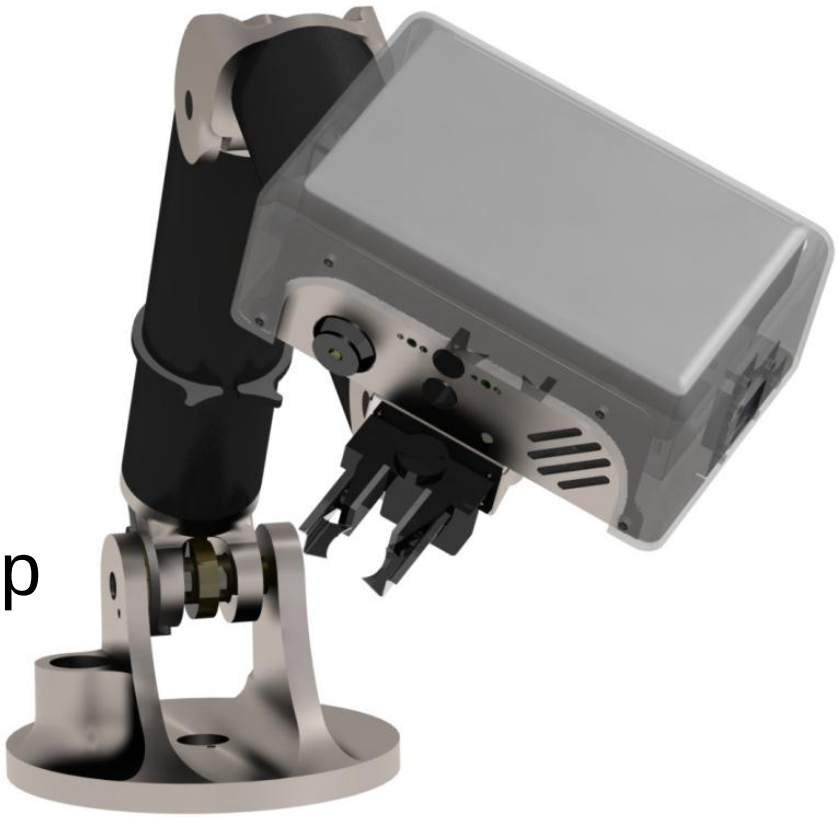
Warwick Mobile Robotics

Presentation of work performed in
the 2010/2011 project

Overview

- Introduction
- Feature changes
- Analysis of competition performance
- Finance and Sponsorship
- Conclusions

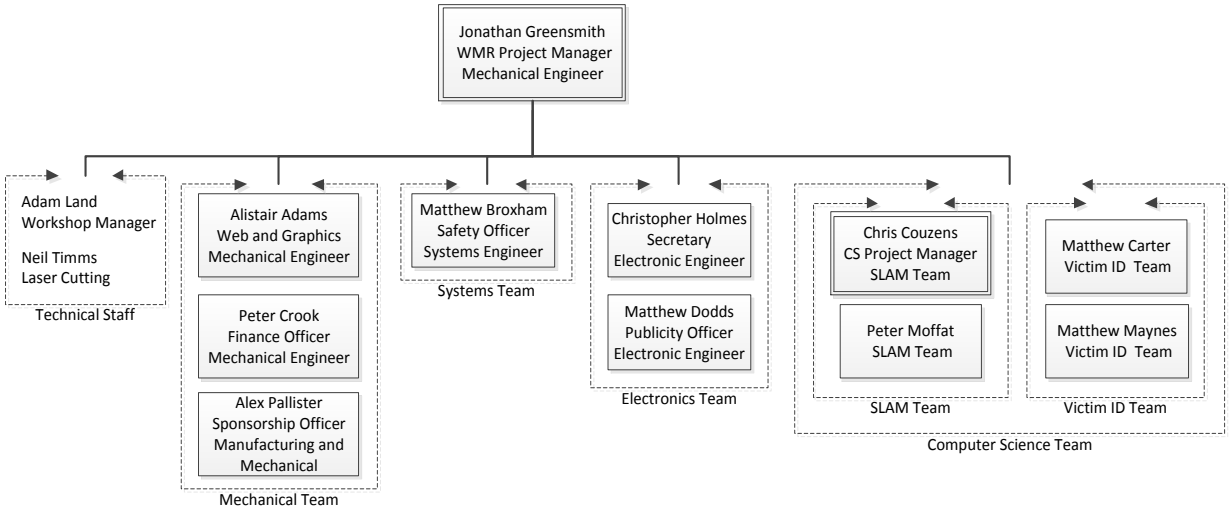


The WMR Team

- Multidisciplinary team
  - Mechanical, Manufacturing, Systems and Electronic
- Team assigned admin and tech roles

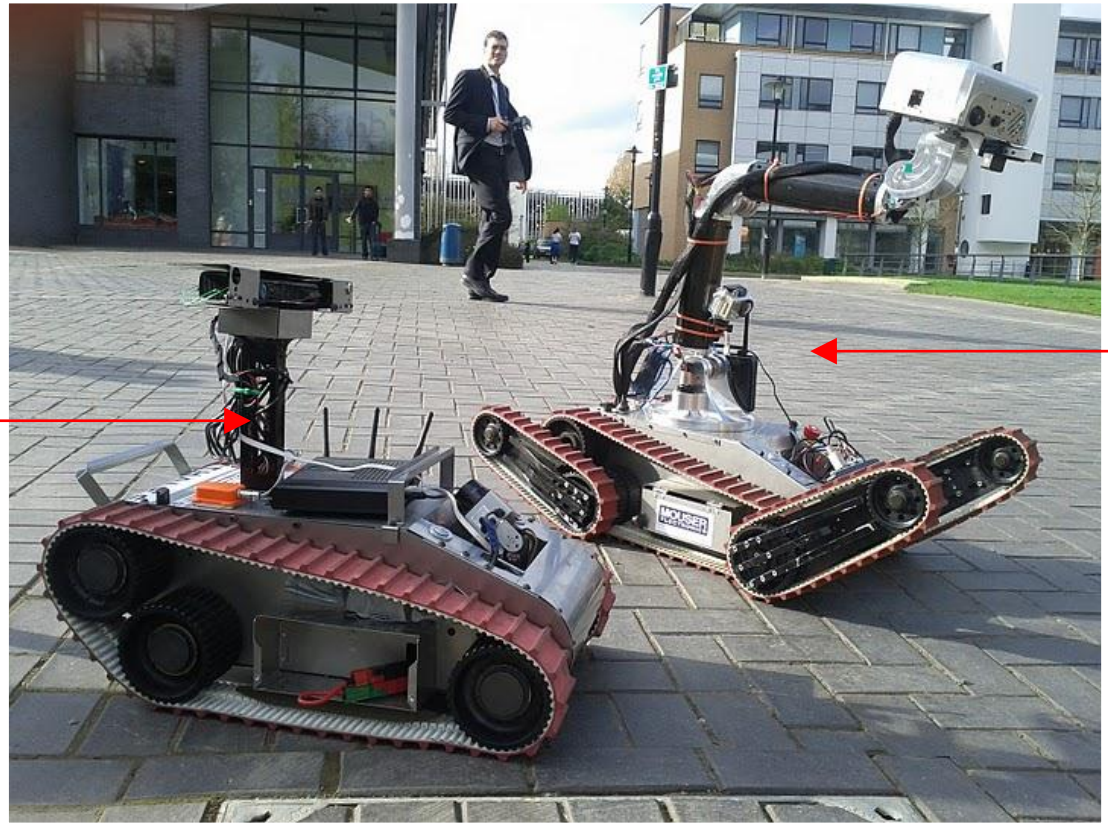
Management

- Team divided into teams to clarify roles
  - Computer Science team included in organisation
- Structure not rigid
  - Functional working groups formed



USAR Robots

USAR-A,
Autonomous
Urban Search &
Rescue



USAR-T,
Teleoperated
Urban Search &
Rescue

Aims

- Develop USAR-T and USAR-A Systems
  - Mechanical
  - Electronic
  - Control
- Commercial viability
- RoboCup German Open

Objectives

- Identify and address weaknesses with the previous platforms
- Raise sufficient sponsorship to fund project
- Continually increase awareness of WMR brand

The Competition

The RoboCup Rescue Competition

- Purpose:
  - “To develop and demonstrate advanced robotic capabilities for emergency responders using annual competitions to evaluate, and teaching camps to disseminate best-in-class robotic solutions.”

The RoboCup Rescue Competition

- Points scored through victim identification:
  - Visual
  - Thermal
  - Audio
- Real-time mapping
- Payload delivery.

