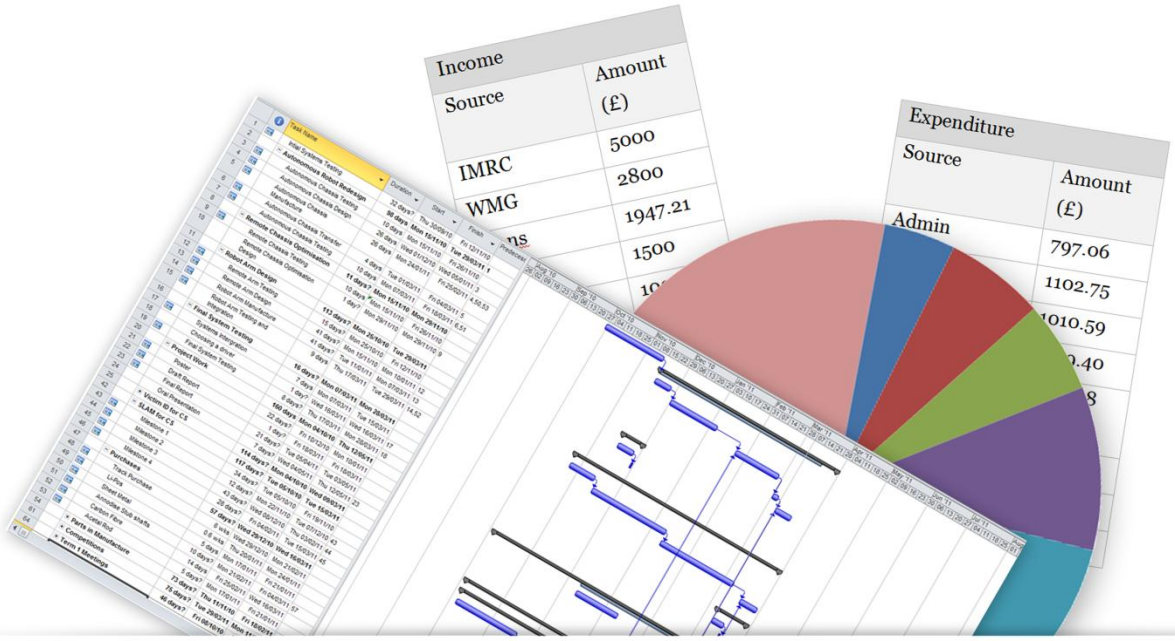
Warwick Mobile Robotics



Business, Publicity, Finance & Management Report

WMR Search & Rescue 2010/11

3

Sponsored by

WARWICK IMRC Innovative Manufacturing Research Centre

THALES

MOUSER ELECTRONICS

WMG Innovative Solutions

xsens

HARWiN

School of Engineering
The University of Warwick

The Vice Chancellor
The University of Warwick

Contents

1 Introduction

As Warwick Mobile Robotics (WMR) moves into its 4th year, the team has started to consider the future of the group and the possibility of outgrowing the competition. This has resulted in the 2010/11 team considering a new business approach not previously considered in full, including the prospect of commercialisation.

The following Business, Publicity, Finance and Management report discusses a business feasibility study through analysis of commercialisation of the Urban Search and Rescue (USAR) robots and a strategy for this. Tying in with this is marketing of the product aiding in the publicity throughout the 2010/11 academic year.

This year's team has pushed a sponsorship drive in order to build on an ever growing network on corporate contacts as well as raising vital funds to develop the WMR robots. This is outlined in the financial section.

The success of the project has relied on effective project management, including project planning techniques and target setting.

2 Project Management

When taking on a project of this magnitude, it is important to ensure that it is planned in detail to ensure an effective team with thorough planning of time, resources and good communication. The Microsoft Project planning tool was used to facilitate this. Microsoft Planning was used to create a detailed schedule for the project to help keep all tasks on track. Other tools and techniques for used for planning as well as team organisation and structure are detailed in this section.

2.1 Organisational Structure and Teams

An organisational structure was created to clarify the roles and additional responsibilities of individual members. This structure was not used rigidly and a horizontal hierarchy was sometimes implemented.

The WMR Urban Search & Rescue team is divided into further two teams; the mechanical team who were responsible for the design and manufacture of the robots, and systems team who responsible for the programming and electronic systems. The teams coordinate through a formal weekly meeting with project supervisors and more regular informal meetings. Tasks are assigned to teams then distributed amongst individual team members. As the Computer Science team were again working on the autonomous robot to this project, they have also been added to the group organisation.

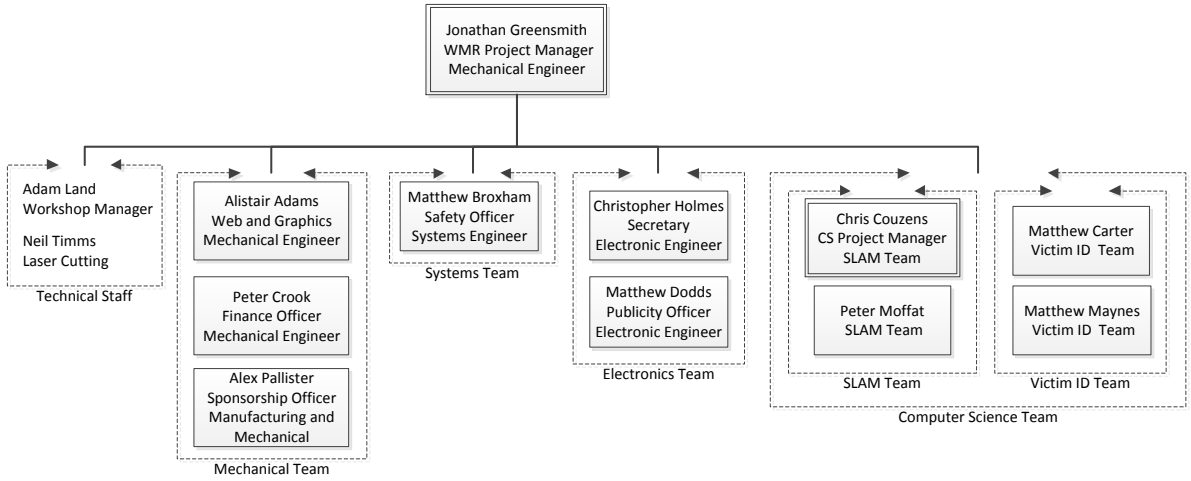


Figure 1: Organisational Structure of team and roles

Each member of the WMR team was assigned work according to their individual speciality, competencies and preferences. Team members were responsible for all work assigned to them for each role they fulfil.

2.2 Meetings

To effectively monitor the progress of the project group meetings were held throughout the duration of this project alongside meetings held with the project directors.

The weekly group meetings were an informal group discussion with progress being monitored more closely on a regular basis. This also gave the team a forum to pose ideas and designs to the rest of the team.

The formal meetings with the project directors took the form of an assessment of the group's progress, followed by a discussion of areas of special interest were brought to the attention and advice was sought for from the supervisors. The group then discussed actions that needed to be taken and aims for the next meeting.

2.2.1 Computer Science Team Involvement

This year, the WMR team have formed a closer link with the Computer Science Team as one of last year's issues was lack of communication between the teams. So regular meetings were held with the Computer Science team and they were encouraged to work alongside the engineering team, creating a more informal structure with the CS team.

Along with this, CS team were required to submit targets and milestones and progress reports. They also were asked to submit purchase request forms as they had no sponsorship to buy equipment needed.

