IMPROVEMENT OF RADIO NETWORK SITE SURVEY FOR THE THAI CELLULAR PHONES MARKET

by

Mr. Kittichai Apintanaphong

A Final Report of the Three - Credit Course
CE 6998 Project

Submitted in Partial Fulfillment
of the Requirements for the Degree of
Master of Science
in Computer and Engineering Management
Assumption University

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Project Title	Improvement of Radio Network Site Survey for the Thai Cellular Phones Market
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Academic Year	November 2001

The Graduate School of Assumption University has approved this final report of the three-credit course. CE 6998 PROJECT, submitted in partial fulfillment of the requirements for the degree of Master of Science in Computer and Engineering Management.

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ABSTRACT

Radio Network Site Survey is a process to find the suitable location for Radio Base Stations. Radio Base Station is one part of cellular network, which will interface between user and network. Without a suitable location for Radio Base Station, the quality of network can not be improved. With high competition in Thai cellular market, bad quality of network will impact the sales net. When the competition of subscriber's sale is increased, a competition between building better network is also increased. Not only the existing competitor will need the best location, the new entrants will also need the best location for their network.

The implementation in each phase is about 9 months. Radio Network Site Survey has been finished within the first three months. Otherwise, implementation can't be finished on time. Nowadays, the process of Radio Network Site Survey has not been improved for a long time. The current process can support only 120 sites per phase. Double team is one solution for double capacity. But with the increasing number of new sites, improvement of Radio Network Site Survey is the way to increase capacity and reduce cost as well.

The main improvement of the process is to split the Radio Network Site Survey team in to two teams, separated by functionality and duration of work. This improvement will be applied by using the method from work measurement and work analysis.

That is why this project is initiated. The improvement of Radio Network Site Survey should replace the old system and support the large number of new sites.

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I am indebted to the following people and organizations. Without them, this project would not have been possible.

I wish to express sincere gratitude to my advisor and Dean of CEM, Dr Chamnong Jungthirapanich, chairman of the Advisory Committee, Prof.Dr. Srisakdi Chamonman, both from Assumption University.

There are always in endeavors such as this one an array of people and/or organizations that are deserving of thanks and acknowledgement. To the many who facilitated me in my project I would very much like to offer my heartfelt gratitude.

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Special appreciation is due to my family for their fervent and continuous encouragement. Finally, my greatest appreciation is reserved for all those people currently helping to make this system a reality in their own organizations and advancing our collective understanding of this new system.

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I. INTRODUCTION

1.1 General Background of the Project

Great Subscriber growth prospects for Thai Cellular Phones Market

Thailand's current cellular penetration level of 7.6%, with a total cellular market of only 4.7 million subscribers, implies that the Thai cellular sector is still far from being saturated and has substantial room for further growth. High handset prices, an economic recession, and an uncompetitive market have held back subscriber growth in recent years. But with falling handset prices and increased competition, the pent-up demand for cellular services is expected to manifest itself in strong growth in subscriber numbers for the next 2-3 years.

With Higher GDP per capital than both the Philippines and China, but with lower cellular penetration levels, we believe that there is definitely room for a strong growth in Thailand. Thus, we are projecting that Thailand's total cellular market can grow by 3,100,000 in 2001. Actual 1Q01 growth of 780,700 net new subscribers suggests that this estimate is achievable.

The Thai cellular market is the only one in the region where handsets are still sold for profit (margins on handset sales were 28% and 3% for AIS and TAC in 1Q01 respectively), in contrast to subsidies employed in most other markets. It is also one of and increasing limited number of the markets where fixed line penetration (9% at the end 2000) exceeds cellular penetration (6% at the end 2000). These two factors illustrate the historically uncompetitive nature of the Thai cellular market and the constraint on growth.

However, things are changing fast. Margins on handset sales are declining fast and expected to be very low by 2H01. Meanwhile following tariff declines, cellular long distance charged are now below those fixed lines. Cellular services are suddenly becoming affordable for the mass market and this will release of a lot of pent-up demand leading to strong subscriber growth.

AIS, which is known as the clear quality leader in the Thai cellular market, is expected to continue to have a better network with a significantly higher coverage and much more base stations than TAC. As of now, AIS has a coverage of more than 90% of Thailand, compared to TAC's 53%. The premium network quality comes at a price though, as service charges are higher. We believe that a large part of the potential subscriber base is willing to pay more to ensure that the cellular connections are more reliable and that the number of 'no network' message is reduced.

We expected AIS to add about 800 base stations and six mobile switches during 2001, which will bring its total number of base stations to 3,297, while the total number of switches will be increased to 25. This means that it is successively improving as already good network, while TAC needs to substantially upgrade a network, which lags behind, and it currently is not up to par. TAC currently has 2,097 base stations and an estimated 16 MSC's (mobile switching centers).

With this number of base station, it is increasing from year 2000 about 4 times. The method to find the location of the new base stations needs to be improved to support the increased demand.

1.2 Significance of This Project

This project will focus in one part of the expansion project, Radio Network Site Survey. The objective of the project is improving the process of Radio Network Site Survey. The present method of Radio Network Site Survey, which had been used for many years, can't handle the increasing number of base stations. We need to improve the process and do an analysis for these jobs.

1.3 Objectives

This project will focus on the improvement of the process of Radio Network Site Survey. Following issues will be delivered.

(a) To investigate the problem in current process of Radio Network Site Survey.

(b) To solve the problem and apply the new idea which will be the fast rollout of the network.

(c) To find the standard time for Radio Network Site Survey.

1.4 Statement of the Problem

With this number of subscribers forecasting, we expected that there would be not only competition in marketing to keep their own market share, but also the competition to building the expansion network will be high. The present method of Radio Network Site Survey can handle only 200 Sites per years, which will not be enough to handle the increasing subscriber. And if the network cannot handle, it impact the quality of the network.

II. LITERATURE REVIEW

2.1 Thai Cellular Phones Market (Olausson, 2001)

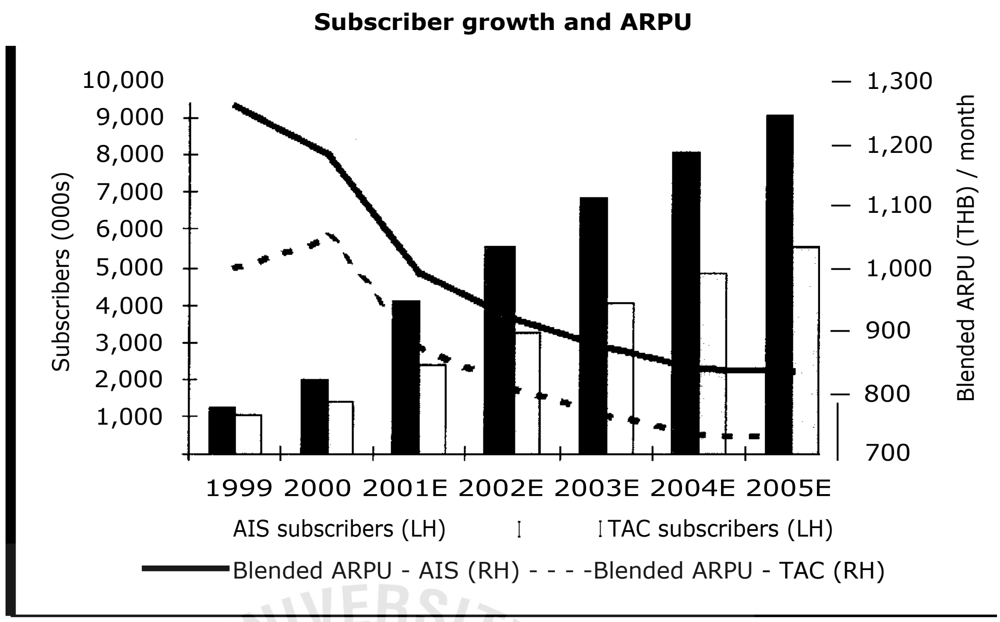
2.1.1 Cellular Fitness Test — AIS vs. TAC

With increasing affordability and a low penetration level, the Thai cellular market is set to explode as pent up demand is released. The AIS/TAC duopoly is firmly entrenched and both companies are expected to be strong beneficiaries of the market's growth. We favor AIS over TAC due to a superior network, strong branding and low financial risk. We believe the new entrant CP Orange will have a tough time.

(1) Thailand's total cellular subscriber base is projected to grow by 85% to 6.8 million subscribers at the end of 2001, and a further 41% in 2002.

(2) Although blended ARPUs are expected to decline by approximately 16% in 2001 and 8% in 2002, the strong subscriber growth will more than offset this effect, leading to strong margin and free cash flow improvements.

(3) AIS's superior network and brand equity translating to pricing power means that it does not have to follow TAC into a price war to maintain market dominance. This threatens the viability of CP Orange.



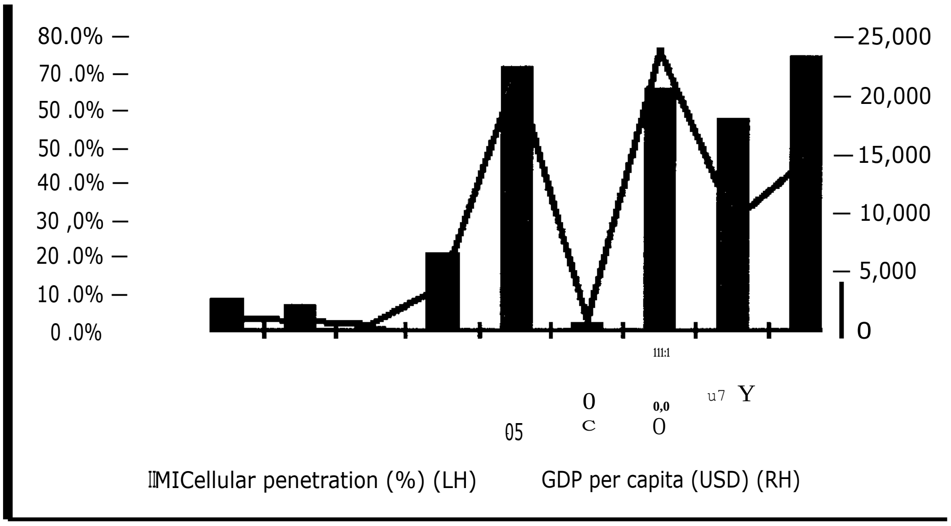
Source: IWICS, TAC, AIS

Figure 2.1. Subscriber Growth and ARPU.

2.1.2 Great Subscriber Growth Prospects

(1) Low Penetration at Present: Room for Further Growth

Thailand's current cellular penetration level of 7.6%, with a total cellular market of only 4.7 million subscribers, implies that the Thai cellular sector is still far from being saturated and has substantial room for further growth. High handset prices, an economic recession, and an uncompetitive market have held back subscriber growth in recent years. But with failing handset prices and increased competition, the pent up demand for cellular services is expected to manifest itself in strong growth in subscriber numbers for the next 2-3 years.



Source: TWIGS

Figure 2.2. Cellular Penetration and GDP per Capital in 2000: Asian peers.

With a higher GDP per capita than both the Philippines and China, but with lower cellular penetration levels, we believe that there is definitely room for strong growth in Thailand. Thus, we are projecting that Thailand's total cellular market can grow by 3,100,000 in 2001. Actual 1Q01 growth of 780,700 net new subscribers suggests that this estimate is achievable.

(2) Pent-up demand and increasing affordability

The Thai cellular market is the only one in the region where handsets are still sold for a profit (margins on handset sales were 28% and 3% for AIS and TAC in 1Q01 respectively), in contrast to subsidies employed in most other markets. It is also one of an increasingly limited number of markets where fixed line penetration (9% at end 2000) exceeds cellular penetration (6% at end 2000). These two factors illustrate the historically uncompetitive nature of the Thai cellular market and the constraint on growth.

However, things are changing fast. Margins on handset sales are declining fast and are expected to be very low by 2H01. Meanwhile following tariff declines, cellular long distance charges are now below those of fixed lines. Cellular services are suddenly becoming affordable for the mass market and this will release of a lot of pent up demand leading to strong subscriber growth.

2.1.3 Subscriber Adds Ramping Up

(1) 1Q01 Subscriber Growth - Highest Ever in Thailand

We have seen record subscriber growth in 1Q01, with both AIS and TAC registering record high net subscriber additions in March. AIS added an impressive 155,900 net new subscribers in March, while TAC added 179,700. In 1Q01 AIS added 453,100 subscribers, of which 227,500 subscribers were in the prepaid segment, while TAC added 306,600 net new subscribers, of which prepaid was 61,700.

Table 2.1. Thailand's Subscriber Growth in 1st Quarter 2001.

1Q01 steer growth — total Thailand (*Mar market			
	1Q01 net adds	*1Q01 ending subs.*	*4Q00 ending subs.*
AIS	453,100	2,430, 500	1 ,97 7,400
TAC	306,600	1,7 09,800	1,403.200
DPC	21,000	231,000	216,000
Others		44,000	44,000
Total	**780,700**	**4,421,300**	**3,640,600**

Sattire. PNICS, MS, TAC, DPC, TOT, CAT

(2) Strong Subscriber Growth for Both TAC and AIS

While both AIS and TAC are expected to post strong subscriber growth in the next few years, we expect AIS's subscriber growth to be higher than that of TAC, and we expect AIS to get higher quality subscribers in comparison to TAC, because of the premium service which its cellular network offers. AIS has a much stronger position with the prepaid market and corporate subscribers than TAC. This higher quality nature of AIS subscribers also means that ARPU is less vulnerable to decline. We believe that AIS can maintain prices at a 15% premium to TAC without significantly impacting its market share.

We expect AIS to add 2.1mn net new subscribers in 2001, while TAC should be able to add 1 mn, mainly due to its newly launched DTAC campaign.

AIS has been very successful with its prepaid service, One 2 Call, and currently has 668,800 prepaid subscribers. TAC has not been too successful with its prepaid service yet, but we believe that this will change with the new revenue share agreement with the TOT and when the DTAC rebranding campaign bears fruit. One of the major advantages of the prepaid product is that it eliminates bad debt risk for the operators, and also billing and staff costs. For the customer it reduces the need to pass a credit check, have a bank account and it is also a convenient and flexible product, which allows budgeting of expenditure.

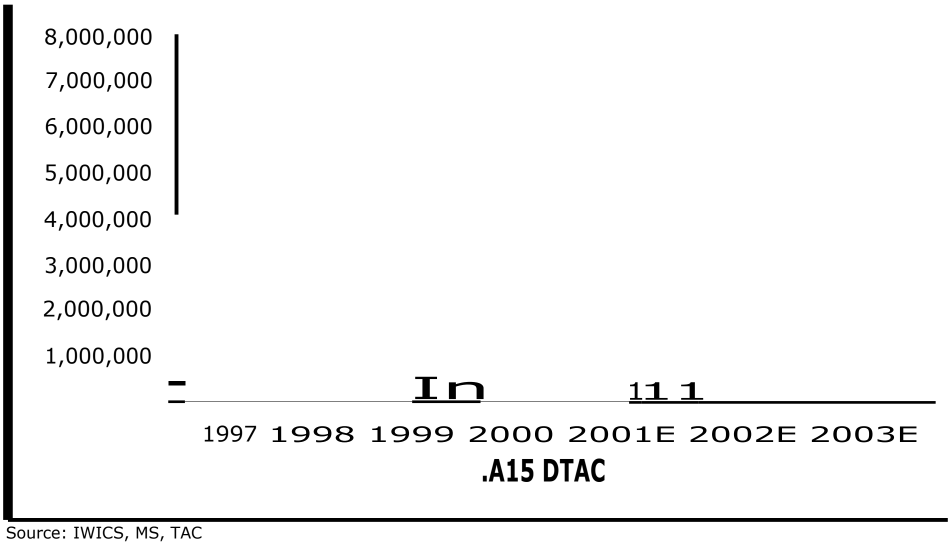


Figure 2.3. Subscriber Growth Projections — AIS and TAC.

Since AIS now has 2,624,700 (end of April figure) subscribers which puts it 49% higher than TAC's subscriber base of 1,825,100 subscribers, we do not foresee any threat to its dominant position, even with TAC and its aggressive DTAC campaign. While the DTAC promotions and pricing is very low, AIS can afford to charge more than the competition because the subscribers which it is targeting value the better service which it offers. We have already seen a record breaking April net subscriber addition of 194,200 for AIS beating its March net subscriber addition of 155,200 and by far exceeding TAC's April net subscriber addition of 115,300. This shows that subscriber growth remains very strong despite the launch of the DTAC campaign. We believe that its strong brand equity and better service means that TAC will find it hard to 'steal' subscribers from AIS.

2.1.4 Churn Expected to Increase

With annual chum levels of about 18% for TAC in 2000 and AIS's chum estimated to be about 15%, there is a visible element of switching between different promotions in the market to get the best value offering possible. Churn is expected to remain high for both operators in the near future, and can even increase when CP Orange launches its services in early 2002 (could be delayed even further but we expect a launch within 1H02). The increasing popularity of prepaid service increases churn, as it is much easier for cellular subscribers to change from different promotions and cellular operators. Lower airtime charges and handset prices also has a strong effect on churn, as changing from one operator and package to another becomes easier. Once handset prices are close to zero, and differences in airtime charges between different operators are virtually erased, differences in service quality have more of an impact on churn. This means subscribers may churn away from an operator with inferior network quality, since pricing is not the critical issue for decisions on different operators. If AIS has a much higher network quality, and pricing is slightly higher, one could see churn away from a TAC network because of higher network quality and service.

2.1.5 Pricing of Services

(1) TAC's DTAC Campaign Puts Pressure on AIS

The DTAC campaign, which waives monthly fees and offers low, flat rate pricing nationwide, has put pressure on AIS to also lower prices. The initial response to TAC's DTAC campaign was a rather weak March promotion from AIS. As the success of TAC's campaign became clear, AIS launched the substantially more competitive April promotion. The April promotion makes it much more attractive than its previous offering for existing and new subscribers to use the AIS network.

