HIKARI SYSTEMS CORP.

May 20, 2001

Dr. Andrew Rawicz
School of Engineering Science
Simon Fraser University
Burnaby, British Columbia
V5A 1S6

Re: ENSC 340 Project Proposal for an Indoor Positioning System

Dear Dr. Rawicz,

The attached document, *Proposal for an Indoor Positioning System*, provides an overview of our proposed project for ENSC340. Our project is to design an indoor positioning and guidance system. The purpose of this system is to help users find their destinations quickly and provide information on the most efficient route in an unfamiliar building equipped with our system.

This proposal outlines the concepts of our solution, budget and financing, team organisation and development plans. We point out the problems with available products on the market and other alternative solutions, and show how our system will address these issues. Business opportunities after the completion of this project will be analysed.

Here at Hikari Systems Corp., we have a team of five experienced and enthusiastic engineering students: Gregory Fung, Ivan Ho, Ming Jiang, Aguilar Lam, and Sherman Yin. If you have any questions or concerns, please do not hesitate to contact me at gwfung@sfu.ca

As the name of our company suggests, which means "light" in Japanese, we are confident that our project will become the guiding light for our customers.

Sincerely,

Gregory Fung
Project Leader
Hikari Systems Corporation

Enclosure: *Proposal for an Indoor Positioning System*

HIKARI SYSTEMS CORP.

Proposal for Development of the Indoor Positioning System

Team Members:

Gregory Fung
Ivan Ho
Ming Jiang
Aguilar Lam
Sherman Yin

Submitted to:

Dr. Andrew Rawicz,
Steve Whitmore,
School of Enginering Science
Simon Fraser University

May 22, 2001
Version: 1.0

Executive Summary

Having overslept, you only have fifteen minutes before an important meeting start. You arrive on site with just moments to spare. With much on your mind, you miss most of the directions to the meeting room the receptionist gives you. After getting yourself lost, you search desperately for a directory…

Indoor navigational aids are useful whenever people are visiting buildings. Global Positioning System (GPS), where one's position on the planet may be tracked by satellites in the orbit, is useful in outdoor environments. In indoor or multi-level facilities, GPS cannot accurately pinpoint locations of users. Hikari Systems Corp. proposes the Indoor Positioning System (IPS) for indoor environments, featuring accurate user location display and route guidance based on destination search.

The market projection for GPS units is estimated at 600 million by the year 2004 (Rangestar Wireless 2001). The major market for GPS rest is transportation, such as automobiles, ships, and aeroplanes. On the other hand, the indoor navigation systems are targeted for facilities ranging from office buildings, libraries, hospitals, shopping centres, universities, and more. Clearly, this can be an even larger market than for GPS.

Our development team, which consists of five motivated engineering students with a wide variety of experiences, anticipates that our functional prototype will be ready in August 2001. The estimated cost of developing the prototype is about $600. To assist in bringing this idea to market, we are seeking investors and business guidance. Development details and analysis of business opportunities will be presented in this proposal.

At Hikari System Corp., we are determined to provide the guiding light to indoor navigation.

…Remembering that your company headquarters has just installed the Indoor Positioning System (IPS), you pull out your handheld PC. What do you know! The screen is already displaying the shortest route to the conference room. You follow the directions on the screen effortlessly and everyone gives you a warm welcome because you arrive at the room on time.

Table of Contents

1 Indoor Navigation

1.1 Introduction

Everybody has experienced the trouble and frustration of having to find a location in an unfamiliar building. Whether it is a particular store in a shopping mall, a subject section in a library, the lecture hall for writing an exam, the meeting room of a job interview, or the hospital room of a sick relative, receptionist and directories do not provide adequate guidance to your destination. In this age of information technology, the tools are available for a better solution to this problem.

While there are many devices in the market for positioning and navigation, most of them fail to address the problem mentioned. Most are based on the popular Global Positioning System (GPS), which is great for outdoor positioning; for indoor applications, they are limited by the required line of sight to four satellites and cannot distinguish adjacent levels. Other solutions include digital compass and map display capability, but fails to identify the user's location on the map.

