

# FINAL REPORT

## MOBILE APPLICATION FOR GEOLOCATION OF IMAGERY AND COLLABORATION MAGIC



**Prepared for:**

OR680/SYST798 Capstone Project course at George Mason University

**Prepared By:**

MAGIC Team

Jeff Carpenter

Thomas Haas

Dawin Wright

Erika Rojas Mejia

SYST 798 / OR 680 Spring 2010

Course Professor: Dr. Kathryn Laskey

Project Sponsor: Kurt Rogers, Integrity Applications Inc.

# Executive Summary

This report summarizes the results of a study by the Mobile Application for Geolocation of Imagery and Collaboration (MAGIC) Team to perform the first round of system engineering to determine the feasibility of pursuing MAGIC as a business opportunity. The capability of smartphones to calculate the geolocation of objects within multiple images was identified by the sponsor as the project's focus, but before developing an application to execute this capability several questions must first be answered. It is the goal of this report to address the following questions:

- Who would use this capability and how would they use it?
- Can the accuracy requirements for these users be met with existing smartphones?
- What is the system required to do and how should it be designed?
- Could developing this capability be profitable and what development path should be pursued?

A user analysis was performed to identify potential groups of users. The two primary user groups targeted for this effort were Emergency Responders and Casual Users. A Technical Feasibility Analysis assessed both user groups and identified threshold and objective performance requirements. The Feasibility analysis then identified currently available systems and modeled their predicted geolocation performance. The initial results indicate that the threshold requirements are achievable and that the objective requirements may be met under specific conditions. The confirmation that this capability is feasible with currently available smartphones was a key milestone in this effort. Based on those results, a Concept of Operations (CONOPS) then was developed to describe how the users will interact with MAGIC on their smartphones. The Technical Feasibility Analysis and CONOPS were used to guide the development of a complete system architecture and to capture high level system requirements. The System Description Document provides details of the MAGIC system's CORE model, which was used to define the system architecture and track requirements. A Business Case Analysis was also developed to identify trends in the current market, explore viable options for development and marketing to the targeted users, and make a recommendation for the development path IAI should pursue. The Business Case Analysis recommends developing MAGIC for the Casual User on Google Android supported smartphones first, with both a free "Lite" and for-purchase "Full" version of the application.

# Table of Contents

---

Executive Summary .....	2
Introduction .....	5
Objectives and Scope .....	6
Technical approach .....	7
Technical Analysis .....	9
Concept of Operations .....	11
Model / Architecture .....	13
Business Case Evaluation .....	16
Final Recommendations .....	18
Future Work .....	20
References .....	23

## Appendices

---

Concept of Operations .....	Appendix A
Potential User Analysis .....	Appendix B
Use Case Analysis .....	Appendix C
Technology Feasibility Analysis .....	Appendix D
Accuracy Assessment & Sensitivity Analysis .....	Appendix E
System Design Document .....	Appendix F
Requirements Traceability Matrix .....	Appendix G
Sub-Function Descriptions Document .....	Appendix H
CORE Model .....	Appendix I
Business Case Analysis .....	Appendix J
Rough Order of Magnitude and Return on Investment Analysis .....	Appendix K
Customer Survey .....	Appendix L
MAGIC Earned Value Management .....	Appendix M

# Table of Figures

---

Figure 1: Iterative Design Approach.....	8
Figure 2: Work Breakdown Structure (WBS) for the MAGIC Project .....	8
Figure 3: Example Activity Diagram: Sharing Images and Points-of-Interest.....	11
Figure 4: Identifying a Point-of-Interest's Pixel.....	12
Figure 5: MAGIC External System Diagram .....	13
Figure 6: Provide MAGIC Services.....	14
Figure 7: MAGIC Component Architecture .....	15
Figure 8: High Level Traceability Mapping of MAGIC Requirements .....	15
Figure 9: Instantiated MAGIC Architecture .....	21

# Introduction

## Background

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 previously unavailable services for consumers. For example, many smartphones have the capability to take a photograph and 'tag' it with the geographic location at which it was taken. However, the location at which the photograph was taken may not be as interesting or useful as the location of objects captured in the photograph. By using the increasingly advanced suite of smartphone sensors to determine position and orientation of the camera, a mobile application, or app, could conceivably use triangulation and other photogrammetric methods to calculate the location of objects within images from multiple images.

## Problem Statement

Engineers within IAI's Geographics Services division, observing this theoretical possibility of using smartphones to geolocate objects within images, want to know whether and how they can leverage their expertise in photogrammetric analysis, sensor systems engineering, and software prototyping to develop and market this capability for the smartphone platform. Specifically, IAI would like to know:

- Who would use this capability and how would they use it?
- Can the accuracy requirements for these users be met with existing smartphones?
- What is the system required to do and how should it be designed?
- Could developing this capability be profitable and what development path should be pursued?

## Document Description

This document is the Final Report for the Mobile Application for Geolocating Imagery and Collaboration (MAGIC) team of George Mason University SEOR students performed for their Capstone Project. It captures the major findings and recommendations resulting from the teams' analysis, research, and design efforts. Its numerous Appendices make up the supporting documentation for these findings and recommendations, and are referenced often throughout the main body of this Final Report.

# Objectives and Scope

The objective of this project is to explore the design space and potential market for a Mobile Application for Geolocation of Imagery and Collaboration (MAGIC) system that can use the sensors and computational capabilities of smartphones available on the market today to determine the geographic location of objects within photographs.

The scope of this project is limited to the analysis, research, and design necessary to determine the feasibility of implementing this capability for a handheld application, and a preliminary assessment of the architecture necessary to enable sharing and collaboration. A summary of the results from the project are captured in this report and details are provided in the primary deliverables and supporting documents. The primary deliverables are the MAGIC CONOPS, Technical Feasibility Analysis, System Description Document and the Business Case Analysis. These documents and other supporting documentation answer the major questions presented in the problem statement. See Table 1 for a complete mapping of the problem statement to these deliverables. Due to limitation of time and personnel this effort does not include a complete engineering analysis of the services, interfaces and resources necessary to enable full sharing and collaboration of images and point of interest generated by MAGIC. It is recommended that an analysis of these capabilities be performed as a follow on effort.