2.3 Other Communication Methods

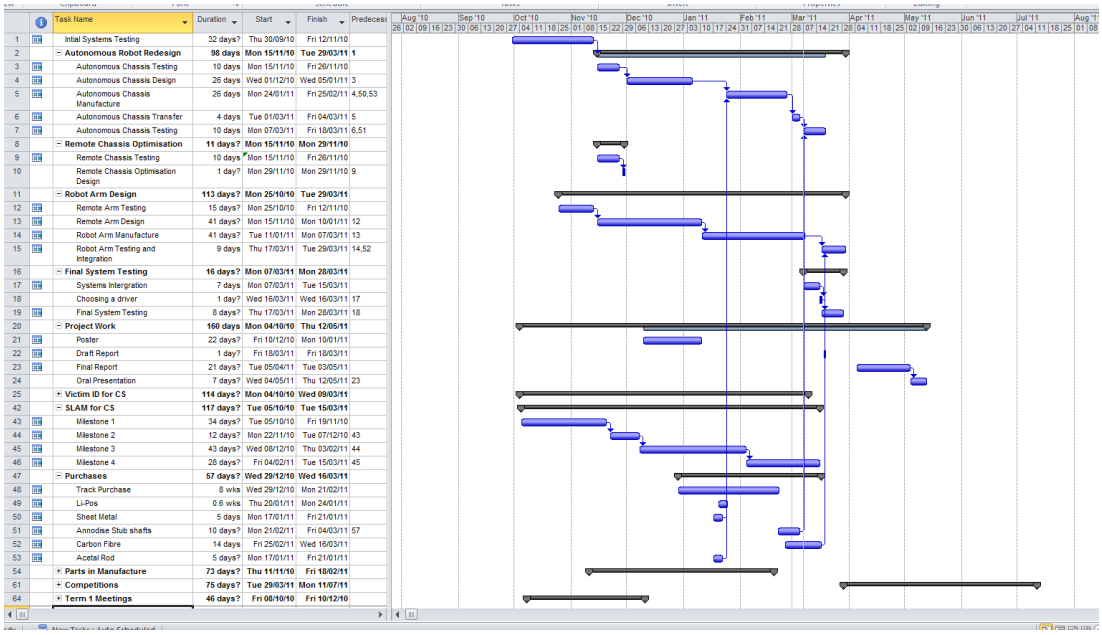
With a group of this size, good communication was essential. The main way that the group communicated with one another was by using e-mails. This was an easy and reliable way to communicate. However, the group also used other mediums, such as the social networking site, Facebook. This gave the group an easy and informal way of sharing ideas and becoming closer as a group. The group also set up a Wiki Google site, which meant that each member's

calendar could be added to a central calendar, showing when times were free for meetings. This form of communication was echoed with the Computer Science team.

2.4 Project Planning

Similar to other projects, Microsoft Project planning tool was created to detail the schedule for the project, taking into account the purchases ordered, as well as parts being manufactured.

With the project directors monitoring progress throughout the year, it is important to assess and manage the progress of the team week to week. To ensure delivery of targets, weekly meetings with team are held throughout the project, with less formal meetings held more regularly. Tasks are assigned amongst team members who then send job requests to the technical staff.



	Task Name	Duration	Start	Finish	Predecess
1	Initial Systems Testing	32 days?	Thu 30/09/10	Fri 12/11/10	
2	**Autonomous Robot Redesign**	**98 days**	**Mon 15/11/10**	**Tue 29/03/11**	1
3	Autonomous Chassis Testing	10 days	Mon 15/11/10	Fri 26/11/10	
4	Autonomous Chassis Design	26 days	Wed 01/12/10	Wed 05/01/11	3
5	Autonomous Chassis Manufacture	26 days	Mon 24/01/11	Fri 25/02/11	4,50,53
6	Autonomous Chassis Transfer	4 days	Tue 01/03/11	Fri 04/03/11	5
7	Autonomous Chassis Testing	10 days	Mon 07/03/11	Fri 18/03/11	6,51
8	**Remote Chassis Optimisation**	**11 days?**	**Mon 15/11/10**	**Mon 29/11/10**	
9	Remote Chassis Testing	10 days	Mon 15/11/10	Fri 26/11/10	
10	Remote Chassis Optimisation Design	1 day?	Mon 29/11/10	Mon 29/11/10	9
11	**Robot Arm Design**	**113 days?**	**Mon 25/10/10**	**Tue 29/03/11**	
12	Remote Arm Testing	15 days?	Mon 25/10/10	Fri 12/11/10	
13	Remote Arm Design	41 days?	Mon 15/11/10	Mon 10/01/11	12
14	Robot Arm Manufacture	41 days?	Tue 11/01/11	Mon 07/03/11	13
15	Robot Arm Testing and Integration	9 days	Thu 17/03/11	Tue 29/03/11	14,52
16	**Final System Testing**	**16 days?**	**Mon 07/03/11**	**Mon 28/03/11**	
17	Systems Intergration	7 days	Mon 07/03/11	Tue 15/03/11	
18	Choosing a driver	1 day?	Wed 16/03/11	Wed 16/03/11	17
19	Final System Testing	8 days?	Thu 17/03/11	Mon 28/03/11	18
20	**Project Work**	**160 days**	**Mon 04/10/10**	**Thu 12/05/11**	
21	Poster	22 days?	Fri 10/12/10	Mon 10/01/11	
22	Draft Report	1 day?	Fri 18/03/11	Fri 18/03/11	
23	Final Report	21 days?	Tue 05/04/11	Tue 03/05/11	
24	Oral Presentation	7 days?	Wed 04/05/11	Thu 12/05/11	23
25	**Victim ID for CS**	**114 days?**	**Mon 04/10/10**	**Wed 09/03/11**	
42	**SLAM for CS**	**117 days?**	**Tue 05/10/10**	**Tue 15/03/11**	
43	Milestone 1	34 days?	Tue 05/10/10	Fri 19/11/10	
44	Milestone 2	12 days?	Mon 22/11/10	Tue 07/12/10	43
45	Milestone 3	43 days?	Wed 08/12/10	Thu 03/02/11	44
46	Milestone 4	28 days?	Fri 04/02/11	Tue 15/03/11	45
47	**Purchases**	**57 days?**	**Wed 29/12/10**	**Wed 16/03/11**	
48	Track Purchase	8 wks	Wed 29/12/10	Mon 21/02/11	
49	Li-Pos	0.6 wks	Thu 20/01/11	Mon 24/01/11	
50	Sheet Metal	5 days	Mon 17/01/11	Fri 21/01/11	
51	Annodise Stub shafts	10 days?	Mon 21/02/11	Fri 04/03/11	57
52	Carbon Fibre	14 days	Fri 25/02/11	Wed 16/03/11	
53	Acetal Rod	5 days?	Mon 17/01/11	Fri 21/01/11	
54	**Parts in Manufacture**	**73 days?**	**Thu 11/11/10**	**Fri 18/02/11**	
61	**Competitions**	**75 days?**	**Tue 29/03/11**	**Mon 11/07/11**	
64	**Term 1 Meetings**	**46 days?**	**Fri 08/10/10**	**Fri 10/12/10**	

Figure 2: Screenshot of MS Project plan

The milestones that the Computer Science team set were also included in the Gantt Chart, seen in Appendix 1 so the WMR team could monitor their progress.

2.4.1 Resources

There are many resources that are available in a project of this size. The resources included the project directors and other external consultants.

2.4.2 Project Directors

The WMR Urban Search & Rescue team has its progress monitored by the project directors, Dr Peter Jones and Dr Emma Rushforth. The directors monitor progress, moderate peer assessments and provide on-going advice and guidance using their relevant expertise. The two project directors also control the project accounts and therefore must approve all purchases on their cost codes.

2.4.3 External Consultants

A list of external project consultants can be seen below, along with their specific areas of knowledge:

Consultant	Area of knowledge
Adam Land	Manufacturing processes and design
Stefan Winkvist	Electronic design and project knowledge
Redland Sanders	Mechanical design and project knowledge
Neil Timms	Laser Cutting

Table 1: External Consultants

2.4.4 Timescale

The timescale of this project was actually 6 months as the RoboCup Rescue German Open was earlier this year than other years. This meant that within a few short months, the group had to accustom their selves to the task in hand and implement all changes.

2.4.5 Milestones

Most of the targets that were set for the team were met. However, with delays, these milestones needed to be updated and modified on a regular basis.

2.5 Execution

After the planning stage of the project, the plan is executed using several different methods.

2.5.1 Planning

Using the planning that is in place and maintaining progress and then taking the necessary control actions to maintain progress. The Gantt chart was referred to regularly during the project.

2.5.2 Reports

Formally, the WMR team were not required to submit progress reports during the project as progress was monitored at either weekly meetings or by constant communication with the rest of the team.

The Computer Science Team was required to submit reports. These reports included justification for purchases that were made for them by the WMR team. Progress reports were also required. This meant that the engineering team could keep track of the progress that was made and monitor the possible risks. Purchase request forms were required as the Computer Science Team had not generated any of their own income yet they still needed equipment and funding for travel to the RoboCup German Open.