Hikari Systems Corp proposes an Indoor Positioning System (IPS) for guiding users in an unfamiliar building. A handheld electronic organiser, known as a PDA, communicates with a network of beacons installed in the building to determine the location of the user and guide the user to the desired destination. We have chosen the PalmOS PDA platform due to its increasing popularity, allowing most of the PDAs currently in use to run IPS software and locate their owners without specialised hardware.

Allowing users to select their destination and guiding them there visually or vocally (optional), the system would save much time and frustration spent searching for a destination an IPS-enabled building. Destination selection is made easy with the choice of selecting from a menu or by doing a name or room number search. The shortest route displayed on the PDA will be updated as the user travels to the destination, making the interactive map easy to understand and to follow. With these features provided in the palm of the hand, searching for a location will become an almost effortless task. Properly equipped, this tool will also be invaluable for visually impaired. The voice instructions given by the PDA will allow these users to find a place without help from others. To the user, the route guidance system behaves as described in Figure 1.

This document is a proposal providing an overview of our system, including capabilities exploration, marketing considerations, and business opportunities. Existing and possible alternative solutions will be discussed. Finally, prototype development plans, scheduling, and team organisation will also be presented.

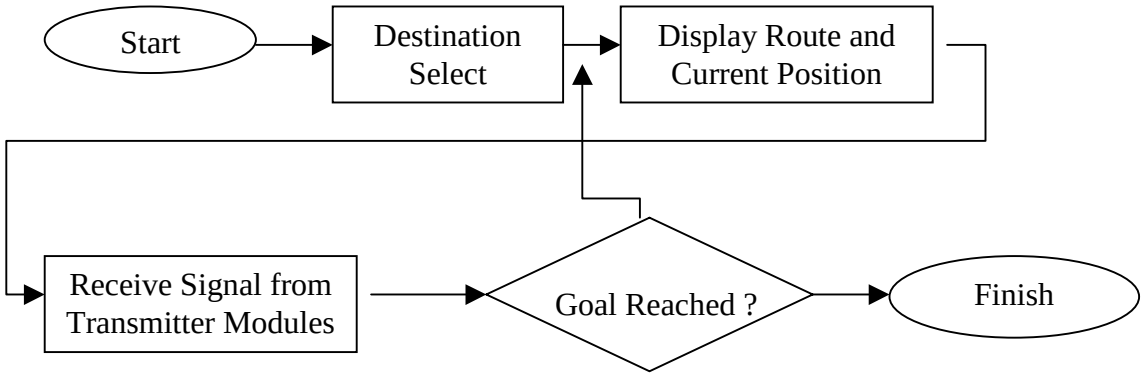

Figure 1. IPS action flowchart for route guidance

1.2 Alternative Solutions

1.2.1 Paper Maps

For many public sites, paper maps are given out to visitors. While the inexpensive solution has been used for many years, it relies on the map-reading skills of the user to find their destinations. Studies show that those who orient themselves using landmarks are less successful at using maps to find their way (Weiten 1998). In complicated environments such as large multi-level sites, maps are not adequate for a large portion of people.

1.2.2 Electronic Maps

Maps can also be shown on modern electronic devices and handheld computers. They hold more maps and more information than a comparable paper version, but are limited in map area shown by the screen size. For some, not have to fold maps is worth the extra cost of the device.

The Palm Navigator from PNI Corp. is an inexpensive add-on module for the Palm III PDA. It adds their ±2° digital compass and map display capability to the Palm. However, it is still up to the use the map properly to find their way.

1.2.3 Staff as Guides

For large groups, tour guides are effective in presenting a selected set of features to customers or visitors, especially for visually impaired. However, the entire group must gather at one time and follow one fixed presentation and its schedule. For those who like to enjoy their favourite exhibits and skip others, a personal guide would be necessary for a much high cost.