The DTAC promotion is clearly an aggressive promotion, and is targeted at recruiting more users in the low end segment, whereas AIS remains focused on the higher end of the market. Both campaigns seem to be successful so far, but TAC will probably hurt itself by lowering airtime fees and waiving monthly fees. It shows how hungry and eager TAC is to recruit new users. TAC's April net subscriber addition of 115,300 was disappointing and 36% or considerably below March's net addition of 179,700 subscribers.

Pricing comparison — TAC and AIS

TAC's DTAC promotion

Package	*MontNy fee (THB)*	*Airtime payment (THB)*	*Free airtime (THB)*
Dprompt	None	THB5	None
Dille	TliB2 50	Tl1134	None
Dmedium	None	Tl41J3 la irtime fee: 111W 50 for 250 min.)	None
Dmax	None	r l 1E12010lw fee: Tl4131,200 for 600 min.)	None

AIS April promotion

Package	*Monthly fee (THB)*	*Airtime payment (THB)*	*Free airtime (THB)*
Promotion 1	300	Peak time normal rate.Off-peak 50% discount	None
Promotion 2	500	250	1,000
Promotion 3	500	500	2,500
Promotion 4	500	750	4,500

Sauna: IWICS, AIS, TAC

Assigned DTAC promotion take-up

	Mat-01	*Dec-01*	*Mar-02*
DTAC / Non-DTAC split on digital subscriber base			
DTAC packages	49%	92%	*100%*
Non-DTAC packages	51%	8%	0%
Postpaid DTAC package assumption			
Dlde	30%	30%	30%
Dmediurn	35%	40%	40%
Dmax	s5%	30%	30%

5011 : FMCS, TAC

Figure 2.4. Pricing Comparison - TAC and AIS.

(2) ARPU will be Coming Down (More so for TAC)

The promotions above, which are indeed both aggressive, will inevitably lower ARPU. TAC expects, by the end of 2001, that 90% of its subscriber base will be signed up on its DTAC packages. We estimate that AIS postpaid ARPU should come down by about 6.5% in 2001, while TAC should see an average 8% decline in the same year. We are expecting blended ARPUs (postpaid and prepaid) to decline by an average 16% in 2001 and 8% in 2002 for the two operators, as significantly more prepaid users are added on to the subscriber base. AIS's net subscriber growth of 194,200 in April constitutes a 25% increase from March's 155,900, while TAC's April net addition of 115,300 was a sharp decline of 36% from March's record of 179,700. We are expecting that the subscriber reaction going forward will continue to be strong. A key difference between the different promotions is that AIS's promotion is only available to old/new subscribers who buy a new handset, while TAC's package is available to both new and old subscribers. AIS's promotion is cheaper for very heavy cellular usage, as it gives a lot of free minutes. Thai cellular rates are low in comparison to other markets especially Europe low end, but handsets are still very high (in Europe handsets are given away free if subscribers sign up for long term contracts).

Different Target Users for Each Operator

TAC and AIS are targeting different kinds of users. AIS, which is more focused on the prepaid market and high end corporate users, will probably have a high degree of brand loyalty with customers. Any low end users which belong to AIS' subscriber base may be tempted to migrate to TAC. Network quality could hold back migration from taking place. We believe that low end users are more likely to sign up for TAC's system, as it is clearly much more economical than that of AIS. While TAC is targeting low end users in less urban areas outside of Bangkok, this strategy could prove destructive unless the company is able to install sufficient network capacity. With AIS lowering fees, it can, if it wants to, penetrate a high amount of low end users, if necessary. One thing is clear, and this has been obvious in the past: sacrificing network quality for subscriber recruitment is dangerous.

With a low current cellular penetration of 7.6% in Thailand, and more affordable handsets, both of these operators have room to grow.

(4) Future Promotions - AIS May Step Up the Intensify

One cannot expect AIS to avoid further retaliation, especially if TAC's new push proves very successful and if TAC steals subscribers from AIS, or if the bulk of subscriber growth tends to sign up for TAC's services.

Retaliation may be held back by the fact that AIS's new April promotion is already quite competitive, and some subscribers may be willing to pay a premium for a higher quality service.

TAC's recently launched DTAC offering is valid for five years, while AIS April promotion is on offer for three years. It will take time for the subscribers to decide which package is more suitable for them.

(5) Value Added Services Pricing

TAC's DTAC promotion waives monthly service charges on value added services, but the company does charge for usage. AIS still charges monthly service charges for value added services (as well as usage). We believe that value added services usage will gradually increase from an estimated current 2% of total revenues to about 5% by 2003. This compensates for any decrease in ARPU from lower airtime charges. On the whole, since TAC has lowered service charges across the board, it may seem that the company should have a higher effect of revenue increase, but we believe that AIS's high end user subscriber base would be more likely to use value added services such as SMS and e mail, because these users are generally in the higher income brackets. Going forward, we expect GPRS to greatly enhance and increase value added services usage, as the mobile Internet services are data unit based and not time based. There could be an introduction of a set service charge for unlimited usage, as has been introduced in Finland by Sonera, whereby the equivalent of THB600 is charged for unlimited usage per month.

2.1.6 Quality of Network

(1) Clear Advantage Through Its Superior Network for AIS

AIS, which is known as the clear quality leader in the Thai cellular market, is expected to continue to have a better network with a significantly higher coverage and much more base stations than TAC. As of now, AIS has a coverage of more than 90% of Thailand, compared to TAC's 53%. The premium network quality comes at a price though, as service charges are higher. We believe that a large part of the potential subscriber base is willing to pay more to ensure that the cellular connections are more reliable and that the number of 'no network' messages is reduced.

We expect AIS to add about 800 base stations and six mobile switches during 2001, which will bring its total number of base stations to 3,297, while the total number of switches will be increased to 25. This means that it is successively improving an already good network, while TAC needs to substantially upgrade a network which lags behind, and is currently not up to par. TAC currently has 2,097 base stations and an estimated 16 MSC's (mobile switching centres).

Digital network comparison — present and future

TAC	*Dec-00*	*Feb-01*	*Apr-01*	*Dec-01*
Population coverage (%)	50%	51.7%	53%	70%
Number of base stations	1,711	1,971	2,097	2,847
Switches IMSC)	10	11	16	20
AIS	*Dec-00*	*Feb-01*	*Apr-01*	*Dec-01*
Population coverage 1%)	90%	90%	95%	97%
Number of base stations	2,497	2,518	2,538	3,297
Switches (MSC)	19	19	20	25

se urc: iwIcS, MS, TAC

Figure 2.5. Network Comparison — Present and Future.

(2) Continue to Upgrade the Network Needed for TAC

Due to TAC's higher frequency at 1800 MHz the company needs to install more base stations than AIS, whose digital GSM system operates at a 900 MHz frequency, and it would, as such, be much more expensive than AIS to cover the majority of the country. TAC admits that its strategy is not to cover all parts of the country, but it does want to have a strong presence in major urban centres of the country.

When price differences in the future get successively reduced, the cellular market subscribers will demand higher quality of network from the operators. Neglect of the importance of service and an emphasis on only low price can be disastrous for an operator like TAC.

2.2 Design of the Task

The design of the actual tasks involved in producing a product or service is almost as important as the design of the product or service itself. The task must be designed such that it can be carried out efficiently and effectively using whatever resources are devoted to it. The choice of resources is an important preliminary step. Automation may he used to a greater or lesser extent, the extent that is feasible is of course changing as technology develops, but the operations manager's task tends to be easier if tried methods are used rather than methods at the frontiers of technology. Where full automation is not used the capabilities of the labour force become an important consideration. (Krajewski, 1998)

Trouble free operation depends very strongly upon the design of the human/machine interface, and the degree to which this leaves the human component of the system with a meaningful and integrated task which is within his or her capabilities. (Krajewski, 1998)

The availability of skills within the work force, the susceptibility of the workforce to training, and the availability of appropriate training facilities must all be taken into account. At one extreme the task could be designed to be carried out entirely manually by largely unskilled labour, while at the other it could be fully automated. Usually an appropriate correct solution lies somewhere between these extremes. (Krajewski, 1998)

Job design specifies a job's content, the employee skills and training needed to perform that job, and the degree of specialization appropriate for the job. Job design is an important part of a firm's operations strategy because it defines the amount of flexibility needed in the work force. (Gallaway, 1994) Successful job design

(1) improves efficiency through analysis of the job's work elements,

(2) improves productivity through consideration of technical and human factors,

(3) increases the quality of the final product or service, and

(4) increases worker satisfaction.

Traditional job design was invented more than 100 years ago by Frederick Taylor. His approach, known as scientific management, is based on the philosophy that any operation can he improved by breaking it into components and studying the work content of each component to improve work methods. Taylor believed that managers should study jobs scientifically, using careful analysis, experimentation, and tools such as flow diagrams and process charts to find the most economic way to perform a task. Later in this chapter we discuss some of Taylor's techniques for studying work methods and arriving at standards. (Gallaway, 1994)

Taylor stressed the need for managers to train workers in the new method in order to improve efficiency. He believed that management must accept the responsibility for coordinating work so that output is not restricted by poor planning and timing. Taylor also believed that scientific management would work only if the economic benefits of increased output were shared by both management and workers that is, workers received greater pay for increased productivity. (Gallaway, 1994)

Taylor's methods dealt primarily with the engineering aspects of job design: ways to best reach, grasp, and move objects; the number of repetitions to be performed before a rest was needed; and the best physical position for the worker. Undoubtedly, scientific management techniques practiced by industrial engineers contributed greatly to the rise in U.S. productivity between 1900 and 1950. (Gallaway, 1994)

Many managers have applied Taylor's concepts to increase productivity in both manufacturing and service industries. These applications often led to job specialization, low levels of worker flexibility, and vertical organizations. New approaches to job design being used by some organizations today involve team building and developing cross functional linkages to increase worker flexibility. These approaches consider the behavioral aspects of a worker's job performance, such as the effects of safety, noise, ventilation, illumination, and monotony. In this section we address an aspect of job design that concerns managers - the degree of worker flexibility - because it relates directly to the discussion of organizational restructuring. (Gallaway, 1994)

Job Specialization

A job with a high degree of specialization involves a narrow range of tasks, a high degree of repetition, and, presumably, great efficiency and high quality. For example, an appliance repairperson specializing in refrigerators can quickly diagnose problems and make the correct repairs based on previous experience; a heart specialist can diagnose and treat heart problems better than a general practitioner. Consider the tasks required in a fast food restaurant where the employees take the order, prepare and package the meal, and accept payment. This job design becomes inefficient as the volume of orders increases because the employees start bumping into each other. Alternatively, the tasks could be divided into two jobs: one an order taker who also keeps the French-fryer going, draws drinks, packages the meal, and accepts the payment; the other a burger maker who does all the grill work. (Gallaway, 1994) Specialization results in benefits such as

(1) less training time needed per employee because the methods and procedures are limited,

(2) faster work pace, leading to more output in less time, and

(3) lower wages paid because education and skill requirements are lower.

However, the arguments against job specialization suggest that narrowly defined jobs lead to

(1) poor employee morale, high turnover, and lower quality because of the monotony and boredom of repetitive work;

(2) the need for more management attention because the total activity is broken into a large number of jobs for a large number of employees, all of whom have to be coordinated to produce the entire product or service; and

(3) less flexibility to handle changes or employee absences.

The degree of specialization should relate directly to the competitive priorities of the firm. A high degree of specialization tends to support the competitive priorities of a firm with line flows: low costs, consistent quality, and little product variety. A low degree of specialization tends to support the competitive priorities of a firm with flexible flows: customization, high performance design, and volume flexibility. However, some firms that compete on the basis of low costs and consistent quality (e.g., Motorola and AT&T) are exploring organizational models based on less specialization. (Gallaway, 1994)

Alternatives to Specialization

People work for a variety of reasons: economic needs (to cam a living), social needs (to be recognized and to belong to a group), and individual needs (to feel important and to feel in control). These factors influence how people perform their jobs. In narrowly designed jobs, workers have few opportunities to control the pace of work, receive gratification from the work itself, advance to a better position, show initiative, and communicate with fellow workers. Alternative strategies to overcome the boredom of highly specialized jobs and increase worker flexibility include job enlargement, job rotation, and job enrichment.

Job Enlargement. - Adding additional similar tasks to workers' jobs; this is refered to as horizontal job enlargement. (Gaither, 1987) The horizontal expansion of a job that is, increasing the range of tasks at the same level is called job enlargement. The employee completes a larger proportion of the total work required for the product or service. Typically this approach requires that workers have various skills, and it is often accompanied by training programs and wage increases. Besides reducing boredom, job enlargement has the potential to increase employee satisfaction because the worker feels a greater sense of responsibility, pride, and accomplishment. For example, the Capita Credit unit of AT&T Capital Credit Corporation, which leases telecommunications, computer, and other equipment, is organized so that teams of workers perform three major leasing functions for a customer: receiving applications and checking credit ratings, drawing up contracts, and collecting payments. Other financial institutions often devote three separate departments to these functions and design the jobs with a high degree of specialization. Employees at Capita Credit feel responsible for the quality of the service they provide and understand how their activities contribute to the success of the business as a whole. With this job design Capita Credit processes up to 250 applications a day, more than double the number of a bank using the traditional job design processes. (Gallaway, 1994)

Job Rotation. - Training workers to perform several jobs so that they can be moved about from job to job during the work shift. (Gaither, 1987) A system whereby workers exchange jobs periodically, thus getting more diversity in task assignment, is called job rotation. This approach is most effective when the jobs require an equal level of skill. For example, workers at a family restaurant may rotate duties from bossing tables to cooking meals to taking orders from the patrons. Because workers learn many aspects; of the job, job rotation increases the skills of the work force, giving management the flexibility to replace absent workers or to move workers to different workstations as necessary. In addition, rotating jobs can give each worker a better appreciation for the production problems of others and the value of passing only good quality to the next person. (Gallaway, 1994)

Job Enrichment. - Adding more planning, inspecting, and other management functions to workers'jobs; this is referred to as vertical job enlargement. (Gaither, 1987) The most comprehensive approach to job design is job enrichment, which entails a vertical expansion of job duties. That is, workers have greater control and responsibility for an entire process, not just a specific skill or operation. This approach supports the development of employee empowerment and selfmanaged teams, whereby employees make basic decisions about their jobs. For example, a chef at an elegant restaurant may be given the responsibility of purchasing ingredients at the market and arranging her own work schedule. Job enrichment generally increases job satisfaction because it gives workers a sense of achievement in mastering many tasks, recognition and direct feedback from users of the output, and responsibility for the quality of the output. (Gallaway, 1994)

Sociotechnical system studies - Attempts to design jobs that adjust production technology to the needs of workers. (Gaither, 1987)

2.3 Work Standards

The first organized approach to improving the productivity of labor arose in the United States at the turn of the century from the work of the pioneers of scientific management, Frederick W. Taylor, Frank and Lillian Gilbreth, and others. Their approach was to standardize the labor element of production: standard methods and standard times. Nonstandard labor practices were simply too expensive and wasteful. (Schonberger, 1994)

Scientific management (so named by U.S. Supreme Court Justice Louis Brandeis) as born in a period of transition and could be thought of as the last phase of the

Industrial Revolution. Earlier phases concerned invention, mechanization, standardization parts, division of labor, and the factory system. Machines and parts were standardized; and labor was divided into narrow specialties. Prior to scientific management, however, labor productivity was controlled more by supervisors' skill than by design. Taylor's and the Gilbreths' techniques for methods study (or motion study) and time study extended science into the realm of the line employee. (Schonberger, 1994)

Now that we have explored some aspects of job design let's turn to measuring the volume of work produced per unit of time, called an output rate. The rate of output is influenced by flow strategy, process choice, technology, and job design. The first step in measuring an output rate is determining a normal level of performance. A work standard is the time required for a trained worker to perform a task following a prescribed method with normal effort and skill. Robots of the same type perform the same repetitive tasks with little variation in output rate, but human output is more difficult to evaluate because skill, effort, and stamina vary from one employee to another. (Schonberger, 1994)

Managers use work standards as a management tool in the following ways. (Schonberger, 1994)

(1) Establishing prices and costs. Managers can use tabor and machine time standards to develop costs for current and new products, create budgets, determine prices, and arrive at make or buy decisions.

(2) Motivating workers. Standards can be used to define a day's work or to motivate workers to improve their performance. For example, under an incentive compensation plan, workers can earn a bonus for output that exceeds the standard.

(3) Comparing alternative process designs. Time standards can be used to compare different routings for an item and to evaluate new work methods and new equipment.

(4) Scheduling. Managers need time standards to assign tasks to workers and machines in ways that effectively utilize resources.

(5) Capacity planning. Managers can use time standards to determine current and projected capacity requirements for given demand requirements. Work force staffing decisions also may require time estimates.

(6) Performance appraisal. A worker's output can be compared to the standard output over a period of time to evaluate worker performance and productivity. A manager's performance can be measured by comparing actual costs to standard costs of a process.