**Table 1: Problem Statement and Applicable Deliverables**

<b>Problem Statement</b>	<b>Applicable Deliverables (primary deliverables are bold)</b>
Who would use this capability and how would they use it?	<b>Concept of Operations</b> Potential User Analysis Use Case Analysis
Can the accuracy requirements for these users be met with existing smartphones?	<b>Technology Feasibility Analysis</b> Accuracy Assessment & Sensitivity Analysis
What is the system required to do and how should it be designed?	<b>System Description Document</b> Requirements Traceability Matrix Sub-Function Descriptions Document CORE Model
Could developing this capability be profitable and what development path should be pursued?	<b>Business Case Analysis</b> Rough Order of Magnitude (ROM) and Return on Investment (ROI) Analysis Customer Survey

# Technical approach

The approach to this project began with conducting a technical feasibility analysis to determine whether the capability being requested was attainable. This was a critical piece of the project, because a negative result would ultimately eliminate any reason to move ahead with further development of the application for currently available smartphones or those in the foreseeable future. Had the analysis found that current smartphone technology wasn't capable of meeting the performance requirements of the candidate users, the scope of the project would have shifted to determining the technological advances in smartphone-sensors required to achieve this minimal performance. While the analysis ensured that the capability was feasible, it also provided ideas for who would use the system as well as how it would be used.

The MAGIC design team used the knowledge gained from this analysis to begin identifying target users and developing a concept of operations (CONOPS). Brainstorming sessions as well as customer surveys were conducted in order to identify a set of users (casual and emergency responder) along with a set of possible use case scenarios. These two documents provided the basis for a system architecture and high level requirements document. In parallel with this effort, a business case analysis was performed to determine whether such an application could be profitable and to provide a rough cost estimate along with a potential ROI for various options. The project deliverables described in Table 2:

**Table 2: Project Deliverable Descriptions**

Deliverable	Description
<b>Technical Feasibility Analysis</b>	The Technical Feasibility Analysis studied the users' needs, identified current smartphone hardware and performed an evaluation of the geolocation capabilities.
<b>Concept of Operations (CONOPS)</b>	The Concept of Operations document describes who the users are, how they would use the MAGIC application, and for what purpose.
<b>System Description Document (SDD)</b>	The System Description Document provides a graphical and textual representation of the MAGIC system's functions as well as components.
<b>Business Case Analysis (BCA)</b>	The Business Case Analysis describes the expected cost and Return on Investment (ROI) in the development of MAGIC for the users, and makes a recommendation on how best to proceed in the short and long term.

An iterative/spiral model was used in the beginning of the of the design approach with the intention to achieve deliverable milestones with the completion of each iteration. [Figure 1](#) illustrates this.



Figure 1: Iterative Design Approach

The initial cycle was used to perform the preliminary research and begin compiling the results. The goal of the second iteration was to refine the initial findings with more detailed research and analysis. The third iteration would result in the final deliverables and final report. In the process of performing the first iteration, the MAGIC team realized that it would be more efficient to use the traditional Vee model due to time and personnel limitations. The team developed a work breakdown structure, and the remaining schedule was re-baselined to complete all major tasks and deliver the abovementioned deliverables on time. The WBS is shown in Figure 2 below. Additional project management information is provided in Appendix M: MAGIC Earned Value Management (EVM).

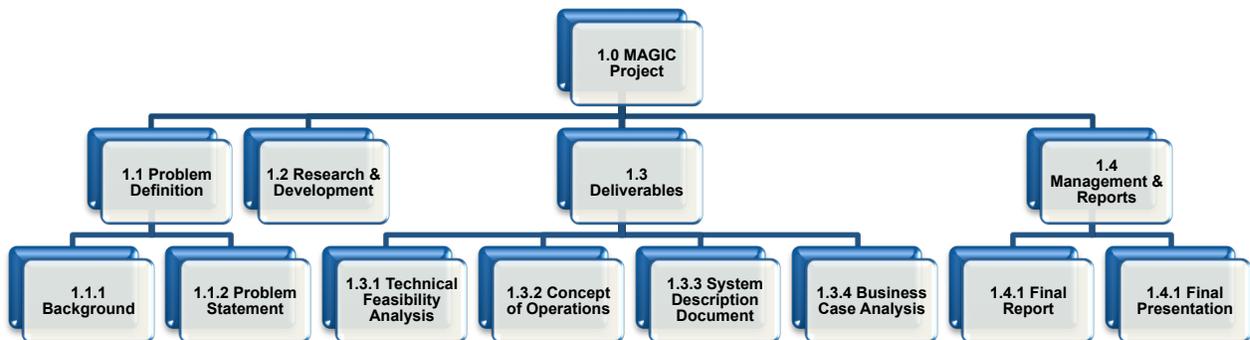


Figure 2: Work Breakdown Structure (WBS) for the MAGIC Project

# Technical Analysis

The purpose of the Technical Feasibility Analysis was to identify and compare the needs of the MAGIC users identified in the MAGIC CONOPS to the currently available technology to determine whether the proposed application could meet their needs, and if so what current platforms and systems might provide the best user experiences. This analysis looked at three primary areas of concern:

1. The first was the geolocation requirements and performance. The analysis looked into how accurately the users will need to know the location of points of interest (POI) and how they will share image and POI data.
2. The second portion of the analysis looked at several smartphones currently in the market place to identify their capabilities and examine if they are able to meet the user's needs.
3. The last portion of the analysis looked at possible methods to enable image and POI sharing for the users. It identified current social networking services to determine whether their interfaces are sufficient to support these services, or if additional data services will be needed to support the sharing portion of the MAGIC application.

Analysis of the two users groups identified two different sets of performance requirements. The least stringent requirements were for the Emergency Responders and these requirements were set as the threshold requirements. The MAGIC Team would only recommend proceeding with development of MAGIC if these threshold requirements could be achieved. The Casual User requirements were more stringent and therefore set as the objective requirements. The necessary technology and operational techniques necessary to achieve these requirements were identified in Appendix D: Technical Feasibility Analysis. The users' requirements are presented in Table 3.

