics function. The RTAF has the benefits of no unnecessary investment in assets such as repair workshops and item production, assurance of receiving the supplies for maintenance and that unserviceable items are repaired correctly, and sharing the risks with the supply owner, especially during repairing and transportation. The benefits of using 3PL confirm that 3PL is useful in the trend of outsourcing some logistics activities to other firms that have more professional and effective assets for service improvements and cost reduction.

This outsourcing trend in supply procurement and management to 3PL is presently wider since customers are making lower investments in supply production. 3PL will find other customers to share purchasing in the same type of supply, which decreases the investment cost in procurement. In addition to repairing items, pooling them in the central warehouse for many customers not only reduces the procurement and repair cost but also records the faults that occurred and helps to repair items with the same faults faster next time. Therefore, the strategy to use the pooling programme in supply support is one of the better methods for new products with new technology such as new-generation fighter aircraft, whereas the stock levels of supplies have to be considered in wartime to ensure that they are sufficient for logistics support since the central warehouse is located far away from the MOB.

6.3.2 Logistics information management

To support new-generation fighter aircraft such as the Gripen 39 C/D with logistics information management, information and communication technology (ICT) is used since it impacts on all the parts of the life cycle of products, services, and business; moreover, it is an enabler of changes in the organization, working methods, communication, and attitude (Pintelon et al., 1999). Two computer programs – FENIX E and the MGSS – are used in logistics support. On the other hand, e-mail is mainly used for communica-

tions to receive and send information when some logistics information is not available in these two computer programs.

FENIX E manages supply information, for instance how long LRUs have been used in the aircraft, when they need preventive maintenance, and records of their repairs. Moreover, this program is used for supply reordering when LRUs are not serviceable and new ones are needed, or the stock levels of spare parts and consumables run too low. The connection between FENIX E in Thailand and FENIX in Sweden uses the ordinary Internet, although the program needs an individual username and password to log in and access to enter or receive information. That is to say, the availability of historical data in a user-friendly database and smooth and fast external communication can help to improve the process (Pintelon et al., 1999).

The MGSS is not the only program to help analyse faults; the *Aircraft Maintenance Publication* (AMP) as a digital file in the same computer is also used to make the maintenance analysis faster than that for the previous generation of fighter aircraft. Since the data in the empirical findings show that many of the faults that occurred in Thailand are not the same as the faults that occurred in Sweden, using the MGSS speeds up the corrective maintenance process and increases the availability or FMC of the aircraft.

Another important issue in logistics information management at present is to record the consumption of supplies accurately using the ARM in FENIX E to forecast the supply requirements in the future. This record will help the RTAF in the future to prepare for spare parts and consumables procurement after the two years' initial support and inform the supplier that services the pooling programme to increase the stock level of LRUs in the local store at Wing 7.

6.3.3 Maintenance

Maintenance support for aircraft, such as corrective and preventive maintenance, always needs the same resources to process: they are personnel, material, documentation, and management information system. Personnel are the RTAF technicians who were trained for eleven months in Sweden. Pintelon et al. (1999) stated in relation to training that it is a time-consuming and expensive process that is not only required for inexperienced workers but also for the more experienced workers who need additional training in order to maintain newly acquired equipment. Moreover, they have to keep the core values of the RTAF in mind, especially regarding two concepts, airmanship and responsibility, when they are training and working. Material is supplied in three types: LRUs, spare parts, and consumables. Documentation is an AMP that takes the form of both paper and digital files. The management information system is FENIX E, which manages not only supply information, but also maintenance information to record all repair activities in aircraft with supplies. FENIX E is an advanced IT system and it is obvious that the more advanced the IT applications for maintenance are, the more easily this can be accomplished (Pintelon et al., 1999).

Furthermore, the performance measurement in maintenance can be proved by whether the aircraft availability or FMC has been 70% as a monthly average or not. Nevertheless, the RTAF technicians' performance is already measured by the SSG to ensure that they are performing well in maintenance and have more confidence in the eMaintenance process with the two computer programs.

6.3.4 Transportation

Supplies in the pooling programme and two years' initial support are transported by the commercial company named DSV. Since DSV is a worldwide company, it is useful that the FMV decided to use this company for transportation. The responsibility of DSV is to transport and take care of supplies from the central warehouse and repair workshop in Sweden through local, regional, and international means of transportation to the local store in Wing 7, and vice versa. It is the second time that local transportation in Thailand has been outsourced to a commercial company after transporting jet engines and making changes to the transportation strategy of the RTAF. However, customs clearance is still the responsibility of the RTAF since all the supplies in this programme are declared as military equipment for waiving taxes. In addition, this outsourcing is only managed by the FMV since the RTAF signed an agreement, made a payment, and has contact with logistics support only with the FMV as a single point of contact. That is to say, the FMV is 4PL.