Areas of Controversy

Work standards often are a source of conflict between management and labor. When an organization uses output standards as the basis for pay, unions or workers may object if they believe that standards are set "too high" and management may object if they believe that standards are set "too low." Both groups benefit from setting achievable standards because setting output standards at either extreme makes planning for appropriate capacity levels difficult, increases costs, and reduces profits. (Schonberger, 1994)

Managers themselves disagree over the use of engineered work standards to increase productivity. Some managers believe that employees need to be involved in determining work standards, that time studies dehumanize workers, and that the costs of large industrial engineering staffs and the hidden costs of labormanagement conflicts outweigh the benefits of elaborate standards. Others believe that using engineered standards for piecework incentives actually defeats their purpose of increasing worker productivity because employees will have little incentive to improve their work methods. Workers also may lose sight of quality as they race to meet standards. (Gallaway, 1994)

2.4 Methods of Work Measurement

The key to creating a work standard is defining normal performance. Suppose, for example, that the manager of a fast growing company that manufactures frozen pizza wants to create a standard for pizza assembly. To assemble the pizza, a worker spreads sauce over the pizza shell, adds pepperoni and cheese, places the pizza in a box, and puts the assembled product on a cart for fast freezing. The entire process takes 20 seconds. At this pace a worker could assemble 1440 pizzas in an eight-hour day. (Gallaway, 1994)

Before settling on 20 seconds as the standard, however, the manager must consider whether all the employees have the skills of the observed worker. He may he exceptionally energetic, experienced, and efficient. Moreover, the estimate of 20 seconds per pizza did not account for fluctuations in pace or scheduled rest periods. Generally, the time per unit observed over a short period for one employee should not be used as a standard for an extended period of time for all employees. (Gallaway, 1994)

Work measurement is the process of creating labor standards based on the judgment of skilled observers. Managers often use informal methods to arrive at labor standards. They can develop simple estimates of the time required for activities or the number of employees needed for a job on the basis of experience and judgment. (Gallaway, 1994) Formal methods of work measurement available to the manager include

(1) the time study method,

(2) the elemental standard data approach,

(3) the predetermined data approach, and

(4) the work sampling method.

Moreover, an analyst may use more than one approach to obtain needed work measurement information. (Gallaway, 1994)

(1) Time Study

In time study analysts use stopwatches to time the operation being performed by workers. The results of these observed timings are then converted into labor standards that are expressed in minutes per unit of output for the operation. Below are the lists the steps employed by analysts in determining labor standards based upon time study. (Gaither, 1987)

(a) Make sure that the correct method is being used to perform the operation being studied.

(b) Determine how many cycles to time. A cycle is one complete set of the elemental tasks included in the operation. Generally, more cycles must be timed when cycle times are short, when cycle times are highly variable, and when the annual production of the product is high.

(c) Break the operation down into basic tasks, which are also called elements (get part, hold against grinder, adjust machine, etc.).

(d) Observe the operation and use a stopwatch to record the elapsed time for each element for the number of required cycles. The observed element times are recorded in minutes.

(e) For each elemental task, estimate the speed that the worker is working. A performance rating of 1.00 indicates that the worker is working at normal speed, the speed at which a well-trained worker would work under ordinary operating conditions. A performance rating of 1.20 indicates 20 percent faster than normal, and a performance rating of .80 indicates 20 percent slower than normal.

(f) Compute an allowance fraction for the operation. The allowance fraction is the fraction of the time that workers cannot work through no fault of their own. For example, if workers cannot work 15 percent of the time because of cleanup work, rest periods, company meetings, etc., the allowance fraction would be .15.

(g) Determine the mean observed time for each element by dividing the sum of the observed element times for each element by the number of cycles timed.

(h) Compute the element normal time for each element:

Element normal time = Mean observed time X Performance rating

(i) Compute the total normal time for the entire operation by summing the element normal times for all elements.

(j) Compute the labor standard for the operation:

Labor standard = Total normal time / (1 - Allowance fraction)

Although time study offers precision in determining labor standards, in most situations it does require a competent staff of analysts. Additionally, the labor standard cannot be determined before the operation is actually performed. These deficiencies have led to the development of other work measurement techniques that are less expensive and/or may be used in advance of the performance of the operation. (Gaither, 1987)

(2) Elemental Standard Data Approach

If a plant requires thousands of work standards, the time and cost required for the time study method may be prohibitive. When a high degree of similarity exists in the work elements of certain jobs, analysts often use elemental standard data to derive standards for various jobs. In this approach, analysts use a work measurement approach, such as time study, or management opinions, to compile standards for the common elements. The standards are stored in a database. If the time required for a work element depends on certain variable characteristics of the jobs, an equation that relates these characteristics to the time required can also be stored in a database. Once established, the database can provide the data needed to estimate the normal times for jobs requiring these work elements with varying characteristics. However, allowances still must be added to arrive at standard times for the jobs. (Gallaway, 1994)

In addition to reducing the number of time studies or informed opinions needed, the elemental standard data approach can help managers develop standards for new work before production begins. This feature is helpful in product costing, pricing, and production planning. (Gallaway, 1994)

Although the use of the elemental standard data approach reduces the need for time studies or opinions, they can't be eliminated. The analyst should periodically use work measurement methods to check the standards developed by the elemental standard data approach. Specifying all the job variables that affect times for each work element may be difficult;

consequently, this method may not produce good estimates for the normal time. (Gallaway, 1994)

Predetermined Data Approach (Predetermined Time Standard)

The predetermined data approach eliminates the need for time studies altogether. The analyst divides each work element into a series of micromotions common to a variety of tasks. The analyst then consults a published database that contains the normal times for these micromotions, along with modifications for job variables. The normal time for any task can be developed by accessing the database. (Gallaway, 1994)

One of the most commonly used predetermined data systems is methods time measurement (MTM). Actually, there are several MTM databases, but we focus on the most accurate, MTM 1. In MTM 1 the basic micromotions are reach, move, disengage, apply pressure, grasp, position, release, and turn. The normal times for these micromotions, modified for job variables, were developed by trained observers, who applied performance ratings to observations of motion picture studies of workers in various industrial settings. (Gallaway, 1994)

Each micromotion is measured in time measurement units (TMUs). One TMU equals 0.0006 minute. Setting standards from predetermined data involves several steps. (Gallaway, 1994)

(a) Break each work element into its basic micromotions.

(b) Find the proper tabular value for each micromotion. Tabular values account for mitigating factors such as weight, distance, size of object, and degree of difficulty,

(c) Add the normal time for each motion from the tables to get the normal time for the total job.

(d) Adjust the normal time for allowances to give the standard time.

(4) Work Sampling

Work sampling is a work measurement technique that randomly samples the work of one or more workers at periodic intervals to determine the proportion of the total operation that is accounted for in one particular activity. These studies are frequently used to estimate the percentage of workers' time spent in unavoidable delays (commonly called ratio-delay studies), repairing finished products from an operation, supplying material to an operation, and so on. The results of these studies are commonly utilized to set allowances used in computing labor standards, in estimating costs of certain activities, and in investigating work methods. (Gaither, 1987)

Work sampling involves estimating the proportions of time spent by people and machines on activities, based on a large number of observations. These activities might include producing a product or service, doing paperwork, waiting for instructions, waiting for maintenance, or being idle. The underlying assumption is that the proportion of time during which the activity is observed in the sample will be the proportion of time spent on the activity in general. Data from work sampling also can be used to estimate how effective machines or workers are, estimate the allowances needed to set standards for use with other work measurement methods, determine job content, and help assess the cost of jobs or activities. (Gallaway, 1994)

Work Sampling Procedure. Conducting a work sampling study involves the following steps. (Gallaway, 1994)

(a) Define the activities.

(b) Design the observation form.

(c) Determine the length of the study.

(d) Determine the initial sample size.

(e) Select random observation times using a random number table.

(f) Determine the observer schedule.

(g) Observe the activities and record the data.

(h) Decide whether additional sampling is required.

A work sampling study should be conducted over a period of time that is representative of normal work conditions, in which each activity occurs a representative number of times. For example, if an activity occurs only once a week, the study should probably span several months. However, if the activity occurs continuously throughout the week and from week to week throughout the year, the study might cover only several weeks. (Gallaway, 1994)

2.5 Work Method Analysis

2.5.1 Operation Charts

The operation chart, sometimes called operator chart or right- and left-hand chart, is a form of process chart that examines the coordinated movements of a worker's hands. This analysis tool is typically applied after the job has been studied through the use of flow diagrams and process charts. Next, the individual worker's job can be studied with operation charts (both present and proposed methods) to improve the efficiency of the worker's hand motions.

The use of this technique allows analysts a microview of workers' work methods. Work methods can therefore be fine-tuned by removing even small inefficiencies.

2.5.2 Multiactivity Chart

There are several forms of multiactivity charts, but they all have one thing in common: They show how one or more workers work together and/or with machines. Figure 2.9., for example, is a worker and machine chart. This figure illustrates how a clerk in a grocery store works with a customer and with a coffee-grinding machine to produce ground coffee for the customer. We can see clearly from this chart how the clerk coordinates each step of the work with the customer and the machine and the resulting degrees of utilization of the clerk, machine, and customer. These charts are helpful in minimizing worker and machine delay and in determining the optimal number of machines per operator.

We have identified some common, noncost ways of evaluating the productivity of various resources. Terms like efficiency, busyness and idleness, and utilization can be used loosely; they also have precise meanings and can be measured numerically. Examples follow, first for equipment and other nonhuman resources; then for people. (Schonberger, 1994)

A general formula for utilization of labor or machines is(Schonberger, 1994):

Utilization rate = Time in use / Time available

III. RESEARCH METHODOLOGY

3.1 Methodology Overview

The Radio Network Site Survey Improvement process can be classified in to 4 Phases.

(1) Measurement phase

(2) Analysis phase

(3) Improvement phase

(4) Control phase

Totally, the overall period for the improvement will be about three months.

3.2 Measurement Phase

Normally, an agreement between the network operator and supplier will finish around the end of every year. After the contract has been signed, every work can be started. One of the most important work is Radio Network Site Survey. According to the propose to improve the Radio Network Site Survey, the measurement phase has been proposed the example, before the new phase begins. It will take about two days. Following items are the results from the measurement phase.

(1) Draft flowchart for the current process

(2) Job description and tools

3.3 Analysis Phase

After we got the result from measurement phase, the next step is to analyze the data. We called this duration "Analysis phase". Analysis phase will focus on the process of each step. Thus, first is process mapping, not deeply in to the details, but only to compare the workload in each function and utilization. Mainly, we adapted Multiactivity Chart to analyze the work method. The period for Analysis phase is about 2 weeks.

3.4 Improvement Phase

After the problem has been found and analyzed, the new process will be proposed to improve the Radio Network Site Survey. The duration for this phase is 3 weeks. First, after we found the problem from the phase analysis, we proposed the new process and we will have the result as following :

(1) New process flowchart

(2) Schedule for work measurement

(3) Schedule for Radio Network Survey

The second week, we proposed the involved people to use the new process. We will also measure the standard time within this period. The most important thing is work measurement. The third week, we will use to conclude the result. The standard time which we will use will be summarized within this third week.

3.5 Control Phase

After the implementation has been succeeding, we have to control and monitor the whole project. Project report is used for this phase. Project report will consist of the following items.

(1) Backlog report

(2) Daily report

(3) Weekly report

All report will be used for controlling and confirming that the process has no problem. This period will continue until the project closes which will take about three months.

IV. EVALUATION

4.1 Radio Network Site Survey Overview

4. 1 . 1 Objective

The objective of the Radio Network Site Survey is to find appropriate site locations for the Radio Network. Radio Network Site Survey, is the name for the field investigation that has to be performed prior to the definitive radio site selection.

In Thailand, Radio Network Site Survey is contained of "Site Investigation" (SI). Civil works and installation engineering personnel conduct "Site investigation". Their propose is to investigate floor load, suitable antenna installations and if there exists sufficient space and power for the proposed equipment.

Choosing appropriate sites during the Site Survey will substantially affect the overall performance of the radio network system once it is in operation. The Radio Network Site Survey is a general procedure, which shall be used whenever an expansion or a rollout of the network is requested.

4.1.2 Tools

In order to perform a Radio Network Survey, a survey set is required, to verify site positions and antenna directions. The following equipment is recommended; GPS with batteries, Compass, Binoculars, Digital camera, accurate paper maps, measuring tape, inclinometer, coverage plots and site survey forms.

(1) Compass

This is the most common and most used tool of the surveyor. When it is not available, the surveyor may not be able to perform a complete site survey.

The compass indicates the bearing of a certain direction referred from a particular point. As the compass is moved, the compass scale will rotate around the fixed reference marker to indicate the bearing.

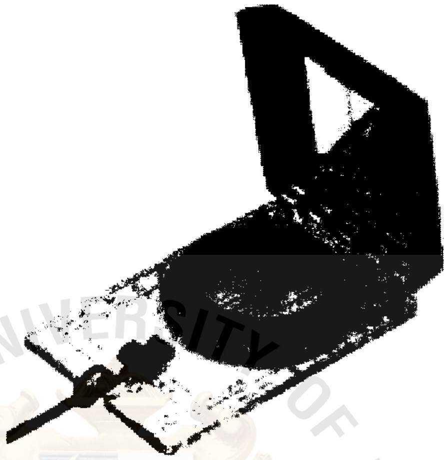


Figure 4.1. A Typical Handy and Sturdy Compass Used for Site Surveys.

The pointer of the compass is a magnetic material, *it must be kept away from metallic structures* (i.e. towers, metal water tanks, and others) within the immediate vicinity when taking a direction or bearing.

The compass should be for the correct Latitude zone, due to the magnetic declination. The magnetic declination must be set for the particular area of the country and is valid for the correct magnetic declination model (e.g. 1995 — 2000).

(2) Camera

The camera will be used to take photos of the sites to be surveyed. The photos will show surroundings of the site, exact locations of the antennas and BTS cabinets, immediate obstructions, site ID and face of the building.

When conducting site surveys, always keep sufficient supply of films and batteries. A handy, quality and auto-focus camera is preferable for site surveys because it will not require complex operation and focusing.

A digital camera could be a good advantage because pictures taken on site can be interfaced directly into the computer as files. The picture files can also be easily included as attachments to the reports and can be sent through e-mail to the main office. This is especially convenient if the surveyor is far from the main office.

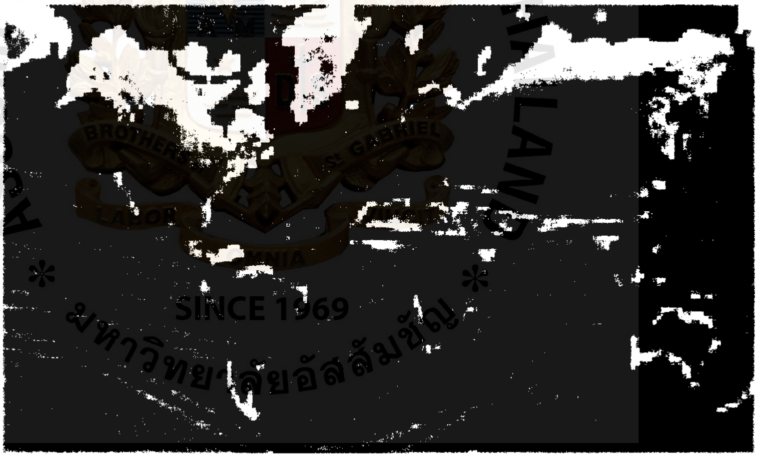


Figure 4.2. The Latitude Zones for the Silva Compasses.

(3) GPS — Global Positioning System

GPS stands for Global Positioning System. The GPS instrument receives information from signals sent from the satellites. In order to derive accurate coordinates of a location, the GPS must be placed in unobstructed location to sight as many satellites as possible. At least four satellites must be obtained to get accurate readings assuming correct map datum is set properly into the GPS. An example of good GPS type is shown below.

These are the Latitude zones for the Silva compasses.

Map datum is a mathematical description of the earth or part of the earth that is necessary to correctly assign real-world coordinates to points on a map or chart. Therefore, *it is very important to set the GPS equipment to the correct map datum.* The map datum used should be the same as the one used for the digitized map in TCP. If the paper map has a different map datum, it should be noted at the RNS report.

Figure 4.3. A GPS Receiver Unit with Multi-Function Feature.

(4) Inclinometer

An inclinometer is a more convenient tool for measuring heights. Measurements can be done on the ground or near the base of a structure. Height measurements can be performed by combination of distance and angle measurements coupled with trigonometric calculation.

4.2 Flowchart

Figure 4.4 shows the process for Radio Network Site Survey. The flowchart can be mapped with Job Description in subject 4.3, Multiactivity Chart in subject 4.4 and Standard time measurement in subject 4.5.4.

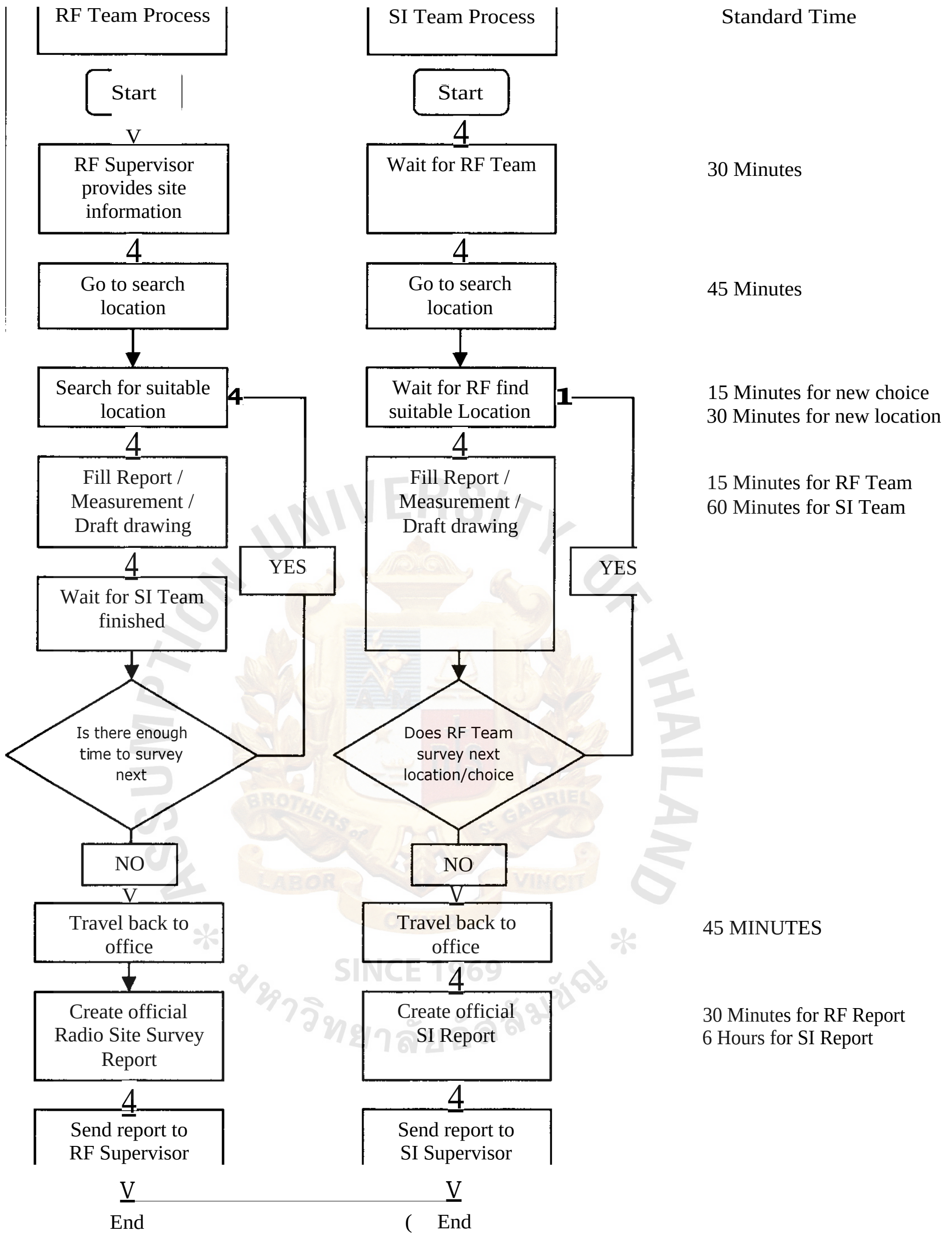


Figure 4.4. Flowchart and Standard Time for the Old Process.