**Table 3: User Geolocation Requirements**

	Threshold Requirements	Objective Requirements
Accuracy (m)	<b>50</b>	<b>10</b>
Confidence (%)	<b>90</b>	<b>50</b>
Bisector / Base Distance (m)	<b>600</b>	<b>300</b>

Three of the most recent and popular smartphones and two of the most popular operating systems were selected to establish the capabilities of the system and model the geolocation capabilities of these systems based on the sensor specifications.

## Smartphones

- Apple iPhone4
- Samsung Galaxy S
- HTC Evo 4G

## Operating Systems

- Apple iOS4
- Android 2.2

Each of the smartphones was able to achieve the threshold requirements and calibration processes were identified that may enable these smartphones to achieve the objective requirements as well.

The final portion of the Technical Feasibility Analysis researched several popular image sharing and social networking sites to identify potential solutions to meet the users' requirements to share images and Points of Interest generated with MAGIC. Twitter and Facebook are not compatible with sharing the necessary image data or POI data. However they should be included in MAGIC as a means to allow users to share a link with their followers and friends to new MAGIC images and POIs as a method to increase awareness of MAGIC, thus potentially increasing MAGIC's user base. It may be possible to share the image and POI data using a combination of Flickr, Google Picasa Web Albums and Google Earth, but it is the recommendation of this study that a standalone server be researched in a follow-on study. A dedicated MAGIC server would likely allow for a simple and manageable sharing and collaboration service not achievable from existing websites, and is likely the only way to meet the sharing and privacy requirements of the Emergency Responder user group.

The complete Technical Feasibility Analysis can be found Appendix D.

# Concept of Operations

The Concept of Operations describes who the users are, how they would use the MAGIC application, and for what purpose. The two user groups, Casual and Emergency Responders were identified in the Potential User Analysis in Appendix B. Once the user groups were identified the MAGIC team documented how each group would notionally interact with MAGIC. Interactions were described as a sequence of actions taken by the user and the subsequent responses expected from MAGIC. Initially, these interactions were captured in Use Case diagrams, and the steps of the sequences described in text. Activity Diagrams were drawn to better illustrate the steps in the sequences, and who performs them; see Figure 3 for an example.

