U.S. ARMY COMBAT CAPABILITIES DEVELOPMENT COMMAND – GROUND VEHICLE SYSTEMS CENTER

LINC and the GVR-BOT

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OUTLINE

- **Background**
- **Operation**
  - Power
  - Batteries
  - OCU software
  - Troubleshooting
- **Integration**
  - Mechanical
  - Electrical
  - Software
- **LINC Payloads**
- **Questions**

Background

BACKGROUND

- iRobot PackBot is an Army fielded small robot used primarily for IED interrogation
- 2 different generations
  - Obsolete 500 version
  - Current production 510 version

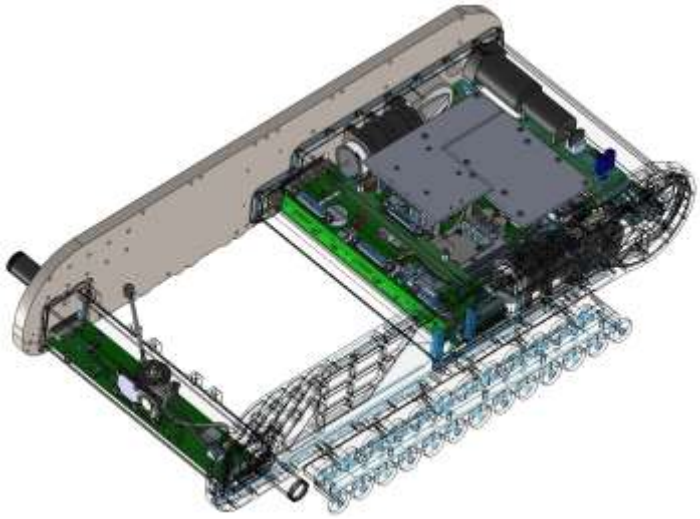
EOD

FASTAC

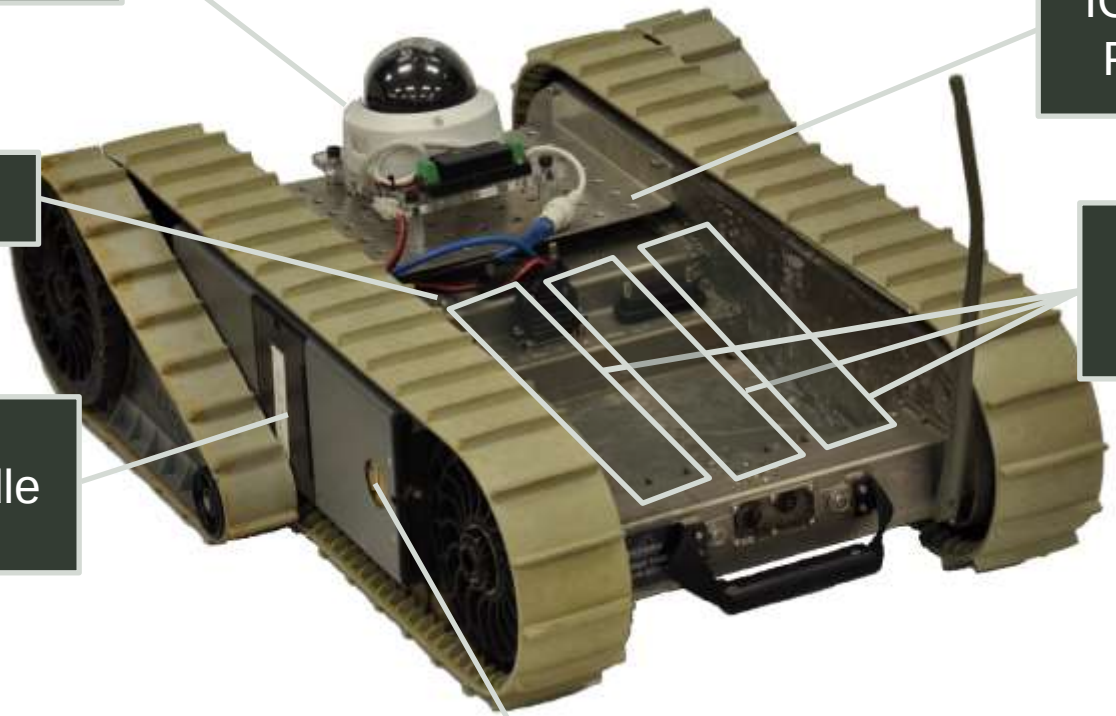
- Different payload configurations make the different models, same base chassis for both:
  - EOD: 3-link arm and fiber spooler
  - FasTac: CAM payload and SAM payload

GVR-BOT

- GVSC-GVR redesigned the PackBot in 2012-2013 to make a research platform called “GVR-BOT”
  - Replaced electronics and software with a ground-up design
  - Reused most mechanical parts
  - Open architecture
  - Design is completely government-owned
  - Designed for IOP V1 / AS-4 JAUS (Interoperability Profile) interfaces



