

APPENDIX A: CONCEPT OF OPERATIONS

MOBILE APPLICATION FOR GEOLOCATION OF IMAGERY AND COLLABORATION MAGIC



Prepared for:
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Introduction

System Description

Today's smartphones are powerful, multi-featured computational devices. The co-existence of sensors and computational capability within a single, mobile platform has enabled the development of services for consumers not previously available. For example, many smartphones have the capability to take a photograph and 'tag' it with the geographic location from where it was taken. However, the location the photograph was taken from is often not as interesting or useful as the location of objects in the photograph. The Mobile Application for Geolocating Imagery and Collaboration (MAGIC) system will utilize the sensors and computational capabilities of smartphones available on the market today to determine the geographic location of objects within photographs taken by these smartphones and share them across devices. Notionally, when two or more photographs taken from different points-of-view contain the same object (the "point of interest", or POI), MAGIC can determine the object's geographic location if it knows the position the photographs were taken from, and their pointing-direction.

Background

Engineers at IAI observed that it is theoretically possible to geolocate objects within images using a smartphone. Given that the capability does not yet exist in the smartphone application market, IAI's Geographics Services seeks to determine if and how it can leverage its expertise in photogrammetric analysis, sensor systems engineering, and software prototyping to develop and market this capability for the smartphone platform.

IAI wants to know:

Who could we market this capability to, and how would they use it? (Concept of Operations document)

Is a useful accuracy achievable with existing technology? (Feasibility Analysis)

How should the system be architected, and what is it required to do? (Architecture Model and System Requirements Specification)

How should we develop and market the system, and what is the expected return on investment? (Business Case)

Document Description

This document is composed of six sections. The first is this Introduction, which introduces the MAGIC system, provides some background, then describes the structure of the rest of the Concept of Operations.

The ‘Common Setup Activities’ Section describes how MAGIC users, both casual and disaster-response user groups, perform setup activities such as downloading, installing, and configuring the device for initial use.

The ‘Casual Use’ Section describes the context of the casual user group, and the typical operational patterns that occur within that context. It also addresses how ‘sharing’, a function unique to the casual-user group, is performed.

The ‘Disaster Response’ Section describes the context of the disaster/emergency response user group, and what the typical operational patterns for MAGIC are during an emergency or disaster.

The ‘Common Operational Activities’ Section describes how users, both casual and disaster-response, interact with MAGIC to perform core operational capabilities such as calculating the location of a point-of-interest, and viewing images and points-of-interest in the context of a map.

The ‘Common Sustainment Activities’ Section describes how users, both casual and disaster-response, interact with MAGIC to perform activities necessary to keep MAGIC functioning properly, such as app-updates, instrument calibration, and troubleshooting.

Common Setup Activities

This section describes basic MAGIC setup activities that both user groups must perform

Download, Install, and Launch

Users are able to download the MAGIC application from either the Apple App Store or Android Market Place, and install it on their iOS or Android mobile device.



Figure 1: MAGIC App Icon

A new MAGIC user is not automatically required to create a new account or log in with any other credentials. All MAGIC capabilities, except image and point-of-interest sharing, are available for personal use without an account or logging in. However, the new user is required to log in with their Google account credentials if they want to share images or points of interest; see the ‘Settings’ screenshots later in this section.

The new MAGIC user taps on the MAGIC app icon to start the application.



Figure 2: Default MAGIC App Navigation Screen

Once the new user accesses the default MAGIC app navigation screen for the first time, simple and friendly pop-up “hints” explain how to use the application, which the new user can choose to close at any time. The new user can re-opening the pop-up “hints” after they are closed via the ‘Settings’ screen; see the Settings section below.



Figure 3: MAGIC Home Screen First Time Pop Up Hints

Note: In future iterations, it is envisioned that a MAGIC website would be available, and new user could link to it via the mobile device’s web-browser. The new user could ask ‘how to’ questions via the website, and report problems. For this iteration, the MAGIC website was not included in the architecture or business case.

Configuring the Settings

New users can also configure their MAGIC application via a ‘Settings’ button available on the bottom navigation toolbar. New users can set up sharing by providing their Google credentials; turn the ‘Public Sharing’ and ‘Proximity Alerts’ options on/off; turn ‘Helpful Hints’ on or off; and configure their Facebook and Twitter accounts for link-sharing to those sites.



Figure 4: MAGIC App Settings Screen

If the new MAGIC user wants to share the images, metadata, and points-of-interest they create with MAGIC, they must authenticate on the Settings screen using their Google account credentials.

Note: It is envisioned that in future iterations, MAGIC users would be able share images and points-of-interest anonymously, in case they don't wish to authenticate or create an account. This capability was not included in the architecture or business case.

