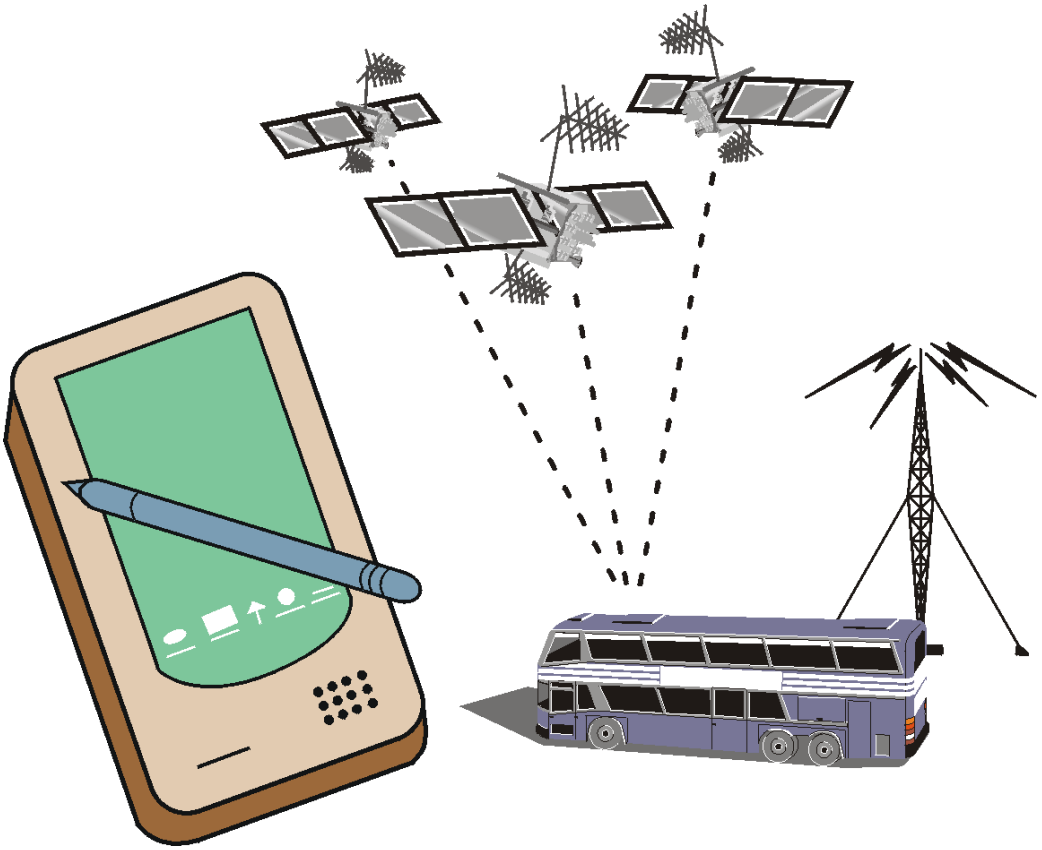
GPS Mass Transit Tracking System

Group #9 - Project Proposal



Group Members:

Andrew Zimmer (Group Leader)
Anthony Khiami
Tom Pitera

Project Advisor: Prof. Bruce McNair
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I pledge my honor that I have abided by the Stevens Honor System

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I. Abstract

The GPS Mass Transit Tracker is a system designed to trace the location of city busses and provide real-time information on their whereabouts to the systems users. Due to various traffic jams, road construction, and accidents, it is next to impossible to provide accurate scheduling on when busses will arrive at their designated stops. This system will allow users to select their desired bus route as well as their location of pickup and they will be provided with the coordinates of the next bus(s) that will be arriving to their location (including their rates of travel). Through the use of mapping software, these coordinates will be translated to a beacon on a map so that users can actually track the busses movements.

The system will be broken into four main categories including:

1. The GPS receiver / information transmitter
2. The network infrastructure required for data acquisition
3. The database needed for tracking and querying of information
4. The user end device and software to display bus locations

Each of these categories will require extensive research to determine the most efficient and cost effective ways to implement a reliable and functional system.