BASE GVR-BOT ANATOMY



KEY FEATURES OF GVR-BOT GEN. 1.2

Weight (without batteries and flippers): 11.8 kg (26 lbs)
Size: 68.0 X 40.5 X 18.0 cm (26.8 X 15.9 X 7.1 in)
Tracked Flippers: 1.0 kg each (2.2 lbs) / **Untracked Flippers:** 0.4 kg (0.9 lbs) each
Top Speed: 2.0 m/s (4.5 mph)
Ambient Temperature Range: -20 to +50 C (-4 to +122 F)

Main processor

- Intel Atom E680T, 1.6 GHz
- 1GB DDR2 soldered RAM
- 3.6GB soldered NAND Flash

Power

- Up to four BB-2590 Li-Ion batteries (requires one battery cradle per two batteries)
- Base chassis consumes approximately 30 Watts when powered up and stationary

Payloads

- Four payload ports
- Three payload bays can physically contain existing, modified PackBot 510 payload tub sized modules
- Mounting rails for the fourth payload bay can be installed above the Front Electrical Housing (not included), if an IOP Mounting Plate is not installed

Communications

- Communicates with any Wi-Fi enabled computer at 2.4 GHz frequency
- Maximum communications range is ~250m
- Internal router separates internal network from external communications

Software Interface

- Designed to meet the IOP V1 standard, internally (between components) and externally (to OCU)

Sensors

- Internal Attitude Heading Reference System (AHRS) provides accelerometer, heading, and orientation information
- Internal GPS Transceiver with external antenna port – a SSMB Jack connection is needed to attach an antenna (not included)

Flippers

- Two detachable flippers may be included and can be rotated continuously in either direction (tracked and untracked flippers)

GVR-BOT CUSTOMERS

- **A partial list of GVR-BOT customers, past & present:**
  - ARL CISD and ARL VTD
  - US Military Academy (USMA) at West Point
  - Stanford Linear Accelerator Center (SLAC)
  - PM UGV – for the REP 16.1 and 17.1 programs
  - PM UGV – surrogate for the CRS(I) program to evaluate requirements
  - DARPA – HACMS (High Assurance Cyber Military Systems) program
  - ERDC – Geospatial Research Laboratory MOWLES project
- **At last count more than 52 different projects**

BENEFITS OF GVR-BOT

- Research for small robots can now be done on a common platform and shared easily across organizations

- **No Export License (ITAR) is required**

- All aspects of the design are configuration managed: mechanical models, electrical designs, all software source code, configurations, tools and issues tracking
- Platform runs ROS (Robotic Operating System) Indigo

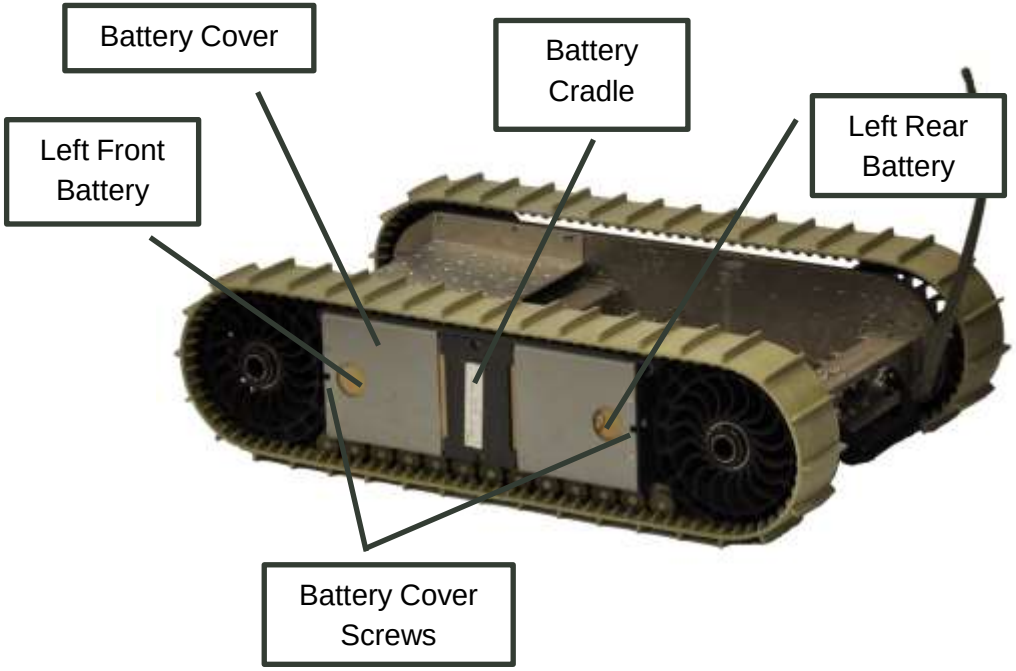
Operation

OPERATION

- **Batteries**
  - Installing batteries
  - Charging batteries
- **Power**
  - Power on / Power off
- **OCU software**
  - MOCU 3
  - ROS controller
- **Troubleshooting**
  - Blink codes
  - GDT