The FMV staffs manage Gripen logistics support as 4PL to integrate services to customers by handling three distinct types of flow through the supply network: the physical flow and financial flow are supplied by other providers but managed and coordinated by them, and the information flow is their own operation (Huemer, 2006). Figure 6-2 presents the connection between the FMV as 4PL and their supplier and customer.

Figure 6-2 Illustration of the FMV as 4PL (Source: adapted from Huemer, 2006)

Finally, all the logistics functions involve each other. When changing a strategy in a function, it affects the others, so a strategic change in logistics support should be thought out together with all the logistics functions to achieve efficiency and effectiveness in logistics and operations. Following the analysis in this chapter, a summary of all the chapters of this thesis is presented in the next chapter: conclusions.

7 Conclusions

This chapter concludes the analysis to answer the research questions straightforwardly and to follow the purpose of this thesis, which is to find out how to support the new 4.5 generation fighter aircraft in four logistics functions and prevent future possible problems. There are three research questions in this thesis that require answers.

Question 1: What has been the main problem area in logistics support for fighter aircraft?

From the analysis, the author can conclude that the logistics support for new complex equipment with a long supply line is still difficult and the main problem area in the new system as Gripen 39 C/D tends to be the same problem area as in the existing system as F-16 A/B, although this area or logistics function is already outsourced to 3PL and 4PL. The main problem area is *supply*.

According to the thesis's purpose, a preventive way to solve this main problem area is to increase the stock level in the local store near the customer to achieve maintenance requirements and increase the budget for the pooling programme to induce the supplier to invest and keep more supplies in the local store. Moreover, the model of the hybrid P/S strategy can be viewed as a theoretical development of the study regarding how the supplier supports the RTAF with the supply and logistics information system.

Question 2: How can the lessons learned from logistics support in the existing system be incorporated into the new system?

Lessons learned in logistics support from the old system can be incorporated into the new system by *planning.* The planning in the four logistics functions is important for reducing the possible future problems and it is another way to prevent the problems. In contrast, many factors affect the planning, for instance the serviceability of the supplier and the limited budget of the customer as a government organization so that is not possible to meet the customer's needs because complex equipment is expensive in both product value and logistics support. In addition, it is a good way to deal with the purchasing and sustaining of a new system with a government organization such as the FMV as a supplier that does not think too much about profits but considers that the relationship between the two countries and spreading the market in the future are more important. Moreover, the important issue in planning that should be improved during the operation of the complex equipment is maintenance and material planning because a lack of supplies can be avoided if the planning is carried out in advance.

Question 3: How can we support the new-generation fighter aircraft in the four logistics functions?

There are four logistics functions to support the fighter aircraft of both previous and new generations: supply, logistics information management, maintenance, and transportation. The pooling programme is used to overarch two logistics functions – supply and transportation – and to ensure that the customers receive supplies at an appropriate time after their order. Moreover, this programme reduces the investment cost in the repair workshop and shares the risks from customer to supplier. This programme is one of the outsourcing methods to move some functions out of the organizations to 3PL and 4PL to acquire more professionalism in the process and certainty regarding the items needed.

For logistics information management and maintenance, ICT plays an important role in reducing the complexity of equipment such as 4.5 generation fighter aircraft. The COTS product from the business context is applied to the military context with additional modules to fulfil customers' requirements and based on simple communication via the Internet. A system such as FENIX E has many functions, including recording historical information and generating a maintenance process chronologically that helps the technicians achieve greater efficiency in maintenance and other people in preparing and planning. To analyse the faults after aircraft operation, the MGSS is used to attain better accuracy and speed up the maintenance process. In contrast, using ICT effectively needs time to gain the appropriate experience and skills.

In conclusion, the purpose of this thesis has been achieved and the research questions answered from the empirical data received by the methodology and referring to theories in the frame of reference. In addition, the author found that the tendency of military logistics at present is to use business logistics as an additional module to fulfil some lacks of competency since business logistics is well developed in efficiency and cost reduction that the military as a government organization needs to achieve.

8 Discussion

From the research study in this thesis, the author has learned a great deal about logistics support for 4.5 generation fighter aircraft, such as the Gripen 39 C/D, compared with previous experiences with fourth-generation fighter aircraft, such as the F-16 A/B. There is more complex equipment but it is easier to conduct logistics functions if people have ICT skills and are familiar with the systems since ICT helps greatly in the process and with information management.

