UNMANNED AERIAL VEHICLE (UAV) TECHNOLOGY IN THAILAND, AND APPLYING MARKETING IN THE MINING INDUSTRY

BY

MR. PISATE PAISIRIYUENYONG

AN INDEPENDENT STUDY SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE PROGRAM IN MARKETING
(INTERNATIONAL PROGRAM)
FACULTY OF COMMERCE AND ACCOUNTANCY
THAMMASAT UNIVERSITY
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ENTITLED

UNMANNED AERIAL VEHICLE (UAV) TECHNOLOGY IN THAILAND,
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the degree of Master of Science Program in Marketing (International Program)

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Independent Study Title	UNMANNED AERIAL VEHICLE (UAV) TECHNOLOGY IN THAILAND, AND APPLYING MARKETING IN THE MINING INDUSTRY
Author	Mr. Pisate Paisiriyuenyong
Degree	Master of Science Program in Marketing (International Program)
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Independent Study Advisor	Professor Malcolm C. Smith, Ph.D.
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ABSTRACT

This study is a contemporary topic in applied marketing focusing on the area of technology. The study of " Unmanned Aerial Vehicle (UAV) Technology in Thailand, and Apply Marketing in The Mining Industry" has been chosen to be an independent study topic. The objectives are to describe UAVs use in Thailand' s mining industry, to investigate UAV technology applied to aerial inspection and monitoring, and its effectiveness and advantages for the mining industry in Thailand, and to study how UAV technology can be introduced into the mining industry in Thailand.

Data and insights were obtained from secondary and primary research. Secondary research was gathered through various sources such as journals, published articles, newspaper, and the Internet. Primary research included conducting in-depth interviews with decision making units in 10 mining organizations, a government organization and 3 players who provide UAV product or service in the industry.

Key findings from this study are an overview of the analysis of the application of UAV technology in the Thai mining industry and will serve as a guide so that mining organizations can understand more about the application of UAVs to the mining industry. It would give the reader, who may provide UAV technology in the mining industry, insights and applications for UAV product or service for decisions

regarding strategic business directions. Also, this study would be of interest to Thai government officials, people associated with UAV technology, and technology related firms.

Keywords: UAV technology, drone, mining industry, Thailand market adoption

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I would also like to extend my deepest appreciation to all of the respondents of young Bangkok urbanites, who are my friends, colleagues, and all my beloved classmates of MIM 29. All of the information and data were helpful and highly contributed to my study. Thank you for such great cooperation, and interesting opinions.

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Mr. Pisate Paisiriyuenyong

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Symbols/Abbreviations	Terms
UAVs	Unmanned Aerial Vehicles
DPIM	Department of Primary Industries and Mines
B2B	Business to Business
B2G	Business to Government

CHAPTER 1
INTRODUCTION

1.1 Problem Statement and Research Purpose

Unmanned Aerial Vehicles (UAVs) are small-size aircraft without a pilot controlled by a monitoring unit on the ground and can be integrated with various electric devices depending on the objectives of usage. For example, for military, inspection, and agricultural management purposes, an additional high-resolution camera may be attached to the UAV. UAVs can be integrated with cameras or sensors that enable them to take sky-view pictures, and deliver a 3D model simulation of the inspected area (TheUAV, 2016).

Mining area inspection is one of many fields where UAV technologies can be helpful. Two examples of using UAVs in the mining industry are to create a topographical survey, and to provide a safety investigation. When conducting a topographic survey on an open mine area, the UAVs will deliver pictures showing a graphical image represent actual surface presenting the rock slope. This will help with future planning and the monitoring of dust particles after blasting in open-pit mines, which in turn will allow mine users to know the exact remaining volume of rock. Thus, future operating costs can be calculated. Generally, mine operators work on mine areas that have different slopes and shapes. If the slope is too steep, an accident might occur during the operation. UAV application allows us to examine the slope of each mine area and this information can be used to establish safety regulations at the mine site (McLeod et al., 2013).

In the same year, the Department of Primary Industries and Mines of Thailand revealed that there were 233 square kilometers of mining area and 432 mining organizations in Thailand. UAV technology has been widely used in the mining industry worldwide; however, few Thai mining organizations use this technology, which might be a result of the low awareness of the benefits of UAV technology, the high cost of initial investment, or the ineffectiveness of the past generation of UAV technology (DPIM, 2016).

This is an applied study in marketing of the Unmanned Arial Vehicle technology business which focuses on the mining industry in Thailand. The first objective was to obtain an overview of the market of UAV products and services in Thai industry including structure, conduct, and performance. The second objective was to gain insight into the application of UAV technology in Thailand' s mining industry. The last objective was to provide suggestions concerning how UAV technology can be introduced to Thailand's mining industry.

The result of this study will help those that are interested in the UAV market in Thailand obtain a clearer understanding of the market situation regarding the overall UAV industry, including UAV products and services. The study will also help interested business organizations introduce UAV products or services to the mining industry in Thailand.

1.2 Research Objectives

This is an applied study in marketing of the Unmanned Arial Vehicle (UAV) technology to the mining industry in Thailand and focuses on the area of technology. The objectives of this study are as follows:

1. To describe the UAVs utilized in Thailand' s mining industry, including the following:
    a. Structure, major players, technology, barriers, and government regulation
    b. Industry's players and their channels
    c. Cost structure, and sales performance
2. To investigate UAV technology applied to aerial inspection and monitoring, and its effectiveness and advantages for the mining industry in Thailand
    a. How mining organizations apply UAVs to the mining industry
    b. What benefit from adapting UAV technology in mining operation organizations will be received
3. To study how UAV technology can be introduced into the mining industry in Thailand
    a. Adoption process: awareness, interest, evaluation, trial, and adoption of UAV in the mining industry
    b. How the decision-making units in the organization work

The next chapter reviews relevant literature concerning the UAV technology, its applications in the mining industry, the UAV industry in Thailand comprising barrier to entry, main players, and government reactions, and theoretical concepts. Following this chapter, the study focuses on the in-depth interview incorporating with the information derived from secondary and primary research. In the final part of this independent study, the data and results are analyzed and this is followed by the conclusions.

CHAPTER 2
REVIEW OF LITERATURE

2.1 UAV Technology

Unmanned Arial Vehicles (UAVs) or drones are aircraft without the presence of a human pilot aboard that are used to perform intelligence, observation, and investigation missions (Lozano, 2010). UAVs have an integrated number of systems and sub-systems that include the aircraft frame, an integrated payload, a ground control station, and aircraft launching, recovery, and communication systems (Austim, 2010).

