Polebridge Ranger Station
Glacier National Park

GPS Project Report
for

NR 235

by
John Kyle

December 12, 2005
Abstract

A sub-meter Global Positioning System (GPS) receiver was a valuable tool in mapping the Polebridge Ranger Station in the northwest corner of Glacier National Park in an efficient manner. With associated computer software, a useful digital map of the many and varied facilities was created for use by Glacier National Park (GNP) with a degree of accuracy necessary for facility and resource management.

Table of Contents

Abstract 2

List of Illustrations 3

List of Appendices 3

Introduction 4

Materials and Methods 4
  Location 4
  Time Frame 4
  Explanation of Equipment 5
  Equipment/Accuracy 5
  Base Station 6
  Mission Planning/Discussion 6
  Data Dictionary 7
  GPS Collection Procedures 7

Results and Discussion 8
  Problems 8
  Paper Maps 11
  Metadata 11

Conclusions 11

Recommendations 11

Literature Cited 12
List of Illustrations

Figure 1 .................................................................................. MobileMapper CE

Figure 2 ............................................................... Satellite SV and PDOP Graphs

Figure 3 ................................................................. Sky Plot, One Hour

Figure 4 ................................................................. Sky Plot, Twelve Hour

Figure 5 ........................................................................ Uncorrected Road

Figure 6 ........................................................................ Corrected Road

Figure 7 ........................................................................ Uncorrected Buildings

Figure 8 ........................................................................ Corrected Buildings

Figure 9 ........................................................................ Building Corner Points

Figure 10 ......................................................... Manually Corrected Buildings

List of Appendices

Appendix A - Data Dictionary 13

Appendix B - Metadata 19

Appendix C - Final Map, Surface Features 21

Appendix D - Final Map, Electrical and Phone Systems 22

Appendix E - Final Map, Propane System 23

Appendix F - Final Map, Water and Sewer Systems 24
Introduction

As a frequent volunteer in Glacier National Park, I contacted Richard Menicke, GIS Coordinator for GNP, about a GIS project which would be useful to GNP. He suggested the mapping of the Polebridge Ranger Station.

The principal objective of this project was to digitally document the facilities of Polebridge Ranger Station for use by Glacier National Park. The documentation took the form of feature shape files containing GPS location coordinates and miscellaneous information which were then brought together in ArcGIS for visualization. The facilities include the buildings, water, sewer, electrical, propane and telephone services. There are numerous reasons for needing such documentation, simple basic inventory of resources, reporting to Homeland Security, maintenance of the facilities, and accounting. Even with all of these benefits, the National Park Service has limited staffing for preparing such documentation. At the conclusion of this project, the documentation will be made available to Glacier National Park.

The remainder of this report will explain the equipment, methods and conclusions related to completing this project.

Materials and Methods

Location
Polebridge Ranger station is located at the northwest entrance of Glacier National Park. The area covers the entrance station, generator and maintenance buildings as well as the residences. There is a water well and storage tank to supply water. Sewage lift tanks assist with the processing of sewage.

Many of the facilities were burned in a 1988 fire with only a couple of buildings remaining. These were moved to make room for all the new facilities which were principally built in 1989. Simple schematic site maps exist for these facilities. Many of these are outdated as numerous undocumented changes have been made. Making it doubly difficult for Glacier National Park to document the facilities is the remoteness of the Ranger Station from the Park headquarters.

Time Frame
The actual project of mapping the Polebridge Ranger Station was selected prior to the beginning of the course. Several visits were made to the Ranger Station at the beginning and mid October to review the area with the Park Rangers and entrance station personnel. Reggi Altop was the Ranger who was the primary contact. He gave a tour of the facilities as well as locating the site maps of the facilities. With this information, a data dictionary was created. After familiarization with the GPS receiver equipment, data collection began at the end of October. As experience was gained in both equipment necessary to accomplish accurate data collection and of the actual facilities, the data collection phase continued to nearly the end of November.
Explanation of Equipment
The Thales MobileMapper CE (MMCE) was the GPS receiver used to collect all of the data in this project. It is a combination 14-channel GPS receiver and mobile handheld device running the Windows CE.Net operating system (Clarke, 2002). Windows CE.Net is a powerful 32 bit, multitasking and multithreaded operating system used in such devices. The ArcPad software from ESRI is the interface between the GPS portion and the user. Some of the unique features of ArcPad will be noted below. Other features of the MMCE are integrated Bluetooth wireless technology, touchscreen, field replaceable battery, and built-in alphanumeric keypad. It is designed for outdoor and industrial environments being waterproof to 1.5 meters, to withstand drops onto concrete from 1.5 meters and to have an operational temperature range of -10 C to +60 C.

