

Requirements

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#  Introduction

**1. Environmental Change**

Our planet’s temperature is rising. Research shows Earth’s average surface temperature has increased 0.6 degrees Celsius (1.8ºF) over the last 100 years. This increase in temperature can be linked to the recent environmental trend known as global warming. Global warming is partially caused by the rising levels of greenhouse gasses (GhG). Greenhouse gasses reside in Earth’s atmosphere, absorbing and transmitting radiation.

Historically, greenhouse gases allowed life on Earth to flourish due to its characteristic of trapping heat in the atmosphere and keeping the planet within habitable temperatures. However, levels of carbon dioxide, methane, and nitrous oxide have intensified substantially over the last century. The most influential of these gases is carbon dioxide for the role it plays in temperature increase. Levels of carbon dioxide in the atmosphere are higher now than it has been over the last 650,000 years. Extraneous amounts of carbon dioxide in the earth’s atmosphere is the main cause of global warming. This increase is partially due to the burning of fossil fuels such as oil, coal, and natural gas. Another reason for the increase in carbon dioxide is having fewer forests to soak up the gas from the atmosphere; this is known as deforestation.

As global warming continues to worsen, calamity has arisen on our planet. Global warming leads to the reduction of glaciers, which are very important to the survival of salmon and polar bears. Global warming also causes rising water levels, creating favorable living conditions for mosquitoes. These favorable conditions have led to the rise of mosquito-associated diseases such as West Nile Virus, Malaria, and Dengue Fever in Asia, East Africa, and Latin America. Another effect includes oceans absorbing more carbon dioxide causing the water to become more acidic leading to damage to many species.

There are many ways we can slow down the process of global warming and help save our planet. Many small and traditional actions include recycling, using fluorescent bulbs, driving less or driving a hybrid. We could drastically reduce our carbon emissions if we stopped driving cars and operating large industrial factories, but this solution obviously isn’t practical in our modern time. A first step to fighting global warming without halting industrial progress is the planting of new trees all over the world. After all, one single tree can reduce atmospheric carbon dioxide by about 915 kilograms (~1 ton) over its lifetime.

**2. Clean Air Action Corporation (CAAC)**



Clean Air Action Corporation (CAAC) develops and implements low cost strategies to clean up the air in ways that make good business sense. For seventeen years they have helped communities and businesses clean up the air sooner and at lower cost. CAAC is headquartered in Tulsa, Oklahoma and has a subsidiary in Morogoro, Tanzania. Smaller offices are also located in India, Kenya, and Uganda. CAAC has worked all over North America, Europe, Africa, and Asia.

CAAC primarily manufactures NOx, VOC, and GhG emission reductions for various clients. NOx refers to Nitrogen Oxide, a chemical produced during combustion that contributes to global warming and limits the growth of plants. VOCs are Volatile Organic Compounds with significant vapor pressures that can occur naturally or be man-made and can have chronic adverse effects on the environment. GhG are Greenhouse Gasses which are various gases that trap heat and radiation in the atmosphere causing a gradual global warming effect. All of these chemicals and gases have negative effects on the environment. CAAC helps to reduce these emissions while also helping companies meet regulations for acceptable levels of these chemicals.

CAAC has worked with a broad range of clients to help reduce or reverse these emissions. Their satisfied clients include a broad range of companies, such as Shell Chemical, Shell Oil, Ford Motor, General Motors, Pfizer Corporation, Tennessee Valley Authority, and Cumberland Farms. A full list of their clients is available on their website.

Finally, Clean Air Action Corporation (CAAC) has established itself as a catalyst for change in air emission compliance. CAAC has been involved with or responsible for several breakthroughs. For example, they helped establish the first Ozone Alert program for alerting the public of weather conditions that contribute to high ozone levels. They also have helped facilitate the first Interstate and International emission reduction credit transactions. With a wide range of functions and clients, CAAC has established itself as a pioneer in cost effective solutions for air emission problems. One of CAAC’s most unique solutions is their sustainable development project, The International Small Group & Tree Planting Program.