Furthermore, this logistics support in four logistics functions only applies in peacetime. Preparation for wartime should be planned and agreed with the supplier to increase the supply stock level, means of transportation, reserve communication system, and maintenance consultants depending on the situation awareness and threats since the fighter aircraft are highly profitable in protecting the sovereignty of a nation.

In addition to personnel, although the main problem has been found and the logistics support planning performed, the readiness of people who drive all the functions and activities is not complete and will cause non-efficiency and non-effectiveness in the new system. Thus, the preparation of people in the RTAF is one of the most important issues before implementing the new system. The greater the readiness of people, the more effective the logistics and operations.

With reference to the methodology, it was a new task for the author and involved much planning to collect the data. Despite the extent of planning, the amount of responses in the survey the first time the questionnaire was sent to the respondents was quite low. To obtain more data, a second batch of questionnaires was sent out and then an appropriate amount of responses was received. Thus, sending out the questionnaire more than once helps to obtain more responses and informing the respondents in detail will generate more reliability and understanding that will induce the respondents to answer the questionnaires.

Translating the questionnaire to the correct language for the respondents is a strength in conducting the data collection, whereas it is a weakness for interpreting the data since the author had to translate all the data back to English again, which is a double task. If there is to be further research, this issue should be considered carefully to reduce some tasks and gain accurate linguistic data. Moreover, using a web-based survey such as Google Docs is a good method since it reduces the cost of paper questionnaires and there is no need for statistical processes. The data from the questionnaire are summarized automatically in a graph by Google Docs and also put into an Excel file that can be used further if the author needs more analysis of the data.

For the interviews, some interviewees work on specific tasks so they did not want to answer the questions that were beyond their work scope. So, it was not proper to press them to answer all the questions. Allowing the interviewees to select the questions to answer is a good way to avoid conflict and continue the interview until the last question.

Finally, for further study, other logistics functions are waiting to find out if problems occur with them since the limitation of this thesis is that it was able to determine preventive problems for only one logistic function. Moreover, whether examining the logistics planning is proper for operation or not is another interesting issue.

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Appendix 1 Questionnaire

Questionnaire for Survey Research: Preventing Problems in Logistics Support for the 4.5 Generation Fighter Aircraft

This questionnaire is one of the parts of a thesis from Jönköping International Business School (JIBS) and aims to find out the most important among four logistics functions that involve support for fighter aircraft: supply, logistics information management, equipment maintenance and repair, and movement and transportation.

Referring to the Gripen 39 C/D purchase of the Royal Thai Air Force (RTAF), after operating this aircraft, some possible problems may occur in the future concerning the four logistics functions mentioned before. Determining preventive methods for the problems before they occur is a good way to deal with this issue. However, considering the limited time available for the research, we have to select only one logistics function with this questionnaire.

For each question, unless otherwise instructed, please select only one response that best reflects your opinion and information.

1. Which field have you been involved in for the RTAF Gripen programme? (You can answer more than one.)

   □ Program Management Committee (Gripen Office, NPO, Liaison …)

   □ Training (Pilot, Technician, GCI …)

   □ Technology Transfer

2. What is your rank in the RTAF?

   □ Sqn. Ldr.–Gp. Capt.

   □ Flg. Off.–Flt. Lt.

   □ 3FS–1FS

   □ LAC–SGT

3. What is your highest education level?

   □ Doctorate

   □ Master's degree

   □ Bachelor's degree

   □ Others _____

4. How long have you worked in the RTAF until 2011? _____ years.

5. What is your office in the RTAF now?

   □ Royal Thai Air Force Headquarters (DP, DI, DO, DL …)

   □ Support Group (DAE, DCE, DA …)

   □ Wing 7

   □ Squadron 701

6. In the NATO *Logistics Handbook* (2007), the four logistics functions are defined as:

Supply – covers all materiel and items used in the equipment, support, and maintenance of military forces. The supply function includes the determination of stock levels, provisioning, distribution, and replenishment.

Logistics information management – couples the available information technology with the logistic processes and practices to meet the logistic information requirements. To be effective, logistic information systems must facilitate the delivery of the right information to the right people at the right time with the right information security protection.

Equipment maintenance and repair – maintenance means all the actions, including repair, to retain the materiel in or restore it to a specified condition. Repair includes all the measures taken to restore materiel to a serviceable condition in the shortest possible time.

Movement and transportation – it is a requirement that a flexible capability exists to move forces in a timely manner within and between theatres to undertake the full spectrum of the Alliance's roles and missions. It also means the transportation of supplies from one place to another.