2.5.3 Standard Agendas

There was a standard agenda of the directors meeting. These agendas had to have clear objectives with all the key personnel of the group invited to the meeting. With each meeting, there was pre-notification of the time and location of the meeting, with the agenda published ahead of time.

The progress on the actions agreed at last meeting were then discussed; identify important items to add to agenda. The minutes of the meeting were taken by the secretary and then published on the group website under the members section. The minutes recorded with attendants, progress on actions previously agreed, conclusion of discussions and new actions agreed.

2.5.4 Control Actions

To keep the project running on time control actions were introduced. A risk mitigation strategy was implemented to manage the risks and make the project run smoothly.

One particular strategy used a 'traffic light' risk mitigation. When a task was on schedule, then it was marked green. Amber if it was running behind schedule and red if it was seriously behind schedule.

Green

- Task is on or ahead of schedule
- Little or no action to be taken

Amber

- Task is running or is at the risk of running behind schedule
- Remedial action to be taken

Red

- Task is behind or seriously behind schedule
- Emergency action to be taken

2.5.5 Recovery Plans

Within the risk mitigation strategy, there were recovery plans that would help the tasks get on track. At a low level, the subject was discussed internally with suggestion of solution and possible re-allocation of resources to meet deadlines. At a higher level of risk, the recovery plans became more severe, with emergency meetings discussing the urgency of the matter as well as scrapping of the impossible task to save project time.

When a risk became known to a member of the group, a risk report was generated. These were then addressed in group meetings.

2.6 Completion

On completion of the project, there are several sections that need to be studied in detail to give subsequent years a good idea of the possible threats to the project's success.

2.6.1 Lessons

There were several project management lessons that have been learnt over the course of the project. These include the informality of meetings with lack of proper documentation for the project directors to assess at the end of each week. These issues were quickly addressed and meetings became more formal.

As well as this, it is a good idea to track the progress of the group with each member submitting brief progress reports, using the milestones that have been set earlier in the project.

2.6.2 Handover

The final project report shall act as a summary of the key project successes and failures, along with identifying lessons that have been learnt from this project. A separate handover document, entitled Knowledge Transfer Report will be given to next year's group, who will read these reports. This Knowledge Transfer Report will hopefully cut down on the initial time taken for subsequent years to understand the complexity of the project.

3 Project 2010/11 Finances

Financial management is a crucial part of the search and rescue project. Due to the expense of producing a functioning robot, financial sources outside of the university must be obtained and managed. It is necessary to produce a budget in order to ensure that financial resources are distributed to appropriate areas of the project. Due to these factors it is necessary for WMR to keep rigorous documentation of all income and expenditure in order to gauge WMR's performance against the budget and to avoid over spending on any single area or overall.

3.1 Sponsorship and Publicity

3.1.1 Sponsorship

It was clear from the start of this year's project that without any legacy balance passed on from previous years, the WMR team would be required to raise a substantial amount of capital. Previous years have managed to secure equipment and tools from various engineering companies but with a fully working robot, the main focus was on raising cash funding. To do this, the team has driven sponsorship harder than previous years and the result has been a heavily sponsored and publicised team with a widened network of industry contacts for future years.

This year a total budget of £21,297 was raised from various sponsors as shown in Figure 3. The WMR sponsorship package (Appendix 5) outlines two levels of sponsorship; Gold – for sponsors funding £3,000 or more in cash or equivalent equipment value, and Silver – for sponsors funding less than £3,000.

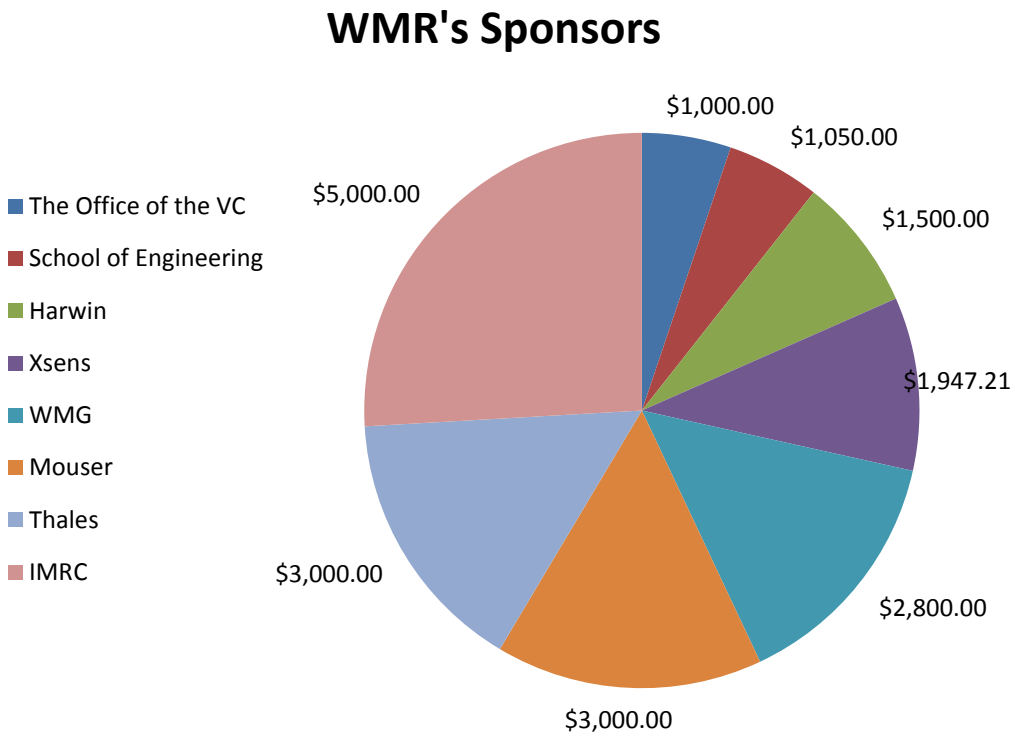


Figure 3: Pie Chart of WMR's sponsors for the 2010/11 year

Out of previous year's sponsors, this year's team has secured continued funding from:

- WMG
- IMRC
- Harwin
- School of Engineering

The team has also secured funding from new sponsors this year:

- Mouser – A large electronic components distributor
- Xsens – A company focusing on 3D motion tracking
- Thales – A large defence contractor
- The Office of the Vice Chancellor of the University of Warwick

Attaining new sponsors was a difficult task this year and involved numerous emails and phone calls to companies through contacts within the University of Warwick and through WMR's own industry contacts. Appeals for sponsors were made through various team members' local newspapers and radio stations with the aid of the University of Warwick's PR department as well as an article drafted up by the team and included in the January Warwick Alumni newsletter. All publicity detailed in section 3.1.2 has mentioned the need for further funding and provided contact details, with little to no response from potential sponsors.

Mouser approached WMR late in 2010 through their ties with Harwin, a long term partner of WMR, with the possibility of Gold sponsorship in order to expand their exposure to the UK market through student projects. Xsens, a Dutch company, requested Gold sponsorship in exchange for a 50% discount on all purchases of their highly sought after and costly 3D motion trackers used on both the teleoperated and autonomous platforms. Thales were contacted through links within the University and positive email contacts were followed up with a meeting with some Thales executives who were happy to sponsor the team with Gold sponsorship. A meeting was requested with Professor Nigel Thrift, the Vice Chancellor of the University, who was reluctant to provide a large cash sum to the project due to the possible perception of favouring the WMR project to others within the University; however he was able to secure the team a cash amount.

Out of all the sponsors this year only Xsens were not willing to provide a cash sponsorship to the team. Receipt of sponsorship in cash form, as opposed to equipment and tooling, helped the WMR by drastically improving the flexibility of purchases and allowed for significant room for necessary emergency purchases required late in the project. The total cash amount raised by the 2010/11 team equated to £17,350 (excluding VAT), a cash sum never before reached by the WMR team.

Relationships with past and present stakeholders are important to the WMR team and all stakeholders are kept informed of team progress through a monthly newsletter. All sponsors are welcome to visit the WMR lab, and the team have entertained visitors from industry (including current and potential sponsors), potential University undergraduate applicants, the Dean of Engineering within the University, and other visitors to the WMG.