2.2 Type of UAVs

There are two types of UAVs: with a fixed wing and with a rotary wing. UAVs with fixed wings are similar to passenger planes or fighter planes. One of the advantages of this type of UAV is the low rate of fuel consumption, resulting in longer operation time per flight. However, one obvious disadvantage is its inability to take off and land vertically. Therefore, there are limitations in the use of fixed-wing UAVs during operation because they require a runway area to take off and land. Figure 1. contains a picture of a fixed-wing UAV currently available in the market (Parrot: ebee).

Figure 1: Fixed-wing UAV (Parrot: ebee Sensefly,

https://www.sensefly.com/drones/ebee.html)

Another type of UAV is one with a multiple rotary-wing, which can take off and land vertically in small places, and additionally it can take both vertical and tilted images as it can move in vertical and horizontal directions. Although multiple rotary-wing UAVs have a low fuel consumption rate compared to fixed-wing UAVs, they can only operate during short operation flights. Thus, this type of UAV is suitable for small areas where there is a limited take-off and landing space and where images have to be taken in vertical or horizontal directions. One example of a multiple rotary-wing UAV that is available in the market is the DJI: Phantom 4, which is shown in Figure 2.

Figure 2: Multiple rotary-wing UAV (DJI, Phantom 4, http://www.dji.com/phantom-4)

2.3 UAV Technology and Applications

In the past, UAV technology has been typically used for military purposes; however, in this present day, it is currently used for various objectives, for example to investigate crop production in agriculture, to observe weather situations, to investigate disaster during an emergency, to investigate traffic flow, and to provide security in unpopulated areas (Lee&Choi, 2016).

UAV technology can be integrated with many devices, such as high-resolution cameras, sound recorders, or transmitters, which allow UAVs to perform different purposes (Cavoukian, 2012). Some examples of utilizing UAVs for commercial or civil purposes are the following: 1) search and rescue; to offer support during emergency rescues; 2) inspection of oil and gas industries, such as pipelines, wind turbines, and power lines; 3) securities; keeping securities at endanger area; 4) precision agriculture; tracking and estimating plant health in order to maximize crop yield; 5) aerial photography; 6) surveying/ GIS; applied in the mining industry to estimate the current mining situation or volume stockpile measurement; 7) unmanned cargo systems; used to deliver small parcels to reduce operation time and cost (Microdrone, 2016).

2.4 UAV Technology Application in the Mining Industry

UAV technology can be developed and used in various applications, for example checking current mine characteristic with "mineral lease agreement points", design mining area by " contour map" that show the level of height, volumetric updates or stockpile management. In Thailand, UAVs can be applied for various applications, such as mapping or survey of mining to control and monitor remaining mining stock piles (Dronecenter, 2016). One example of using UAVs in Thailand is Uawithya, an outsource company in mining industry that uses UAVs to take a picture of the mine area for management purposes.

The apparent example of using UAV technology is to take aerial photography of overall area of mine. The mining organizations are using aerial photography of their mine to compare and update with " mineral lease agreement points" issued by government (DPIM) . The sample will be shown in Figure 3.

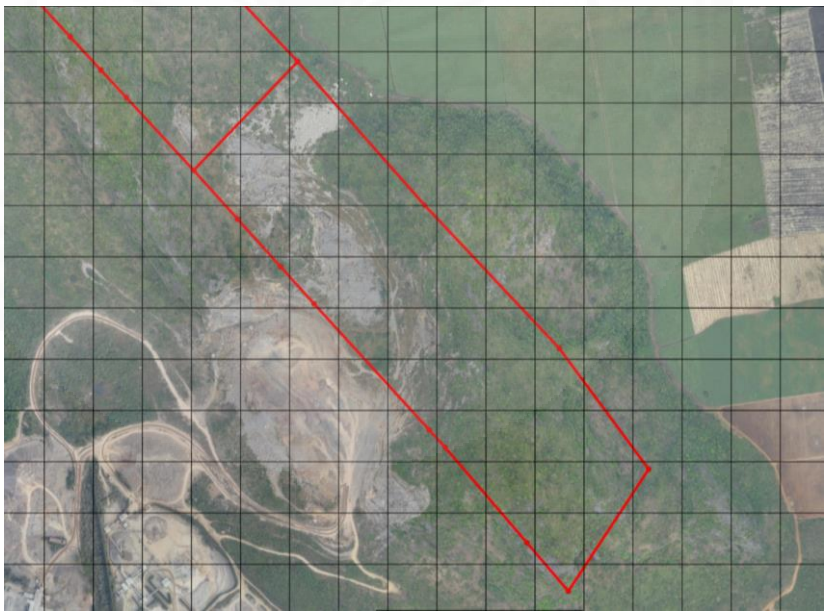

Figure 3: Aerial Photography Survey Producing by UAV Technology with "Mineral Lease Agreement Points" (Source: Company Files)

The aerial map can be integrated with "contour line" or the line that shown different level of height from sea level which shown in Figure 4. This can be used to

design and setting equipment and safety inspection.

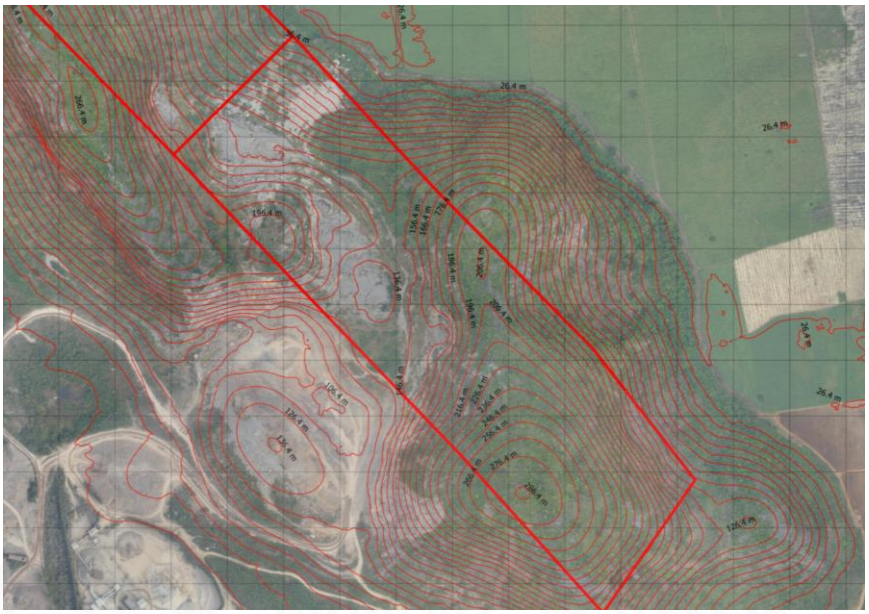

Figure 4: Aerial Photography Survey Producing by UAV Technology with “Mineral Lease Agreement Points” and “Contour Line” (Source: Company Files)

2.5 Barriers to Entry of UAV’s Market in Thailand

Because UAV technology is new to mining industry market, the barriers to entry stem from various factors which are the expensive cost of the initial investment of UAVs and insufficiency in the users’ operation skills. The average market price of fixed-wing UAV is high. For example, the Parrot ebee Sensefly is cost roughly 1.2 million THB, while Trimble UX5 is around 5 million THB. During the flight operation, there are many factors that might damage the UAV, such as severe atmosphere conditions and long distances from the operating units where there is a high change of the loss of UAV controllability. Thus, these factors strongly affect entrance into the market as UAVs are expensive and new for business companies.