**3. The International Small Group & Tree Planting Program (TIST)**

The International Small Group & Tree Planting Program (TIST) empowers farmers from Tanzania, Kenya, Uganda, India, Honduras and Nicaragua to reverse the effects of deforestation, drought and famine through the planting of trees. These planted trees will eventually be sold to companies worldwide in the form of Greenhouse Gas Credits (GhGs) when a company or individual seeks to reduce their global carbon footprint. Currently, a certificate of offsetting greenhouse gasses produced by 1 metric ton of CO2 equivalent (CO2e) sells for $10 in their online store. 



Local farmers from Tanzania, Kenya, Uganda, India, Honduras and Nicaragua are paid to plant new trees in groves around their farmland. However, in order for TIST to be able to offer certificates of GhG, reporting is necessary. The administrative body in charge of GhG certification also requires precise GPS coordinates of the location of these tree groves - not just a simple count of trees planted. In order to satisfy the administrative body, TIST hires and trains local recruits as GPS Quantifiers to walk the perimeter of the tree groves (recording a grove tract) which had previously been planted by local farmers. There are over 50,000 farmers in the program, over 7 million trees in the ground, and an estimated 6,000 more being planted each day.

The success of the TIST Project greatly relies on the accurate information collected for the program’s currenttrees and other project areas (also known as grove tracts). The data is captured by TIST Quantifiersusing Palm mobile devices. These palm devices are used in conjunction with GPS devices. TIST Quantifiers collect this GPS data in a variety of ways to georeference the other information being collected related to valid project areas. Acreage, the third party GPS application currently used by TIST for collecting tract data, has become outdated and no longer meets TIST’s needs.

**4. Team Hakuna Matata**

Hakuna Matata is a Swahili phrase that translates to “There are no worries” in English. Our development will be contributing to offsetting the worry caused by global rising temperatures and greenhouse gas emissions. We’re also indirectly helping farmers in struggling countries maintain their independence and offset the devastating effects of deforestation, drought and famine. We’re helping the world become a little more “worry free”.

Our team consists of an experienced group of software developers, all from varying backgrounds of expertise:

Leah Shanker is serving as the primary role of Team Lead for the project, in addition to serving as an extra set of hands in any area where necessary. She is aiming for a professional career in Embedded Software Development upon graduation at the end of the semester. Her personal strengths include Embedded Software Development and User Interface Development. Her ability to quickly grasp complexities, solve problems efficiently and effectively lead numerous successful teams during her academic career prime her for leadership for this team. Her Computer Science electives taken include Advanced User Interfaces, Embedded Systems, Virtual Worlds, Artificial Intelligence and Computer Security.



Stephen Baier is serving as the primary role of User Interface Designer and Recorder. With an emphasis in games, Stephen Baier has extensive experience with user interface design; picking up practice in classes such as Virtual Worlds, Game Production, Advanced User Interfaces and Software Engineering; implementing interfaces in Java (Swing), SLAG and Actionscript3. Through courses such as Computer Graphics and Operating Systems, Stephen has experience with C and C++ in UNIX, Windows and OS X environments; skills that will be valuable in the course of this project. Having spent one semester as an Aerospace Engineer and two semesters as a Computer Engineer at Embry-Riddle Aeronautical University (ERAU), along with pursuits of personal interest, Stephen has some familiarity with embedded and mobile programming; another valuable trait for this project. Stephen’s strongest trait is his ability to write code.

Brandon Davis is serving as the primary role of System and Document Management, with a secondary role of application development. Planning for a future in Game Production, Brandon Davis has placed an emphasis on communication and the overlaying architectures of any system. Brandon has been exposed to the architecture of various systems through courses such as Software Engineering, Game Production, Automata Theory, and Data Mining. These systems have also exposed Brandon to various implementation languages, such as C/C++, Java, PHP, and Actionscript. With a minor in English, Brandon also focuses on being able to visualize and explain the overall problem and solution. Communication and abstraction are key components to any successful software system and these are what Brandon excels at.

