EXECUTIVE SUMMARY

CONTENTS

1.0 WARWICK MOBILE ROBOTICS

Warwick Mobile Robotics (WMR) is an engineering group project, supported by the School of Engineering at the University of Warwick. The purpose of this project is to create an opportunity for students to involve themselves in development within the field of robotics. In addition to this, the project requires the demonstration of skills from a range of disciplines, from other streams of engineering and business management. To satisfy these requirements, a corporate identity was created with the aim of developing a professional framework for a business and a potential product.

The team consists of eight MEng, final year students selected each academic year from a range of different engineering streams. Supporting the team are two project supervisors, academics, technical staff, administrators and doctorate students. The project is initially allocated a budget from the School of Engineering, but additional funding is acquired through external sponsorship and strategic partnerships with other University bodies and industrial organisations.

In previous years the project has been focused entirely on robotic football and has achieved a high degree of success both nationally and internationally, in the MiroSot Robot Football Championships. This year the team decided that due to factors including lack of interest from British universities, limited scope for technical development and restricted opportunities for business proposals, robot football would not be the central interest of the project.

Potential as a source of publicity and promotion of the new corporate identity, development of robot football was continued in the 2007/08 academic year with limited resources. In March 2008, WMR hosted and won the UK MiroSot and SimuroSot Championships. Whilst robot football development has not been terminated, its ability to provide a challenging technical project has peaked.

Figure 1 – 2008 UK MiroSot Robot Football Championship Final, held at the University of Warwick.

In order to provide a logical progression from robot football several criteria were proposed. The new project would have to address the limitations of robot football in order to be a success. Principally selection was based on the need for long-term interest, a scope for future technical development, a level of competition inherent in the task and application of transferrable technical knowledge established through robot football.

Scope for technical development is required to ensure that the project has a long term lifespan and pose a challenge to future project teams. Additionally, it must contribute to the field of robotics and raise the profile of the discipline at the University of Warwick. The new project should allow technical knowledge to be transferred from robot football, in order to utilise the knowledge base accrued by previous teams. A competitive environment is desirable as it allows the team to focus on a tangible goal with well defined requirements within the limit of the project timeframe.

Based on these requirements, the team used a process of objective analysis to select the new project, the RoboCup Rescue competition. The aim is to simulate a natural disaster scenario, such as an earthquake, to push the development of search and rescue technologies. Participants are ultimately required to produce an autonomous mobile robotic platform. This should demonstrate capabilities in mobility, navigation, sensory perception, mapping and operator interfaces whilst searching for simulated victims, in a recreated earthquake setting. Beyond the competition and the use of the robot as an aid to emergency services, the scope for applications of the robot are wide ranging, including such uses as defence, raw material extraction, pipeline and rail maintenance etc.

Based on these requirements of the new project, the team conceived, designed, manufactured and assembled a new robot that competed in the 2008 German RoboCup Rescue Open.

Figure 2 – WMR Robot at the 2008 RoboCup Rescue German Open.

2.0 OPPORTUNITIES

The nature of WMR has accommodated opportunities for a broader range of stakeholders. Not only is the project of interest to direct sponsors, but now also includes prospects for other academics, investors looking for strategic partnerships and prospective project students.

2.1 AS A BUSINESS

The fact that the search and rescue robot is a viable product (as identified in the Business, Finance and Management Report) gives it the ability to attract serious attention for a wide range of stakeholders. This in turn adds to the feasibility of the project as a business proposal. In addition, due to the open nature of the project there are vast opportunities for diversification into other fields relating to mobile robotics. The team has been approached by organisations from various industries enquiring about potential for the use of the robot in their respective fields.

2.2 FOR INVESTORS

With a newly developed comprehensive sponsorship package, WMR offers opportunities on various levels for investors, both in terms of finance and technical support. Emphasis on clarity has been placed in order to produce a tiered structure that lets the sponsor know exactly what can be expected in return for valuable investment.

Benefits of such investment have included international exposure and logo placement on all publicity, clothing, business cards and prominent positioning on the website and search and the rescue robot.