Upon completion, the Mass Transit Tracker will offer an innovative product that will be extremely marketable to people who live and work in city/suburban areas. It will also be easily integrated into other operations such as cab companies and law enforcement agencies to provide their central locations with information as to where their vehicles are located, allowing more efficient and profitable operation.

II. Project Proposal Plan

II-1. Introduction

Vast amounts of research has been performed and commercialized in many areas of our project. From GPS technology to RF communications, governmental and civilian agencies continue development and refinement of these technologies. The GPS Mass Transit Tracking System is a project intended to compile these various technologies to develop a marketable system beneficial to both public transportation agencies and its users.

The Department of Defense (DoD) currently maintains twenty-four NAVSTAR GPS satellites providing service all areas of the world. In fact, Operation Desert Storm was the first major test of this system, before it became widely available to the general public. Because of its enormous success in tactical maneuvering during the war, many civilian companies foresaw a highly marketable product for automobile and handheld navigation. The GPS Mass Transit Tracking System takes a step further by adding RF transceivers to GPS modules to broadcast the locations and speeds of vehicles in city and suburban areas. These transmissions will be stored in a central database and frequently updated as new information is acquired. The general public will be able to access this information from bus stations or nearby areas to closely approximate the arrival time of the next bus.

Our focus is to generate a working prototype that will allow tracking of an individual(s) moving throughout the Stevens Campus and Hoboken carrying the GPS receiver and RF transmitter that we are building. We will display this information on a PC that will be mimicking a PDA. Once the prototype is functional, we can perform tests

on its reliability and efficiency. After some refinement, it will be assumed that this system can function when placed in mass transit vehicles.

The groups first semester will focus mainly on researching possible solutions and components that will fulfill the needs of the project at hand. Once we have gathered sufficient information, feasibility studies will be conducted to determine which components will provide the best performance and integration within our time and budgetary constraints. The second semester will be geared toward system hardware/software development and testing.

II-2. General Requirements

The GPS Mass Transit Tracking System will be designed around a few initial requirements:

- Acquisition of each vehicle's GPS coordinates every few seconds, depending upon its velocity.
- RF transmission of its location to a central database every few seconds, also depending upon its velocity.
- Transmissions are sent using a protocol that will allow identification of each bus and its route number.
- Users will be able to query the database from bus stops to find location of their next bus.

Each of these requirements posses a unique design challenge. Standard GPS transmissions provide information as to the vehicle's speed. This can be used to determine the length of time between RF transmissions to the central database. To reduce network traffic, a vehicle that is stopped should not have to repeatedly send its location. On the other hand, a vehicle that is moving rapidly will have to transmit its position much more frequently.

Perhaps the most challenging portion of this project lies in the type of network needed to produce reliable and secure transmissions to the central database. There are two alternatives that are presently being considered:

- Star Network – each vehicle will transmit directly to the central location

- Dynamic Ad-Hoc network - vehicles will rely on each other to relay messages across the network until they reach the central location

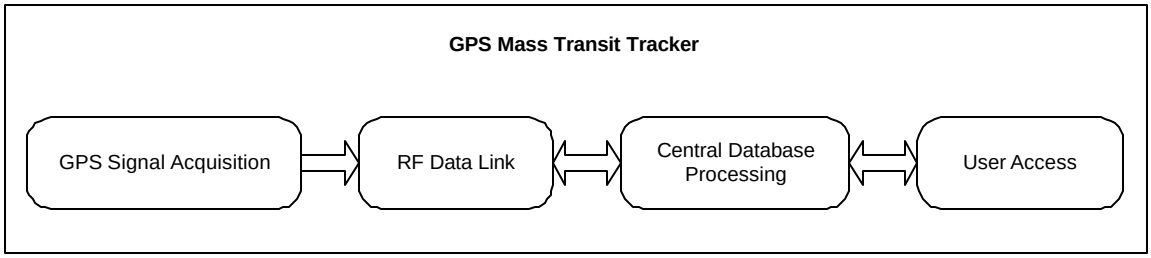
Both of these systems have advantages and disadvantages in performance and cost.

On top of this, each bus has to be distinguished from others that are also using the system. This means that the format of the message sent to the central database must include the bus number. Since busses change their routes on a regular basis, their current route must also be broadcasted and stored in the database. This will later allow users to limit their search to the route that they are looking for.