2.6 UAV Service Players

Currently, there are a few business organizations in Thailand that are using UAV technology for aerial view pictures, surveys, inspection, or agriculture, for example Thai Sky Vision, MBI, SKYVIV, and Celest System. UAVs are well known as devices for taking aerial photography; however, other applications of UAVs such as surveys, inspection, and agriculture are quite limited, resulting in less demand for other applications.

2.7 Thailand UAV Regulations and Laws

In order to have the right to control and to be an owner of a UAV, Thailand regulations require a person or organization to comply with the following: 1) not operate or fly the UAV over restricted areas; 2) the maximum height of operation is limited to not over 400 feet; 3) the radius of control and operation is limited to not over 500 meters or the visual line of sight; 4) the UAV must not be flown over a group of people at less than 150 meters; 5) the UAV must not fly over an object, person, or vehicle at less than 50 meters except during landing or take-off; 6) the use of the UAV has to be approved by a government organization for commercial purposes (DTI, 2015).

2.8 Government Reaction to UAV Technology in the Mining Industry

The Department of Primary Industries and Mines (DPIM) has introduced UAV technology to the mining industry. Most of the mine business organizations lack human resources and a monitoring budget, and this has resulted in inefficiently monitored mining areas and illegal mining operations. UAVs would help to monitor and operate mining areas correctly according to engineering requirements, and finally reduce operating costs and time (DPIM, 2016).

2.9 Government Plan on Thailand 4.0

Thailand has been developing its economic model from Thailand 1.0 to Thailand 4.0. For the first model, "Thailand 1.0," agricultural sector was emphasized. The second model, "Thailand 2.0," emphasized light industries, which helped to develop the country's economy from low-income to middle-income status. "Thailand 3.0" emphasized heavy industries for continued economic growth. The next generation is "Thailand 4.0," which focuses on innovation and creativity. There are three main targets of "Thailand 4.0." The first is becoming a high-income nation through the development of a knowledge-based economy, for example via research and development. The second is moving toward an inclusive society with opportunities for all members of the society. The last is focusing on sustainable growth and development without destroying the environment. The illustration is shown in Figure 5.

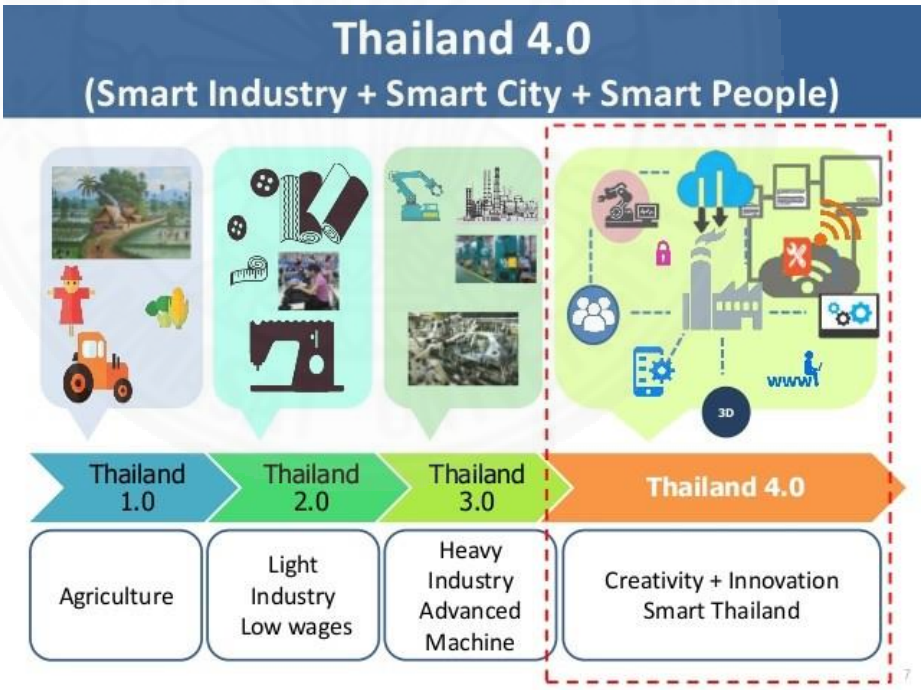

Figure 5: Thailand 4.0 Model (https://www.thailand-business-news.com/economics/54286-thailand-4-0-need-know.html)

2.10 Theoretical Framework

2.10.1 Consumer Adoption Process

In order to apply new products to the mining industry market, an understanding of consumer adoption process theory is helpful. Theoretically, product adoption occurs when an individual decides to become a regular user of a product. The adoption processes are covered in five main steps: 1) awareness—when the consumers becomes aware of the innovation but lacks information about the product; 2) interest—when the consumer seeks information about the product; 3) evaluation—when the consumer considers whether to try the new product; 4) trial—when the consumer tries the product; 5) adoption—when the consumer becomes a regular user of the product (Kotler, 2012)

When considering entering a new product to the market, it is important to consider the person's level of innovativeness or the degree to which each individual is willing to adapt the new idea or new product. There are five groups of people according to Kotler that differ in their motive for adopting or resisting a new product: innovators, early adopters, the early majority, the late majority, and laggards, as shown in Figure 6.

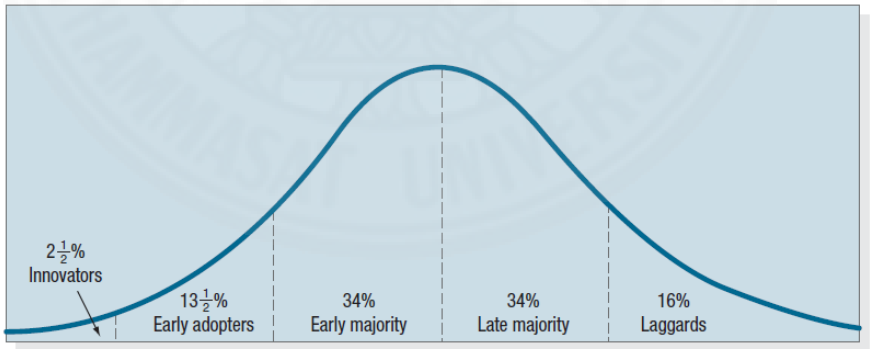

Figure 6: Time of Adoption of Innovations (Kotler, 2012)

2.10.2 Innovation Diffusion Process

As UAVs are an innovative product, it takes time to introduce it to the market. The manner in which innovations spread throughout a market is called the diffusion process. There are 10 factors that affect the spread of innovations.