The RoboCup Rescue Competition

Yellow (Autonomous) Arena

Orange Arena

Red Arena - Ramps and Stairs

Red Arena - Step Fields

USAR-T

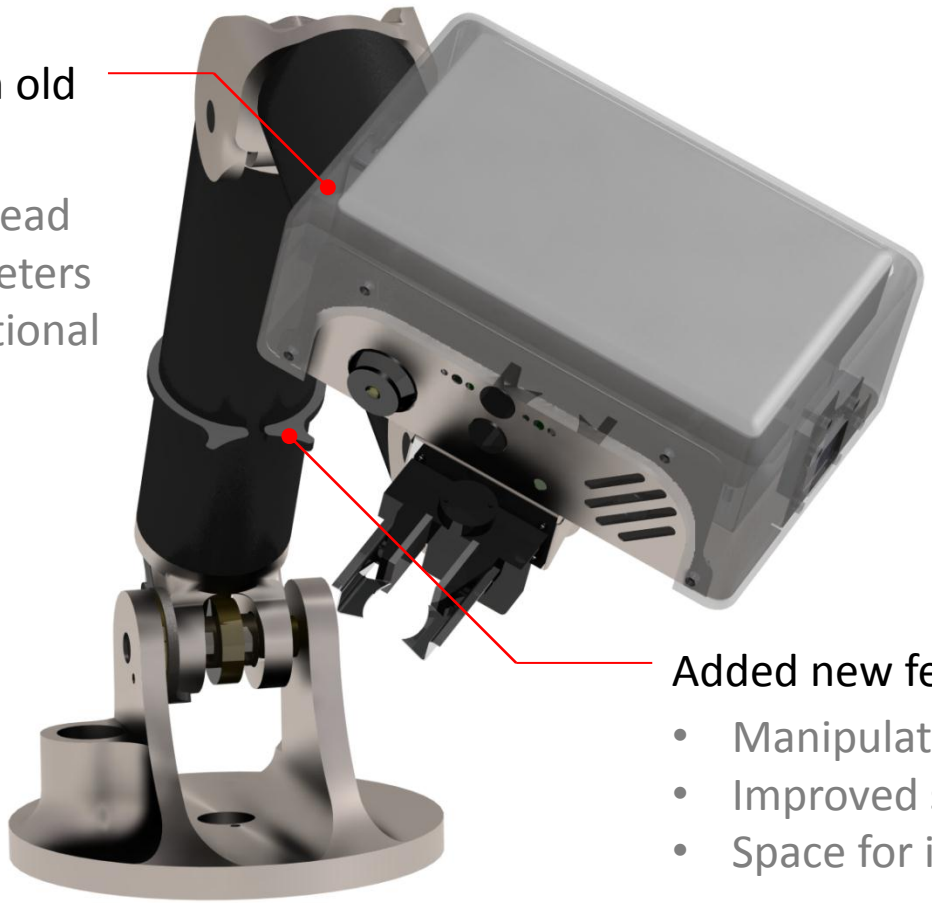
Teleoperated Urban Search & Recue Platform

- Designed to deal with more complex terrain & tasks.

Features of the New Arm

Addressed problems with old arm;

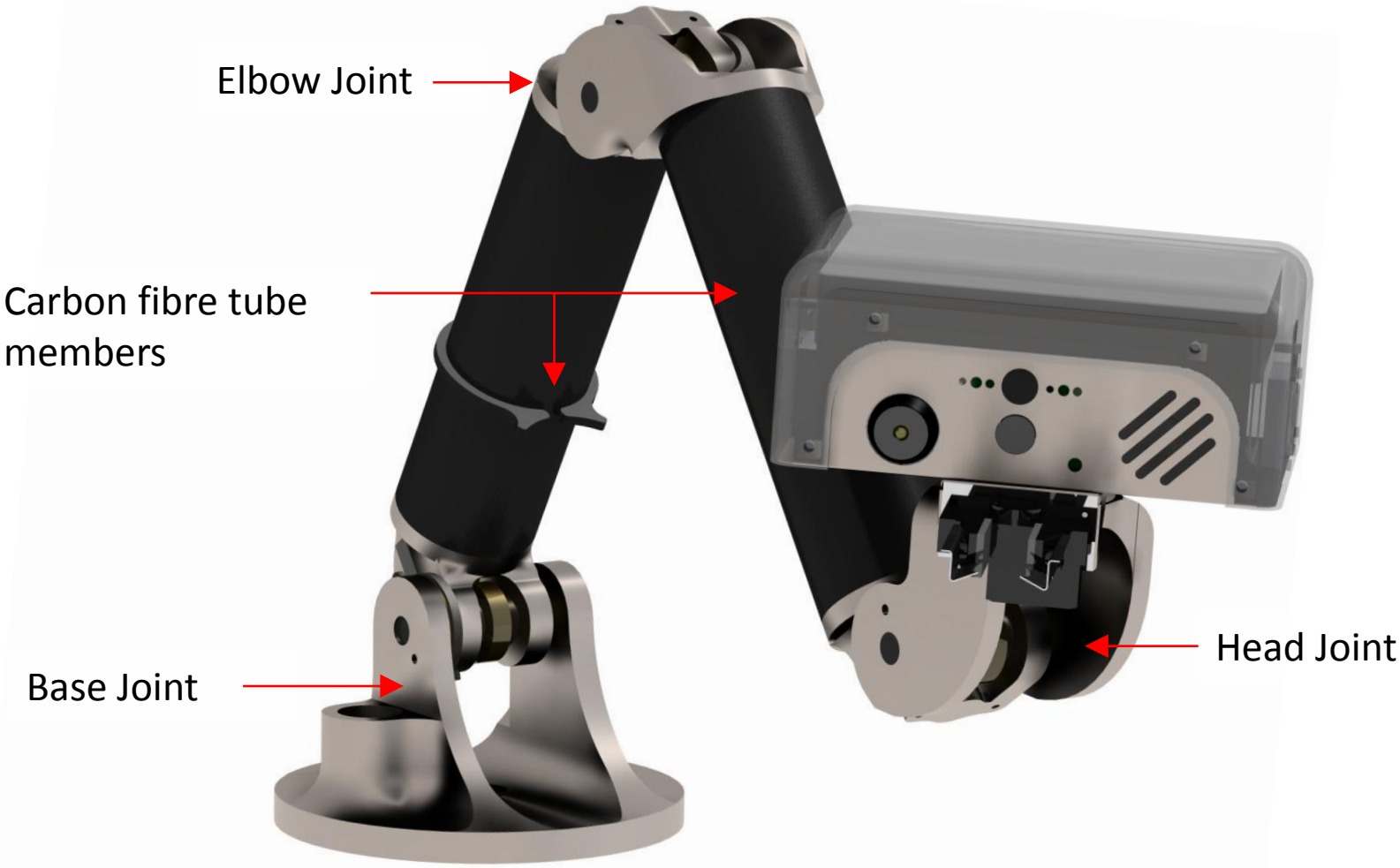
- Excessive play in the head
- Vulnerable potentiometers
- Not designed for additional payloads



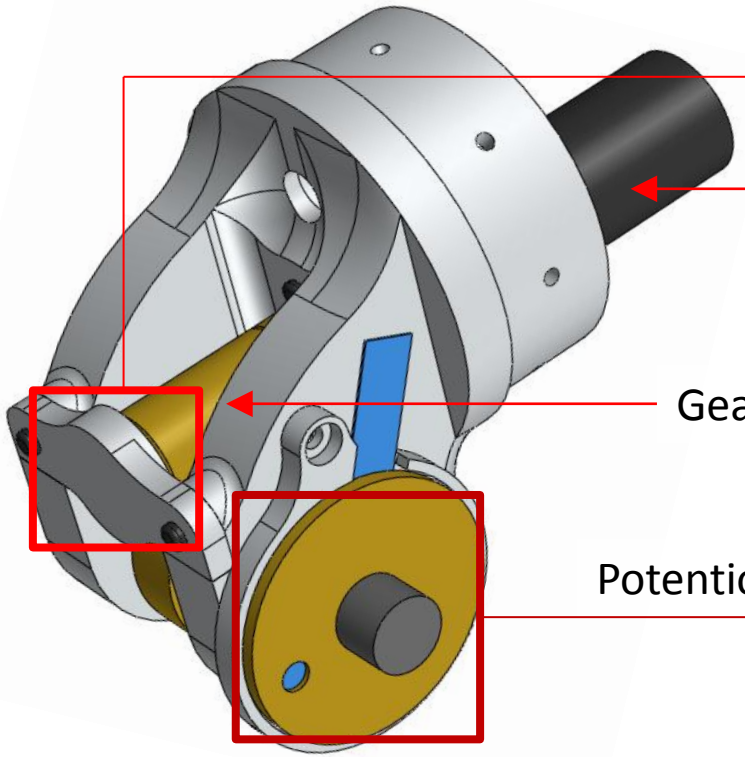
Added new features;

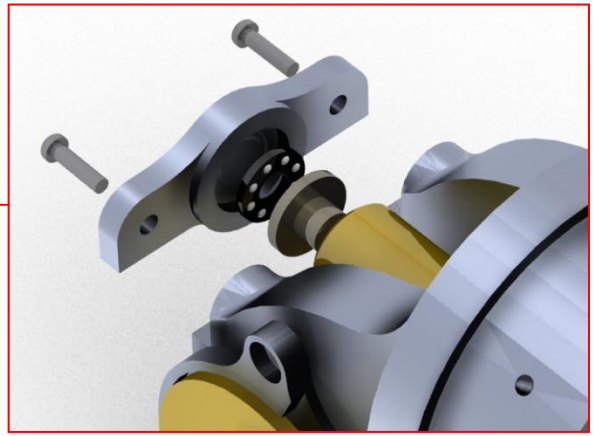
- Manipulator
- Improved strength
- Space for internal wiring

