

# RoboCup 2006 - Robot Rescue League

## Red Knight RoboRescue Squad United States of America

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**Abstract:** High school engineering class designing and fabricating a robot for use in urban search and rescue, with an emphasis on advanced mobility and production value

### 1. Team Members and Their Contributions

- Pat Cannon            Controller Dev. (Mapping & Programming)
- Sam Fulco            Controller Dev. (Programming & Balance System)
- Karl Nosbisch        Controller Dev. (System Hardware & Interface)
- Colin Ryan            Controller Dev. (Mapping)
- Nate Berglund        Mechanical Design (Treads & Arm Development)
- Jason Gilbert         Mechanical Design (Co-arm Development)
- Pat McGuire          Mechanical Design (Encoders)
- Andrew Mossefin     Mechanical Design (Chassis & Drive Train)
- Sean Wyley            Mechanical Design (Arm Development)
- Lyda Robb             Communications & Visual
- Jessica Tobelmann    Communications & Visual
- Matt Blackford        Components Cataloging & Research
- TBD                    Operator
  
- Timothy Jump         Advisor
- Daniel Haeg            TA

## 2. Operator Station Set-up and Break-Down (10 minutes)

- Set-Up
  - Connect Regulated Power Supply to AC outlet (AC 110 volt wall outlet/US)
  - Erect and connect to regulated power supply
    - Power Strip
    - Control Station Laptop
    - Additional Monitor
    - Printer
    - Wireless Access Point
  - Connect to computer
    - access point
    - printer
    - additional monitor
  - Boot the robot computers
  - Boot the command computers
  - Establish communication with robot via remote access program
  - Start needed programs
- Break-Down
  - Reverse of above
- *\*Integrated, Single-case operator station under development*

## 3. Communications

- CONTROL CENTER
  - D-link Access point DWL-8200AP
    - Wireless system
    - 802.11a
    - Port for high-gain antenna
  - Tiltek Antenna TA-5404-8-90
    - Vertically polarized 90 degree sectoral antenna.
    - 15.5 dBi min.
    - Horizontal Plane Beam width: 90 Degrees
    - Vertical Plane Beam width: 7 Degrees
- ROBOT
  - D-link Wireless Gaming Adapter DGL-3420
    - Wireless system
    - 802.11a



#### 4. Control Method and Human-Robot Interface

- Control Method
  - Tele-operation
    - Operator interface with robot with wireless connection
  - *\*Autonomy Under Development*
    - *Bounded*
      - *Retraction routine*
        - *With communication loss, return to previous point of known connectivity*
        - *Wait for prompt to proceed autonomously*
      - *Wall Follow, Collision Detection, Obstruction Avoidance*
        - *Proximity sensors*
  - *\*Tethered Operation Under Development*
    - *Tether deployment/retrieval system operated from robot*
- Human-Robot Interface
  - Command Center
    - Keyboard, mouse, joysticks, monitor
      - Computer - TBD
        - D-link Access point DWL-8200AP
  - Robot
    - D-link Wireless Gaming Adapter DGL-3420
      - Commell LV-674 2.8Ghz Pentium D Mini-ITCX
        - Brainstem GP 1.0 Module
          - ~ Motor controller
          - ~ Sensor input



Brainstem GP 1.0 Module



Networked Brainstems



Commell LV-674 Pentium D Mini-ITX Mainboard



## 5. Map Generation

- Data Collection and Interpretation
  - Hokuyo URG-04LX Scanning Laser Range Finder
    - 240 degree sweep, ten times per second
    - Relays readings to the onboard computer
    - Extraneous readings outside the sensor's range are omitted
  - MicroMag 3-axis Magnetometer
    - Orients range finder readings
      - initiates first reading East
- Readings from range finder and magnetometer analyzed, converted into (x, y) coordinates and plotted using a customized visual basic program
  - Conversion equations:
    - A = Degree offset from magnetometer
    - B = Inverse angular resolution
    - C = Range reading in millimeters
    - D = Conversion factor
    - x coordinate =  $\text{Cos}(A * B * (\text{PI} / 180)) * C * D$
    - y coordinate =  $-1 * \text{Sin}(A * B * (\text{PI} / 180)) * C * D$
  - Plotted data represents a map section
- Map Section Registration
  - Manual placement of registration points
  - Manual alignment of map sections using registration points
- Victim Placement
  - Manual drag and drop markers for victim location and state
- Map Printing
  - Color dot-matrix portable printer



