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Bicycle Theft Prevention in Denmark

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Abstract

This project, completed in Copenhagen, Denmark for the Danish Cyclists Federation, describes the current situation of bicycle theft and security in Denmark and suggests possible solutions to alleviate this problem. Using extensive background research, interviews, focus groups, and field observations, the team determined that a system using radio frequency identification tags and scanning technology would greatly improve on the current frame number system and more easily identify bicycles. Guidelines and important contacts crucial to implementing such a system are included.

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Executive Summary

For the typical cyclist in Denmark, the theft of a bicycle is a significant loss. The financial impact is non-trivial; an ordinary, everyday bicycle easily costs USD 500. While most bicycles are insured, a cycle's insurance value depreciates quickly. Also of great consequence is the inconvenience of losing a cycle. Cycling, for Danes, is a daily activity and way of life. Many Danes, especially in Copenhagen, use their bicycles as their primary mode of transportation. To be robbed of a bicycle, then, may severely limit one's freedom to move about at will, and cause a sizeable financial loss.

This project team was charged with researching how recent technological advancements can be applied to reduce bicycle theft in Denmark. The project was sponsored by the Dansk Cyklist Forbund (Danish Cycling Federation, DCF). Once in Copenhagen, the team verified the severity of bicycle theft and learned more about what was currently being done to remedy it. The team's thorough preliminary research, carried out via literature review and interviews, examined several options for theft prevention. Current theft prevention techniques such as using bicycle locks and bicycle registries were studied in order to evaluate how they might be augmented in a new system. More advanced technology, such as geographic tracking and electronic identification where examined as potential solutions. Recommendations were made to the DCF based on extensive data collection through various methods. The team decided that radio frequency identification (RFID) tagging would be the best theft prevention system the DCF should consider.

The groundwork of the RFID tagging system proposed is actually already in place in Denmark. Every bicycle ridden in Denmark is required by law to be stamped on its

frame with a unique code that can be used to trace bicycles to their original owners. However, the time required to maneuver a bicycle and check to see whether the number corresponds to a legitimately owned bicycle, makes spot-checking bicycles an unreasonable burden on the police force and, therefore, a task with a very low priority.

Securely attaching an RFID tag encoded with the cycle's frame number or similar information would make it possible to efficiently locate stolen bicycles. When a tag is read with an RFID scanner, the scanner can wirelessly query a police-run database to determine if the bicycle is stolen. The process becomes automated and nearly instantaneous. It may well be feasible, whether now or in the very near future, for an official with a scanner to walk down a row of bicycles and rapidly scan each one, pinpointing which, if any, of a rack of many bicycles are stolen, all in a minute or two. This type of system would act to both prevent theft and to locate stolen bicycles.

In order to plan the logistical details of the system chosen, interviews were conducted with those people who would be involved in different aspects of the system. Conversations with cyclists and cycle shops helped the team to refine the system. A number of private companies in the RFID industry were contacted to determine if their product lines would suit the needs of the DCF and Danish cyclists. This group of contacts also included several in Amsterdam, where a similar program to outfit bicycles with RFID tags has recently begun. Insurance companies and government officials were questioned regarding funding and the possibility of making the system either legally compulsory or a prerequisite for insurance coverage. The team encountered mainly positive responses toward RFID technology, and with these stakeholders' opinions, was better able to formulate a plan for the DCF's efforts in combating bicycle theft.

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1. Introduction

In Copenhagen, Denmark, one out of every three citizens cycles to work on a daily basis. Furthermore, 30 percent of the total trips taken in Denmark occur on a bicycle (Coliped). It is no surprise, then, that Copenhagen has earned the nickname "The City of Cyclists." The bicycle is very important to Danes, not just as a sport or hobby but as a way of life. The Dansk Cyklist Forbund (Danish Cyclists Federation or DCF) is a non-governmental organization concerned with the everyday cyclist in Denmark, reflecting the needs and interests of (Appendix A). The DCF works with the government and other non-government organizations, such as the European Cyclists Federation, in their efforts to make cycling a safer, more useful, and more respected form of transportation. The DCF has had a hand in many projects that benefit Danish cyclists, such as the bicycle lanes throughout the country and the City-Bike program in Copenhagen.

One problem facing this cycling culture is bicycle theft, which has been rising significantly despite many efforts to stop it. An international survey of crime victims found that eight percent (approximately one in twelve) of Danish bicycle owners have had a bicycle stolen. This gives Denmark the dubious honor of having the highest rate of cycle theft of the seventeen industrialized nations surveyed, tied with the Netherlands (Kesteren). Costing an average of DKK 2900 (USD 500), a bicycle is a significant investment and replacement is very expensive, whether it is the individual or an insurance company who ends up paying for the loss. In 2004 alone, Danish insurance companies spent about DKK 141 million (USD 25 million) compensating 53,000 victims (Appendix I).

The bicycle is a crucial part of Danish society, and its role as a practical, recreational, environmentally sound form of transportation is still growing. Therefore, the prevention and detection of bicycle theft are valuable pursuits. The methods already in place to curb bicycle theft

vary from basic locking mechanisms to a unique coded frame number system that is required on all bikes. The Danish frame number system will be discussed in Section 5.1.1. Others solutions are more socially-oriented, such as the free public bike system in Copenhagen called City Bike. It is very promising and important that these steps have been taken, but the problem is still increasing. In 2001, 65,066 bicycles were stolen in Denmark. Three years later, in 2004, there were 70,224 bicycles stolen, which marks an eight percent increase in bicycle thefts (Danmarks Statistik). In the first quarter of 2005, there have already been 12,852 bicycles stolen. Obviously this constitutes a serious economic and social issue, and the team set out to address all aspects of the problem and possible solutions.

2. Background Information

A broad survey of background literature was conducted as the first step in completion of this project. The purpose of the research was to learn details on the scope of bicycle theft in Denmark while becoming familiar with existing tracking technology.

2.1 Significance of Bicycling and Theft in Denmark

In the past three years (2002-2004) there has been an average of 69,759 bicycles stolen

Figure 2 - Danes cycling to work and school in Copenhagen

per year in Denmark. With about four and a half million bicycles total in Denmark, the number stolen each year represents about one and a half percent of those owned. More significantly, eight percent of all Danish cycle owners have had a bicycle stolen. In Copenhagen alone, where the population is 501,664, the number of bikes stolen each year is 15,394 (Danmarks Statistik). Therefore, not only does Copenhagen account for 22 percent of all reported bicycle thefts in Denmark, but three out of every 100 residents of Copenhagen have a bike stolen each year. Additionally,

Figure 1 - Bicycles parked outside of a Copenhagen office building.

many bicycle thefts are not reported, meaning the actual total is much higher. One may neglect to report a theft if he or she feels that the bike is too old to receive any money from the insurance companies.

It may be difficult for some Americans to grasp why bicycle theft is such a significant problem in Denmark. In the U.S., the bicycle is no more than a recreational item. The average person does not rely on a bike for daily transportation, nor is it used as a primary mode for carrying groceries and countless other belongings. Many Danes even have bicycles with large boxes on the front in which both children and adults can ride. When a bicycle is stolen in Denmark, it eliminates the owner's ability to perform necessary tasks until a new bicycle can be acquired, which may take a great deal of time. If a claim is placed with an insurance company, it can take up to 20 days to receive any financial compensation (Appendix I). Few Danes have several

Figure 3 - Danes cycling in the cycle-lane and stopped at a red light

thousand kroner on hand to spend at their convenience on any given day. It is a fact that bicycles are more expensive in Denmark than in the U.S., and when that kind of investment is stolen, someone's livelihood is greatly affected.

2.2 Theft Prevention Technology

In order to improve the problem of bicycle theft, protection beyond a standard locking mechanism is needed. Prior to commencing the Denmark project, the team researched several

forms of technology that could be possible to use on bicycles. These topics include radio frequency and global positioning system tracking, as well as, radio frequency identification.

Radio frequency (RF) tracking utilizes radio waves to broadcast a signal that represents the location of a transmitter. The transmitter emits the radio waves which are then picked up by computer some distance away. The transmitter is usually placed on an object of value whose owner wishes to keep close tabs on its whereabouts. Depending on the system, radio waves are either constantly emitted, which generally require a large amount of power, or can be regulated by a receiver. The latter appears most often in vehicle tracking systems such as LoJack or VectorTrac. A receiver allows the transmitter to be turned on and off at any desired moment, so when a car is stolen, the police can simply initiate the tracking system once a report is filed.

Global positioning system (GPS) tracking is also popular for locating stolen vehicles. As an alternative to RF tracking, GPS technology relies on several dozen satellites owned and maintained by the American Department of Defense. These satellites revolve around the earth in orbits that are calculated so that at any time, any location on the planet is within range of at least four satellites. The earthbound aspect of GPS technology uses receivers to intercept data sent through radio waves from the satellites. Using this data, the general location of the object in question can be determined. GPS technology has been adapted to a variety of problems, some of which may be applicable to bicycle theft. As mentioned previously, there are companies that manufacture GPS receivers for tracking automobiles, the most common one being "On-Star." Handheld GPS receivers are also sold simply for the purpose of carrying on one's person. Some companies even produce brackets designed to assist in mounting handheld GPS units on bicycles, making GPS another viable option for this project.

Radio Frequency Identification (RFID) is one of the fastest growing industries for theft prevention and identification of goods. Tiny transponders have been developed for use in bicycles,

motorcycles, laptop computers, products at department stores, and even pets. The transponders consist of a microchip containing a unique identification number that cannot be changed or altered. When one wishes to identify an object, he or she waves a hand-held scanning device near the area containing the chip, and an ID number appears on the scanner. That number can then be linked to any necessary information, such as the name and phone number of the owner or a description of the product in question, all using a computer database. The chips work similarly to standard barcodes. However, the chips are more resistant to the elements, can contain vast amounts of information, and can be scanned at nearly any orientation.

These methods, discussed in greater detail in the Discussion section, showed the greatest promise for preventing bicycle theft and for aiding in early recovery of stolen bicycles. Consequently, the team set out to gather field data on the problem and propose appropriate remedies.

3. Methodology

The team set out to learn more about the problem of bicycle theft and to determine the most effective solution. The methods used to study the issue were literature research, field observations, interviews, questionnaires and focus groups.

Extensive literature research was performed during both the proposal and project periods. This consisted of an overview and analysis of printed materials related to the project. Some of these materials were on the subject of bicycle theft, while many others related to possible solutions, particularly RFID technology and business applications. This literature was drawn from sources such as scientific journals, business journals, magazines, web sites, published statistics and surveys, and conference proceedings. The team began with a broad overview of information related to theft and tracking technology then narrowed the research down to the most useful solutions.

Field observations were a significant portion of the data collection process. These observations consisted of the project team walking around the area of Nørreport Station to evaluate the bicycles that were parked there. The team checked approximately 1,000 bicycles for the presence of locking mechanisms. This station was chosen because the volume of bicycles parked there makes it a high risk location for bicycle theft. The team examined the number of parked bicycles that were locked and unlocked. Details of the field observation work can be found in the Discussion chapter.

The numerous interviews that took place had specific objectives and were conducted using a range of interviewing techniques. The style of interview that was used most often was the unstandardized interview. This method involved preparing a list of questions in advance, although these questions usually changed during the course of the interview. This style was meant to be flexible and designed to work with the responses of the interviewee. Unstandardized interviews

tend to be most effective on a face-to-face basis, so they were performed in this manner whenever possible. However, some interviews had to take place over the phone due to location and time constraints. Bicycle shop owners, law enforcement officials, insurance affiliates, various technology researchers and providers, and Danish political figures were among those contacted in this manner.

Ample data was gathered in a short period of time using an online questionnaire, which was geared toward Danish cyclists, mainly members of the DCF. This method of collection is considered to be a standardized interview because the survey was given to a specific targeted population and followed a set of structured guidelines. The survey consisted of formally phrased questions prepared in advance and presented in exactly the same way to each person. The advantage of doing a questionnaire was that the team easily surveyed a large population, resulting in primarily quantitative data. Some qualitative-response questions were asked and were answered in both Danish and English. The team required the assistance of the team's liaison, Allan Carstensen, and other workers at the DCF to help translate the Danish responses.

Two focus groups were conducted as another method of data collection for this project. Focus groups are normally conducted with five to ten people, in which the interviewer acts mainly as a moderator or facilitator. The interviewer poses questions, but the main goal is for the group to interact, work off of each other, and come up with new ideas and information. One focus group was conducted in Denmark with members of the DCF, and a second was conducted in the U.S. with members of the WPI Cycling Club.

4. Results

The extensive literature research confirmed that bicycle theft is a frequent problem for the Danes and has non-trivial consequences. Other literature was used to evaluate the three new technologies the team studied. Among those studied, RF and GPS tracking had significant characteristics which made them undesirable for use with bicycles. While they work differently, they are both used to locate a missing object. For this reason, they elicit fears of surveillance, and they require power sources, antennas, and expensive hardware. Another technology studied, RFID tagging, seemed to hold promise as a relatively cheap and simple way to identify objects.

Once in Copenhagen, the team members observed bicycle locking practice in busy areas. Only three percent of the approximately 1,000 bicycles counted were unlocked. These observations, along with the interviews with the owners of Copenhagen's Byman, Loke, and Søgade cycle shops, verified Danish cyclists' concern of theft. The cycle shop owners were open to the team's RFID tagging plan and predicted that their customers would be open to it as well. An interview with the Danish crime prevention council was not as helpful as the team expected. Interviews with insurance affiliates provided specific information about the economic impact of bicycle theft. Speaking with researchers clarified the current state of the technologies studied during the literature research and confirmed the team's decision to recommend RFID technology. A number of private companies in the RFID industry were contacted to determine whether their product lines would suit the needs of the DCF and Danish cyclists. Lastly, two members of the Socialist People's party were interviewed. One, a member of the Copenhagen Council, did not believe the system would be worthwhile, nor did he believe it would receive government support. The second, however, a member of the Danish Parliament, was highly interested in the idea and predicted that it had a good chance of being passed through parliament as early as the beginning of 2006.

The questionnaire administered to DCF members illuminated the opinions of a large group (205 cyclists) very involved in bicycling. The group gave details of the methods they use to prevent theft of their cycles and offered feedback on the proposed tagging system. More than half of the respondents believed that an RFID system would be an effective solution to theft. Those who felt differently provided constructive criticism that the team then used to refine its recommendations.

A focus group with DCF members was held in order to clarify the results of the survey. Several of those who attended the focus group echoed the negative comments received from the survey—the main fear was of a potential surveillance system infringing on one's privacy—but their concerns were quickly resolved once the team explained the system in more detail. This suggested that the survey would have received a much larger positive response had the system's description been worded differently. Those who attended the focus group also offered their suggestions for administration of the system, particularly which groups of people should be scanning bicycles.

The team's data collection resulted in a coherent strategy for outfitting bicycles in Denmark with RFID tags and a plan for identifying the appropriate group to perform the task of scanning. Based on the information derived from the literature research and the results of the interviews, questionnaires, and focus groups, the team decided to recommend adoption of the RFID system.

5. Discussion

The results from the team's research, when placed in the context of alternative solutions and the opinions of those in the cycling community, point to an RFID-based tagging system as an effective method to alleviate cycle theft in Denmark. Contacts with technology providers, Dutch people working on Amsterdam's similar system, and those who would have a part in implementing such a system in Denmark all helped to outline a plan for action.

5.1 Potential Solutions to Bicycle Theft

There are numerous possible preventive measures for thwarting bicycle theft, many of which are described in detail. The advantages and disadvantages of each are highlighted throughout this chapter.

5.1.1 Bicycle Locks

The first step one should take in preventing theft is to equip the bike with a standard bicycle lock. There are many different models one can choose, each with its own advantages. One example is a frame lock that is most commonly found in places like Amsterdam and Copenhagen (Figure 4). This lock is attached permanently to the frame, and the steel bar goes through the spokes in order to immobilize the bike. The bike can still be lifted and carried away, but it cannot be ridden while the lock is engaged. Therefore, this type of lock is helpful in combating convenience thefts. However, if one is worried about

Figure 4 - Frame Lock

professional theft, this lock should only be used as a secondary measure. The bike should also be locked to something permanent so that it cannot be moved from the spot without a key. The
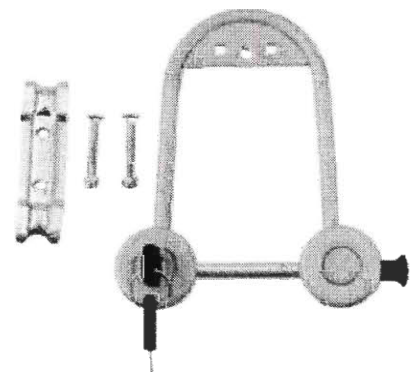
following are examples of locks that are designed for this exact application. These are much rarer in the Copenhagen area than the lock from Figure 4, but they can be observed from time to time.

Cable and chain locks are two of the popular alternatives. Figures 5 and 6 display two such locks: one made by the company Kryptonite, and one by Topeak, respectively. The locks consist of a cable or chain that is wrapped around the bike and the object to which the bicycle is locked. The padlock may be opened by a key

Figure 5 - Cable Lock

or by combination. These are very versatile locking solutions as they are often up to six feet long and can be locked to almost anything. The problem with this type of lock, however, is that professional thieves are known to cut the cables and break the padlocks rather quickly.

The next potential solution is the "U-lock" (Figure 7), which consists of a crossbar and a U-shaped piece of steel. The U-lock is more resistant to theft than cable locks. Unlike cable locks, it cannot be cut or sawed (Langley 178). There are methods of
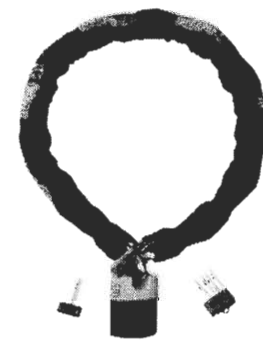
Figure 6 - Cable Lock

Figure 7 - U-lock

defeating these locks, such as freezing (with freon), breaking, prying, drilling through the lock itself, or picking the lock. However, some manufacturers claim to have locks that are impervious even to these methods. Most manufacturers offer a guarantee to reimburse the victim if his or her bike is stolen due to the failure of the lock (Langley 178).

The drawback to using U-locks is that they are not as versatile as cable locks. Due to their shape, size, and inability to flex, U-locks are limited to what they can be locked to. U-locks are also larger, heavier, and more expensive than cable locks.

5.1.1.1 Locking Strategies

Locking a bicycle is not as straightforward as one may think. First, the location of the bicycle should be considered. The best locking strategy is to lock the bike to a permanent fixture in an open and well-lit area or inside a secure room. Next, this permanent fixture must be one that a thief cannot easily lift the bike over—a parking meter, for example, may be short enough to do just that. In this situation, a thief may steal the bike, along with the locking mechanism, and attempt to remove the lock at a later time. It is recommended that bicycle owners use a U-lock to secure the frame to a fixture such as a bike rack or street sign, and also use a cable lock wound through the wheels or a frame lock to make theft more difficult. Other strategies exist, such as turning the locking mechanism of a U-lock toward the ground to make it harder to pick, leaving less space in the U-shaped part to make it harder to pry, and even keeping the lock off the ground so as not to give the thief much leverage when trying to smash or pry the lock (eHow). Lastly, it is recommended that cyclists remove any "quick-release" components or other easily removed parts of the bicycle and either lock these to the bicycle and rack or take them along.

5.1.1.2 Bicycle locks in Denmark (field observations)

The basic bicycle lock is a necessary part of any discussion of bicycle security. A community where few bicycle are locked may be better helped by a campaign to encourage cyclists to lock their cycles than by the most advanced tracking system. To best determine the needs of Copenhagen cyclists, the team conducted field observations with the goal of learning the popularity of locking mechanisms. Casual observations were conducted numerous times in varying areas of Copenhagen, including Parliament, along the canal that runs through the city, and the Østerport and

København Hovedbanegården train stations. The results of these initial forays were that most parked bicycles in Copenhagen are, indeed, locked. A more formal investigation was conducted in Nørreport Station, a bustling train, bus, and metro station in downtown Copenhagen. Numbers of locked and unlocked bicycles were counted in the aboveground section of the station and on nearby streets. The earlier observations remained true: of the 1133 bicycles counted, only 33 were unlocked, which is about three percent. Most bicycles were protected with standard frame locks. Those cycles that did not use the built-in locks generally used a cable, chain, or U-lock to secure one of the wheels to the frame, again rendering the bicycle useless for riding. The bicycle racks at the station were overflowing with cycles, but very few cycles were locked to the racks. The method of immobilizing the cycle is the most practical form of locking in an urban area with a very high volume of cycles – there are simply not enough trees, poles, or other objects to lock the cycles to. The high rate of bicycle locking observed demonstrates that Danish cyclists are concerned about theft and doing what they can to prevent it; a tracking system may indeed be an appropriate next step in theft prevention.

5.1.2 Alarm Systems

An alternative to the standard bicycle lock is the bicycle alarm. Most bike alarms work on the same principle as mechanical bike locks, but they offer added protection. Some alarm systems are incorporated into bike cables. A casual thief would not have a way to cut through a cable and would move on when he saw the cable. However, when a more sophisticated thief, one equipped with bolt cutters, severs the cable, sirens will be set off (LockAlarm). Other devices contain motion detectors invisible to a casual observer that set off a siren when the bike is moved without the alarm being deactivated (Cy-Curity). Some cable alarms incorporate both a motion detector and the ability to detect when the cable has been cut (SecurityWorld). The methods of setting alarms

include keys, combination locks, and remote controlled devices similar to those used to remotely lock and unlock cars.

