



Executive Report

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THE UNIVERSITY OF
WARWICK

Telephone: +44 (0) 2476 574 306

Web: www.mobilerobotics.warwick.ac.uk

Email: mobilerobotics@eng.warwick.ac.uk

Warwick Mobile Robotics
International Manufacturing Centre
University of Warwick
Coventry
CV4 7AL



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1. Introduction

Warwick Mobile Robotics (WMR) is an ongoing student research project for the Warwick Manufacturing Group (WMG). WMG is an institution within the University of Warwick, dedicated to improving organisational competitiveness through the application of technology innovation. Each year, the WMR team compete in the Robocup Rescue League, a global competition that tests robots' search and rescue abilities in a simulated disaster environment. Our group aims are to excel in all areas of the competition with a variety of features on our robot, moving towards a complete product for real world applications. Our primary focus this year has been improving upon the preceding tele-operated robot platform and making use of a new prototype autonomous robot to test SLAM mapping and autonomy.

The structure of the team (Figure 1) is important in implementing effective leadership and is a good reference for decision-making. A horizontal hierarchy approach was utilised for the structuring of the team with decision making taking place during the weekly strategy meetings. This way every member of the team had a good idea about the overall direction of the project and took part in its decision making process.

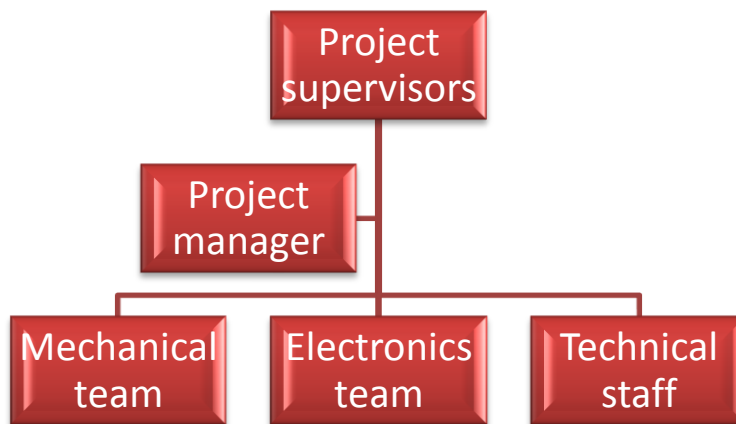


Figure 1 - The horizontal nature of the hierarchy showing the project manager as a mediator between the supervisors and the rest of the engineering team

2. Aims and objectives

The Team's main aim was to develop and advance its mobile robotics capability in time for the 2010 RoboCup Rescue League with the ultimate goal of winning the competition including:

- Redesign robot chassis with possible use of composite materials.
- Design and manufacture new robot solely for autonomous section.
 - Use of laser cutting and folding technology.
 - Work with computer science team for development of A.I. Software.
- Improve reliability of software and controls of robot.
- Develop mapping for both robots using LiDAR (Light Detection And Ranging).
- Design of new arm for robustness and inclusion of more sensors.
- Overall weight reduction for better power to weight ratio with improved range.
- Raise the bar of engineering showcasing Warwick University to the world.
- Improve exposure of WMR and sponsors through global success.

These objectives were set out at the beginning of the project with the aim of winning the RoboCup Rescue European Championship 2010.

3. Design

3.1. Tele-operated robot

The tele-operated robot is designed for the sections of the competition that require good maneuverability over uneven terrain and steep slopes. In the previous year, our robot won best in class for mobility in the European open and so much of the mechanical systems remained the same. Instead we focused on reducing the weight of the robot to obtain longer run times with the optimum battery configuration and to aid in ascending the steeper slopes. We also installed new, more suitable motors to ensure optimum use of the tracks and flippers. Using large tracks and flippers it can negotiate obstacles to locate victims under the operation of a controller from a wireless position with no direct visibility of the robot. Every component has been modeled in Solidworks. This is essential for establishing the optimum configuration of parts, from the positioning of electrical components and wires to the ideal fan cooling arrangement. It is also necessary for creating the CAD files used directly in the laser cutting process. An image of the tele-operated robot can be seen in Figure 2.