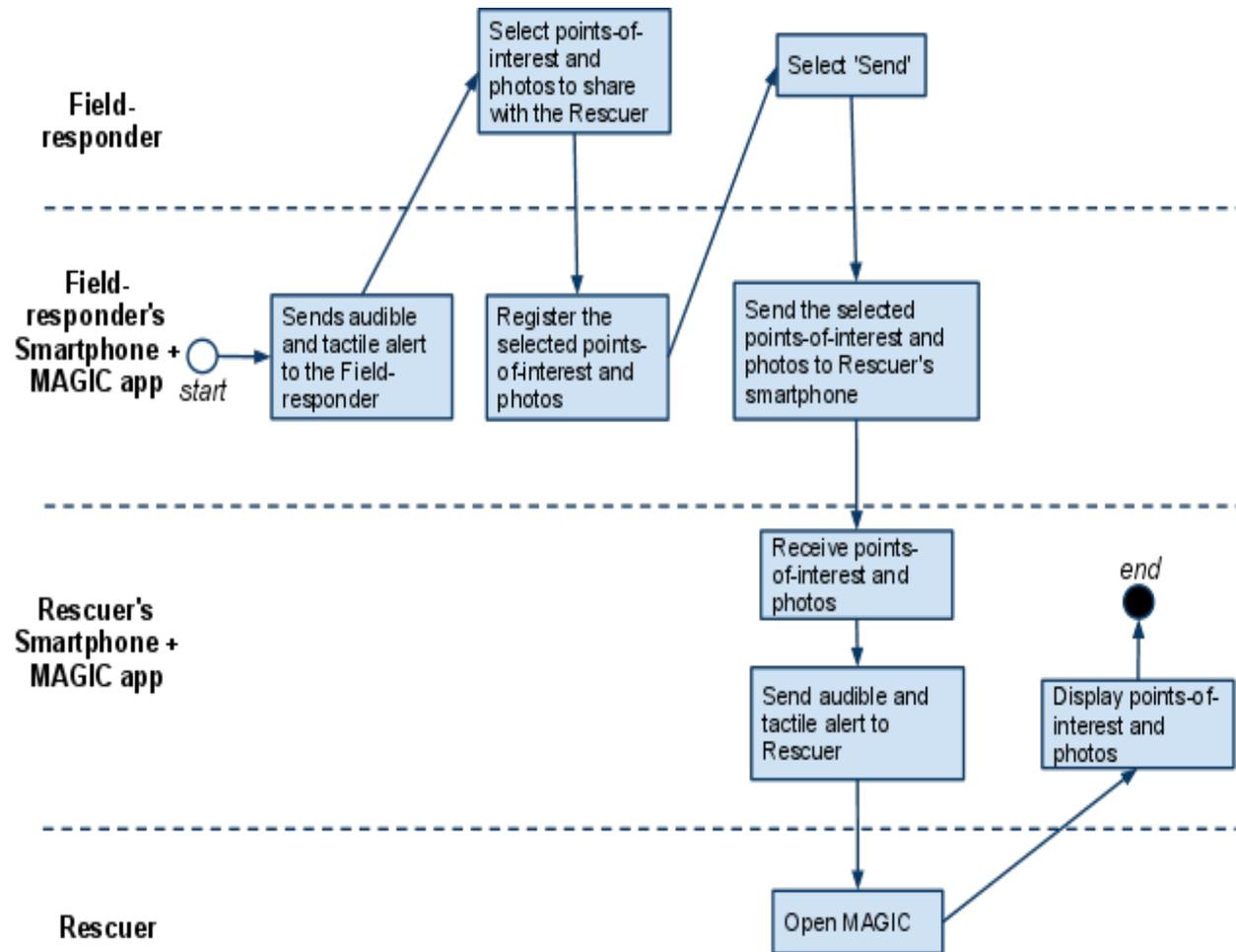
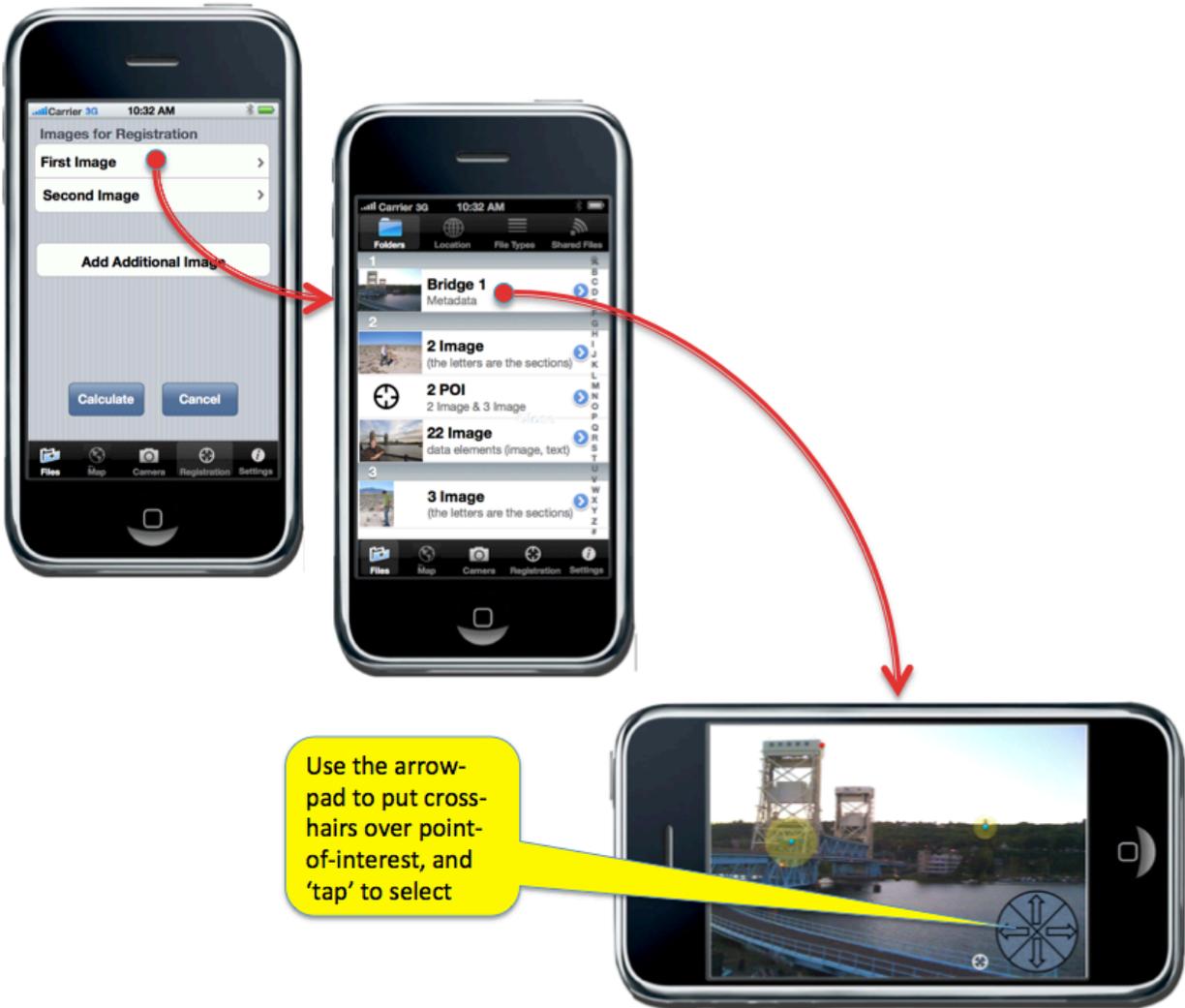


Figure 3: Example Activity Diagram: Sharing Images and Points-of-Interest

These Use Case and Activity diagrams provided valuable input for the Concept of Operations document and the CORE model. The diagrams are captured in Appendix C: Use Case Analysis.

The Concept of Operations document in Appendix A captures many of the same interactions, but describes them using Graphical User Interface (GUI) mockups, which additionally provide a preview of the potential look-and-feel of the application itself. Figure 4 shows an example of a short user interaction.



**Figure 4: Identifying a Point-of-Interest's Pixel**

The Concept of Operations also took a comprehensive look at interactions over the lifecycle of MAGIC. User-interactions at the beginning of the application's lifecycle, such as the download, installation, launch, and configuration of settings are described. Sustainment and maintenance interactions (i.e. those user-interactions necessary to keep MAGIC functioning properly), such as updating the application and calibrating the sensors, are also captured. Lastly, the user-interactions that are unique to the Casual and Disaster Response user groups were described. For the full description of all these user interactions, please see Appendix A: MAGIC Concept of Operations.

# Model / Architecture

The main purpose of modeling the MAGIC architecture was to gain a general understanding of how the MAGIC system could be decomposed, and identify the individual parts, subsystems and services that would need to work together to provide the desired functionality. A high-level overview of how the functionality and responsibilities of the system were partitioned and then assigned to subsystems and components is provided. The MAGIC architecture description is provided in Appendix F: MAGIC System Description Document. The MAGIC system requirements and architecture provide a graphical and textual representation of the system's functions and components.

The development of the MAGIC system architecture was done in three phases. The system context, physical composition and system functions were developed in Phase 1. The System composition provides an overview of the major top-level components of the system and their relationships. The System Functions provide an overview of the major top-level functions of the system and their relationships. The Team defined MAGIC functions based on the External System Diagram shown in Figure 5, the CONOPS, and the use cases of the system. Once the initial development was done the physical and functional architecture was further developed to include mapping the functions to the components.