Individually, cyclists determine whether or not a cycle alarm is a valuable investment. Expense is always a concern for consumers, and USD 50 for a bike alarm is more than many wish to spend. The inconvenience of locking and unlocking one's bicycle at the beginning and end of every trip is a strong disincentive for many cyclists. The weight of the cable and necessity of remembering to carry it also prevent these alarms from being more popular. In regards to the devices that rely on motion sensors, the possibility of false alarms is significant, particularly when locking a cycle in a highly populated area where it is likely that a passerby will innocently jostle the bike.

5.1.3 Scandinavian Bicycle Registry SREG

A bicycle registry can be an easy and efficient way of locating a bike in the event that it is stolen. Registries exist all over the world and can be effective on both the small and large scale. A bicycle registry called SREG has been operating in Denmark for about ten years. The company originated in Sweden and branched out into both Denmark and Finland. For a yearly investment of DKK 164 (USD 30), the bicycle owner's name and contact information, as well as the bicycle's make, model, and unique frame number, is recorded. A decal, similar to the ones described in the following section, is then applied to the bike. The tag is marked with a phone number to call if the bicycle is found and a barcode that can be scanned by police. This barcode method differs from the RFID method in that the barcode is more susceptible to damage and generally has a shorter read range than an RFID tag.

In the event that the bike is stolen, the owner only needs to report it to SREG, not the police and insurance company, which one would normally have to do. SREG also helps the customer financially. For insurance purposes, the value of a bicycle depreciates by 10 percent each year, so

cyclists quickly lose their investments. Also, most insurance companies require the owner to pay a deductible on the claim. SREG will give the owner up to DKK 1000 (USD 175) to make up for this depreciation and deductible. These benefits exist to lessen the hassle one may go through after a bike theft.

Through conversations with an employee at SREG and several bicycle shop owners in Denmark, it became apparent that SREG functions primarily as an extra insurance policy toward bicycle theft. The police have very few scanners to read the barcodes and rarely use the ones they have. Since the barcode tags cannot be easily removed, it is extremely difficult to distinguish between a bike that is currently registered with SREG and one that has been registered in the past. For these reasons, this matter has a very low priority with police.

5.1.4 Decals and Identification Tags

Most bicycle registries such as SREG, the US-based National Bike Registry (NBR), and Datatag in England sell decals and identification tags as part of their theft prevention packages. This type of labeling can come in many different sizes and styles depending on the company. The NBR markets labels inscribed with their insignia. Datatag elaborates on that system by offering their customers marking stencils to engrave on the bike frame. All styles are usually difficult to remove and are moderately priced. The main purpose of decals and ID tags is to alert thieves that the bike is registered so they will look for a different target.

5.1.5 Radio Frequency (RF) Tracking

One advantage of radio frequency tracking is the fact that a person need not have the lost or stolen item in possession to identify it. The system is widely applied to vehicles and can be initiated by a law enforcement official from great distances. This is done by a device called a radio transceiver, which is placed inside the automobile and hidden from plain view. A transceiver is a

device that both transmits and receives radio signals. Another major component to the system is a radio signal receiver. This device is monitored by police officers once tracking begins.

In the event one's automobile is stolen, the owner simply contacts the police, who initiate the tracking system. The transceiver then sends out a signal, and the vehicle can be located within a range of a few hundred feet to several miles. In order to pinpoint the exact location of the automobile, a police cruiser equipped with a receiver must respond to the general area where the car has been located. Once the officer is within a two to three mile radius, the stolen vehicle's whereabouts can be determined more precisely, even if it is stored in a building or shipping container (Pegasus).

Pegasus Technologies, patent holder of VectorTrac, also sells a tracking system for bicycles. This system is not intended for use by cyclists. Instead, it is an entrapment device intended to ease the problem of theft by capturing thieves. Currently, the company markets this product only to law enforcement agencies. The invention is called the ProAct-IV Stolen Bicycle Tracking System or "Bait Bike" Program and costs approximately USD 6000, which does not include the cost of the bike it is applied to (Cecchettini). The theory of the ProAct-IV is to place a valuable bike in a high theft location and allow it to be stolen. The bike then emits a radio signal that can be tracked by police, similar to that of the vehicle tracking systems.

The "Bait Bike" consists of three main components:

1. A bicycle seat equipped with a motion-activated transmitter

2. An alert monitor

3. A mobile or hand-held tracking receiver

The first step to using the "Bait Bike" is to apply the seat to any bicycle of choice. The bike is then placed in an area of high theft. When the bicycle is moved in any way, the device will activate and start transmitting a signal. The signal is then picked up by an alert monitor placed within reception

range of the bicycle. From there the bike's location can be sent to a cell phone or pager or to a receiver in a police cruiser. Pegasus Technologies also distributes a type of invisible spray that can be applied to the bicycle's hand grips. If one wishes to match the thief to the stolen bike, an ultraviolet light can be used to check for the presence of the "clue" spray on the suspect's hands (Pegasus).

The "Bait Bike" has its advantages and disadvantages. The radio frequency that ProAct-IV uses can be picked up by the police with the same equipment used for tracking automobiles, as in the LoJack and VectorTrac systems, so no further investment would be needed. In contrast, Pegasus Technologies does not market this device to the public for several reasons. The cost, USD 6000, is much higher than the cost of most bicycles. This fact alone would make it highly unpopular to consumers. The second disadvantage and possibly the most significant, is that the tracking system cannot be turned on remotely because there is no receiver on the bicycle. In order to have functional receiver, a power source is needed. Unlike automobiles, there are no large batteries on bicycles, and a small battery would require constant replacement. The president of Pegasus Technologies, Jason Cecchettini, addressed the idea of using the motion activated transmitter that is currently used in the "Bait Bike" on public bikes. He stated, "It could work; however, constant false alarms would not only drain the batteries without the bicycle owner's knowledge, but the tracking frequency would constantly be congested with false activations" (Cecchettini). A cost-effective internal power source would need to be developed for this type of system to be considered a viable solution to bicycle theft. The bait bike program, while it may have merits, would be an insufficient answer to bicycle theft in Denmark.

Another form of RF technology that may someday be altered to provide an answer is the WatchMate security system. WatchMate follows the same basis as the above examples, but the tracking system is downsized so it can be worn by a person or applied to a small object. This

technology is used widely in prisons, psychiatric hospitals, and large businesses; it costs between USD 30 and 150 (Loubert 208). The WatchMate contains a small battery that powers a radio frequency transmitter. The transmitter is only activated when the person or object bearing the device steps through, or near, a predetermined location, usually a doorway. WatchMate batteries are designed to last up to two years because power is used only when the transmitter is initiated (Loubert 210). This technology is especially valuable in monitoring inmates or wandering hospital patients. It can also be attached to pieces of expensive equipment to protect against theft.

The disadvantage of the WatchMate style system is that the transmitter is only powerful enough to put out a signal that can be read up to several hundred yards. A larger receiving area would require a much larger battery. This would drastically increase the cost and size of the system, making the current design inappropriate for an urban cycling population.

Applying a tracking system based on RF transmitters to bicycle theft would have several issues to overcome. An antenna is necessary for the system to work, and the system needs some kind of power source. Cars can use the radio antenna for this type of system, but on a bicycle, any kind of antenna would be conspicuous. A thief who breaks a bike's antenna has ruined any possibility of tracking the bike. However, the metal frame of the bicycle, itself, might serve as an antenna, if the resonance frequency of the bike frame were determined. Cars also have a power source readily available – their batteries. A bicycle system would need to incorporate a power source of some kind. The last issue is that the receiving system used by police cars with LoJack is meant for cars, and creating a handheld receiver would be more complicated and expensive (Michalson). If bicycles are taken to places not readily accessible by car, this may be an obstacle.

Many people who responded to the team's survey were concerned with privacy issues. The RFID system would not be able to track a person's whereabouts on demand. The bike would have to be scanned by a police officer and then matched to the owner using the online database. RF

tracking is different in this case because one can establish the bike's location at will. For this reason, the team believes that RF tracking would not receive much support among the Danish cyclists, and, therefore, is not the best solution to bicycle theft at the current time.

5.1.6 Global Positioning System Tracking

As described in the Background chapter, GPS technology uses numerous satellites to pinpoint the location of a desired object. The location is determined by using the signal travel time to calculate the distance between the receiver and a minimum of four satellites (Brain). If there is a known location and a distance, a sphere of possible sites where the object might be can be determined. Each satellite provides a sphere which intersects with neighboring spheres. Possible locations are narrowed down as more intersections are formed. In theory, four satellites would be necessary to identify the receiver's exact location. However, since the receiver must be somewhere on the earth's surface, the planet itself serves as the fourth sphere, so only three orbiting satellites are necessary (Brain).

Several technical issues interfere with the ideal functioning of GPS receivers. Due to the planet having a variety of altitudes rather than being a perfect sphere, three satellites may be insufficient to identify the exact location of a receiver. Fortunately, there are enough satellites orbiting the earth that an object's location can still be obtained. A receiver can simply link up with a fourth satellite in order to collect all the necessary data. Also, the receivers calculate distance assuming that the radio waves travel at the speed of light, but interference in the earth's atmosphere may slow down the waves. This difficulty cannot be easily remedied (Brain). Another complication of GPS technology is that the radio waves sent by satellites may bounce off buildings and generate inaccurate data. This is of particular concern for receivers located indoors or in urban areas (Pegasus).

Several characteristics of GPS technology would be of particular concern when applied to bicycles. As with RF tracking devices, GPS receivers need an antenna to be effective (Pegasus). While an extra antenna may not be noticeable on a car, it would be obvious on a bicycle and might be intentionally damaged by thieves. In order to deter thieves from removing or breaking the receiver, it would need to be either concealed or very durable. However, even a palm-sized device would be difficult to hide on a bicycle, and mounting or encasing a receiver to be resistant to brute force is non-trivial.

Despite these potential problems, in 2003, Japan's National Bicycle Industrial Company became the first corporation to incorporate a GPS-based tracking system into its electric bicycles for the purpose of locating stolen bikes. Each bike uses a GPS receiver to send data about its location to a website run by SECOM, Co., Ltd., a Japanese security company (Panasonic). When a bike is reported stolen, SECOM can quickly locate and then recover it. The electric bike costs between USD 550 and 1100, not including a USD 7.65 per month tracking fee. Unfortunately, the system is not currently sold independently of the electric bicycle. There is promise behind GPS technology, but the team believes, similarly with RF tracking, that privacy concerns, technical problems, and expense overshadow its usefulness as a potential solution at this time.

5.1.7 Danish Frame Number System

The Danes are currently using a unique system for identifying the rightful owner of bicycles. Every bike is required by law to have a special number engraved in the frame, usually under the bottom bracket. This location is where one would normally find a serial number on a bike in the US. The law came into effect during the 1930s in order to help decrease the high rate of bicycle theft.

The number is comprised of three coded character sets. The first letter indicates whether the bike was imported or manufactured in Denmark, while the next two signify the make of the frame.

If this first set begins with a "W", then the bike was an import. Immediately following this is a series of up to five numbers that correspond to its production number in a given year. The final set of characters is a single letter that corresponds to that year. As an example, the frame number WAR567U would indicate that the bike was imported by the manufacturer represented by "AR", that the cycle's production number was 567, and that the cycle was produced in 2001. The number must be engraved at least 4 mm high and in one of several specific places on the frame.

Under this law, it is required that both the producer and bicycle shop record all the necessary information about the bike when it is sold. The producer must note what shop the bike goes to and the shop owner must keep on file for up to five years the name of the purchaser and any necessary contact information. If one's bike is stolen, the owner must go to the shop the bike was purchased from and obtain a copy of the receipt containing the price, frame number, and proof of ownership. All this information must then be submitted to the police, who store it on a computer database and notify the owner if the bicycle is recovered. According to cyclists who took the online survey, the frame number system works but it would be more useful if there was a more efficient way to check the numbers.

5.1.8 Radio Frequency Identification

In terms of application for bicycles, an RFID tagging system would be based on the same principles as Denmark's existing frame number identification system. The RFID chips would simply be used to update the current system. An RFID tag would make the identification of a bicycle so easy that it would be feasible for police to randomly scan bikes at any location, whereas frame numbers are rarely checked on the street. The RFID tag would be advantageous over a barcode system because it would allow for easier scanning and because barcodes are susceptible to marring, an especial disadvantage on bicycles, which are outdoors in all weather.

The success of an RFID-based tracking program in curbing bicycle theft will be shaped in part by the abilities of the tags, readers, and software used. The efforts that some companies are making to use RFID tags as replacements for barcodes in all of their products have resulted in today's typical passive (requiring no power source) tag being common, inexpensive, and more than sufficient for the purposes of the DCF. The tags are small enough and light enough to be affixed to a bicycle without hindering the cyclist in any way.

RFID tags have more than enough memory to contain a unique identification number; a single tag can hold at least two kilobytes of information (Padula 1). All that is needed for a bicycle tag is a few bytes to represent either the frame number or a different unique code. Hundreds or thousands of such codes could be stored on a single chip. The cost of a single tag is approximately ten to fifty cents, a very small amount compared to the cost of a bicycle (Padula 3). The chips have enough memory to uniquely identify individual items in a large retailer at an even finer level of detail than UPCs allow, which is ideal for bicycle application.

Many RFID transponders are designed to be small enough to be placed anywhere on a bicycle. They can be hidden from plain view on any of the main bike components. They may be covered by fabric, but they cannot be read from inside iron or steel at this time. According to Anouk Hespe at the Dienst Infrastructuur Verkeer en Vervoer (DIVV) of Amsterdam, manufacturers in Holland are working on this problem and should have a solution in a short time. One lock manufacturer, AXA Basta, has designed a special external device for enclosing the RFID chip. The container is designed to attach to the frame-tube under the seat. AXA designed special bolts for the device so it cannot be easily removed by a thief (Hespe). The actual chip used in this device is produced by a company called RFID-net, which is also based in Holland.

Any application of technology to a social concern is clearly limited by the state of the available technology. While RFID technology has existed for decades, only in the past five or ten

years has it begun to receive significant attention for the ways that it can be applied to the problems of private businesses and to social problems like theft. While RFID research has resulted in tags that are cheap and versatile, RFID readers are not adapted quite so well to bicycle tracking. Ideally, a bicycle tracking RFID system would use portable scanners with long read ranges so that police officers could scan tags from a distance. This would be of particular importance if the tags were hidden on the bicycle or in different locations on each cycle. However, a longer read range requires a higher frequency reader. Higher frequency readers tend to be more expensive, and they do not read as easily through other materials, particularly metal. This results in very high frequency readers having long read ranges but needing almost the same kind of line of sight required by a barcode scanner (Padula 2). A police officer with a high frequency reader would then still need to find the tag on the bicycle in order to accurately read it, even though the tag would be readable from a greater distance. If tags are located in a standardized place on each bicycle, reading range and line of sight will not be a problem. However, this is a limitation of the technology to keep in mind when looking for just the right solution.

The last aspect of the technology that would limit the abilities of a tracking program is the aspect that is not actually RFID-specific. The plan for any tracking system must take into careful account the capabilities of the technology the system is based on. This includes the software and database used to identify bicycle owners from ID numbers as well as any communication network used to transmit information. In this case, the existing software and networking should be adaptable. The databases that currently exist for the frame number system may require, at most, minimal changes. RFID tagging may well be a viable system to reduce the impact of bike theft.

5.2 Opinions of the Bicycle Industry

Extensive research and various research methods were crucial to the completion of this project. Evaluation of existing data, field study, and the opinions of the various groups concerned all played an important role. This information was analyzed as a whole and recommendations made based on the team's findings. Interviews, focus groups, questionnaires, and field observations were used to gather the following information.

5.2.1 Consumers

The opinions of cyclists were vital to the entire project. It is, after all, their experiences with theft that are the motivation for the project. Understanding what the cyclists viewed as the strengths and weaknesses of a tracking system was invaluable. As a preliminary investigation, the team conducted a focus group with several members of WPI's Cycling Club. An online questionnaire and focus group were conducted in Denmark to learn the cyclists' thought and concerns.

5.2.1.1 WPI Cycling Club

Conducting a focus group with WPI's cycling club was both process-oriented and research-oriented. It provided valuable knowledge on how to facilitate a focus group. The questions posed to the members were centered on their interests as cyclists and their perception of theft. The team explained the project's general aim and details about the available technologies and then asked the attendees for feedback (Appendix D).

5.2.1.2 DCF Member Questionnaire

Surveying the members of the DCF was the most efficient way to gain information from a large number of Danish cyclists. The survey, which was prepared as a standardized series of questions, provided both quantitative and qualitative data. The team decided to use an online questionnaire rather than a mailed survey. An online questionnaire was quick for respondents to fill

out, which most likely increased the response rates; the survey received 205 responses during the week it was available online. The team wrote computer scripts to process the code, so survey responses were returned and tabulated automatically. Several hundred DCF volunteers were e-mailed and requested to fill out the survey, and a link to it was placed on the front page of the DCF's website. The survey questioned respondents regarding their bicycling habits, their experience (if any) with theft, and their efforts to protect their cycles. It outlined the workings of an RFID-based tracking system and asked their opinions of the system (Appendices B1 and B2).

The survey respondents were avid cyclists. The majority cycle every day, and most use their bicycles primarily for transportation. Slightly over half had experienced at least one theft. The survey respondents were a large sample of the population whose opinions were most desirable for the project – those who cycle frequently, all over the city and country, parking their bicycles in public places vulnerable to theft. Eighty-eight percent of the cyclists had invested at least USD 500 into their primary bicycles and related equipment, while 40 percent of total respondents had invested over USD 1000. The survey verified that Danes devote a significant amount of money, time, and energy into their cycles and cycling.

5.2.1.3 Danish Cyclists' Experience with Theft

Two critical points regarding bicycle theft were reaffirmed by survey responses. The first is that cycle theft creates a sizable problem for the owner. Fifty-six percent of the survey respondents personally experienced bicycle theft. This is much higher than the percentage of Danish citizens who have had a cycle stolen (eight percent). It can be assumed that cyclists who had been victims of theft would be more likely to take an interest in the problem of theft and therefore more likely to fill out the survey. For this reason, the high number of theft victims is not meant to be indicative of the prevalence of theft among all cyclists. However, it does mean that the team had 115 people detailing their firsthand experience with bicycle theft. From their responses, one can infer that

bicycle theft results in a serious problem for the victim. Half of the bicycles stolen were worth over USD 500; one in eight was worth over USD 1000. Eighty-five percent of those who had been robbed of a bicycle eventually purchased a replacement, and over half of those actually spent more on the new cycle than they had on the previous one. When this financial impact is coupled with the frequency of bicycle use in Denmark, one can imagine the significant consequences that bicycle theft holds for its victims.

The second major point gleaned from the survey is that bicycle owners are already making efforts to prevent theft. This corresponds with the very high rate of cycle locking documented during the team's field observations. A full 88 percent of those who filled out the survey stated that they always lock their bicycles, while most of the rest said that they usually do. In fact, eighty-nine percent of those with a stolen cycle indicated that the cycle had been locked at the time of the theft. This suggests that locking, while certainly a necessary habit for any cyclist concerned about theft, is insufficient to protect bicycles. Numerous cyclists take precautions beyond the frame lock, as well. Some wrote of using stronger locks to secure their cycles to immovable objects and of keeping the cycles in a building or locked shelter when possible. Others were wary of where they park their bicycles, unwilling to leave a cycle for long at train stations or on the street. A number of people mentioned small measures meant to deter theft, such as keeping the bike looking old and dirty or only parking it in the midst of many of other bicycles. These extra precautions show that Danish cyclists are worried about bike theft. They are fully aware that locking one's bicycle is not always sufficient protection. Considering the amount of money invested into the average bicycle and the fact that thefts continue even among cyclists who are very conscientious about locking their cycles and who have a high awareness of theft, a tracking system is an appropriate next step for combating bicycle theft.

5.2.1.4 Danish Cyclists' Attitudes towards Tracking System

Fifty five percent of survey respondents believed that the proposed RFID tracking system would be an effective solution to bicycle theft; another 25 percent were undecided. However, the focus group later conducted with survey participants indicated that, had the survey provided more specific details about the system, their would likely have been fewer concerns about privacy and the robustness of the RFID tags (Section 5.2.1.5). Seven out of eight said that they would be willing to pay for RFID tags on their bicycles. In fact, half were willing to spend between USD 20 and 40, and another 15 percent would spend more than that amount. With the average cost per person in Amsterdam's system being about ten euros (USD 13), along with the possibility that a tracking system might be government-funded and, thus, have no cost to individual cyclists, added expense for cyclists will be minimal or possibly nothing.

When asked for their general comments on the project, cyclists had a great deal to contribute. A handful of people stressed the need for the chip to be encased in a durable, weatherproof, and tamper-resistant housing. A few pointed to insurance companies as possible sources for funding, either by directly funding the system or by giving discounts to individual cycle owners who choose to participate in it.