Additional software can be installed to complete any needed functionality to being a mobile device.

Equipment/Accuracy
The MMCE is rated at sub-meter accuracy with differential correction using either MobileMapper Office software post processed or a real time beacon.

In a Thales MMCE white paper (Thales White Paper), dynamic line data collection was compared in three different environments, open sky, suburbs, and tree canopy. With differential correction, sub-meter accuracy was achieved in the open sky and suburban environments with standard hand held practices. The tree canopy environment which limits the reception of satellite signals proved not to be suited to dynamic data collection. Static occupation of points for sixty seconds were required to achieve sub-meter accuracy. The Signal to Noise ratio setting was suggested to be adjusted from the default 30 setting to 24 to allow for denser foliage.

A clear view of the sky was not possible for much of the area being mapped, so additional equipment was used to improve accuracy. Two different antenna configurations were used. The first was a low profile antenna set on top of a twenty foot story pole extended to fifteen feet due to an antenna length of 12 feet which determined the maximum height. The second was a geodetic antenna attached to the top of a range pole extended to eight feet. The cable for this antenna was much shorter which limited the maximum height at eight feet.
Base Station
Files from the Flathead Valley Community College Base Station were used to
differentially correct all data collected by the MMCE. Positional data of the Flathead
Valley Community College Base Station is as follows:

- Site ID: MTFV
- Latitude: 48°13'38.91428" North
- Longitude: 114°19'36.59290" West
- Horizontal Datum: NAV83(CORS)
- Vertical Datum: NAVD88
- Height: 905.188 Meter

Receiver operates 24 hours/day, 7 days/week, 1 second epoch

Mission Planning
Using Pathfinder Office Quickplan, the positions of the satellite vehicles were evaluated
for the number of satellites visible at various times and the resulting Position Dilution of
Precision (PDOP) prior to going on site for data collection. The following graphs for
November 23, 2005 demonstrate the results of the analysis for the duration of this project.
As a general rule it was determined that adequate positioning was possible between 9:30
AM and 1:30 PM, then again from 2:00 PM until 3:30 PM. These times were selected
due to the length of time to drive to the site and length of time concerted effort could be
maintained. Eventually the battery life of the receiver also became a limiting factor.

![Graph showing Number of Satellites (Nsats) and associated Position Dilution of Precision (PDOP)](image)

**Figure 2** - Two graphs showing the Number of Satellites (Nsats) and the associated Position Dilution of Precision (PDOP) between 8:00 AM and 8:00 PM
A Skyplot of a short period, such as a half hour to an hour displays relatively clearly where the satellites are located. This can be useful when data collection is planned where the environment is particularly difficult for satellite viewing. See Figure 4, below left. I have found that the Skyplot graph is not otherwise to be of as much use as the plot covering an extended length of time, as is shown below to the right, is difficult to interpret. I therefore did not utilize these graphs for mission planning. I found that a similar graph on the MMCE to be quite useful during actual data collection.

![Figure 3 - SkyPlot, one hour.](image1)

![Figure 4 - SkyPlot, twelve hours.](image2)

**Data Dictionary**
A well planned data dictionary facilitates efficient data collection in the field. A data dictionary was prepared for the general site, buildings and facilities of the Ranger Station. Several feature attributes were created with the concept of filling in the information after the GPS location information had been collected. In this project the data dictionary evolved as knowledge was gained. The final data dictionary used is presented in Appendix A.