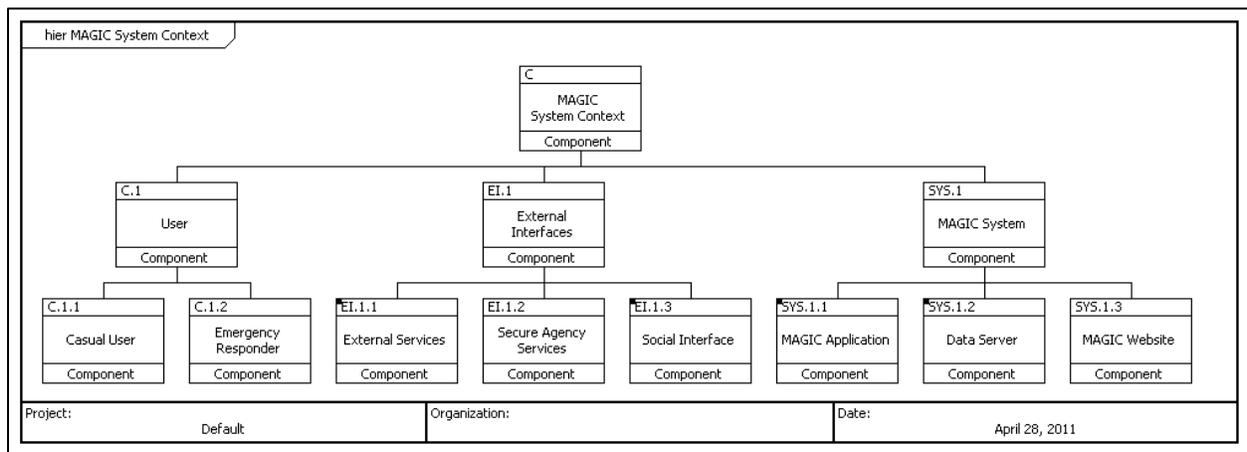


Figure 5: MAGIC External System Diagram

Further decomposition of the functional architecture and the identification of function inputs, outputs and constraints were performed in Phase 2. System Requirements were written and mapped to functions. Phased 3 completed the final Physical and Functional Architectures and all high level system requirements were defined and mapped to the system functions and components. IDEF0 (Integration Definition for Function Modeling) diagrams and Functional Flow Block Diagrams of the system were produced to ensure the system architecture was appropriately captured. The major deliverable from the system model is the MAGIC Systems Description Document, which can be found in Appendix F.

## Level 1 Functional Architecture

The top level function for MAGIC is: Provide Geolocation Services. This function satisfies all of the mission level requirements of MAGIC. Provide Geolocation Services is decomposed by four sub-functions. These functions are:

1. Provide Access to MAGIC Services– this function takes care of major functions needed for a user to obtain access to the system, such as setting up an account, downloading the application and authenticating a user to provided basic or full capabilities of the system.

2. Process Geolocation Services – this function reflects all major functions we expect a user to request or need to perform all MAGIC geolocation capabilities.
3. Enable Set Up of a Command Center – this function will provide certain users the option to set up a command center upon request of such service.
4. Enable Effective Maintenance and Servicing – this function will provide all capabilities necessary to keep a MAGIC App functioning properly for the user, such as performing instrument calibration, receiving App updates, and troubleshooting.

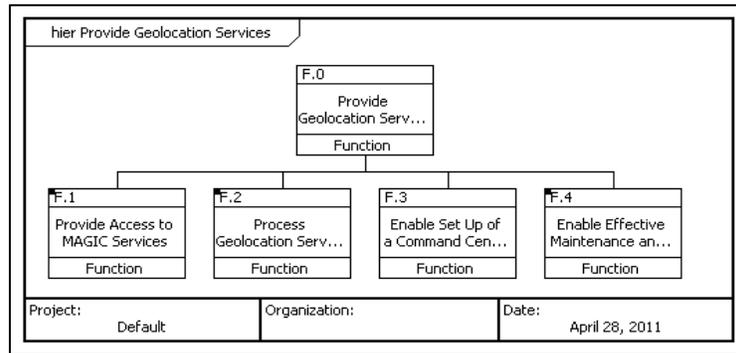


Figure 6: Provide MAGIC Services

## Component Architecture

The component architecture identifies the hardware and software components necessary to enable MAGIC capabilities on the smartphones. The architecture does not specify specific hardware in this analysis because multiple systems are analyzed. Future development should include assessment of specific hardware once a platform and operating system are selected. Figure 7 summarizes the component architecture for MAGIC. The MAGIC component architecture is composed of:

1. MAGIC Application Component: The application component processes all user requests and provides feedback. This component provides all user interfaces, the main registration services components and the sharing service component. It contains the windows and displays necessary for the user to interact with MAGIC.
2. Data Server Component: The Data Server Component comprises of the Imagery Server, Map Server and Sustainment Data Server components of MAGIC. The Data Server Component provides all server capabilities needed for processing of MAGIC services. This component provides all data required to perform MAGIC registration and sharing services.
3. MAGIC Website Component: The MAGIC Website Component will be available for the user in later version of MAGIC. The idea is to enable the user access to MAGIC services over the phone and any device with a web-browser and internet access. Moreover, a workstation interface is to be provided for the Command Center for Emergency Responders.