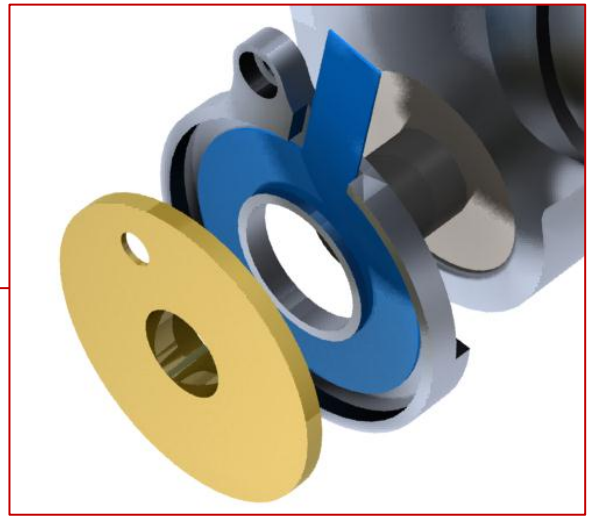
Arm Layout


Elbow Joint
Carbon fibre tube members
Base Joint
Head Joint

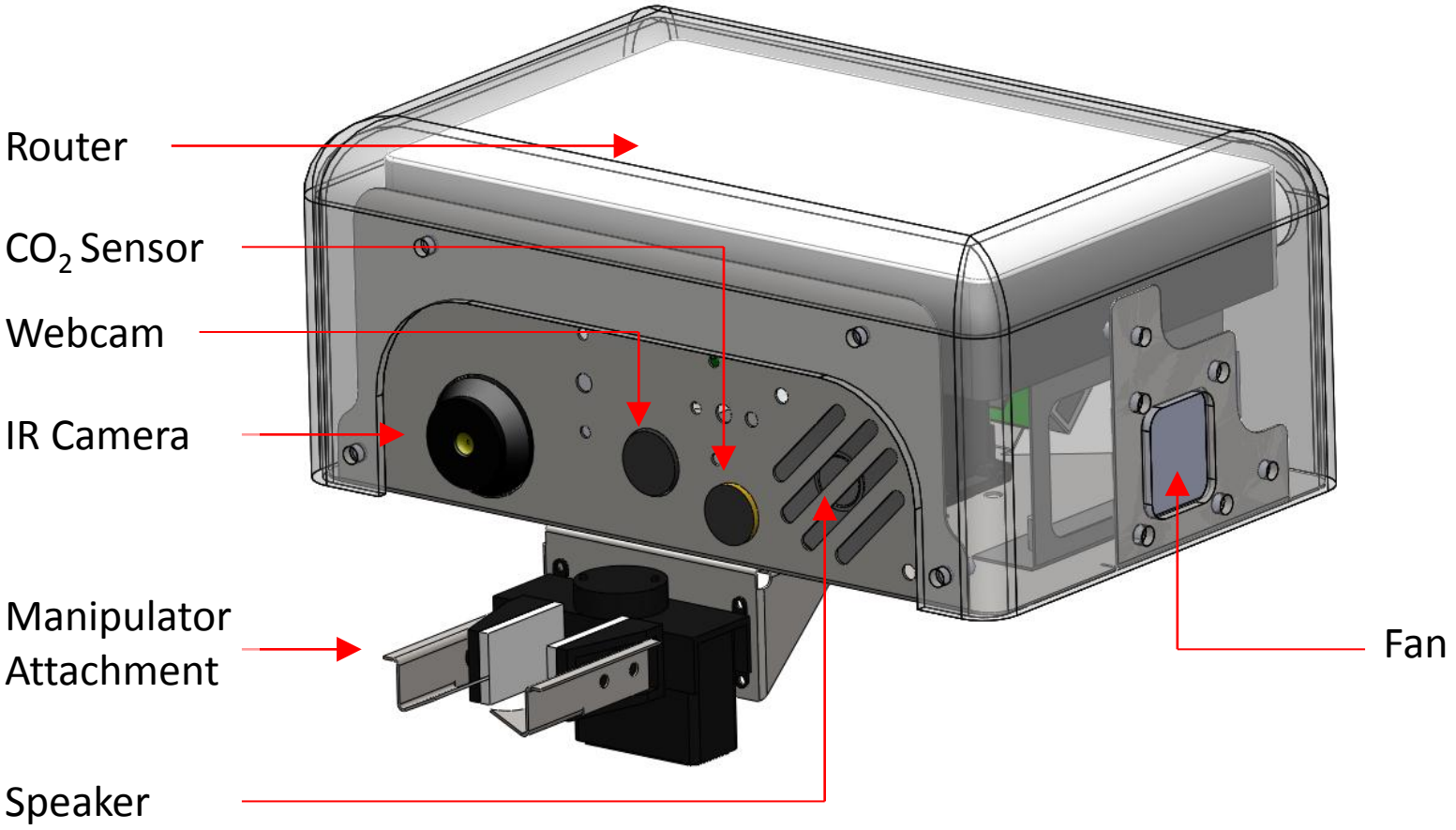
Core Joint



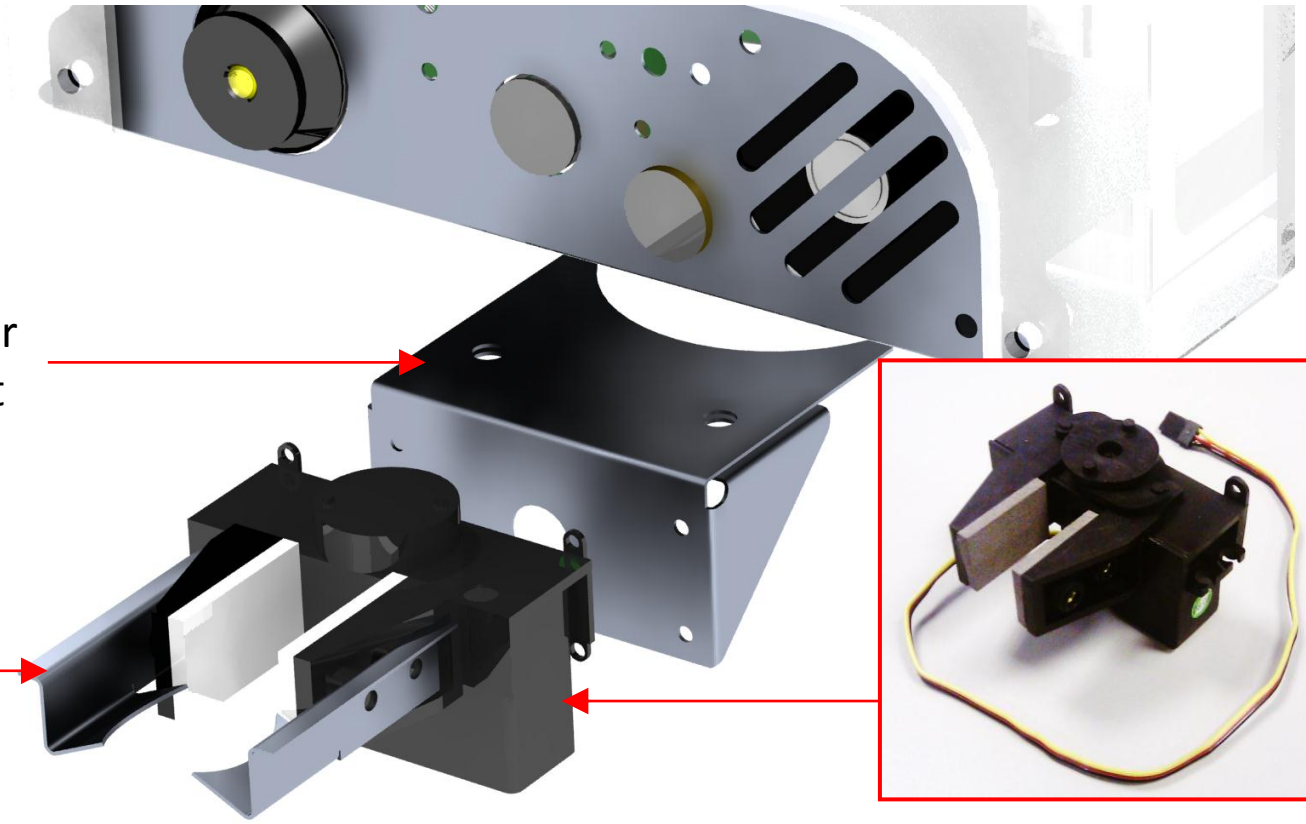




Head Design

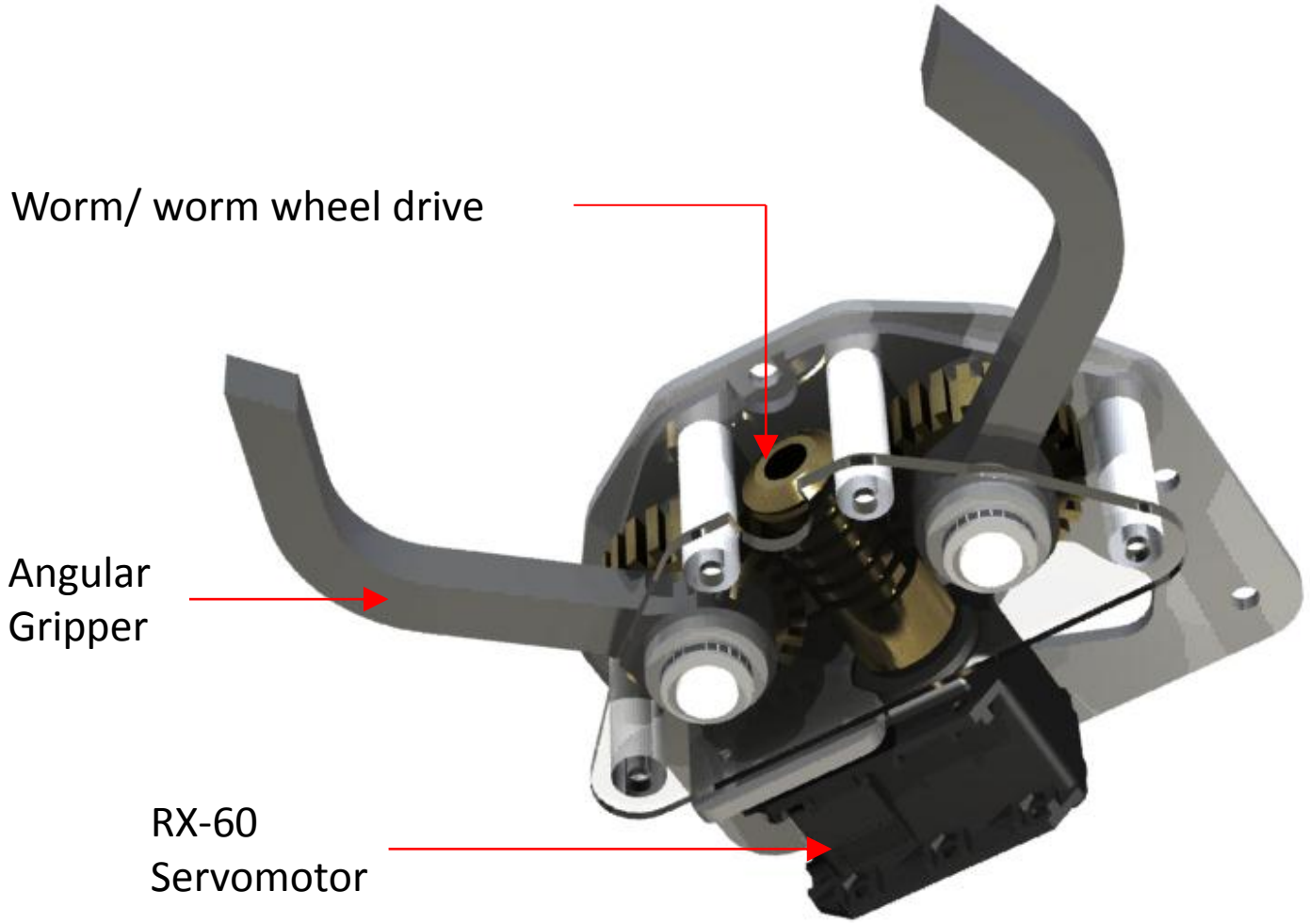

Router
CO_2 Sensor
Webcam
IR Camera
Manipulator Attachment
Speaker
Fan

Manipulator Design



Active Robots,
Little Gripper Kit

New Manipulator Design



Other Modifications

- Reinforced Arm Base plate
- Stack handles and casing
  - Improved the handling of the electronics stack
- Redesigned motor clamps
  - Previous clamps distorted under load

USAR-T Electronic Control Systems

Electronics

- General configuration remains the same
  - Was able to use existing stack plates
  - Hardware may have changed purpose
- Positioning of components changed significantly
  - Loose electronic moved elsewhere
- New electronics hardware
  - Xsens IMU
  - New Router
  - Bespoke Battery Monitor

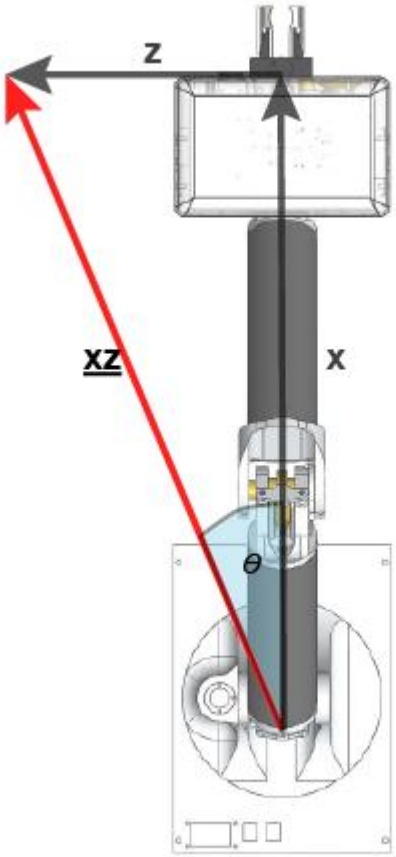
Arm Control

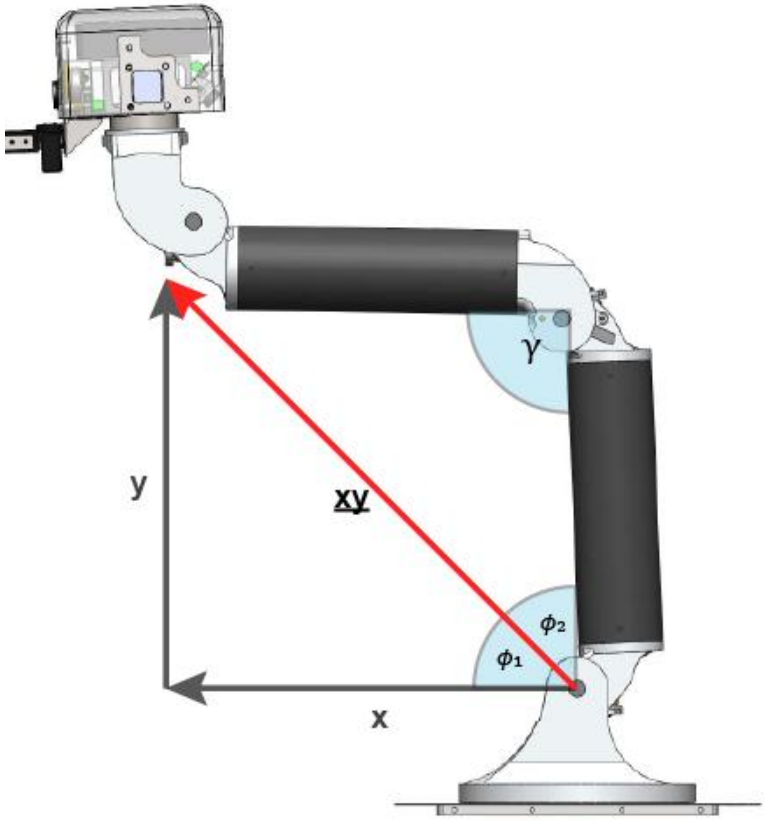
- Same basic electronic configuration
  - More powerful controllers for shoulder
- Added an abstract model in code
  - System attempts the physical structure with joints