First, the type of group is the target group of persons that are ready to accept the innovation; in general, they are young, affluent, and highly-educated people. Second, the type of decision is referred to as individual versus group decisions; innovations will spread faster when purchasing is decided by individual rather than group. Third, market effort is about the firm' s marketing support, which heavily influences the diffusion of the innovation. Fourth, fulfillment of felt needs means that the more consumer' s satisfaction is toward the innovation, the faster the diffusion. Fifth, compatibility of innovation is consistent with the individual's or group's values and beliefs, resulting in more rapid diffusion. Sixth, relative advantage means the more advantage or value provided to users from the innovation product compared to existing products, the more rapid the diffusion. Seventh, complexity of innovation. The more difficult it is to understand and use the product the slower the diffusion will be. Eighth, observability of innovation. Clear benefits from using the innovation results in more rapid diffusion such as that of a cell phone. Ninth, trialability of innovation. The product or service that easier to try, has lower cost to create trial, or lower risk when results go wrong, the more rapid will be the diffusion. For example, laser eye surgery is not easy to try, and the diffusion rate is low; while headache remedies are easier to try, the diffusion rate is high. Tenth, the higher the perceived risk that was linked with trail innovation, the slower the diffusion rate. Risk is about the probability that the unit is not performing as desired, the result when it performs not meet expectation, and the cost to a reverse negative sequence (Hawkins, Best, & Coney (2010) The slow and fast adoption of technology is shown in Figure 7.

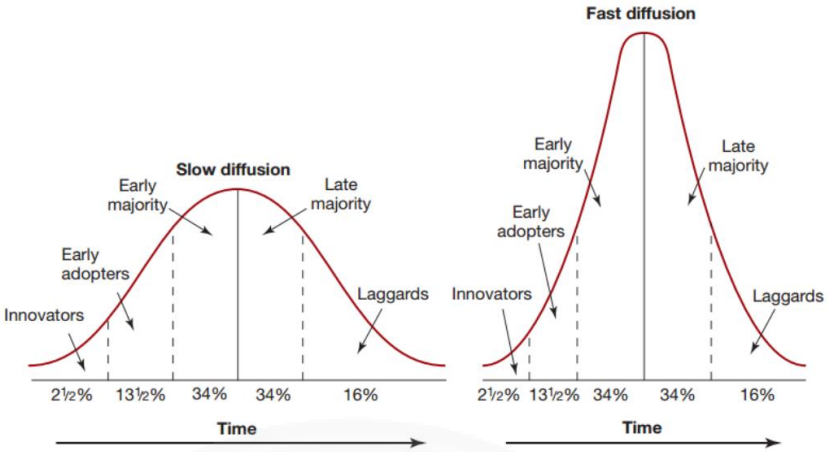

Figure 7: Adoption of an innovative over time (Hawkins, D. I., Best, R. J., & Coney, K. A. (2010)).

2.10.3 Organizational Buying Behavior

Organization buying behavior is comprised of eight steps, which are illustrated in Figure 8. First, problem recognition is a process when someone in the organization realizes problems or needs that can be solved by acquiring a product or service, which can be started with internal or external stimulating factors. The internal factor is a person' s normal needs, while the external factor is a need aroused by something external such as a salesperson or advertisement. Second, general need description is when a need exists, the buyer will define the exact requirements of product or service to correctly purchase to solve the problems. The persons that are involved in this process are engineers, users, purchasing agents, and others. Third, the required product must be specific in terms of technical specifications. Fourth, suppliers who have a capability to fulfill requirements or solve problems of organization will be searched. The buyer can search on the Internet, by phone, or via company recommendations. At this stage, the marketer can participate by contacting the buyer directly. The sales representative plays a major role at this stage. Fifth, the analysis of the proposal is when qualified suppliers are invited to submit proposals. This stage requires skillful sales representatives. Sixth, the supplier selection is similar to consumer purchasing decision. The compensatory (trade-off) model is when customers choose the maximum summation of multi-attributes value which are multiple of product's attribute and weight. Seventh, the order-routine specification is

when a buyer writes the final order with the chosen supplier, listing the technical specifications, the quantity needs, the warranty, and so on. Finally, the performance of the supplier will be reviewed. Two parameters that the organization will evaluate are expectations and perceived performance (Burnett, 2008).

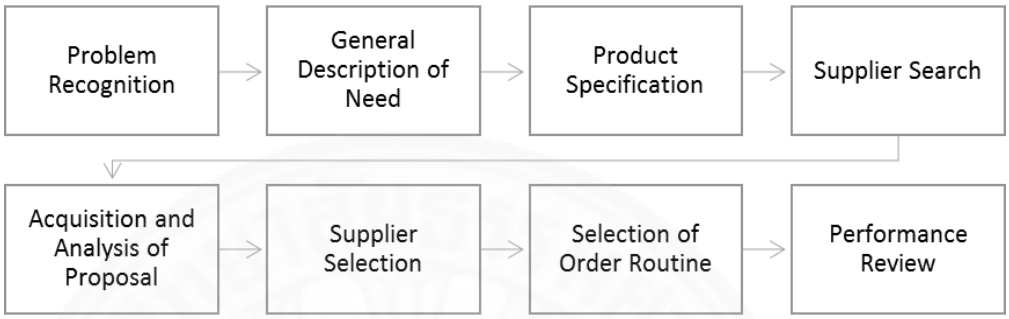

Figure 8: Organizational Buying Behavior

2.10.4 Decision-Making Units in the Organization

The decision-making units of business-to-business (B2B) markets are different from consumer markets for two reasons. First, the B2B market is more complex than the consumer market. Generally, consumer purchasing decisions are made by one or two people. However, that of B2B involves several decision makers with different areas of each expertise. Second, B2B decisions are more complex than consumer buyers. This is because the B2B level requires decisions from both people and organizations (Harrison, 2016).

