THE TEAM WITH THE BIG GUNS
Special Weapons, NSWC Crane

Project Requirements Documentation

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Section 1

Problem Statement

1.1 High Level Problem Summary

The Special Weapons Division at Naval Surface Warfare Center Crane (NSWC Crane) [2] is responsible for testing weapons that are used by the United States Armed Forces, specifically the Navy. In order to test these weapons, it is necessary to be able to quickly and effectively determine how a weapon's reliability, availability, and maintainability (RAM) functions. The weapon's accuracy is taken into account through RAM, as it is dependent upon both the availability (if the barrel is severely worn and must be replaced) and maintainability (as the barrel becomes dirty). Currently, nearly instantaneous results can be determined for super-sonic munitions on specialized ranges with special equipment. For every other situation NSWC Crane encounters, there is a scarcity of automated systems that can handle their weapons testing needs. This causes targets to be collected and held for analysis, and requires tedious hand measurements to be carefully plotted; these results are only as accurate as the person measuring it.

1.1.1 Project Clients

The clients for this project are Jeff Johnson and Chuck Zeller of the Special Weapons Division at NSWC Crane [2]. Jeff Johnson is the manager of the Joint Weapons Engineering Branch, and Chuck Zeller is the Technical Warrant Holder for the Small Arms and Weapons Division. Although the clients are not likely end users of the system, they care about the results of testing weapons. They will be pleased if the efficiency of the testing process can be improved.

1.1.2 Summary of Primary Success Criteria

- The system must allow for target analysis in situations where the acoustic targeting system cannot be used but a paper target can record the position of each shot and a photograph is taken of the target with a digital camera.

- The system must produce data that matches hand measurements within 1% error.

1.1.3 Scope

The scope of this project can be partitioned to satisfy the following client needs:

Need No.	Need Description
1	Accurately identify bullet holes in a paper target
2	Perform data analysis on the locations of the bullet holes
3	The system must be maintainable by contracted Navy/Marine Corps Intranet (NMCI) [10] staff

1.1.4 Not included in the scope of this project

This system will not be integrated with the existing acoustic system.

1.2 Detailed Problem Statement

1.2.1 Function

This section describes the features of the system. Critical importance implies that the feature must be implemented for the project to be a success. Features with an importance of "Important" are significant features that will improve the user's experience and throughput using the program, but are not required to solve the problem detailed above. Finally, "Useful" features may be implemented if there is sufficient time, but they do not determine the project's success or failure. The need that each feature satisfies is also included.

Key Business Features

Feature No.	Need No.	Feature Name	Importance
1	1	Input a digital photograph to the system	Critical
3	1	Zoom in and out of an image	Critical
5	1	Select and unselect bullet holes on the image	Critical
6	2	Analyze the group, including extreme spread, mean radius, and circular error probable	Critical
7	2	Maintain data on each image	Critical
8	2	Input test details (see Section 2.2)	Critical
10	2	Export a report to Microsoft Excel [3]	Critical
11	2	Persist data to a Microsoft Access [4] database file	Critical
4	1	Correctly determine where bullet holes are located on a digital image of a target	Important
2	1	Realign and linearly adjust the image to appear straight	Useful
9	2	Generate a report about the test	Useful

Key Enabling Features

Feature No.	Need No.	Feature Name	Importance
12	3	Must be NMCI [10] compliant	Critical

1.2.2 Form

The key attributes of the software, denoted in detail in the section on Supplementary Specifications, include analyzing an inputed image for bullet holes, being able to correct for the pitch of the image, performing calculations on the locations of the holes, and allowing for data about the test to be inputed.

1.2.3 Economy

Business Context

Currently, the navy collects data on bullets fired from their weapons with an acoustic tracking system. This system can very accurately collect data in real time as the bullets are fired past its microphone sensors. Due to the high cost of these systems, the limited number of these available to the Navy, and the ability of the systems to only record bullets traveling over Mach 1.15, this project will expand these abilities to allow for automated analysis of any test that cannot be currently performed with the acoustic system but can be recorded on a paper target and photographed.