  - Each joint handles communication to controllers
  - Joints hold own specific information (angles, offsets, etc)

Arm Control

- Old arm could only move using joint positions
  - Movement of the arm reduced to angle presets
- Inverse Kinematics allows for xyz movement

IK derivations





Arm Control

- Position tracking
  - Prevents dangerous behaviour through feedback
- With position tracking and xyz movement
  - Translational Operations
  - Linear Interpolation

Manipulator Control

- Uses existing electronics hardware
  - Servo Controller
- Decoupled software system
- Currently supports grip and un-grip operations
  - But easily changeable

Battery Monitor

- LiPo batteries have a voltage threshold
- Below this threshold they will no longer hold a charge
  - Computer Science really like to break them
- ~2.7V limit but 3V is the recommended limit
  - Curve of voltage change is non-linear

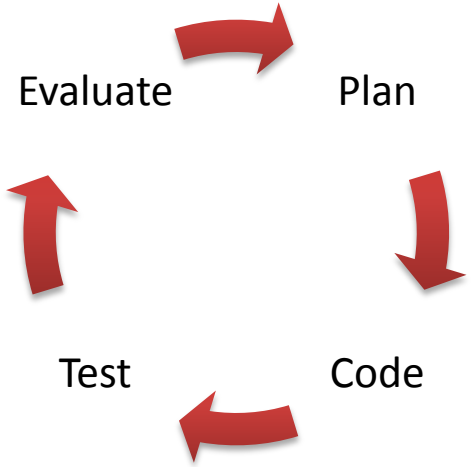
Solution

- Monitors voltage with an Atmel microcontroller
- Works without reliance on the computer
  - Power directly from the batteries
  - Sounds a buzzer should voltage drop too low
- Can communicate serially with the computer
  - Computer sends voltage to the clients