1.2.4 Global Positioning System (GPS)

Installed by the US military, GPS has been introduced for consumer use in the last five years with the availability of affordable navigation tools. These devices usually include GPS receivers to locate the user and a map database to give context such as streets and surroundings. Sometimes the device can also compute the best route from a source to a destination, or store these planned trips for later retrieval.

GPS features positioning accuracy of roughly 10m. For it to function, the receiver must be in line of sight of four satellites above, or be able to receive a supplementary correction signals from a ground station (Dana 2000). Due to these limitations, GPS is not a useful tool for indoor or underground navigation. Also, GPS cannot distinguish adjacent levels or floors of buildings.

The GPS mapping tools are the closest to being a solution for our problem. They are built as standalone units or based on a handheld computing platform. Many standalone products are available for the mobile, aviation, marine and automotive markets (Garmin 2001; Megellan 2001). Some automotive units can guide users to their destinations with turn by turn instructions. Most products use buttons and monochrome LCD displays, while others feature voice prompts and colour LCD displays.

For handheld computers, GPS receivers interfaced with cables to handheld software has been around for several years; integrated receiver modules are being introduced in 2001. Users use buttons mixed with pen-based commands and are given visual instructions on the unit's LCD display.

1.2.5 Indoor Locator Systems

Designed to help blind users locate themselves, the PERSONA system is a experimental system that plays pre-recorded messages when the user arrives at certain locations (Sonnenblick 1998). Using a network of infrared transmitters installed in certain locations, a small waist-mounted unit plays a pre-recorded location name or other warning sounds. For example, as the user approaches a properly equipped stairwell, the unit beeps to alert the user that stairs are nearby, helping prevent dangerous falls. However, the system does not guide users between destinations.

2 Solution: Indoor Position System (IPS)

2.1 Concept

A network of location beacon is installed in key locations in a building, each transmitting its own unique location code with range-limited infrared signals. When this location code is detected and put into context by our software running on a hand-held device, the software can place the user at one location within the building. For an illustration of this technique, see Figure 2.

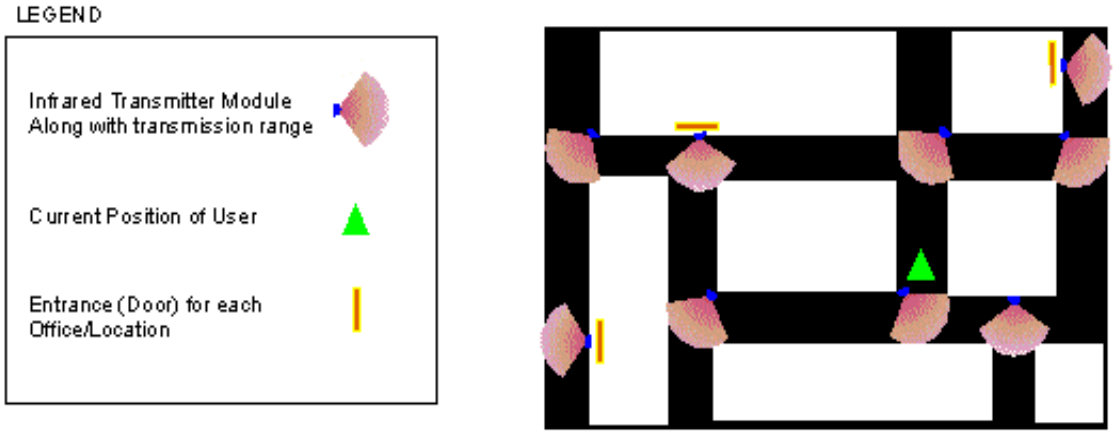

Figure 2. Transmitter layout concept

Using this information, the software can display the user's location on a map. As he traverses the system and passes another beacon, the software updates its location in the building. This information, when combined with a searchable database containing location information, can guide users who are unfamiliar to the building to their destinations turn by turn. Specific for the each building, the software can calculate and return the best route to some user-selected destination.