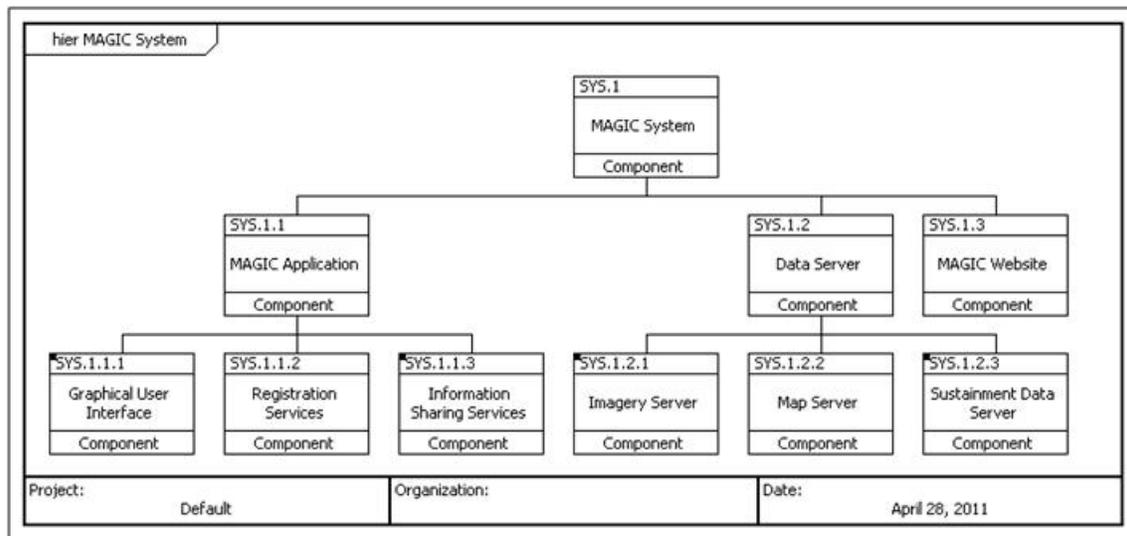


Figure 7: MAGIC Component Architecture

## Functional-to-Component Architecture Mapping

The MAGIC component architecture was mapped to MAGIC functions to ensure that the functional architecture met all the MAGIC System Requirements. The top level requirements were broken down into Functional and Non-Functional requirements. These requirements were then allocated to the top level functions of MAGIC. This is seen in Figure 8 below. MAGIC System Requirements are refined by the system's Functional and Non-Functional Requirements and is the basis of the 'Provide Geolocation Services' function which is allocated to the MAGIC system and the handheld device components.

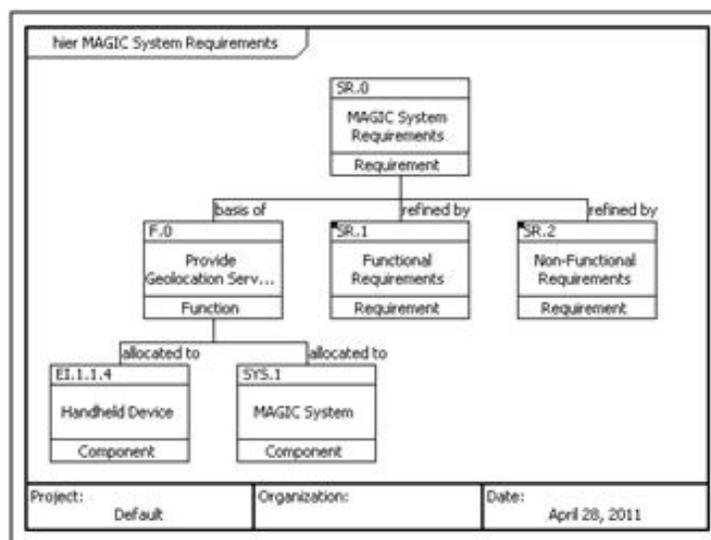


Figure 8: High Level Traceability Mapping of MAGIC Requirements

# Business Case Evaluation

The chief aim of the evaluation process was to determine whether it was economically feasible to build and market an application such as MAGIC. This determination also included an analysis of each viable implementation alternative with the goal in mind to minimize cost and complexity while maximizing profitability. To do this, the first step was to research not only the current and emerging smartphone market, but also the numbers behind mobile internet use, popular application use and customer demographics. The initial scope of the market research included all major mobile platform developers which included Blackberry, Windows, and Palm OS along with Apple iOS and the Android OS. But after further analysis, two primary operating systems were selected for additional consideration. This research revealed that there is indeed a great opportunity to make money with the MAGIC application.

The results of the Technical Feasibility Analysis provided the affirmation needed to proceed with the system engineering process and business case analysis for this project. With a firm understanding of the CONOPS and the architecture, the business case analysis evaluated several design alternatives for the initial implementation. This was done from a cost, benefit and risk perspective. Per direction from IAI (see Appendix L: Customer Survey), the final recommendation is focused on keeping the cost low, projected profitability high, and the design as simple as possible for the first product deployment.

## Market Analysis

To determine the economic feasibility of building and marketing an application such as MAGIC, market research was conducted on the current and projected use of smartphones as well as the mobile application industry, which included both consumer behavior and profitability data. Approximately 31% (70M) of US cell phone users are smartphone consumers (Nielsen, 2010). In 2010, roughly 1 in 5 global mobile subscribers have 3G or better handsets and this number is expected to exceed 5 billion by 2012 (dotMobi, 2011). This information supports the belief that the smartphone industry will continue to grow in the coming years. Research also indicates that there is a tremendous opportunity to generate income from mobile applications for smartphones. In the last three years over 300,000 mobile applications have been developed. In 2010, these applications were downloaded 10.9 billion times. Future projections show global downloads will reach 76.9 billion in 2014 and will be worth \$35 billion (Haselton, 2010). The most used applications are location based applications and social networking applications such as Google Maps and Facebook, respectively (Nielsen, 2010).

To determine the most viable initial design approach, market research was conducted on the leaders of the smartphone industry. Apple's share of the smartphone operating system market actually declined from 27.9% in October 2010 to 27% in March 2011 (Nielsen, 2011). Android seems to be the clear leader as their market share has risen from 22.7% in October 2010 to 37% in March 2011. Additionally, 50% of Android users are between the ages of 18 and 34, which cover a significant portion of our targeted age range of 15 to 40 for casual users, while only 43% of Apple's users fall into the same range (Nielsen, 2010).