After we reviewed the old process, we found that idle time occurred because both teams had to wait for each other to complete their own work. Then, surveyor will step to the next process.

Thus, the new process was proposed with team separation. Team one will be called "RF Team", which consists of RF Engineer and Site acquisition. Team two will be called "SI Team", which consists of Civil Engineer, Installation Engineer and Draftsman. The new process for both teams is shown as in Figure 4.5 and 4.6.

With the new process, utilization of each team will be improved, which will encourage the productivity and cost.

As the new process will be separated in to two teams, on the first day Radio Network Site Survey will be concerning to RF Team (Team one) only. RF Team has to make a stock for SI Team (Team two), which will survey on the next day.

With the new process, the location that already surveyed and approved by RF Team will be called "Stock". All Stock should be sent to SI Team to do survey within the next day. All stock that SI Team can't be do within the next day will be called "Back log". SI Team has to maintain backlog to be not over than two sites. Because capacity for one SI Team is about three Sites, whenever the number of backlog is over than 2 sites, next day, SI Team has to assign some staff to clean it out.

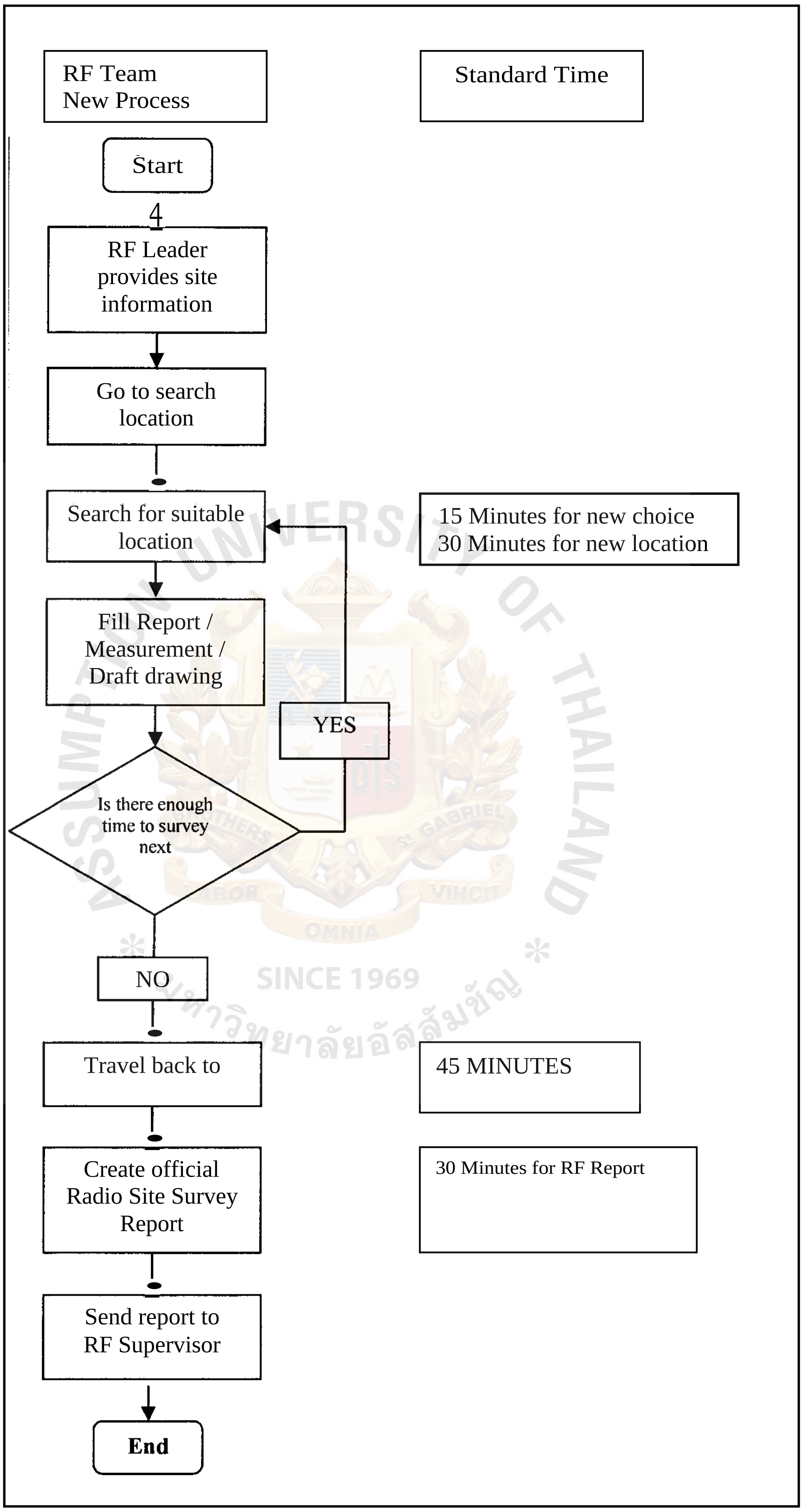


Figure 4.5. Flowchart and Standard Time for RF Team with the New Process.

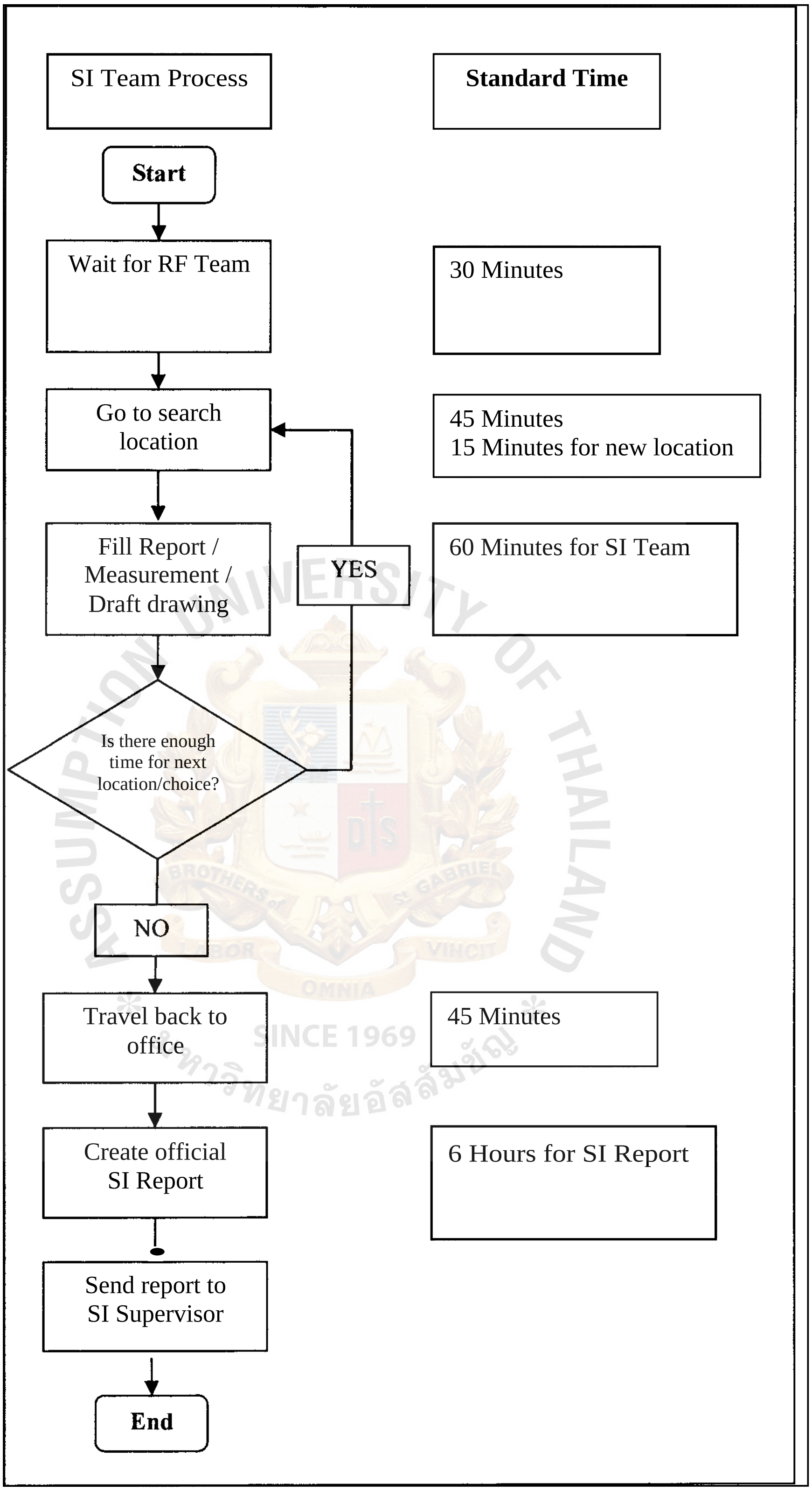


Figure 4.6. Flowchart and Standard Time for SI Team with the New Process.

4.3 Job Design

4.3.1 Existing's Job Description

Before we improve the process for Radio Network Site Survey, we have to focus on the existing job description for each staff. One team of Radio Network Site Survey will contain 5 people.

(1) RF Engineer.

(2) Site Acquisition.

(3) Civil Engineer.

(4) Installation Engineer.

(5) Drawing / CAD Technician.

Each position will be controlled by function supervisor. We can define job description for each worker as below.

RF Engineer: RF Engineer is a person who will lead Radio Network Site Survey team. RF Engineer will receive Site Survey Information, Search Area from RF supervisor. RF Supervisor will prepare Site Survey Information which will contain the site's proposal, antenna height, antenna downtilt, antenna type and direction. And Search area will contain Latitude, Longtitude, Radius of location area and Location details (nearest building or point which we can observe more easily). Some Search area will have an additional drivetest result. Additional drivetest result will make it easier for RF Engineer to make a decision to choose the location and will help RF Engineer to reduce the result with missing objective. The search area's example is contained in Appendix E.

RF Engineer will guide the driver to the nearest place which is in the map. The next step, RF Engineer will find the centre of the search area by using GPS to find the exact latitude and longtitude which were defined in the search area. After RF Engineer has found the centre of the search area, RF Engineer will search the location which is suitable for building the site. When RF Engineer can find the suitable place, RF Engineer will told Site Acquisition to contact and negotiate with the owner. If the owner allow to access the area, RF engineer will go to the rooftop and make a decision to continue working.

After RF Engineer made a decision to continue with this location, RF Engineer will take a 360 degree photo, Site photo, Photo of point which will make a pole or tower construction. And RF Engineer will measure the necessary value and fill the form. The necessary values in the form are described below.

(1) Location which will contain Latitude, Longtitude.

(2) The building's height.

(3) Tower's Type and height.

(4) Proposed Antenna height. The proposed Antenna height can't be higher than the building's height sum with Tower's height.

(5) Antenna's Direction.

(6) Antenna's tilt.

(7) Site owner's name, location, contact number and contact person (if applicable).

(8) Obstracles, distance and direction to be obstructed.

(9) Other information eq. Base station type, antenna type, configuration and alternative number.

Some information have to been matched within the team such as Tower's Type, Base station type, etc.

Site Acquisition: After RF Engineer found the suitable place, he will notify Site Acquisition. Site Acquisition will contact and negotiate the site's owner. Site

Acquisition must try to convince Site's Owner to let Site's Owner allow the team to access to rooftop and find the suitable room or space. At the same time, Site Acquistion has to tell the truth to the Site's owner. Because if the site has been selected, without telling the truth to Site's Owner, that will impact the maintenance team to access the site for the next time. Site's Ownerwill feel unhappy when they was taken the advantage. They might obstruct every time when we need to enter the site. Therefore, Site Acquisition will have one album which contains variance photo of complete site to show to the Site's Owner. This album will be called "Site Example". Site Example will help to negotiate with Site's Owner and make it easier for the Site's Owner to make a decision.

Civil Engineer: Civil Engineer will be the person who makes a calculation of the floor load of the building. This will ensure that the building can be constructed a site without any problem. If Civil Engineer found any problem, he will propose the solution to make a site strong enough to make a construction. Civil Engineer needs to make a detailed measurement such as distance between pole, the thickness of pole, floor load, etc. Because he has to make sure that the building will not collapse. Standard time for Civil's measurement in one place is about one hour.

Installation Engineer: Installation Engineer will be the person who calculates the space or room to install equipment. Installation Engineer will also design the equipment type, location, feeder's route, Antenna's mounting, etc. Standard time for Installation's measurement in one place is about one hour.

Drawing / CAD Technician: Drawing / CAD Technician will collect all information in the site and make drawing details. All information which Drawing / CAD Technician collect will include civil and Installation information. After Drawing /

CAD Technician collects all information, he will come back and make a real drawing from the draft one within the office.

After Radio Network Site Survey, there will be many results from each function.

(1) RF Site Survey Report : Responsible by RF Engineer.

(2) Civil Calculation Report : Responsible by Civil Engineer.

(3) Draft Drawing Report : Responsible by Installation Engineer and Drawing / CAD Technician.

All reports will be checked and approved by function supervisor. RF Site Survey Report will be the first significant report. RF Site Survey Report needs to be checked and approved first. Because if Site location cannot solve the problem of the network, it will not be necessary to select that site. At the same time, if Civil Result or Installation result can't be approved, there will be other solution to solve the problem. Such as if the building cannot handle the floorload, the Civil will can propose an additional construction to make the building strong enough to handle the floorload.

After all first reports are completed, Site Acquisition will be allowed to contact and negotiate with the Site's Owner. During the negotiation and wait for the Site's Owner to make a decision, BOM and Fully Drawing for construction and installation are preparing to attach with Site Leasing. Standard time for this period is two weeks.

4.3.2 Proposed's Job Description

To support the new process, Job enlargement and Job enrichment will be applied to the workers in all functions. One Radio Network Site Survey team will be split in to two teams. The first team will be called "Radio / Site Acquisition Team (RF Team)". And the second team will be called "Site Investigated Team (SI Team)". Both teams will be working as the paralell process. So both team must have the basic knowledge of the other team. Job Enlargement will be applied. Job Enrichment will be used to improve the quality of the survey.

RF Engineer: Job Enlargement — RF Engineer must have a basic knowledge about civil works and site installation. Because he should be able to calculate whether the tower can be installed and whether there is enough space for equipment. With the basic civil and site installation knowledge, number of site rejection will be reduced. Job Enrichment — RF Engineer must have a knowledge in optimization the network. RF Engineer will have a better decision making to choose a good location, which will help to solve the network's problem. RF Engineer will also have to know the knowledge in product.

Site Acquisition: Job Enlargement — Site Acquisition must have all basic knowledge in Radio, Civil and site installation. All knowledge will make site acquistion know in some technical details. This will make it easy for the Site Acquisition to negotiate with the owner. And when the site has a problem, Site Acquisition team can solve the problem first, while waiting for the technical team. This will make the Site's Owner have a smooth emotion, and it will be easier to make a contact. Job Enrichment — Site Acquisition has to know.

Civil Engineer and Installation Engineer (SI Team): Job Enlargement — Because survey team will be split in to two teams, and both teams will not be at the site at the same time, thus, SI Team must have the basic knowledge in Radio Team. Because when SI Team finds that the building doesn't match with their requirement, they have to modify the site with less impact to the necessary factor in Radio parts. Or if there is an impact, they have to know the solution to solve the problem. And SI Team must learn some contact method from Site Acquisition. Because when the SI Team do their jobs, Site Acquistion will be not able to stay with them. If there are some emergency cases which will make the Site's Owner feel unhappy, they will discuss with the Site's Owner first.

4.4 Multiactivity Chart

For the study, we applied Multiactivity chart to find the suitable procedure and the utilization for each worker. Actually Multiactivity chart normally is used for the activity between human and machine. But we can apply it to this process. Both the old process and new process multiactivity charts are shown in Appendix A.

From the Multiactivity Chart in Appendix A., we can calculate the utilixation and productivity from the old process as in Table 4.1.

Table 4.1. Utilization for the Old Process.

	RF Team	SI Team
Idle Time	180 Min.	150 Min.
Working Time	300 Min.	330 Min.
Total Time	480 Min.	480 Min.
Utilization	62.50%	68.75%
Number of sites/choices	2/4	2/4

After we improve the Radio Network Site Survey Process, Utilization and productivity will be improved as in Table 4.2.