This route can be presented to the user in a graphical form, likely being lines marking routes on a map of the building and can also indicate to the user the next direction to take on the route. Other useful information can be given to the user once the user's location is known, such as special location descriptions, warnings, or nearby facilities. These and other features can be added to make the system more user-friendly. The next section will go into these features in greater detail. The most important feature in this system is the ability to locate where you are on a map at all times.

To present this information to the user in a convenient, portable device, we selected personal digital assistants (PDA) as our user platform. Due to the declining costs of PDAs in recent years, it has built a significant user population. The most popular platform, PalmOS, boasts graphics capabilities and built-in communication hardware. The PalmOS standard provides the user hardware infrastructure to make the IPS system accessible to a large audience. This reduces development costs, broadens the appeal of the system, and allows a lower cost product for the user.

In theory, this system can also be applied to roads and outdoor environments as well, however the highly popular GPS system may be more suited for this task. For mixed indoors and outdoors environments, however, our system give much more flexibility in small confines and would be more suitable.

The IPS concept can be applied to many environments having diverse needs. It can also be adapted with little effort to work with existing databases. Some possibilities are discussed in the following pages:

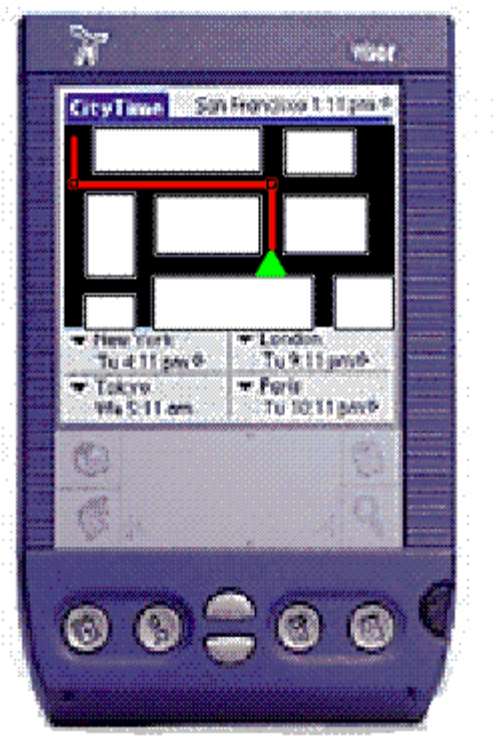

Figure 3. Conceptual Drawing of Map Display and Route Guidance on PDA

2.1.1 Shopping Malls

With IPS system in large shopping malls, beacons in front of each store and facilities like information centres and washrooms can be associated with information about that location in the IPS database. For shops, each would have its name, store category (footwear, women's fashion, etc.), and possible consumer special offers entered into the database. The shopper can then search for their destination based on the product of interest, store name or category.

2.1.2 Museums and Amusement Parks

Museums often have plaques which contains the description of each of its' many exhibitions. The visitors often have to crowd around to read the plaque. The IPS system would be used to provide the information to each individual user on his/her hand-held device and perhaps even play an audible pre-recorded message about the exhibition to the user. This would require that each exhibition have one unique beacon located in the vicinity and that adjacent exhibitions be separated by a few meters. Interesting exhibitions can then be searched for by category, dates, artists, etc.

2.1.3 Schools / Corporate Buildings

Locations of offices of faculty, staff, or employees are often very difficult and confusing in large school/company buildings. Each office or even cubicle can have a unique beacon placed in the vicinity allowing searches to be performed on the department or employee name.

2.1.4 Hospitals

For visitors, IPS can help guide them through unfamiliar hospital complexes in their emotional times. For caregivers, IPS can be linked into existing patient information databases to help these professionals to identify important information quickly for more effective and accurate treatment.