USAR-T Software Development

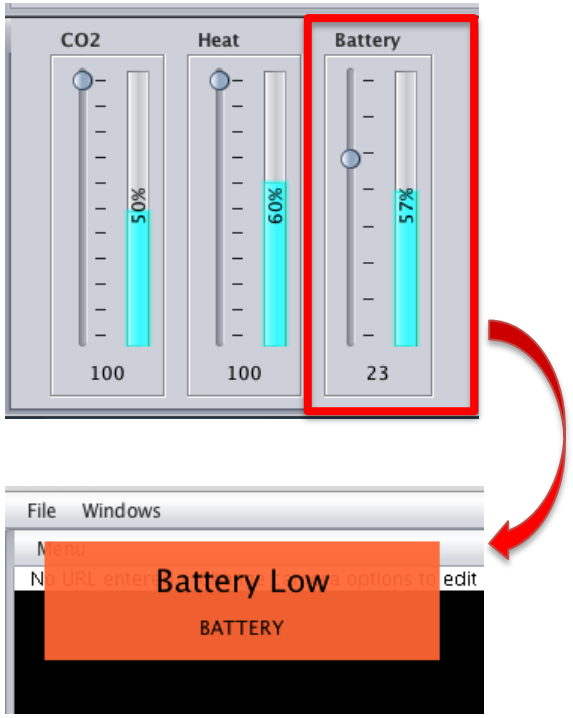
USAR-T Software

- If it ain't broke don't fix it?
- It **was** broke, so we fixed it.
- How? Complete Restructuring
  - Agile Development
  - Object Orientation



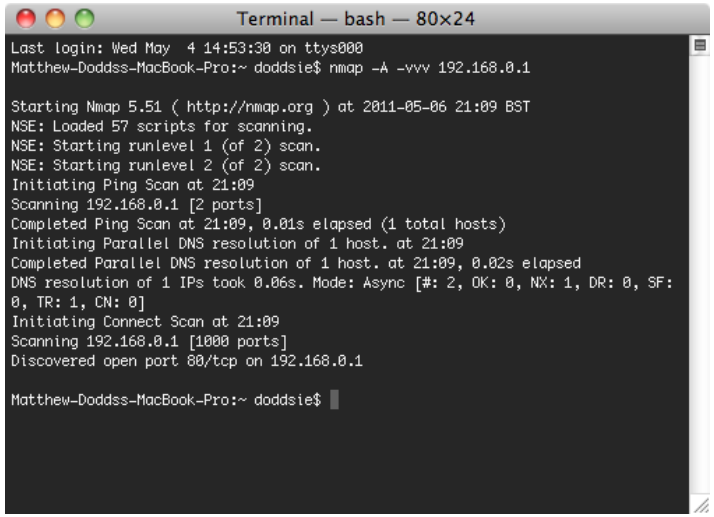
USAR-T Software

- Client software rebuilt
- New user-friendly interface
- Assisted control systems
- New features added
  - Two-way communications
  - Notification System

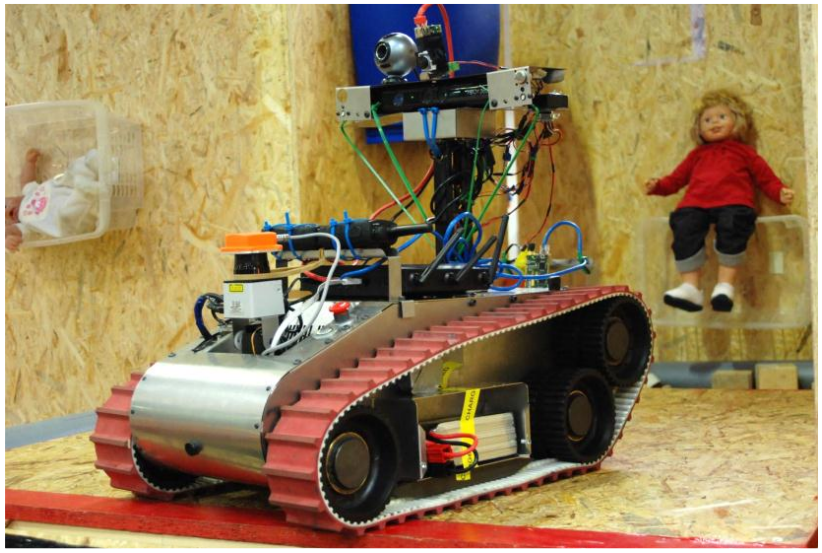


USAR-T Software

- Server software restructured
- Encapsulation
  - Extensibility
  - Readability
  - Changeability
- Arm Control
- Messaging system



USAR-A



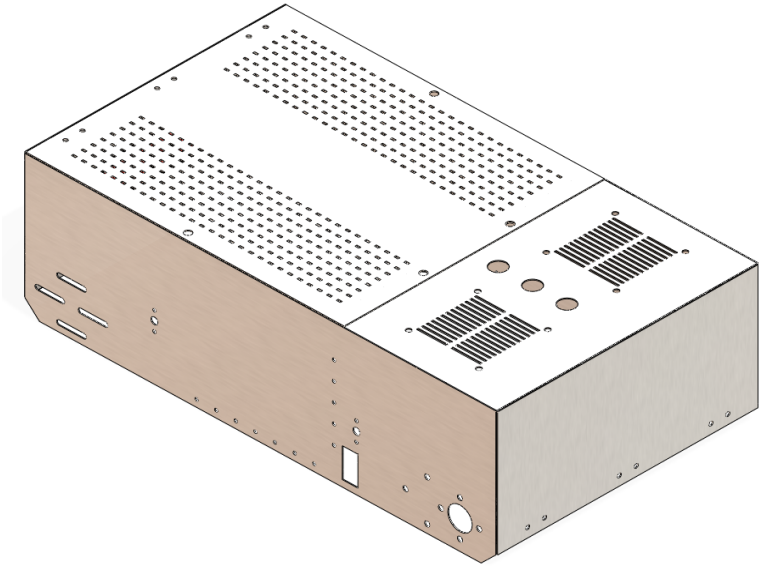
Autonomous Urban Search & Recue Platform

- Autonomous navigation, mapping and victim identification

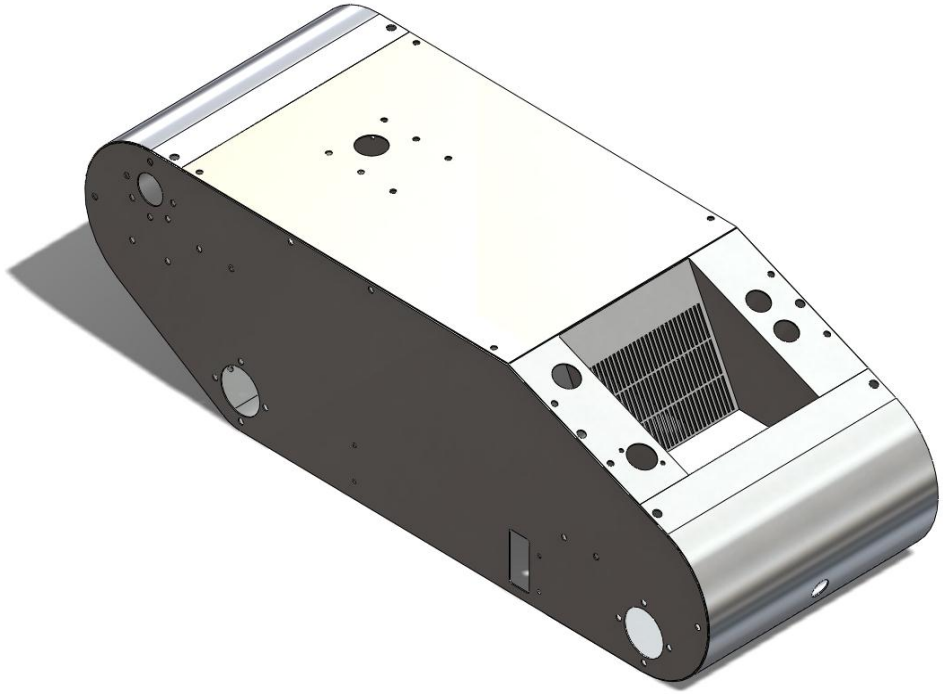
Mechanical Design Aims

- Increased strength
- Increased standardisation
- Increased Mobility
  - Increased ground clearance
  - Centre of mass
  - Improved drive train