**GPS Collection Procedures**
Good GPS practices as were identified from course work, numerous discussions with knowledgeable people and from the white paper were carried out for maximum accuracy. Specifically, all data was collected by averaging data points over a thirty second period at one second intervals. This necessitated the use of a pole to hold either the receiver or an antenna for stabilization during data collection.

The ArcPad software on the MMCE is capable of static vertices collection in polyline mode which is in contrast to dynamic streaming vertices. Some other GPS receiver software either do vertices collection in continuous line form by time positioned in one spot or not capable at all. This capability was used to collect line data with thirty second averaging at one second intervals.
Results and Discussion

Problems
After gaining proficiency with the equipment, there were two major issues which persisted throughout the data collection process. The first issue arose due to the facilities all being underground. It took significant effort to understand the meaning of the site maps. Several of the facilities were modified and were undocumented since the site maps made at the initial rebuilding of the area. There were numerous discussions with Reggi Altop to locate and identify the various facilities. He has been a resident at the Ranger Station since it had been rebuilt and had some memory of the changes made. Even so, mapping of the below ground facilities involved a bit of guessing. The mappings for these particular facilities cannot be totally relied upon for precise location but can be used for conceptual arrangement.

The largest issue was the multipathing of the GPS signals in the timbered areas. The buildings were mostly in timbered areas so two of the most difficult situations were encountered simultaneously. The multipathing was encountered and noted on the first day of data collection with reference to the roadway which showed spurious locations. This led to using a twenty foot story pole (Beall, 2005) set at fifteen feet with a low profile antenna on top for collecting building information. Basically the roof line was mapped at the corners. After post processed differential correction of the shape files, the roadway cleaned up, Figures 5 & 6, but the buildings remained strangely shaped, Figures 7 & 8. This indicated that even the use of a story pole did not adequately solve the issue.

![Figure 5 - Uncorrected Road](image1)

![Figure 6 - Corrected Road](image2)
In speaking with a representative for Thales (Silver, 2005), the use of a geodetic antenna was suggested and a loan of one was arranged. The geodetic antenna was placed on top of a range pole set at eight feet. This was the maximum height achievable with the length of the cable which came with it.

Offsetting is a technique where a point is taken at some distance away from the actual desired position. The bearing and distance to the actual position is either noted or entered in the process. The reason for this technique is usually due to an inability to get an accurate reading at the actual point. Depending upon the software used, the collected point is either automatically or manually adjusted. ArcPad 6, which currently used on the MMCE, does not have the automatic capability as a standard feature. An offset extension is available from the ESRI web site. This was copied to the MMCE. I was not able get the extension to work properly so it was not used. ArcPad 7 has been released and has an offset function.

I decided to map the corners of the building taking bearing and distance measurements to correct the points. The differentially corrected points were in a rectangular form indicating that accurate measurements had been achieved. Using these collected points, the building data was adjusted in ArcGIS to match the point boundaries.
The issue of a well prepared data dictionary was part of the learning process. Entering data with a stylus is laborious and difficult in inclement conditions. Menu type data attributes is one alternative to assist with efficient data entry. This requires a tremendous amount of preplanning which may defeat the concept of overall efficiency for a one time project. For larger amounts of information, post data collection information entry seems more appropriate.

I discovered that the MobileMapper Office export function, particularly after the post processing of data, truncates any text to a maximum of twenty characters in the shape files. This limits the amount of data which can be entered in the field which is not necessarily a bad feature, but it also limits the amount of data which can be entered post data collection. Fortunately Excel is capable reading the data files and altering the field length. For me this is a work around and not an ultimate solution but at least the task can be accomplished.
Paper Maps
The data shape files were brought into MobileMapper Office from the MMCE using MS Active Sync to differentially correct the data. This data was then exported to a folder for corrected data. ArcGIS 9.0 was used to analyze and create a map of the area. The shape files were converted to datum UTM NAD 83 Zone 12 as this is the standard datum of Glacier National Park. Technically, Polebridge is just outside Zone 12 to the west, but not by much so this slight deviation is accepted to be consistent with the rest of GNP. Several maps are presented with different focuses. See Appendices C through F for the final results.