Note: It is envisioned that in future iterations, new MAGIC users would be able to create MAGIC-specific accounts not tied to Google or other third-party organizations. Notionally, if a new user selects the option to create an account with MAGIC, the new user is queued to enter a unique ID and email address. MAGIC will send an email to the indicated address, providing an initial password. When the new user enters their unique ID with this emailed password, they are prompted to enter a new password of their choosing. This capability was not included in the architecture or business case.

When the Public Sharing option is turned On, all images and points-of-interest that are shared, are shared with the entire MAGIC user community. When this option is turned Off, content that is shared is only shared with the user's Google contacts.

Note: In future iterations, it is envisioned that MAGIC users would be able to select specific contacts to share images and points-of-interest with, rather than with all contacts /friends or the entire MAGIC user community ("Public Sharing"). The capability to share specific data with specific contacts is not included in the architecture or business case.

The Proximity Alerts option allows the user to receive push-notifications when they are at or near a point-of-interest shared to them by one of their Google contacts. Once notified, the MAGIC user is able to view the associated images.

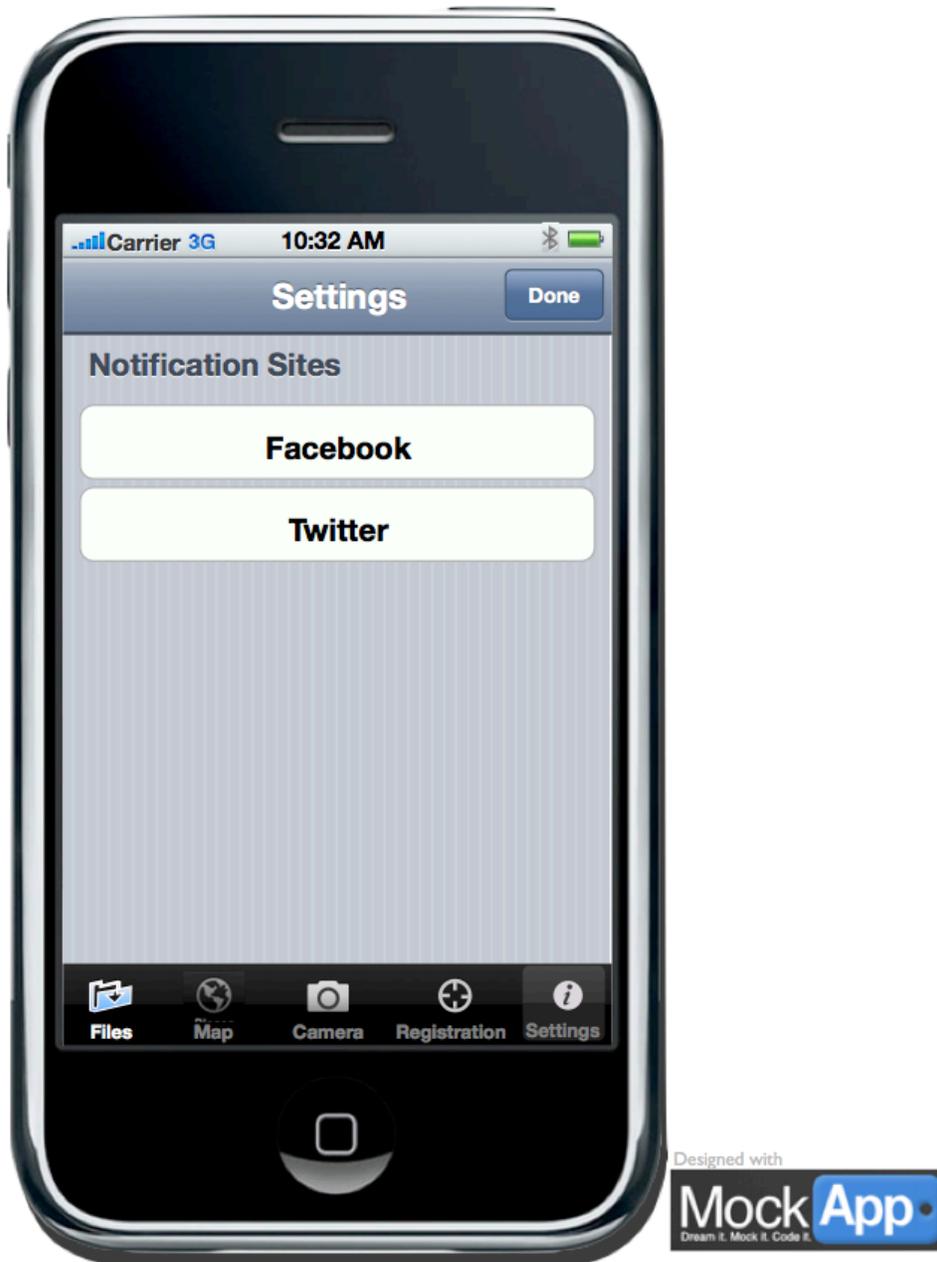


Figure 5: MAGIC App Settings Screen

By selecting either the Facebook or Twitter buttons on the Settings screen, the MAGIC user is prompted to login with their Facebook and/or Twitter credentials. If this is done, the MAGIC user will have the option to post a link to their Publically shared content on their Facebook ‘Wall’ or their Twitter account (note that only publically shared images and points-of-interest can be posted to Facebook or Twitter; content shared only with the user’s Google contacts cannot be linked to in this fashion).