Nathan Gross is serving as the primary role of Website Administrator and secondary role of Hardware Manager. A semester away from attaining a bachelors in Computer Science, Nathan Gross is self-determined, outgoing, hardworking, dependable, and eager to learn and grow professionally when associated in software development. Nathan has laid an emphasis on web development, software architecture, and game production. Considerable experience can be shown through courses such as Web Development, Virtual Worlds, Computer Graphics, Software Engineering, and Operating Systems. Through the course of his career he has been divulged in several languages including PHP, Javascript, Perl, ASP, Java, C, C++, and other strong tools such as HTML, CSS, MySQL, and AJAX. Nathan is ready to prove that he is versatile and can perform well in many kinds of positions.

**Existing Implementation**

**1. Current Process**

The TIST Project’s current implementation includes the long outdated software package, Acreage. Acreage talks to an external GPS device (via serial port on the Zire 71, Bluetooth on the Centro) and offers the GPS Quantifier an interface for recording and deleting grove tracts. The software was designed by a programmer in South Africa who has since stopped maintaining it or publishing any updates whatsoever. With the numerous unhandled errors in the Acreage software, coupled with the older Palm hardware - the GPS Quantifiers experience a great deal of annoyance due to errors, sometimes even causing the device to reboot.

Pendragon Forms 2.0 (Forms) is used for local data storage on the device as well as synchronization with the TIST.org servers when the GPS Quantifier reaches an Internet cafe in one of the local villages. Because neither the Zire71 nor the Centro devices have on-board GPS, the Acreage software communicates to the external GPS devices for location information. The GPS Quantifier walks the perimeter of the tree grove to record a new grove tract. Acreage displays previously recorded grove tracts, allowing the GPS Quantifier to delete erroneous tracts.

Below are some screenshots of the current implementation. The left two are from Acreage, displaying two different views of a grove. The right two are from Pendragon Forms 2.0 - notice excessive message pop-ups.



**2. Problems with Current Implementation**

Our clients shipped us both the Palm Zire71 device and the Palm Centro device, both with Acreage and Forms installed. In addition, we were also given the external GPS Devices that were being used in the field by the GPS Quantifiers. Our team took a hike around the grassy area near the NAU Engineering Building, plotting our own grove tracts and taking notes about the current user experience as well as problems encountered.

**2.1 Poor Interface Design**

Although we were eventually able to successfully plot grove tracts for both devices, it took a great deal of referencing the user’s manual and trying to figure out what purpose each of the options served. For example, from the application screenshot above, what do each of the checkboxes marked “Auto”, “Man” and “User” in the Acreage program actually do? This is only one example of confusing interface elements that don’t match the user’s mental model.

**2.2 No Source Code**

The original developer of Acreage was a man in South Africa who has long since stopped responding to e-mails sent by our client. The original developer has not issued an update to Acreage in several years and it looks like he never will. Moreover, since the software was not released open source and source code was never provided to TIST, Acreage is not maintainable or update-able with future functional requirements.

**2.3 Intensive Training Required**

Acreage is not the easiest or most intuitive piece of software to use. A twenty-page training manual is given to each of the GPS Quantifiers with screenshots of every possible phase and every application error that occurs and how to deal with it. In addition to the manual, GPS Quantifiers are required to attend a two week classroom training session, followed by a tag-along apprenticeship where they follow another GPS Quantifier out to a job site to watch them in action. For more information about our users, please see our User Profile.

**2.4 Lack of Modularity**

The current implementation has several applications working together, but hardly seamlessly. Forms calls Acreage to begin the data collection process, but Acreage never releases control back to Forms. This requires the user exit out to the menu and manually re-launch the Forms application to continue the data synchronization process.

**2.5 Missing Functionality in Acreage**

Problems with the Acreage software include advertised functionality that was never actually completed in the released product.

*2.5.1 No Editing of Existing Grove Tracts*

Acreage has an incomplete menu item for allowing the GPS Quantifier to edit existing grove tracts, but that functionality has reportedly never actually worked. It simply causes an application error to fire, usually resulting in the device rebooting.

*2.5.2 “Auto” Setting Not Functioning Properly*

Under the Acreage Toolbar Tab for Menu > Options > Preference, there is a “Map Scale” setting. The possible values are some numbers of an unknown scaling unit (0.1, 1, 2, 5, etc.) and “Auto”. As the name would suggest, the “Auto” setting is intended to inscribe the track as large as possible inside the drawing space. This should be the ideal setting to use while collecting tracks; however, it does not function properly.