2.2 Features

The IPS system:

- Highlights the last received transmitter location that user passed on map
  Similar to the "You are here" marker on many maps that are often found in large buildings.
- Allows the user to scroll through any map and browse location information
- Searches its database for destination as requested by room #, department, occupant or functional name
- Shows route from current location to selected destination on map
- Shows orientation of device through compass headings
- Is Adaptable for simple set-up for each customer site
  The information necessary to adapt the IPS map to the customer site only requires a mapping of the beacon locations to the customer site's map. Also if extra display information is desired, a list of location information mapped to each beacon is also necessary.
- Has special features designed for the visually impaired:
  - Simple one key access to main features of the IPS system
  - Audio and speech directions at intersections
  - Add Braille display unit to basic handheld computing platform

2.3 Usage Model

Imagine visiting a corporate building with the IPS system implemented. Since you have a compatible PDA, the receptionist offers you the IPS application and site information for the building. Within 10 seconds, the program is loaded through the infrared connection. Launching the IPS icon, the program first displays a map centred on your current location. Tapping on map features reveals some information about the site, such as

"Meeting Room A, ext. 4693". To find an office, you can select a name from a list, or search for your host Mark Johnson by his name or room number. Once the destination is selected, the shortest route appears on the map to direct to guide you. As you walk, both the route and your position icon is updated as you walk pass the small transmitters mounted high in your view throughout the building. After meeting with Mr. Johnson, you search under "C" and select "cafeteria"; once again you follow the directions and enjoy a fresh cup of coffee. As you return to your office, you delete the entire database from your handheld with a single command.

If you were given a hardware expansion module as well, the deluxe version of IPS offers an even better experience. Installation becomes as simple as plugging the module into the handheld. As you turn, the program updates a compass on the screen to help you find the proper direction to travel. Near intersections, the unit also helps you by providing a tone that changes pitch to indicate what direction to travel in. Optionally, the unit also speaks out route commands, such as "turn left" or "go up the stairs".

2.4 Business Opportunity

2.4.1 Market Survey

To estimate the business potential of a solution to this problem, we look at the possible markets that may be served by our product.

2.4.1.1 Corporate Buildings

Corporate buildings should be the largest market for IPS installations. We expect that high-technology companies, with a high proportion of PDA users among their employees, will make up much of our client base.

Large corporations invest substantial amounts in infrastructure for their buildings to impart a professional and leading edge image to their clients. These intangibles leave lasting impressions with visitors representing other firms, often paying off handsomely in lucrative contracts. Besides the aforementioned benefits of easier navigation for employees and visitors, companies can improve the impression of their visitors by installing the IPS system. By having IPS, visitors will likely be impressed by the firm's attention to detail. Their host has considered their unfamiliarity and has a solution to assist them. This surely shows the visitor that the firm pays attention to details and is customer-oriented.

2.4.1.2 Shopping Complexes

To attract the busy young professional shopper, complexes can improve their shopping experiences by helping them find merchandise and stores quickly. The technology can also be used for highlighting special offers or paid advertising. These capabilities are sure to attract leading-edge facilities to bring in new customers. Around the world, we

expect the greater emphasis on "gadgetry" in Japan and Asia will welcome our technology to accelerate growth in these markets.

2.4.1.3 Libraries and Museums

Museum tours are often a frustrating experience: large crowds often make them difficult to follow, the tour guides announcements are usually difficult to hear, and little time is spent at each exhibit. A personal hand-held tour guide, with descriptions of exhibits only a pen-tap away, would be a welcome tool for many visitors. We expect that museums that cater to PDA-enabled visitors, such as urban professionals, to be the first to embrace our system.

2.4.1.4 Hospitals

Information in hospitals is critical and ever evolving. In an environment where accuracy and timeliness is critical, a location-based patient information system that keeps up with the changes would be very valuable for both medical professionals and visitors.

For treatment purposes, current paper-based charts are part of a large, well-tuned process in administering care. However, improvements to the process are ever necessary to allow more efficient care. For example, senior doctors overseeing a large ward must either track many patients' medical records in their minds or they must refer to charts about the patient frequently. If patients' information can be delivered and highlighted on their handheld computer for them as they approach, they can survey more accurately and efficiently.