Which logistics functions have you ever been involved in in your work?

(You can answer more than one.)

   □ Supply

   □ Logistics Information Management

   □ Equipment Maintenance and Repair

   □ Movement and Transportation

7. From your work experience, please scale these logistics functions by their importance to supporting the 4.5 generation fighter aircraft such as the Gripen 39 C/D.

	Definitely important	Important	Probably important	Probably not important
Supply	□	□	□	□
Logistics Information Management	□	□	□	□

	Definitely important	Important	Probably important	Probably not important
Equipment Maintenance and Repair	□	□	□	□
Movement and Transportation	□	□	□	□

8. According to the experience and lessons learned from the RTAF's operation of fighter aircraft, many problems have occurred and already been solved. How frequently have these problems occurred in your work?

Problems	Frequency			
	Often	Sometimes	Rarely	Never
Spare parts are out of stock				
Long lead-time restocking				
Lack of budget support				
Late delivery of supply				
New information system				
Failure of information system connection				
Disfunctional information system				
Technicians' repositioning and promotion				
Officers' retirement				
Lack of personnel				
Obsolete technical publications (TOs)				
Equipment readiness				
Limited means of transportation				
Old regulations				
No innovation				
Wrong vendor selection				

9. When some logistics problems occur in your work and office, how often do you become involved and have opportunities to solve them?

   □ Always

   □ Very often

   □ Fairly often

   □ Sometimes

   □ Almost never

   □ Never

Comment: ----------

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10. As you are in the RTAF Gripen programme and someone who works with Gripen fighter aircraft, which logistics function do you expect to create the most possible problems in the future? Please rank these four logistics functions by filling in 1 to 4 (1 = most possible and 4 = least possible)

    _____ Supply

    _____ Logistics Information Management

    _____ Equipment Maintenance and Repair

    _____ Movement and Transportation

11. Considering the most likely problem in question 10, how will you deal with this problem if it occurs in the future?

THANK YOU FOR COMPLETING THIS QUESTIONNAIRE.

ALL YOUR ANSWERS ARE COMPLETELY CONFIDENTIAL.

Flt.Lt.Agkarapol Chantarang

RTAF Master Scholarship Student in Military Logistics

Appendix 2 Questions for the interviews

To obtain more data for answering the research questions, interviews with the Swedish Support Group (SSG) and some RTAF officers are being carried out. The questions for the interviews are as follows and are divided into three main questions and some subquestions.

Question 1: How can you support the RTAF Gripen 39 C/D in four logistics functions: supply, logistics information management, equipment maintenance and repair, and movement and transportation?

- What is your responsibility?
- What is your understanding of the four logistics functions?
- I heard that the RTAF uses a pooling programme for Gripen logistics support; how does the pooling programme support the four logistics functions?
- Can you describe the processes in the pooling programme?
- Are there any documents to describe the pooling programme?
- Are there any systems used for logistics information management, and what do they look like (functions and process)?
- What is your advice and help for equipment maintenance and repair to RTAF officers?

Question 2: What is the most important logistics function to prevent problems?

- If there are problems in Gripen logistics support, what has been the main problem in your opinion?
- What is the reason for the main problem?
- Which logistics function is most related to the main problem?

Question 3: How can the most important logistic function be dealt with when possible problems may occur in the future?

- When the problems occur, do you have some opportunities to help RTAF officers solve the problems?
- How did you help them?
- What should be improved in the logistics function that involves the problems in your opinion?
- What do you think about cancelling the pooling programme and undertaking procurement directly from the OEM since this programme is costly?
- Other issues?

Appendix 3 NATO logistics functions

Supply

Supply covers all the materiel and items used in the equipment, support, and maintenance of military forces. The supply function includes the determination of stock levels, provisioning, distribution, and replenishment.

Materiel

Production or acquisition logistics covers materiel from the first phase of the life cycle to its final disposal from the inventory. The first part of the cycle, from specification, design, and production, is clearly a function of production logistics. The reception of the equipment into service, its distribution and storage, repair, maintenance, and disposal are clearly a consumer logistics task. However, the initial design of the equipment, which is part of production logistics, has to take account of the consumer aspects of repair and maintenance, and therefore involves both disciplines.

Services

The provision of manpower and skills in support of combat troops or logistic activities includes a wide range of services, such as combat resupply, map distribution, labour resources, postal and courier services, canteen, laundry and bathing facilities, burials, etc. These services may be provided either to one's own national forces or to those of another nation and their effectiveness depends on close cooperation between operational, logistic, and civil planning staff.