2.3 FOR STRATEGIC PARTNERSHIPS

Since WMR has a strong presence within the School of Engineering and is situated in a highly reputable University, access to graduates can be an attractive opportunity to potential employers. Through strategic partnerships WMR can benefit from the support of a professional institution and similarly the institution can contract minor research and open channels for recruitment.

2.4 FOR STUDENTS

Negotiations between the Department of Computer Science and the School of Engineering to outsource the development of artificial intelligence as a group project are underway. This highlights the wide range of opportunities available for other students to get involved with WMR, both directly and indirectly. For example the robot arm redevelopment has been proposed as a third year project.

3.0 AIMS AND OBJECTIVES

To maintain a structured and disciplined approach, all of the team's activities had to be justified as a means to achieving certain aims and objectives that had been deemed necessary to compete successfully. These aims and objectives were also used as the basis for setting out detailed requirements and which in turn dictated the specifications of the robot, as well as other activities such as publicity.

3.1 AIMS

- Redesign the project's corporate identity and image
- Optimise our MiroSot strategy for national championships
- Design and build a RoboCup Rescue certified robot

3.2 OBJECTIVES

- Develop a new marketing strategy to attract sponsors and raise the profile of the School of Engineering
- Develop a robot chassis capable of navigating the scenario terrain
- Build a test environment for the robot
- Produce a sensor array capable of mapping the environment
- Provide support for tele-operation and autonomous navigation
- Investigate the implementation of victim identification using thermal imaging, motion, sound and CO2 sensors
- Compile a handbook detailing the rules and regulations of the challenge as well as the learning experiences of the team for the benefit of the next team
- Create a new website to generate interest in the project
- Renovate the existing laboratory facilities to project a more professional image
- Compete at the European RoboCup Rescue league within 3 years

A benefit of setting out these detailed aims and objectives, the team had an effective means of gauging the success of the project as a whole and as a useful indicator of progress throughout the year.

4.0 TECHNOLOGIES

Throughout the last year the team has had to develop engineering solutions to meet the requirements of producing a search and rescue robot to compete in the RoboCup Rescue competition. This started with develop of transferable technologies from robot football such as the vision system, PIC microcontrollers and coordinate based mapping system. It continued with development of different technologies necessary to address the new challenges set by RoboCup Rescue. Key technologies include:

- Differential drive system for controlling the track system
- Remote client application for robot control and communications
- Flipper assembly for optimum terrain navigation
- Robot arm kinematics system for versatile terrain mapping and victim identification

Specific technologies were chosen based on a number of factors ranging from terrain geometry, team familiarity with the technology, funding etc. Details of the various technologies used, why they were chosen and how they were implemented can be found in the relevant sections of the main and technical reports. Due to the iterative nature of the projects development, future teams will be free to investigate alternative technologies as they deem necessary and appropriate.

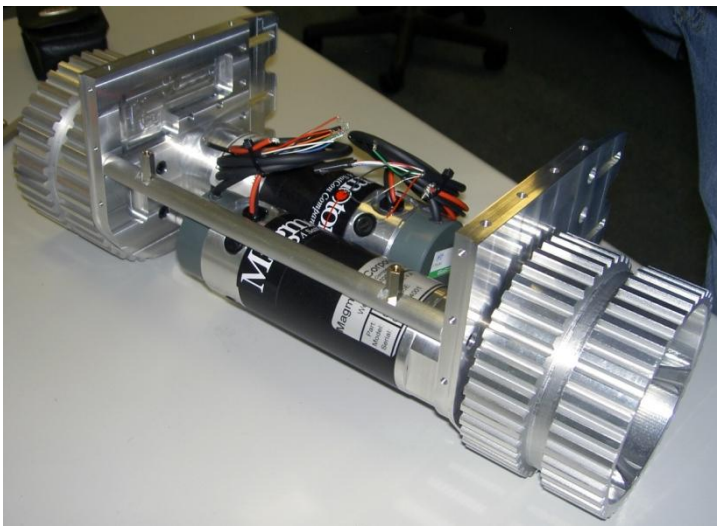


Figure 3 – Rear differential drive system assembly.