For visitors often in emotion distress, a guide to help their loved one in large hospital complexes is desirable. An informational system for this purpose would be much simpler than for physicians.

2.4.1.5 Homes and Buildings for Visually Impaired Persons

An important niche market, visually impair persons require much help in learning new environments. Using one button access, pen-based input and voice or audio output, handheld computers can help them find their way to a specific place by giving instructions at intersections. The system will not replace their keen sense of direction, but it will be of great help. Also extremely useful are warnings near dangerous locations such as stairwells.

For private homes, most individuals cannot afford an expensive solution, so system simplicity will be a key factor for this market. However, a solution for these users has the most social benefit as well, so it is well worth pursuing.

2.4.2 Cost Analysis

2.4.2.1 Transmitters and Installation

IPS transmitter stations, being small, simple and compact, can be built very inexpensively in production. Based on early designs, these should cost about $8US each. Should IR reflectors be needed to allow better communication, they should cost roughly 50 cents each. Mounting hardware for both can be standardised into only a few configurations for low cost as well, unless the customer site has special requirements.

The only building infrastructure needed by the transmitters is standard AC line power. All certified electricians are qualified to install transmitters. Other than following recommended mounting positions we provide for each site, no special expertise is required. This allows for a reasonable installation cost.

2.4.2.2 Software Set-up for Site

The complexity of the site information package is proportional to the number of nodes in the system and the number of items and fields associated with each node. With proper set-up tools, building this package is a matter of entering location data and associating them to the proper nodes.

2.4.2.3 On-going Support

For basic information changes, users are provided tools to update their own databases. This will be the area that requires the most support; we will likely charge customers for help in the update process beyond telephone technical support.

2.4.3 Revenue Streams

Our main source of revenue would be site installations. This involves designing the IPS network, overseeing its installation, and setting up the site information database for the first time. This is an involved exercise and should be charged accordingly. Because home installations for the visually impaired will be extremely cost sensitive, special discount rates should be considered for this market.

As customers evolve their buildings, they will require updates and maintenance to both the networks and their information database. While we provide tools for basic text changes to the locations, some would rather outsource this activity back to us. Other updates such as network expansion and database functionality additions will also bring us additional income.

For user hardware, sales of springboard modules to installation sites will be the largest category. These modules, lent out to users by the building, will need service as well. Sales of modules directly end users will be limited to the small population of staff and frequenters of IPS-equipped sites, and visually impaired home users of IPS.

2.5 Criteria for Feasibility

2.5.1 Simple User Interface

The main objective of the user interface is to allow the user to easily find his/her current location on a map on the screen, and be able to navigate around the facility under the system. Searches and directory lists are merely one tap away. The map rotates with the user's orientation to make it easy to read. The detection of the network signals is automatically performed without user intervention.

2.5.2 Cost for transmitter network

The cost of the sensor network should be kept low so that a large number of them is affordable. The more transmitters there are in the network, the more precise and transparent the usage experience will be.

2.5.3 Package size / Portability

The handheld PC and the hardware expansion should be easy to carry. The size of the hardware expansion should not be much larger than the expansion slot provided by the handheld PC. However, initial prototypes may be larger with debug capabilities.

3 Development Plan

The following sections will outline the first 4 months of the IPS system's development plan. This plan will take us up to the completion of the prototype development phase, at which point we will have a working prototype to demonstrate our system.

3.1 Goal

We plan to implement the core features as discussed previously in section 2.2, including:

- Show user location on floor plan map,
- Search for location and occupant / functional name,
- Show user compass orientation,
- Complete, integrated user interface development,
- Audio and vocal directional guidance, if time permits.

We intend for the core functionality of location searches, user location and route guidance to be available for the wide audience of PalmOS users. This means that we will be using the built-in infrared port receiving transmitter information. As functionality of PDAs grow, other technologies such as Bluetooth may be used.