Decision-making units or DMUs in the organization can be defined as a group of people that make collective decisions about the purchasing of goods or services. DMUs can be defined according to six roles, which are users, influencers, buyers, initiators, deciders, and gate keepers (Vliet, 2014). It is possible for one person to have several roles. First, users are people who use goods or services and have an influence on the specifications. Second, the influencers are people who define requirements of the purchase and have a high influence on the purchasing process which can be found at all levels of the organization. Third, the buyer is the person that makes the decision to purchase products or services, and find supplier options, negotiate, and place and order. In the organization, buyers are the people that take

responsibility for the purchase department. Fourth, the initiator is the person that knows the exact problem and tries to find the solution, and is the most important person in the DMU. Fifth, the decider is the final person that takes responsibility for making decisions concerning the choice of the supplier. Finally, the gate keeper is the person that determines the type of information that will be delivered to a certain player and as a consequence he or she can influence the decision-making process strongly (Vliet, 2014).

CHAPTER 3
RESEARCH METHODOLOGY

The research on Unmanned Aerial Vehicle (UAV) technology in the mining industry in Thailand focused mainly on insights from mining organizations, government, and players in the mining industry. It employed exploratory research and qualitative methodology, which is in-depth interview as shown in Figure 9.

Figure 9: Research Methodology

3.1 Research Methodology

3.1.1 Secondary Research

Secondary data was conducted to get an overview of UAV technology, Thailand mining organization, major UAV players, market barriers, and government regulations, as well as to have a better understanding of the topic under study. The data was obtained from credible published sources and website both Thai and International. Secondary research sources as follows: 1) Published online reports or journals related to UAV technology and the mining industry 2) Articles and studies under the area of study.

3.1.2 Primary Research

To get overall UAV technology market information in the mining industry, in-depth interviews with three main organization groups were conducted which were mining organizations, government organization, and UAV technology suppliers and

service providers. Two types of questionnaires were created for the mining organizations and UAV technology product and service providers. Insight information from government organization, the DPIM, was attained by observing a meeting.

The in-depth interviews of mining organization were conducted from January to February 2017. The interviewees came from 10 mining organizations and they held in different roles in the industry. This was done to maximize the chance of discovering key results.

Regarding the in-depth interviews with the mining organizations, respondents were part of decision-making units. There people were owners or engineers in the organizations. The scope of the questionnaire was the product-adoption process of customers, including awareness of UAVs in the mining industry, their interest, how they evaluate the use of the technology, their intention to try new technology, and the adoption rate of UAV technology. Moreover, the buying-decision process was examined, including what mine organizations' current problems are, how they search for information, how they evaluate choices, what factors influence the decision making, and their post-purchasing behavior or experience with the application of UAVs. An example of the questionnaire can be seen in Appendix A.

The insight from government organization, the DPIM, was attained by observing in a private meeting won 19th January at DPIM office, Bangkok. The respondent is Khun Sura Phetpirun, Director Bureau of Engineering and Land Rehabilitation of DPIM. The picture of minute of meeting was shown in Figure 10.

Figure 10: Minute of meeting with DPIM

The in-depth interviews of UAV technology product or service provider were arranged during February 2017. To make an appointment for the in-depth interviews with industry players, a letter was issued to explain and clarify about interview' s objectives. A sample of the letter can be seen in Appendix B. Furthermore, an example of the questionnaire can be seen in Appendix C. There were only two players of UAV technology service providers who responded to the in-depth interview request which are TEAM consultant and AEC-MBI (Thailand).

3.2 Sampling Plan

Ten mining companies (B2B), government (B2G) organizations, and key players in Thailand UAV market participated in the interviews. In order to learn how mining organizations can apply UAVs to their work (Objective 2) and to know how UAVs can be introduced to the industry (Objective 3), the target respondents were comprised of the decision-making units in mining companies or government organizations that were influencers who are technical engineers, deciders who are purchasing officers or government officers, or users who are mining organization owners.

3.3 Data Collection

The exploratory research data were collected using various database sources. These sources were literature reviews and other published articles that were available on the Internet.

The qualitative data research was conducted using in-depth interviews, which took two months, from January to February 2017. These interviews were face-to-face or were telephone interviews based on convenience. The method for contacting the respondents was to use the internal connections of the mining organization.

3.4 Limitations of the Study

Due to the limit of time and resources, this study aimed to be a preliminary research exploring UAV technology and its application in the mining industry. The limitations are as follows:

1. Since UAV technology is new to the mining industry, the number of respondents was limited.
2. Regarding the small sample size through the use of the non-probability sampling method, the findings from the in-depth interviews may not represent the entire mining industry.
3. The sample selection may not cover all mining organizations to reflect accurately the overall industry.

Overall, the limitations of this study did not influence the findings or results, but the small sample size may have made this study inappropriate for case study or proof supporting business decisions. Therefore, the further quantitative study may generalize the data to represent UAV market in the mining industry.

CHAPTER 4
RESULTS AND DISCUSSION

4.1 Secondary Research – Key Findings

UAV Industry Overview

UAV technology can be applied in several industries. There are numerous major applications in Thailand, which are surveys in the mining industry, precision agriculture, and construction. UAVs are mostly used in the mining industry by taking aerial photos to investigate changes, design quarry areas, and surveys in inaccessible areas.

There are few companies that provide UAV technology by offering both services or products. Some companies sell UAV products and train people in UAV operations to mining organizations while other companies provide survey services to mining organizations.

Barriers to the entry of UAV technology in the mining industry

There are two major barriers to the entry of UAV technology in the mining industry, which can be categorized according to the demand and supply side.

For the demand side, consumers that are mining organizations play an important role. As UAV technology is new to the market, there are few mining business organizations that know about or recognize the benefits of using UAV technology in their mine. Thus, at the present time, there is less demand for using UAV technology in mining organizations.

Regarding the supply side, the UAV producer and service provider organizations in Thailand lack product knowledge and a huge amount of investment is required. UAV technology is innovative and new to the market. Therefore, skillful operators are required that have technical knowledge of UAVs. This is because there is a high risk to lose UAVs from external factors, such as bad weather conditions or miss-communication from ground operating units, and human error such as incorrect planning of flight operations.

In order to provide aerial surveys, both hardware (UAVs) to collect images and software to process picture output are required. The cost of initial investment is high—more than 1.2 million THB
(ref: ebee Sensefly, https://www.sensefly.com/drones/ebee.html) for hardware, and 0.3 million THB for software.

Government organizations' reactions to UAV technology

Government regulations also play an important role in the overall UAV market and mining industry in Thailand. They have launched regulations to control UAV owners and organizations. According to the DTI, UAV owners or organization have to comply with 4 regulations: operating UAVs in allowed areas, limited height, limited radius of operation, and a clear of group of people (DPIM, 2016).