Chassis changes

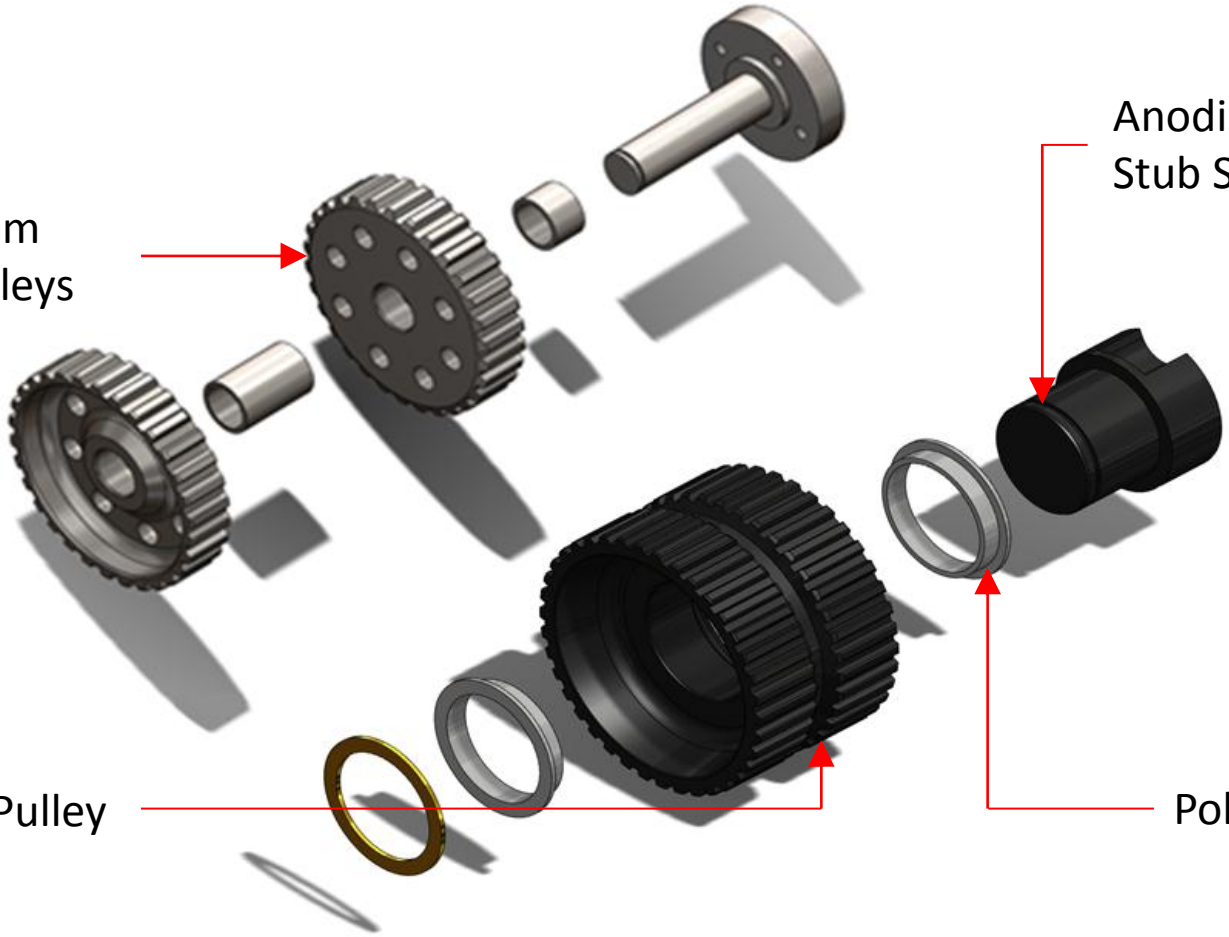


2009/10 Chassis



2010/11 Chassis

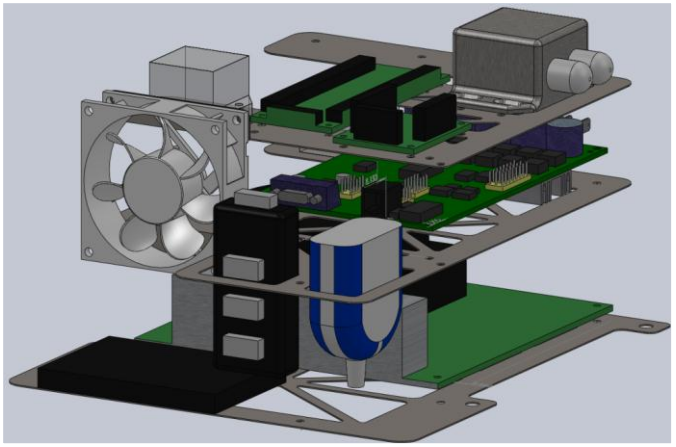
Drive-train changes

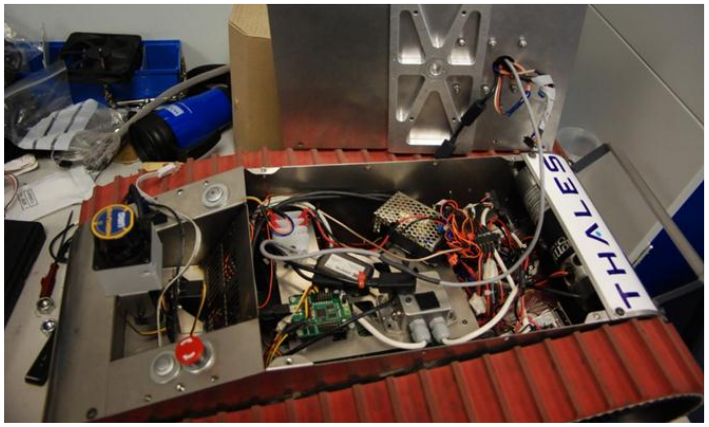


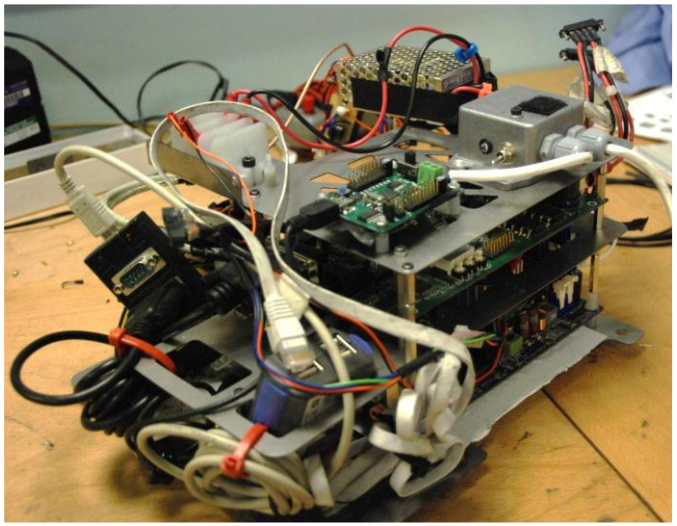
USAR-A Electronics

USAR-A Electronics

- Required specifications achieved;
  - Accessibility of connectors
  - Reorganisation of wires
  - Vibration reduction
  - Space for adequate ventilation
  - Earthing and fusing



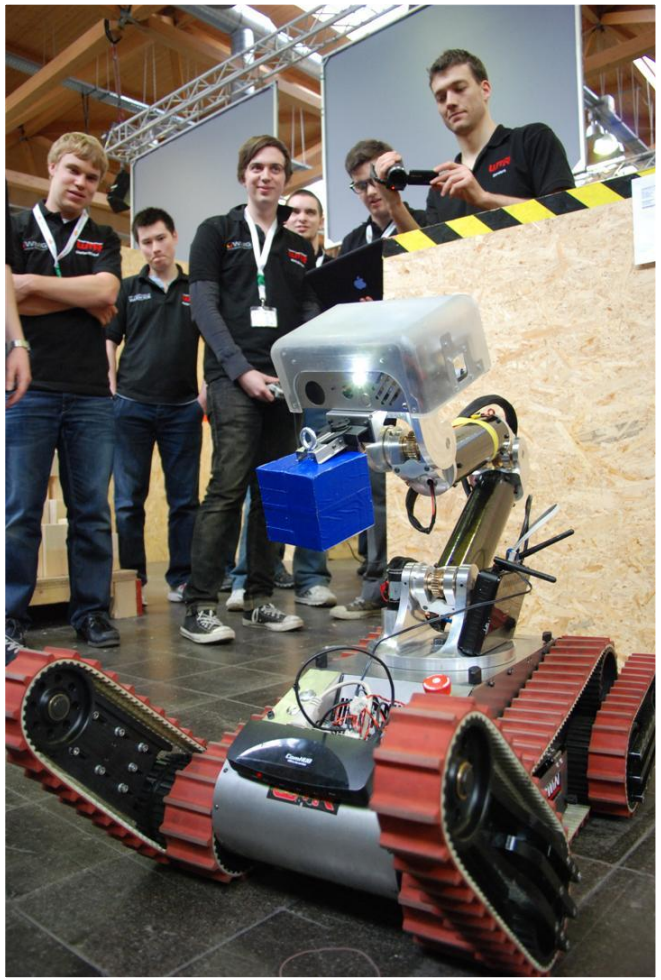




WMR at the Competition

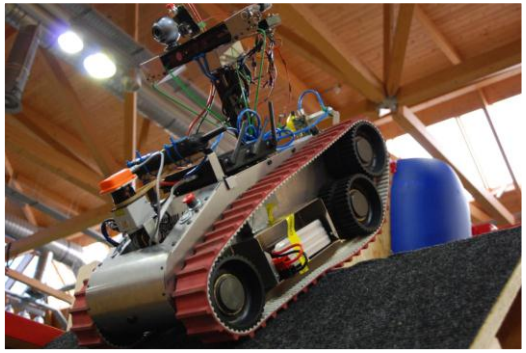
WMR at the Competition

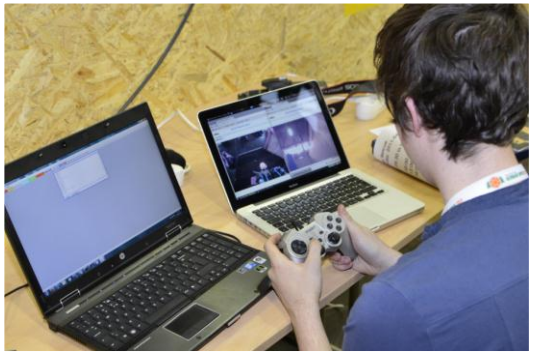
- Chain of events:
  - Miscommunications
  - Manufacturing delays
  - No testing time
  - Hardware failure
- Demonstrated mobility and manipulation of payload to judges
- Still recommended for the World competition in Istanbul