Some principle technological recommendations for future teams consist of:

- Weight reduction through the investigation of light weight, impact resistant materials
- Compact gearing alternatives with lower power consumption
- New battery technologies
- Miniaturisation/standardisation of parts

5.0 METHODS

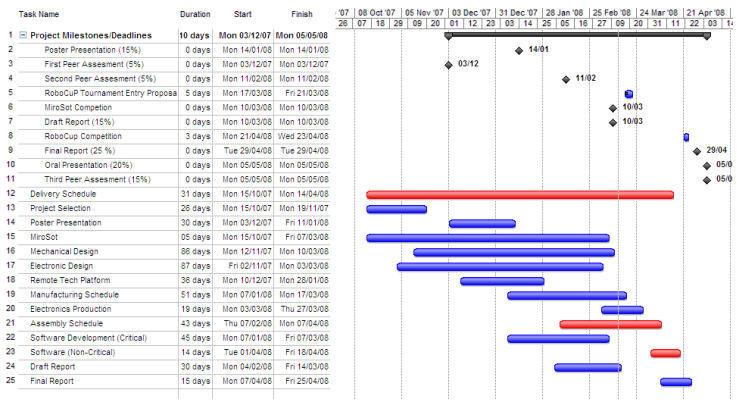
5.1 PROJECT MANAGEMENT

To successfully achieve the aims and objectives the project would need careful planning and organisation. The structure of the team was not a standard organisational model and therefore required a degree of flexibility in terms of managing individuals. This was also the first time that the project was run and a large number of changing factors had to be considered throughout the continuous management of the project.

To deal with the unorthodox organisational structure a clear hierarchy was developed with central roles (Manager/Secretary, Technical Director) to coordinate the team. Weekly formal meetings with the supervisors were held to monitor progress and receive feedback. Communications were a key factor in coordinating the team. Among the tools used were, e-mail, telephones, websites, online forums and frequent informal meetings.

To help with planning activities for the project as well as managing risk the team used a Gantt chart with an incorporated risk register. The Gantt chart facility found in Microsoft Project allowed the project to be management at several different levels. A comprehensive project overview can be broken down into individual sections dealing with specific activities such as machining operations, deliveries, printing etc. Time and resources were allocated based on priority, which was based on such factors as; machine availability, delivery schedule and linked activities.

To help manage risk the plan included a traffic light system that indicated the status of the activity and its potential for failure. Green indicated low risk and on schedule activities. Yellow indicated activities that were delayed within the planned time slot or were deem highly critical. Red indicated delays beyond the allowable time and problems encountered. A list of critical activities were entered into a risk register which assessed how managed the risk. Additionally activities that were not critical yet flagged up yellow were added to the register.



	Task Name	Duration	Start	Finish
1	Project Milestones/Deadlines	10 days	Mon 03/12/07	Mon 05/05/08
2	Poster Presentation (15%)	0 days	Mon 14/01/08	Mon 14/01/08
3	First Peer Assesment (5%)	0 days	Mon 03/12/07	Mon 03/12/07
4	Second Peer Assesment (5%)	0 days	Mon 11/02/08	Mon 11/02/08
5	RoboCuP Tournament Entry Proposal	5 days	Mon 17/03/08	Fri 21/03/08
6	MiroSot Competion	0 days	Mon 10/03/08	Mon 10/03/08
7	Draft Report (15%)	0 days	Mon 10/03/08	Mon 10/03/08
8	RoboCup Competition	3 days	Mon 21/04/08	Wed 23/04/08
9	Final Report (25 %)	0 days	Tue 29/04/08	Tue 29/04/08
10	Oral Presentation (20%)	0 days	Mon 05/05/08	Mon 05/05/08
11	Third Peer Assesment (15%)	0 days	Mon 05/05/08	Mon 05/05/08
12	Delivery Schedule	31 days	Mon 15/10/07	Mon 14/04/08
13	Project Selection	26 days	Mon 15/10/07	Mon 19/11/07
14	Poster Presentation	30 days	Mon 03/12/07	Fri 11/01/08
15	MiroSot	05 days	Mon 15/10/07	Fri 07/03/08
16	Mechanical Design	86 days	Mon 12/11/07	Mon 10/03/08
17	Electronic Design	87 days	Fri 02/11/07	Mon 03/03/08
18	Remote Tech Platform	36 days	Mon 10/12/07	Mon 28/01/08
19	Manufacturing Schedule	51 days	Mon 07/01/08	Mon 17/03/08
20	Electronics Production	19 days	Mon 03/03/08	Thu 27/03/08
21	Assembly Schedule	43 days	Thu 07/02/08	Mon 07/04/08
22	Software Development (Critical)	45 days	Mon 07/01/08	Fri 07/03/08
23	Software (Non-Critical)	14 days	Tue 01/04/08	Fri 18/04/08
24	Draft Report	30 days	Mon 04/02/08	Fri 14/03/08
25	Final Report	15 days	Mon 07/04/08	Fri 25/04/08