The Department of Primary Industries and Mines (DPIM) has issued new regulations that will drive the UAV industry to growth, forcing all mining organizations to annually report their quarry status to the DPIM by using aerial photos taken from UAVs as they need to control mining organizations under regulations, such as preventing mining without patent permit and gathering the proper taxes.

Industry players and their channels

There are few UAV service providers in Thailand. The major players are AEC-MBI (Thailand) *(http://www.aec-mbi.com/)* Thai Sky Vision *(http://www.thaiskyvision.com/)*, ESRI *(http://www.esrith.com/th/index.html)*, SKYVIV *(http://www.skyviv.com/)*, and Celest Systems *(http://www.celestsystem.com/)*.

UAV technology in the mining industry is categorized as business-to-business, as a product or service is being sold to the business organization. Thus, the major channel for contacting or reaching the customer is via direct marketing, including email, face-to-face pitching or presentations, telephone contact, or online marketing.

Pricing structure

In the view of mining organizations, if they need to utilize UAV technology in their mine, there are two options, which are purchasing UAVs for self-operation or

seeking UAV service providers. Thus, the price structure can be categorized according to two type: product and servicing.

Product

When mining organizations consider using UAV technology in their operation, they have to consider purchasing both hardware and software. Hardware is the UAV technology product. It might be fixed wing or multi-rotor type. For fixed wing UAV product, price is between 1.2 and 5 million THB depending on the type of UAV. In contrast, the price of multi-rotor UAVs is much cheaper than fixed wing units, ranging from 40,000 to 70,000 THB. Another component is the software used to process collected data that costs between 0.3 and 0.5 million THB. The price range can be shown in Table 1.

	PRODUCT	**PRICE RANGE**
HARDWARE	FIXED WING: Parrot-ebee, Trimble - UX5	1.2-5 Million THB
	MULTI-ROTORS: DJI Phantom	40,000-70,000 THB
SOFTWARE	PROCESSING SOFTWARE	0.3-0.5 Million THB

Table 1: UAV Product's Price Structure

Servicing

Using UAV technology in the mining organization by purchasing technology and operating by organization requires a huge amount of investment; however, hiring a UAV service provider is more convenient and cost saving. The price of a UAV operation is based on servicing area in unit of square kilometer. The price range of a UAV service provider varied from 20,000 to 100,000 THB per square kilometer which shown in Table 2.

UAV SERVICE PROVIDER	PRICE RANGE (Per Square Kilometer)
AEC-MBI	20,000-24,000 THB
Thai Sky Vision	20,000-24,000 THB
ESRI	50,000-60,000 THB
SKYVIV	100,000 THB
CELEST SYSTEMS	20,000-25,000 THB

Table 2: UAV Service's Price Structure

Applying UAV Technology in the Mining Industry

According to Lee & Choi, the applications of UAV technology in the mining industry can be aerial photography surveys, the planning of the mine, and work management. In order to describe this in greater detail, the application of UAV technology in the mining industry can be categorized based on purposes, which is mine surveying, mine operations, drilling and blasting, mine safety, mine construction, and so on.

In mine surveying, UAVs can be used in pit and dump management, stockpile management, and mapping of steep inaccessible inclines. UAVs can also be used at mine sites for such applications as fleet management, road maintenance, and water

management. They can also be used in the drilling and blasting process which allows an organization to manage the mine site before and after blasting, and identify misfires or wall damage. UAVs can also be used for mine safety operations such as storm damage assessment, surface stability monitoring, joint mapping, dust monitoring, and slope stability analysis. Additionally, it can be used during construction by monitoring and reporting the progress of a mine site. Other applications would be conveying belt inspections, ground heating monitoring, or facility management. Summarize applications of UAV technology are shown in the Table3.

TYPE	APPLICATION
Mine Surveying	Pit & dump management Stockpile management Mapping of steep inaccessible inclines
Mine Operations	Fleet management Road maintenance Water management
Drilling & Blasting	Pre-& post-blast management Identification of misfires & wall damage
Mine safety	Storm damage assessment Surface stability monitoring Joint mapping Dust monitoring

	Slope stability analysis
Construction	Progress monitoring & reporting
Others	Conveyor belt inspection Ground heating monitoring Facility management (Pipe, pump, lights, towers)

Table 3: Application of UAV technology in the mining industry

There are a number of benefits from applying UAV technology in the mining industry; however, the level of UAV application is low in small-size mining organizations due to expensive initial investment costs for UAV technology and the lack of professional expertise.

Aerial mapping surveys produced by UAV technology can substitute traditional land surveys produced by humans. According to the DPIM, the error rate of UAV surveys is only 2 percent compared to traditional surveys. Thus, the survey results from UAV technology can replace the traditional survey.

4.2 In-Depth Interviews with Mining Organizations – Key Findings

According to the objectives of the study, besides the understanding of UAV technology utilized in the mining industry, how to introduce UAV technology into the industry is needed as well. Thus, the in-depth interviews with mining organizations were conducted with 10 organizations.

Classification of mining organizations and their UAV technology adoption level

The mining organization can be categorized into two groups, those that are of a small-size, which are local business organizations, and those of a large size, which are public companies with complex working organizations. The in-depth interviews

were conducted with 6 small-size mining organizations and 4 large-size mining organizations. The factors that helped to differentiate the small-size and large-size organizations were the number of employees, the revenue, and the size of the mine.

Adoption process of UAV technology in the mining organization

Segment 1: Small-size mining organization (n=6)

Most small-size mining organizations (n=5 of 6) know about UAV technology but do not know what practical benefits they can receive from this technology. They know that there are other mining organizations that use UAV technology to improve their working operations by taking aerial photographs or by mapping. However, they are still not interested in UAV applications as they have used the traditional method very well and believe that it is unnecessary for them.

Segment 2: Large-size mining organization (n=4)

The majority of large-size mining organizations (n= 4) have tried utilizing UAV technology at their mine site to check that their mine operations have not exceeded the allowed mine lease area, to manage their production plans by measuring the existing mine volume or stockpile measurement, and to create a visual 3D model of the mine for a construction plan. One large-size mining organization has recognized that UAV technology is very important for it. The chief engineer of this mining company stated the following: " We have utilized UAV technology in our working process as it helps us to reduce operation cost by replacing human labor in surveys of large and unreachable area" and " We used aerial picture and 3D model creating from UAV to plan our new mine site to setting new machines." Therefore, it can be clearly seen that large-size mining organizations have recognized and already tried UAV technology at their mine site.

Acceptance level of UAV technology in the mining organization

UAV technology has been well adopted in medium to large size mining organizations; however, it cannot completely replace the traditional organization' s work procedure. An in-depth interview with Khun Nattapong, the mining manager of Sahachart Sethakit Co. , Ltd. , reviewed some of the limitations regarding UAV

technology acceptance. He stated that "UAV technology have been utilized on daily mining operation for measuring stockpile and calculating current mine volume." However, the processed data from UAV technology cannot be accepted by the financial department because the data from UAV are estimated data and the financial department requires accurate data from actual measurement tools.