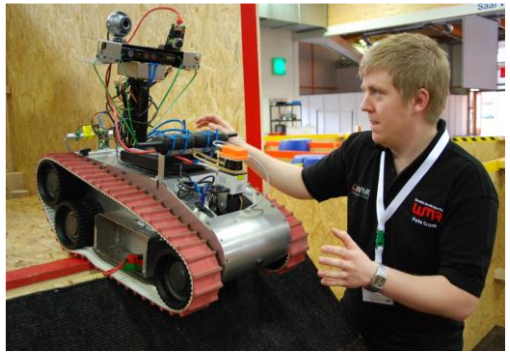


WMR at the Competition

- Awarded best in mobility
  - Using the augmented USAR-A
  - Adapted for teleoperation to allow the team to compete

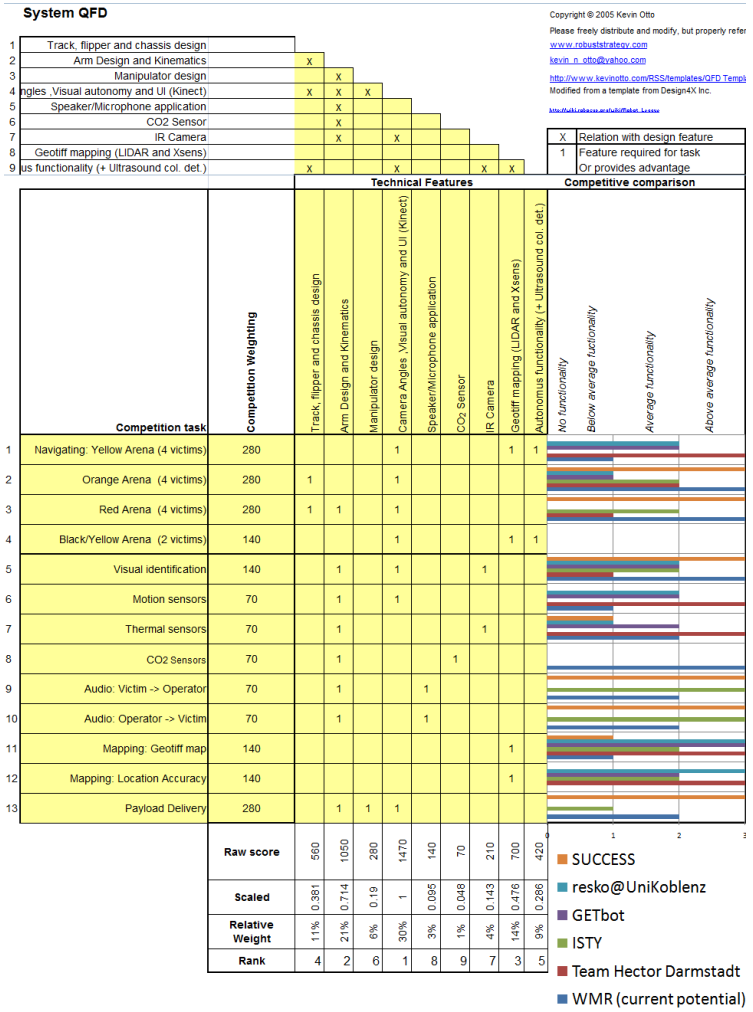






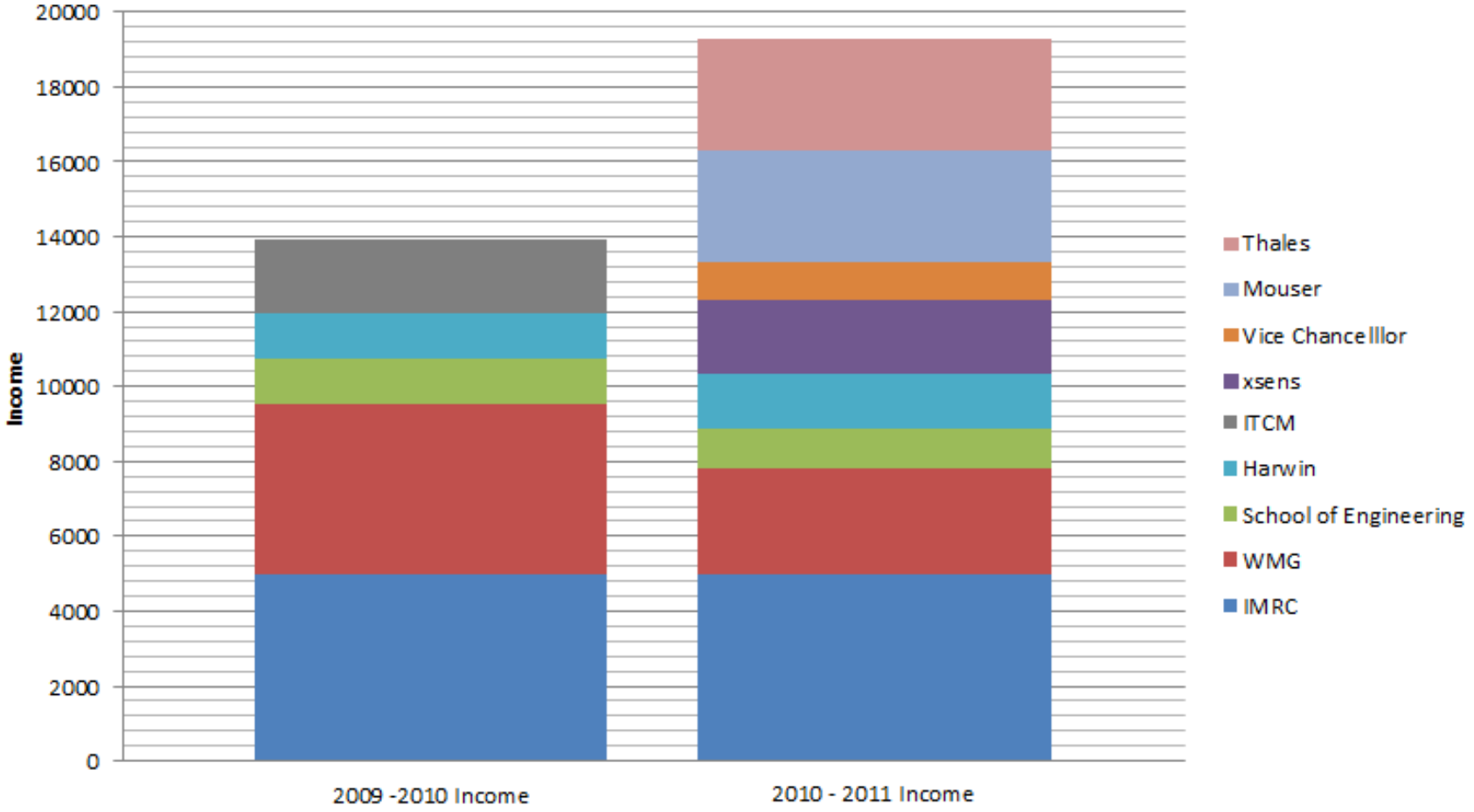
Quality Function Deployment

- Quality Function Deployment:
  - Competition points system treated as customer requirements
- Defined order of importance:
  1. Camera angles & UI
  2. Arm design
  3. Geotiff mapping
  4. Track and flipper design
  5. Autonomous functionality
- WMR could have performed better under different circumstances.