3.1.2 Publicity and Promotions

In order to justify an increase in the cost of Gold sponsorship this year from £2,500 to £3,000, the team has been heavily involved in all forms of publicity to increase the team's exposure to the UK and Europe. This year's team has featured in local newspapers, UK regional television, international news programs, local radio, German magazines, and online articles and videos in order to truly build upon a WMR brand name.

Figure 4 WMR after filming with Ortis Deley from the Gadget Show

Warwick Mobile Robotics has appeared in the public view more this year than other years:

- Television:
  - BBC Midlands Today
  - BBC Click with an estimated international viewership of 75 million
  - The Gadget Show
- Online:
  - IET's E&T Magazine website (E&T 2011)
  - WMR Twitter @WMRobotics (WMRobotics 2010)
  - Official Xbox Magazine online (OXM 2011)
  - Swindon Link (Ogle 2011)
  - AZO Robotics (AZO Robotics 2011)
  - BBC News Technology (Lee 2011)
  - Tweakers (Moor 2011)
- Radio:
  - BBC Radio Cambridgeshire
  - BBC World Service: Digital World
- Newspaper:
  - Coventry Observer (Carpenter 2011)
  - Coventry Telegraph
  - Warwick Boar (Pearce 2011)
  - Ely Standard (Ely Standard 2011)
  - Staines Informer
  - Coleraine Times
  - Milton Keynes Citizen (Milton Keynes Citizen 2011)
  - Yorkshire Press

- Magazines:
  - EE Times European magazine with an estimated readership of 70,000 (Bourne 2010)
  - E&T Magazine with an estimated readership of 150,000
  - Swindon Link
- Exhibition Centre
  - WMR Stand at The Gadget Show Live 2011 13th – 17th April in the NEC, Birmingham

3.1.3 Events

The main annual event that WMR attends is the RoboCup European Open, held at the Messe Hall in Magdeburg. In terms of publicity, the competition provided the team with exposure to 26 Junior RoboCup teams and 56 research teams from around Europe. The event was open to the public and the team entertained four days of public and German-national media attention.

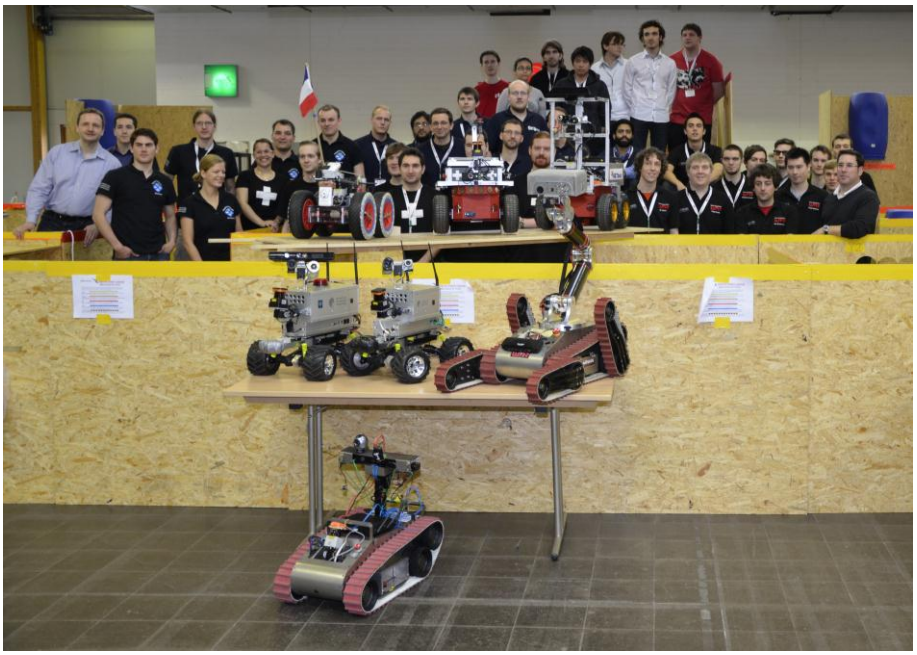


Figure 5 WMR at the RoboCup Rescue Challenge, Magdeburg

The largest public event that WMR has attended to date is the Gadget Show Live exhibition at the NEC in Birmingham. This five day event was larger than the 2010 show which had over 66,000 visitors and 396 press visitors and provided the team with an excellent method of face-to-face contact with the British public.

Figure 6 WMR Demonstrating at the Gadget Show Live Arena

This year, WMR continued to maintain the relationship with Remotec by visiting their facility and organising a date for next year's team to visit Remotec early in the year. The team has also held many meeting in the WMR office/lab with several different companies, including Thales, Harwin and IBM. This has been in an effort to raise awareness of the WMR brand as well as raise sponsorship for the team and help in both WMG and WMR's industrial relations.

3.2 Management of Finances

Due to the nature of WMR's work financial accounting is pivotal to the success of the project. WMR must secure multiple sources of finance, which are raised through sponsorship, and budget for the areas in which it is to be spent.

3.2.1 Budget 2010-2011

The 2010-2011 budget is based on what costs were expected to be incurred at the start of the year, and on the previous year's budget. It also includes expected income

Income	
Source	Amount (£)
School of Engineering	1200
WMG	4550
IMRC	5000
Other	4250
Total	**15000**

Expenditure	
Source	Amount (£)
Admin	0
Arm	2000
Chassis	400
Electronics	1500
Office Equipment	3000
Robocup	1200
Sensors	3000
Travel	3900
Total	**15000**

3.2.2 Actual accounts 2010-2011

Costs incurred were significantly higher than budgeted in most areas. However income was also greater than expected. This lead to a surplus of £1157.21 at the end of the project year.

Income	
Source	Amount (£)
IMRC	5000
WMG	2800
Xsens	1947.21
Harwin	1500
Vice Chancellor	1000
Mouser	3000
Thales	3000
School of Eng	1050
Total	**19297.21**

Expenditure	
Source	Amount (£)
Admin	797.06
Arm	1102.75
Chassis	1010.59
Electronics	1809.40
Office Equipment	3527.78
RoboCup	1180.00
Sensors	4059.44
Travel	4652.98
Total	**18140.00**