While the responses expressing pleasure that someone was studying bicycle theft reaffirmed that theft is an issue that needs to be addressed, the critical responses provided valuable information as well. Several respondents expressed concerns for their privacy, though these comments were generally directed at the idea of surveillance rather than specific concerns about the tagging system. Not surprisingly, a portion of the cyclists said that they would prefer a system that prevents bike theft in the first place. The tagging system's main application is the recovery of stolen bicycles, although it should also function as a deterrent to thieves, since it should make stealing bikes for long-term use much more difficult. Other respondents believed that the electronic system would be no better than the current frame number system. While they are correct that the frame number

system already assigns a unique identification number to each bicycle, police rarely check the frame numbers on bicycles to determine if they have been stolen. The advantage of the tagging system would be that bicycles could be instantly checked. Police would have the ability to randomly check bikes where it has not previously been practical.

Concern that police would be unwilling to scan bicycles was mentioned more often than any other objection to the system. Those who doubted the efforts of the police did not necessarily doubt the effectiveness of the system; as one respondent said, "Uanset systemets teoretiske effektivitet er det usikkert om pollitiet gider ofre ressourcer på at bruge det" ("No matter the theoretical efficiency of the system, 1 don't think the police allocate the resources needed to run it.") Respondents did not believe that bicycle theft is a priority of the Danish police force. Some were skeptical of the electronic system because the police do not currently look for stolen bikes – "The police do not do much to pick up stolen bikes at all," wrote one person.

One can understand why a police officer would be unwilling to manually check frame numbers of random bicycles. The officer would need to have the bicycle in hand, maneuver it so that the frame number is visible, mark down the number, and then check to see if that number had been reported stolen, perhaps by contacting the station. This process would be very troublesome, not something that an officer would have the time to do repeatedly throughout the course of a day. In contrast, scanning an RFID-tagged bike and determining whether it is stolen would take seconds, and one would be able to scan multiple bicycles at the same time. The electronic system would greatly smooth and speed up the process of locating stolen bicycles.

The success of the tracking system depends heavily on bicycles being scanned regularly, but it may be discovered that the Danish police do not currently have the time or money to devote to the work of scanning. If this is indeed the case, another group will have to be appointed to perform the

task. Funding for the system may need to include funding for police departments to allocate to scanning bicycles.

Alternatively, the police force may not be the best choice for scanning bicycles. Rather than coming from the federal or city government, money for the system could come from insurance companies, who would then be motivated to employ people to look for stolen bicycles. According to Torben Makholm of SREG, this is already done with stolen cars. Insurance companies would be unlikely to fund a pilot program, however, so this would be a shift of responsibility several years after the system's founding.

Another possibility would be for the tracking system to be government-funded but for the actual scanning to be done through contract with a private company. There is a precedent for this model as well; some municipalities in Denmark employ private companies to write parking tickets rather than giving the job to police. The concerns about police that showed up in the survey results were valid and showed the team an area that was more complicated than initially expected. Most of those surveyed believed that the proposed system would be effective, and an even more decisive majority would be willing to put their own money into such a system, based only on a few sentences of description. If their questions and concerns were answered, doubtless even more would support the integration of electronic tagging into the world of cyclists.

5.2.1.5 Refining the Questionnaire: Focus Group

The team held a focus group with members of different branches of the DCF in order to clarify the results of the questionnaire and to fill in any gaps in the plan for a tagging system. The members of the focus group initially had some reservations about the system but were much more positive after their questions were answered and details of the system were explained. One group member arrived at the focus group with privacy concerns. These issues disappeared when the team explained that the RFID system worked by tagging bicycles, not by tracking their geographic

locations, which had not been clear in the survey. Another group member wanted an explanation of the mechanism securing the RFID chip to the bicycle before he would support the idea. Once the encasements being used in Amsterdam were described, he found the system worthwhile. These reactions indicate that some of the negative responses received in the survey may be the result of an insufficient description of the RFID system within the survey. An explanation phrased slightly differently, with more details regarding the chip cost and privacy issues, might well elicit an even more positive reaction. Simply explaining the system as one for "tagging" rather than for "tracking", as it had been called in the survey, clarified the system's purpose for the focus group. Those in attendance believed that the system should be required, ideally by law, for simplicity's sake and because they were skeptical that participation in a voluntary system would be high enough for that system to be effective.

The focus group discussed at great length the question of who should scan bicycles. Some thought that scanners should be given to as many groups as possible in order to maximize the number of cycles scanned, while others believed that very few people should possess the scanners to reduce the possibility of criminals acquiring them. The idea of thieves with scanners was later determined to be a minor problem because the security of the system lies primarily in access to the database, not possession of the scanner. A stolen scanner could simply be blocked from the database. The group did not believe that parking attendants would be good candidates to scan cycles, since that group is already overworked and has a difficult job. The attendees suggested municipality workers, who already spend time collecting abandoned bicycles. They suggested employees at train stations, who also devote energy to taking care of abandoned bicycles and who could scan the bicycles and notify the owners as easily as they now have the cycles taken away to be scrapped. All of the members of the focus group agreed that the police should have scanners, but they believed that police alone would not scan enough bicycles for the system to be worthwhile.

Their feedback on this issue was particularly helpful, as was their interpretation of the RFID system. The description in the survey had been somewhat flawed, which was important to keep in mind when drawing inferences from the survey's results.

5.2.2 Bicycle Shops

Non-standardized interviews with bicycle shop owners took place in the U.S. and in Denmark. The objective of the bicycle shop interview in the U.S. was to gauge the overall knowledge of bicycle registries and existing security devices. The National Bike Registry distributes packages to bike shops who, in turn, sell them to their customers. It was advantageous to know the popularity of such products in today's market to project their usefulness toward Danish cyclists. The questions and notes from the interview with the owner of Easthampton Bike (Massachusetts) can be found in Appendix E4.

A similar approach was taken to query the stake that Danish bicycle shops have in the issue. The objective of these interviews was to get input on the Danish frame number system, judge the popularity of SREG, and to determine the interest shop owners might have selling an RFID device. The questions were mostly open-ended to allow for any input that was initially overlooked. Interviews were conducted at three shops in Copenhagen: Byman Cykler, Loke Cykler, and Søgade Cykler (Appendices E1, E2, and E3, respectively). The same questions were asked of each shop owner, and the answers they gave often reflected the results of the survey as well as the other shop owners' opinions.

5.2.2.1 Shops and Bicycle Theft

Through the bicycle shop interviews, the team learned how shop workers fit into bicycle theft. Shops collect personal data such as name, address, and phone number from each customer who buys a bicycle. By law this information must be kept for at least five years. The purpose of this is to act as a proof of purchase in the event that the bicycle is stolen and there is no paper

receipt to be found. The owner of Søgade Cykler, Henrik, explained that this is as involved in bicycle theft cases as shops get. Someone who has his or her bicycle stolen would not contact the shop where the bicycle was bought. Police who recovered a stolen bicycle would not go to the shop to seek out its owner, either. The information connecting individuals to the frame numbers of their bicycles is held by the police themselves.

Although they are not involved in the events following the theft of a bicycle, shop owners do, of course, speak with their customers about all kinds of bicycle-related matters, including theft. One owner stated that his customers were somewhat concerned about theft, but thought that because most bikes are insured, the theft of a bicycle was an inconvenience but not a financial difficulty. Unfortunately, the value of a bicycle depreciates each year by 10 percent, and insurance companies may also charge a deductible amount before compensating the rest of the bicycle's value. The other two owners both stated that they believe their customers are very concerned about cycle theft. It is known that theft is a common problem and that all kinds of bicycles are vulnerable.

5.2.2.2 Shops and a Tracking System

The proposed electronic tagging system was explained to each shop owner at the beginning of each interview. All three owners reacted positively, saying that the theory of electronically tagging bicycles was sound. All three said that they would be willing to install the system in their shops if necessary and would do so cheaply. Henrik and Dan both stated that the ten euros (USD 12) that the tagging program in Amsterdam costs per person was more than reasonable, while Lars estimated that he would charge less than fifty Danish kroner (ten U.S. dollars) for installation. The owners were all fairly certain that the tagging system would be desirable to their customers, particularly at such a low price.

The shop owners also offered some constructive criticism regarding the project. The owners of Byman and Søgade reminded the team of the need for the chip to last for many years and to be in

some kind of durable, weatherproof container so that it would not be damaged by water, salt, or any other condition of being outdoors. One owner mentioned that some cyclists might object to any extra weight on their cycles, but then decided that the only bicycles light enough for such a minor extra weight to be noticeable would be expensive racing bikes that would too valuable to be left them parked on the street anyway. Two of the owners echoed the concerns from the survey that the system requires the cooperation of the police. They doubted that the police currently have enough manpower to devote any extra time to scanning bicycles. One believed that the matter of scanning would be carried out more efficiently if placed in the hands of a private company rather than in the police force. He recommended giving that responsibility either to insurance companies or to another private business like Europark, which is one of the companies employed by the Danish government to write parking tickets in certain areas. The interviews with the bicycle shops reaffirmed the motivation behind the project and helped to refine the plans for the tracking system.

5.2.3 Private Enterprise

One of the first questions to ask when implementing a tagging system may be where the actual hardware is going to come from. To this end, the team contacted several private companies that are in the RFID industry and inquired into their product lines.

5.2.3.1 Datatag

If the DCF wishes to work with a single company on all aspects of implementing a tracking system, a viable option could be Datatag. Datatag originated in England during the early 1990s. They currently market their products for use in bicycles, motorcycles, trailers, all types of machinery, and countless other items. They have a customer base of over one million in England alone, as well as, thousands more in Sweden, Holland, Italy, Belgium, and Ireland. They have not begun any operations in Denmark but, similarly with any company, would like to expand their customer base (Datatag).

Datatag manufactures the DAT100 and the DAT300, which are tiny transponders not much larger than a grain of rice. These circuits can withstand a strike from electric shock or magnetic waves. Datatag also produces the DAT500, which is slightly larger but has a self-adhesive backing, allowing it to be easily attached to a bicycle frame or other expensive parts. A general bicycle protection package that contains one of these various transponders costs around USD 40 (Datatag).

Datatag is the most popular company of its kind in England and has recently shown significant growth. The company has distributed hundreds of scanners free of charge to police forces in various European countries. A network of over 3,500 scanners is currently in place (Datatag).

Datatag works directly with the police departments, insurance companies, and governments of the countries that agree to their service. In order for a country to utilize Datatag as a resource for theft prevention, a detailed business plan with input from each of these groups must be submitted. This plan must include quotes on the financial commitment the government is willing to make. When Datatag agrees to set up their computer network in a particular country, the databases, scanners, and other necessary equipment are supplied free of charge by the company. The tags however, must be purchased by consumers. The full details of the agreement are unknown at this time due to confidentiality concerns within the company. Datatag will only release specifics when a detailed summary of the plan is submitted by the interested government (Datatag).

When an agreement is made, Datatag volunteers to train the local police forces on the proper method for using all the equipment and the online database. Instructions on proper scanning procedure, which includes inserting a probe into the seat-tube of the frame and scanning the tags from a distance less than fifteen centimeters, are also demonstrated (Datatag).

Having to insert a probe into the bicycle frame would not be practical if an officer wished to easily scan an entire bike rack. Datatag expects that several tags will be placed on the bike, both

inside and outside of the frame, as well as many decals to ward off thieves. If a tag or decal is removed, marks are left on the frame, showing that the bicycle was tampered with and thus making it suspicious. Datatag is also currently working to improve their scanners so they can read an ID number at a greater distance (Datatag). Details on when the improvements will be completed are unavailable at this time.

One of Datatag's strengths is its financial security. Datatag is a subsidiary of the Matsui Company of Japan, a firm that has a yearly turnover of approximately USD 150 million (Datatag). For this reason, one can expect that money invested in Datatag's products is unlikely to disappear due to financial troubles on the company's part. However, there is certainly still the risk, as in any tagging system, that bicycle theft will not actually be relieved by the system.

5.2.3.2 Alien Technology
Alien Technology is a developer of RFID tags that does not specifically target the bicycle industry. However, they were contacted by the project team and were receptive to the idea. Alien Technology currently sells a tag that is about ten centimeters long and less than one centimeter wide. This particular tag could be applied to a bicycle if it were placed inside the tire (Appendix L2). It is thin enough that it would not interfere with or puncture the inner tube. Unfortunately, the tag could not be placed inside of the frame tubing and still be dependably scanned. The read range of Alien Tech's scanners can reach up to two and a half meters in an optimal orientation. Each tag costs less than two Danish kroner but can be cheaper when purchased in large quantities.

5.2.3 Insurance Companies
Another important stake in the situation of bicycle theft is held by the insurance companies that compensate victims. Last year alone, insurance companies in Denmark spent DKK 141 million (USD 25 million) compensating such individuals (Forsikringsoplysningen). Thus, in developing and implementing the prescribed system, insurance companies must be included and consulted.

They have the potential to help fund the system, and they could offer more incentive for consumers to take part in the system. If the RFID system is not mandated by law, then a consumer would have the right to reject it and go without it. If an insurance company, in this scenario, were to offer a discount on a customer's premium rate for installing an RFID tag on his bicycle or buying a bicycle with one built in, then consumers would be more likely to adopt the system. Similarly, an insurance company could refuse to cover an individual's bicycle if it is not protected by the RFID system, much like the current situation in which insurance companies will not cover bicycles that are not protected by approved bicycle locks.

The Insurance House—a trade group representing all insurance companies in Denmark—said that this sort of action would not be taken without concrete evidence demonstrating that the system would be successful in saving insurance companies' money. However, it has come to the team's attention that insurance companies funded the computer system that currently records and keeps track of the frame numbers—including whether or not they have been recorded stolen—for all bicycles in the country (Appendix G). Therefore, using various results of this report and data that will soon be available from Holland (see section 5.3.1), it should be possible to gain support from insurance companies.

5.2.4 Police

The police are a crucial part of the potential solution. It may be the case that bicycle theft is currently a low priority on their list of problems to deal with, but it is important that something be done (Appendix G). The proposed system is intended to make the job of checking bicycles extremely easy and routine. If this were the case, bicycle theft would not need large amounts of new resources devoted to it but could still be alleviated. Officers could carry scanners to check any bicycles they pull over during a shift. There could also just be a small addition of a routine, maybe

just once a week, during which a couple of police officers check certain areas where stolen bicycles are commonly left.

Another suggestion that has been made is to possibly put additional scanners into the hands of other groups that have an interest in the situation and are already out in the street working every day. In this case, there would be more manpower devoted to the task of scanning bicycles. This will require some amount of cooperation between the police and these other groups, which may come about in the form of a liaison. Whatever the exact details of the system implemented, the Danish police will be involved somehow, whether directly by having officers scan bicycles or by authorizing another group to scan bicycles and flag those cycles that are determined to be stolen.

5.2.5 Crime Prevention Council

Det Kriminalpræventive Råd, or Crime Prevention Council, is a governmental organization in Denmark concerned with all types of crime (Appendix F). The Council takes care of educating the population about crime, training the police, and preventing young people from turning to crime. They do this through various publications, conferences, and seminars. This organization showed interest in the team's ideas and efforts concerning bicycle security. This organization communicates frequently with insurance companies and could potentially convince them to take a certain course of action, such as funding a pilot program for a new bicycle security system or buying a new computer system to keep track of frame numbers and stolen bicycle reports. The Police Inspector of the Crime Prevention Council, Henning Maigaard, mentioned that the Council itself would be willing to contribute some money— DKK 5000 or 10,000 (USD 1000 to 2000)—to this project if an application were completed. This offer, though small, should be considered as an aid to starting a pilot program for the proposed system.

5.3 Implementation of an RFID Tagging System

Being able to implement an electronic tagging system depends on the abilities of the technology available. In order to investigate this, the team researched the current state of the RFID industry and was in close contact with those involved with running a similar system in Holland.

5.3.1 Amsterdam Bicycle Theft Program

In Amsterdam, there are approximately 750,000 people residing in the greater city area with over 600,000 bicycles (I Amsterdam). As one can imagine, the situation is similar to Copenhagen in which bicycle theft is a great problem. Approximately 16 percent of all bicycles in the city are stolen each year ("Frequently"). In an attempt to reduce bicycle theft, Dutch bicycle manufacturers now equip new bikes with a special locking mechanism that contains an RFID microchip. This was done by the manufacturers mainly for a marketing scheme but the idea has been very successful. According to the chairman of the van de Stichting ART (the ART Foundation, a Dutch crime prevention organization), Ferry Smith, the locks cost the consumer only an extra five euros (seven U.S. dollars) compared to a standard locking mechanism. The bicycles themselves also cost slightly more because special mounts are built into the frame to accommodate the locks.

One disadvantage is that new bicycles make up only a small fraction of the total bikes in Holland, so it will take some time before the majority of bicycles in Amsterdam have the electronic tag. Despite this, the Amsterdamse Fiets Afhandel Centrale (AFAC) has begun an effort to make electronic identification more common for bicycles within the city.

In April 2005, a pilot test was initiated in which 10,000 bicycle owners were given a device containing an RFID chip. The device is meant to be bolted to the frame-tube, directly under the seat of any bicycle. The first 10,000 devices were paid for by the AFAC and the Ministry of Transport and were distributed free of charge to the cyclists (Hespe). Because the pilot program is so new,

there is not any specific data yet on how well the system is working, although it is expected to be successful. Any increase in tagged bicycles will only improve the system's success.

The chip containment devices are attached to the bicycle frame using bolts designed specifically for this purpose, making them extremely difficult to remove. AXA Basta (Stenman Holland) is the company responsible for creating the container, while RFID-net distributes the chips. As mentioned previously, the devices were distributed for free; however, the original cost was EUR 90,000 (USD 120,000) for the initial 10,000 chips (Hespe). The scanners that are used to read the chips cost around EUR 200 (USD 270) each, depending on the model. Fortunately, many scanners were already owned by the police, allowing financial savings. The total cost of the pilot program was approximately EUR 128,000. Of this, EUR 84,000 was financed by the Ministry of Transport and EUR 45,000 was given by the Council of Amsterdam (Hespe).

The latest model of RFID scanner that is in use by Dutch police now is one that uses general packet radio service (GPRS) tracking. GPRS is an extension of cell phone technology and enables a device to communicate wirelessly with a network such as the internet. For purposes of the tracking system, this communication takes place over the closed network containing the frame number database. This central database contains information on all the registered bicycles and contact information of their owners. When a RFID tag is scanned, a red or green light appears on the scanner. This light informs the law enforcement official if the bike in question has been reported stolen. The scanners in use by the Dutch police generally have minimal problems receiving a signal from the chips, even though the chips are near a metal bike frame. Although metal can sometimes interfere with the readability of electronic tags, few problems arise so long as the scanners are close enough to the tag, preferably ten to twenty centimeters away. This short read range may seem slightly impractical if an officer wanted to just walk down a bike rack and do a quick scan. However, the devices are always attached to the bicycles in the same location, so the

officer always knows where to aim the scanner. In the event that a chip-containing device is removed from a stolen bike, this fact would be obvious because markings are left on the frame when tampering occurs. The officer can automatically assume that the bike is stolen and then take the necessary steps to locate the rightful owner.

Holland can serve as an invaluable resource to those who wish to begin a similar system in Denmark. The Dutch precedent is a compelling argument, since the situation there is very similar to the one in Denmark. Bicycles are just as prevalent and just as important to their citizens, and they are also stolen just as frequently. Through communication with experts on their system, it should be possible to acquire further data supporting the new system they are using. (N.B: Chairman of the ART Foundation, Ferry Smith, whose contact information can be found in Appendix O, has access to progress reports showing data on the Dutch system thus far. The team requested this information, but Mr. Smith was on vacation at the time the request was made, so the information is on its way but did not make it into this report. The team recommends that Mr. Smith be contacted for further inquiry about the progress of Holland's RFID system.)

5.3.2 Opinions of Politicians

In order for the RFID system to work efficiently, it is necessary that as many bicycles as possible are outfitted with a tag. The best way to achieve this is to have financial support by the Danish national government and Copenhagen government. The initial road was paved after the project team conducted an interview with a member of the Danish Parliament.

One member of the Socialistisk Folkeparti (Socialist People's Party, or SF party), Poul Henrik Hedeboe, who deals primarily with issues concerning traffic and cycling laws, was interviewed in order to obtain information regarding the logistics of implementing a tracking system, as well as to gain insight on the thoughts of a government official (Appendix M2). When the idea was proposed to him, the MP was very interested in the idea, and he informed the

interviewees that his party would stand behind the idea as well. SF is the sixth largest political party in Denmark, receiving about six percent of the total vote ("Danish"). The politics of SF tend to be mostly left wing, and, according to the MP, most other left wing parties would support the idea as well. For this reason, support should be wide spread on this issue.

Details of the Dutch system were explained to Poul Henrik to give him an idea of possible cost for a pilot program. He believed that an estimated DKK 1,000,000 (USD 175,000) was a reasonable initial amount to ask of Parliament. The process of obtaining the money will be made a lot easier when data on the program in Amsterdam becomes available. Any proof that a RFID tracking system does in fact work would make a compelling case. If this data can be obtained soon, a proposal for funding could be submitted to Parliament at the end of 2005. If that proposal were to pass, action could begin as early as January 2006.

The project team feels that the most logical place to begin a pilot program in Denmark would be in Copenhagen, or perhaps one of the other large cities, such as Århus or Odense. The leader of the SF party within the Copenhagen Council, Sven Milthers, who is also a member of the municipal board of Copenhagen, was contacted and questioned about possibly starting a bicycle tracking system in the city. His opinion was quite different than that of MP Poul Henrik Hedeboe. He did not believe that such a program should involve the government. It should be run strictly by the insurance companies, including any possible funding and the entire scanning procedure. He also believed that it should be a completely voluntary program. In his opinion, an electronic identification system would only benefit the more expensive bicycles. He doubted owners of less expensive bicycles would have any interest in purchasing a tag. He did not believe that government funding would be available or that the idea would gain support among the various parties.