Metadata
Metadata is a valuable tool to explain the circumstances surrounding the data collected. This can include standard information such as the author, date and other information. Additionally, limitations of the data collected can also be listed as was the case in this project. See Appendix B for the information for this project map. There is also metadata information for each feature file but has not been update as of yet.

Conclusions
Accuracy versus time has always been an issue with mapping projects. Using sub-meter GPS receivers is a valuable tool in the process of collecting spatial data. As with any mapping project, planning is of utmost importance in achieving desired results. With such planning, GPS receivers can be used to efficiently collect data for resource and facility management as this project demonstrated.

From the difficulties encountered in this project with collecting accurate data in tree canopied areas, it is apparent that proper GPS data collecting practices are especially important in timbered areas. One of the specific requirements is averaging data at specific points for at least thirty seconds, with one minute intervals being even better. The use of a geodetic antenna is also an important component to the success of accurate data collection in difficult multipathing situations. For ease of use and stability, both the antenna and receiver need to be mounted on a range pole.

Recommendations
The Thales MobileMapper CE can be recommended as meeting the requirements of sub-meter mapping when utilized with good GPS data collecting practices and differentially corrected positions even if the use of a geodetic antenna is required in difficult situations. It is therefore a suitable solution for resource and facility management.
Literature Cited


Appendix A - Data Dictionary

"Polebridge", Dictionary, "Created by John Kyle"
"Bridge", area, "Above Ground", 5, seconds, 1, Code
   "Description", text, 30, normal, normal

"Roadway", line, "Above Ground", 5, seconds, 1, Code
   "Description", text, 30, normal, normal, Label1

"Building", area, "Above Ground", 5, seconds, 1, Code
   "Building number", numeric, 0, 0, 10000, 0, normal, normal, Label1
   "Purpose", text, 80, normal, normal, Label2
   "Width (feet)", numeric, 1, 0.0, 200.0, 10.0, normal, normal
   "Length (feet)", numeric, 1, 0.0, 200.0, 10.0, normal, normal
   "Porch width (feet)", numeric, 1, 0.0, 100.0, 10.0, normal, normal
   "Porch length (feet)", numeric, 1, 0.0, 40.0, 10.0, normal, normal

"InterDish", point, "Above Ground", 5, seconds, 1, Code
   "Description", text, 30, normal, normal

"InterCable", line, "Below ground", 5, seconds, 1, Code
   "Description", text, 30, normal, normal

"Wellhead", point, "Below ground", 5, seconds, 1, Code
   "Description", text, 30, normal, normal

"SpiderLn", line, "Below ground", 5, seconds, 1, Code
   "Description", text, 30, normal, normal

"WaterLine", line, "Below ground", 5, seconds, 1, Code
   "Size (inches)", numeric, 0, 0, 100, 2, normal, normal, Label1
   "Notes", text, 30, normal, normal

"WatMajShut", point, "Above Ground", 5, seconds, 1, Code
   "Description", text, 30, normal, normal

"WatBuildShut", point, "Above Ground", 5, seconds, 1, Code
   "Description", text, 30, normal, normal

"WatStorTnk", area, "Below ground", 5, seconds, 1, Code
   "Description", text, 30, normal, normal

"WatTankCov", point, "Above Ground", 5, seconds, 1, Code
   "Size (inches)", numeric, 0, 0, 100, 2, normal, normal
"PhoneLine", line, "Below ground", 5, seconds, 1, Code
 "Description", text, 30, normal, normal

"PhoneBox", point, "Above Ground", 5, seconds, 1, Code
 "Description", text, 30, normal, normal

"SewDrainFld", area, "Below ground", 5, seconds, 1, Code
 "Description", text, 30, normal, normal

"SewAccCov", point, "Above Ground", 5, seconds, 1, Code
 "Size (inches)", numeric, 0, 0, 100, 2, normal, normal

"SewLiftStn", point, "Below ground", 5, seconds, 1, Code
 "Description", text, 30, normal, normal

"Gate", line, "Above Ground", 5, seconds, 1, Code
 "Type", text, 20, normal, normal, Label1