## Description of Alternatives

The next step in the evaluation process was to look at several options for the initial implementation and provide a benefit and cost analysis for each one. The description of benefits, risks and issues for each alternative fed into the generation of a rough order of magnitude and potential return on investment for each solution. The purpose behind this is to assist in reducing risk in future implementation efforts while providing the basis for a confident investment decision. Finally, after identifying the leader of the smartphone OS sector, a cost and benefit analysis was generated for each design alternative. The alternatives discussed in the BCA are:

- Alternative 1 – Casual Users on the Apple iPhone platform
- Alternative 2 – Casual Users on the Android platform (Recommended)
- Alternative 3 – Emergency Responders on the Apple iPhone platform
- Alternative 4 – Emergency Responders on the Android Platform

The 1st and 2nd alternatives had very similar risks and issues, but the second alternative provided more benefits as Android has a larger market share and there are no fees for the Android Software Developers Kit and a much smaller onetime fee to publish application to the Android Market for sale. Apple charges a one-time license fee and 30% of the application listing price, which decreases the ROI for this option. In addition to this, the Android alternative indicates less cost (\$764K) than the Apple platform alternative (\$840K). The last two alternatives had more risks and higher costs associated with them in that a competitive contract would have to be won first in order to obtain the customer. Secondly, there was a higher potential for cost overruns due to the nature of contract vehicles and to the fact that this capability is somewhat unprecedented. Based on these results it is the recommendation of the MAGIC team that the initial application be designed for the Android operating system and targeted for the casual user. For a complete explanation, please refer to the BCA in Appendix J.

# Final Recommendations

The follow sections summarize the recommendations of the study, organized by the questions posed in the Problem Statement.

## Who would use this capability and how would they use it?

The MAGIC team recommends targeting ‘casual’ users and ‘disaster / emergency response’ users. A ‘casual user’ is any smartphone owner who would use MAGIC for personal pleasure, such as tourists, teenagers, and photographers. ‘Disaster / emergency response’ users are members of an emergency or disaster response organization, such as the Federal Emergency Management Agency (FEMA), who would use MAGIC to improve their ‘situational awareness’ of the disaster or emergency zone. The recommendation to target these two user groups was based on their perceived profitability and minimum required performance, which was expected to be achievable by MAGIC with existing smartphone technology. Please see Appendix B: Potential User Analysis for additional information on how these user groups were selected, Appendix C: Use Case Analysis for an assessment of how MAGIC is expected to be used by the disaster response users, and Appendix A: MAGIC Concept of Operations for additional information on how MAGIC is expected to be used by these two user groups.

## Can the accuracy requirements for these users be met with existing smartphones?

The preliminary accuracy assessment showed that the threshold requirements set by the Emergency Responder user group can be met with the technology used in current smartphones. Additionally the implementation of calibration techniques and instructions for the users enable the smartphones to achieve the objective requirements set by the Casual User group. Based on this assessment it is reasonable to proceed with further system design and development. The capability to share images and points of interest may be able to be met by integrating with existing websites; however the MAGIC team recommends that a standalone MAGIC server be assessed as a means to meet the users sharing and collaboration needs. A standalone MAGIC server would allow the MAGIC developer to customize the implementation and manage all interactions.

## What is the system required to do and how should it be designed?

The system will leverage current sensor, processing and data storage and communication capabilities available in current smartphones. The application will provide several user interfaces to allow users to view and manage MAGIC data, take new images, calculate new point of interest and shares these images and points of interest. The requirements for the system and the interactions of these hardware components, user interfaces and data flows are captured in the MAGIC System Description Document and the associated CORE architecture. It is recommended that a MAGIC sharing service be developed; however the assessment of that capability is outside the scope of this effort.

## Could developing this capability be profitable and what development path should be pursued?

The MAGIC team recommends initially designing the application on the Android platform and targeting the casual user first. This option provides the lowest cost, highest predicted profit, and the 2<sup>nd</sup> best design approach in terms of complexity. At a cost of \$764K, a download price of \$1.50 would return the initial investment after approximately 510,000 downloads. Combining this with an ad-supported “Lite” version of the application and the potential profit goes up dramatically. Designing an application for the casual

user first would consequently set up the strongest foundation for pursuing an application designed specifically for emergency responders in the future. This recommendation is predicated on market research analysis as well as alternative benefit and cost analysis. Please see Appendix J: Business Case Analysis and Appendix K: Detailed ROM and ROI analysis for a detailed report of the analysis.

## Future Work

This study focused on designing MAGIC for use on a handheld smartphone. During the project several aspects of the system were identified which were outside the scope of the project and will require additional analysis before proceeding with development of MAGIC.

## Standalone MAGIC Server

While working on the Concept of Operations and Technical Feasibility Study, it became obvious that a standalone server capability for MAGIC was necessary. This analysis should include:

- A website providing information about the application, mechanisms for users to provide feedback, and links to download the application are crucial from a business / marketing perspective
- The capability for users (particularly disaster-response users within a ‘Command Center’) to have laptop or desktop access to MAGIC data and capabilities would greatly expand MAGIC’s value to those users. For example, it could allow MAGIC to support social media for users, such as tagging / commenting particular images and points-of-interest, and forum discussions.’
- Allowing users to create unique accounts and authenticate directly with MAGIC servers would give IAI greater control over how image / point-of-interest sharing occurs

## ‘Anonymous’ Sharing

One issue the MAGIC team wrestled with was how to address the privacy desired by casual users. MAGIC requires the sharing of time and location data to compute points-of-interest and some user may not want this information about them made available. One possibility the team discussed was the ability to share images and points-of-interest anonymously: images and their metadata would be stripped of any user data that could be traced to the particular smartphone of origin. The team did not have time to include this option in the architecture or cost estimates.

## Sharing with Specific Contacts

The MAGIC team originally envisioned the capability for casual users to pick specific images and points-of-interest to be shared with specific friends or contacts. Due to time constraints, this capability was simplified in the CONOPS and architecture to either sharing publically (all MAGIC users can see it), or sharing privately (all friends / contacts can see it). The capability to share specific images / points-of-interest with specific contacts would increase the value of MAGIC to both casual and disaster-response users.

## Notification of Casual Users in a Disaster Zone

An idea discussed by the team was the notification of casual users caught within a disaster zone. A push-notification, similar to a ‘text’, would inform the casual MAGIC user that they could assist the disaster response effort by publically sharing images or points-of-interest that could be helpful. The MAGIC team did not have time to address this capability in the architecture or cost estimate.

## Assisted Second-Image Search

A capability that seems feasible but was not incorporated into the architecture or cost estimate was the ability to identify images whose points-of-view and useful ranges overlap, meaning they could conceivably contain a point-of-interest in common. While identifying the location of a point-of-interest, the user has to identify the appropriate pixels within two images. After the first pixel is identified, MAGIC could shorten the list of available images from which to choose the 2<sup>nd</sup> pixel by removing those images that could not possibly have a point-of-interest in common.