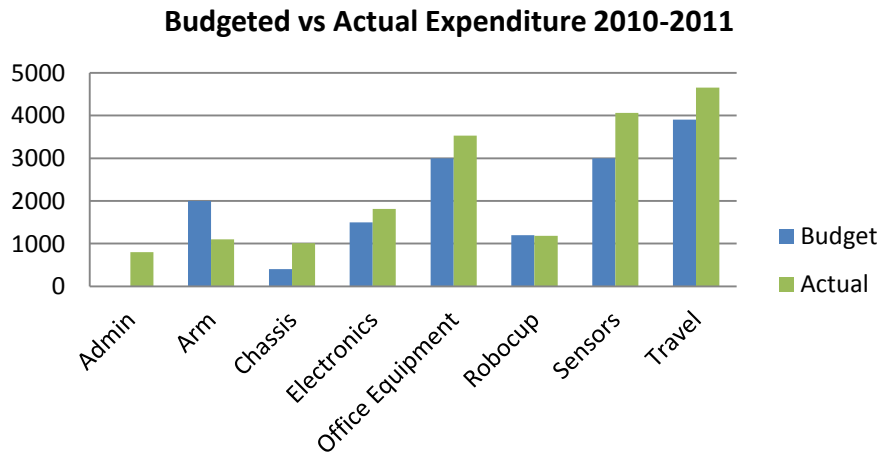


Figure 7: Budgeted vs Actual expenditure 2010-2011

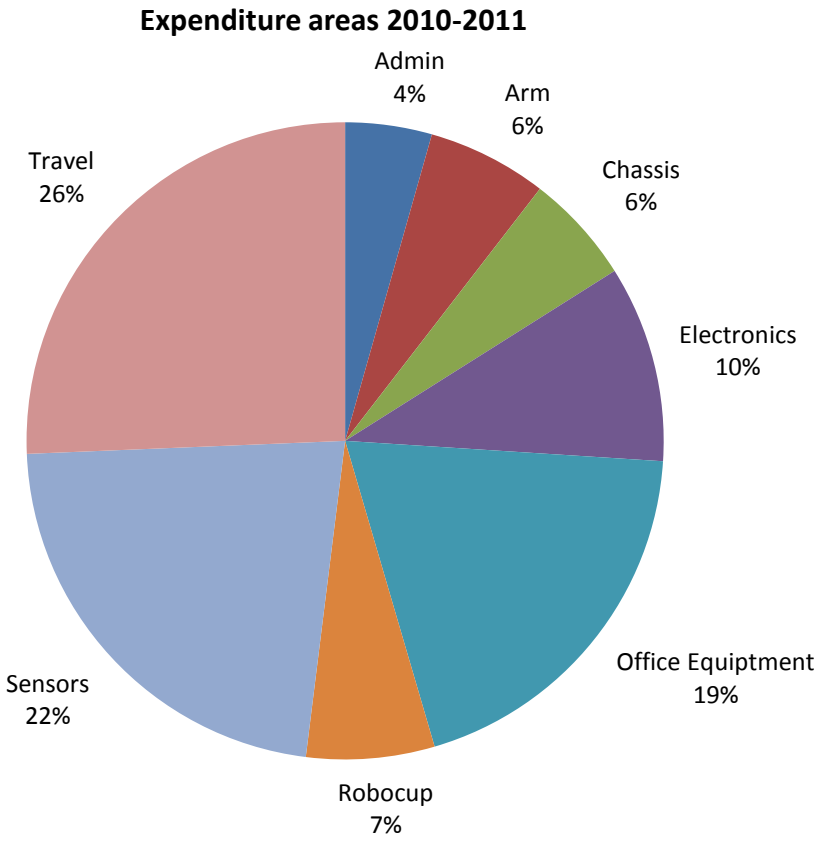


Figure 8: Expenditure areas 2010-2011

3.2.3 Costing

Due to WMR's position as a student group the team gains access to manufacturing equipment, technicians and academic advice, which would ordinarily incur costs. It is useful to consider these costs as they represent costs that would be incurred if WMR was a commercial entity. The hourly rate costs are estimated using the handbook for undergraduate individual projects ES327 (University of Warwick 2010). Production costs are based on estimates on what it would cost to use an external contractor. The number of units is estimated based on previous years estimates and adjusted using the team's best judgement.

Expense	Cost Per Unit (£/hr)	Number of Units (hrs)	Total Cost (£)
Equipment, Parts and Consumables			
Rescue robot, Parts and Consumables			7982
Other Equipment			3528
Other costs			6629
Man-hours			
Time worked by Alistair Adams	15	400	6000
Time worked by Matthew Broxham	15	400	6000
Time worked by Peter Crook	15	400	6000
Time worked by Matthew Dodds	15	400	6000
Time worked by Jon Greensmith	15	400	6000
Time worked by Christopher Holmes	15	400	6000
Time worked by Alexander Pallister	15	400	6000
Consultation with Dr. Peter Jones	50	25	1250
Consultation with Dr. Ken Young	50	10	500
Consultation with Dr. Emma Rushforth	50	25	1250
Consultation with Mr. Adam Land	20	100	2000
Consultation with Stefan Winkvist	20	100	2000
Consultation with Redland Sanders	20	25	500
Production			
Machining undertaken by Mr. Adam Land	50	180	9000
Laser Cutting by Mr. Neil Timms	40	40	1600
Machining by Carl Lobjoit	50	50	2500
Total Project Cost			**80,739**

Table 2: Estimated Project Costs

There are other costs that have not been accounted for such as inherited office space, tools and other equipment, these are assumed to have been accounted for in previous years reports. It is assumed that these costs were accounted for in previous year, the only products that are subject to significant depreciation is IT equipment that was replaced this year and therefore depreciation has not been accounted for. Overheads such as the costs incurred by administration staff at the university and WMG have also not been accounted for as these are not direct costs and are difficult to estimate.

3.2.4 Closing Statements

WMR successfully managed finances in the 2010-2011 year. Financial resources were utilised effectively with appropriate amounts being invested in equipment and products whilst retaining some funding which will benefit the 2011-2012 year. For these reasons the 2010-2011 WMR team have left the group in a stronger position than it was at the end of the 2009-2010 project year.

4 Search & Rescue Robots as a Product

4.1 Viability of Commercialisation

This year's WMR team has been the first to consider the commercialisation of the USAR range. The team had a meeting with David Calvert from Warwick Ventures Ltd to discuss this in detail. Warwick Ventures Ltd is a subsidiary of the University of Warwick and deal with the commercialisation of various research products generated by the University, so were the ideal contacts for a decision such as this. According to Calvert, there are two main options in bringing a product to market (Calvert 2011):

1. License the product in order to pitch it to companies for manufacture
2. Create a spin out company

In order to make a decision on how to bring the product to market, the team had to consider who the target customer is; what the product's differentiator is; what intellectual property rights the team owns; and the current market. This can then lead on to a commercialisation strategy.

4.1.1 Customers

The USAR robots are a very niche product with no current alternatives available off-the-shelf. Currently, the nearest alternative used in disaster areas are over-capable bomb disposal robots such as the Remotec Wheelbarrow (Northrop Grumman 2011) used in the New Zealand Mining Disasters in November 2010 (BBC News 2010), these are expensive solutions and have to be specially loaned out from defence companies.

A search and rescue robot could be targeted towards 3 possible market segments: non-governmental organisations, government groups, and companies involved in potentially hazardous areas such as mining companies.

4.1.1.1 Urban Search and Rescue Operations

International search and rescue operations are advised by the International Search and Rescue Advisory Group (INSARAG) a group who operate within the United Nations group. INSARAG aims to establish standards for international USAR teams and methodology for international coordination in earthquake response. Members of INSARAG are both earthquake-prone and responding countries and organisations. (OCHA United Nations Office for the Coordinations of Humanitarian Affairs 2002). INSARAG has 79 members; these members can be subdivided into governmental and non-governmental groups.

4.1.1.1.1 Non-governmental organisations (NGOs)

There are 23 Non-governmental search and rescue groups within INSARAG making up around 30% of urban search and rescue teams.

RAPID UK is part of the INSARAG group and is an example of a non-governmental organisation who works specifically within urban search and rescue (RAPID UK 2011). This organisation is an ideal customer for WMR given the nature of their work. Currently RAPID does not use robotic aids but does use some technological aids, including highly sensitive microphones used to detect both sound and vibrations.

Non-governmental search and rescue groups tend to be funded by donations it can be assumed that they have a limited budget. It is therefore likely that these groups will be especially sensitive to the cost benefits of WMR products. These groups are unlikely to invest in unproven technology due to limited resources. It is this reports recommendation that WMR should not target the NGOs market segment for these reasons.

4.1.1.1.2 Government Groups

The remaining 56 (70%) of groups within INSARAG are government organisations. The interest from these groups will vary significantly. The UK is unlikely to have a requirement for USAR robots due to the lack of applicable circumstances within the UK. Figure 9 shows areas with higher seismic activity, these areas are more likely to be interested in purchasing or using WMR USAR robots. These countries are spread worldwide and to generalise their characteristics is difficult, however it can be assumed that government groups have access to

greater resources than NGOs. This makes them more likely to purchase new technology, although this may be less true of late due to the global economic downturn.

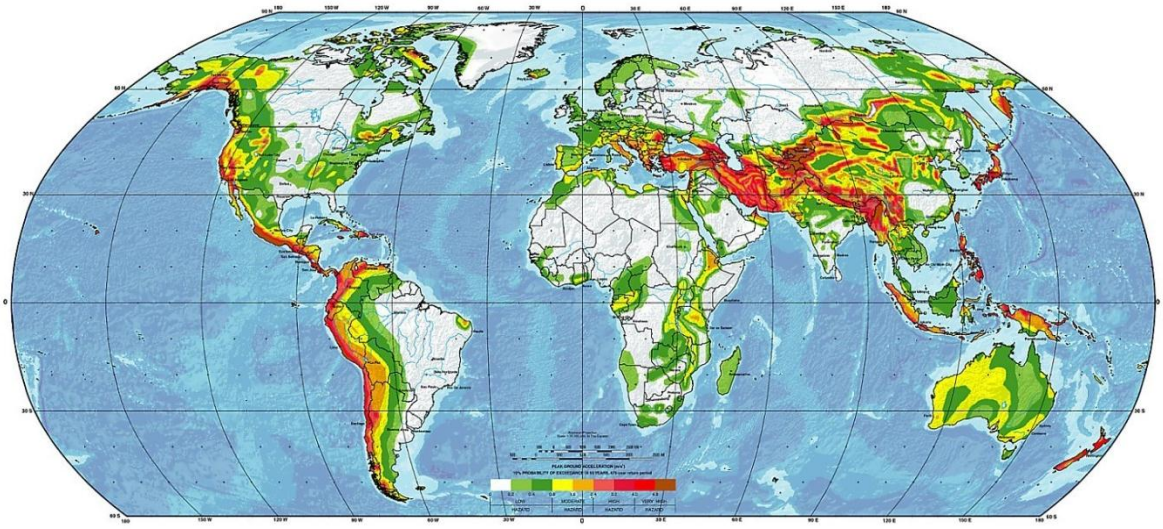


Figure 9: Global Seismic Hazard Map (D. Giardini 1999)

4.1.1.1.3 Mining Companies

It is likely to be a consideration of many mining companies following the mining disasters of the past 6 months in Chile and New Zealand to have safety mechanisms in place in the event of a mine collapse. Furthermore, financial difficulties encountered by the San Esteban Mining Company (Central de Noticias Tucumán 2010) show the necessity for a large amount of funding and resources to be put into safety of mining to ensure long term security. The team anticipates a growing demand for mitigation and contingency plans for mining disasters. Although these may mainly be focused on preventing mining collapses, it will also lead to increased spending in equipment used in case of disasters.