"Fence", line, "Above Ground", 5, seconds, 1, Code
 "Type", text, 20, normal, normal

"MailboxSt", point, "Above Ground", 5, seconds, 1, Code
 "Description", text, 30, normal, normal

"DisplSign", line, "Above Ground", 5, seconds, 1, Code
 "Type", menu, required, required, Label1
   "Information"
   "Regulation"
   "Other"

"FeeDepositB", point, "Above Ground", 5, seconds, 1, Code
 "Description", text, 30, normal, normal

"Sign", point, "Above Ground", 5, seconds, 1, Code
 "Type", menu, required, required, Label1
   "Fee"
   "Keep Right"
   "Fishing Access"
   "One Way"
   "Glacier Park"
   "Authorized Vehicles"
   "Toilet"
   "Speed"
   "Stop"
   "DoNotEnter"
"Other"

"FireHydrant", point, "Above Ground", 5, seconds, 1, Code "Description", text, 30, normal, normal

"FireHoseCab", point, "Above Ground", 5, seconds, 1, Code "Description", text, 30, normal, normal

"WatPumpBox", point, "Above Ground", 5, seconds, 1, Code "Description", text, 30, normal, normal

"WellElecBox", point, "Above Ground", 5, seconds, 1, Code "Description", text, 30, normal, normal

"WellAccCov", point, "Above Ground", 5, seconds, 1, Code "Size (inches)", numeric, 0, 0, 100, 2, normal, normal

"WeatherStn", area, "Above Ground", 5, seconds, 1, Code "Description", text, 30, normal, normal

"PhonJunBox", point, ",", 5, seconds, 1, Code "Description", text, 30, normal, normal

"DieselTank", area, "Above Ground", 5, seconds, 1, Code "Size (gallons)", numeric, 0, 0, 100000, 1000, normal, normal

"PropanTank", area, ",", 5, seconds, 1, Code "Size (gallons)", numeric, 0, 0, 100000, 1000, normal, normal

"ProGasLine", line, "Below ground", 5, seconds, 1, Code "Description", text, 30, normal, normal

"ProMajShut", point, "Above Ground", 5, seconds, 1, Code "Description", text, 30, normal, normal

"GasPump", point, "Above Ground", 5, seconds, 1, Code "Description", text, 30, normal, normal

"GasEmergShut", point, "Above Ground", 5, seconds, 1, Code "Description", text, 30, normal, normal

"ProTankCov", point, "Above Ground", 5, seconds, 1, Code "Description", text, 30, normal, normal

"ProResShut", point, "Above Ground", 5, seconds, 1, Code
"ClothesLine", line, "Above Ground", 5, seconds, 1, Code
"Notes", text, 30, normal, normal, Label1

"RadioTower", point, "Above Ground", 5, seconds, 1, Code
"Notes", text, 30, normal, normal, Label1

"ProTnkRisr", point, "Above Ground", 5, seconds, 1, Code
"Notes", text, 30, normal, normal, Label1

"ElecPullBox", point, "Above Ground", 5, seconds, 1, Code
"Notes", text, 30, normal, normal, Label1

"WatWellLin", line, "Below Ground", 5, seconds, 1, Code
"Size (inches)", numeric, 0, 0, 100, 2, normal, normal
"Notes", text, 30, normal, normal

"WatTankLin", line, "Below Ground", 5, seconds, 1, Code
"Size (inches)", numeric, 0, 0, 100, 2, normal, normal
"Notes", text, 30, normal, normal

"WatTretLin", line, "Below Ground", 5, seconds, 1, Code
"Size (inches)", numeric, 0, 0, 100, 2, normal, normal
"Notes", text, 30, normal, normal

"ElecJuctBx", point, "Above Ground", 5, seconds, 1, Code
"Notes", text, 30, normal, normal

"ElecBrakBx", point, "Above Ground", 5, seconds, 1, Code
"Notes", text, 30, normal, normal

"SewerLine", line, "Below Ground", 5, seconds, 1, Code
"Notes", text, 30, normal, normal, Label1