## Internal Camera Calibration

The initial accuracy study assumed that the pixel used in the calculation was at the center of the images and was unaffected by lens distortions. To enable the geolocation of objects not centered in the images the lens distortions of these smartphone cameras should be investigated. If it is determined that significant errors are present it may be necessary to explore developing a generic or sensor specific correction capability for lens distortions, principal point offsets or atmospheric refraction. Generic corrections could be applied to the generic sensor model with regular updates to MAGIC. Another option to explore would be creating camera specific support files that provide sensor specific corrections depending on what sensor generated the image being used. This solution would require the sensor model to interface to a configuration file and lookup table, both of which could be provided in updates to MAGIC.

## Video and 3D Capability

Smartphones also have video recording capabilities and may be a useful input for MAGIC. The ability to select an object from multiple videos or frames from a single video should be investigated as a potential follow-on capability for MAGIC. Additionally, 3D cameras and displays are being implemented in several smartphones. The integration of these technologies should also be considered.

## Instantiated Architecture Description

The system architecture should be updated from the generic components to the planned instantiated architecture. Based on the recommendation in this study the instantiated architecture would be an Android based application for casual user with a standalone MAGIC sever. The architecture would support a detailed requirements analysis for MAGIC. Figure 9 shows the generic architecture mapped to the recommended components.

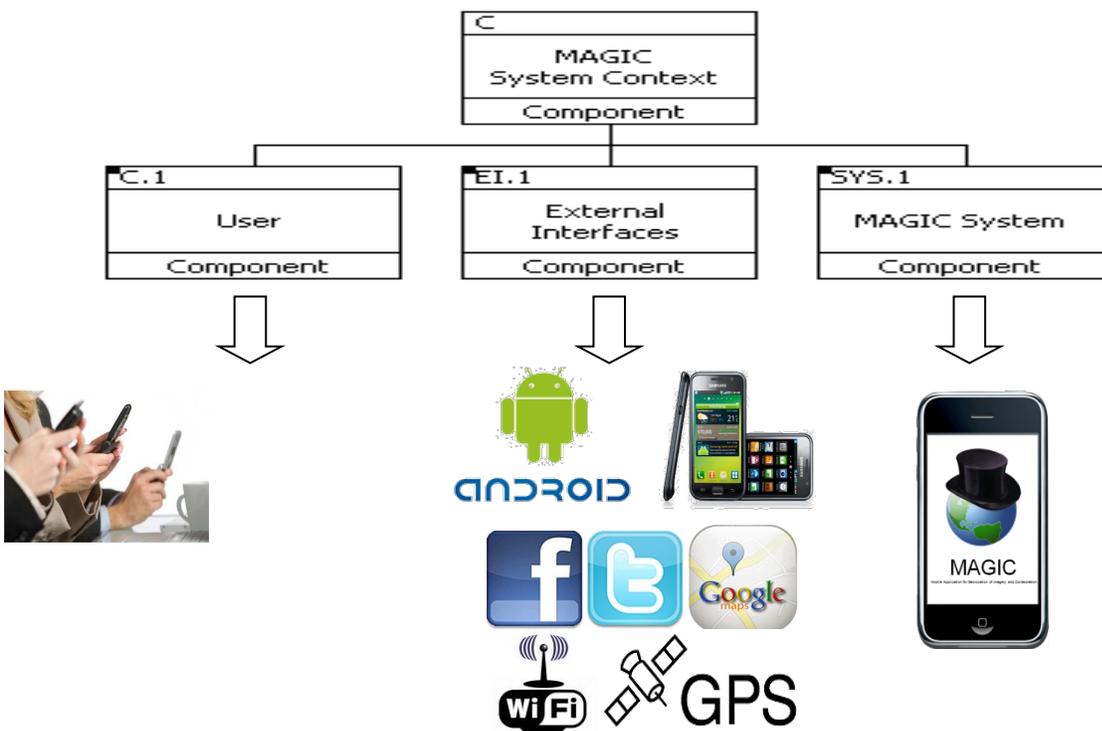


Figure 9: Instantiated MAGIC Architecture

## Detailed Requirements Analysis

The current system architecture identifies a generic physical architecture and primary functional architecture. Once a decision is made to proceed with developing MAGIC for a specific operating system and or platform, another round of analysis should be performed to derive requirements for system-specific hardware, system functions, data flows, data formats and system interfaces.

## Edge Detection

Some modern applications have demonstrated the ability to detect edges within images to do things such as identify a face within a picture. It is conceivable that MAGIC could incorporate this technology, and 'pre-process' images to have discreet objects within the image already identified – the user would only need to select one of these discreet, pre-identified objects as the “object-of-interest”.

## References

Each Appendix lists the References used by the deliverable document within that appendix. Below are only those References used within the main body of the Final Report itself.

- dotMobi. (2011, March). *Global Mobile Statistics 2011*. Retrieved from mobithinking.com:  
<http://mobithinking.com/stats-corner/global-mobile-statistics-2011-all-quality-mobile-marketing-research-mobile-web-stats-su#popular-activities>
- Haselton, T. (2010, March 17). *Mobile App Industry Will Surge to \$17.5 Billion in 2012*. Retrieved from mobileburn.com: <http://www.mobileburn.com/news.jsp?Id=9014>
- Nielsen . (2010, November). *State of the Media - US Audiences and Devices*. Retrieved from nielsen.com: [http://blog.nielsen.com/nielsenwire/online\\_mobile/factsheet-the-u-s-media-universe/](http://blog.nielsen.com/nielsenwire/online_mobile/factsheet-the-u-s-media-universe/)
- Nielsen. (2011, April 26). *Who is the Most Wanted*. Retrieved from nielsen.com: [http://blog.nielsen.com/nielsenwire/online\\_mobile/u-s-smartphone-market-whos-the-most-wanted/](http://blog.nielsen.com/nielsenwire/online_mobile/u-s-smartphone-market-whos-the-most-wanted/)