Table 4.2. Utilization for the New Process.

	RF Team	SI Team
Idle Time	30 Min.	0 Min.
Working Time	450 Min.	480 Min.
Total Time	480 Min.	480 Min.
Utilization	93.75%	100.00%
Number of sites/choices	4/8	3/6

The productivity from RF Team will be increased from 2 sites/ 4 choices to 4 sites/ 8 choices. At the same time, SI Team will increase the utilization to be 100% and the productivity will be increased from 2 sites/ 4 choices to 3 sites/ 6 choices.

After SI Team finishes the survey, they will need to make a draft drawing and calculation to guarantee that the building can support all equipments, which will take two days to complete the drawing for three sites or six choices. After all drawing has been checked and approved, site acquisition team will go to negotiate with the site owner. After the success in negotiation, site leasing will be handovered back and work can be start.

With the new process, we will lose the first day of survey for SI Team. Because on the first day, RF Team will start survey and there will be no choice for SI Team. At the same time, RF Team will be idle on the last day.

4.5 Result

4.5.1 Radio Network Site Survey Plan

Site name was named by priority. The highest priority site will be ranked at the top and named as "Site#001". All sites were separated in to two areas. Two RF teams will take responsibility in each area. Radio Network Site Survey Plan for all sites are shown in Appendix B.

4.5.2 Standard Time Measurement

With the new process, we arranged the schedule to measure standard time for each team as in Appendix C. Two supervisors from RF and four supervisors from SI will follow every team and measure time for each process.

Totally sampling 24 sites or 48 choices, all measurement values were shown in Appendix C.

From Appendix C, we can summarize the average standard time in each activity with the estimated time as in Tables 4.3 and 4.4.

Table 4.3. Average Standard Time in Each Activity for RF Team.

Activity	Standard time (MM.)	Estimate time in the new process (MM.)
Discuss area with supervisor	30.33	30
Travel to the search area#1	46.50	45
Travel back to the office	35.00	45
Reporting	36.33	30
Find the suitable place (Choice#1)	29.83	30
Find next choice (Choice#2)	15.58	15
Fill form / Take photo	15.23	15

Table 4.4. Average Standard Time in Each Activity for SI Team.

Activity	Standard time (Min.)	Estimate time in the new process (Min.)
Travel to Location#1	46.38	45
Travel back to the office	45.25	45
Take Photo / measure room / Draft result	59.69	60
Travel to the location from RF Team's result	14.19	15

From the measured standard time, the average value is not different from the estimation. Many activities in RF Team need more time for working. However, it can be compensated with some activity and idle time which will occurr on each working day. For the SI Team, due to the improvement of the process, utilization is highly efficient.

4.5.3 Project Report

Backlog report : Backlog is the number of sites already surveyed by RF Team, but are waiting for SI Team for more than one day. After Radio Network Site Survey schedule was done, we can estimate new sites already surveyed by RF Team, but still has not been surveyed by SI Team within the next day. The estimated backlog in each day was shown on Appendix D.

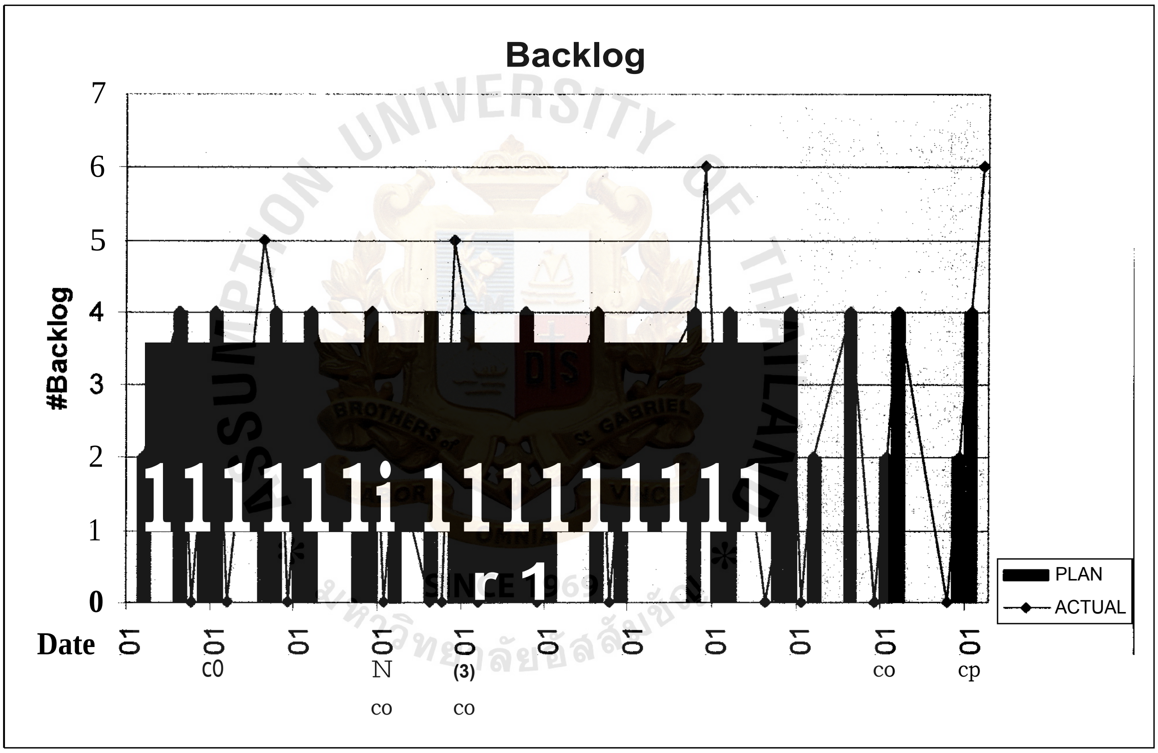


Figure 4.7. Chart Show Number of Backlog in Each Day.

Backlog was controlled by Project coordinator. When the number of backlog is higher than the forecasting, Project coordinator will send a reminder to SI supervisor. Supervisor has to investigate the problem. We found that most reasons which made number of backlog higher than the estimation came from sickleave from SI Team. Solution to solve this problem is whenever there is only one engineer in SI Team take a sick leave, SI Supervisor has to assign some staff to work instead or they may need to work by themselves.

Due to the Bangkok area has been separated in to two zones, each RF engineer will be assigned to take a full reponsibity in each zone. The number of backlog in each zone will be controlled to not be over than 2 sites. For all Bangkok areas, number of backlog should not be higher than 4 sites.

Backlog should be cleared day by day. But the total number will be included in the weekly report.

Weekly report: Project coordinator will take a responsibility to control all teams. There will be a weekly report which will be reported to project manager. Weekly report will consist of Plan and actual status with the accumulated number of site already done a survey by both two teams.

Table 4.5. Weekly Report.

WEEK		WK01	WK02	WK03	WK04	WK05	WK06
RF TEAM	Plan	16	56	96	136	176	208
	Actual	16	56	92	132	176	208
SI TEAM	Plan	6	48	84	126	168	198
	Actual	6	48	84	126	168	198
BACKLOG	Plan	2	0	4	2	0	2
	Actual	2	0	4	2	0	2

WEEK		WK07	WK08	WK09	WK10	WK11	WK12
RF TEAM	Plan	232	264	304	336	360	360
	Actual	232	264	304	336	360	360
SI TEAM	Plan	222	252	294	324	360	360
	Actual	222	252	294	324	354	360
BACKLOG	Plan	2	4	2	4	0	0
	Actual	2	4	2	4	6	0

Weekly report will be summarized from daily report. Weekly report will be used to reporting to project manager. If there are any doubt, daily report will be used to clarify in the details. Daily report is contained in Appendix D.

4.5.4 Result Comparison

When the implementation phase had been started, the duration for Radio Network Site Survey should not be over than the first three months. Because after Radio Network Site Survey, there will be an installation of site which will take a longer period to finish. And we have to plan for an on-service site one by one or separate in to a batch. Because with a higher number of new sites, if we plan to onservice them together at the same time, every site has to be finished at the same time that will make a high cost. There will be the same number of installation team as the number of sites. If the number of site is increasing, the number of team will be increasing too.

Table 4.6 shows the comparison between the old process and the new process. From the table, the result of manhour in RF Team in the new process is about 50 percent of the old process. And the manhour for SI Team will be reduced approximately 33 percent as well.

Table 4.6. Comparison between Old Method and New Method.

	OLD METHOD		NEW METHOD	
	RF Team	SI Team	RF Team	SI Team
Number of sites (Sites)	360		360	
Number of day (Days)	45		45	
Productivity per day (Sites)	2	2	4	3
Require Team (Team)	4	12	2	8
Number of Staff in team (Person)	2	3	2	3
Man-hour per worker per day	8	8	8	8
Man-hour per Team per day	16	24	16	24
Man-hour in each activity	2,880	12,960	1,440	8,640
Total Man-hour (Hrs)	15,840		1,0080	

V. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

From focusing on Thai cellular phone market, the network expansion in year2001 will increase as double, compared with the current network. Thai cellular phone market will have the high competition both in subscriber sales and network expansion. The capacity to support the network expansion is not enough to support the network growth. There will be a problem in expanding the network. The main objective of this project is to review and improve the process of Radio Network Site Survey.

From the literature, Job design will be consisted of the following items:

(1) Job Rotation

(2) Job Enlargement

(3) Job Enrichment

(4) Sociotechnical system studies

Mainly for the job design, we applied Job Enlargement and Job enrichment to improve the utilization and productivity. For Job rotation, we didn't apply it, because the job is specified for each function.

For measurement work, there are many methods for the work measurement.

(1) The time study method

(2) The elemental standard data approach

(3) The predetermined data approach

(4) The work sampling method

The result from the work measurement is work standards. Standard time is one of the most useful measurement values to create the schedule in the project. There are two methods used in work method analysis. One is called Operation chart. And the another one is Multiactivity chart. In this project we adapted multiactivity chart for analysis use.

The duration for overall improvement is three months. First two days will be spent on measurement phase. In measurement phase, we will create some examples and get all information from those examples. The next two weeks is analysis phase. We will analyze the data from the measurement phase. Next phase is improvement phase, we will propose the new process and use it. Standard time is also measured in this duration. Improvement phase will take about about 3 weeks. The last phase is control phase. After the result was successful in the improvement phase, we have to control and monitor the actual running project which we proposed. This phase will take the rest time until the project was ending.

After investigating the old process of Radio Network Site Survey, we can conclude the old process was not suitable for the current situation. Thai Cellulars market has a very high competition. Network operators have to compete and try to make a higher market share. Not only the sale record of subscriber, there is a competition to build the network to support the increasing subscriber number.

The problem of the old process of Radio Network Site Survey is they can not handle a higher number of sites, if there is a limitation of resources. Improvement of Radio Network Site Survey is needed. From the multiactivity chart, we can calculate the utilization of each worker, separated by function. Utilization of the workers is around 60-70 percent only. The main problem is when RF engineer is searching for a suitable location, other workers (SI Team) is waiting for RF engineer. That is why the utilization of SI Team is too low. Similarly, when SI Team was working, RF Team have to wait until SI Team finishes. Then, they can continue working. This will make a low utilization in RF Team also.

To solve the problem, team separation was introduced, mainly by functionallity and duration of work. With this method, utilization of each team is around 90-100 percent. And the production rate of each team is also increased.

From the study result, capacity of RF Team was doubly. And capacity of SI Team was increased 50 percent. In other words, with the same number of sites and the same implemented duration, manhour of RF Team can be reduced 50 percent and manhour of SI Team can be reduced about 33 percent.

With the new process, the measurement of standard time was introduced also. Standard time will be used for arranging the project's schedule of Radio Network Site Survey. Without the standard time, project schedule will be not accurate or controllable. With the result of standard time, it was consistent with the new process. The project schedule can be controlled and is more accurate.

With the new process and the standard time which we can measure, the estimated number of team between RF Team and SI Team is one team per four teams. The flow of the Radio Network Site Survey will be not obstructed.

5.2 Recommendations

This project focused on only the high level of Radio Network Site Survey. For a better improvement, the investigation needs to focus deeply in to the details. To investigate the deep details, it will concern the specific job, which needs a specialist to analyze the details. Such as there will be some values which will be measured during Radio Network Site Survey. But there is no need to use those measurements. It can reduce the process and there is no need to work for the useless task. The improvement of automatical tools will be the one that can be developed.

One major problem which every team has found, but not concerned the process, is the traffic jam in Bangkok. The traffic jam in Bangkok has a great impact on standard time of travelling. With the worst of traffic jam in Bangkok, the ability to control this activity is impossible.

Another problem is job enlargement. When we proposed RF Team to make a roughly detail for SI Team, there were many errors. Similarly, when SI Team found some problem and made the decision to solve the problem, some decision was wrong and it effected the network's quality. Because of the specific job and too much difference in the detail of tasks, the job enlargement can not be tangibly successful. Because the duration of the overall project is only nine months, and we allow to take Radio Network Site Survey only three months or less. Thus, the improvement of the process was so tight, and the schedule as well. Because the training was arranged after Radio Network Site Survey had begun. The knowledge was not used in this project. The next step that we recommened to focus is about the result of job enlargement, which will be the longterm planning.

There will be another part in the project which can be improved. Some tasks were cascaded from Radio Network Site Survey.

(1) Building a Tower. After the contract for a site was signed, next step is building the site which will consist of a tower. And there are many types of tower, such as Self support, Guy mask, pipe, pole and wall mount.

(2) Space Preparation. One thing which is most important is space preparation. Design for a site should have some space for the expansion in the future. And every building has a different size of room.

(3) Installation Equipment. Site installation is one of the most challenging tasks. The problem can occur anytime during the installation. Most of the problems have to be solved by installation engineer. The knowledge of every engineer should be measured and improved.

Some tasks are the same as Radio Network Site Survey which can be used to adapt for the task. Some of them are described as in the following items.

(1) Cabinet Expansion. AIS will be the owner for every site. After suppliers have done their works at site, it will be hanovered to AIS. AIS has a full authority to do anything with their own site. Some times, the drawings didn't match with the drawings which were in the AIS' hand. If there are more expansions in the existing site, supplier has to re-survey for those sites. This will take more time and if we have the updated database which will be shared with AIS, all expansion tasks will be faster.

(2) Online Approval. There are many documents which will be sent between AIS and supplier. Some documents need to be approved by AIS staff. There shoud be a development to use digital signature to approve some document. This will make a document transfer faster than the previous phase.

(3) Site Databases. To cover all the process, there should be one database which links between all section. The designation of database will concern every one involved with this project. At the same time, all site information will be kept as historical. If there are any doubt about information, we can open the site database and search for all activities which had been done for this site.

From the list above, Site Database is one of the most important. There are some information concerning many staff involved in the project. If one person has a missing information, those information will make many people confused. Thus, the best method is to share the database together and only some authorized people can access them. This will be a big project and also an interesting one.

APPENDIX A

MULTIACTIVITY CHART

Table A.1. Multiactivity Chart for Old Process.

TIME	Time in Minute	RF Team	Time in Minute	SI Team
0800	30	Discuss area with supervisor	30	Idle
0900	45	Travel to the search area	45	Travel to the search area
	30	Find the suitable place	30	Idle
1000	15	Fill form / Take photo	60	Take photo / measure room / Take draft result
	45	Idle		
1100	15	Find the other choices	15	Idle
	15	Fill form / Take photo	60	Take photo / measure room / Take draft result
	45	Idle		
1200		LUNCH		LUNCH
1300	30	Find the suitable place	30	Idle
	15	Fill form / Take photo	60	Take photo / measure room / Take draft result
1400	45	Idle		
	15	Find the other choices	15	Idle
1500	15	Fill form / Take photo	60	Take photo / measure room / Take draft result
	45	Idle		
1600	45	Travel back to the office	45	Travel back to the office
	30	Reporting	30	Idle
1700				

Table A.2. Multiactivity Chart for the new process.

TIME	Time in Minute	RF Team	Time in Minute	SI Team
0800	30	Discuss area with supervisor	45	Travel to the location from Team A's result
	45	Travel to the search area#1		
0900			60	Take photo / measure room / Take draft result
	30	Find the suitable place#1		
1000	15	Fill form / Take photo	60	Take photo / measure room / Take draft result
	15	Find the other choices		
	15	Fill form / Take photo		
	30	Find the suitable place#2		
1100			15	Travel to the location from RF Team's result
	15	Fill form / Take photo	60	Take photo / measure room / Take draftresult
	15	Find the other choices		
	15	Fill form / Take photo		
1200		LUNCH		
				LUNCH
1300	30	Find the suitable place#3		
			60	Take photo / measure room / Take draft result
	15	Fill form / Take photo		
	15	Find the other choices		
	15	Fill form / Take photo		
1400	30	Find the suitable place#4	15	Travel to the location from Team As result
			60	Take photo / measure room / Take draft result
	15	Fill form / Take photo		
	15	Find the other choices		
1500	15	Fill form / Take photo		
	45	Travel back to the office	60	Take photo / measure room / Take draft result
1600	30	Reporting		
			45	Travel back to the office
1700	30	Idle		

APPENDIX B

RADIO NETWORK SITE SURVEY PLAN

Table B.1. Radio Network Site Survey Schedule.