With the exception of a few people whom submitted the online survey, this was the first strong negative opinion toward the matter. The fact that a similar bicycle tagging program had

begun in Amsterdam did not change Sven's thoughts. He was adamant that the insurance companies should take full responsibility if such a system began in Copenhagen. He felt that it would be unreasonable to ask the police or any other municipal workers to complete the task of scanning bicycles. After hearing the councilmember's stance on this idea, it is obvious that a considerable amount of data and evidence showing that an RFID system actually works would be necessary to push such an idea through the Copenhagen Council. In light of the councilmember's comments, proposing the system to the national parliament may be more beneficial than presenting it to the Copenhagen Council.

6. Conclusions and Recommendations

After extensive research and a complete analysis of the results, the team decided on the best possible system to combat bicycle theft. Here, the team looks forward to the future of this system. Recommendations on how to implement the chosen system and possibilities for future improvement and innovation are covered below.

6.1 Recommendations

The team has concluded that the best solution to help the problem of bicycle theft is the use of RFID tag and scanner technology. The expectations are that radio frequency identification will provide a more useful and versatile way of recognizing bicycles than the existing frame number system. It is a vast improvement over locating a number that may be hard to find or see and manually running that number through a database to discover the ownership details. The equipment for such a tagging system is available through the various companies mentioned, including Datatag, RFID-Net, and Alien Technology.

The Danish Cyclists Federation, along with the rest of the groups concerned in Denmark, should pursue this system with the goal of outfitting every bicycle in the country with an RFID tag. The first step, however, will be to initiate a pilot program or test program. The pilot program should be held within the city of Copenhagen because it accounts for over 20 percent of all bicycle thefts in Denmark, making it the easiest place to get meaningful data. The pilot program should be geared toward use on bicycles already on the road rather than new bicycles.

Such a program would be most effective if it were distributed free of charge to a representative population of the city. It should be given out to enough people that a significant portion of the total bikes are initially outfitted. Of course, the system will not live up to its full potential until it is installed on most bicycles—preferably all—but it will give an indication of the

logistics of the system and how to execute it correctly. In Amsterdam, a similar test program is underway, in which the first 10,000 bicycles are outfitted free of charge.

The funding for such a program is important to consider. The most likely candidate capable of offering the necessary funds is the insurance companies of Denmark. They spend over DKK 141 million (USD 25 million) each year compensating bike theft victims (Forsikringsoplysningen). If they were convinced that they would save a significant amount of money through this system and that spending some of their money would accelerate its implementation, then funding may be possible. Additionally, a member of Parliament, Poul Henrik Hedeboe, mentioned that one million Danish kroner was a reasonable amount to request from Parliament for funding a test program (Appendix M2).

After the pilot program is in place for several years and results are tabulated, the decision can be made on a more permanent solution. For this system to work, it is crucial that as many bikes as possible be covered by the system. Therefore, one must consider how to get everyone to accept the system. The easiest way may be to first convince the government to accept the system. Parliament could mandate that all bicycles must be outfitted with an RFID tag by a certain date.

If there is a problem gaining such support from the legislators, then the insurance companies can again be of use. Currently, insurance companies will not cover theft of a bicycle unless it is equipped with an approved lock. It is possible that they their guidelines could be adjusted to require an RFID tag as well. With that requirement in place, only bicycles equipped with an RFID tag would be compensated if stolen.

6.2 Future Possibilities and Changes

The ultimate goal of stopping bicycle theft in its entirety is one that may never be met. The most one could hope for is that the RFID system becomes a deterrent of bicycle thieves. If this were the case, the system would have a profound effect on consumer confidence and the entire

bicycle industry. Here the team discusses the future possibilities of the RFID network, keeping in mind that the ideal system may take time to evolve.

6.2.1 RFID Scanning Network

As discussed, RFID tags have many advantages, but they also have their limitations. One limitation is that the read range of the scanners is quite small. However, as the technology progresses, this is one area that is being addressed. It would be advantageous to have a long enough read range that scanners could be used in passing police cruisers. The scanners could automatically identify every bike and wirelessly access the database. The officer would be alerted by the scanner when a stolen bike is located, as described in Section 5.3.1. This is the logical progression of where the technology could be in the next several years, but there are more far reaching, automated possibilities to consider.

It is plausible that one day, automated scanners could be installed at strategic locations in or around Copenhagen and other large cities; telephone poles or streetlights are two places to consider. Anywhere that there is a permanent power source could potentially house a scanner. These scanners would be programmed to constantly scan the area, and when an RFID tag was read, information could be sent directly to police databases via GPRS technology. If a stolen bike were scanned, an effective way to communicate this information to the police force would be to have any important information print out automatically at the nearest police department. If there were enough scanners installed around the city, it would be easier for the police to apprehend the individual and return the bike to the rightful owner.

The social implications of the described system are important to consider. It is possible that such a system could be used irresponsibly to exploit one's privacy. Imagine that the government or police—or another official body—used the scanners to track a certain bicycle, not necessarily a stolen one, with a different goal in mind. As a result, the privacy of this individual would be

invaded as long as he or she was cycling. This has a distinctively disagreeable Orwellian feel. There is also the possibility that someone other than the government may access the information provided by these scanners. In this case, criminals may be able to perform similar searches. If one cannot guarantee that the scanners will be used exclusively for locating stolen bicycles, too much risk would be involved, and the public may not accept this specific type of system.

6.2.2 RF or GPS in the Future

Radio frequency and global positioning system tracking technologies are currently popular for automobile recovery; however, as discussed previously these technologies are not ready for bicycle application at this time. Specifically, there is no power system that is small enough, light enough, and powerful enough to be practical on a bicycle long-term. Also, the technologies require an antenna that would be cumbersome on a cycle. As these technologies are developed, however, there may be a place for them in the bicycle world. Perhaps a new compact energy cell will be developed that can store large amount of energy and adapt for use in RF or GPS tracking. The energy could be transferred while pedaling, as it already powers bicycle lights and computer systems. The issue of whether the system could be rendered useless by a potential thief is crucial, but can be addressed. The systems could be concealed and safeguarded from criminals, or they could be password protected and tamper resistant. Someday, one might be able to use the entire bicycle frame as an antenna rather than having a more common, breakable version. The aforementioned scenarios show why GPS and RF should not be simply abandoned; they should remain in the back of the minds of those who wish to end bicycle theft. These types of technologies may one day mature into the ideal solution.

7. Works Cited

Archers Direct. Archers Direct: Country Information. 2004. Archers Direct. 31 Jan. 2005

    <http://www.archersdirect.co.uk/countryinfo.php?countryid=dnk>.

Bicycle Habitat. 10 Worst cities for bike theft. 2000.

    <http://bicyclehabitat.com/site/page.cfm?PageID=139>.

Bicycle Retailer and Industry News. *Statistics.* Bicycle Retailer. 26 Feb. 2001. Bicycle Retailer

    and Industry News. 5 Feb. 2005

    <http://www.bicycleretailer.com/bicycleretailer/images/pdf/statistics.pdf>.

Bikeregister.com. Bikeregister.com – the Log Book for Bikes. n.d. Selectamark Security Systems

    PLC. 6 Feb. 2005 <http://www.bikeregister.com>.

Brain, Marshall, and Tom Harris. "How GPS Receivers Work." Howstuffworks. 2005.

    HowStuffWorks, Inc. 4 Mar. 2005 <http://electronics.howstuffworks.com/gps.htm>.

Bryan-Bown, K and T Savill. Cycle Theft in Great Britain. Crowthorne, Berkshire, England:

    Transport Research Laboratory, 1997.

Cecchettini, Jason. "Bicycle Tracking.*"* E-mail to Kristopher Houle. 31 Jan. 2005.

City Bike. Company home page. <http://www.bycyklen.dk/engelsk/frameset.html>.

Coliped. Association of the European Two-Wheeler Parts' & Accessories Industry. n.d.

    <http://www.coliped.com> .

Cy-Curity. Remote Activated Bicycle Alarm. n.d. Innovative Security Products, Inc.. 7 Feb. 2005

    <http://www.cy-curity.com>.

"Danish Parliamentary Election, 2005." Answers.com. n.d. Wikipedia. 4 May 2005

    <http://www.answers.com/main/ntquery?method=4&dsid=2222&dekey=Danish+parliament

    ary+election%2C+2005&gwp=8&curtab=2222_1>.

Danmarks Statistik. StatBank Denmark. n.d. StatBank Denmark. 7 Feb. 2005

      <http://www.statbank.dk/statbank5a/default.asp?w=1280>.

Dansk Cyklist Forbund. Index skabelon til dcfweb. n.d. Danish Cycling Federation. 17 Feb. 2005

      <http://www.dcf.dk>.

Datatag. Datatag.co.uk. n.d. Datatag. 6 Feb. 2005 <http://www.datatag.co.uk>.

eHow.com. How to Avoid Bicycle Theft. n.d. <http://www.ehow.com/how_1733_avoid-bicycle-

      theft.html>.

Forsikringsoplysningen. n.d. 3 May 2005 <http://www.forsikringsoplysningen.dk/>.

"Frequently Asked Questions: Tips and facts about bicycle theft." Fietsendiefstal.nl - Geef

      Fietsendieven Geen Kans! n.d. Amsterdamse Fiets Afhandel Centrale. 4 May 2005

      <http://www.fietsendiefstal.nl/english/#tipsfacts>.

Gongloff, Mark. "Consumer Confidence Plunges." CNN.com. 25 Feb. 2003. Central News

      Network. 28 Feb. 2005 <http://money.cnn.com/2003/02/25/news/economy/consumer/>.

I Amsterdam. 26 Apr. 2005. 4 May 2005 <http://www.iamsterdam.com>.

Kesteren, J.N.van; Mayhew, P.; & Nieuwbeerta, P. "Criminal Victimisation in Seventeen

      Industrialised Countries: Key-findings from the 2000 international Crime Victims Survey."

      2000. < http://www.unicri.it/icvs/publications/pdf_files/key2000i/>.

Krag, Thomas. *Bicycle Economy in Denmark.* Thomas Krag Mobility Advice. Sept. 1997. 31 Jan.

      2005 <http://www.thomaskrag.com/1997vcbceconomy.html>.

Langley, Jim. Take a Bike Out of Crime: A buyer's guide to Security Devices. Bicycling. v31,

      April 1990. page 178.

LockAlarm. Cable Lock & Alarm. n.d. LockAlarm. 7 Feb. 2005

      <http://www.lockalarm.com/cable%20lock%20alarm1.htm>.

Loubert, Gary. *Crime Countermeasures: Technology developments in the RF tracking and locating of personnel and objects.* Proc. of Institute of Electrical and Electronics Engineers International Carnahan Conference, October 14-16, 1992. 206 – 212.

Hespe, Anouk. Personal interviews and e-mails. 14 – 25 Apr. 2005.

Michalson, Dr. William R.. Personal interview. 21 Feb. 2005.

Mozer, David. *Infrastructure, Policy, Planning, and Design Digest.* International Bicycle Fund: Promoting sustainable transport and economic development and cross-cultural understanding worldwide. 2005. International Bicycle Fund. 31 Jan. 2005 <http://www.ibike.org/engineering/infrastructure.htm>.

National Bike Registry. "National Bike Registry – Prevent Theft: Register your bike in the NBR Database!" n.d. National Crime Prevention Council. 6 Feb. 2005 <http://www.nationalbikeregistry.com>.

North Denmark Online. Bicycles. n.d. <http://www.northdenmarkonline.dk/praktisk/bicycles.htm>.

Oddershede, Erik. *SV: Statistics – Bicycles.* E-mail to Jennifer Schweers. 1 Feb. 2005.

Padula, Richard. "Is RFID ready for the plant floor?" Plant Engineering. 1 Dec. 2004: 33-. Academic Universe. Lexis-Nexis. Worcester Polytechnic Institute, Worcester, MA. 11 Apr. 2005 <http://web.lexis-nexis.com/universe>.

Panasonic. "Matshushita Electric (Panasonic) Introduces the Industry's First GPS-equipped Electric Bicycle." Panasonic. 17 Jun. 2003. Matshushita Electric Industrial Co.. 7 Feb. 2005 <http://panasonic.co.jp/corp/news/official.data/data.dir/en030617-1/en030617-1.html>.

Pegasus Technologies. Pegasus Technologies, Inc.. 2002. Pegasus Technologies, Inc.. 7 Feb. 2005 <http://www.pegtech.com>.

SecurityWorld.com. "Cable Alarm Lock." n.d. SecurityWorld.com. 7 Feb. 2005

<http://www.securityworld.com/locks/cablealarm.html>.

Transalt.org. Transportation Alternatives. Bicycle Theft: A Major Deterrent to Cycling. n.d.

<http://www.transalt.org/blueprint/chapter11/>.

Vej & Park. City of Cyclists. 30. Sept. 2004.

<http://www.vejpark.kk.dk/byenstrafik/cyklernesby/uk/>.

8. Appendices

The following appendices represent information that was not placed in the body of this report but is still important to the project as a whole. Included is an in depth description of our sponsor, detailed transcriptions of the survey responses and each interview that took place, as well as a list of important contact information. This reading may be important to a reader that wishes to better understand the implications of what was done and where the information was gathered. It is crucial to anyone who wishes to continue the work of this project.

Appendix A: The Danish Cyclists Federation

The following is a description of the organization sponsoring this project: The Danish Cycling Federation. Their aims, objectives, and some history and infrastructure of the organization can be found here.

The Dansk Cyklist Forbund, or Danish Cyclists Federation (DCF), is sponsoring this project. The organization was founded on October 16, 1905 in order to represent and protect the rights of Danish cyclists. Most importantly, the organization focuses on the everyday cyclists who use bicycles for their daily commute or other routine travels. Those who are cycling enthusiasts have a completely separate organization representing their interests. According to the DCF's website,

> The objects of the Federation are to improve safety, unhindered access, confidence and comfort for cyclists; to encourage a greater number of people to use a cycle - and to use it more; to reduce the effects of traffic on the environment; to ensure that the cycle is regarded as a serious transport form; to achieve improved interplay between the cycle and other forms of transport; and to ensure that all destinations can be reached on a cycle without the need to take a diversion.

This goal is achieved through political lobbying at all levels, from national to municipal. In addition, the DCF is represented on various government councils and interest organizations whose concerns range from road safety to equipment standards. Its headquarters is located in Copenhagen, but it operates out of local branches across the country. Currently the DCF is made up of forty-one branch associations and twenty representatives in areas without official branches. The representatives are appointed by DCF management, whereas the officers of the local branches are elected by the respective members. All elected officers and appointed representatives are volunteers and report to the Federation's director in Copenhagen. All members have a part in running the organization just as if they were stockholders in a public company.

Due to the sheer volume of bicycles in Denmark, one may not be surprised that bicycle theft is a big issue. This problem infringes directly upon the Federation's mission statement's pledge to improve cyclist confidence, safety, and unhindered access. Therefore, the Federation has become interested in a potential tracking system for bicycles. This research team has been given the task to determine possible solutions and to determine their feasibility and/or necessity.

Appendix B1: DCF Questionnaire: Response Statistics

What follows is the questionnaire that was sent to DCF members along with statistical representations of their responses.

We are a group of American students in the third year at Worcester Polytechnic Institute in Massachusetts. We are completing a project with the DCF as part of our bachelor degree. The goal of the project is to determine whether an electronic tracking system is necessary and feasible as a solution to the problem of bicycle theft in Denmark. Your opinions as cyclists are very important to us as we explore this problem and try to determine the best course of action.

Total number of survey respondents: 205.
Total number of respondents with at least one bicycle stolen: 115 (56%)

Part 1: Bicycling Habits

1. Are you a member of the Dansk Cyklist Forbund?
    Yes: 90.2%
    No: 9.8%

2. How often do you use a bicycle?
    Every day: 83.9%
    Once or twice a week: 10.7%
    A few times a month: 3.4%
    Less than once a month: 1.5%

3. What is your primary type of cycling?
    Normal transportation: 81.5%
    Recreation: 16.1%
    Competition: 2.4%

4. Approximately how much money have you invested into your primary bicycle and any cycling equipment?
    Less than 1000 DKK (Less than ~175 USD): 2.9%
    1000 to 3000 DKK (~175 to ~520 USD): 9.3%
    3000 to 6000 DKK (~520 to ~1030 USD): 48.3%
    6000 to 10000 DKK (~1030 to ~1725 USD): 19.5%
    10000 to 15000 DKK (~1725 to ~2600 USD): 12.2%
    15000 to 20000 DKK (~2600 to ~3500 USD): 3.9%
    More than 20000 DKK (More than ~3500 USD): 3.9%

5. Do you insure this bicycle?
    Yes - it's part of my homeowner's insurance: 93.2%
    Yes - I have insurance specifically for my bicycle: 1.5%
    No: 4.9%

6. If not, why not?
   Too expensive: 0.0%
   Not worth the trouble: 55.6% (of those who do not insure)
   Other: 44.4% (of those who do not insure) *(See Appendix B2 for free responses)*

Part 2: Experience with Bicycle Theft

Please fill out this section only if you have had a bicycle stolen.
If not, please <u>continue on to Part 3.</u>

1. Approximately how much was the cycle worth?
   Less than 1000 DKK: 12.2%
   1000 to 3000 DKK: 34.8%
   3000 to 6000 DKK: 38.3%
   6000 to 10000 DKK: 13.9%
   10000 to 15000 DKK: 0.9%
   15000 to 20000 DKK: 0.0%
   More than 20000 DKK: 0.0%

2. Where was the cycle stolen from?
   Inside a home: 9.6%
   Yard, courtyard, or street near home: 31.3%
   Train station: 18.3%
   Outside a shop or business: 13.0%
   Work: 18.3%
   Other: 10.4% *(See Appendix B2 for free responses)*

3. Had the cycle been locked or otherwise protected?
   Yes: 88.7%
   No: 10.4%

4. Did you report the theft to police?
   Yes: 90.4%
   No: 8.7%

5. If no, why?
   (See Appendix B2 for free responses)

6. Did you report the theft to your insurance company?
   Yes: 81.7%
   No: 18.3%

7. If so, did the insurance company compensate you for the bicycle?
   Yes: 91.5% (of those who reported the theft to their insurance company)
   No: 8.5% (of those who reported the theft to their insurance company)

8. Was the bicycle ever recovered?
   Yes: 17.4%
   No: 77.4%

9. Have you purchased a replacement bicycle?
    Yes: 84.3%
    No: 14.8%

10. If so, did you invest more or less money into the replacement bike?
    More: 57.7% (of those who bought a replacement)
    Less: 15.5% (of those who bought a replacement)
    Approximately same amount: 26.8% (of those who bought a replacement)

11. Has your attitude towards cycling changed as a result of the theft? How so?
    (See Appendix B2 for free responses)

Part 3: Theft Prevention

1. When you leave your bicycle unattended, how often do you lock it?
    Always: 87.8%
    Usually: 10.2%
    Sometimes: 4.1%
    Rarely: 0.0%
    Never: 0.0%

2. What other precautions, if any, do you take to prevent theft of your cycle?
    (See Appendix B2 for free responses)

Part 4: Tracking Systems

We are proposing for a simple microchip to be installed on bicycles. Each chip would contain a unique identification number. Police would have scanners that could read the identification number on any bicycle. If the bicycle is reported stolen, it could then be returned to its rightful owner. This chip system would serve as a modernization of the current Danish frame number system.

1. Do you feel that this would be an effective solution to bicycle theft?
    Yes: 55.6%
    No: 19.0%
    Undecided: 25.4%

2. How much would you pay for such a system to be installed on your bicycle?
    Nothing: 13.2%
    Less than 100 DKK (less than ~20 USD): 20.5%
    100 to 250 DKK (~20 to ~40 USD): 49.8%
    250 to 500 DKK (~40 to ~90 USD: 11.7%
    500 to 1000 DKK (~90 to ~175 USD): 3.9%
    Greater than 1000 DKK (greater than ~175 USD): 0.0%

3. Do you have any further concerns or comments?
    (See Appendix B2 for free responses)

Appendix B2: DCF Questionnaire: Open-ended Responses

The following is a summary of the open-ended responses to the questionnaire posed to DCF members. Some were answered in Danish, which is reflected here. An English translation follows the Danish.

If [bike is not insured], why not?

Too expensive: 0
Not worth the trouble: 5
Other: 4

Other reasons for not insuring bicycle:

*** you wont get payed very much if the bicycle is more than a few years old, eventhough its still much worth for the owner.
*** Ingen forsikringer *(question misunderstood)*
*** The compensation is too low (my bike is app. 10 years old and I minimize the risk of theft by other means
*** Cyklen er gammel. *(bicycle is old)*

Other places cycles were stolen from:

*** Shared bicycle stable
***
*** Garage
*** from a locked cellar
*** outside a school
*** near a sport center
*** Nearby a highway
*** At the stairways to my apartment (behind a locked door)
*** overnatning i et lille ungdomslejr *(campsite)*
*** on holyday in Sweden. The cycle was locked and placed on our car overnight.
*** halmtorvet *(campsite)*
*** School

Reasons for not reporting theft to police:

*** because it wasn't locked
*** Jeg fandt den kort efter ved et nærliggende indkøbscenter. *(Found it myself)*
*** Hjemmebygget cykel uden stelnummer *(Homemade bike without frame number)*
*** It was an old bike
*** I looked for it and found it in a few days.The bicycle was too old to get money from insurance.
*** Very old bike
*** gl.cykel - ingen erstatning *(Old – would get no insurance)*
*** I had lost the documentation for the frame number
*** I had forgotten to lock my bike.