Casual Use

Casual users, such as tourists, use their smartphone to take pictures of landmarks, landscapes, or any scene they consider interesting. Objects in the pictures can be identified by tagging and labeling the pixel in the image that best represents the object. When the user indicates two or more images contain the same object by labeling the appropriate pixel as such in each image, MAGIC estimates the object’s geographic location, and stores it as a point-of-interest.

For example: in **Figure 6** below, Image A and Image B both contain the peak of a nearby mountain (the point-of-interest, or POI), but the images themselves were taken from different perspectives. When each Image was taken, the smartphone captured the geographic position of the photographer and the camera’s pointing-direction, and appended that data to the image itself. The photographer of Image A shared her image (and associated location / pointing information) with the photographer of Image B over the cellular network, who was then able to identify the common POI within each of the images. MAGIC, using triangulation and other photogrammetric methods, estimated the location of the POI based on the location and pointing information of the two images.

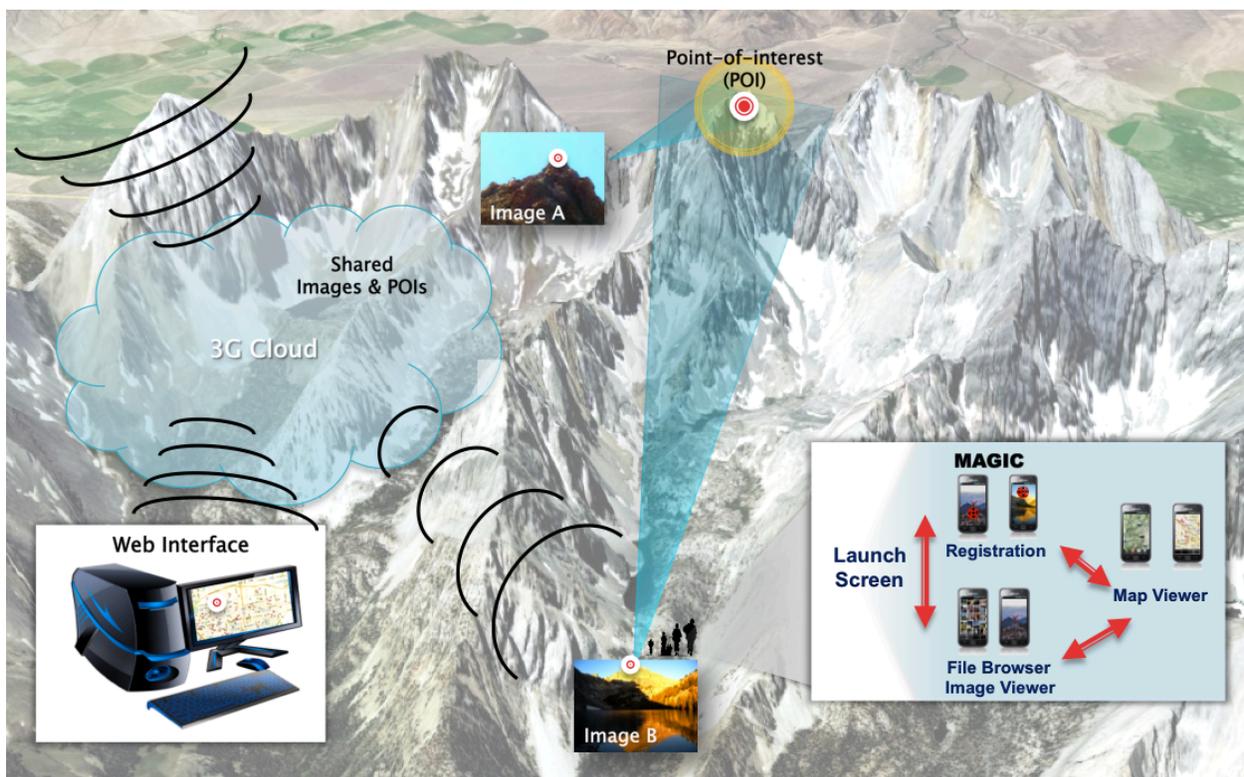


Figure 6: MAGIC System Context

Sharing

The casual user is able to share specific images, metadata, and computed point-of-interest locations with the MAGIC user community (‘Public Sharing’), or just their Google ‘contacts’ who also have MAGIC.



Figure 7: MAGIC Public Sharing Pop-Up

When Public Sharing is on, a pop-up will confirm with the user that they want to share it with the entire MAGIC user community.

When a new image or point-of-interest is shared with a casual user, MAGIC alerts the user with a short audible alarm and vibration (similar to a new text-message notification).