Customer Organizational Constraints

Any user that has the program should be able to use all features included. It should contain many elements that modern web pages have for the sake of familiarity (drop down menus, auto completion, calendars for dates).

Development Organizational Constraints

Students from Rose-Hulman Institute of Technology will develop this software. Because all three students are unfamiliar with image recognition, the prototypes will be developed as sprints before an architecture is defined, analyzing how different algorithms fare against the targets presented. Only after the results of the sprints are known will an architecture be settled on.

With Rose-Hulman and NSWC Crane about 90 minutes away from each other, meetings between the client and design team will be held as phone conference calls and e-mails. Major milestones, such as prototype development in mid-November, usability testing, and final deliverables will be performed in person if possible.

Key Risks and Uncertainty

The key risks and uncertainty of the project are specified in the project plan.

1.2.4 Time

Historical Context

Before any weapon can be used by the Navy, it must undergo a strict set of tests to test its RAM, because "the loudest sound in the world is a 'click' when you expect a bang." One of the key tests that the Navy performs is analyzing where bullets travel once they have left the barrel of the gun. There are two main ways that these tests are performed: shooting paper targets, and using acoustic targeting systems.

Measuring by hand has posed many problems for the Navy. It is expensive to pay someone an hourly wage to record the target data when it can be automated. It is also difficult for people to manage the size of numerous large cardboard targets. Accuracy may be called into question when the only data points are those measured by hand; mistakes have been known to happen due to the sheer number of points being recorded as quickly as possible.

Current Context

Currently, the Navy has a system in place that can record super-sonic munitions traveling past microphones, pinpointing those rounds to within a millimeter in a three dimensional space. This system can only be used on special ranges where this half million dollar equipment is set up, and it can only be used on super-sonic munitions (munitions with speeds above Mach 1.15). This makes this system viable on only a small number of the tests performed by the Navy. In the majority of instances where this is not a viable solution, paper targets are used. People must then measure each hole on a target by hand, plotting the x- and y-coordinate of each point. When these tests are being completed, there are hundreds of targets to record, some as small as a sheet of paper, some as large as a six foot square of cardboard. Each target takes between 5 and 15 minutes to record and causes a backlog in the data recorded, allowing targets to build up until it is nearly unmanageable.

Only the acoustic system and recording targets by hand will directly compete with this system. Because of the limited number of acoustic systems and the significant overhead with hand recording targets, this system will have a high potential for use upon completion. The system will allows for all of this data to be captured in a photograph, allowing for faster processing time and making it easier to preserve a digital record of the actual target for future reference.

Future Context

After development of this system, the development has been encouraged to continue working on the project on our own for amateur gun shooters. The Navy currently has no plans to develop the application further, though the Navy will be required to maintain the system upon completion at the end of May 2009.

Development Time

- Two prototyping sprints (outlined in the project plan) must be completed by 15 November 2008.
- An initial release must be completed by the end of Winter Term, 2009.
- A final deliverable must be completed by the end of the 2008-2009 school year.
- Additional information about the project's development can be found in the project plan document.

Section 2

Use Cases

2.1 Processing a Set of Images

The user selects a set of images which are processed and corrected.

Actors Field Technician

Basic flow

1. The user opens a file select dialog, chooses one or multiple files, and clicks "OK".
2. The user is prompted for information about each image selected.
3. The user enters each image's information (see Use Case 2.2).
4. The user saves the data entered.
5. The processed files are presented in a list for the user to select from.

Alternate flows

- A file selected is not JPEG [5] or PNG [6].
    1. All valid/supported files are processed normally (the basic flow).
    2. The user is alerted to unprocessed files after processing has completed.
- The user finishes inputting file information before processing is complete.
    1. A progress indicator is displayed until processing is complete.