*** I chased the person and got the bicycle back

Changes in attitude as a result of theft:

*** Nej, jeg elsker at være cyklist. *(No)*
*** Man tænker over hvor man stiller cyklen.Det er ikke alle steder hvor man vil have cyklen til at stå. *(More careful when placing the bike)*
*** no
*** No
*** no
*** No
*** No
*** no
*** Not a bit! - Well, it's a nuissance, but what's the alternative? sitting behind a steering-wheel? NEVER!!
*** no...
*** No
*** I dont like too place my bike in cityes.
*** Jeg sørger for at stille cyklen indenfor i skuret. *(Put bike in shed.)*
*** No - I still enjoy cycling very much
*** I bought one more lock for my bicycle. Now I also have cable lock, which enables me to fix it to a fence or other "not moveable objects".
*** No
*** I bought a lock (approved by the insurance company) that can lock teh bicycle to a fence or likewise.
*** No, it was annoying, but I still love to bike. I have had another bicycle stolen, which I never had back, and my wife had her stolen two years ago. Last year my primary bike was stolen, but this time the police found it after one week - with no damages.
*** Nej.
*** nej
*** No!
*** nej
*** Man skal holde sin cykel ornligt aflåst overalt *(More careful when locking)*
*** Jeg tænker mere over, hvor jeg parkerer min cykel, og hvor længe *(Careful when parking)*
*** nej
*** no
*** nej
*** Bought better lock
*** I use bigger locks and my competition/recreation-bike are kept inside my apartment.
*** no
*** No
*** NO
*** Jeg har sørget for flere låse til min cykel. *(I use more locks.)*
*** No, not really. It's part of life...
*** Nej.
*** Not at all
*** No
*** Yes, I now use safe locks only.

*** nej, jeg fandt min cykel og fik den repareret *(question misunderstood)*
*** nej
*** Nej
*** Made me more aware of the need for precautions in addition to locking.
*** No
*** No
*** Nej bestemt ikke *(No.)*
*** No, not at all. Why should it change? Bicykling is a wonderfull way of transport and recreation and enjoying the fresh air and nature everyday.
*** Nej. Jeg kan ikke undvære min cykel. Det er hurtigere at cykle på arbejde end at køre i bil. Det er lettere at købe ind, fordi man altid kan finde en plads til cyklen. Jeg nyder også at cykle ud i naturen, når det er godt vejr. *(question misunderstood)*
*** no
*** No
*** No. I bought one more. So now I have a bicycle for daily transportation and a much faster one for recreation
*** Nej
*** Nej Jeg har ikke andre transportmuligheder *(question misunderstood)*
*** nej
*** nej
*** No
*** nej det er hvad man kan forvente *(No)*
*** Overhovedet ikke. Ingen spade af en cykeltyv skal forhindre mig i at nyde mine cykler! *(No, I refuse to let a thief control my life!)*
*** Jeg passer mere på hvor jeg sætter min cykel, og låser oftere den med en ekstralås til et eller andet som er fast. *(More careful when parking and use extra locks more.)*
*** No.
*** Nej - men nu bruger jeg to låse i stedet for en enkelt. *(More locks)*
*** jeg låser min nye cykel bedre (også kædelås)og jeg vil har købt en billigere cykel. *(More careful when locking)*
*** No
*** no
*** nej
*** No (small shortcomming of your question form: above relates to my latest theft- experience, add one "by trainstation" & one by a shop & one locked to the fence outside a temporary address in England)
*** Jeg lader helst ikke min cykel "overnatte" nogen steder. *(Careful when parking.)*
*** jeg bruger ikke længere min cykel til at køre til togstationen, ligesom den nu boltes fast til mit rækværk hjemme *(Lock it better at home and don't leave it at the train station.)*
*** Nu er jeg endnu mere påpasselig med at sætte min cykel uden for den ejendom, jeg bor i. *(More careful when parking.)*
*** Nej
*** nej
*** nej, det sker desværre for tit *(question misunderstood)*
*** Nej det har den ikke, jeg elsker at cykle og vil altid gøre det uanset om der mistes en cykel eller 2. *(No, I love cycling and will keep on in spite of thefts.)*

*** Min holdning som cyklist er at det nemmere at cykle, det er sjovt og det giver god motion. Tyverierne har ikke ændret på min livsstil. *(No, cycling is fun and good exercise. Thefts will not change that.)*
*** No
*** No
*** Min holdning har ikke ændret sig *(No.)*
*** more pecautions *(I have hade at least 4 bicycles stolen)*
*** nej
*** No
*** No

Other precautions taken to prevent theft:

*** Den står aldrig ude om natten, der er den låst inde i kælderen. *(Keep it locked in cellar)*
*** I always lock it with one lock on the bicycle (fastgjort til stellet). Very often, I use a cable lock as well; whereever possible, I lock the bike to something which cannot be moved or broken.
*** The cycle appears to be heavy, slow and dirty
*** Sometimes I use a wire lock to secure my bike to a fixed object - depends on the locality.
*** No
*** Normally I put in my apartment in nights. At publicplaces I lock it together with som big stuf that couldn't that easy be mowed.
*** I avoid leaving it away from home overnight, if possible
*** Put it beside a really, really nice looking, expensive bike.
*** Chain with padlock - if possible to a fence or post.
*** Dobbeltlås *(Double lock)*
*** I never park it for a longer period of time in the street or at the station. Then I use an older bike. I always use 2 kinds of locks.
*** Try not to leave it in 'unsafe' places. Make sure it is locked
*** I lock the frame to something if I feel it is needed.
*** both keylock and chainlock
*** keep it in a shed
*** keeping a close overview, when shopping. If not possible: Always locked!
*** NONE
*** I try not to leave it at train stations late atin the evening if possible.
*** I park it in my garage.
*** The cycle is parked i a closed yard at home
*** I don't clean it so much, so it looks old and a bit unattractive to steal.
*** I always take it inside if that is possibilitet
*** Tidligere satte jeg navn på. Det har jeg ikke aktuelt. Har ikke fået stjålet cykel i over 25 år trods årlig kørsel på ca 5.000 km. *(I used to mark my bike, but have not had a theft in 25 years.)*
*** At home I keep it a locked shelter
*** See part 2.
*** Lock it with a wirelock - if possible attached to a fence or alike
*** Den står aldrig ude om natten *(Don't leave out at night.)*
*** Til hverdag står min cykel ved en togstation natten over. Derfor sikrer jeg den med en ekstra kabellås til cykelstativet. *(Extra lock)*
*** My NOT everyday bicyles are locked together inside a shed where the door is locked.
*** I put my locked bike in a locked room in a locked basement during the night

*** I have 3 bicycles and I always use the oldest one when I have to leave it at the station or other places for longer time

*** At the train station I use a locked room. At home we have the bikes in our garage (and the car outside).

*** Ingen.

*** sætter den i cykelkælderen , eftermiddag/aften, når jeg ikke skal bruge den mere, den dag *(Leave in cellar at night)*

*** I am using a extra wirelock to fasten to building parts etc.

*** Place it in a public or crowded place.

*** Prøver at låse den fest til noget ikke flytbart *(Try to lock to something)*

*** Låser den om muligt fast til lygtepæl el. lign. *(Try to lock to something)*

*** jeg tænker på hvor jeg stiller den *(Careful when parking)*

*** Låser den fast til noget *(Lock to something)*

*** Try to place it in locked rooms

*** har en kædelås som jeg låser cyklen til et stakit, cykelstativet eller andet med *(Extra lock and lock to something)*

*** I let it look like a wreck to make it less tempting.

*** I have two locks

*** Keep it inside the house at home and at work

*** Sætter den i aflåst rum hjemme og på arbejde *(Put in shed)*

*** Cyklen står i cykelkælder i ejendommen jeg bor i. *(Put in cellar)*

*** a big padlock and a chain

*** I put my bike and my family's bikes into a locked shelter every night

*** I don't place it at railway stations and - if possible - I place in a bicycle shed

*** After work I put my transportation bike in a cellar. And the competition bike in my appart

*** I never leave it over nights in stations or streets.

*** Tlf.number on my bike, easier to get again, when it will be found.

*** When paring at the railway station I never leave at the end of a row of bicycles - always in between loads!

*** Ja, før låste jeg kun cyklen med bastalåsen, derefter skaffede jeg mig også en wirelås. Desuden bruger jeg DSB's aflåste cykelskur. *(Got extra lock and use the lockable shed at the train station.)*

*** locking to something fixed with second lock (chainlock) when left at riski places ei railroadstations

*** I use the locked, indoor cycleparking at my work

*** I do think about where I leave it, for instance, I don't leave it at the train station over night.

*** Place it in the bacement.

*** Avoid parking by the major stations.

*** Der er steder, hvor jeg ikke sætter min cykel, fordi jeg tror der er for stor risiko for at den bliver stjålet. *(Careful when parking)*

*** Use of an ordinary inexpensive bicycle

*** I never leave my byke outside my home over the night.

*** sætter den ind i gården eller cykelskuret *(Put in yard or cellar)*

*** Bruger sommetider en kædelås, for at gøre cyklen fast til en eller anden stander. *(Lock to something)*

*** Jeg stiller den ikke på "usikre" steder. *(Careful when parking.)*

*** I've bought a strong "U-lock" with which I almost always attach my bike to a lamp post, traffic sign or other fixed installations. In addition I always park my bike in the cellar at home and generally seek to minimize parking in public areas during the evening & night.

*** I lock my bicycle to something, you can not move.

*** My bicycle is seldom left on the street, if this is necessary I use a cable lock.

*** Udover fastmonteret godkendt lås, sikres cyklen med wire *(More locks)*

*** wire lock to fasten the biken to a lamp post or something alike, and/or to secure the quick lock-front wheel.

*** Hjemme har jeg den inde i lejligheden. *(At home I bring it inside)*

*** None

*** I park it in a locked bicycle room in the basement during the night. (the room is common for residents in the block)

*** Tænker over hvor jeg placerer den undgår stationer eller bruger stationscykel *(Careful when parking)*

*** nothing else

*** At the railway station I place the cycle in a protected and locked area.

*** Låser den fast med en wirelås til en lygtestander *(Lock to something)*

*** none - apart from the fact that I allways keep them inside the house during the night.

*** Når den er hjemme, altid under lås. *(Locked down)*

*** Sometimes I also use a wire.

*** "Vejerlås" spændt fast til noget "fast ejendom". *(Lock to something)*

*** I never leave my cycle unattended for long periods of time. At night its locked away.

*** Ingen *(Nothing)*

*** I use public transportation when attending cafe and restaurant's, or park it very close to the place I visit. My bike is a vital part of my life :-)

*** Fået bedre låse, hvad jo også kræves, og somme tider to låse på *(More / better locks)*

*** Double lock, one at rear wheel and a chain round front wheel and a some solid - if possibly.

*** har en kasse bagpå og en rem hængende og daske, så den ikke ser spor spændende ud. *(Have a box put on the back to make the bike look bad.)*

*** kædelås ude over den alm. Lås *(More locks)*

*** Har flere cykler, som jeg prioriterer efter hvor jeg stiller dem. *(Choose bike after risk profile of area)*

*** Overvejer hvor jeg absolut ikke vil sætte den, også afhængigt af tidspunkt *(Careful when parking)*

*** køber billig cykel på politiauktion til daglig transport *(Got cheap bike for everyday use)*

*** stiller den ikke på offentlig gade om natten (så vidt muligt) samt på stationer om natten og i det hele taget ikke på hovedbanegården *(Don't leave out at night or at main train station.)*

*** No other precautions

*** Jeg sætter min cykel i aflåst cykelrum hjemme, ved S-togstation og på arbejdsplads. Hvis den ikke står i aflåst rum, låser jeg - udover almindelig cykellås - altid cyklen fast til cykelstativet med ekstra lås. Jeg har flere cykler og sætter aldrig racercyklen uden opsyn og kun i aflåste cykelrum. *(Locked in at home, extra locks in risky areas, never leave my racing bike.)*

*** I do not lock my bike when at home, it is parked just outside the entrance to our house, in a quiet garden city in Western Jutland.

*** ingen *(Nothing)*

*** wirelås til faste genstande *(Lock to something)*

*** Ingen *(Nothing)*

*** Sætter den altid i cykelkælder om natten. *(In cellar at night)*

*** jeg har investeret i nøgle til aflåset cykelparkering ved stationen *(Have bought key for bike locker at train station.)*

*** Låser den evt. med ekstralås til en fast genstand *(Extra lock)*

*** Unless at home, I usually use an ekstra lock and chain the bicycle to a stationary object, e. g. a lamppost.

*** Jeg bruger almindelig lås og en kædelås, som jeg låser cyklen fast til f.eks. et hegn med. *(Lock to something)*

*** i langtid parkering , binder dem til fast genstand . *(Lock to something when leaving bike for a long time.)*

*** I have one lock on the bike and one wirelock to lock around the bike and something

*** Hvis cyklen skal overnatte på skolen låser jeg den ind i et besværligt og overfyldt rum *(If the bike stays at school overnight, I lock it in a room.)*

*** I'm avoiding parking my bike in areas with relatively great risc of theft...

*** en kædelås *(Extra lock)*

*** 1) Let it look old & dirty (applies to primary & secondary bicycle)

*** Sørger for ikke at stille den alt for mørke og skjulte steder. *(Careful when parking)*

*** Stiller cyklerne et sikkert sted, f.eks. garage, overvåget sted...

*** i aflåst indhegning på arbejdet, låst fast med wirelås på bopælen *(Place inside fence with extra lock)*

*** Jeg sætter altid min cykel ned om natten. *(Put in cellar)*

*** extra lås, låst inde. *(Lock in, extra lock)*

*** Navn og telefonnr. på cyklen *(Tagged bike with name and phone number.)*

*** Wire-lås *(Wire lock)*

*** I avoid leaving it for prolonged periods (more days)

*** wirelås til fast genstand *(Lock to something)*

*** JEg har 2 lås på min cykel sådn at jeg kan lås den fast til noget. *(Lock to something)*

*** Mine to dyreste cykler låser jeg altid fast til faste genstande, hvis jeg parkere en af dem på gaden, hvor jeg ikke vil have udsyn til cyklen i længere tid. Jeg ejer også en "havelåge" som jeg ikke låser fast til stativer med videre, men som jeg kun låser med den påmonterede lås. *(Beat up bike, only use normal lock for good bike, lock to something)*

*** None

*** None

*** I dont leave my cycle on/at the station or other places I find risky.

*** Ved tog stationen står cyklen i aflåst rum. *(Lock in shed at train station.)*

*** the locks are much better nowadays, and I use bicycle shed in the yard where I live and a locked bicycle shed at the station.

*** undgår så vidt muligt at parkere den på "udsatte steder" *(Careful when parking)*

*** Sometimes i lock it with an extra lock to items such as lightposts and other street inventory

*** I keep it indoors

*** brug af wirelås. undgå "udsatte" placeringer

*** if I leave it over nigth at the railway station (f.ex.) I use an extra wire lock/chain

*** Jeg kan låse den inde der hvor jeg bor nu.

Other comments:

*** 1) This microship is only worth the price, if it's impossible to remove it from the bike. Often, not only bikes, but part of the bike, is stolen. A microship in a wheel could be a posibility.

2) I would consider the microchip only, if I could be sure that my bike was not under supervision without my explicit agreement.

*** Bicycle and -lock manufacures in Holland have come very far in developing such a system (transponder chip hidden in lock or in frame)

It will not be effective against "occational theft" (=use bike once and dump it in a shrubbery)
It is dependant on that someone (=the police?) will actually have time and resources to use it
- it would probably only work in a 1984/fahrenheit 451 society with checkpoints on every street corner
*** This form cannot be submitted in Firefox. Another time, please tell that in advance, since there's no reason to waste time; I don't write all the stuff again.
*** Burde give en reduktion på forsikringen *(Should give reduction in insurance premium)*
*** A chip system would also allow tracking of my lawful movements. Big brother is watching you - probably also the CIA. Thus I would oppose the idea if it was suggested.
*** I fear the chip could easily be removed by the thief.
Even though compensated by insurance company it only covers the value of the bike when the bike is new, because of 10 percent deduction per year.
*** Great that someone take up the subject of bicycle theft!
*** Can it be deactivated on bikes just left at the train stations - never to be picked up (fetched) again by their owners.
*** I would only be willing to pay if it's really effective. I don't really believe in it. It is a condition, that the police more effectively are searching for stolen bikes at all. I don't think they have the time or the ressources for that.
*** The Danish police-constables have an awquard feeling about being involved in further work! When all time (and overtime)has been spent looking after national or international politicians during frequent World Bank-, EC-, NATO-meetings, visits of internationally and overwhelmingly important participants and their numerous summons in the city-area, there is not much manpower (m/k) left for surplus duties e.g. looking after bikes (or dogs, cats, old ladies, or whatever is in the common interest of common people - well how on earth would you expect the police to carry on such a job?

- One other thing: With this chip installed, I'm afraid, that an opening-up for hunting of bicyclist for whatever reason might be figured from any authority, could take place in the future! - No-thanks!
*** The price I would like to pay for the system would depend on how much I payed for the bycycle.
*** Its a good idea - together with the internet - it has to be possible to thange owner.
*** Jeg forventer, at politiet ikke bare skal tæt på og scanne, men at man kan få den _fundet_ ved tyveri. *(question misunderstood)*
*** I would like to know who should keep track of the chips (police, DCF, assurance companies ?)
*** Jeg vil ikke betale en høj forsikringspræmie for at andre stiller deres cykler foran værtshuse og banegårde og på den måde får cyklerne stjålet. Hvis vi fik et system med præmier som er afhængige af antallet af skader på samme måde som bilers kaskoforsikring, ville jeg forsikre cyklerne. Jeg har 6 cykler til en samlet værdi af 40.000 Kr. Kun den billigste bliver stillet på farlige steder. *(I don't want to pay a high premium just because others leave their bikes in risky areas. If insurance companies would introduce premiums depending on individual amount of damage like with cars, then I'd insure my bikes. I have six bikes, worth a total of 40,000 crowns, and only the cheapest gets left in risky areas.)*
*** Man skal sikre sig, at chipsene ikke bare kan findes og tages af *(you have to make sure that the chips cannot be removed)*
*** Normally the bike is keeped in a locked garage. On biking/camping weekends it is usually parked on the campingsite unattended and also often left unattended for several hours during visits to tourist attractions, restaurants, shops etc.
When left unattended it is always locked.

The bike already has a unique number identifying it. It cannot be scanned electronically, but anyone can see it visually. I don't really get the idea of putting an electronic identifyer on the bike, but maybe i overlooked something.

*** If chip could/would be scanned "on the fly" when passing scanner in street, like police speed-control-photo-razzias, the risk os using a stolen bike would increase. I think this would lower the number of stolen bikes, and I would therefore be willing to pay more for the chip, - maybe 250-500 dkr.

*** JA, jeg tror, meget få cykler bliver "fundet". Politiet finder faktisk mange cykler, men det sker typisk på et tidspunkt, hvor den bestjålne har fået erstatning og har købt en ny cykel. Derfor (tror jeg) de fundne cykler sælges på politiauktion og politiet enten selv scorer pengene eller de fordeles til de forsikringsselskaber, der har erstattet tabet for cyklisten. Chip - god ide!! vh Anne Haarløv *(question misunderstood)*

*** Each bycycle has a number that can registrate it if it is stolen. I think that is sufficient.

*** Yes, I don't think the police are visible enough in the streets. A lot of bicycles are stolen i Denmark, but only very few of them are solved by the police. One of the reasons is that it has a low priority.

*** My bike has been stolen once. It is some 30 years ago. And the bike was handed back the same evening with just the lock broken. So, what is the problem !? :-)

*** I'm not sure it would be such a big difference from our current frame number system

*** I am not confident that will change much. Many stolen bikes are thrown away, send out of the country or "stripped". The frame number system actually worked the last time I had my bike stolen, but even though people know, that the police can identify the owners of a bike, the bikes are stolen.

*** Høje straf for cykeltyveri. *(Stricter punishments for bicycle theft.)*

*** A very good idea.

*** Uanset systemets teoretiske effektivitet er det usikkert om pollitiet gider ofre ressourcer på at bruge det. *(No matter the theoretical efficiency of the system, I don't think the police allocate the resources needed to run it.)*

*** Det bliver lettere at finde cyklen igen, men det hindrer ikke brugstyverierne. *(It'll make it easier to find stolen bikes, but it won't stop unorganized thefts.)*

*** nej

*** The attitude the danish police has towards bicycle thefts makes it very doubtfull whether a chip-based system would work.

*** How about a webside where stolen bikes a listet. A system like that is to be found on www.bikebuster.dk. And if my bike where stolen I would immidialtly put it on this page. That way it would be hard to sell,-if a buyer checks the site.....