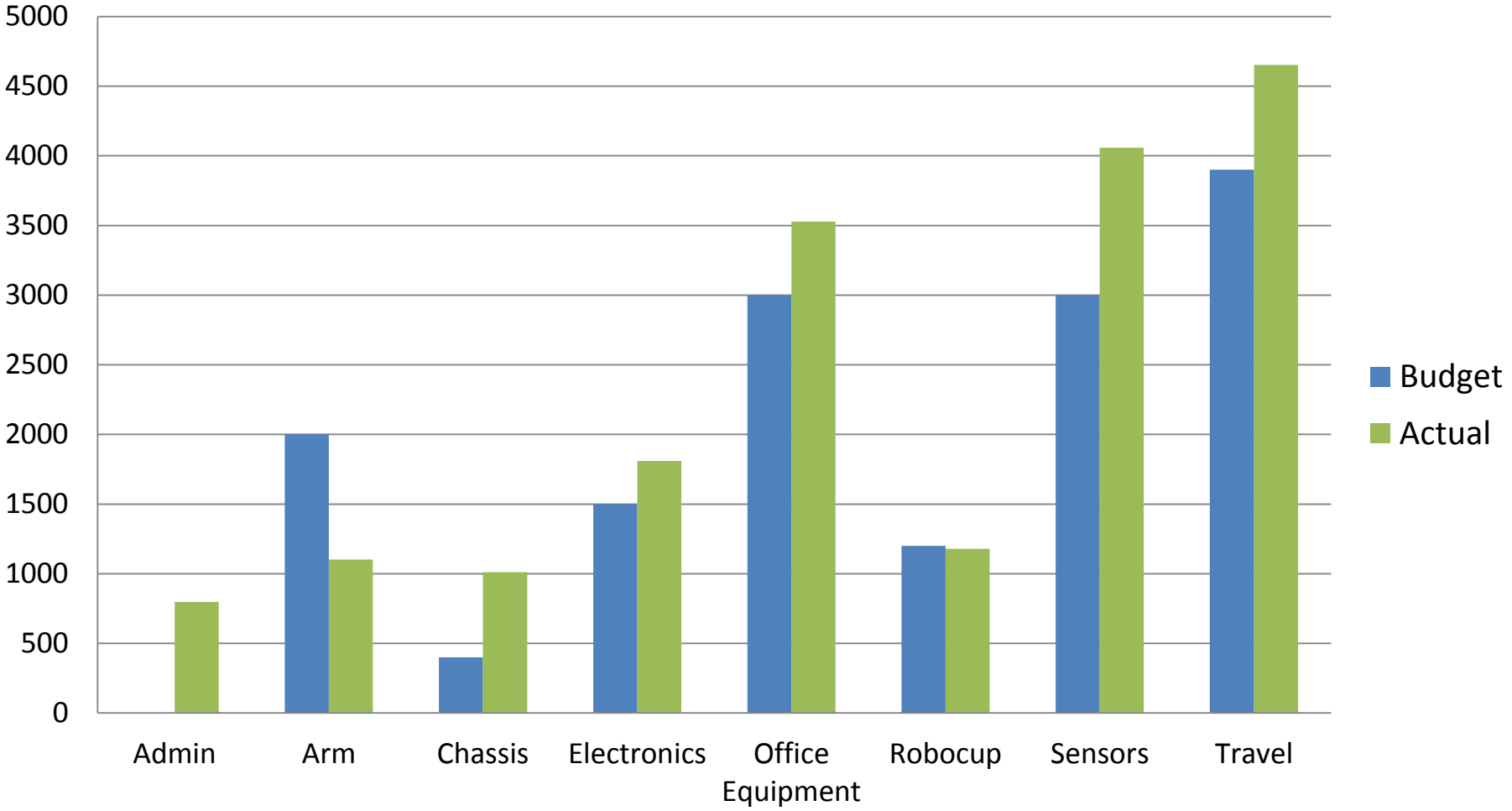


Finances

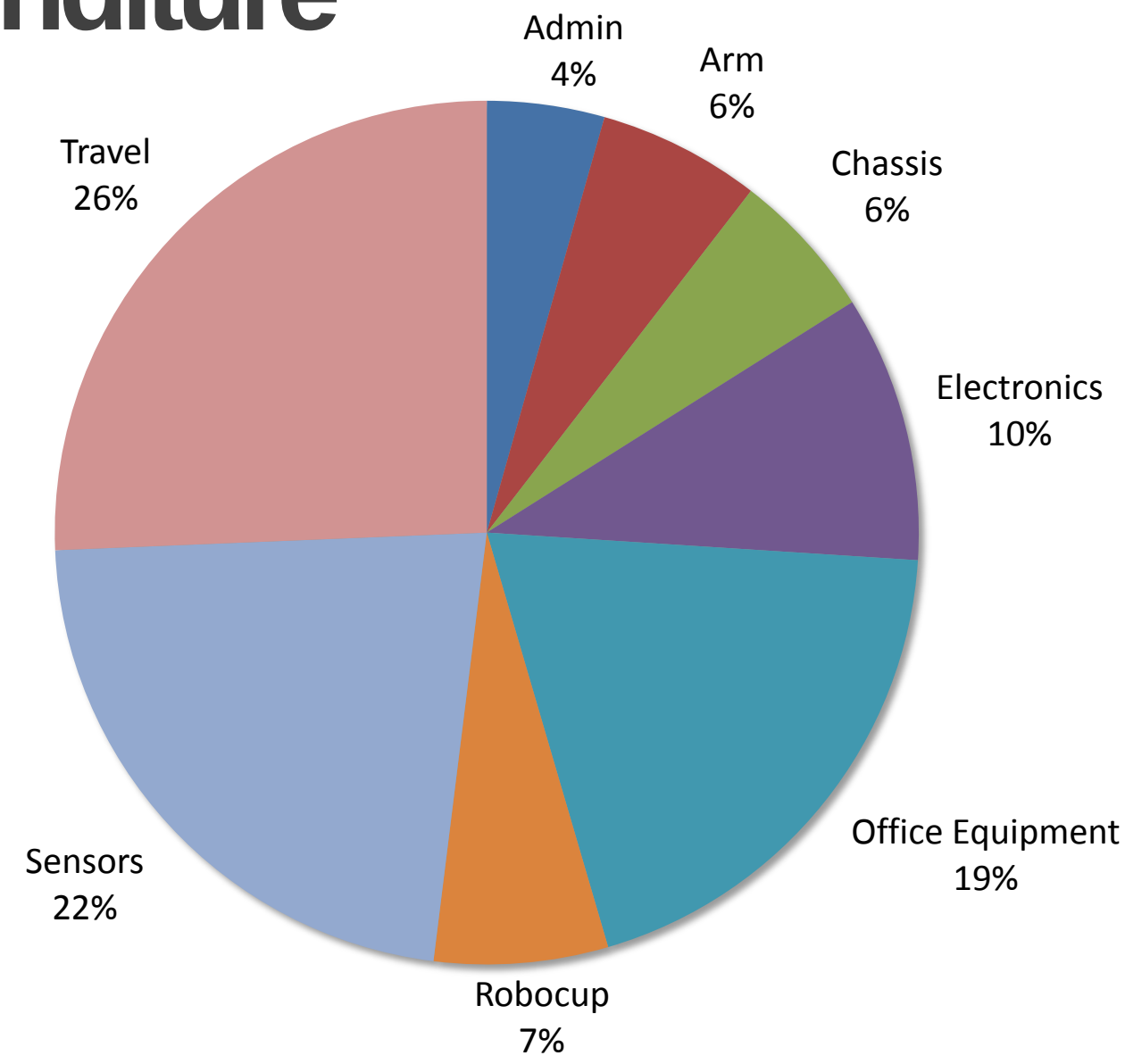
Income


20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Income
2009 -2010 Income
2010 - 2011 Income
Thales
Mouser
Vice Chancellor
xsens
ITCM
Harwin
School of Engineering
WMG
IMRC

Expenditure



Expenditure



Balance

Income	Expenditure	Balance
19297	18140	1157

Sponsorship, Publicity & Commercialisation

Sponsorship

HARWiN

THALES

School of Engineering

The Office of the Vice-Chancellor

xsens

Publicity

cnet

NEWS OF THE WORLD

ColeraineTimes

Midlands Today
BBC NEWS

XBOX ADDICT.COM

E&T
ENGINEERING & TECHNOLOGY

tweakers.net

Milton Keynes Citizen

YORKSHIRE POST

The University of Warwick Students' Newspaper
THE BOAR .org

Stainesinformer

BBC WORLD SERVICE

Ely Standard

XBOX
OFFICIAL XBOX MAGAZINE

Coventry Observer

the Gadget show LIVE
NEC BIRMINGHAM
13th-17th April 2011

EE Times

Coventry Telegraph

BBC CAMBRIDGESHIRE

BBC NEWS TECHNOLOGY

A to Z robotics
The A to Z of Robotics

LINK MAGAZINE
The positive newsforce in Swindon

the Gadget show

RoboCup Rescue

Publicity: BBC Click

Publicity: Gadget Show

Publicity: Gadget Show Live

Commercialisation

- Analysis of Current Situation
  - Unique Selling Point
  - Market Conditions
  - Possible Customers
  - Competitors
- Meeting with Warwick Ventures
  1) License the product
  2) Create a spin out company

In conclusion

Ongoing Work

- Autonomous Assistance
- Weight Reductions
- New Manipulator Design
- Further Battery Monitor Integration
- Linear Actuator

Conclusion

- Many developments to USAR-T and USAR-A
  - Position in competition disappointing
- Created opportunities for next years team
  - Improved the handover due to the complexity of the project
- USAR range not yet viable commercial product

Warwick Mobile Robotics

Thank you for your attention