	Area	RF Team	SI Team	RF SURVEY DATE	SI SURVEY DATE
SITE#001	1	1	1	1-Mar-01	2-Mar-01
SITE#002	2	2	2	1-Mar-01	2-Mar-01
SITE#003	2	2	2	1-Mar-01	2-Mar-01
SITE#004	1	1	1	1-Mar-01	2-Mar-01
SITE#005	1	1	1	1-Mar-01	2-Mar-01
SITE#006	1	1	3	1-Mar-01	2-Mar-01
SITE#007	2	2	2	1-Mar-01	5-Mar-01
SITE#008	2	2	4	1-Mar-01	5-Mar-01
SITE#009	2	2	4	2-Mar-01	5-Mar-01
SITE#010	1	1	3	2-Mar-01	5-Mar-01
SITE#011	2	2	4	2-Mar-01	5-Mar-01
SITE#012	2	2	5	2-Mar-01	5-Mar-01
SITE#013	1	1	3	2-Mar-01	6-Mar-01
SITE#014	2	2	5	2-Mar-01	6-Mar-01
SITE#015	2	2	5	2-Mar-01	6-Mar-01
SITE#016	1	1	7	2-Mar-01	6-Mar-01
SITE#017	2	2	6	5-Mar-01	6-Mar-01
SITE#018	1	1	7	5-Mar-01	6-Mar-01
SITE#019	1	1	7	5-Mar-01	6-Mar-01
SITE#020	2	2	6	5-Mar-01	6-Mar-01
SITE#021	2	2	6	5-Mar-01	6-Mar-01
SITE#022	1	1	8	5-Mar-01	6-Mar-01
SITE#023	2	2	1	5-Mar-01	6-Mar-01
SITE#024	1	1	8	5-Mar-01	6-Mar-01
SITE#025	2	2	1	6-Mar-01	7-Mar-01
SITE#026	1	1	8	6-Mar-01	7-Mar-01
SITE#027	2	2	1	6-Mar-01	7-Mar-01
SITE#028	2	2	3	6-Mar-01	7-Mar-01
SITE#029	1	1	2	6-Mar-01	7-Mar-01
SITE#030	2	2	3	6-Mar-01	7-Mar-01
SITE#031	2	2	3	6-Mar-01	8-Mar-01
SITE#032	1	1	2	6-Mar-01	8-Mar-01
SITE#033	1	1	2	7-Mar-01	8-Mar-01
SITE#034	1	1	4	7-Mar-01	8-Mar-01
SITE#035	1	1	4	7-Mar-01	8-Mar-01
SITE#036	2	2	5	7-Mar-01	8-Mar-01
SITE#037	1	1	4	7-Mar-01	9-Mar-01
SITE#038	2	2	5	7-Mar-01	9-Mar-01
SITE#039	2	2	5	7-Mar-01	9-Mar-01
SITE#040	1	1	7	7-Mar-01	9-Mar-01

Table B.1. Radio Network Site Survey Schedule. (Continued)

	Area	RF Team	SI Team	RF SURVEY DATE	SI SURVEY DATE
SITE#041	2	2	6	8-Mar-01	9-Mar-01
SITE#042	1	1	7	8-Mar-01	9-Mar-01
SITE#043	1	1	7	8-Mar-01	9-Mar-01
SITE#044	1	1	8	8-Mar-01	9-Mar-01
SITE#045	1	1	8	8-Mar-01	9-Mar-01
SITE#046	1	1	8	8-Mar-01	9-Mar-01
SITE#047	2	2	6	8-Mar-01	9-Mar-01
SITE#048	2	2	6	8-Mar-01	9-Mar-01
SITE#049	1	1	1	9-Mar-01	12-Mar-01
SITE#050	2	2	2	9-Mar-01	12-Mar-01
SITE#051	2	2	2	9-Mar-01	12-Mar-01
SITE#052	2	2	2	9-Mar-01	12-Mar-01
SITE#053	1	1	1	9-Mar-01	12-Mar-01
SITE#054	2	2	3	9-Mar-01	12-Mar-01
SITE#055	2	2	3	9-Mar-01	13-Mar-01
SITE#056	1	1	1	9-Mar-01	13-Mar-01
SITE#057	2	2	3	12-Mar-01	13-Mar-01
SITE#058	1	1	4	12-Mar-01	13-Mar-01
SITE#059	2	2	5	12-Mar-01	13-Mar-01
SITE#060	1	1	4	12-Mar-01	13-Mar-01
SITE#061	2	2	5	12-Mar-01	14-Mar-01
SITE#062	2	2	5	12-Mar-01	14-Mar-01
SITE#063	1	1	4	12-Mar-01	14-Mar-01
SITE#064	2	2	6	12-Mar-01	14-Mar-01
SITE#065	1	1	7	13-Mar-01	14-Mar-01
SITE#066	2	2	6	13-Mar-01	14-Mar-01
SITE#067	2	2	6	13-Mar-01	14-Mar-01
SITE#068	1	1	7	13-Mar-01	14-Mar-01
SITE#069	2	2	1	13-Mar-01	14-Mar-01
SITE#070	2	2	1	13-Mar-01	14-Mar-01
SITE#071	2	2	1	13-Mar-01	14-Mar-01
SITE#072	2	2	3	13-Mar-01	14-Mar-01
SITE#073	2	2	3	14-Mar-01	15-Mar-01
SITE#074	2	2	3	14-Mar-01	15-Mar-01
SITE#075	2	2	5	14-Mar-01	15-Mar-01
SITE#076	2	2	5	14-Mar-01	15-Mar-01
SITE#077	2	2	5	14-Mar-01	15-Mar-01
SITE#078	2	2	6	14-Mar-01	15-Mar-01
SITE#079	2	2	6	14-Mar-01	16-Mar-01
SITE#080	2	2	6	14-Mar-01	16-Mar-01

Table B.1. Radio Network Site Survey Schedule. (Continued)

	Area	RF Team	SI Team	RF SURVEY DATE	SI SURVEY DATE
SITE#081	2	2	1	15-Mar-01	16-Mar-01
SITE#082	2	2	1	15-Mar-01	16-Mar-01
SITE#083	1	1	7	15-Mar-01	16-Mar-01
SITE#084	1	1	8	15-Mar-01	16-Mar-01
SITE#085	2	2	1	15-Mar-01	19-Mar-01
SITE#086	1	1	8	15-Mar-01	19-Mar-01
SITE#087	2	2	3	15-Mar-01	19-Mar-01
SITE#088	2	2	3	15-Mar-01	19-Mar-01
SITE#089	1	1	8	16-Mar-01	19-Mar-01
SITE#090	1	1	2	16-Mar-01	19-Mar-01
SITE#091	1	1	2	16-Mar-01	19-Mar-01
SITE#092	2	2	3	16-Mar-01	19-Mar-01
SITE#093	2	2	5	16-Mar-01	19-Mar-01
SITE#094	1	1	2	16-Mar-01	19-Mar-01
SITE#095	2	2	5	16-Mar-01	19-Mar-01
SITE#096	2	2	5	16-Mar-01	19-Mar-01
SITE#097	2	2	6	19-Mar-01	20-Mar-01
SITE#098	1	1	4	19-Mar-01	20-Mar-01
SITE#099	2	2	6	19-Mar-01	20-Mar-01
SITE#100	2	2	6	19-Mar-01	20-Mar-01
SITE#101	2	2	1	19-Mar-01	20-Mar-01
SITE#102	1	1	4	19-Mar-01	20-Mar-01
SITE#103	1	1	4	19-Mar-01	21-Mar-01
SITE#104	2	2	1	19-Mar-01	21-Mar-01
SITE#105	1	1	7	20-Mar-01	21-Mar-01
SITE#106	1	1	7	20-Mar-01	21-Mar-01
SITE#107	1	1	7	20-Mar-01	21-Mar-01
SITE#108	2	2	1	20-Mar-01	21-Mar-01
SITE#109	2	2	3	20-Mar-01	22-Mar-01
SITE#110	1	1	8	20-Mar-01	22-Mar-01
SITE#111	2	2	3	20-Mar-01	22-Mar-01
SITE#112	2	2	3	20-Mar-01	22-Mar-01
SITE#113	2	2	5	21-Mar-01	22-Mar-01
SITE#114	1	1	8	21-Mar-01	22-Mar-01
SITE#115	2	2	5	21-Mar-01	22-Mar-01
SITE#116	1	1	8	21-Mar-01	22-Mar-01
SITE#117	2	2	5	21-Mar-01	22-Mar-01
SITE#118	2	2	6	21-Mar-01	22-Mar-01
SITE#119	1	1	2	21-Mar-01	22-Mar-01
SITE#120	1	1	2	21-Mar-01	22-Mar-01

Table B.1. Radio Network Site Survey Schedule. (Continued)

	Area	RF Team	SI Team	RF SURVEY DATE	SI SURVEY DATE
SITE#121	1	1	2	22-Mar-01	23-Mar-01
SITE#122	1	1	4	22-Mar-01	23-Mar-01
SITE#123	1	1	4	22-Mar-01	23-Mar-01
SITE#124	1	1	4	22-Mar-01	23-Mar-01
SITE#125	1	1	7	22-Mar-01	23-Mar-01
SITE#126	1	1	7	22-Mar-01	23-Mar-01
SITE#127	2	2	6	22-Mar-01	26-Mar-01
SITE#128	1	1	7	22-Mar-01	26-Mar-01
SITE#129	2	2	6	23-Mar-01	26-Mar-01
SITE#130	2	2	1	23-Mar-01	26-Mar-01
SITE#131	1	1	8	23-Mar-01	26-Mar-01
SITE#132	1	1	8	23-Mar-01	26-Mar-01
SITE#133	1	1	8	23-Mar-01	27-Mar-01
SITE#134	2	2	1	23-Mar-01	27-Mar-01
SITE#135	1	1	2	23-Mar-01	27-Mar-01
SITE#136	1	1	2	23-Mar-01	27-Mar-01
SITE#137	1	1	2	26-Mar-01	27-Mar-01
SITE#138	2	2	1	26-Mar-01	27-Mar-01
SITE#139	1	1	4	26-Mar-01	27-Mar-01
SITE#140	1	1	4	26-Mar-01	27-Mar-01
SITE#141	1	1	4	26-Mar-01	27-Mar-01
SITE#142	2	2	3	26-Mar-01	27-Mar-01
SITE#143	1	1	7	26-Mar-01	27-Mar-01
SITE#144	1	1	7	26-Mar-01	27-Mar-01
SITE#145	2	2	3	27-Mar-01	28-Mar-01
SITE#146	2	2	3	27-Mar-01	28-Mar-01
SITE#147	1	1	7	27-Mar-01	28-Mar-01
SITE#148	1	1	8	27-Mar-01	28-Mar-01
SITE#149	1	1	8	27-Mar-01	28-Mar-01
SITE#150	2	2	5	27-Mar-01	28-Mar-01
SITE#151	2	2	5	27-Mar-01	29-Mar-01
SITE#152	1	1	8	27-Mar-01	29-Mar-01
SITE#153	1	1	2	28-Mar-01	29-Mar-01
SITE#154	1	1	2	28-Mar-01	29-Mar-01
SITE#155	1	1	2	28-Mar-01	29-Mar-01
SITE#156	1	1	4	28-Mar-01	29-Mar-01
SITE#157	2	2	5	28-Mar-01	30-Mar-01
SITE#158	2	2	6	28-Mar-01	30-Mar-01
SITE#159	1	1	4	28-Mar-01	30-Mar-01
SITE#160	2	2	6	28-Mar-01	30-Mar-01

Table B.1. Radio Network Site Survey Schedule. (Continued)

	Area	RF Team	SI Team	RF SURVEY DATE	SI SURVEY DATE
SITE#161	2	2	6	29-Mar-01	30-Mar-01
SITE#162	1	1	4	29-Mar-01	30-Mar-01
SITE#163	1	1	7	29-Mar-01	30-Mar-01
SITE#164	1	1	7	29-Mar-01	30-Mar-01
SITE#165	2	2	1	29-Mar-01	30-Mar-01
SITE#166	1	1	7	29-Mar-01	30-Mar-01
SITE#167	1	1	8	29-Mar-01	30-Mar-01
SITE#168	2	2	1	29-Mar-01	30-Mar-01
SITE#169	1	1	8	30-Mar-01	2-Apr-01
SITE#170	2	2	1	30-Mar-01	2-Apr-01
SITE#171	1	1	8	30-Mar-01	2-Apr-01
SITE#172	1	1	2	30-Mar-01	2-Apr-01
SITE#173	2	2	3	30-Mar-01	2-Apr-01
SITE#174	1	1	2	30-Mar-01	2-Apr-01
SITE#175	2	2	3	30-Mar-01	3-Apr-01
SITE#176	1	1	2	30-Mar-01	3-Apr-01
SITE#177	2	2	3	2-Apr-01	3-Apr-01
SITE#178	2	2	5	2-Apr-01	3-Apr-01
SITE#179	2	2	5	2-Apr-01	3-Apr-01
SITE#180	1	1	4	2-Apr-01	3-Apr-01
SITE#181	2	2	5	2-Apr-01	4-Apr-01
SITE#182	2	2	6	2-Apr-01	4-Apr-01
SITE#183	1	1	4	2-Apr-01	4-Apr-01
SITE#184	2	2	6	2-Apr-01	4-Apr-01
SITE#185	1	1	4	3-Apr-01	4-Apr-01
SITE#186	1	1	7	3-Apr-01	4-Apr-01
SITE#187	1	1	7	3-Apr-01	4-Apr-01
SITE#188	1	1	7	3-Apr-01	4-Apr-01
SITE#189	2	2	6	3-Apr-01	4-Apr-01
SITE#190	2	2	1	3-Apr-01	4-Apr-01
SITE#191	2	2	1	3-Apr-01	4-Apr-01
SITE#192	1	1	8	3-Apr-01	4-Apr-01
SITE#193	1	1	8	4-Apr-01	5-Apr-01
SITE#194	2	2	1	4-Apr-01	5-Apr-01
SITE#195	2	2	3	4-Apr-01	5-Apr-01
SITE#196	1	1	8	4-Apr-01	5-Apr-01
SITE#197	2	2	3	4-Apr-01	5-Apr-01
SITE#198	2	2	3	4-Apr-01	5-Apr-01
SITE#199	1	1	2	4-Apr-01	9-Apr-01
SITE#200	2	2	5	4-Apr-01	9-Apr-01

Table B.1. Radio Network Site Survey Schedule. (Continued)

	Area	RF Team	SI Team	RF SURVEY DATE	SI SURVEY DATE
SITE#201	1	1	2	5-Apr-01	9-Apr-01
SITE#202	1	1	2	5-Apr-01	9-Apr-01
SITE#203	1	1	4	5-Apr-01	9-Apr-01
SITE#204	1	1	4	5-Apr-01	9-Apr-01
SITE#205	1	1	4	5-Apr-01	10-Apr-01
SITE#206	2	2	5	5-Apr-01	10-Apr-01
SITE#207	1	1	7	5-Apr-01	10-Apr-01
SITE#208	1	1	7	5-Apr-01	10-Apr-01
SITE#209	2	2	5	9-Apr-01	10-Apr-01
SITE#210	2	2	6	9-Apr-01	10-Apr-01
SITE#211	1	1	7	9-Apr-01	10-Apr-01
SITE#212	2	2	6	9-Apr-01	10-Apr-01
SITE#213	2	2	6	9-Apr-01	10-Apr-01
SITE#214	1	1	8	9-Apr-01	10-Apr-01
SITE#215	2	2	1	9-Apr-01	10-Apr-01
SITE#216	1	1	8	9-Apr-01	10-Apr-01
SITE#217	2	2	1	10-Apr-01	11-Apr-01
SITE#218	2	2	1	10-Apr-01	11-Apr-01
SITE#219	1	1	8	10-Apr-01	11-Apr-01
SITE#220	1	1	2	10-Apr-01	11-Apr-01
SITE#221	2	2	3	10-Apr-01	11-Apr-01
SITE#222	1	1	2	10-Apr-01	11-Apr-01
SITE#223	1	1	2	10-Apr-01	17-Apr-01
SITE#224	2	2	3	10-Apr-01	17-Apr-01
SITE#225	2	2	3	11-Apr-01	17-Apr-01
SITE#226	1	1	4	11-Apr-01	17-Apr-01
SITE#227	2	2	5	11-Apr-01	17-Apr-01
SITE#228	2	2	5	11-Apr-01	17-Apr-01
SITE#229	1	1	4	11-Apr-01	18-Apr-01
SITE#230	2	2	5	11-Apr-01	18-Apr-01
SITE#231	2	2	6	11-Apr-01	18-Apr-01
SITE#232	2	2	6	11-Apr-01	18-Apr-01
SITE#233	1	1	4	17-Apr-01	18-Apr-01
SITE#234	2	2	6	17-Apr-01	18-Apr-01
SITE#235	1	1	7	17-Apr-01	18-Apr-01
SITE#236	1	1	7	17-Apr-01	18-Apr-01
SITE#237	2	2	1	17-Apr-01	18-Apr-01
SITE#238	2	2	1	17-Apr-01	18-Apr-01
SITE#239	1	1	7	17-Apr-01	18-Apr-01
SITE#240	1	1	8	17-Apr-01	18-Apr-01

Table B.1. Radio Network Site Survey Schedule. (Continued)