4.1.2 Product Differentiator

The USAR product's differentiator, or Unique Selling Proposition (USP), is that it is a complete solution designed for search and rescue operation, able to identify victims in a host of different ways, and has high manoeuvrability. Designing a product for public use or marketing will require research into what specifications would be required by potential customers. Currently, the robots are designed to restrictions and targets outlined through the RoboCup Rescue competition. These outlines cover current regulations as the competition itself is used to aid in defining government standards through the National Institute of Standards and Technology (NIST). However, it is unknown to the WMR team what specifications may be required by end users of such as system if bought privately.

The competition requirements have led to the WMR team developing a fully integrated system in a modular fashion. This has meant that further development is easily achieved and can be quickly transferred. The autonomous platform has also been standardised to aid in transfer of technology into the teleoperated platform.

4.1.3 Intellectual Property

Intellectual Property (IP) rights protect the author against infringement providing a competitive advantage for the holder. As it is a condition of the RoboCup Rescue competition the WMR has published all technical reports, therefore are not able to patent any intellectual property since they have entered the public domain. This ultimately means that any future competitors would be able to take any areas of best practice and the WMR team's product differentiators and incorporate them into their own products.

4.1.4 Commercialisation Strategy

When considering any strategy of bringing a product to market, a business must consider the marketing segmentation, market entry, timing, and marketing mix.

4.1.4.1 Market Segmentation

The choice of which market segment to enter into can be decided through the size of the potential market, the level of competition, the potential for future growth, and any perceived need for our product. There is currently no commercial market for this specific product. Therefore, it is possible the USAR product will enter into a new market. This would ensure monopolistic sales for a short amount of time until new products enter the market. The level of competition will start at none, but the capabilities of potential competitors are far above the capabilities of the WMR team and would have the financial backing of defence companies.

Being market pioneers has numerous advantages and disadvantages. (Tuersley 2010) Advantages include:

- Creating a *Temporary Monopoly* giving *'Super-Normal'* profits.
- Higher brand loyalty
- Higher *'Switching Costs'* for customers
- Broader product ranges that pre-empt competition
- Reduced costs through the *Experience Curve* and *Economies of Scale*

The disadvantages are associated with uncertainty:

- Next bench syndrome
- Uncertainty

4.1.4.2 Market Entry

Although monopolistic sales at the start of launch would be greatly beneficial, the lack of intellectual property rights greatly lowers the barriers to entry into this market. Patenting our design and sensor array system would protect us in a market and create a barrier to entry, however this is not possible as our design details have already been released into the public domain. It is possible the high manufacturing capabilities required will be a barrier to entry; however defence companies should have no problem competing on manufacturing resources and the relatively low capital requirements of the materials and equipment.

Future growth of the market is low and erratic due to the target customer being directly related to natural disasters or safety failures, both of which are unpredictable. The group perceives a very high need for our product in the current market place as products currently used are not made for this application. The USAR range is specifically manufactured for this market and search and rescue purposes.

4.1.4.3 Timing of Entry

The timing of commercialisation has never been more appropriate than at the time of writing. Following two major mining disasters in the last 6 months in the Chilean mining collapse in August 2010 and the Pike River Mine disaster in New Zealand in November 2010 the world has a high awareness of the safety issues involved in mining and the need for equipment to aid relief efforts. Additionally natural disasters such as the Christchurch earthquakes in September 2010 and February 2011 and the devastating earthquake in Japan in March 2011 have further shown the need for remotely operated equipment to locate victims in hazardous areas. As a result of this the WMR team has received wide spread international publicity as described in full in section 3.1.2, this has been further fuelled by the University press release of the WMR team utilising the Microsoft Kinect, coinciding with Microsoft's public release of a software development kit of their product (Cellan-Jones 2011).

Figure 10: Photo of the destruction of the February 2011 Christchurch earthquake (BBC News 2011)

4.1.4.4 Marketing Mix

The Marketing mix can be considered to consist of 4 P's: Product, Place, Price and Promotion (McCarthy 1993). These 4 P's are the basic components which make up the foundations of any marketing plan. It is therefore prudent for WMR to analyse these areas with respect to the USAR range of products.

4.1.4.4.1 Product

The product must be capable of meeting or exceeding capabilities for its application, in this case search and rescue. The required and actual capabilities are outlined in the General and Technical Reports. The benefits of USAR are largely tangible i.e. the benefit of the functionality the robot provides for the customer. However there could be considered intangible benefits as USAR products could raise the profile of the University of Warwick. There is however little intangible benefit for the customer.

4.1.4.4.2 Price

Since there are no products currently on the market which would directly compete with WMR it is difficult to gauge an appropriate market price. However a price could be extrapolated from the costs incurred by WMR to produce the current and previous generation of USAR. The cost of this years and previous years development is included in section 0. This cost however represents the cost of producing only the prototype, the more

USARs produced the lower the cost will be according to learning curve and economies of scale. Due to the market which USAR will operate the price and quality is likely to be high.

4.1.4.4.3 Promotion

The USARs are a highly specialised product with a very narrow market. Due to this narrow market it is likely that WMR would have to deal with a small number of customers, however these customers are likely to be very large groups such as government bodies. This small market would allow WMR to form strong relationships with customers that would in turn allow WMR to fully appreciate the customer's needs and expectations. Simulation exercises such as the RoboCup Rescue competition give the product credibility however to generate significant commercial interest it would be necessary to demonstrate USAR abilities in a genuine operational environment.

4.1.4.4.4 Place

Low sales volumes and high unit costs dictate a personal approach to sales. Distribution channels will be direct to the consumer as the product is highly specialised and therefore does not require a centralised location for purchase.

4.1.5 Competition

Whilst a market may exist for teleoperated robots, there are currently no suppliers of search and rescue specific robots although other robots are often modified for search and rescue use, these are known as substitute products. Substitute products for USAR robots are typically bomb disposal robots.

4.1.6 Commercialisation Conclusion

It is the opinion of the WMR team that the project is still very much at a developmental stage and requires further work before it can be fully considered as a fully working and completely reliable product. With the numerous unfortunate natural disasters this year, there is more interest than ever in investing in technologies designed for use in aid work brought about through earthquake and tsunami destruction. The USAR platforms have received worldwide media coverage linking the robots to the aid work involved, thereby reinforcing the social value of this project and increasing international recognition and awareness of the WMR brand.

A varied list of potential customers has been researched, however a major factor throughout is the cost of the product. Many of the customers WMR foresees showing an interest in the USAR robots have low budgets or are charities. It is difficult to predict how much costs will lower with an increase in production volume, but due to the infrequency of natural disasters, it can be assumed that some companies and government groups would be more comfortable leasing out bomb disposal robots created by companies with government defence ties already. This being said, WMR have received speculative enquiries into the cost of such a robot and already have ties with larger robotics companies such as Thales and Remotec.

The product's USP is a major advantage in comparison to commercially available alternatives. The USAR robots are a niche product, designed specifically for search and rescue operations and intensively tested annually at the German RoboCup Rescue Challenge. This serves as proof of the capabilities of the robot and links with the National Institute of Standards and Technology, ensures the robot is in line with current rescue robot standards.