## 6. Navigation and Localization

- Visual
  - Sony Full-Circle 360° Camera Module RPU-C2512
    - Images a full 360 degrees in one operation
    - Focus adjustment for distance not required
    - Interface Board RS232
    - Point and click software
- Sensor
  - \*TBD
    - *Wall Follow*
    - *Collision Detection*
    - *Obstruction Avoidance*
    - *Distance Traveled*
    - *Transpondence*



## 7. Victim Identification

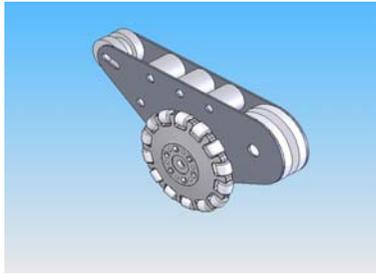
- Visual
  - Irisys 1011 Universal Thermal Imager
    - Heat Recognition
  - Sony Block Camera FCB-EX780B/EX780BP
    - 300x zoom ratio (25x optical, 12x digital)
    - Auto ICR to achieve near-infrared sensitivity
    - Motion
    - Form
    - Victim State
    - Victim Tags
- Auditory
  - Sennheiser MKE 300 Super-Cardioid Shotgun Condenser Camera Mountable Microphone
- Sensor
  - Vernier CO<sub>2</sub>-BTA CO<sub>2</sub> Gas Sensor
    - CO<sub>2</sub> detection



## 8. Robot Locomotion

- **MECHANICAL**
  - Main Chassis
    - 2x aluminum side plates
    - 1x aluminum center plate
  - Arms
    - 2x aluminum plates
  - 3x Pulleys
    - 1x tread
  - Mobility (on stairs or uneven terrain)
    - 2x opposing abdominal belts
    - 4x independent lifting arms
  - Mobility (on flat surfaces)
    - 4x 6" omni-wheels
  - Drive Power
    - 2x MP-36064-545, 64:1 motors
    - Belt and pulley system
  - Lifting Power
    - 4x MP-36256-545, 256:1 motors
    - Belt and pulley system

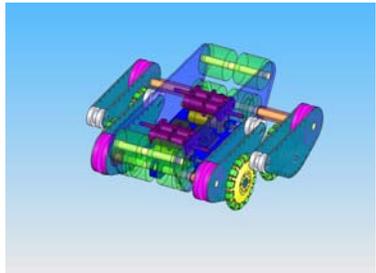




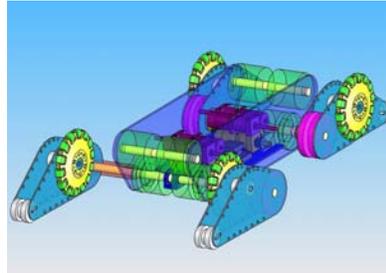
Arm assembly with omni wheel



Omni Wheel



Robot collapsed isometric view



Robot Extended Isometric view

## 9. Robot Locomotion

### ● CONTROL

- Arm Positioning
  - Components
    - US Digital E5S Optical Quadrature Shaft Encoder
      - Measures arm speed and direction
      - Zeros the arm position
- Balance System
  - Components
    - Spark Fun Electronics, Sense-IMU-203 Inertial Measurement Unit
      - ADXL203 accelerometer
      - ADXRS 300 Gyro
  - Modes
    - Flip/Fall Prevention
      - Motors shut down when robot reaches pre-determined incline
      - System also used in fall protection-if robot drives over an edge, arms swing out and stabilize platform--catches robot.
    - Passive Balance
      - Components platform kept level to ground
    - Over-ride
      - At critical tilt angle, operator chooses to resume driving
    - Off
      - Robot drives on four wheels on flat ground



## 10. Other Mechanisms

- *\*Dual axis, self-leveling gimbal under development*
  - Stability for mapping and visual evaluation
    - Sony Full-Circle 360° Camera Module RPU-C2512
    - Hokuyo URG-04LX
  