	Area	RF Team	SI Team	RF SURVEY DATE	SI SURVEY DATE
SITE#241	1	1	8	18-Apr-01	19-Apr-01
SITE#242	2	2	1	18-Apr-01	19-Apr-01
SITE#243	1	1	8	18-Apr-01	19-Apr-01
SITE#244	2	2	3	18-Apr-01	19-Apr-01
SITE#245	1	1	2	18-Apr-01	19-Apr-01
SITE#246	1	1	2	18-Apr-01	19-Apr-01
SITE#247	2	2	3	18-Apr-01	20-Apr-01
SITE#248	1	1	2	18-Apr-01	20-Apr-01
SITE#249	1	1	4	19-Apr-01	20-Apr-01
SITE#250	1	1	4	19-Apr-01	20-Apr-01
SITE#251	1	1	4	19-Apr-01	20-Apr-01
SITE#252	2	2	3	19-Apr-01	20-Apr-01
SITE#253	2	2	5	19-Apr-01	23-Apr-01
SITE#254	1	1	6	19-Apr-01	23-Apr-01
SITE#255	2	2	5	19-Apr-01	23-Apr-01
SITE#256	1	1	6	19-Apr-01	23-Apr-01
SITE#257	1	1	6	20-Apr-01	23-Apr-01
SITE#258	2	2	5	20-Apr-01	23-Apr-01
SITE#259	1	1	7	20-Apr-01	23-Apr-01
SITE#260	2	2	8	20-Apr-01	23-Apr-01
SITE#261	2	2	8	20-Apr-01	23-Apr-01
SITE#262	1	1	7	20-Apr-01	23-Apr-01
SITE#263	2	2	8	20-Apr-01	23-Apr-01
SITE#264	1	1	7	20-Apr-01	23-Apr-01
SITE#265	1	1	1	23-Apr-01	24-Apr-01
SITE#266	2	2	2	23-Apr-01	24-Apr-01
SITE#267	1	1	1	23-Apr-01	24-Apr-01
SITE#268	2	2	2	23-Apr-01	24-Apr-01
SITE#269	1	1	1	23-Apr-01	24-Apr-01
SITE#270	2	2	2	23-Apr-01	24-Apr-01
SITE#271	2	2	3	23-Apr-01	25-Apr-01
SITE#272	1	1	4	23-Apr-01	25-Apr-01
SITE#273	1	1	4	24-Apr-01	25-Apr-01
SITE#274	2	2	3	24-Apr-01	25-Apr-01
SITE#275	2	2	3	24-Apr-01	25-Apr-01
SITE#276	1	1	4	24-Apr-01	25-Apr-01
SITE#277	2	2	5	24-Apr-01	26-Apr-01
SITE#278	1	1	6	24-Apr-01	26-Apr-01
SITE#279	1	1	6	24-Apr-01	26-Apr-01
SITE#280	1	1	6	24-Apr-01	26-Apr-01

Table B.1. Radio Network Site Survey Schedule. (Continued)

	Area	RF Team	SI Team	RF SURVEY DATE	SI SURVEY DATE
SITE#281	2	2	5	25-Apr-01	26-Apr-01
SITE#282	1	1	7	25-Apr-01	26-Apr-01
SITE#283	1	1	7	25-Apr-01	26-Apr-01
SITE#284	2	2	5	25-Apr-01	26-Apr-01
SITE#285	1	1	7	25-Apr-01	26-Apr-01
SITE#286	2	2	8	25-Apr-01	26-Apr-01
SITE#287	2	2	8	25-Apr-01	26-Apr-01
SITE#288	1	1	1	25-Apr-01	26-Apr-01
SITE#289	2	2	8	26-Apr-01	27-Apr-01
SITE#290	2	2	2	26-Apr-01	27-Apr-01
SITE#291	1	1	1	26-Apr-01	27-Apr-01
SITE#292	2	2	2	26-Apr-01	27-Apr-01
SITE#293	2	2	2	26-Apr-01	27-Apr-01
SITE#294	1	1	1	26-Apr-01	27-Apr-01
SITE#295	1	1	3	26-Apr-01	30-Apr-01
SITE#296	2	2	4	26-Apr-01	30-Apr-01
SITE#297	2	2	4	27-Apr-01	30-Apr-01
SITE#298	2	2	4	27-Apr-01	30-Apr-01
SITE#299	1	1	3	27-Apr-01	30-Apr-01
SITE#300	1	1	3	27-Apr-01	30-Apr-01
SITE#301	2	2	5	27-Apr-01	2-May-01
SITE#302	1	1	6	27-Apr-01	2-May-01
SITE#303	2	2	5	27-Apr-01	2-May-01
SITE#304	1	1	6	27-Apr-01	2-May-01
SITE#305	2	2	5	30-Apr-01	2-May-01
SITE#306	1	1	6	30-Apr-01	2-May-01
SITE#307	1	1	7	30-Apr-01	2-May-01
SITE#308	2	2	8	30-Apr-01	2-May-01
SITE#309	2	2	8	30-Apr-01	2-May-01
SITE#310	2	2	8	30-Apr-01	2-May-01
SITE#311	2	2	1	30-Apr-01	2-May-01
SITE#312	1	1	7	30-Apr-01	2-May-01
SITE#313	2	2	1	2-May-01	3-May-01
SITE#314	1	1	7	2-May-01	3-May-01
SITE#315	1	1	2	2-May-01	3-May-01
SITE#316	2	2	1	2-May-01	3-May-01
SITE#317	2	2	3	2-May-01	3-May-01
SITE#318	1	1	2	2-May-01	3-May-01
SITE#319	1	1	2	2-May-01	4-May-01
SITE#320	2	2	3	2-May-01	4-May-01

Table B.1. Radio Network Site Survey Schedule. (Continued)

	Area	RF Team	SI Team	RF SURVEY DATE	SI SURVEY DATE
SITE#321	2	2	3	3-May-01	4-May-01
SITE#322	1	1	4	3-May-01	4-May-01
SITE#323	2	2	5	3-May-01	4-May-01
SITE#324	2	2	5	3-May-01	4-May-01
SITE#325	2	2	5	3-May-01	8-May-01
SITE#326	2	2	6	3-May-01	8-May-01
SITE#327	1	1	4	3-May-01	8-May-01
SITE#328	2	2	6	3-May-01	8-May-01
SITE#329	2	2	6	4-May-01	8-May-01
SITE#330	2	2	1	4-May-01	8-May-01
SITE#331	1	1	4	4-May-01	8-May-01
SITE#332	2	2	1	4-May-01	8-May-01
SITE#333	1	1	7	4-May-01	8-May-01
SITE#334	2	2	1	4-May-01	8-May-01
SITE#335	1	1	7	4-May-01	8-May-01
SITE#336	1	1	7	4-May-01	8-May-01
SITE#337	1	1	8	8-May-01	9-May-01
SITE#338	2	2	3	8-May-01	9-May-01
SITE#339	2	2	3	8-May-01	9-May-01
SITE#340	1	1	8	8-May-01	9-May-01
SITE#341	2	2	3	8-May-01	9-May-01
SITE#342	1	1	8	8-May-01	9-May-01
SITE#343	1	1	2	8-May-01	10-May-01
SITE#344	2	2	5	8-May-01	10-May-01
SITE#345	2	2	5	9-May-01	10-May-01
SITE#346	1	1	2	9-May-01	10-May-01
SITE#347	1	1	2	9-May-01	10-May-01
SITE#348	1	1	4	9-May-01	10-May-01
SITE#349	2	2	5	9-May-01	11-May-01
SITE#350	2	2	6	9-May-01	11-May-01
SITE#351	1	1	4	9-May-01	11-May-01
SITE#352	2	2	6	9-May-01	11-May-01
SITE#353	1	1	4	10-May-01	11-May-01
SITE#354	1	1	7	10-May-01	11-May-01
SITE#355	1	1	7	10-May-01	11-May-01
SITE#356	1	1	7	10-May-01	11-May-01
SITE#357	1	1	8	10-May-01	11-May-01
SITE#358	1	1	8	10-May-01	11-May-01
SITE#359	2	2	6	10-May-01	11-May-01
SITE#360	1	1	8	10-May-01	11-May-01

APPENDIX C

STANDARD TIME MEASUREMENT

Table C.1. Schedule for Monitoring Standard Time.

	Dayl	Day2	Day3	Day4
RF Supervisor#1	Monitor RF Teaml	Monitor RF Teaml	Monitor RF Teaml	
RF Supervisor#2	Monitor RF Team2	Monitor RF Team2	Monitor RF Team2	
SI Supervisor#1		Monitor SI Teaml		Monitor SI Team5
SI Supervisor#2		Monitor SI Team2		Monitor SI Team6
SI Supervisor#3			Monitor SI Team3	Monitor SI Team7
SI Supervisor#4			Monitor SI Team4	Monitor SI Team8

Table C.2. Average Time from Monitoring for RF Team.

		Discuss area with supervisor	Travel to the search area#1	Travel back to the office	Reporting
Dayl	RF Teaml	21	42	30	45
	RF Team2	40	42	33	46
Day2	RF Teaml	33	67	28	40
	RF Team2	31	45	32	32
Day3	RF Teaml	28	53	43	30
	RF Team2	29	30	44	25
Average		30.33	46.50	35.00	36.33

Table C.3. Average Time from Monitoring for RF Team (2).

			Find the suitable place (Choice#1)	Fill form / Take photo	Find next choice (Choice#2)	Fill form / Take photo
Dayl	RF Teaml	Locationl	30	14	16	14
		Location2	24	16	17	14
		Location3	29	13	17	13
		Location4	39	14	5	12
	RF Team2	Locationl	30	16	21	12
		Location2	32	17	11	20
		Location3	33	13	15	14
		Location4	29	14	17	12
Day2	RF Teaml	Locationl	31	19	16	20
		Location2	40	11	12	11
		Location3	30	15	23	16
		Location4	30	25	21	17
	RF Team2	Locationl	34	15	13	13
		Location2	21	13	14	14
		Location3	29	14	15	14
		Location4	32	11	14	15
Day3	RF Teaml	Locationl	19	16	11	21
		Location2	20	18	26	11
		Location3	20	21	15	15
		Location4	40	12	14	16
	RF Team2	Locationl	39	19	15	15
		Location2	35	14	16	17
		Location3	21	21	15	15
		Location4	29	14	15	15
Average			29.83	15.63	15.58	14.83

Table C.4. Average Time from Monitoring for SI Team.

		Travel to Location#1	Travel back to the office
Day2	SI Teaml	41	32
	SI Team2	44	46
Day3	SI Team3	55	34
	SI Team4	48	40
Day4	SI Team5	49	42
	SI Team6	30	38
	SI Team7	49	90
	SI Team8	55	40
Average		46.38	45.25

Table C.5. Average time from monitoring for SI Team (2).

			Take Photo / measure room / Draft result for Choice#1	Take Photo / measure room / Draft result for Choice#2	Travel to the location from RF Team's result
Day2	SI Teaml	Locationl	57	60	12
		Location2	62	63	13
		Location3	48	56	-
	SI Team2	Locationl	70	51	20
		Location2	65	65	14
		Location3	56	64	-
Day3	SI Team3	Locationl	52	60	15
		Location2	54	52	16
		Location3	65	69	-
	SI Team4	Locationl	62	51	21
		Location2	66	59	10
		Location3	55	60	-
Day4	SI TeamS	Locationl	71	60	14
		Location2	55	61	13
		Location3	60	63	-
	SI Team6	Locationl	61	60	12
		Location2	63	59	12
		Location3	49	60	-
	SI Team?	Locationl	50	57	11
		Location2	61	58	14
		Location3	65	68	-
	SI Team8	Locationl	71	62	10
		Location2	50	60	20
		Location3	60	59	-
Average			59.50	59.88	14.19

APPENDIX D

PROJECT REPORT

Table D.1. Estimated Backlog in Each Day.

DATE	RF TEAM	SI TEAM	BACKLOG
1-Mar-01	8	0	0
2-Mar-01	8	6	2
5-Mar-01	8	6	4
6-Mar-01	8	12	0
7-Mar-01	8	6	2
8-Mar-01	8	6	4
9-Mar-01	8	12	0
12-Mar-01	8	6	2
13-Mar-01	8	6	4
14-Mar-01	8	12	0
15-Mar-01	8	6	2
16-Mar-01	8	6	4
19-Mar-01	8	12	0
20-Mar-01	8	6	2
21-Mar-01	8	6	4
22-Mar-01	8	12	0
23-Mar-01	8	6	2
26-Mar-01	8	6	4
27-Mar-01	8	12	0
28-Mar-01	8	6	2
29-Mar-01	8	6	4
30-Mar-01	8	12	0
2-Apr-01	8	6	2
3-Apr-01	8	6	4
4-Apr-01	8	12	0
5-Apr-01	8	6	2
9-Apr-01	8	6	4
10-Apr-01	8	12	0
11-Apr-01	8	6	2
17-Apr-01	8	6	4
18-Apr-01	8	12	0
19-Apr-01	8	6	2
20-Apr-01	8	6	4
23-Apr-01	8	12	0
24-Apr-01	8	6	2
25-Apr-01	8	6	4
26-Apr-01	8	12	0
27-Apr-01	8	6	2
30-Apr-01	8	6	4
2-May-01	8	12	0
3-May-01	8	6	2
4-May-01	8	6	4
8-May-01	8	12	0
9-May-01	8	6	2
10-May-01	8	6	4
11-May-01	0	12	0

Table D.2. Daily Report.

		WK01		WK02				
DATE		1Mar	2-Mar	5-Mar	6-Mar	7-Mar	8-Mar	9Mar
RF TEAM	Plan	8	8	8	8	8	8	8
	Actual	8	8	8	8	8	8	8
SI TEAM	Plan	0	6	6	12	6	6	12
	Actual		6	6	12	6	6	12
BACKLOG	Plan	0	2	4	0	2	4	0
	Actual		2	4	0	2	4	0

		WK03				
DATE		12-Mar	13-Mar	14-Mar	15-Mar	16-Mar
RF TEAM	Plan	8	8	8	8	8
	Actual	8	8	8	8	4
SI TEAM	Plan	6	6	12	6	6
	Actual	3	9	12	6	6
BACKLOG	Plan	2	4	0	2	4
	Actual	5	4	0	2	4

		WK04				
DATE		19-Mar	20-Mar	21-Mar	22-Mar	23-Mar
RF TEAM	Plan	8	8	8	8	8
	Actual	12	8	8	8	4
SI TEAM	Plan	12	6	6	12	6
	Actual	6	12	6	12	6
BACKLOG	Plan	0	2	4	0	2
	Actual	2	2	4	0	2

		WK05				
DATE		26-Mar	27-Mar	28-Mar	29-Mar	30-Mar
RF TEAM	Plan	8	8	8	8	8
	Actual	12	8	8	8	8
SI TEAM	Plan	6	12	6	6	12
	Actual	6	12	3	9	12
BACKLOG	Plan	4	0	2	4	0
	Actual	0	0	5	4	0

Table D.2. Daily Report. (Continued)

		WK06			
DATE		2-Apr	3-Apr	4-Apr	5-Apr
RF TEAM	Plan	8	8	8	8
	Actual	8	8	8	8
SI TEAM	Plan	6	6	12	6
	Actual	6	6	12	6
BACKLOG	Plan	2	4	0	2
	Actual	2	4	0	2

		WK07		
DATE		9-Apr	10-Apr	11-Apr
RF TEAM	Plan	8	8	8
	Actual	8	8	8
SI TEAM	Plan	6	12	6
	Actual	6	12	6
BACKLOG	Plan	4	0	2
	Actual	4	0	2

		WK08			
DATE		17-Apr	18-Apr	19-Apr	20-Apr
RF TEAM	Plan	8	8	8	8
	Actual	8	8	8	8
SI TEAM	Plan	6	12	6	6
	Actual	6	6	12	6
BACKLOG	Plan	4	0	2	4
	Actual	4	6	2	4

		WK09				
DATE		23-Apr	24-Apr	25-Apr	26-Apr	27-Apr
RF TEAM	Plan	8	8	8	8	8
	Actual	4	12	8	8	8
SI TEAM	Plan	12	6	6	12	6
	Actual	12	3	9	12	6
BACKLOG	Plan	0	2	4	0	2
	Actual	0	1	4	0	2

Table D.2. Daily Report. (Continued)

		WK10			
DATE		30-Apr	2-May	3-May	4-May
RF TEAM	Plan	8	8	8	8
	Actual	8	8	8	8
SI TEAM	Plan	6	12	6	6
	Actual	6	12	6	6
BACKLOG	Plan	4	0	2	4
	Actual	4	0	2	4

		WK11				WK12
DATE		8-May	9-May	10-May	11-May	14-May
RF TEAM	Plan	8	8	8	0	0
	Actual	8	8	8	0	0
SI TEAM	Plan	12	6	6	12	0
	Actual	12	6	6	6	6
BACKLOG	Plan	0	2	4	0	0
	Actual	0	2	4	6	0

APPENDIX E

SEARCH AREA AND RF REPORT

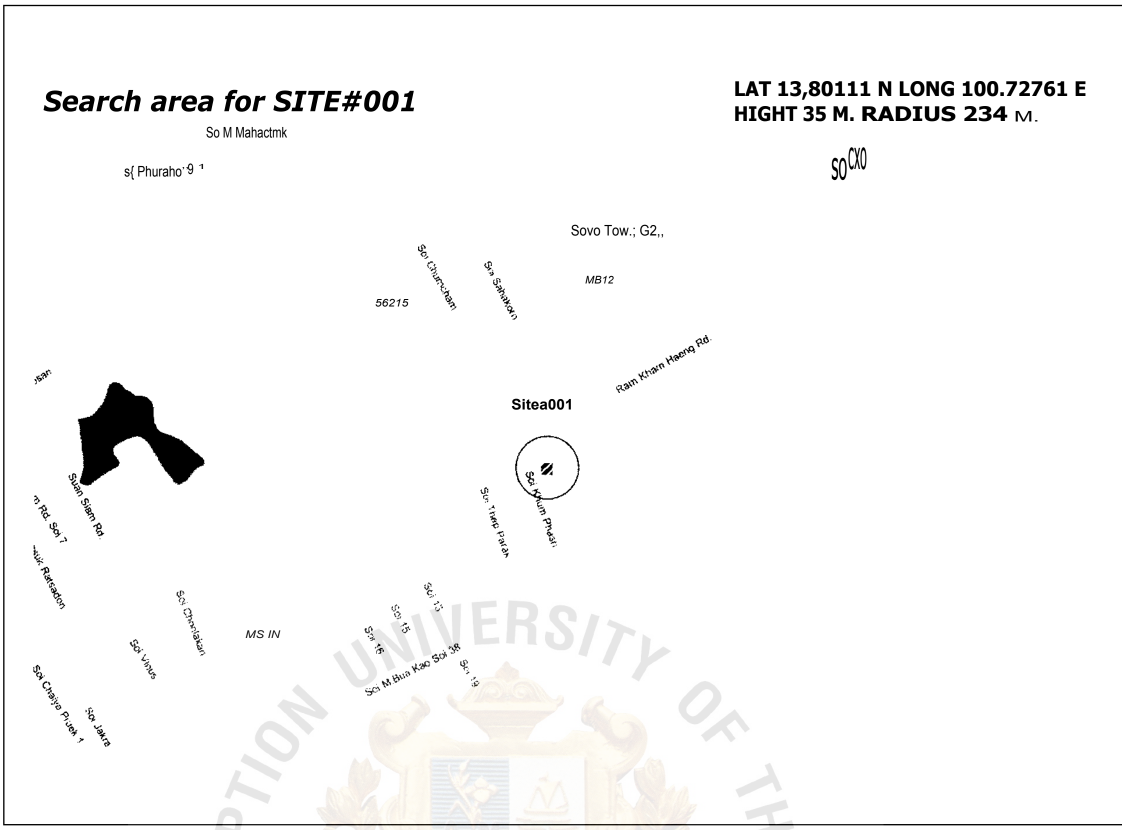


Figure E.1. Search area.