Consumer's decision making regarding the use of UAV technology service providers and approaching channels

According to Khun Thanapiphat Vituchulichot, managing director of S. Silathong Saraburi Co., Ltd., UAV technology is very new to the market and there are fewer players that provide UAV products or services. He has tried using UAV technologies by outsourcing UAV service providers at mine sites for taking aerial pictures to generate 2D maps, 3D maps, and stockpile measurements. He knows that UAV can be greatly adapted to the mining organization for monitoring mine sites, mine design and construction, and the measurement of the production. The major factor for servicing UAVs is the advantages and price range of services. He claimed that "the price range should be around 20,000 to 23,000 THB per square kilometer, and quality of the servicing and resolution of output pictures is also important." In addition, Thanapiphat highlighted that the best channel UAV service provider could approach to the mining organization is through the Internet and referral from friends in the industry.

4.3 In-Depth Interview with UAV Service Providers – Key Findings

According the secondary research, one factor that drives the utilization of UAV technology in the mining industry is the supply side, which is the UAV technology retailer or service provider.

Limitations of UAV technology service providers in Thailand

Khun Kwanchai Phromna, a co-founder of AEC-MBI (Thailand), who has more than 5 years of experience in land survey using UAV technologies by providing aerial mapping and survey services to mining organizations.

Although UAV technologies provide huge benefits to mining organizations, the high cost of initial investment costs for UAV technology and the lack of skillful UAV operators are major obstacles to UAV technology market expansion in the mining industry.

UAV technology can be used as a preliminary planning for mining management. The top-viewed aerial maps generated by UAVs enable mining engineers and management teams to plan and design sites before the actual construction begins. Three-dimension mapping can be used in visualizing actual mine sites and for safety planning.

The starting cost is high, as it includes hardware (UAV, receiving telemetry, ground control units) and software (route path planning and data processing units). With regards to this high cost, it would be more convenient for mining customers to use UAV services. The lack of skillful UAV operators could result in damage to the UAV. In order to operate the UAV, a skillful engineer is necessary for planning the flight, and control during takeoff and landing. If the UAV is damaged, it could result in two major problems: a huge amount of expense for maintenance, and loss of opportunities to operate for the other services.

Mining Organizations' Behavior Toward UAV Technology

According to Khun Kwanchai Phromna, AEC-MBI (Thailand) co-founder, mining organizations can be categorized according to their behaviors into un-planned and well-organized mining organizations. The un-planned mining organization lacks operation management for quarries or mines and unintended to use UAV technology in helping manage their mining resources. In contrast, the well-organized mining organization which generally recruits mining engineers as their consultant is interested in using UAVs because they believe technology will increase their work efficiency and reduce operating time and labor costs.

4.4 In-Depth Interviews with Government Organizations – Key Findings

Government organizations have played an important role in driving UAV technology application in the mining industry. The Department of Primary Industries and Mines is the government organization responsible for developing Thailand' s mining industry by supporting private mining organizations.

Government Organization's Action Regarding UAV Technology

The DPIM has known about and has tried to utilize UAV technology to support their regular work, such as observing mining organizations and preventing them from conducting quarry mining outside the allowed mine lease and collecting taxes from quarry mining.

The face-to-face meeting at Department of Primary Industries and Mines with Khun Sura Phetpirun, Director Bureau of Engineering and Land Rehabilitation of the DPIM, revealed some of the huge advantages of UAV technology applications. He stated the following: "Currently, DPIM is facing a lack of human workforce problem that causes them unable to monitor mining organizations." He also added that "UAV can be used to take aerial picture of mine areas to prevent mining out of legalized areas or mining leases." Furthermore, he claimed that the benefit of UAVs is huge as the accuracy from UAV mapping results is as same as with the traditional methods and it can replace the traditional monitoring method using a human workforce.

Significantly, the Department of Primary Industries and Mines has a plan to announce a new regulation that would increase the demand for using UAV technology in the mining industry by the end of August 2017. The regulation will force every mining organization to report the current environmental mining situation by taking aerial photographs using UAV technology annually.

CHAPTER 5
CONCLUSIONS AND RECOMMENDATIONS

From the data analysis and the results of how the mining industry utilizes unmanned aerial vehicle technology, the implications for UAV technology were concluded in the view of business, market trend, and opportunity as follows.

5.1 Limited Utilization of UAV Technology in the Mining Industry

The research results show that the level of use of UAV technology in the mining industry is low. According to secondary research, there are numerous UAV technology applications in the mining industry, such as mine surveying, mine operations, drilling and blasting, mine safety, mine construction, and so on. However, most mine organizations use the technology only for mine surveying, that is, taking aerial photos to check the "mine lease" and stockpile management. This is because UAV technology is new to the market, and consumers do not know what is possible for UAV applications, and there are few experts on the technology.

5.2 The Mining Industry Adoption Process

Among the two segments of the mining organization those that are small and those that are large, the level of UAV technology adoption is different. Most large-size mining organizations have attempted to use UAV at their mine site because they believe that the technology can produce huge advantages to them by reducing operation costs and time. However, most small-size mining organization have awareness but have not used UAV technology in their mine operations. The key difference between these two groups is the size of the mining area, as a UAV can produce more benefits for bigger-size mines as it requires a smaller human workforce and less operation time.

5.3 Big Opportunity for UAV Technology in the Mining Industry

UAV technology, however, can be applied in a number of industries such as agriculture or construction, and the mining industry could be the first market to adopt this technology. This is because UAV technology can produce huge benefits to the mining organization by surveying large areas within a few days compared to the traditional method that uses a human workforce.

In the view of UAV technology product and service providers, the mining industry is a "blue ocean" market. The number of players in the industry is limited, as UAV in the mining industry requires skillful experts and huge investment costs for both hardware and software.

5.4 A government Organization, the DPIM, as the Key UAV Market Driving Factor

The present research shows there is low adoption of UAV technology in the mining industry, especially in small-size mining organizations; however, it is felt that the UAV market in the mining industry will significantly grow. After having a face-to-face meeting with the DPIM, the Department of Primary Industries and Mines, the new regulation that will be launched will force every mining organization, including small to large-size organizations, to report the current aerial photography of their mine site to the department annually. Thus, the demand for using UAV technology will absolutely increase. Therefore, the government organization, DPIM, will be the major factor to drive UAV technology in the mining industry.