*2.5.3 Cross-hair Display*

When collecting points in Acreage, a cross-hair appears denoting the person's current position. Unfortunately, it only appears when you are actively collecting points. It would be great if this cross-hair was also displayed when the GPS was connected but Acreage was not actively collecting points. This would allow the quantifier to locate a previously collected track, without actively collecting points. At the moment, the Quantifiers are required to collect points in order to locate the track, then restart the process to get read of the junk points collected during their wandering.

**2.6 Unhandled Errors in Acreage**

The older Palm hardware simply reboots when unhandled application errors are thrown. Unhandled errors in the Acreage software cause the hardware to reboot, wasting the valuable time of our users, the GPS Quantifiers.

*2.6.1 Quirky Bluetooth Communication*

The Palm Centro version of Acreage handles Bluetooth communication with the external GPS device in a very poor manner. It does not close the Bluetooth port properly after finishing, creating a state where no new data can be input until both the GPS Device and the Centro are rebooted. Another problem found is Acreage attempts to communicate over the Bluetooth port to initiate a new connection, even when it has already properly connected to the Bluetooth GPS Device. These problems cause unhandled application errors and sometimes cause the device to reboot.

*2.6.2 Frequent Runtime Errors*

Runtime errors in Acreage occurred almost every time we tested out the software. It was nearly impossible to complete a task without an error dialog popping up with a random error code and no explanation. This seems like a product of poorly developed code.

**Our Solution**

**1. Solution Overview**

Team Hakuna Matata will be rewriting Acreage, used by GPS Quantifiers in the field to accurately record, edit and delete grove tracts. We will be naming our GPS quantifier application GroveTrotter (GT). Because the TIST Project intends to eventually move to a different unspecified hardware platform in the future, we have designed our solution to be as modular as possible, separating out data communication into its own section.



The already existing software to communicate with the TIST.org servers is called Pendragon Forms 2.0 (Forms). Our solution will implement middle-ware for parsing Forms data and formatting output for use with Forms, but we will not be rewriting any piece of the already existing Forms software. The Forms Parsing and Forms Data Input pieces will be designed with orthogonality in mind, as these are the pieces that will likely need to be swapped out with newer communication frameworks in the future.

The GPS Quantifier walks around the perimeter of the tree grove, recording a grove tract using the GroveTrotter (GT) software. GT communicates with an external GPS device to gather location information while the GPS Quantifier records the grove tracts.

One of the main issues the GPS Quantifiers face is the lack of a steady Internet connection. In order to synchronize collected data with the TIST.org servers and gather information about future grove tract assignments, the GPS Quantifiers need to seek out a local village and use the connection at an Internet Cafe.

The TIST Project collects and reviews GPS data in a number of different ways. While Acreage has become inadequate and substandard, the development of a new GPS application, GroveTrotter, will be fully capable of meeting the project’s demands. The basic key features required are as follows:

1. Collecting, saving, and loading tracts
2. Calculating the area, length and other basic information about a tract
3. Pausing and editing of a tract while it is being collected
4. Reviewing multiple tracts at the same time
5. Navigating a user to a single GPS location
6. Allowing the user to navigate to an existing tract (whether stored from a previous monitoring event or recently taken)

Forms Parsing involves gathering data from the Forms specification, packaging up the data and sending it to GroveTrotter (GT) using a documented data standard, which will be outlined at a later time. GT will then convert the input into the user-selected language and user-selected measurement system for a localized user interface experience.

Forms Data Input focuses on aggregating collected GroveTrotter (GT) data, packaging it up to Forms standard for data and sending it to Forms for local data storage. Once the GPS Quantifier reaches a steady Internet connection at a local Internet Cafe, they will use Forms to synchronize their data with the TIST.org servers.

Designing for modularity means that if in the future TIST decides to move away from Forms for data management, the only pieces of GroveTrotter (GT) that would need to be updated would be the two Forms pieces. None of the GT application code would need to be updated, provided the hardware remained the same.

# Functional Requirements

##### 1. Plotting TractsReading and recording of GPS data to form a tract is the most pertinent functionality of the current implementation of Acreage and the GroveTrotter (GT) application. GT will need to continuously store, display and manage GPS coordinates as Quantifiers navigate tree groves.