*** does the battery last for 16 years. A bike has to last for 16 years, with no problems and without any service

*** I have had one bike stolen in 20 years. That is not a huge problem!

*** I don't think a chip would prevent theft. It might be easier to finde the bicycle but that demands that the police has the time and the will to spend the time scanning bicycles. I think it has a very low priority!

*** I don't beleave in it, then the police have no time for it. When I could pay an "Foundingoffice" money for searching every time my bicycle was stolen I wil give op to 250 d.kr. for the chip.

*** Bicykles eqiuped with this chip left at stations or other places could be identified and the owners noticed about the bicycle. This may prevent the number of bicycles left everywhere.

*** Chippen skal være på cyklen når man køber den. *(The chip should be installed when you buy the bike.)*

66

*** I am worried that this could be one of the steps towards a Big Brother society. I might have two bikes in that case - one with and one without the tracing system.
*** Thank you for your work!
*** Big Brother is Watching You - I don't want any kind of surveilance system.
*** Jeg synes idéen er fin. *(I think it's a great idea.)*
*** I think the only effective means against bicycle theft would be a GPS-based tracking system - as seen on current high-class cars.
*** no
*** skynd jer at få etableret et chipssystem! *(Hurry up, get the chip system working!)*
*** Basically it's a good idea, but I very much doubt that the police will use the system effectively which will render the system pretty much useless. My scepticism is based primarily on experiences with the frame number tracking system, which already today allows the police to check bicycles to see if they've been reported stolen. To my knowledge the police has never put much of an effort into such control and hence it has hardly resulted in the capture of any thieves/users of stolen bikes.

Further concerns of mine include
- some stolen bikes are thrown away after a single trip or "cannibalized", i.e. only certain parts are used, while the frame and other parts are thrown away
- perhaps the chip can be removed or the security of the system compromised in other ways
- the system doesn't work, if stolen bikes are smuggled out of the country
*** Could this chip be traced, if the bike would be thrown into the sea or a river?
*** Many bikes are thrown in canals or just left lying anywhere. The chip would not help these cases.
*** Do the police have time for this?
*** Når dagligvare forretningerne - for at undgå butiks tyverier - kan sætte en chip på hver eneste mælk, ost, tyggegummi o.s.v., for langt under 1 krone pr. styk, burde det da ikke være så dyrt på cykler. Noget andet er så, at det jo ikke er bedre end et stelnr.; politiet skal stadig undersøge den enkelte cykel og det har de ikke tid til. *(In supermarkets, they can chip-mark items for less than one crown; it should not cost more on bikes. Secondly, it's no different than the frame number system, and the police don't have time to check that.)*
*** No
*** I can't see, that a chip should make any important difference - compared to the costs of such a system.
*** I suppose that the frame number is unique too, so I can't see, why it is better with a microchip. - In my case it was a problem, that it was stolen in another country and that insurance compagnies pay nothing for an elder cycle, all though the cycle has a big value for the owner. - (I have 2 cycles, a expensive one for everyday-bicykling and a cheeper, elder and leight for recreation tours. And it was the cheep and old one, which was stolen.)
*** Jeg ville muligvis betale mere, hvis jeg købte en ny og dyrere cykel. *(I would possibly pay more if I bought a new, more expensive bike.)*
*** The system is OK if it's impossible to remove the chip. It might not help much because a great number of bicycles ends up in the water or are left with great damages. Unfortunately the Police does not do much to recover stolen bicykles.
*** Hvis det virker er det rigtigt godt, men hvilken stand er cyklen i når den kommer tilbage? Det er derfor jeg svarer "ved ikke". Hvis cyklen kommer tilbage uden en skramme vil jeg være interesseret i at betale mere for en chips, men det er der jo ingen garanti for. Der er heller ingen garanti for at man fanger tyven? Gør man ikke det er det intet værd, idet tyven tager cyklen, måske

ødelægger den og hvad skal man med en fundne ødlagt cykel??. *(What if it works great, but what state will the bike be in when it comes back?)*

*** Cyklen kan nemt blive ødelagt og så er den jo ikke sjov at finde efter tyveri *(The bike might be ruined, and what do you want with a ruined bike?)*

*** RFID is a widespread technology used around the world - its good and realiable. A very good idea.

*** Politiet har ikke resourcer hertil. I forvejen gøres der jo intet for at finde stjålene cykler. Jeg har prøvet at ringe til politiet fordi jeg havde fundet en sjålet cykel, men der sket intet fra politiets side trods jeg ringede tre gange! *(Police haven't got the resources. The police don't do anything anyway!)*

*** Hvis et sådant system skulle vise sig at være gunstigt bør forsikringsselskaberne nedsætte præmien for dem der anvender det. *(If the system is efficient, insurance premiums should be reduced.)*

*** Det kunne være noget der hang sammen med ens forsikring *(It should be part of your insurance.)*

*** No other comments

*** More than twenty years ago I had my old bike stolen at the rail station in the northern part of Copenhagen. It was reported, but was never found.

*** This great idea should be payed by the insurancecompanies.

*** Når påolitiet ikke prioriterer cykeltyveri tror jeg ikke på systemet *(As the police don't do anything anyway, I don't believe in the system.)*

*** Hvem har ressourcerne til at styre dette system? Jeg tvivler på det kan lade sig gøre. Men ideen bør vel prøves af.... *(Who has the resources to run the system? I doubt it's possible, but I guess it should be tested...)*

*** I dont know if such think helps. The police do not do much to pick up stolen bikes at all. If they dont pick them up, they can't find the owner.

*** Maybe my insurance company would be interested in paying for the chip

*** Har længe undret mig over at denne mulighed ikke eksisterer. Jeg forestiller mig det vil have stor præventiv virkning at blot nogle cykler er udstyret med chips. Det er dog vigtigt, at de er svære at fjerne! *(I've been wondering why there was not such a system possible. I would imagine it would have great preventative potential even if only a few bikes had the chip; however, it should be impossible to remove.)*

*** Seems to be a good idea...

*** forsikringen må betale for et chipsystem *(Insurance companies should pay for the chip system.)*

*** A similar project with limited success:

It has been a requirement either to have a chip shot into your dog or to have it "tatooed" in its ear for ID- purpose for more than 10 years. The Police haven't aquired the equipment or learnt how to use it yet.

If the RFID-chip could be read on long distance, like 10m, and organisations like dcf could get list of "stolen tagged bicycles" and some equipment to scan stations, it could help.
It is a general feeling that a significant part of the stolen bicycles are exported. How to get those on their way out in a container?

-

Good luck with your project, the difficult part i not the 20 cents for the hardware on each bicycle, but the part about getting the listing sold, maintained and used.

*** Jeg tror ikke at chippen løser tyveriproblemet, men det gør måske at cyklen hurtigere bliver fundet igen. *(I don't think it would prevent theft, but bikes would be retrieved faster.)*

*** Chippen skal være meget lille og placeret diskret. *(The chips would have to be small and discreet.)*

*** det vil være en fin hjælp til stelnummeret, men det vil ikke afholde uærlige folk fra at stjæle en cykel en aften på stationen for at komme hjem eller i byen *(It would be a good supplement to the frame number, but I don't think it would prevent the "going home thief".)*

*** God ide ift. at få ryddet op i cykler, der står rundt omkring i byer og fylder (uden en retmæssig ejer). Udgiften kunne holdes omkring 100 kr. til en sådan chip! *(Good idea because it would help clean up all the bikes just lying around without rightful owners.)*

*** Nej

*** the chip may easily be removed/destroyed, if needed

*** It could be an obligation (by insurance)and put on all new bikes

*** It vould be better if you could see on a map, where the bicycle is, could be gps. I don't think it helps much that the police has to find the bicycle first - they don't do that.

*** chip-systemet lyder til at være en god ide

*** I cannot see how this system should prevent persons of stoling cycles;

*** Da politiet er underbemandet er cykeltyveri noget af det der prioriteres lavest. Dette finder jeg helt forståligt (men skide irriterende, når det er en selv det går ud over). Derfor tror jeg at en chip på cyklerne ikke vil have nogen effekt.

Appendix C: Focus Group with DCF Members

The following is a summary of the focus group conducted with members of the DCF on May 3, 2005, at 17:30, facilitated by Kevin Glynn, Kristopher Houle, and Jennifer Schweers. In attendance were Mike Bosworth, Roger Christensen, Lars Alexandersen, and Stefan Morbers. At the beginning of the focus group, the project team explained details of the tagging system, including technology, cost, installation, and logistics.

General discussion regarding bike theft:

There was disagreement about what purposes bikes are stolen for. One group member theorized that most bicycles stolen are shipped out of the country for resale, to Poland or elsewhere in Europe. Another thought this was unlikely, that most thefts are for convenience. He did not believe that there is much of a problem with organized crime in Denmark, in part because if there were, police would catch someone engaging in it eventually. It would be too suspicious to be driving around at night with a truck, picking up bicycles. Another group member commented on the possibility of bikes being stolen so that their parts can be sold off. One group member had lost a bike to theft almost twenty years earlier; it was recovered five years later when a police officer stopped someone for a minor infraction, checked the frame number, and discovered that the bike was stolen.

General discussion regarding tagging system:

Very promising aspects of the system include being able to identify abandoned bicycles rather than having them scrapped as well as being able to check frame numbers quickly, since it currently is not worth the trouble to randomly check the numbers, although they are checked when cyclists are stopped by police. The ease with which a thief can remove the tag will greatly affect the success of the tagging system. Shops, however, may need to be able to remove the tag in order to service the bike or if the tag becomes damaged. There may be a problem with would-be thieves breaking into bike shops to steal whatever tools are needed to remove the RFID tags from the bikes. Also keep the status of bicycle importers in mind. Very few bicycles are actually manufactured in Denmark, though some are assembled here. Most come from the far east, particularly Taiwan. If told to put chips into the bikes, they will put chips into the bikes, though; they make whatever is ordered. This would be different from Holland though, where many bikes are actually manufactured in Holland and all of the Dutch manufacturers are now putting chips in their bikes. There is a significant waiting time to the system. So many bicycles are sold in Denmark that if every new bike were outfitted with a chip, there would quickly be plenty of bicycles on the street with chips. There also need to be a significant number of bicycles reported stolen before scanning would be worthwhile, though. If police begin a scanning campaign and find that every bicycle they scan is legitimately owned, they will quickly lose interest in scanning. As far as price is concerned, the nine or ten euros paid per person in Holland is reasonable. Seventy crowns would be fine and a hundred might be all right; once the price rises closer to two hundred crowns, the tag becomes too expensive.

Discussion on whether system should be required or voluntary:

The system should be required. If it is voluntary, not enough people will participate to make the system worthwhile. If not required by law, it could perhaps be required by insurance companies, as

certain locks are now required, so that one cannot insure a bicycle unless it has this electronic tag. It would be simpler, though, for the requirement to come from government rather than private insurance companies. Also, you need to keep in mind that some people will not want the chip on their expensive bikes, and you will need to take this into account.

Discussion on who should take care of scanning bicycles:

Some members thought scanners should be widely distributed to different groups, while others thought that as few people as possible should have scanners to reduce the possibility of criminals acquiring scanners. However, criminals having scanners was discussed and the consensus was that it should not be much of an issue. The main security issue would be the security of the database, not the scanners themselves, and, were a scanner to be stolen, it could be blocked from accessing the database. Whatever groups have scanners need to also have the power to hold onto a bicycle learned to be stolen. They could, for example, be given to the owners of large bike shops, but these owners do not currently have the authority to confiscate a bicycle that they find to be stolen. Scanners should be given to police, but not only police. There was some disagreement as to whether or not the police have resources to devote to scanning bikes, but there was general agreement that the police alone would not likely scan enough bicycles, whether for lack of resources or lack of desire. Parking attendants are already overworked and harassed; it would not be a wise choice to have them perform the scanning. Train companies such as DSB, or whoever it is that owns the train stations, are a possibility. They already put energy into clearing up abandoned bicycles, so they might as well scan the bikes instead of just scrapping them. There is the possibility of the fire department, since they already dredge the lakes and canals to pull out abandoned bicycles. The police alone would be insufficient. Police in Denmark work by campaign – for a week, they warn the population that they're going to be checking bicycles, and then they do it. They won't routinely check bicycles. People associated with train stations are a definite possibility, though. Municipality workers would also be a possibility, whoever it is that picks up abandoned bikes. You could give scanners to those at train stations to scan heaps of bikes at stations and then to municipality workers to scan racks of bikes at schools; that could work. There are probably people somewhere in the municipality infrastructure who could scan bikes.

Discussion on other methods of combating bike theft:

SREG was discussed; the group was not especially impressed by it. They said that many or most new bikes in Denmark are sold with it included, so at least one member had owned bikes with SREG protection, but he did not renew the membership and doubted that many other people did. One interviewee's son had just had a bicycle stolen; the bicycle had been bought with an SREG membership that had since expired, but he was not at all dismayed that the bike was no longer protected.

Other comments:
Keep in mind that in Denmark, biking is a normal part of life, used for basic transportation. For that reason, campaigns to encourage people to wear helmets have not been successful; helmets are seen as unnecessary because biking is not viewed as anything special. Compare this to Australia, where biking is done for sport and for longer distances, where cycling gear is more popular and helmets are mandatory. It's a very different culture. Biking is popular in both Denmark and Australia – bike sales recently surpassed car sales in Australia – but they have two different cultures

Appendix D: Focus Group with the WPI Cycling Club

The following is the list of questions and answers from a focus group with members of the Worcester Polytechnic Institute Cycling Club. It was facilitated by Kristopher Houle and Jennifer Schweers and took place at 14:00 on February 17, 2005. The following members of the WPI Cycling Club were present: Christopher Rehm (Advisor), Theodore McDonald (President), and Matthew Finch.

1.) How often do you ride?

   Usually 4-6 days a week, more often when the weather is nice (April to October).

2.) Do you ride for recreation, transportation, or both?

   Mostly for recreation but also for transportation up to 1-2 miles.

3.) How much money have you invested in your bicycles?

   USD 1000 - 2000 for road and mountain bikes; race bikes up to USD 5000.

4.) What types of places do you ride?

   Mostly country roads but city roads, trails, and race tracks occasionally.

5.) Has anyone had their bicycle stolen or known someone who has?

   Chris Rehm states that "Someone once tried to steal my bike while I was riding it in Washington D.C. Other than that, no." The others had not experienced any theft.

6.) What types of places do you view as a high theft location?

   Considering the value of our bicycles, basically everywhere. Risk is not so prevalent in places with a large cycling community.

7.) What precautions do you as cyclists take to prevent theft?

   When we lock our bikes, we usually use a Kryptonite U-lock but we try to take our bicycles inside most places we travel. Chris Rehm keeps his bicycles inside his house; all of the cyclists have taken their bicycles inside stores with them to prevent theft.

8.) Has anyone ever registered their bicycle with their local police department or any other bicycle registry?

   Chris Rehm states that "I was required to register my bicycle with the police department when I lived in Arkansas. We were given a sticker to put on our bike and I believe that was a big deterrent for theft."

Other members: "No." They did comment on the fact that bicycle shops typically ask for identifying information from the people they sell bikes to and then associate this information with identifying information about the bicycles that they buy, a register-type system but on a small scale.

9.) Have you heard of the National Bicycle Registry?

No. Upon learning about it, however, they were interested in registering.

[At this point, the team gave an introduction to the objective of the project, focusing on details for the RFID tracking system.]

10.) Would you ever consider purchasing an RFID tracking systems?

Yes.

11.) How much money would you be willing to spend on such a system?

Any reasonable amount of money. The highest price named for a system was about USD 40, which the cyclists deemed reasonable.

Extra Notes

The members of the WPI cycling club had concern with the weight of a tracking system. The project team ensured them that with the RFID system, weight would not be an issue because the devices can be as small as a grain of rice.

Appendix E1: Bicycle Shop Interview: Loke Cykler

The following interview took place with Lars of Loke Cykler, on 12 Norrebrogade in Copenhagen. It was conducted by Kevin Glynn during the morning of April 20, 2005.

[The project's goals, the RFID tracking system being proposed, and the pilot program in Holland were explained at the beginning of the interview.]

1.) How effective do you believe this system would be for preventing bicycle theft?

Sounds like a very good idea. Seems like it could be very effective, but if these scanners are given to police to use, they won't use them, I don't think. They just don't have the man power, so they won't concentrate on it. You would need to have it be done through a private company probably.

2.) How much might you charge for installation? Do you think your customers would find this investment worthwhile?

If it's as easy as it sounds to install the tag, it wouldn't be an expensive thing. Probably 50 kroner or less, but it depends. I think customers would definitely pay this and consider it a worthwhile investment, especially if they were buying a new bike anyway. Even if someone were coming in just to have a bike fixed or tuned we could offer it and explain why it is useful.

3.) Approximately how large is your customer base, in terms of number of bikes sold?

Probably about 500 bikes each year.

4.) Do you collect any personal information from your customers for the purpose of matching missing bicycles to their original owners?

Yes, by law we have to take their personal and contact information. That way, there's a sort of receipt or proof that you bought the bike here.

5.) How concerned do you believe your customers are about bicycle theft?

They are definitely concerned. I talk to people almost everyday that have had bicycles stolen. Sometimes they end up just buying a new bike from the super market. They get a cheap, low-quality bike because they figure it's just going to be stolen again anyway.

6.) Is your shop associated with SREG?

Yes, we have an arrangement where most bicycles coming out of this shop are sold with a six month membership to SREG included. Then they have to renew the subscription if they still want it.

7.) Do you have many people renew?

Yes, actually a number of people come back to renew the membership.

8.) What are your thoughts on the system SREG uses?

I think it's a good idea. I don't really know if it works, like if it gets people's bikes returned to them or if it stops people from stealing bicycles, but I think it's a good idea. The stickers that go on the bike are ugly, but I just hide them down here where you can't really see it. I think that SREG basically just pays people 1000 kroner. It doesn't seem like they do much else. They have some people walking around looking for bicycles that are stolen, but I don't know if they ever find them.

9.) Do you foresee any problems with the proposed RFID system?

Just that the police shouldn't be the ones to control the system. It should probably be a private company, maybe insurance companies or something like Europark. Europark is who writes parking tickets now in Denmark. The government doesn't do it anymore. Now this company has the authority through a contract with the government, and it seems to run more efficiently. It these scanners were in the hands of a group like that, then I think the system would be more effective.

Appendix E2: Bicycle Shop Interview: Søgade Cykler

The following interview took place with Henrik of Søgade Cykler in Copenhagen. It took place the morning of April 19, 2005 and was conducted by Kristopher Houle and Jennifer Schweers.

[The project's goals, the RFID tracking system being proposed, and the pilot program in Holland were explained at the beginning of the interview.]

1.) How effective do you believe this system would be for preventing bicycle theft?

The system is a good idea and could potentially be effective so long as the technology is robust.

2.) How much might you charge for installation? Do you think your customers would find this investment worthwhile?

Installation would be cheap; the nine euros or so that a tag costs through the Holland program is certainly reasonable. Most customers would probably find this a cheap, worthwhile investment.

3.) Approximately how large is your customer base, in terms of number of bikes sold?

About five hundred bikes sold each year.

4.) Do you collect any personal information from your customers for the purpose of matching missing bicycles to their original owners?

Name, address, phone number, etc. are collected for every bike sold. They are required by law to be kept for five years, but we usually have them around longer than that. If a bike is stolen, the customer can come to us for proof that the bike was bought from the shop, so the information-keeping works as a kind of receipt. Customers do not report stolen bikes to us, and police do not come to us when a stolen bike is recovered to locate the customer.

5.) How concerned do you believe your customers are about bicycle theft?

Somewhat concerned, but because of insurance, theft is mostly an inconvenience. The amount that insurance companies will reimburse typically decrease by 10 percent each year. Depending on the insurance company, a set amount (deductible) may also be unavailable to a victim of cycle theft.

6.) Is your shop associated with SREG?

Yes, most bikes sold in the shop come with SREG for free, and most customers want them. The shop has an agreement with SREG, as do certain manufacturers, though the manufacturers have a closer relationship with SREG than the shop does.

7.) What are your thoughts on the system SREG uses?

Not sure how effective the system is, being unaware of any statistics of SREG's success. The SREG system is a good idea in theory, though.

8.) Do you foresee any problems with the proposed RFID system?

The chip must be very sturdy. Keep in mind the weather damage and wear and tear that bicycles receive. These cause other bicycle parts to wear down quickly. The chip (or its casing) must be able to withstand water, salt, etc. without significant damage.

Appendix E3: Bicycle Shop Interview: Byman Cykler

The following interview took place with Dan of Byman Cykler in Copenhagen. It took place the morning of April 19, 2005 and was conducted by Kristopher Houle and Jennifer Schweers.

[The project's goals, the RFID tracking system being proposed, and the pilot program in Holland were explained at the beginning of the interview.]

1.) Approximately how large is your customer base, in terms of number of bikes sold?

   About four hundred bicycles are sold each year.

2.) Do you collect any personal information from your customers for the purpose of matching missing bicycles to their original owners? How do you keep records these records?

   Yes; the law requires that records are collected from each customer and kept for at least five years after the sale.

3.) How concerned do you believe your customers are about bicycle theft?

   Very concerned; all kinds of bikes are stolen – old and beat-up ones are well as new ones in mint condition.

4.) Is your shop associated with SREG?

   Many of the bicycles sold in the shop come with an SREG sticker and six-month membership. The shop has no agreement with SREG; it is the manufacturers that do.