Unfortunately, the team believes commercialisation is not a valid option for the USAR-T and USAR-A due to potential problems in the future with respect to intellectual property rights. WMR are not protected should a competitor wish to produce an identical product as all technical details of the USAR robots are made public, this means WMR cannot patent any of their designs. Although this may not be a problem in the initial stages of market entry, it would expose the team to future problems that cannot justify the high set-up costs and time required.

4.2 Product Maturity Analysis

In order to consider the commercial aspects of WMR it is useful to define the maturity of the product. Ordinarily this is measured against the product lifecycle model (Vernon 1979) (Appendix 3) however as the product in question is not yet commercialised it is more useful to use Technology Readiness Levels (Appendix 4). Technology readiness levels were originally developed by NASA in order to assess the maturity of emerging technologies (Director 2009). The TRLs are currently used by many organisations worldwide including the MOD. The TRLs also give a roadmap to steps which must be taken to achieve full technology deployment.

According to the TRLs the WMR rescue robots are TRL 6, Technology model or prototype demonstration in a relevant environment; The relevant environment being the RoboCup Rescue competition in Magdeberg Germany.

Although the USAR robots have changed significantly over the last 3 years, they have been at TRL-6 for that period (Warwick Mobile Robotics 2009). It would be beneficial to WMR to

take the Search and rescue robots to TRL-7, however this requires the robot to be used in an operational environment.

This is difficult due to numerous factors as the product is currently primarily designed for the RoboCup Rescue competition there would be significant shortcomings in a real world environment, such as USAR-T's reliance on a WiFi network. Another issue is that the real world operational environment is in an area affected by an earthquake. WMR cannot send USAR robots or WMR team members to these areas for several reasons; difficulty and expense of travel, the unpredictability of location, the dangerous environment of an earthquake zone and the WMR teams limited mobility due to other commitments.

4.3 Ansoff's matrix market position

The purpose of Ansoff's matrix is to provide a practical framework for selecting a firm's expansion route in a growing market by reasoning that long-range planning was necessary to drive managerial decision making when the speed of change exceeded the firm's ability to respond. Ansoff argued that strategic planning was essential for firms operating in a complex, turbulent environment. (Proven Models 2005)

To simplify this process Ansoff proposed a matrix (Appendix 2) which considers:

- the *products* - what it sold; and
- the *markets* - to whom they are sold.

(Ansoff 1987)

As this year WMR looks to become more commercially viable it is a useful model to consider. The USAR robots are currently at the prototype phase or TRL-6. However for the purposes of this report it will be considered that they are ready for commercialisation. This is a reasonable approach as the functionality of the product would be largely the same should they be commercialised.

WMR search and rescue currently has two products a teleoperated and an autonomous robot (USAR-T and USAR-A respectively). One of the aims of this year was to bring these products closer to uniformity, with the ultimate aim of producing USAR-AT a platform capable of both autonomous and teleoperated functions. Although it was not possible to achieve a complete merge of the two products this year, significant steps have been taken to make it a reasonable target for next year.

The 2011 USAR robots are based on the development of the robots over the last 4 years. A product which has never been commercialised, the product can therefore still be considered new.

Although WMR has never sold a USAR robot, WMR has carried out research and development activities solely on mobile robotics for the last four years. Therefore mobile robotics is considered a current market for WMR.

According to Ansoffs matrix WMR should use a product development strategy in order to develop from research to commercial operations. This growth strategy is considered medium risk. Ordinarily this product development consists of selling new products to existing customers, this is not quite the case regarding WMR as the group has no customers this is due to the research nature of the group and the lack of emphasis on commercial activity in previous years. Typically uncompetitive or immature products in the portfolio create risk this

must be counterbalanced by a strong customer focus and innovation processes. Innovation is a strong area of WMR, however customer focus is a relatively weak area. It is of vital importance that in the future WMR must become far more customer focused in order to become a commercial group. This would involve moving away from the RoboCup Rescue competition the group currently focuses on (Proven Models 2005).

Should the search and rescue market be considered a new market Ansoff's matrix would suggest a diversification strategy. Diversification is the highest risk strategy. Marketing new products to new markets and requires acquiring experience in both sectors.

	Existing Products	New Products
Existing Market	Market Penetration	Product Development
New Market	Market Development	Diversification

Table 3: Ansoff Matrix (adapted from (Ansoff 1987))

4.4 Porters 3 generic strategies

The generic strategies are useful to characterise strategic positions at the simplest and broadest level (M. E. Porter 1985).

		Competitive Advantage	
		Lower Cost	Differentiation
Competitive Scope	Broad Target	1. Cost Leadership	2.Differentiation
	Narrow Target	3a. Cost Focus	3b. Differentiation Focus

Figure 11: Porters Generic Strategies (M. E. Porter 1985)

Due to the lack of competition within rescue specific robots cost leadership is of no advantage to WMR. It is also unlikely that WMR would be able to compete on cost with substitute products due to the group's small size. Therefore competitive advantage should be achieved through differentiation. The target market is narrow due to USAR robots very

specific application. Therefore according to Porter's generic strategies differentiation focus is the appropriate strategy.

Differentiation focus is when a firm seeks differentiation in its target segment. The target segments must either have buyers with unusual needs or else the production and delivery system that best serves the target segment must differ from that of other industry segments. WMR is unlikely to differ in production and delivery systems as these are beyond the core competencies of the group. Currently WMR differentiates itself by producing search and rescue specific robots the differentiation is highlighted by the comparison of competitors' products, detailed in the General Report . (University of Cambridge Institute for Manufacturing n.d.)

4.4.1 Porter's five forces

Porter's five forces is a study of an industry's characteristics. As an industry's structure determines its relative economic attractiveness, the profit potential of all companies within that particular industry varies. This is a useful exercise as it will outline how profitable a new search and rescue robot specific market is likely to be (M. Porter 1979).

4.4.1.1 Industry competitors

There are no companies currently producing robots specifically for rescue purposes. However substitute products could be considered competitors. Their competitiveness is assessed in the General Report.

4.4.1.2 Buyers

Potential buyers are outlined in section 4.1.1. Customers will likely be government bodies such as the military and rescue services. The number of buyers will be low so should WMR secure a large order contract, this would make up a large proportion of earnings. This would give such a buyer significant bargaining power. The product is designed to be customisable to a certain degree and therefore it is expected that the buyer will specify certain parameters. The product is therefore designed for specification which should minimise the impact of the buyers influence over product design. Due to lack of competition however buyers looking for a rescue specific robot would have little choice and therefore less bargaining power. Due to these two contradicting factors it is unclear on the amount of influence a buyer will have over WMR.

4.4.1.3 Suppliers

Many of the suppliers involved with the search and rescue robots have little bargaining power as the parts they supply are generic and could be purchased from numerous other suppliers. However there are a few items such as the LiDAR and the Xsens IMU which are highly specialised products and would be difficult to replace with such high quality. As WMR buys in such small quantities the suppliers of these components do have a lot of influence. These components should be labelled as strategically important and effort should be made to maintain a good relationship with these companies. Research should be undertaken for alternative suppliers of these products in order to ensure the future stability of WMR.

4.4.1.4 Substitutes

Search and rescue operations have in the past been largely carried out by substitute products. These have primarily been military robots used for bomb disposal which are not ideally suited for rescue operation but are capable of certain functions. Substitute robots are a significant threat as identified in section 4.1.5. Many of these robots outperform USAR robots in a number of areas. These robots are established in operating in difficult environments, they can be considered the benchmark which USAR robots must outperform in certain areas in order to differentiate.

4.4.1.5 Potential entrants

The threat of new entrants is high, WMR holds no patents and can therefore not stop new competitors making very similar products. As WMR is currently a small research group with limited funds and no full time employees, WMR achieves no economies of scale. It would be very easy for a company already developing mobile robots to design a search and rescue specific model.

4.5 PESTEL analysis

A PESTEL analysis shows an understanding of the wider meso- and macro-economic environment in which organisations operate. It is a useful tool for strategy analysis (Proven Models 2005) (Gillespie 2007).

