Fuel Cells For Robots

Pavlo Rudakevych
iRobot
Product Needs

- Military/Police/Search and Rescue
  - PackBot
  - Gladiator
  - ThrowBot/UGCV

- Industrial and Oil
  - CoWorker
  - MicroRig
PackBot

- Mission capable robots
- Rugged, portable tools for minimal casualty engagements
- Assisting behaviors
- Small size and weight
System Concept
System Concept
System Concept Continued

- Modular payload bays
  - 3 primary
  - 1 head
  - 4 side pods
- Each payload socket supports
  - Ethernet
  - 2 Analog video inputs
  - USB
  - 2 serial ports
  - Raw power input/output
  - FARnet (low latency motor/sensor bus)
- Mission Specific Sensors/Effectors
System Concept Continued

• On-board functionality
  – Full Pentium III system
  – Accelerometers
  – GPS
  – Compass/Inclinometers
  – Health (temperature, current, etc)
  – Radio
  – Active power routing
  – Active power conservation
    • User or system specified conservation measures
  – Intelligent payload management
Packbot Capabilities

- Climbing/scrambling
- Rugged (survives drops of 3m)
- Expandable (payloads)
- Low profile (thermal, visible)
- Watertight to 3m
- Quiet
- Fast (4+ m/s)
Mission Sensors/Prototype Payloads
Power & Duration

- 230 Watt-Hours Capacity (2 NiCad packs)
- 3x with LiIon secondary, 5x Lithium primary (est)
- 16-30 Volts (24 nominal), 30amp fuse
- Payload Power Supplies Supported
  - Lithium
  - Fuel Cells
  - Hybrid power
- Using NiCad Packs
  - 2+ hours at 2.2 m/s (on-road)
  - 2+ hours at 1.5 m/s (off-road)
  - 12+ hours (sentry/monitoring duty)
- Each NiCad Pack about 6lbs.
Other MilSys

- **ThrowBot**: pocket sized, 1kg
  - 9-12V, 1-2A, 25WHr
- **Gladiator**: 800lb class
  - 2 kW continuous @48 Volts,
    - 5 kW peaks
  - total: 30 kWh over 24 hrs
  - One dimension <12"
- **Military front end**:
  - strip hydrogen out of diesel
MicroRig Overview

- MicroRig is a fully autonomous downhole robotic vehicle.
- Its purpose is to carry oil field sensors to the bottom of oil wells to take data critical for reservoir management.
- This information is very valuable to the oil companies in that if the reservoir is properly managed, more oil may be recovered at less cost.
- Currently sensors are carried down on ends of long cables or pushed down on the end of long flexible tubes.
Successful Return from 7000 ft.

Chain and Idler Close-up

MicroRig at end of run
Competitive Advantage Against Coiled Tube

• The MicroRig has the most competitive advantage in the newer non-vertical (highly deviated) wells. These wells have sections that are greater than 50 degrees from vertical.
• In these wells, gravity alone will not get the sensors to the bottom, so the old technology requires them to be pushed down on the ends of flexible coiled tube.
• These wells are 15 to 25 k ft deep. As a result, the spool of coiled tube is huge, not to mention the handling equipment to push the tube and the control van. For offshore wells, a coiled tube unit requires a barge for transportation.
MicroRig being lowered into well
No Need for Tube or Cable

- The MicroRig is fully Autonomous, so there is no need for connection to the surface.
- The MicroRig ships in two 7 ft long shipping cases that may be flown to the site on a helicopter.
- The MicroRig uses behavioral software to carry out the mission as well as health monitoring such as remaining battery capacity.
- The MicroRig currently uses 32 D-D lithium primary cells as its fuel source.
MicroRig Operation in Pressurized Well
Project Backing

- The MicroRig project currently receives fund from:
  - BP
  - Halliburton
  - Marathon Oil
  - Stat Oil
MicroRig Power

- Small Vehicle Specs:
  - Max Environmental Temperature: 125 deg C
  - Average Power: 200 watts
  - Peak Power: 300 watts
  - Voltage: 105 to 120V (200 V max)
  - Mission duration: 24 hrs ave (longer is better only draws 200 watts returning)
  - Min Capacity: 10 Mega Joule (10 * 10^6)
  - Max OD for Cell Packaging: 1.687"
  - Length: < 20 ft.
MicroRig Power

- Large vehicle Specs:
  - Max Environmental Temperature: 125 deg C
  - Average Power: 700 watts
  - Peak Power: 900 watts
  - Voltage: 150 to 200 V or higher
  - Mission duration: 24 hrs average
  - Min Capacity: 50 Mega Joule \((50\times10^6)\)
  - Max OD for Cell Packaging: 3.25”
  - Length: < 20 ft.
CoWorker
Coworker is:

- An internet connected remote presence robot.
- A revolutionary new form of worker to worker communication.
- A more cost effective way to closely link multiple worksites.
- A way to enable your best workers to be in two or more places at once.
- A new way to work...
CoWorker

- Digitally controlled pan/tilt/zoom camera -- Allows you to see the office from a whole new angle.
- High quality speaker and microphone -- Audio quality lets you carry on a conversation.
- Rugged platform that turns on a dime -- Highly maneuverable & easy to drive. Makes getting around the office easy.
- Ethernet 802.11 LAN radios -- Robust wireless communication.
CoWorker

- Bus Voltage 18 to 30V, 24 nominal
- 15AHr lead acid batteries
- 2.5A active non-driving current
- Max 10A continuous driving
  - fuzed
Review

• Military/Police/Search and Rescue
  – PackBot (scooter class)
  – Gladiator (bicycle class)
  – ThrowBot (cell phone class)

• Industrial and Oil
  – CoWorker (bicycle)
  – MicroRig (high temp, cyl form factor)