- *\*Pan/tilt device under development*
  - Omni-directional control for optimum search efficiency
    - Irisys 1011 Universal Thermal Imager
    - Sony Block Camera FCB-EX780B/EX780BP
  
- *\*Illuminators under development*
  - Increased visual control
    - LuxDrive BuckPuck 700mA Dimmable DC LED Driver
    - LXHL-LW6C White V Portable Star white LED
      - Lambertian lens
      - 5 Watt, 120 Lumen
  
  - *\*UV illuminator*



## 11. Team Training for Operation (Human Factors)

- Practice with locomotion controls
- Training in C and assembly programs
- Interpret and navigate using streaming video from a video camera

## 12. Possibility for Practical Application to Real Disaster Site

- Advanced mobility platform
  - Low cost
  - Stable, robust
  - Inertial sensor feedback
    - reduces the possibility of tipping over

## 13. Areas in Need of Improvement

- No heat shielding
- Not waterproof
- No autonomous driving
- Extensive driver training required
- Map segment integration not autonomous
- Victim inclusion on map not autonomous
- Victim identification not autonomous

## 14. System Cost

Part(s)	Quantity	Total Cost	Internet Site
<b>Operator Control</b>			
TBD			
<b>Robot Control</b>			
Commell LV-674 Pentium D Mini-ITX Mainboard	1	\$365.00	<a href="http://www.logicsupply.com/product_info.php/products_id/489">http://www.logicsupply.com/product_info.php/products_id/489</a>
Intel 2.8Ghz CPU	1	\$279.99	<a href="http://www.tigerdirect.com/applications/SearchTools/item-details.asp?EdpNo=1477438">http://www.tigerdirect.com/applications/SearchTools/item-details.asp?EdpNo=1477438</a>
BUFFALO D2U533B-2GKIT RAM	1	\$138.83	<a href="http://www.newegg.com/Product/Product.asp?Item=N82E16820150630">http://www.newegg.com/Product/Product.asp?Item=N82E16820150630</a>
<b>Victim Identification</b>			
Irisys 1011 Universal Thermal Imager IRI 1011	1	\$1,500.00	<a href="http://www.irisys.co.uk/data/UK_leaflet_IRI1011.pdf">http://www.irisys.co.uk/data/UK_leaflet_IRI1011.pdf</a>
Sony Block Camera FCB- EX780B/EX780BP	1	\$587.00	<a href="http://www.sony.net/Products/ISP/products/ccb/FCBEX780B.html">http://www.sony.net/Products/ISP/products/ccb/FCBEX780B.html</a>
Vernier CO2-BTA CO <sub>2</sub> Gas Sensor	1	\$249.00	<a href="http://www.vernier.com/probes/co2-bta.html">http://www.vernier.com/probes/co2-bta.html</a>
Vernier LabPro Sensor Interface	1	\$220.00	<a href="http://www.vernier.com/mbl/labpro.html">http://www.vernier.com/mbl/labpro.html</a>
Vernier LoggerPro 3 Software	1	\$160.00	<a href="http://www.vernier.com/soft/lp.html">http://www.vernier.com/soft/lp.html</a>
Sennheiser MKE 300 Super-Cardioid Shot- gun Condenser Cam- era Mountable Micro- phone	1	\$169.95	<a href="http://www.bhphotovideo.com/bnh/control-ler/home?A=details&amp;kw=SEMKE300&amp;is=REG&amp;Q=&amp;O=productlist&amp;sku=47031">http://www.bhphotovideo.com/bnh/control-ler/home?A=details&amp;kw=SEMKE300&amp;is=REG&amp;Q=&amp;O=productlist&amp;sku=47031</a>
<b>Mapping</b>			
Hokuyo URG-04LX	1	\$2,500.00	<a href="http://www.hokuyo-aut.jp/products/urg/urg.htm">http://www.hokuyo-aut.jp/products/urg/urg.htm</a>
<b>Navigation</b>			
Sony Full-Circle 360° Camera Module RPU- C2512	1	\$986.00	<a href="http://216.245.175.12/AVCat/CTL999/index.cfm?rcs_id=999&amp;ProdID=341598">http://216.245.175.12/AVCat/CTL999/index.cfm?rcs_id=999&amp;ProdID=341598</a>
Interface Board RS232 (for Sony 360 camera)	1	\$108.00	<a href="http://216.245.175.12/AVCat/CTL999/index.cfm?rcs_id=999&amp;ProdID=341598">http://216.245.175.12/AVCat/CTL999/index.cfm?rcs_id=999&amp;ProdID=341598</a>
<b>Communication</b>			
D-link Access Point DWL-8200AP	1	\$550.00	<a href="http://www.dlink.com/products/?pid=415">http://www.dlink.com/products/?pid=415</a>
D-link Wireless Gam- ing Adapter DGL- 3420	1	\$99.99	<a href="http://games.dlink.com/products/?pid=383&amp;#DGL-3420">http://games.dlink.com/products/?pid=383&amp;#DGL-3420</a>
Tiltek Antenna TA- 5404-8-90	1	\$250.00	<a href="http://www.tiltek.com/final/pdfs/TA-5404-8-90.pdf">http://www.tiltek.com/final/pdfs/TA-5404-8-90.pdf</a>