Casual users also can post a link to their Publicly shared images and points-of-interest to Twitter and Facebook. For this option to be available, the user must configure their Facebook and Twitter accounts on the 'Settings' screen. The friends / followers who click on the posted link can only view the 'tweeted'

point-of-interest if they download MAGIC to their smartphone, and log in to MAGIC with their Google account.

Note: In this iteration, viewing, sharing, and commenting on images and points-of-interest is limited to what can be done on the smartphone platform. However, it is envisioned that in future iterations, casual users could also access their account from a workstation or laptop. Through a web-interface, users could search and view all Publicly-shared images, metadata, and points-of-interest, as well as ones shared personally with them, layered over Google Earth. By selecting a point of interest, a user could see all images taken of it. Casual users can provide comments on points-of-interest and images, and read the comments made by others.

Disaster Response

Casual Users in the Context of a Disaster

Casual users, when initially caught up in a disaster zone, may begin to use their MAGIC app to identify points-of-interest within the disaster zone that require attention from emergency-response personnel (e.g. a victim stranded in a flood). If a casual user were to do this, they would have to share their images and points-of-interest publically.

When the emergency-response organization establishes a Command Center (i.e. a centralized base for response/recovery decision making), they will be able to access these already identified points-of-interest within the disaster zone that have been shared publically. Knowing the time the disaster began and the geographic region it covers, the emergency response organization can request all points-of-interest and images taken by MAGIC apps within the time-frame and physical region be forwarded to the Command Center.

Note: It is envisioned that in the event of a disaster, casual MAGIC users identified within the disaster zone would be notified that they could assist the disaster response efforts by sharing any images and/or points-of-interest that may be helpful. Magic users will be enabled to share their images and point of interested directly with rescuers and/or the Command Center. This capability was not explicitly addressed in the architecture, or cost estimate / business case.

Disaster/Emergency Response Personnel

Members of the emergency-response organization that are operating in the field (i.e. in the disaster zone) will also be equipped with MAGIC, allowing them to add to the stream of images, labeled pixels, and points-of-interest that feed the Command Center to support its crucial decision-making function. All emergency-response personnel in the field are equipped with a version of the MAGIC app that is configured to automatically forward all images, pixels, and points-of-interest to the Command Center, rather than manually select items for forwarding or sharing (this extra manual step to 'share' items with the Command Center may not be easy to take by someone acting within the disaster zone).

Within the Command Center, emergency response personnel have access to all images, pixels, and points-of-interest in the disaster zone from all available sources. They use web-based or workstation-based tools to perform activities such as:

- quickly and efficiently search the material provided by many MAGIC users in the field
- preview images
- view sets of images whose field-of-view and range overlap (by automatically identifying these 'sets' of images, MAGIC helps the Command Center personnel to focus their search for points-of-interest)
- identify and compute new points-of-interest
- share specific images and/or points-of-interest with specific emergency responders in the field

Emergency-response personnel operating in the field are notified by an audible / tactile alert (similar to how one receives a new text on a smartphone) when an image or point-of-interest is shared with them by the Command Center.

Common Operational Activities

This section describes common MAGIC tasks performed by both user groups (casual and disaster-response).

Registering Images to Calculate a New Point-of-Interest

A MAGIC user must register two or more images via the 'Registration' screen, accessible from the bottom navigation toolbar, in order to calculate a new point-of-interest.