	Factor	Potential impact	Comments
Political	Government policies	High	Government policy on emergency services spending and technology policy is key to sales and product design.
	Wars and Conflicts	Low	Majority of companies WMR are involved with are based in developed countries where the likelihood of conflicts is low.
	Stability of the political environment in which the product is likely to be sold	Medium	The global seismic hazard map (D. Giardini 1999) shows where there is most seismic activity, and therefore most potential market for the USAR robots. These countries are diverse some areas are politically stable some others are not, this could affect sales.
	Government trading agreements such as EU, NAFTA, ASEAN, or others	Medium	WMR could benefit from the EU free trade agreement between member states. WMR customers are unlikely to be based in the UK. However this ease of trade lowers barriers to entry and thus gives an increased risk of competition.
Economical	Product specific Taxation	Low	With any product there is a potential for government legislation to impose a tax to either the consumer or WMR. However the USAR products are at very low risk due to their nature.
	Interest Rates	High	Due to the high cost and low sales volume of USAR products cash flow is likely to be an issue. It is likely that WMR will require significant bank loans and therefore exposure to interest rates.
	Exchange rates	High	Much of the market and suppliers for USAR products is abroad therefore exchange rates will greatly affect WMR.
	Home and foreign economic trends	Low	Economic trends tend to greatly affect consumer products, USAR products are not consumer products so are less effected by economic trends.
Social	Buying patterns	Medium	If rescue services start using USAR products, this is likely to affect other sales, as the products

			become more proven.
	Ethical issues	Low	There are no foreseeable ethical issues with USAR products.
	Attitudes to foreign products and services	Medium	Governments typically have incentives to use domestic companies to produce equipment. It is not known if this would be an issue WMR due to the differential nature of the product.
Technological	Technological advancement by competitors	High	Many competitors a large companies and have a great potential to gain technological advantages over WMR
	Potential to innovate	High	Competitors with experience in robotics are likely to produce innovative products.
	Patents and licensing	Medium	There may be licensing issues with certain off the shelf technologies used in USAR robots.
Environmental	Climate	Low	Robots have very little impact on climate. However the disposal of the LiPo batteries must be managed appropriately. This does have a slight environmental impact.
Legal	Workplace legality	Low	WMR is a student research group which complies with all laws regarding the workplace.
	Legality of USAR products	High	There is a possibility that a USAR robot could cause injury due to malfunction, human error or misjudgement. The legal liability of such an event has not been researched. Another legal issue is passing appropriate trading standards such as British electronic standards.
	Consumer laws	Low	Laws against unfair practices such as misleading descriptions of the product. WMR is currently well within these laws the capabilities of USAR are well documented.
	Competition laws	Low	Ensuring customers are not exploited by firms with monopoly power. Although WMR would be the only group providing rescue specific robots, bomb disposal robots are considered substitute products.

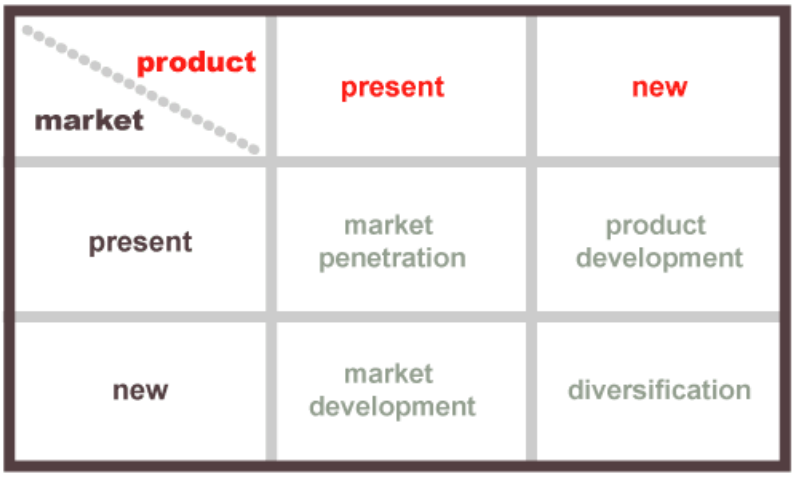
			Companies producing bomb disposal robots are far larger than WMR.
	Employment laws	Low	Laws regarding redundancy, dismissal, working hours and minimum wages. These do not affect WMR
	Health and safety legislation	Low	WMR complies with health and safety law as enforced by WMG.

Table 4: PESTEL Analysis

5 Appendices

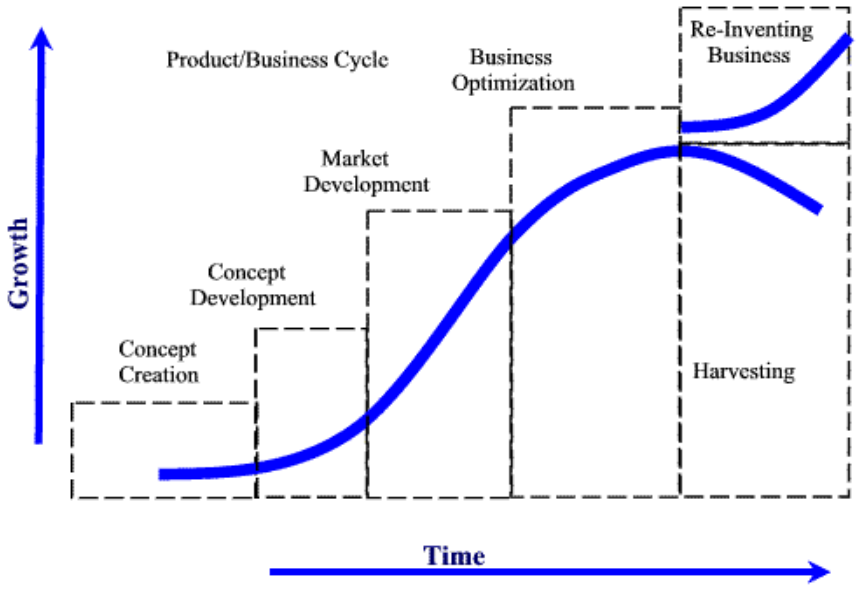
Appendix 1: Gantt chart

Appendix 2: Ansoffs Matrix



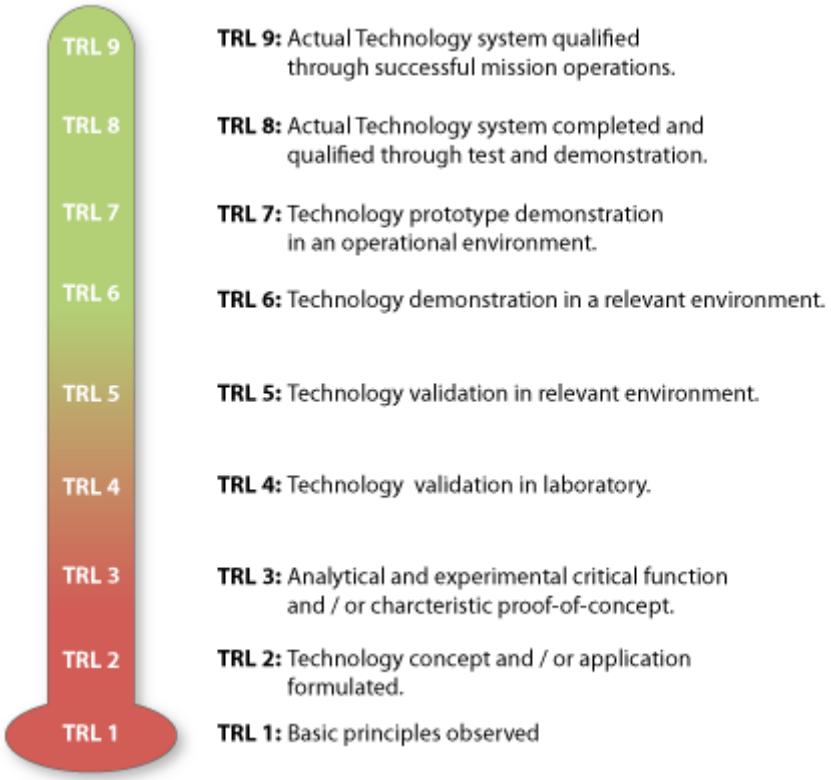
Ansoffs Matrix (Ansoff 1987) image ref: (Proven Models 2005)

Appendix 3: Product Life Cycle



Product Life Cycle (Arundel Street Consulting, Inc. 2003)

Appendix 4: Technology Readiness Levels



Technology Readiness Levels (Defence 2010)

Appendix 5: WMR Sponsorship Package

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