5.) What are your thoughts on the system SREG uses?

   The system is not useful, almost to the point of being a hoax. The police do not scan SREG bikes and I do not think they even have scanners. Some are not aware of SREG at all. Most customers do not renew their memberships with SREG after the initial one runs out. In general, SREG is a joke.

6.) How effective do you believe this system would be for preventing bicycle theft?

   Could be effective; a good idea.

7.) Would you be willing to install this type of system on the bicycles you sell and work on?

   Yes.

8.) How much might you charge for installation? Do you think your customers would find this investment worth while?

Customers would likely take to the system. The price of tags being used in the Holland pilot is certainly cheap enough.

9.) Do you foresee any problems with this type of system?

The chip (or its casing) must be durable enough that a thief could not easily remove or incapacitate it. There may be some objections to adding more weight to bicycles, particularly racing cycles. However, racing cycles are not likely to be left lying around in the street anyway, so they would not need the chip. There also needs to be enough manpower in the police force that time can be devoted to scanning bikes. One person with a scanner could very quickly scan a lot of bikes in a train station, but the police need to be willing to put forth effort for the system to work.

Appendix E4: Bicycle Shop Interview: Easthampton Bike

The following interview was conducted with Matthew Still, the owner of Easthampton Bike (Easthampton, Massachusetts). It was led by Kristopher Houle and took place at 17:00 on February 19, 2005.

1.) Approximately how many bicycles do you sell per year?

About 200 bikes

2.) When you sell a bicycle, do you collect the information such as serial number, model, and make before it leaves the shop?

Yes I do. The city ordnance in Easthampton requires every person to register his or her bicycle with the police department. After doing this, the person is given a license plate for their bike. I record the information to give the customers the extra security. If a problem arises, I can look back in my files to see if I can match the frame with person who purchased it.

3.) Have you ever had to revert back to your files for this type of situation? If so, was it successful?

One time I had to match specific components back to the original purchaser. This was difficult because only frames usually have serial numbers. Nevertheless, I was able to find the information and the parts were returned.

4.) Do you tend to sell a large number of bicycle locks?

About 50 percent of bicycle purchasers buy a lock with the bike.

5.) What style of bicycle lock is most commonly sold?

Mainly cable locks. U-locks are not as popular because of the weight and bulkiness.

6.) Do you feel that your customers are concerned with bicycle theft?

For the most part no, but some customers are.

7.) Other than Easthampton Police registry program, are you familiar with any other bicycle registries, such as the National Bicycle Registry?

No

[After a brief description of the NBR and their packages]

8.) Would you be interested in carrying the NBR packages?

Yes. I would like some more information if it's available.

[At this point the interviewer gave a brief description of the RFID tracking system.]

9.) Do you think that an electronic tracking device like the one just described would be useful and popular for bicycle application?

Yes and no. The device would have to be well hidden and protected from thieves. Once thieves find out where in the bike the chips are located, they could be removed. The chips would have to be in some type of small case welded inside the frame tubing. If this was achieved then the system might be very useful for locating bikes.

Appendix F: Interview with Danish Crime Prevention Council

The following interview was conducted by Kevin Glynn at 13:00 on April 27, 2005 with the Police Inspector of Denmark's Crime Prevention Council (Det Kriminalpræventive Råd), Henning Maigaard.

1.) What exactly is the role of Det Kriminalpræventive Råd in relation to the local police departments? In relation to bicycles and bicycle theft?

> We are a national council concerned with all types of crime. We are primarily concerned with educating Danes, especially young people, to prevent them from becoming criminals. The police are our biggest partner, in a sense, in that we give them literature—pamphlets, periodicals, etc.—and educate them on how to educate school children and the like. As far as bicycles and bicycle theft goes, it is a very low priority for police here, so we do not put much emphasis on this type of crime. The last publication we made was probably 4 or 5 years ago, but there was no interest in it, so I don't think we will make another one for quite a while.

2.) How does your organization ensure that the police are following through with their responsibilities?

> We don't really have any sort of authority over the police, so it's not up to us that they are fulfilling their responsibilities.

3.) How much of a concern do you feel that bicycle theft is for Danish citizens?

> I myself know many people who have had a bicycle stolen 2, 3, or even 4 times, and the police do nothing about it. The bicycles are very seldom returned to the owner, as well, so I think it is very much a concern for Danish citizens.

4.) What is the current process taken by police officers when a bicycle is reported stolen?

> They log it into the computer system. The computer system is actually relatively new, and it is used to keep a record of the frame numbers of each bicycle and also to record them as stolen. It was paid for by the insurance companies.

5.) What is the process when a bike that is believed to be stolen or lost is located?

> Usually the way it works is people—who live in the area or work in the area for the city—notice a bicycle or a couple of bicycles that have been left in the same place for

a few days or a couple weeks and they assume they are stolen. Then they might just put them into their trunk and take them down to the police station. The police then look up the frame number of the bike. If it is reported stolen, they then check to see if the owner got money from the insurance company. If they did get this money, then the police just give the bicycle back to the insurance company because it is now their property, and then the insurance company either trashes the bike or sells it. Otherwise they contact the rightful owner and give it back to them. I've never known anyone who has got their bike back in this way, though.

Police do have campaigns once or maybe twice a year, where they go out for a couple days looking for stolen bicycles, checking each frame number to see if it is stolen. They find many stolen bicycles, but most have, of course, already been compensated by the insurance company, so the bike goes back to them, not the original owner.

6.) Do these processes differ from police department to police department?

No. Each police department can look up this information in the computer system because it is a closed net (not exactly internet) for only police. Then they follow the procedure described above.

7.) How frequently are bicycles reported stolen?

[Mr. Maigaard cited a printout taken from the Forsikringsoplysningen (Insurance Company Trade Group) website, from which this following information comes:

There were 50,786 bicycles stolen in 2002, 52,117 in 2003, and 53,336 in 2004.]

8.) How frequently are stolen bicycles recovered?

Not very frequently. Almost all bicycle thefts are compensated by insurance companies. Very few are recovered before the 20 days are over.

[Team explained proposed tracking systems]
9.) Do you think that an electronic tracking system for bikes would be a helpful tool in theft prevention?

Yes, I believe it would be very helpful, but it probably wouldn't be best to put the scanners in the hands of the police. Bicycle theft just doesn't have a high enough priority for the police. Burglary and violence get most of the attention. There are some people who would be more likely to make use of the system because they are already out working in the streets. There are groups of people that work for the

insurance companies, often they are retired police officers with good knowledge of crime, that walk around looking for stolen cars. These people might be better suited to be given a scanner. Since they are already out looking for stolen cars it wouldn't be so hard for them to also scan bicycles at a train station or abandoned in an odd location. Also, there are people who are employed by the municipalities, cleaning streets, collecting garbage, writing parking tickets, etc. These people are often interested in this sort of thing as well. If scanners could be handed out to people doing these jobs and they were trained on how to use them, they might be able to make a difference also. People responsible for the city-bike program could also be helpful with this because they are always interested in trying to keep the city-bikes inside Copenhagen.

10.) How supportive of such a system would your organization be? Would police be?

As I said before, bicycle theft is a pretty low-priority point with police here, so they may not be very interested in doing the extra work it may include. We would probably be very supportive of it, but I don't know how much we could actually offer. If it were something that the police could just mount inside their cars that would automatically scan for these RFID tags, then it would probably be very well accepted. However, you said that the read range of these scanners is not yet capable of such a read range.

11.) Who would be responsible for administering any new database software?

As I mentioned, the insurance companies funded that computer system for the frame number system, so I imagine they would also help out with this one if it were to go to the police. Possibly, the scanners would be able to access the database even if non-police officers were using the scanners. That way it would operate using the database that is already in use, and just the tags and scanners would need to be distributed.

Further comments: We are also willing to give some money to a project such as this if we see that it is worth it. Maybe only 5000 to 10,000 DKK, but it's something. There is an application on our website: www.dkr.dk.

Appendix G: Interview with WPI Police Chief John Hanlon

The following interview with the Director of Public Safety for Worcester Polytechnic Institute, John Hanlon, was conducted by Kristopher Houle at 13:00 on February 15, 2005.

1.) How long have you been a police officer?

I spent 26 years with the MA State Police and retired in 1990. I began as the Director of Public Safety at WPI that year.

2.) Do you feel that bicycle theft is an issue on campus?

No. There are few students that use bicycles as a mode of transportation. Those that do tend to keep them inside buildings or locked up.

3.) What is the current process taken by you or your officers when a bicycle is reported stolen?

An initial report is filed with dispatch then an officer conducts an interview with the bicycle owner and retrieves information about the bike such as a serial number, make, model, and color. This information is then entered in to the LEAPS computer system which is a state-wide database for stolen items. If the bicycle shows up in another city, it can be traced back to WPI. Lastly, a formal report is filed.

4.) Can this system be accessed by police departments in other states?

Yes it can.

5.) What is the process when a bike that is believed to be stolen or lost is located?

The information of the bike is entered into the LEAPS system to see if a report has been filed.

6.) Have these processes ever differed at other police departments you've work at?

(Question not asked because of previous explanation of the LEAPS system)

7.) Is it rare for bike thieves to be apprehended and convicted?

Generally, I believe thieves are usually apprehended less than 10 percent of the time. However, theft is not a big problem on campus and we are quite aware of the local thieves. Close tabs are kept on these individuals.

8.) From your experience, are there any places you view as a high risk for bicycle theft?

City parks are usually a place of high risk. For instance, when children leave their bikes somewhere and go play elsewhere. Theft from households occurs often when bicycles are left out in the front yard.

9.) Are you aware if people tend to lock their bikes at these places?

Question not asked

10.) Have you ever heard of the National Bicycle Registry?

No I have not, but one of the younger officers may have. I was in upper management by the time it began (1984).

11.) Have any police departments you've worked at ever used the NBR database to locate bicycle owners? Not Applicable (N/A)

12.) If so, was the system successful? N/A

13.) Easy to use? N/A

14.) Do you think that an electronic tracking system for bikes would be a helpful tool in theft prevention?

(After a brief explanation of how the RFID system works):
I think it sounds like a good idea as long as the device is completely hidden from sight.

15.) Does the WPI Police run the laptop security program on campus?

Yes

16.) If so, please explain briefly how the system works?

You will have to speak to Neil Spellman about this because he is in charge of the program.

Appendix H: Interview with SREG: Torben Makholm

The following interview took place on April 5, 2005 at 10:00 with Torben Makholm. It was conducted by Kristopher Houle and Jennifer Schweers.

1.) We understand that SREG provides coverage for up to DKK 1000, is this correct? How else does SREG operate? Do you incorporate the Danish frame number into your system?

SREG incorporates as much information as possible into a database. This includes the frame number, make/model #, and any necessary information about the owner. SREG provides a decal that is difficult to remove and that contains a unique ID number. If your bike is registered with SREG and it is stolen, SREG will compensate the owner up to 1000 DKK to make up for the amount an insurance company will not pay. There is a 30 day waiting period before this money is given out and full documentation concerning payment from the insurance company must be submitted.

SREG can also be used for registering other items such as keys, wallets, laptop computers, and any other valuables.

2.) Approximately how many bicycles are registered with SREG? How many bicycles are registered in Scandinavia or SREG's entire customer base?

About 0.6 million in Denmark, and about 2.6 million across Scandinavia (Denmark, Sweden, Finland).

3.) Approximately how many bicycles are reported stolen to SREG each year?

About 4,500 in Denmark

4.) Does SREG make any effort to locate stolen bicycles?

No one physically goes out looking for bikes but if a bike if found and called in to SREG, they will notify the insurance companies and the original owner.

5.) If so, how many of the bicycles reported stolen are eventually located?

About 15,000 in all of Denmark, Scandinavia, and Finland.

6.) Is it strictly the police who locate stolen bikes and report them to you or can anybody do so?

Anyone can report a bike found by calling the phone number on the sticker.

7.) How much does an SREG membership cost? What length of time is it for?

The standard cost is DKK 164 for a 1 year membership. The price may be higher depending on the plan (DKK 198).

8.) How often do people renew their membership with SREG?

We are happy with our renewal rate.

9.) How closely do you work with the local police departments, insurance companies, or other organizations?

Primarily with SSF (a Swedish version of the Crime Prevention Council).

10.) What manufacturers are you associated with? How many bicycle shops (in Copenhagen) support SREG?

Will receive more information in a follow up email.

11.) Does SREG receive funding from any other sources (than the ones just mentioned)?

No

12.) Would SREG have the money to finance a "bike corps" to look for stolen bikes? Would members be interested in such an idea?

SREG has looked into a similar idea referred to as "bike-busters." The Communication Company was involved in this idea.

13.) Would SREG support financially a system where each registered bike was to be tagged with a microchip that when scanned could trace the bike to its rightful owner. An ideal system would be one where a police officer could walk along a bike rack, easily scan each bicycle, and be alerted by his scanner if one of the bikes had been reported stolen.

SREG has done research on a very similar idea, however, they did not see RFID as a logical solution. It was found to be too expensive and there were problems with reading the signal from the tag because of the metal bike frame.

14.) What type of data would you look for before giving financial assistance for such a system?

They would have to see that the system actually worked properly and that it was cost effective. The system would also have to be implemented to the majority of existing bikes. In order for the efforts of the police to be useful, many people must have the tag inside their bicycles. If the popularity of the system is too low, it will not work. The logistics of the entire system would also be necessary.

Appendix I: Interview with Danish Insurance Trade Group

The following is a summary of an interview with Knud Knudsen of Forsikring & Pension, which was conducted by Kevin Glynn on April 1, 2005. Forsikring & Pension is the trade group that represents and speaks for all insurance companies in Denmark.

The goal of our project is to determine whether an electronic tracking system is necessary and feasible as a solution to the problem of bicycle theft in Denmark. We are proposing for a simple microchip to be installed on bicycles. Each chip would contain a unique identification number. Police would have scanners that would read the identification number on any bicycle. If the bicycle is reported stolen, it can then be returned to its rightful owner. This chip system would serve as a modernization of the current Danish frame number system.

1.) It has come to our attention that Danes may not always report a stolen bicycle to the insurance company or police. How many victims do you estimate neglect to report the theft each year?

I don't know. Of course this happens sometimes, but we can't be sure how often it happens or how common it is.

2.) How many total policy holders do insurance companies compensate for a bicycle theft each year?

About 51,000. There are more reported, but according to Knud Knudsen almost all of them are compensated, therefore this estimate should be very accurate. There are maybe 1,000 claims that are not compensated, which is a small portion of the 51,000 claims that are.

3.) How much do insurance companies spend each year investigating/preventing bicycle theft?

Nothing. This is a job for the police. If the bicycle hasn't been located after 20 days from reporting it stolen, then we give them money. If it is located within that time period, then it is returned to the rightful owner.

4.) How much do insurance companies spend each year compensating victims of bicycle theft

About DKK 141 million

How common is it for bicycles to be insured under a special personal property policy, specifically for the bicycle? About how much does this normally cost?

Not common because normal homeowners insurance covers multiple (six or seven) bikes, each of which is protected for up to DKK 7,000. Bicycles sometimes cost upwards of 20,000, but to insure a bike for more than DKK 7,000, one must contact their insurance company and set up a special contract specifically for the item. This is not very common.

5.) If a system were implemented that made it easier to locate stolen bicycles and potentially prevent future thefts this may cut down on time and money spent by insurance companies with regard to bicycle theft claims. If such a system were implemented, would insurance companies consider adjusting the premium? If so, how would this adjustment be determined?

It would have to be in effect for a few years before the insurance companies would make a decision like that, and it is more likely that they would just make it a requirement to have the system installed on your bike in order to be covered in the event of a theft.

6.) In the U. S., insurance companies fund organizations called Industrial Trade Groups or Industrial Trade Organizations, which conduct research that interests insurance companies. For example, the Highway Safety trade group works with automobile insurance companies to decide what sort of damage to cover under their insurance policies. They simply look into questions and concerns of insurance companies in order to come up with solutions. Is the system similar in Denmark? If so, what trade groups do insurance companies work with here that specifically concern bicycles and bicycle theft?

Not the same thing in Denmark. It seems as though they have something similar to this, but it is not a permanent group as established as in the States. Instead, interested groups will send an employee to be a part of a group, such as a group that tests bike locks. The Insurance House, the DVN, the Police, and the DCF all sent an employee to be a part of one such group. They are the ones who decided which bike locks were acceptable and which were not.

7.) It has come to our attention that some insurance companies have groups of people, normally retired police officers that go around the city with the intentions of locating stolen vehicles. Would insurance companies be interested in funding such a program for locating bicycles, in which each person in this group would be given a scanner to scan areas most likely to contain stolen bicycles?

Yes, this is the case with stolen automobiles, but they don't currently have anything like this in place for bicycles. In order for it to be considered for bicycles, there would need to

be an easy way to scan the ID number (our proposed system hopefully). If an officer could walk by a bicycle with his scanner held out and easily scan many bicycles at a time then it would be quite feasible to have a force such as this.

Appendix J: Interview with Sullivan, Garrity, and Donnelly (Worcester)

The following are the questions posed to Jack Curran, the president of the Worcester branch of Sullivan, Garrity, and Donnelly Insurance Agency, and summaries of his answers. The interview was conducted by Kevin Glynn at 16:00 on February 8, 2005 in the Insurance Agency's office on 10 Institute Rd Worcester, MA. The purpose of the project was explained prior to the interview.

1.) How could someone insure a bicycle in the U.S.?

We do not insure bicycles in the U.S., but one can insure personal property under their homeowner's insurance. Therefore, a bicycle would fall under this category. However, most bicycles would not be insured specifically, they would just fall under the homeowner's insurance automatically.

2.) If a tracking system came out for something, not necessarily bicycles, that was similar to Lojack for automobiles, would you fund a pilot program to test the system and determine whether it could warrant a discount on the premium?

No. No insurance company would do that sort of research. Premium discounts do occur such as the 35 percent that one saves on car insurance by installing and using Lojack, but the insurance company didn't do the research to determine that. Instead, Insurance Companies and Agencies support what are called Industrial Trade Groups or Trade Associations. These associations are the ones who research problems such as theft. There are standards set by these associations, as well as technology tested. They are the ones that the insurance companies listen to, and then we make are decisions based upon their research and reports.

Appendix K1: Interview with Researchers: Neil Rankin of WPI

The following are the questions posed to Neil Rankin, an adjunct professor in Worcester Polytechnic Institute's department of computer science, and summaries of his answers. The interview was conducted by Jennifer Schweers at 12:00 on February 9, 2005. The purpose of the project was explained prior to the interview.

1.) What sources of information would you recommend for gathering information about RFID technology?

There is such a wealth of information available that no particular source stands out. Sufficient information about the workings of such systems is available through simple web searches and Wikipedia.

2.) How cost-effective could a tracking system based on tracking technology be?

A system based on RFID tags could be extremely cost effective. The tags themselves are very cheap. They are inexpensive enough that some stores have begun to attach an RFID tag to each product and then scan them when doing inventory. There are proposals to outfit individual items sold in the produce sections of grocery stores, even individual vegetables, to have tags attached to them so that shoppers can scan the items and learn about where they were grown and in what conditions. Currently, there is a tire company that places tags inside of its tires, although their reasoning for this is unclear. Although Professor Rankin was not sure exactly how much it costs to produce an RFID, these situations suggest that the tags are cheap enough that the cost they would add to a bicycle would be negligible. The scanners, however, are more expensive and may be hundreds of dollars – again, the exact amount is uncertain.

3.) What privacy concerns would be likely with such a system?

The privacy concerns depend on exactly what type of system is used. A system that tracks the location of bicycles at any given time would be of greater concern than a system where bikes are only scanned when they are turned in to police. Professor Rankin cited the old Massachusetts system of registering all bicycles with a license plate as an example of a widely accepted identification system. The RFID tagging system would be similar. Because no identifying information is carried on the tag itself, only a number that is then matched to information in a secure database, privacy concerns would likely be minimal.

Further notes

There is a difference between "active" and "passive" RFID tags. Passive tags are smaller and have no power source, whereas active tags are equipped with a battery and are larger and heavier. Active tags can be read by scanners that are farther away; the New York Thruway and the Massachusetts Turn-Pike toll highways use active tags in their automatic tolling system. Rankin's opinion was that the European public is more accepting of electronic tagging and tracking than the American public and that such tracking is more prevalent in Europe.

Appendix K2: Interview with Researchers: William Michalson of WPI

The following is a summary of the interview with Doctor William R. Michalson, associate professor of electrical and computer engineering at Worcester Polytechnic Institute. The interview was conducted by Jennifer Schweers on February 21, 2005 at 9:00. It was highly open-ended. The interviewer explained the project's aims and current knowledge and then asked for feedback on the team's proposed solutions.