Finally, a system will be set up so that users can request locations of the busses that they are waiting for. Whether it be a text display that translates the buss's coordinates to a street location, or a map that displays a beacon representing the next bus, the public must be able to access this information in real time. Again, the types of networks above will have to be considered to determine the most effective way of providing this service.

II-3. Design Approaches

The design of the GPS Mass Transit Tracker will consist of 4 required elements: GPS signal acquisition, RF data link, database processing, and user access. Several alternatives are proposed for each component, and a decision will be weighed based on implementation cost and performance. The goal is therefore to obtain the required functionality with the best performance at the least cost.



GPS Signal Acquisition

The location of the mass transit vehicle (or other target) will be determined using Global Positioning System technology. The signals for this geo-location service are handled using an integrated chip that determines satellite location and distance to calculate static data such as latitude/longitude coordinates and dynamic data such as velocity and direction. This is a standard part manufactured and implemented by several companies. The following are the alternatives for this project:

- *Development Kit* – A development kit offers the full features of GPS capability and the necessary hardware to immediately start system integration. This avoids the time loss and problems associated with prototyping, which would be especially difficult given limited resources. Several development kits are available but only one (with less accuracy) meets the budget: **Synergy-GPS M12+ Starter Kit**. The M12+ features a chip set made by Motorola, an accuracy

of 25m, and all interconnection hardware including antenna; the cost of the kit is $144 with educational discount.

- *Off-the-shelf Receiver* – An off-the-shelf GPS receiver features the basic functionality of GPS tracking with little or no hardware intervention. This alternative generally provides higher performance for a lower cost. Two alternatives for this segment are the following: **DeLORME Earthmate GPS Receiver** and **Garmin GPS V**. Both of these receivers have an integrated antenna and are WAAS enabled, so an accuracy of <3m is possible. The Earthmate is a stand-alone receiver with a USB interface; the cost is ~$100. The GPS V has an integrated user display with tracking and mapping software; these features are not applicable to this project, but the receiver has an external RS-232 interface and the device is owned by a group member.

RF Data Link

The GPS data will need to be accessed and transferred to a remote system for database processing and user access. This will require the use of some RF wireless data link. Although it is still undetermined whether the mobile nodes (i.e. mass transit vehicles) will be configured as star or ad-hoc network, a radio transceiver will always be required at the GPS receiver. For the prototype, two such devices will be required for testing. The following are the alternatives identified for the data link:

- *Two-way Radio (FRS) Integration* – The wireless data link can be implemented using an application-specific baseband processor: **CML Microcircuits CMX882**. This chip would be used at the component level to interface directly with an FRS radio. It accommodates a data transfer rate of 2400bps and features packet data signaling suitable for GPS interfacing. This chip

can be acquired at an insignificant cost; the cost of a development kit is yet unknown. This chip will also require a pair of FRS radios for the prototype, which can be acquired for ~$50 (up to 5mi range).

- *Radio Modem* – A wireless data modem can be acquired as an OEM module featuring an integrated modem, RF circuitry, RS-232 interface, and an optional external antenna: **MaxStream XStream**. This wireless transceiver operates at 900MHz or 2.4GHz, depending on model, and can be acquired in a development kit containing a pair of transceivers and all necessary hardware to start system integration. The out-of-the-box range is up to 7mi (LOS), but can be increased to 20mi (LOS) with an optional high-gain antenna; the cost of the kit is $219 with educational discount.

  A planned graduate project advised by Professor McNair will require the implementation of a distributed (ad-hoc) network using wireless transceivers. A cooperative effort with this project may waive the cost of the radio modem for the GPS Mass Transit Tracker. Of course, this is only applicable if such alternative is selected for this leg of the design.

Database Processing

Identification and tracking data from the wireless data link will be processed at a remote system hosting a database. Although the physical network structure is to be determined, GPS data from the transit nodes will need to be stored and managed by a central host. This database will store pertinent data to track and predict arrival/departure times of a mass transit vehicle, including a unique ID (e.g. bus number), current location, route information (local), average times between stops, and other statistical data to be determined. Considering budget and start-up time, a practical tool to implement this

database management system would be Microsoft Access or a simple application created with C++.