- A file cannot be processed.
  1. After the user saves the data entered, a pop up states which file was not able to be processed.
  2. The user chooses whether to try again or to skip the unprocessed image.
  3. If the image is not able to be processed, it is not included in the list and the basic data is saved to the database.

Pre-conditions

1. The images exists on the computer running the software.
2. The user has permission to access the images.

Post-conditions

1. The relevant statistical information and meta data that have been calculated or collected are displayed to the user.
2. The image used is displayed with the holes found by the software marked.

Special Requirements None

2.2 Adding Image Information

While an image is being processed, the user is asked for information regarding the image. This information is included in a report (see Section 2.5) along with the image.

Actors Field Technician

Basic flow

1. The user is presented a window with fields appropriate for the type of data, thumbnail, and filename of the current file.
2. The user inputs the requested information about the testing conditions for the image.
3. The user saves the data.

Alternate flows

- Invalid data (e.g. impossible date) is input.
  1. The user is alerted to the invalid data.
  2. The user corrects the mistake.
  3. The user saves the data.
- Another image is queued up for processing after the current one.
  1. The current image is processed normally.
  2. A new information window pops up for the next image in the queue.
- Processing on the submitted image fails.
  1. The user is allowed to continue entering in data.
  2. The user saves the data entered.
  3. A pop up informs the user that the image failed to process.
  4. The user either selects to try again or to save the data as is.

Pre-conditions The image(s) are being processed.

Post-conditions

1. The image information is saved with the chosen image.

Special requirements None

2.3 Add Missed Hole

The hole-finding algorithm has determined what it thinks to be holes. In the event that it has missed a hole, the user must manually add the holes in question.

Actors Field Technician

Basic flow

1. The image is presented with indicators covering each of the calculated bullet holes.
2. The user clicks a new indicator and drags it over one of the missed holes, placing it over the center of the hole.
3. The user clicks a button to save changes.

Alternate flows

- The user opts to not save changes.
  1. The user is asked whether changes should really be discarded.
  2. If the user chooses to not save the file, then the image retains its original indicators.

Pre-conditions The image has been processed and there are holes found that were not labeled.

Post-conditions All holes have an indicator denoting their position.

Special requirements None

2.4 Remove Incorrectly Labeled Hole

The hole-finding algorithm has determined what it thinks to be holes. In the event that it mislabels a hole, the user must remove the indicator from the image.

Actors Field Technician

Basic flow

1. The image is presented with indicators covering each of the calculated bullet holes.
2. The user clicks on an indicator on the image.
3. The user clicks a button to delete the selected indicator.
4. The user clicks a button to save changes.

Alternate flows

- If the user does not click on an indicator and still clicks the button to delete the selected indicator, nothing will happen.
- If the user chooses to save changes with an indicator still highlighted, the highlighted indicator will remain on the image and all other changes will be saved.
- Should the user not save changes, the image would retain its original indicators.

Pre-conditions The image has been processed and there are holes found that were not labeled.

Post-conditions All holes have an indicator denoting their position.

Special requirements None

2.5 Generating a Report

Once all of the data is inputed and the correct holes are identified, the user may wish to print out a report about the test to use later. This use case details creating a report.

Actors Field Technician

Basic flow

1. The user selects the desired images from a list of processed images.
2. The user clicks a button to generate a report.
3. The user is prompted for export options and the report is created.

Alternate flows

- The report cannot be generated or saved
    1. The user is notified with a pop up telling informing them that the report was unsuccessfully generated and to try again.
    2. The user remains at the same screen.

Pre-conditions The images that are going to be in the report have been processed.

Post-conditions For each image, a file containing the desired data for the chosen images has been output in a format that can be read by a program, such as Microsoft Excel [3].

Special requirements The user must have access to Microsoft Excel in order to open the report.