Figure 4 – Condensed Project Plan Overview.

5.2 DEVELOPMENT

During the project there were three main areas of development; MiroSot robot football, RoboCup Rescue hardware and RoboCup software. Robot football development was independent and activities were self-contained within the project. It was designated a certain level of resources and ran parallel to the creation of the search and rescue robot.

Although both the hardware and software development for the search and rescue robot required different resources, expertises and working methods, they are highly interdependent. In order for successful completion of the project aims and objectives within the given time frame, the team required the two areas of development to be running concurrently.

The Remotec bomb disposal platform proved crucial in allowing the electronics and software to be developed while the new search and rescue chassis was still being designed, manufactured and assembled.

Figure 5 – Remotec software development chassis.

A close relationship with the technical staff at the International Manufacturing Centre was established to help manufacture custom parts, to receive guidance throughout the project on mechanical issues and for general support.

All aspects of the search and rescue robot development were well documented, including commentary on code, procurement log, theoretical calculations and portfolios containing component schematics. The technical reports clearly show the design adaptations and innovations the design teams have made in order to bring the robot from concept to completion.

6.0 OUTCOME

In terms of the aims and objectives set for robot football the team has been successful in achieving them through winning the UK MiroSot and SimuroSot Championships. This fulfils the potential development of robot football as far as competition in the UK is concerned. Robot football is highly successful as a tool for garnering publicity and future teams may decide that further development may be beneficial in order to compete successfully in Europe.

6.1 GERMAN OPEN 2008

Figure 6 – Teams competing at the 2008 RoboCup Rescue German Open.

By attending the 2008 German Open the team were able to meet many of the aims and objectives set at the start of the project, as well as provide exposure for sponsors at the world's biggest industrial fair, the Hannover Messe. In addition, the team were able to gain valuable experience in terrain navigation and victim identification and received positive feedback from industrial bodies regarding the quality of the robot design.

Examples of lessons learned through actual competition include:

- For optimal stair climbing the centre of mass requires to be positioned further forward
- Teeth profiles are required for additional grip whilst climbing obstacles
- A more robust robot arm design

Overall entering the German Open and competing was a great way of testing the robot and proving the goals originally set for the project were successfully met. Next year's team can look forward to having a strong base for continuing progress towards a robot that can win the championship.

7.0 A NOTE FROM THE TEAM

In addition to achieving the development of a working search and rescue robot within the span of a single academic year, the team feels the main success is the fact that the change and new direction has opened up a number of opportunities. Besides the options already highlighted, WMR has created a platform from which future teams can make a choice in terms of what they wish to achieve. A two year roadmap has been outlined for the continuation of developing the search and rescue robot specifically for the RoboCup Rescue competition. However, it is still a great starting point for participants to take research forward in a direction of their choice, depending on abilities and interests. This has created a project that is versatile and can adapt the changing requirements of the Masters program.