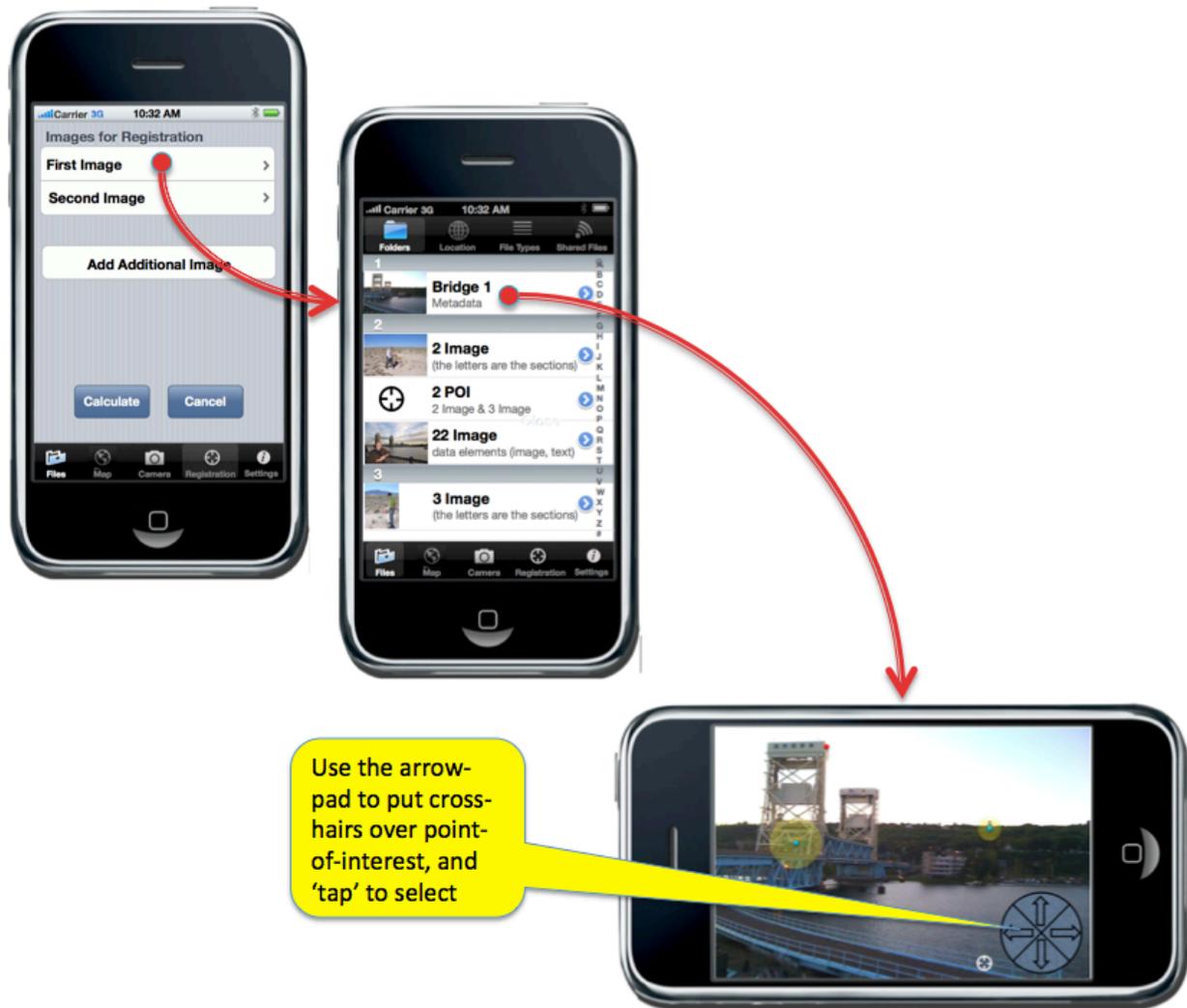


Figure 8: MAGIC Registration Process

When the MAGIC user selects 'First Image', they are navigated to the File browser to select their intended image. Once selected, they are navigated to a view-screen that displays the image, and provides controls for the user to move and precisely place crosshairs over the point of interest. Standard smartphone controls, such as the 'pinching' motion to zoom in or out, can be used to more precisely place the crosshairs.