The features that require hardware support will be built for the Handspring Visor PDA. Being part of the PalmOS family of devices, the Visor has an extremely flexible

hardware expansion port, known as the *Springboard* slot. Using this access port, we can build an extremely elegant hardware attachment to the handheld.

The prototype will consists of a functional, installed transmitter network, with roughly 20 transmitters; a software package for PalmOS PDAs with information about the test site; and a springboard hardware module to extend the functionality of the PDA for our unique features. If time or budget permits, we will expand our transmitter network, add more information to the site database, and create site set-up tools to simply system installation.

3.2 Budget

We will need to purchase components and services for the proposed prototype. Based on preliminary system concepts, our estimated costs are shown in Table 1.

Table 1. Budget for System Components

Part	Estimated Cost
Transmitters	$10 ea. x 20 = $200
Software Development Kit for PalmOS	Freeware
Electronic Compass	$30
Micro-controller	$10
Wires	$5
Speakers	$10
Slot Plastic for Handheld	$100
PCB Printing	$200
Misc.	$50
Total	**$605**

3.3 Funding

Funding for this project will come from several possible sources: the Engineering Science Endowment Fund, personal funds from team members, Dr. Andrew Rawicz, and possibly industrial sponsors.

Looking at a budget of about $500 to $600 and past donations to similar projects, it would be reasonable to assume that the Engineering Science Endowment Fund could donate $100 to $200. The group members are prepared to cover the balance. However, we are hopeful that Dr. Rawicz would support our effects to reduce this cost. In the past, he has supported student projects in the biomedical stream, especially devices that assist the handicapped or the elderly. Also, given the immediate market opportunity we present, we are seeking alliances with established companies or private investment; efforts are under way towards this end.

3.4 Timeline & Milestones

Development will follow the timeline seen in Table 2. Key milestones in our development are also included, which will help the team stay on-track for timely completion. These dates may be adjusted slightly as more information becomes available.

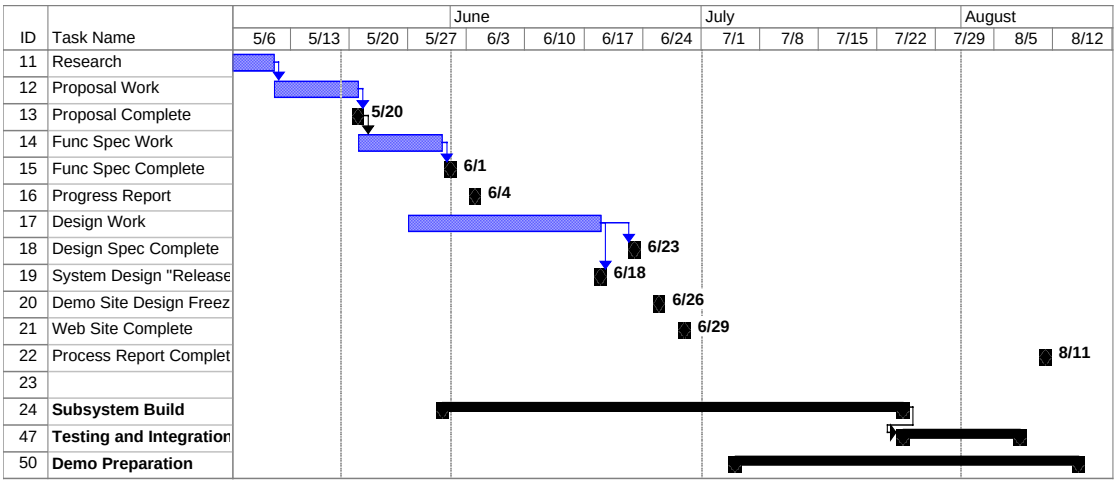

Table 2. Timeline and Milestone Chart

3.5 Organisation

Hikari Systems Corp. consists of five enthusiastic fourth year engineering students. All of us have experiences in working with teams in previous courses or work terms. We are fully aware of what it takes to bring the most out of each member for the most efficient and friendly work environment.