##### 2. Tract DisplayQuantifiers need to verify the tracts they record; this is currently done visually as the tracts are displayed in a 2D manner. GT needs to support visualization of tracts, just as Acreage does, and should additionally automatically scale the tract(s) to fit the size of the screen.

##### 3. Tract ManagementQuantifiers commonly need to delete and edit tracts after plotting and may be required to pause and restart during the plotting process. Editing tracts would involve trimming erroneous points or removal of points that need to be replotted. Sometimes obstacles prevent Quantifiers from completing a tract without leaving the actual tract path. Because of this, GT must allow tract collection to be paused and continued at a later time.

**4. GPS Device Communication**As neither the Zire71 nor the Centro has a built-in GPS device, both communicate to external GPS devices (for more details see the Hardware Requirements). GT will need to use the appropriate port to access external GPS data, depending on which GPS device is currently being used. The integrity of this communication needs to be improved upon from the existing implementation, which frequently errors out and forces the user to restart their device.

**5. Data Integrity**The Zire71 has a flash memory system which requires constant battery power. If battery power runs out, the entire device memory, including installed programs and recorded grove data will be wiped out. GT will need to offset this risk by backing up all data to the SD Card of the hardware device.

**6. Position Indication**With their current software, TIST Quantifiers can run into trouble determining if they are on the correct tract or not. For this reason, GT needs to indicate to its users where they are relative to their target tract.

**7. Pendragon Forms 2.0 Communication**
Pendragon Forms 2.0 is the application responsible for handling communication between individual devices and TIST.org servers. GT needs to send tract information to Forms, as well as load previous tracts from Forms.

**Non-Functional Requirements**

**1. Hardware Requirements**

TIST has specific and inflexible hardware requirements. These constraints cannot be changed or modified as TIST does not plan on purchasing new hardware in the immediate future. The devices TIST Quantifiers currently use were chosen because these devices survive in the rugged deployment environment, whereas most (modern) devices would be far too frail.
TIST uses two different mobile platforms, the Zire71 and Centro. GroveTrotter (GT) will be developed for these platforms, adhering to the specific requirements of each. Both platforms use the Palm OS; a specific SDK was provided by the sponsor which is compatible with both devices. Each device will need to talk to an external GPS device, as neither has one built-in.

**1.1 Palm Zire71**



* Uses serial port to talk to external GPS device.
* 1GB SD memory.

**1.2 Palm Centro**



* Uses Bluetooth to talk to external GPS device.
* 8GB SD memory.

**2. Usability Analysis**

**2.1 User Profile**The profile of TIST Quantifiers dictates specific educational, training, travel and environmental constraints. Hakuna Matata’s design will take this user profile into consideration during our design phase.

*2.1.1 Minimal Education*
Users have been described as commonly having no more than a high school education. Most have had little or no exposure to computers. English is assumed to be their third or fourth language.

*2.1.2 Training Provided*

TIST trains its Quantifiers for three months before they are expected to collect tract data alone; this training includes classroom and on the job training. New users are first taught the quantifying process in a classroom setting, learning the software and expected usage. Later, these Quantifiers-in-training are taken by experienced users as apprentices to practice recording grove tracts on a job site.

*2.1.3 Travel Requirements*

Users travel many miles before and after the use of GT. Much of this travel is across areas with under developed transportation networks. While using GT, users will travel along grove tracts, which will vary in size. Due to these high travel requirements, users will spend more time with their device in their pocket versus actually using it.

*2.1.4 Harsh Environment*TIST Quantifiers reside in Tanzania, Kenya, Uganda, India, Honduras and Nicaragua. Many of the groves reside on harsh and rugged terrain.

**2.2 Interface Options**Since users operate in Tanzania, Kenya, Uganda, India, Honduras and Nicaragua, the user interface should accompany preferences for many different measurement systems and languages. The current implementation of Acreage uses a preferences menu for selecting measurement system and language; this paradigm should be continued in GT to maintain what the current users are used to.