There are two problems at hand: the problem of identifying a recovered bike and that of locating a stolen bike. Let's look at location first, which has been addressed for vehicles by systems like LoJack. The signal sent out by the bike's transceiver does need to be picked up by something. With LoJack, police cars are outfitted with four antennae, one on each corner of the roof, which are continually scanned. Signals from stolen vehicles cause a Doppler disturbance which is then analyzed to determine which direction the signal is coming from. This is the simplest, cheapest way to pick up signals from the stolen cars. One problem with implementing such a system with bicycles is that the transceiver must have an antenna. In cars, the radio antenna is used, but on bicycles, an antenna would be conspicuous and easily destroyed by a thief. The frame of the bicycle itself could be used as an antenna, provided you calculated the resonating frequency of the metal in the frame. The transceiver would need power, but very little, only in the order of microwatts. This could be provided for a long time by a single rechargeable battery; if you wanted to, the turning of the pedals could be channeled to charge the battery and would provide plenty of power to keep the battery charged, assuming that anyone concerned enough to use such a system is probably a regular cyclist. Sending signals out after the bike is stolen takes more power, but since there is a limited time frame where it is likely to recover the stolen bike, power will probably not be the limiting factor. For LoJack to work, there does need to be a police car equipped with the system somewhere in the area; a car stolen in rural Arkansas, for example, will probably not be picked up by LoJack. In more urban areas where most of the local police have been outfitted with the system, it works. Having many bikes in the same area with this system would not create any kind of jamming problem, unless all of the bikes had been recently stolen and were therefore all sending out signals. The electronics for such a system are small enough that they could feasibly be contained inside the bike's seat post.

GPS systems would be another option that would locate a stolen bicycle. Again, an antenna is needed, and this would be conspicuous on a bicycle. If the antenna is damaged, the GPS will not function. Also, GPS systems work only so long as satellites are visible. If a bicycle is taken indoors, the system is useless. Problems are also created in large cities like New York, where narrow streets and tall buildings create "urban canyons" that disrupt signals. This may or may not be a problem in Copenhagen, depending on how high buildings there tend to be. GPS systems can be small; there is a kind of watch device called Guardian Angel that is currently marketed to parents for keeping track of their children; the parent can place a call and be given the child's approximate location.

Cell phone-like devices – not necessarily actual cell phones, but devices that use similar electronics – also pinpoint location. There is a system called E-911, with a counterpart in Europe called 411, that pinpoints the location of 911 calls made from a cell phone, if that phone is E-911-enabled, to within tens of meters. Again, a small antenna is needed. The advantage of this is that it works wherever there is cell phone coverage, which is particularly widespread in Europe. The European 411 is likely a bit more advanced than the American E-911 because of the higher popularity of cell phones in Europe.

You have also likely read a lot about RFID tags, which have become popular. These would solve the identification problem. Texas Instruments produces many of them. The tag can be very small, but it would need to be on the outside of the bike. It could be hidden under the seat or under fabric, but not inside metal. The tags are very cheap themselves; the scanners police would use to read them are likely only several hundred dollars. If unknown bicycles are often recovered, this might be your best solution. If bicycles are being stolen and scrapped for parts, none of these systems is going to deter much. If bikes are being turned in often, though, it may be that all that is needed is a central database matching bicycle serial numbers to their owners, which they may or may not have. Finding out more about the thefts, for example, how often stolen bicycles were locked, would be helpful in determining what the best solution is. A complex solution may not be necessary.

Appendix L1: RFID Industry interview: Datatag

The following interview took place on April 1, 2005, with Maureen from the Datatag company and was conducted by Kristopher Houle.

Technical Questions:

1.) We understand that your RFID tracking system can be applied for bicycle use, by putting a RFID tag inside the frame of the bicycle. How is it that the tag can be placed inside a metal bicycle frame and still be scanned by an electronic signal? Does the frame material of the bicycle make a difference?

The scanner cannot read through metal. Usually a probe is inserted into the seat-tube to read the transponder there. Other transponders and decals are also placed on the exterior of the bicycle.

2.) At what distance does a scanner have to be from the microchip to read the ID number?

The scanner must be within 6 inches, but improvements are in the works.

3.) What information do the scanners provide? Do they simply retrieve the id number, or do they instantly tell if the bike has been reported stolen?

They simply read the ID numbers but it is possible to program in specific numbers.

Business Questions:

4.) In what countries does Datatag currently operate?

UK, Ireland, Holland, Belgium, Italy, Sweden

5.) How large is your customer base in each of these countries?

In the UK, over a million customers.

6.) Do you have plans to expand in these countries and to other nations in the E.U.?

Yes, France, Germany, and Spain are of special interest. However, a solid business plan with details on the financial commitment the country is willing to make is necessary before Datatag will distribute their scanners and computer systems.

7.) Would it be likely that Datatag may someday operate in Denmark?

It is possible but close contact and several meetings will have to take place with the insurance companies and police departments before this can happen.

8.) Could you supply us with a few names of cities or precincts in which Datatag is currently operating?

[No response available.]

9.) How often are bicycles reported stolen to Datatag?

Often, everything is stored on the Datatag database. The police do not need to be contacted because they can access the database 24 hours a day, seven days a week.

10.) How many of these bikes are later found and returned to the rightful owners?

[Exact statistics unavailable.]

11.) How much of a commitment (time and money) is necessary in order to acquire the equipment needed to run the system (specifically for Denmark's 4.5 million bicycles)?

There must be a thorough business plan made before Datatag will agree to distribute its system. The business plan must include the financial commitment that the country is willing to make. (Maureen could not reveal an estimate of how large the financial commitment would be.)

12.) How much of a commitment (financial, personnel) does it take to maintain the system once it is in place? i.e. do you need someone to be updating the database, replacing or repairing equipment, etc?

It is necessary to update the system and make sure it is in working order. Therefore, some money must be allotted for this matter.

13.) Insurance companies in Denmark spend 141 million Danish Crowns every year, and they would be very happy to cut down on this number. If Insurance Companies in Denmark were to require the Datatag system on their bicycle insurance policy, would you offer any sort of guarantee in percent reduction of bicycle theft?

Datatag will not offer any type of guarantee on a reduction in theft.

Appendix L2: RFID Industry interview: Alien Technology Corporation

The following phone interview took place on April 6, 2005, with Malcolm from Alien Technologies.
It was conducted by Kristopher Houle.

[The interview began with an explanation of the project and its goals.]

1.) What kind of tag would be the best for this type of system?

   Perhaps an EPC Class 1 RFID tag.

2.) What are the dimensions of this tag?

   Between 9 -11 cm long, and less than 1 cm wide

3.) What is the maximum range for the proper scanner?

   About 2.5 meters

4.) How much would a tag and scanner cost?

   Tags: For 2000 tags, the cost would be about 30 cents per tag.
           For over a million tags, the cost would be about 19 – 20 cents per tag.

   Scanners: Alien Technologies does not manufacture scanners. MaxID and Psion Teklogix
   are the main producers of these scanners.

5.) Do you currently distribute products to Denmark?

   Yes, a small amount

6.) Is there ever a problem reading tags that are close together?

   The anti-collision technology is good enough that this is rarely a problem

Appendix L3: RFID Industry interview: 3M

The following interview was conducted over the phone with Sales Associate, Anders Poulsen, of 3M. It was conducted over the phone on April 5, 2005 by Kevin Glynn.

1. We understand that you use RFID tags in libraries in order to keep track of all material in your catalogs. We are interested in applying this sort of system to bicycles in order to mitigate the problem of bicycle theft. How does the RFID system with the handheld scanner work in libraries?

    Each piece of material—books, CDs, videos—is outfitted with its own RFID tag. Then someone scans down a row or pile of books. The handheld scanner can send the information to a computer as text where it can be printed out. It will flag any ID numbers of material that should not be there, and it can also let one know if there is a book that doesn't belong on (or is missing from) a particular shelf.

2. What is the range of these scanners?

    The scanners need to be within 10 or 20 inches of the RFID tag, but the closer the better. Within 10 inches it is ordinarily very accurate. As they get further apart, sometimes the scanner will miss one of them or confuse two of them. This is especially tough when scanning CDs because there are sometimes more than one CD in the same case.

3. Is there a solution for this problem, or is this just a limitation of the current technology?

    This is just a limitation of the current technology that is being worked on.

Appendix M1: Interview with Politician: Sven Milthers

The following interview with Sven Milthers, leader of Socialistisk Folkeparti (SF) within the Copenhagen Council took place on May 2, 2005. It was conducted by Kristopher Houle over the telephone.

Questions

1.) What exactly is your role in the government?

   I am a member of the municipal board of Copenhagen and leader of SF within the Copenhagen Council.

After a brief explanation of project, ideas, and goals the following questions were asked.

2.) What are your initial thoughts on the project?

   This system would not be worthwhile for all bicycles. It would likely only benefit owners of very expensive bikes. It should not be made a requirement of all bicycle owners within the city.

3.) Where would the rest of the Copenhagen government stand on the issue?

   This idea would not gain much support within the Copenhagen Council

After explaining the program in Amsterdam, Sven's reaction was very similar. He did not feel that any sort of system should be introduced by the government. He felt that it should be completely voluntary and be organized by the insurance companies. The police should not be involved in this matter, and can only be ordered to by the Danish government, not the Copenhagen government. He also did not believe that any funding would be available from the Danish government for this project. There would have to be a lot of data that the system works somewhere else before his opinion could change.

Appendix M2: Interview with Politician: MP Poul Henrik Hedeboe

The following is an interview with MP Poul Henrik Hedeboe, a member of the Socialistisk Folkeparti (Socialist People's Party). It took place on April 15, 2005 at Christiansborg at 14:30, and it was conducted by Kristopher Houle and Jennifer Schweers.

[The project was explained at the beginning of the interview.]

1.) What are some of the major issues your party is concerned with?

Not centered around particular issues, but generally leaning to the left side of the political spectrum.

2.) What exactly is your role within your party?

Especially concerned with laws dealing with traffic, cycling.

3.) What are your initial thoughts on the project?

Positive reaction to project. Cycle theft is a serious problem in Denmark, with the number of cycles around. Project could be very effective.

4.) Where would your party stand on the issue?

Party would most likely support the project.

5.) Do you have a sense for what kind of support this idea may receive from other political parties? What sort of issues might they have with the system?

Social Democrats and Social-Liberal Party would most likely support the tracking system. Venstre (Liberal Party) would be unlikely to want it, because of the added expenditure and because they would be suspicious of giving more power to the police and the government.

6.) What would be the process for creating a law that requires all bikes to be equipped with an RFID tag? What kind of data would be necessary?

A law could be proposed in late 2005; the spring 2005 deadline has already passed. If proposed in fall 2005, it could be enacted by early 2006. It would be best to have some kind of data. The system could be piloted with private money, perhaps in Odense, and data from that pilot would make it more likely that a law would pass to cover all of Denmark – assuming, of course, that the system works. Data from the tracking system being implemented in Holland would also be very convincing.

7.) What would be the process for getting funding for this type of system in Denmark?

Part of the law to require the system would be to have funding put in the next year's budget.

8.) How long would it take to receive this type of funding?

Were a law to be passed, the funding would be part of this law. So, again, 2006 would be possible.

9.) From what department of the government would this money come?

Transport minister.

10.) In Amsterdam, the cost of a trial system for 10,000 bikes was approximately DKK one million. If there was a movement to do a similar test here in Copenhagen, what do you think would be a reasonable amount of money to request from Parliament?

A million crowns would certainly be reasonable for such a system.

Further Comments:

May want to look into local politics as well as, or rather than, national ones. Copenhagen politicians may be of particular help, since Copenhagen's government leans a little more to the left than the national government and because bike theft is even a more pronounced problem in Copenhagen. The Eastern cities in general would likely be more receptive to the tracking system. Try Sven Milthers, a politician in Copenhagen who deals with traffic issues as well. Also consider the possibility of having scanning done by someone other than the police, since there is something of a feeling that the police do not have the resources to devote to bike theft. There are groups of people, not police, that check cars around the city for parking violations; perhaps they could scan bicycles as well.

Appendix N1: Interview with Dutch Contact: Ferry Smith

The following interview was conducted by Kevin Glynn at 11:30 on April 12, 2005 with Ferry Smith, the chairman of the ART foundation. The ART foundation is a Dutch Crime Prevention organization that deals mostly with bicycle theft. The purpose of the project was explained prior to the interview.

1.) It has come to our attention that the Netherlands currently has a system in place that uses RFID tags to identify bicycles in order to control bicycle theft. How does this system currently work?

> Yes, about six years ago, we began planning this system. The idea is to have a unique electronic identification tag (RFID tag) in every bicycle in the country. There is already a large computer system, or database, for registering the bicycles and reporting them stolen. Police are equipped with special scanners that can read the identification number in the RFID tag and let them know if it's a stolen bicycle. In order for this to be an effective system, however, we need many bicycles to be registered with a tag, and we need many bicycles to be reported stolen. Not until we reach a sort of critical mass of stolen bicycles will the system be worthwhile for police to use.

2.) Denmark already has a method of uniquely identifying bicycles with their frame number system. Is it really necessary to implement an electronic system in your opinion?

> For Holland, there is no question. With 17 million bicycles in the country and such a high rate of bike theft, this electronic system has much potential. It is much easier than reading a number off the frame and looking for it on a list of stolen bikes' numbers.

3.) How long do you expect it to be before the system is fully effective?

> It's going to be another two years probably, before the system is fully functional. Not until most bikes are tagged and not until enough are registered as stolen will it finally be up to speed. Furthermore, there have been many computer systems at the various police buildings that had to be incorporated into the network. This has taken time, as well.

4.) How will you manage to get a tag on every bicycle?

> Right now, every new bicycle built in Holland comes with a tag that uniquely identifies the bike. They are installed in the frame lock that locks the rear wheel. Not every new bike is covered, however, because many imported bicycles do not include the tag. We would like to cover used bikes, as well, so we have a test program this spring where 10,000 used bikes will be fitted with a tag for free in the city of Amsterdam. If this works well then we hope to have these aftermarket RFID tags for sale in bike shops.

5.) Is there any extra incentive for consumers to purchase this tag; for example, are there any discounts on insurance? If so, how was this achieved?

Yes, there are small discounts to one's insurance rates. Insurance companies took the initiative to give some discount on their products. They assume that bicycles with a better identification are less stolen. In the first period this seemed to be right. Later on, when the system works completely, the effect should be even bigger as trading a stolen bicycle becomes even more difficult. The database with stolen bicycles becomes public in a few months and will be of help for those who want to buy a bicycle. It than can be easily checked if it is reported stolen or not.

6.) You said that all new bikes made in Holland are sold with an RFID tag built-in to the lock. However, I was wondering how this is achieved. Is it mandated by law that the manufacturers must do this?

Manufacturers equipped the bicycles on a voluntary basis. Mainly because it brings them some marketing advantages. In Holland bicycle theft is an item to consider when buying a new bicycle, so people are interested in state of the art theft prevention.

Besides that, Dutch manufacturers are part of a working group in which better identification was launched as a useful method for crime prevention. This working group is a combination of private and public parties. There's no law but just a sense of urgency to cooperate and help to solve the problem.

7.) How did the police react when this plan was proposed to them? Were they reluctant to accept it? Do they use it as they are supposed to now or neglect the system?

The police also take part in this working group. They can work more efficiently by using new identification techniques. In future they will be able to check ten bicycles instead of one in more or less the same time. So it is likely that they will have better results with the same enforcement.

In practice however it still is difficult to operate the system. As mentioned many police computer systems had to be connected to the central database, and that takes some time. So full functionality is expected one or two years later as originally planned.

8.) How do the scanners work? Do they communicate wirelessly with the central database?

It depends on the model. The latest model uses GPRS technology, which is an extension of cell phone technology that enables wireless communication from the scanner to the central database. A police man just needs to point the scanner at a bicycle equipped with a tag, and then either the red light or the green light will flash on the scanner. Red means the tag corresponds to a bicycle that has been reported and registered as stolen. Green means it hasn't been reported stolen.

9.) What is the read range of these scanners, and how much do they cost?

The read range is 10-20 centimeters, each scanner costs about €200 depending on the model and the number ordered.

10.) It has come to our attention that in order to be read, these tags cannot be in contact with or encased in metal. How are they put inside a bicycle lock and how are they attached to a used bicycle frame?

> The bicycle locks are made specially so that the tag can be embedded into them and then covered by an epoxy coating. They can still be read, but they cannot be removed without removing the lock, which is permanent. In the case of used bicycles, they are stuck to the bicycle frame and remain on the outside, not actually in contact with the metal and not encased in metal. They are made specially so that they're very difficult to remove. If one does successfully remove one, it leaves permanent marks behind that cannot be removed. Therefore, it is very obvious that they have been tampered with.

11.) How much do the tags cost?

> The consumer pays about five euros extra for a lock with a tag. Because they are all OEM fitted, the consumer pays just a little bit extra for the bicycle

12.) From what manufacturers are you purchasing the tags and scanners?

> A company called RFID-Net.

13.) How much does it cost to operate the computer system?

> The cost of operating the system is very difficult to say, because various parties such as police, manufacturers and the government contribute to the system. There is a financial contribution from the government yearly, but I don't know exactly how much that is.

14.) From where are you receiving funding for the implementation of this program?

> As it was mentioned, the consumer pays extra for the RFID tag. Taxpayers supply the money for the scanners that the police are equipped with, and taxpayers also are responsible for running the system.

(N.B: The team called in a follow up to the interview and requested access to progress reports showing the success of their system thus far, but Mr. Smith was on vacation at the time the team made the request; therefore the information is on its way but did not make it into this report. It is recommended that Mr. Smith be contacted for further inquiry about the progress of Holland's RFID system).

Appendix N2: Interview with Dutch Contact: Anouk Hespe

The following interview took place over several emails ranging from April 14 – 25, 2005. The emails were between Anouk Hespe of Amsterdam's Dienst Infrastructuur Verkeer en Vervoer and Kristopher Houle.

[After given a brief explanation of the teams views of an ideal RFID system the following questions were asked.]

1.) What are the similarities and differences between the system currently in Amsterdam and the one just described?

The tracking system in which any number of bicycles can be scanned quickly and easily will be in place in Amsterdam in the near future. As of 27th of April, a pilot program will begin and the AFAC will place 10,000 tags on various used bikes for free over the next several months.

2.) From what I understand, you will be trying this system on 10,000 used bikes beginning on 27 April. Has a similar system already been in use for new bikes? If so, how long has it been around and is it different to the one beginning this month?

Yes, nearly all new bikes have a lock with a chip inside of it. This system has been working for a few years. It is not possible to buy this special lock apart from the new bicycles, so it cannot be used for used bikes. The best thing to do is to put the chip inside the frametube (this you can only do with new bikes, because you have to give it a place in the production process. It's to expensive to do it afterwards.) A problem to be solved will be how to make it possible to read the chip through iron/steel. They are working on this, and the changes are good that there will be a solution for this problem in a short time.

3.) From what manufacturers are you purchasing the chips and scanners from?

Stenman Holland (AXA Basta) is building the containment device for the chip. The chip and scanners are delivered by RFID-net.

4.) How much does each chip and scanner cost?

In the pilot program, we get 10,000 chips for €90,000, so nine euros each. I don't know the price of the scanner, because the police (our partner in this project) already had them. However, they would not have paid the market price.

5.) How close do the scanners have to be to the chips in order to get an accurate reading?

Somewhere between 10-20 cm.

6.) Where exactly are the chips going to be placed on the bikes? Will the metal from the bike frame interrupt the signal from the chip?

The chip will be placed on the frametube under the seat. There is no interruption from the metal from the bike.

7.) How will the chips be attached to the bike? Will they be difficult to remove or hidden from view?

The chip is inside a metal container, this will be placed around the frametube, under the seat. It is possible to read the chip through the device simply by waving the scanner near it. It will be very difficult to remove, because AXA designed special bolts that cannot be removed after placing them on the bike.

8.) From where are you receiving funding for the implementation of this program?

€45,000 will be financed by Council of Amsterdam and €83,000 from the Ministry of Transport (national government).

9.) On April 27, the trial period will begin. How are the devices going to be distributed to the bicycle owners? Will all 10,000 people have to bring their bikes to a certain location and be installed all together? Or will the devices be sold in various bicycle shops where anyone could buy one and install it themselves?

The tags will be distributed for free during registration actions on the street. These registration periods have already begun and take place three days a week at certain locations, including at the AFAC (see the site: http://afac.amsterdam.asp4all.nl/). The AFAC is the place where wrongly parked bicycles are gathered. It will take a few months to install all the tags, because people cannot install the tags themselves.

Appendix O: Important Contacts

The following contact information was gathered over the course of the team's project work and has been compiled here as a convenient collection of important contacts concerning the business of planning and implementing an RFID tracking system for bicycles in Denmark.

Jens Kristian Weidlich
Dansk Varefakta Nævn
Phone: 33 79 09 79
Website: http://www.varefakta.dk/

Bjarne Pedersen
Det Kriminalpræventive Råd
Phone: 43 44 88 88
Website: http://www.dkr.dk/sw159.asp

Henning Maigaard
Police Inspector, Det Kriminalpræventive Råd
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Email: hm@dkr.dk

Vej & Park
Address: Njalsgade 13
         2300 København S
Phone: + 45 33 66 35 00

Parkering
Address: Gammeltoftsgale 17
         1355 København S
Phone: + 45 70 80 80 90
Email: parkering@btf.kk.dk
Website: www.parkering.dk

Forsikring og pension
Address: Amaliegade 10
         1256 København K
Telephone: 33 43 55 00
Website: www.forsikringenshus.dk

Crime prevention council
Website: http://arkiv.dkr.dk/eng/
Phone: 43 44 88 88

SREG
Address: Dampfærgevej 3, 3 -
         2100 København Ø

Phone: 70 15 01 11

Cykelbranchen (Erik Oddershede)
Dansk Cykelhandlere
Address: Middelfartvej 123, 1
           Postboks 770
           5200 Odense V
Phone: 65 92 33 00
Email: info@danskecykelhandlere.dk