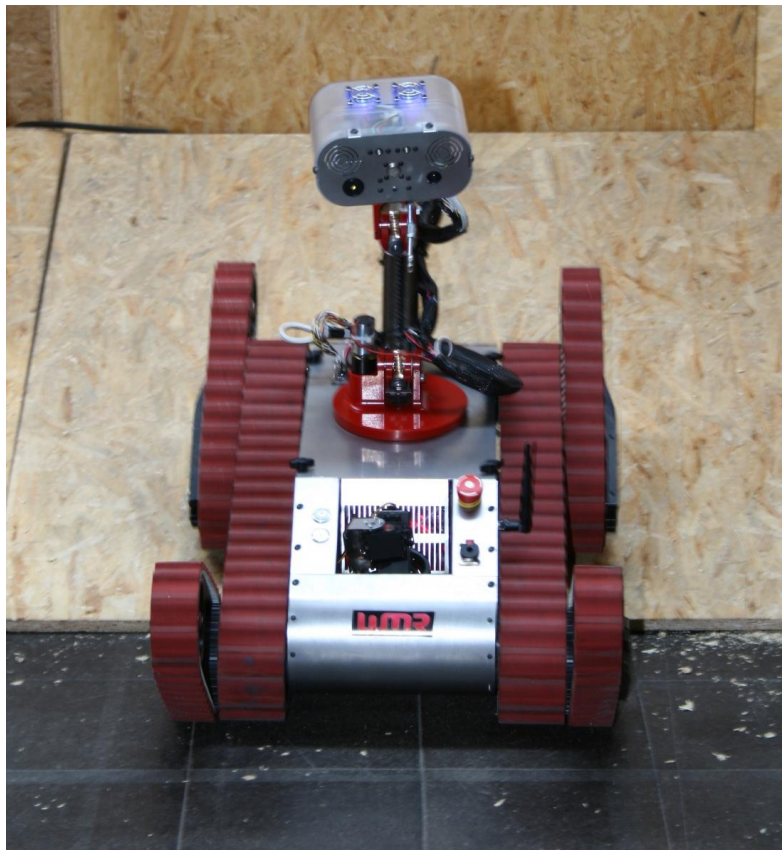


Figure 2 - Tele-operated robot

3.2. Autonomous robot

During the initial stages of the project, a decision was made by the team to enter two robots, each specifically designed to meet the requirements of the zones in which they will compete. This meant designing and manufacturing an entirely new robot capable of self-navigation, mapping and indentifying the state and location of victims. In order to reduce the magnitude of the task, the robot was designed to use many of the existing spare components available to the team. In addition, the software design was largely outsourced to a team of Warwick University Computer Science students. An image of the autonomous robot can be seen in Figure 3.



Figure 3 - Autonomous robot



4. Publicity, finance and management

4.1. Publicity

To launch and maintain a project of this magnitude a significant amount of funding was required and so acquiring this capital was one of the team's main focuses throughout the year. In order to secure this funding a rigorous publicity campaign was launched at the forefront of the project. This included contacting past sponsors with the aim of securing continued support, and branching out to new companies in search of funding. WMR is fortunate enough to be housed within the Warwick International Manufacturing Centre (IMC) and thus managed to secure a large amount of funding from Warwick based research groups, Warwick Manufacturing Group (WVG) and the Innovative Manufacturing Resource Centre (IMRC). In addition to this WMR's relationship with local engineering firm ITCM was also maintained proving it as a valued partner. In an effort to create new relationships with industry, several companies were contacted including Harwin, who have a good relationship with the University, and Maxon motors, whom the project had dealt with in the past. In addition to this we produced a quarterly newsletter, nation-wide press releases, presentations to sponsors and posters.

4.2. Finance

To achieve the goals of the project significant financing was required. Table 1 shows the different sources of funding for the project. This year, a total budget of £16,950 was available. A total of £15,450 was spent over the course of the year.