*2.2.1 Measurement System*

There is not currently an exhaustive list of all measurement systems required; but the needs extend beyond standard and metric, requiring specific measurement systems like the Kenyan mansana and the Nigerian mansana. This functionality would allow TIST to cut down on training time for GPS Quantifiers.

*2.2.2 Language*There is not currently an exhaustive list of all languages required by the system, but GT is required to support multiple languages. This functionality would allow TIST to cut down on training time for GPS Quantifiers

**2.3 Use Scenarios**
There are two particular use scenarios as described in TIST’s Tract SOP (Standard Operating Procedure).

*2.3.1 Initial Quantification*In the first case, Quantifiers are required to take two complete tracts that match visually on the screen of their Palm device. One of these tracts will be chosen to represent the grove for all subsequent quantification. Quantifiers are required to keep taking tracts until they have two that match and accurately represent the physical area of the grove. One tract is designated as the primary, completing the initial quantification.

*2.3.2 Subsequent Quantification*
In the second case, the primary tract will have been downloaded to the Quantifier’s Palm device during a sync. When the Quantifier reaches the grove, it will display on the Palm device and will be used to help guide the Quantifier when taking a secondary tract. A secondary tract is one taken during normal quantification when a primary tract already exists. The Quantifier will look at the secondary tract and compare it to the primary tract; if there is a visual match, the Quantifier will go on to the next step in quantification. If there is not a good match, the Quantifier will need to repeat the process until a visual match is found. A secondary tract is taken every time a grove is quantified.

**2.4 Performance Requirements**There are five performance requirements that the Grove Trotter (GT) Application must meet. These include performance based on plotting, displaying, and managing tracts. Performance must also adhere to GPS device communication, data integrity, position indication, and Pendragon Forms 2.0 communication.

##### *1. Plotting Tracts*Tract plotting time varies based on grove size. Users should be able to start and stop grove plotting at the ease of a single button, within 2-5 seconds, after standard TIST training.

##### *2. Tract Display*Users should be able to view current and previous tracts in 5-10 seconds, after standard TIST training. The rendering process should take no noticeable time and impose no lag on continued use.

##### *3. Tract Management*Users should be able to delete tracts in 2-5 seconds, after standard TIST training. Users should be able to delete tract point in 2-5 seconds per point, after standard TIST training.

*4. GPS Device Communication*The Zire71 and Centro must be able to connect to its external GPS devices and receive a GPS Signal data within 3 attempts and before 30 seconds of hold-up. Obviously this performance is not solely susceptible on GT, due to dependency on satellite positions.

*5. Position Indication*Users should be enable/disable position indication within 2-5 seconds, after standard TIST training.

**Execution Plan**



**Milestone 1 (Wednesday, February 23) Data Test Harnessing**
Forms Parsing & Forms Data Input - Parse the data coming in from a new assignment from Pendragon Forms 2.0 and verify output is correct to Forms.

**Milestone 2 (Wednesday, March 2) Zire71 Serial GPS Device Communication**
Connect to the Zire71 serial port, read GPS location information from the external device, verify.

**Milestone 3 (Wednesday, March 2) Centro Bluetooth GPS Device Communication**
Connect to the Centro Bluetooth port (including possible pairing), read GPS location information from external device, correctly close the Bluetooth port, verify input.

**Milestone 4 (Wednesday, March 9) Record/Delete Tracts**
Record linear grove tracts and store in Forms. Allow deletion of grove tracts form Forms.

**Milestone 5 (Wednesday, March 9) Display Tracts**
Display recorded grove tracts on top of one another in a meaningful way. Add cross-hair display.

**Milestone 6: (Wednesday, March 16) Edit Existing Tracts**
Allow for the removal of arbitrary location points from previously recorded grove tracts.

**Milestone 7: (Wednesday, March 23) Map Scaling & Polish**
Develop the three different map scaling options for the customer and polish out application code, seamlessly integrating between Forms and GroveTrotter.

**Milestone 8: (Wednesday, March 30) User Testing & Performance Requirements**
Conduct Usability Analysis, including User Testing and Performance metrics. Change application as necessary to meet Usability and Performance requirements.

**Milestone 9: (Wednesday, March 30) Refinement**
Address any remaining errors or issues with the application, add finishing touches to application.

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