**Locomotion Mechanical**

MP-36064-545, 64:1 Drive Motors	2	\$80.30	<a href="http://banebots.com/osc/product_info.php?cPath=36_63&amp;products_id=230">http://banebots.com/osc/product_info.php?cPath=36_63&amp;products_id=230</a>
MP-36256-545, 256:1 Arm Actuation Motors	4	\$125.00	<a href="http://banebots.com/osc/index.php">http://banebots.com/osc/index.php</a>
AndyMark 6" Omni-wheel	4	\$168.00	<a href="http://www.andymark.biz/plastic-omni.htm">http://www.andymark.biz/plastic-omni.htm</a>
BANDO Synchro-Link, H-Pitch Belts with Custom Tread Teeth	6	\$240.00	<a href="http://www.lwbco.com/">http://www.lwbco.com/</a>
BANDO Synchro-Link, XL-Pitch Belts	14	\$70.00	<a href="http://www.lwbco.com/">http://www.lwbco.com/</a>
Aluminum Flanged Pulleys, H-pitch & XL-Pitch	48	\$300.00	<a href="http://www.sdp-si.com">http://www.sdp-si.com</a>
SAE-841 Bronze Bushings	16	\$20.00	<a href="http://www.mcmaster.com">http://www.mcmaster.com</a>
Fabrication Supplies and Labor	Var.	\$1,000.00	
Steel Axles			
Aluminum Plate			
3D Printed Parts			
Fasteners			
Misc. Supplies			

**Locomotion Control**

MicroMag 3-axis Magnetometer	1	\$55.00	<a href="http://www.sparkfun.com/commerce/product_info.php?products_id=244">http://www.sparkfun.com/commerce/product_info.php?products_id=244</a>
Spark Fun Electronics, Sense-IMU-203 Inertial Measurement Unit	1	\$125.00	<a href="http://www.sparkfun.com/commerce/product_info.php?products_id=413">http://www.sparkfun.com/commerce/product_info.php?products_id=413</a>
IFI Victor 884 Speed Controller	6	\$900.00	<a href="http://www.ifirobotics.com/victor-884-speed-controller-robots.shtml">http://www.ifirobotics.com/victor-884-speed-controller-robots.shtml</a>
US Digital E5S Optical Quadrature Shaft Encoder	4	\$47.00	<a href="http://www.usdigital.com/products/e6/">http://www.usdigital.com/products/e6/</a>

**Other Mechanisms**

LuxDrive BuckPuck 700mA Dimmable DC LED Driver 3021DE700	2	\$47.98	<a href="http://www.luxeonstar.com/item.php?id=862&amp;link_str=240::241&amp;partno=3021DE700">http://www.luxeonstar.com/item.php?id=862&amp;link_str=240::241&amp;partno=3021DE700</a>
Star Bright LED LXHL-LW6C	2	\$55.90	<a href="http://www.luxeonstar.com/item.php?id=378&amp;link_str=202&amp;partno=LXHL-LW6C">http://www.luxeonstar.com/item.php?id=378&amp;link_str=202&amp;partno=LXHL-LW6C</a>

**Total** **\$11,397.94**