2.6 Feature Relation

		Use Cases				
		Processing a Set of Images	Adding Image Information	Add Missed Hole	Removing Incorrectly Labeled Hole	Generating a Report
Features	1	x				
	2	x				
	3					
	4	x				
	5			x	x	
	6	x				
	7					
	8	x	x			
	9					x
	10					x
	11					

Section 3

Supplementary Specifications

3.1 Introduction

This section collects and organizes those requirements not able to be captured in the use cases developed for the system. These requirements fall into several distinct categories including functions, usability, reliability, performance, and others.

3.1.1 Scope

This document applies to the small arms targeting system being developed for Naval Surface Warfare Center Crane (NSWC Crane) [2].

3.2 Functionality

The system must be able to:

1. Import an image of an arbitarily-sized target
2. Allow the user to zoom in and out on a target
3. Allow the user to specify locations of bullet holes
4. Allow the user to select a target paster (a small sticker approximately 1"x1") on the photograph
5. Record the following data about a target:
   (a) Filename of the original image

(b) Filename of the compressed, low resolution image
(c) Date target fired upon in DD-MM-YYYY format
(d) Time target fired upon using a 24-hour clock
(e) Date image file processed in DD-MM-YYYY format
(f) Time image file processed using a 24-hour clock
(g) Last name of the target's shooter
(h) First name of the target's shooter
(i) Firing range location
(j) Distance from weapon to target in yards
(k) Firing range temperature from the following choices:
    i. Cold (temperature $<$ 50 degrees)
    ii. Ambient (50 degrees $\leq$ temperature $\leq$ 95 degrees) (default option)
    iii. Hot (95 degrees $<$ temperature)
(l) Weapon Data
    i. Weapon nomenclature
    ii. Serial number
    iii. Weapon notes - general area for additional weapon information such as:
        A. Ancillary equipment used
        B. Hot weapon
        C. Rate of fire
(m) Ammunition Data
    i. Caliber
    ii. Lot number
    iii. Projectile mass
    iv. Ammunition notes - general area for additional ammunition information such as:
        A. Temperature
        B. Conditioning
(n) Total number of shots fired

6. Reports generated will include all calculated and inputed data, as well as a thumbnail of the image, into the Microsoft Excel [3] report.
7. Save calculated data to a Microsoft Access [4] maintained database

The system should be able to:

1. Identify bullet holes in the target and display them to the user
2. Generate an on-screen report about the test

The system may be able to:

1. Realign and linearly adjust the image to appear straight

3.3 Usability

1. Users should be able to load an image into the program within 3 seconds of time that they can load that image into an image editor like GIMP [11].
2. Users familiar with the system should be able to input the data related to the target (see section 3.2) in 30 seconds.
3. New users should be able to use the targeting system after reading the user's manual.
4. Returning users should be able to use the system without referencing the user's manual.

3.4 Reliability

1. Normal operations of the system should not produce errors.

3.5 Performance

1. The system must be able to accurately record the locations of the bullet holes within one millimeter, even when the target color and the background color are similar.
2. The system must be able to compute statistics for a target within 1% error of the existing acoustic system for targets which can be analyzed by the acoustic system.
3. The system must be able to compute statistics for a target within 1% error of the statistics determined by hand.
4. The maximum angle at which the image of the target may be taken from perpendicular to the target plane must be determined and recorded in the user's manual.
5. The system must be able to analyze images with a minimum resolution of 4 Megapixels.
6. The system must be able to process an image in the amount of time it takes a trained user to input the data related to the target (see section 3.2), which is about 30 seconds.

3.6 Testability

1. The system will be developed in a development environment separate from the testing and production environments to allow for regression and load testing to be performed.
2. Test cases will be built from the use cases and supplementary specifications.
3. The program must pass all use cases to make program as bug free as possible.

3.7 Supportability

1. There are no specific supportability requirements, although common coding and commenting practices must be followed.
2. One update will be distributed to the client in the end of May, 2009, as part of version 2 of the software.

3.8 Design Constraints

1. The software must be able to load JPEG [5] and PNG [6] image files and process them.
2. Reports must be generated to a format that can be read by Microsoft Excel [3].
3. Data must be saved to a file that can be read by Microsoft Access [4], as this is on the list of applications that have already been approved by NMCI [10].