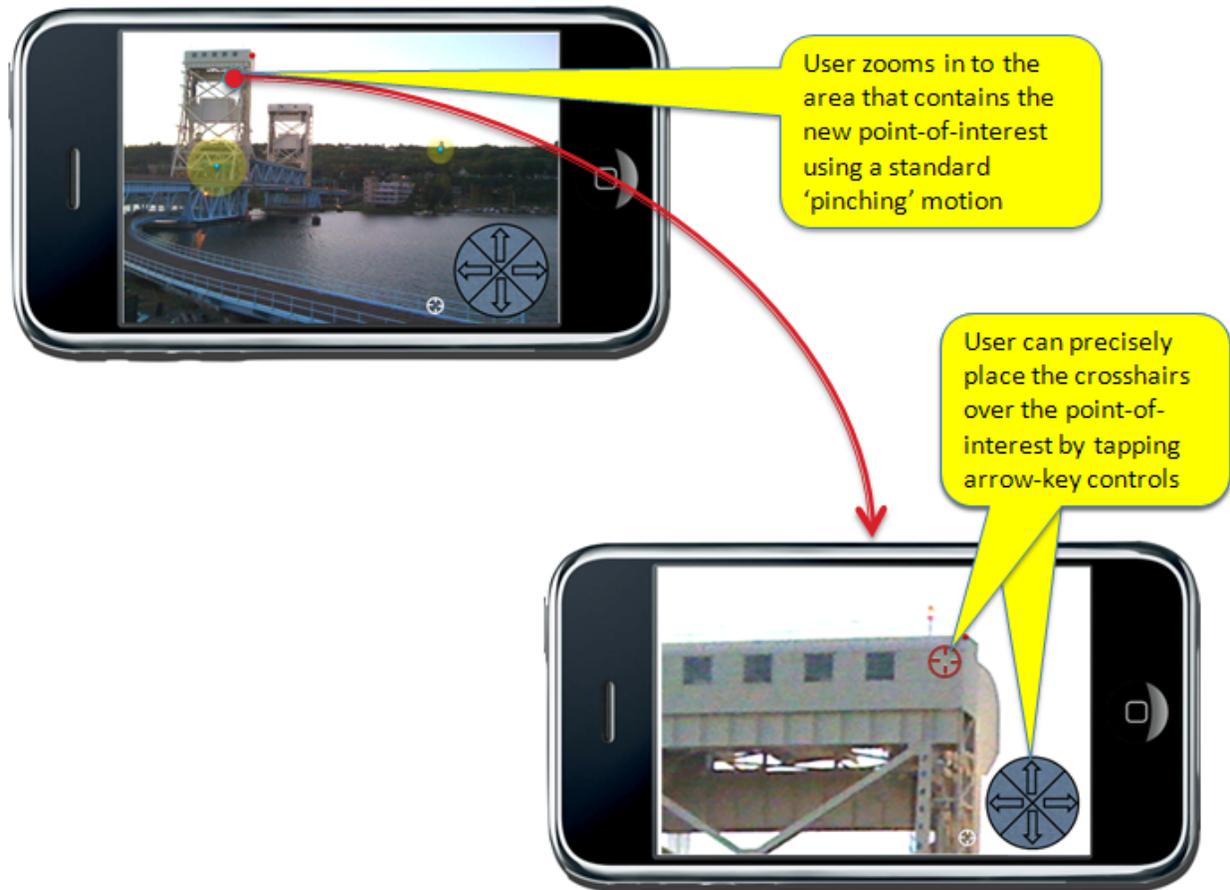


Figure 9: MAGIC Selection of Pixel Activity

Once the point-of-interest is selected, the user is brought back to the Registration screen. They are required to perform the identical process for a second image; and optionally can elect to include even more images by selecting 'Add Additional Image'.

Note: It is envisioned that in future iterations, the mobile MAGIC application would help users find the second (and subsequent) images by only listing images in the File browser who's field-of-view and range overlap (and therefore could potentially have a point-of-interest in common) with the first image. This capability was not explicitly addressed in the architecture or the cost estimate / business case.

Once two or more images are registered, the user can select the 'Calculate' button. Once the results are displayed, the user must name the point-of-interest using the smartphone's keyboard.