The focus of interest for this group, however, is hardware development and interfacing. The software aspect will most likely stage the greatest challenge in the implementation of the GPS Mass Transit Tracker for this reason. This challenge will be tackled using reference books and consultation with experienced programmers both on-campus and off-campus.

User Access

The end user interface occurs between the host database and some terminal to be determined. Several possibilities have been suggested for this element of the GPS Mass Transit Tracker: a PDA or other wireless handheld device, an internet terminal, and/or a public display. These are all plausible alternatives for user access into the database, but the extent of this implementation will be determined by the constraints of time and team membership and economic analysis. A wireless handheld device and an internet terminal will allow access from a remote location. Both of these solutions enable a prospect of convenience for commuters unaware of their mass transit status. A similar solution can be applied for cab companies or other vehicle tracking applications. The public display will require an extended cost to cover the expense of monitors at all bus stop locations, but will open the tracking data to all users of the mass transit system.

The prototype for the GPS Mass Transit Tracker will most likely incorporate the database and user display into the same PC terminal. This will provided secure and sufficient tracking information of the mass transit vehicle (or other applicable medium).

II-4. Project Budget

Being that our project is currently still in the development stages our financial expenses are still very minimal. All of the development is being done by the group so there are not any labor expenses. Most of our spending is done in buying various parts needed to create a test bed for our project to run on. Our project is divided into four major sections. The following outlines the expenses we have incurred thus far, these will be updated as our project matures.

Material, Parts, and Test Equipment:

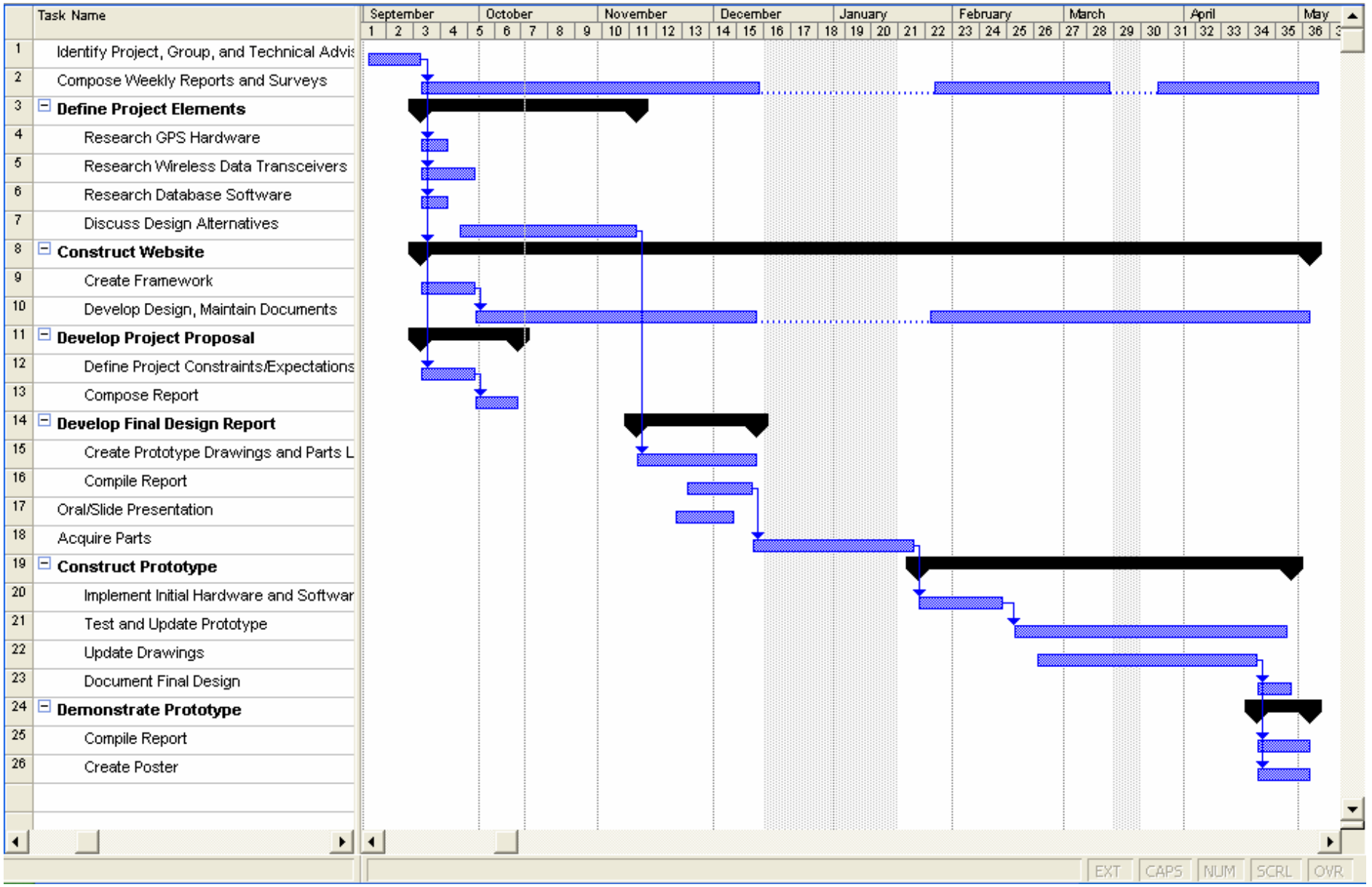
GPS Signal Acquisition:
(We will choose one of the following)
1. Synergy-GPS M12+ Starter Kit - **$144** (Student Cost)
2. DeLORME Earthmate GPS Receiver - **$160**
3. Garmin GPS V - $400