5.5 A Recommendation for UAV Technology Marketers

As the time of this writing, the UAV market in Thailand is on early stage and there are not many current players in the industry. Thus, introduction of the new product and service organization in UAV technology into the country context has been noticed as a high opportunity. Additionally, in the near future, all mining organizations will be forced by DPIM to report their annual aerial pictures taken by UAV which will be legalized by the end of August 2017. Therefore, it is essential for marketers of UAV technology product or service organizations to encourage their

companies to be certified follow the criteria of DPIM to sustain the existing of business in the long run.

In the meanwhile, marketers should promote their UAV product to the large size mining organizations without ignoring to offer their service to those are small. This because the large organizations already have a strength financial situation and their own professional human resources, who are engineers or mining specialists, whereas the small to medium size organizations are lacking these kinds of resources. Thus, purchasing and operating the UAV by themselves might not be suitable to the later organizations. These different characteristics can help the marketers understand the circumstances of decision making on not only what to sell but also whom to sell.

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APPENDICES

APPENDIX A
QUESTIONNAIRE FOR MINING ORGANIZATION

Introduction

Hi, my name is Pisate Paisiriyuenyong. I' m a master degree student of marketing program, Thammasat University. I'm currently working on market research to study of using UAV or drone technology in mining organization. The purpose of this questionnaire is for study only and this data will be kept in secret.

Screening

S1. What is your name?

S2. What is your mobile phone number, and email?

S3. What is your company name and type of company?

S4. What is your position in the company?

S5. What is your company's mine size in square kilometer?

Body

B1. Do you aware of UAVs or drone technology?

B2. Do you know how to apply UAV in routine mining operation? (Objective: 2a)

- Stockpile
- Topographic map
- 2D mapping
- 3D mapping
- Contour generation
- Safety investigation
- Routine job planning

B3. Do you know of how to use UAVs or drone technology in mining operation? Why? (Objective: 3.A.1)

B4. Do you interested in using UAVs or drone technology in mining operation? Why? (Objective: 3.A.2)

B5. What are purchasing factors for using drone in mining industry? (Objective: 3.A.3)

- Price range, what price range per square kilometer is reasonable?
- Quickness of operation
- Quality of final work
- Other, please specify

B6. Have you or your company trail to use UAV or drone in mining operation? (Objective: 3.A.4)

- If yes, do you satisfied or what
- If no, why?

B7. What is your main channel to contact drone service provider?

- Internet
- Reference from other company
- Regional radio

B8. Have you known other drone service providers in Thailand? (Objective: 1.A)

- If yes, please specify.

B9. How your organizations apply UAVs to the mining industry? (Objective: 3.A.5)

- Stockpile
- Topographic map
- 2D mapping
- 3D mapping
- Contour generation
- Safety investigation
- Routine job planning

B10. What benefit from adapting UAV technology in mining operation organizations will be received? (Objective: 2.B)

- Save operation cost
- Faster operating time
- UAV or drone is more accuracy than human workforce

B11. Who will take responsibility to decision trial or using UAV or drone in mining operation? (Objective: 3.B)

- Mining engineer
- Project advisor
- Mine organization owner

Thank you for your cooperation.

Table: Matching between QUESTION and OBJECTIVE

QUESTION	**OBJECTIVE**
B2	2.A
B3	3.A.1
B4	3.A.2
B5	3.A.3
B6	3.A.4
B9	3.A.5
B10	2.B
B11	3.B

APPENDIX B
INVITATION LETTER FOR IN-DEPTH INTERVIEW OF UAV TECHNOLOGY PRODUCT AND SERVICE COMPANY

Date: Day Month Year

Dear “Company Name”,

My name is Pisate Paisiriyuenyong, I am a Master Degree student in Marketing from Thammasat University. Currently, I am working on my independent study project, the topic is “Unmanned Aerial Vehicle (UAV) technology in Thailand, and applying marketing in the mining industry”

UAV technology have numerous advantages to mining organization and its industry such as mine survey, operation, drill and blast management, mine safety regulation monitoring, and construction. However, the utilization of UAV in mining industry in Thailand is quite low.

The objective of this study is to describe the UAVs utilized in Thailand’s mining industry, to investigate UAV technology applied to aerial inspection and monitoring, and its effectiveness and advantages for the mining industry in Thailand, and to study how UAV technology can be introduced into the mining industry in Thailand.

I am writing this letter to request to conduct short in-depth interview which would take around 1 5 to 3 0 minutes via face to face conversation, mobile phone, or skype based on your convenience. Please let me know when is your available date and time for this interview.

Pisate Paisiriyuenyong

Master degree in Marketing

Thammasat University

APPENDIX C
QUESTIONNAIRE FOR UAV TECHNOLOGY PRODUCT AND SERVICE COMPANY

Introduction

Hi, my name is Pisate Paisiriyuenyong. I'm a master degree student of marketing program, Thammasat University. I'm currently working on market research to study of using UAV or drone technology in mining organization. The purpose of this questionnaire is for study only and this data will be kept in secret.

Screening

S1. What is your name?

S2. What is your mobile phone number, and email?

S3. What is your company name and type of company?

S4. What is your position in the company?

Body

B2. How to apply UAV in routine mining operation? (Objective: 2a)

- Stockpile
- Topographic map
- 2D mapping
- 3D mapping
- Contour generation
- Safety investigation
- Routine job planning

B4. Do most of company interested in using UAVs or drone technology in mining operation? Why?

B5. What are purchasing factors for using drone in mining industry?

- Price range, what price range per square kilometer is reasonable?
- Quickness of operation
- Quality of final work
- Other, please specify

B6 . Company trail to use UAV or drone in mining operation, are they satisfied?

- If yes, do you satisfied or what
- If no, why?

What benefit from adapting UAV technology in mining operation organizations will be received? (Objective: 2.B)

- Save operation cost
- Faster operating time
- UAV or drone is more accuracy than human workforce

4Ps

- Product?
- Accuracy, 2d, photogrammetry, report?
- Price range, how much?
- What channel you use to promote business organization?
- Do you have any promotion?
- What is your process of doing services?
- People training?

Have you known other drone service providers in Thailand? (Objective: 1.A)

- If yes, please specify.

BIOGRAPHY

Name	Mr. Pisate Paisiriyuenyong
Date of Birth	December 30, 1988
Educational Attainment	2016: M.S. in Marketing, Thammasat University
	2012: B.S. in Aerospace Engineer, RMIT University, Australia
Work Position	Marketing Executive Celest Systems Co.,Ltd.
Work Experiences	2017-present: Marketing Executive Celest Systems Co.,Ltd. 2015-2016: Design Engineer Honda R&D Asia Pacific 2014-2015: Service Engineer Siam Kubota Corporation Co.,Ltd.