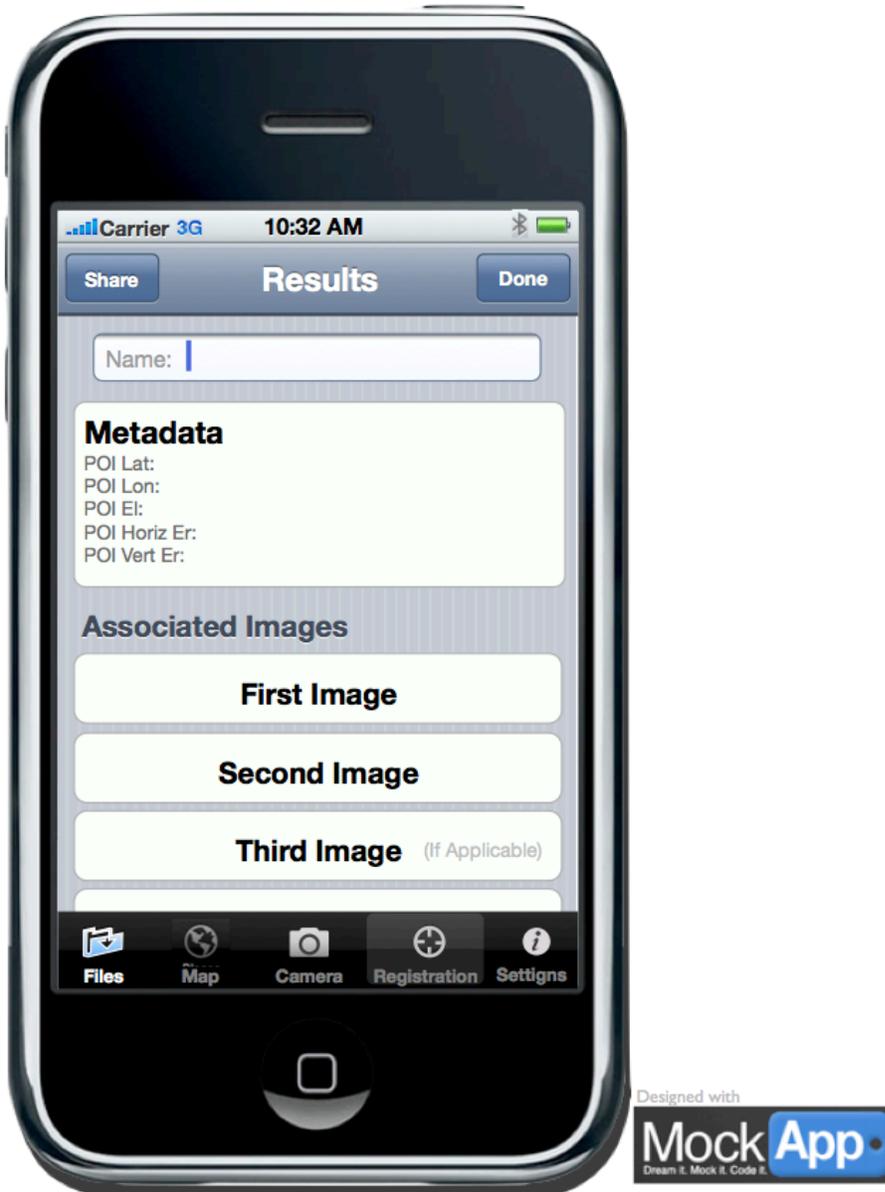


Figure 10: MAGIC App Results Screen

Finding Images and Points-of-Interest via the Map

MAGIC users can view geo-location data layered over Google Maps by going to the 'Map' screen. Users can choose to view just images, just points-of-interest, or both.



Figure 11: MAGIC App Map Screen

Note that users can view 1) only the data stored locally on the phone, 2) local data plus images / POIs shared with the user by his/her Google contacts, or 3) all publicly shared images and points-of-interest. This option can be selected on the Map's Setting page.

Other Google Maps capabilities, such as Search and 'Center on my location' are also available from this screen.

The user can tap on an image or POI icon on the map, and view the given item. If the item is not stored on the smartphone (i.e. it is a publicly or privately shared image / POI), the MAGIC user can choose to download the selected item.



Figure 12: MAGIC App Image Download Process

Take an image and browse stored images

By navigating to the Camera GUI via the toolbar, a user is able to 1) take an image with all the metadata MAGIC needs to determine a POI, 2) initiate a calibration process (discussed in a previous section), or 3)

navigate to the image browser. Images taken via this Camera GUI are immediately saved and made available to the user via the image browser.



Figure 13: MAGIC App Registration Process Using Picture from Camera

In the image browser, the user is able to navigate between all the stored images with either the forward / back arrow buttons, or by the conventional touch-screen swiping motion. A ‘back’ button in the browser returns the user to the Camera GUI; a ‘Share’ button takes the user to a screen that allows them to share the currently-viewed image and any associated POIs.

A ‘registration’ button initiates the process for calculating a new point-of-interest by pulling up the recticle and arrow keys. If a user identifies a POI-pixel in the image this way, they are navigated to the Registration GUI, where the ‘first image’ will already be populated. The user will then have to follow the previously-described process for registering the second image to calculate the point-of-interest.

Browse images and points-of-interest with the top toolbar

The default screen presented to the user every time they open the application is the File Browser. From this screen, the user is able to scroll through the images and points-of-interest stored on the smartphone. The top toolbar provides various ways to sort and view the available data in the File Browser.



Figure 14: Explanation of MAGIC App Top Icons

The ‘Folders’ button groups images and points-of-interest that are in common. For example, if Image A and Image B were used to calculate POI 1, then Image A, Image B, and POI 1 would all be shown in a folder together. If Image B were also used with Image C to compute POI 2, then Image B would also be shown in a folder with Image C and POI 2.

The 'Location' button groups POIs and images by their approximate location. For example, you would be able to see all images taken and POIs located in the Washington DC area, as distinct from those taken in NYC.

The 'File Types' button sorts the files by their respective type: images, points-of-interest, and POI-pixels (that haven't been used to calculate a POI's location yet, for example).

The 'Shared Files' button sorts the data by those images and POIs that have been private shared by the user and with the user, those that have been publically shared by the user, and those that have not been shared yet.

Common Sustainment Activities

This section describes the activities necessary to keep a MAGIC App functioning properly for the user, such as performing instrument calibration, receiving App updates, and troubleshooting. These activities are ‘common’ because they are performed by both casual and disaster-response users.

Instrument Calibration

Upon startup, MAGIC performs a built-in test / diagnostic to estimate the quality of its own calibration. If the diagnostic produces a bad result, MAGIC will notify the user that its instruments need to be calibrated (in order to improve pointing direction estimates).

Via the Camera GUI page, the user can select a button that guides them through a manual calibration process for the smartphone’s compass. The process is expected to involve rotating the phone repeatedly by hand to disorient the compass, then photographing either the sun or the moon, depending on the time of day. Per the hour/angle method for calibration, MAGIC re-calibrates itself by knowing the time of day and the geographic location the photograph is taken from.