3.9 User Documentation and Help System Requirements

1. A user's manual will be given to the client. It must contain instructions on:
   (a) How to use the software
   (b) Performance capabilities of the software
   (c) Restrictions of the software

3.10 Purchased Components

1. NMCI [10] will bear the cost of the infrastructure of the network share drive the software will reside on.

3.11 Interfaces

3.11.1 User Interfaces

1. The user interface will be prototyped at a later date to determine how the user interface should function.
2. The system should provide options like form-filled drop down menus and calendar inputs.
3. The system should require minimal typing, being navigable as much as possible via a mouse.

4. The “Weapon Nomenclature” and “Caliber” user inputs should be drop-down menus populated with the typical options chosen
5. The “Weapon Nomenclature” and “Caliber” should have the ability to add new options to the to help minimize user errors.

3.11.2 Hardware Interfaces

1. The system does not have direct interfaces to hardware.

3.11.3 Software Interfaces

1. The system must run on Microsoft Windows 98, 2000, XP, and Vista [1].
2. The system should be able to export reports to Microsoft Excel [3].
3. The system must be able to persist data to Microsoft Access [4].

3.11.4 Communications Interfaces

1. The application will be run on NMCI’s network with clients connecting to a NMCI [10] share drive.

3.12 Licensing and Security Requirements

1. This system and any future revisions of this system may be used by the United States government [7] and Department of Defense [8] contractors free of charge.
2. Rights to the system belong to Andrew Houvener, Matthew Jacobs, Jeffrey Johnson, Sriram Mohan, Micah Weaver, Charles Zeller, and Rose-Hulman Institute of Technology.
3. The security of the host machine will be sufficient to secure the application and the data it produces.

3.13 Legal, Copyright, and Other Notices

1. This system comes as is with no warranty.

3.14 Applicable Standards

1. There are no specific applicable standards, although common coding and commenting standards must be used.

3.15 Internationalization and Localization

1. This solution only needs to be written in English.

3.16 Physical Deliverables

The following will be given to the clients at the completion of the project:

1. The complete program code on a compact disc with installation instructions.
2. The user's manual as defined in section 3.9.
3. A programmer's manual which could be used by outside contractors to perform maintenance on and expand the system.

3.17 Installation and Deployment

1. The client must be able to easily install and uninstall from the compact disc delivered as defined in section 3.16.

Glossary

The **Joint Photographics Experts Group (JPEG)** [5] is a committee for image standards. JPEG is more commonly associated with an image file format. It is used for compression, but the compression causes some loss of data.

Mach number is the velocity of an object divided by the velocity of sound.

Microsoft Excel [3] is a spreadsheet program created by Microsoft Corporation.

Microsoft Windows [1] is a family of operating systems created by Microsoft Corporation. The operating systems provide a layer of abstraction between computer users and the underlying hardware.

NAVSEA [9] stands for Naval Sea Systems Command. This branch of the Department of Defense's mission is to develop, deliver, and maintain ships and systems on time, on cost for the United States Navy. It exists to serve the seaman.

Naval Surface Warfare Center Crane (NSWC Crane) [2] is the third largest naval base in the world. NSWC Crane's mission is to "provide engineering and technical services with a product focus in sensors, electronics, electronic warfare and special mission weapons..." [2].

NMCI, also known as Navy Marine Corps Intranet, supports all of the software and network solutions for the United States Navy. This is the department that will have to be consulted for final product distribution, as well as for database development.

NSWC stands for Naval Surface Warfare Centers. The NSWC centers are divisions of NAVSEA that perform specific duties within the NAVSEA organization. NSWC is the primary weapons depot for the United States Navy.

Portable Network Graphics (PNG) [6] is an image file format. It has no loss of image data.

super-sonic is defined to be any object traveling at or above 1.15 Mach.

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