Thorough records were kept of purchases to ensure efficient budgeting of resources. Section 4 of the Business, Publicity, Finance and Management Report contains detailed analysis and discussion of the financial management of the project.

| Source of Funding | Cost Code | Budget (£) |
|-----------------------|-----------|------------|
| School of Engineering | 01ESEE44 | 1,200 |
| WMG | 01ESWM23 | 4,550 |
| IMRC | 01ESWM23 | 5,000 |
| ITCM | ITCM | 2,000 |
| Harwin | HARWIN | 1,200 |
| Carried forward | 01ESWM23 | 3,000 |
| Total | | 16,950 |

Table 1 – Sources of funding

4.3. Management

When taking on a project of this magnitude it is important to ensure thorough planning of time and resources in order to effectively meet deadlines. To help facilitate this, a Microsoft Project planning tool was used to create a detailed schedule for the project and to help keep all tasks on track, an example of which can be seen in Figure 4.

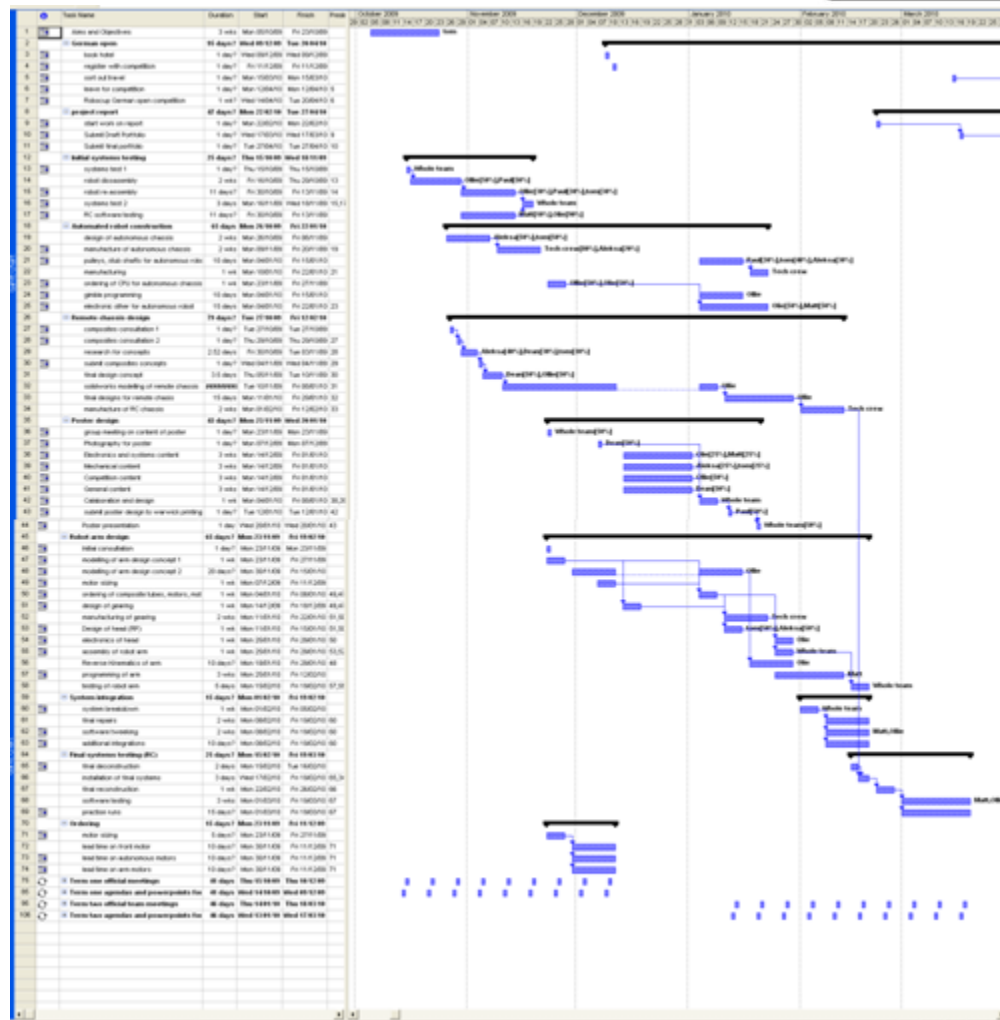


Figure 4 - Microsoft project file detailing tasks and deadlines throughout the year

Initially major deadlines such as the competition and submission deadlines were set out and major tasks were planned to meet them. Eventually larger tasks were separated into individual components and assigned resources such as personnel and machining equipment. Using this tool the project was not only able to effectively plan a work schedule but also map out when key decisions needed to be made such as purchasing orders with long lead times.