RF Data Link:
(We will choose one of the following)
1. CML Microcircuits CMX882 Development kit – Cost not available at current time
2. FRS radios - **$50**
3. MaxStream XStream - **$219** (Student Cost)

Database Processing:
A group members' laptop will act as a central database for testing purposes.

User Access:
A group members' laptop with wireless connectivity will act as a user access point.

II-5. Project Schedule



III. Conclusion

The intent of our project is to create a means for the user to be able to track a transit vehicle such as a bus or taxi. Our project will provide a way to determine the location and velocity of the vehicle by using a GPS locator coupled with a RF transceiver that will transmit the data to a central database. This information will then be available for download by a commuter waiting at a bus stop to determine the location and expected time of arrival for a bus. This information can also be used by a taxi cab company to determine which taxi cab it should send to a waiting customer.

Our group is going to research several GPS locators to determine the most useful and cost efficient product available. GPS locators are available with different range accuracies and also with different connectivity options to transfer the data it has obtained. Our project will couple the GPS locator with an RF transmitter. Several RF transmitters are being reviewed to determine the maximum distance they can operate without data distortion. The database portion or the project is currently the most challenging one because a programming effort is required and the group consists of hardware oriented electrical engineers. Our group will learn how to create a database that will allow the end user to query the database for specific vehicle location. The final area is the device the end user will use to acquire the data, for this we will setup a laptop with a wireless connection that will query our database for the information.

After integrating all of these components, the end result will be a working prototype of our system. We can then perform an analysis of the system's performance and make changes as necessary to improve its efficiency.

IV. References

Commercial Telecommunications Standards - http://www-comm.itsi.disa.mil/ - Website posted by U.S. Defense Information Systems Agency providing descriptions of communication standards.

GPS History, Chronology, and Budgets – http://www.rand.org/publications/MR/MR614/MR614.appb.pdf - Document providing history of the development of current NAVSTAR GPS network

"The Global Positioning System" (The Aerospace Corporation) - http://www.aero.org/publications/GPSPRIMER/GPS-Primer.pdf - Document identifying the history, development, and applications of GPS

Manufacturers/Distributors:

- Synergy-GPS (www.synergy-gps.com) – GPS development kits (Motorola)
- DeLORME Professional (www.delorme.com) – innovative GPS user hardware
- Garmin (www.garmin.com) – GPS navigation hardware
- CML Microcircuits (www.cmlmicro.com) – Two-way radio microelectronics -*CMX882* (http://www.cmlmicro.com/Products/TwoWay/CMX882.htm)
- MaxStream (www.maxstream.net) – Wireless modem networking -*XStream-DEV Kit* (http://www.maxstream.net/products_studentdev.html)

V. Appendix

More information about FCC regulations can be found at: www.fcc.gov