Due to the project size and time constrain, everyone on the team will have to contribute to the technical development process, while each person will also take on non-technical tasks. Gregory Fung will be the project leader, guiding the team through the development process. Ivan Ho will be the main marketing contact, integrating the needs of prospective clients with our concept. Ming Jiang will manage the financial issues, including budgeting and seeking funding. In charge of internal affairs, Aguilar Lam will address concerns within the team to ensure smooth progress. Finally, Sherman Yin will perform public relation duties, which include managing our presence on the Internet and our contacts in the media.

The technical aspects of the project will be divided into hardware and software portions. Team members will work in one or both of these areas depending on their experience and the work required. Members will work together towards the project goals to the best of their ability.

To ensure effective communication between team members, there will be a weekly meeting to update each member of the status of our project, along with discussions about problems encountered and concerns of each member. We will take turns organising and leading these meetings to ensure each team member has the chance to exercise and develop leadership skills.

3.6 Team Members

Gregory Fung
Gregory Fung is a fourth year student in the systems option. He has experience in several projects with embedded hardware and software, as well as a good appreciation of system design for team execution and clean integration. His meticulous, procedural view to problem solving, combined with his hands-on approach, makes him a solid contributor in design and prototyping processes.

Ivan Ho
Ivan Ho is currently in the fourth year of his Bachelor of Applied Science Degree at Simon Fraser University. He is studying in the Electronic Option in the School of Engineering Science, where he plans to excel in the field of telecommunications. As one of the co-founders of Hikari Systems Corp., he brings a detailed-oriented mindset to the team, and is capable of analysing electronic systems in a careful manner. Through his co-op opportunity at Advanced Telecommunications Research Institute (ATR), Kyoto, Japan, he has become knowledgeable in the development of infrared data communication, which could be the core medium between system devices in our business solution. He can further contribute to the team with his in C/C++ and documentation.

Ming Jiang
Ming Jiang is a fourth Year Electronics Engineering student at SFU. His work experiences at Nortel, PMC-Sierra, and Asahi Kasei (Japan) have given him valuable experience in real project work that is applicable to this project. He has done work on high-level hardware design as well as high-level programming, which will prove useful in the software development portion of this project.

Aguilar Lam
Aguilar Lam is a fourth year electronics engineer student at Simon Fraser University. He has experience in RF telecommunications technology from working in the advanced R&D R9000 team at Glenayre Electronics. He is currently working at Spectrum Signal Processing in the DSP wireless team where he is working with Digital Signal Processing Boards. He brings to the team experience in C/C++ and assembly programming, and also knowledge in Digital Signal Processing and wireless data packet transmissions.

Sherman Yin
Sherman Yin is a fourth year Computer Engineering student at Simon Fraser University. His previous co-op experience in Canada and Japan includes Raytheon Systems Canada Ltd., Spectrum Signal Processing Inc., and Sony Digital Network Applications Inc.

These work terms contribute to his ability to work well with people from different backgrounds, and also enhanced his communication skills on the international level. Furthermore, he has worked with a team and developed a similar shortest route program in one of his previous courses. He is also experienced in software programming in several different languages and digital circuit design in VHDL.

4 Conclusion

Hikari Systems Corporation is confident that the Indoor Positioning System will save users much valuable time and frustration during searches in unfamiliar buildings. The IPS concept, being a derivative of the GPS working model, has been indirectly proven in both military and consumer environments. Given the current PDA market and the projected costs of the system, the business prospects appear bright as well.

The IPS prototype, scheduled for completion in August 2001, will serve as a basis for further evaluation and development of the IPS system. We have the experience and skills necessary to build and demonstrate the power of the concept. Beyond the prototype, future plans includes improving usability and adding functionality enhancements to make the user end of the system a complete solution for indoor navigation for the visually impaired. Furthermore, integration with specialised database systems, such as in hospitals and libraries, will greatly improve the appeal of our system to these communities. We are confident that the IPS concept will be recognised as a simple and cost-effective solution for indoor navigation.

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