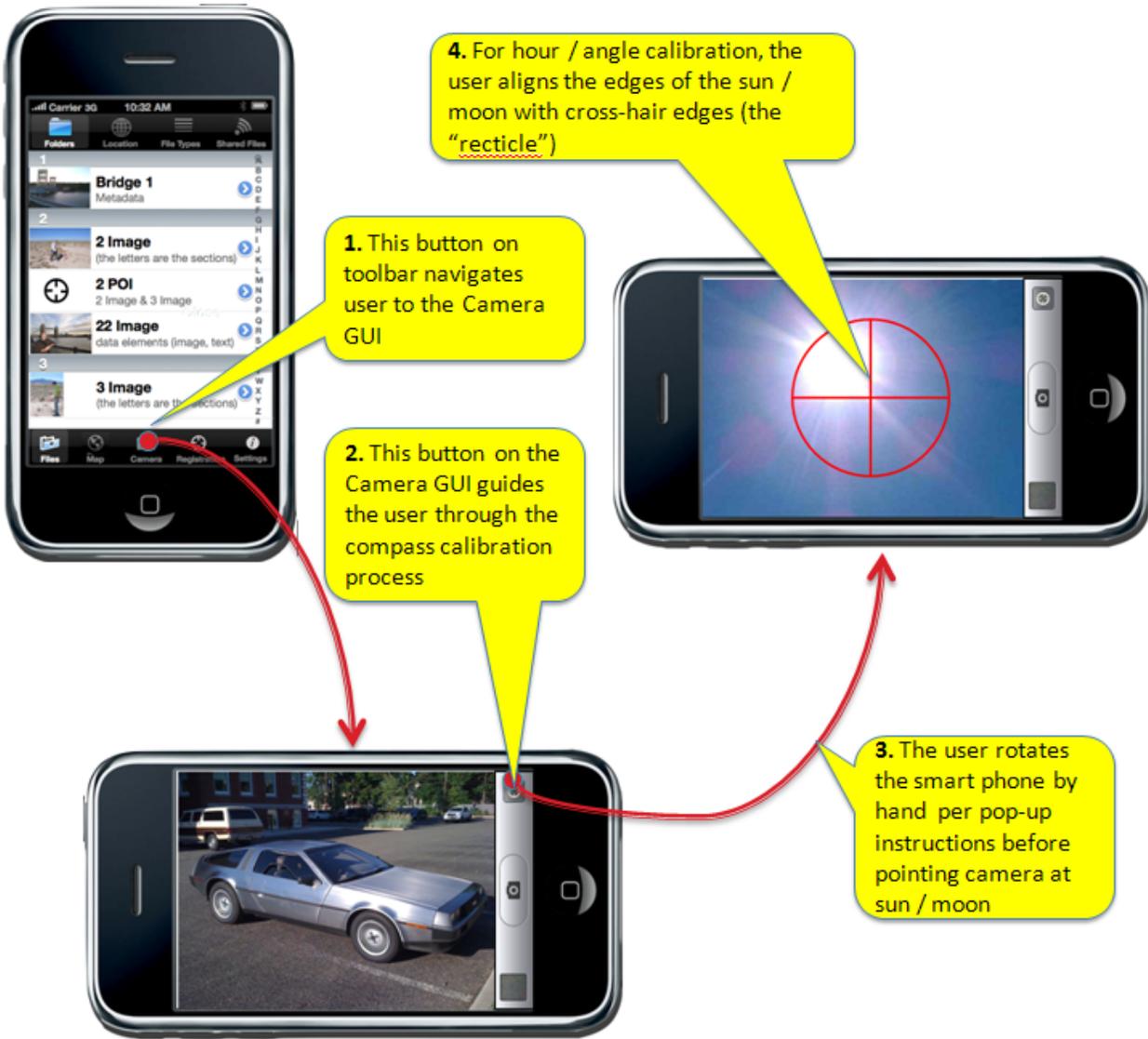


Figure 15: MAGIC APP Calibration Process

MAGIC App Updates

Updates to the MAGIC App are pushed to the Apple and Android Marketplace Store. The user must access the App Store, choose to update the MAGIC App, and enter their Apple / Google ID before download and installation can begin. Use of the upgraded App can begin immediately; reboot of the mobile device is not necessary.

Backup and Mobile Device Upgrade

Any data (images, points-of-interest, etc) that the user shares, publicly or privately, is 'backed up' on a MAGIC server, and can be retrieved by the user using their account ID over the web. For data that the user doesn't share, 'backup' only occurs when the user synchronizes their mobile device with their desktop or laptop (e.g. connecting an iPhone to a computer and allowing it to 'synchronize' with iTunes).

If a user replaces their mobile device with a dissimilar one (e.g. switching from an iPhone to an Android device), they can install MAGIC on the new device, and authenticate with the same credentials they used on their old device. While configuring the new device, the user can indicate that they no longer use the old device, and download all of the user's shared MAGIC data from the MAGIC server.

Problem Reporting and Troubleshooting

MAGIC users can report problems through the Apple App Store / Android Marketplace Store.

Note: In future iterations, it is envisioned that problems could be reported directly to a MAGIC website. A 'Help' button available on the default navigation screen would link the user to the MAGIC application's website via the mobile device's web-browser. In addition to reporting a problem, users can ask troubleshooting questions in an open forum via the website. This capability is out of scope for this project, and is not reflected in the architecture, feasibility study, or business case.