"SepticTank", area, "Below Ground", 5, seconds, 1, Code
"Notes", text, 30, normal, normal, Label1

"BuildCornr", point, "Above Ground", 5, seconds, 1, Code
"Notes", text, 30, normal, normal, Label1

"Barrier", line, "Above Ground", 5, seconds, 1, Code
"Notes", text, 30, normal, normal

"LiftEmerg", point, "Above Ground", 5, seconds, 1, Code
"Notes", text, 30, normal, normal
Appendix B - Metadata

Identification_Information:

Citation:
    Citation_Information:
        Originator: John Kyle
        Publication_Date: December 12, 2005
        Title: Polebridge Ranger Station

Description:
    Abstract: The map digitally documents the facilities of the Polebridge Ranger Station.
    Purpose: This data is an inventory of resources for reporting to Homeland Security,
    maintaining the facilities and provide information to accounting.
    Supplemental_Information: The GPS mapping of the below ground features were
    approximation of information taken from site maps and the rememberances by Reggi Altop of
    changes made.

Time_Period_of_Content:
    Time_Period_Information:
        Single_Date/Time:
            Calendar_Date: REQUIRED: The year (and optionally month, or month and day) for which
            the data set corresponds to the ground.
            Currentness_Reference: REQUIRED: The basis on which the time period of content
            information is determined.

Status:
    Progress: REQUIRED: The state of the data set.
    Maintenance_and_Update_Frequency: REQUIRED: The frequency with which changes and
    additions are made to the data set after the initial data set is completed.

Spatial_Domain:
    BoundingCoordinates:
        West_Bounding_Coordinate: REQUIRED: Western-most coordinate of the limit of coverage
        expressed in longitude.
        East_Bounding_Coordinate: REQUIRED: Eastern-most coordinate of the limit of coverage
        expressed in longitude.
        North_Bounding_Coordinate: REQUIRED: Northern-most coordinate of the limit of
        coverage expressed in latitude.
        South_Bounding_Coordinate: REQUIRED: Southern-most coordinate of the limit of
        coverage expressed in latitude.

Keywords:
    Theme:
        Theme_Keyword_Thesaurus: REQUIRED: Reference to a formally registered thesaurus or a
        similar authoritative source of theme keywords.
        Theme_Keyword: REQUIRED: Common-use word or phrase used to describe the subject of
        the data set.

Access_Constraints: REQUIRED: Restrictions and legal prerequisites for accessing the data set.
Use_Constraints: REQUIRED: Restrictions and legal prerequisites for using the data set after access is granted.

Point_of_Contact:
Contact_Information:
  Contact_Person_Primary:
  Contact_Person: John Kyle
  Contact_Position: Volunteer
Contact_Address:
  Address_Type: mailing and physical address
  Address: 773 5th Ave WN
  City: Kalispell
  State_or_Province: MT
  Postal_Code: 59901
  Country: USA
  Contact_Voice_Telephone: 406-257-0328

Native_Data_Set_Environment: Microsoft Windows XP Version 5.1 (Build 2600) Service Pack 2; ESRI ArcCatalog 9.0.0.535

Distribution_Information:
  Resource_Description: Map Files

Metadata_Reference_Information:
  Metadata_Date: 20051207
  Metadata_Contact:
    Contact_Information:
      Contact_Organization_Primary:
        Contact_Organization: REQUIRED: The organization responsible for the metadata information.
        Contact_Person: REQUIRED: The person responsible for the metadata information.
        Contact_Address:
          Address_Type: REQUIRED: The mailing and/or physical address for the organization or individual.
            City: REQUIRED: The city of the address.
            State_or_Province: REQUIRED: The state or province of the address.
            Postal_Code: REQUIRED: The ZIP or other postal code of the address.
          Contact_Voice_Telephone: REQUIRED: The telephone number by which individuals can speak to the organization or individual.

Metadata_Standard_Name: FGDC Content Standards for Digital Geospatial Metadata
Metadata_Time_Convention: local time

Metadata_Extensions:
  Online_Linkage: http://www.esri.com/metadata/esriprof80.html
  Profile_Name: ESRI Metadata Profile