ERICSSON 5.

SURVEY REPORT 1(9

Prepared (also subject responsible if other) - ...A tril Yukirau) EXEO Waraporn Chayubon		No.-..,0 I I	
Doc responsthpproved-ionomouiviegatene ECTDUN Kittichai Apintanaphong	I Checked-tginloo	Date-sun I Rev- At, March 02,2001 A	File -tot REPORT- 01

RF SURVEY REPORT **EI ACCESS 0 NO ACCESS**

Site name : SITE#001

Site ID and alternative : SITEI1001 (A)

Visiting date : 01/03/01

RF surveyor : K.Suwat

RE AIS::"

Site IcSiriohal

Address : Khum Than Thong Apartment,284/64 Soi Boon Mak 2,Song Prapa,Don Muang Bangkok 10210

Nominal Co-ords. Lat : N 13° 55' 12.7" Long: E 100° 35' 40.4"

GPS Co-ords. Lat: N 13° 55' 11.1" Long: E 100° 35' 39.0"

Map Co-ords. Lat: N Long: E

2 Mark position on map 2 A4 sketch from above Map datum: Indian-Thailand

Photos taken : 2 360 deg. Panorama 2 site photos ®street photos of property x

At approximately height : 15.60 m

Height of building [m] : 14 m Tower height [rn] . Guy 16 m

Proposed antenna height [magi] 25 m Antenna direction(s) [deg] . 30,150,270

Proposed antenna tilt [sect 1, sect.2, sect.3] : 4,6,4 Antenna Gain [dBi] : 15.5

RBS Type 2202 Configuration 3+3+2

Surroundings:

Obstacles	Direction [deg]	Distance [m]	Height [m]

Comments :

Contact person : K.Yot
Address cont.. Khum Than Thong Apartment,284/64 Soi Boon Mak 2,Song Prapa,Don Muang Bangkok 10210
Phone cont.: 982-1492-5(149)
Fax :

Building owner:
Address owner.
Phone owner.

Choice 1 out of alternative : A Off grid [m] : On
Status: RI OK CI **NOT OK** (with the condition above)

Figure E.2. Example of RF Survey Report Pagel .

ERICSSON 1⁄4

SURVEY REPORT 2(9

Prepared (also subject responsible if other) - AsulaurifoolfbAadruu) EXEO Waraporn Chayubon	No -e.	
Doc respons/Approved-uandmouit/otialau 1 Checked4Jaine ECT/X/N Kittichai Apintanaphong	Date-Sun I Rev-tund March 02,2001 A	File- REPORT- 01

Site : **SITE#001(A)**

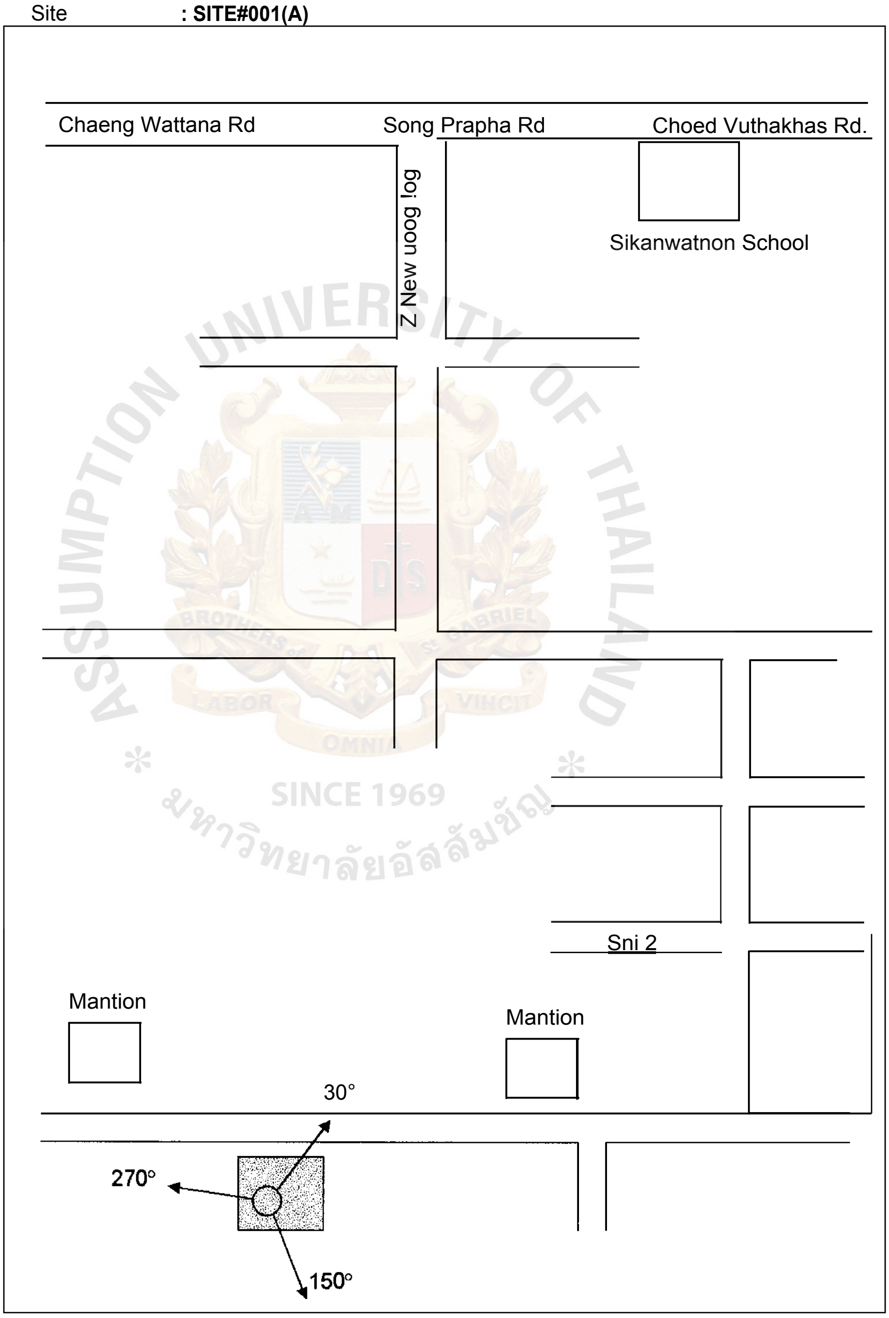


Figure E.3. Example of RF Survey Report Page2.

ERicssoN

SURVEY REPORT 3(9)

Pricsma UliihlibliCITAlipiPil:4164.111• I.:0Am se•m2a:••••.1 EXEO Warapom Chaython		kilkerwe I I	
D., .4....4,......--••••••.A. 6,1a n ECTIX/61 Kittichai Apirtanaphong	I Chlikhl•igno	11J11.• iv·· I 12.p.-.1. March 02,2001 A	Fld—A. REPORT- 01

Site Photo	SITE#001(A)

Site Photo	ANTENNA POSITION

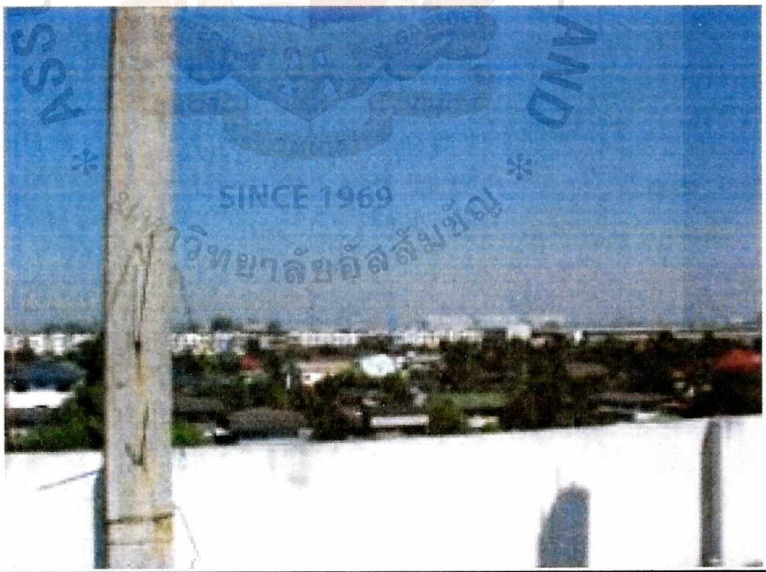
Figure E.4. Example of RF Survey Report Page3.

ERICSSON 5111

SURVEY REPORT 460

Fnipsia ulogibblzindpepatbVadici• .r..C...".44.;,..1 **B(E0 Warapom Chaython**	Itay.a I I	
Di% 114.31\115pplVdd..=•••risA 6.,M.. I Darloa•i.C., **ECT/XIN Krtt hai Ppirtanaphong**	0.11111 ke I Rii,A6 **March 02.2001 A**	FiF•irr, **REPORT- 01**

Direction	0°



Direction	30°

Figure E.S. Example of RF Survey Report Page4.

ERICSSON Si

SURNEr REPORT 60)

Pronhi ulikdibioeirawat4.1f4ail• ..:m.C...!..4..;.....1 EXECI VUlarapom Chayttion	Ma..' I I	
DOC *4:1:411appCil wr •"' m • 6.Ar• I CFrchho. .. ECT/XiN Krttichai Pipirtanaphong	DJ111- n.= I R. - - tu1arch 02,2001A	Fl4..4. REPORT- 01

Direction	60°

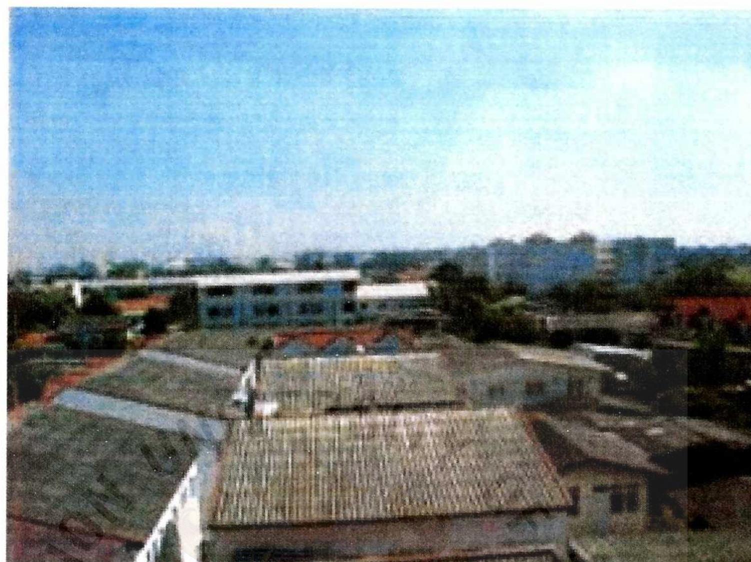
Direction 90°

Figure E.6. Example of RF Survey Report Page5.

ERICSSON

SLIRWY REPORT 6(g)

Pril:41111 uliadiblicimpapdtblrel.el• .z..(.. AA. Z....; **EXEO** **Warapom ChayLbon**	*hoo.a*	
ut ..₊d4p....--••••=.A. 4,,.a,. I Chiilghl•itm **ECTNN** **Kittbhai** **Ppirtanaphong**	11.111F k= Rv.-A.. **March 02,2001 A**	**Fli,A** **REPORT- 01**



Direction	120⁺

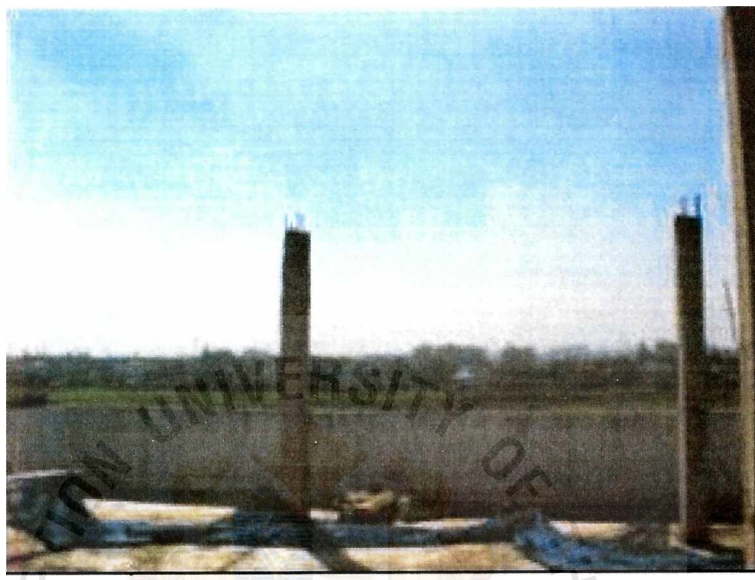
Direction	150°

Figure E.7. Example of RF Survey Report Page6.

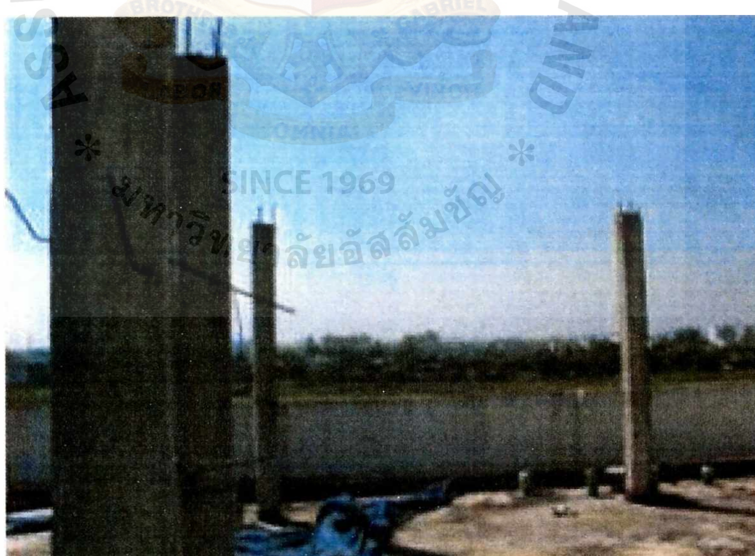
ERICSSON

SURVEY REPORT

Prippawa uYaa.hMccwpsdtelafah• ..''..E. A44.r...1 **EXEO Warapom Chayubon**	Ma•...	
bac wpm diveAti -m• • •rm.A. 4.7... I Ciakid•I,G. **ECTI KittiDhai Ppirtanaphong**	rine- kt IIte....1.. **March 02,2001A**	FLP•A. **REPORT- 01**



Direction	0



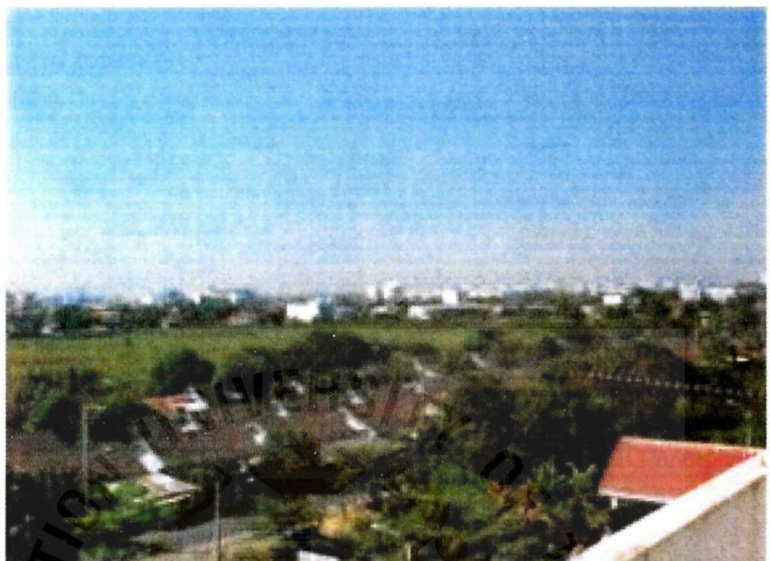
Direction	210°

Figure E.8. Example of RF Survey Report Pagel.

ERICSSON

SURVEY REPORT 8( )

FTIFpiii ulicAbblioniptrit41164eri• ..-:..E. :.=:,.;rand REO Warapom Chaython	111r/retie		
a. 111441.11611,10•11d.m•••••••.A. '.4.W.. ı CFahm.:4,. ECTNIN Krttichai .Apirtanaphong	Dibi-;se March 02,2001A	Rei-ml,	Fld- A. REPORT- 01



Direction	240°

O

Direction	270°

Figure E.9. Example of RF Survey Report Page8.

ERICSSON

SURVEY REPORT 9(€0

Pripzid uldediblacimpaolblpbreiba41..--..E...:W4. r...1 EXEO **Warapom Chaylon**	Ma...a I I	
(162 M41104116ppdad-•••••••••.A. 6µ7e• I CI.E1+1..:{. **ECTI** **Krttiehai Apirtanaphong**	Cula-;= Re a. March 02.2001 A	na••.r.. **REPORT- 01**

Direction	300°

Direction	330°

Figure E.10. Example of RF Survey Report Page9.

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