Section 5 of the Business, Publicity, Finance and Management report contains a more detailed discussion of the management techniques employed.

5. Outcomes

5.1. Final design

The 2009/10 WMR team won the 2010 RoboCup Rescue European Championships, using both their tele-operated and autonomous robots (Figure 5).



Figure 5 - WMR team 2010

At the RoboCup Rescue League competition the tele-operated robot was almost entirely without mechanical fault. There were concerns about the likely level of damage to the relatively thin stainless steel sheet chassis. However, there was no damage even after the most arduous terrain was navigated through. This may have been due the large amount of tension the chassis plates were under.

As for the autonomous robot, when driving over the ramps in the arena the robot was found to slam down causing damage to the robot as the centre of gravity was very far to the rear. With the centre of gravity so far rear, it also meant turning on slopes was inaccurate. To improve this two, 1.5kg weights were added to the front of the robot. This seemed to help with the turning of the robot but did not improve the slamming over ramps.

5.2. Evaluation against aims and objectives

The Team's main aim of developing and advancing its mobile robotics capability in time for the 2010 RoboCup Rescue European Championship has been achieved successfully. The ultimate goal of winning the competition and hold our best in class mobility title has also been achieved successfully. A breakdown of the achievements is given below:

- Complete redesign of robot chassis with the use of laser cut sheet steel:
 - Reduced weight of chassis by 9kg
 - Larger space for electronics and other internal components
 - Easy-to-remove arm platform
 - Quick assembly due to panel design
- Design and manufacture of a new robot solely for the autonomous section:
 - Use of laser cut sheet steel for simple and spacious design
 - Successful integration with Computer Science team
 - Working test platform for SLAM
 - Working test platform for victim identification
 - Basic mapping capabilities achieved at competition
- Improved reliability of software and controls of robot:
 - Communication lag problems resolved by improved cooling and new router
 - Improved software controls through advanced GUI and reprogramming of controls
- Developed mapping for one robot (autonomous) with the use of LiDAR
 - Mapping capabilities have not been achieved on the tele-operated robot because of compatibility issues between the two robots
- New arm with improved robustness and inclusion of more sensors:
 - 5 DOF arm
 - Carbon fibre tubes for weight reduction and increased stiffness
 - Infra-red, two-way communications, LED's, CO2, front and rear camera capabilities



- Overall weight reduction of 3kg:
 - Improved power to weight ratio and range
- Numerous publicity opportunities:
 - Newspaper articles, BBC news coverage, radio stations, quarterly newsletters to sponsors, presentations and website updates
- Increased profile and exposure of WMR, Warwick University, WMG and other sponsors through winning the competition.

6. Conclusions

- Warwick Mobile Robotics has achieved 1st place overall and best in class for mobility at the RoboCup European Open 2010.
- The robot chassis has been redesigned giving a weight saving of 9kg compared the 08/09 robot, giving an improved power to weight ratio.
- The overall weight reduction, after the addition of the arm, was 3kg.
- The autonomous robot has been designed and completed successfully.
- The autonomous robot achieved mapping as well as navigation capabilities.
- The software for the tele-operated robot has been improved, with the addition of 3D arm control and interfacing with the new sensors.
- The tele-operated robot and arm run on Maxon motors, giving reliable and efficient operation.
- A new battery compartment, designed for ease of use and speed, has successfully been implemented.
- A new arm with five Degrees of Freedom has been developed and tested successfully.
- A new head with extended sensory feedback has been developed and tested successfully.
- The cooling system for the robot has been improved with the implementation of a new electronics stack and one large fan.
- New Harwin connectors have been incorporated, providing reliable and quick connections.
- Substantial funding has been raised for the project with the following sponsors: Warwick University School of Engineering, WMG, IMRC, ITCM, Harwin Interconnect and Maxon Motors.

- Carbon fibre panels have been hand crafted and can be utilised in future projects.
- For publicity, WMR newsletters, an appearance on BBC South Today and various news articles have been achieved.
- Continued publicity with Newspaper articles, BBC news coverage, radio stations, quarterly newsletters to sponsors, presentations and website updates.
- Increased profile and exposure of WMR, Warwick University, WMG and other sponsors through winning the competition.



Figure 6 - 1st place RoboCup Rescue European Championship