Logistic information management

Logistic information management couples the available information technology with logistic processes and practices to meet the NATO Commander's and nation's logistic information requirements. NATO and nations have numerous users requiring executive, managerial, and operational logistic information. To be effective, logistic information systems must facilitate the delivery of the right information to the right people at the right time with the right information security protection. They should cover all the logistics functions and interface between these functions and other functional areas as required. The NATO logistics systems need to be interoperable with both existing and emerging national and NATO systems. Interfaces with industrial systems should also be considered where practical and cost-effective.

Equipment maintenance and repair

Maintenance means all the actions, including repair, to retain the materiel in or restore it to a specified condition. The operational effectiveness of land, naval, and air forces will depend to a great extent on a high standard of preventive maintenance, in peacetime, of the equipment and associated materiel. Repair includes all the measures taken to restore materiel to a serviceable condition in the shortest possible time.

Movement and transportation (M&T)

It is a requirement that a flexible capability exists to move forces in a timely manner within and between theatres to undertake the full spectrum of the Alliance's roles and missions. It also applies to the logistic support necessary to mount and sustain operations.

Reception, staging, and onward movement (RSOM)

RSOM is the phase of the deployment process that transitions units, personnel, equipment, and materiel from arrival at ports of debarkation (PODs) to their final destination. Although RSOM is an operational matter, it requires the provision of a significant degree of logistics support. RSOM planning and execution requires therefore considerable integration with logistic support, M&T, and host nation support (HNS) planning.

Petroleum logistics

The NATO Petroleum Supply Chain has to be able to respond to the full spectrum of the Alliance's operational requirements and to the deployment distances and dispersions envisaged, taking specifically into account increased cooperation between NATO and partner nations and their respective military and civil authorities. Financial considerations, economies of scale, and the need for enhanced interoperability make it necessary continuously to seek new and innovative ways of delivering the fuel's capability.

Explosive ordnance disposal (EOD)

EOD involves the investigation, detection, location, marking, initial identification, and reporting of suspected unexploded ordnance, followed by the on-site evaluation, rendering safe, recovery, and final disposal of unexploded explosive ordnance. It may also include explosive ordnance that has become hazardous by damage or deterioration. The NATO EOD Technical Information Centre (EODTIC) holds records of all past and present ammunition and explosives, and provides an immediate advisory service on EOD problems.

Infrastructure engineering for logistics (IEL)

Infrastructure engineering for logistics, while not exclusively a logistic function, will require close co-ordination with logistics as its mission is very closely aligned with logistics in terms of facilitating the logistic mission of opening lines of communication and constructing support facilities. The engineering mission bridges the gap from logistics to operations and is closely related to the ultimate success of both. The acquisition, construction, and operation of facilities form the basis of the NATO Security Investment Programme (NSIP). This is the term generally used in NATO for installations and facilities for the support of military forces.

Medical support

This function entails the provision of an efficient medical support system to treat and evacuate sick, injured, and wounded personnel, minimize man days lost due to injury and illness, and return casualties to duty. An effective medical support system is thus considered a morale booster and a potential force multiplier. Though medical support is normally a national responsibility, planning must be flexible and consider coordinating multinational approaches to medical support. The degree of multinationality will vary depending on the circumstances of the mission, and be dependent upon the willingness of nations to participate in any aspect of integrated medical support. Medical care also plays a vital role in force protection.

Contracting

Contracting has become increasingly important to the conduct of operations, particularly when operating beyond NATO's area of responsibility. It is a significant tool that may be employed to gain fast access to in-country resources by procuring the supplies and services that the commander requires.

Host nation support (HNS)

The availability of HNS offsets the requirements for general and organic military support and thereby affects the size and scope of the Combat Service Support (CSS) force that must be committed to an operation.

(Source: NATO, 2007)

Appendix 4 NATO classes of supply

Class I

Items of subsistence, e.g. food and forage, which are consumed by personnel or animals at an approximately uniform rate, irrespective of local changes in combat or terrain conditions.

Class II

Supplies for which allowances are established by tables of organization and equipment, e.g. clothing, weapons, tools, spare parts, vehicles.

Class III

Petroleum, oil, and lubricants (POL) for all purposes, except for operating aircraft or for use in weapons such as flame-throwers, e.g. gasoline, fuel oil, greases, coal, and coke.

(Class IIIa – aviation fuel and lubricants)

Class IV

Supplies for which initial issue allowances are not prescribed by approved issue tables. Normally includes fortification and construction materials, as well as additional quantities of items identical to those authorized for initial issue (Class II) such as additional vehicles.

Class V

Ammunition, explosives, and chemical agents of all types.

(Source: NATO, 2007)