BATTERIES

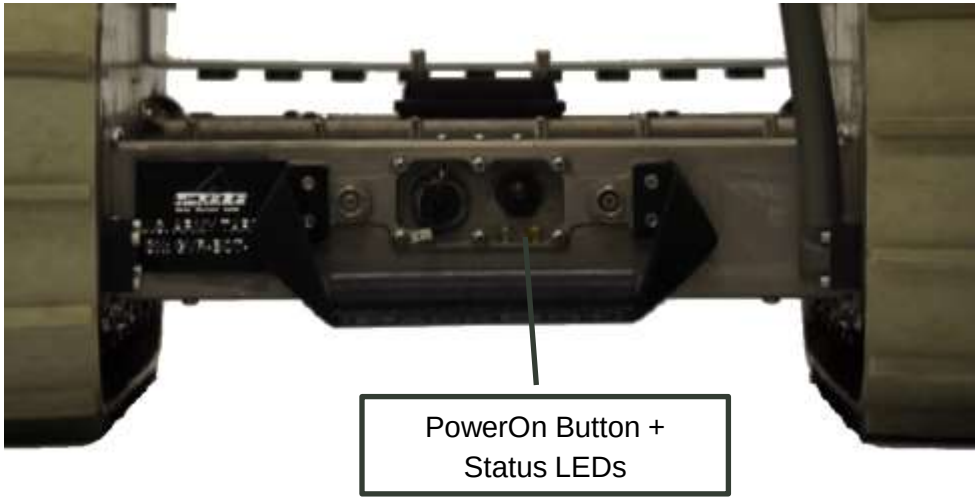
- **GVR-BOT operates using two (2) BB-2590 batteries**
  - Li-Ion rechargeable military batteries (6.8 ~ 9.9 A-h, depends on exact model)
  - To install, batteries are angled in toward the cradle and pushed into place
    - A lock system holds them in place when installed, but they can shake out over rough terrain
    - A Battery Cover can be used to ensure they stay in place under all conditions, but this requires a Phillips head screwdriver to back out two captive screws



BB-2590s

POWER

- With charged batteries installed, the robot is powered on by pressing the PowerOn Button located at the rear of the robot
- The robot should begin by flashing the Green Status LED
- After approximately 60 seconds, the Status LED should become solid green: the robot is now booted up and ready
- Power off by pressing and holding the PowerOn button for 5 seconds

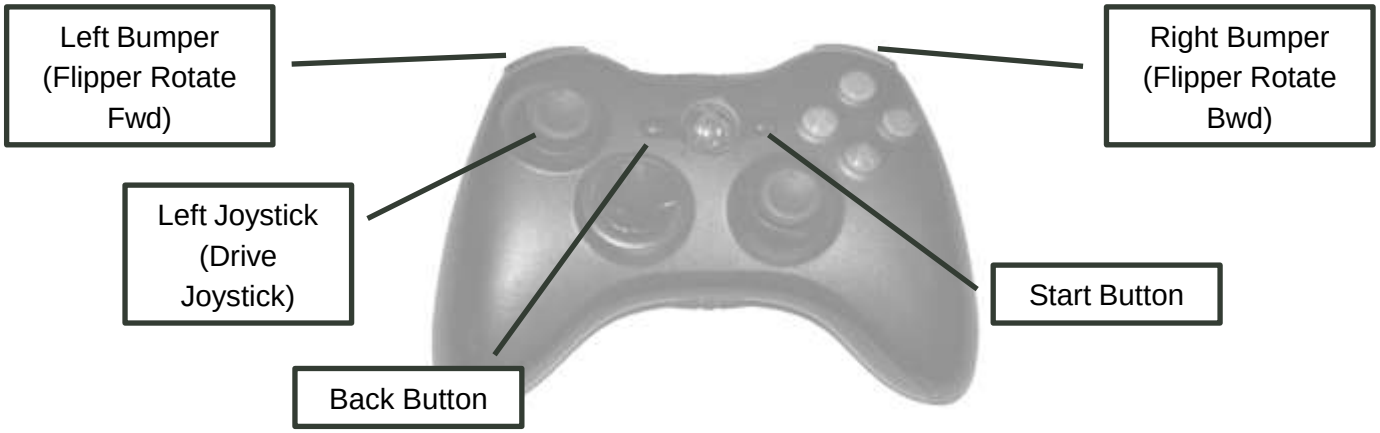


OCU SOFTWARE

- **OCU (Operator Control Unit) is hardware to control a GVR-BOT**
  - Laptop, tablet, phone, …
  - **OCU HARDWARE IS NOT INCLUDED WITH THE ROBOT**
- **There are two software packages provided to tele-operate the GVR-BOT**
  - MOCU 3 (Windows laptop only)
  - GVR-BOT software (Linux)
- **Xbox Handset is also included with the robot**
- **Installation instructions for both software sets are included in the User Manual**

OCU TELE-OP

- **Connect to the robot's wi-fi from your device**
  - Allow the DHCP on the robot to assign your device an IP address
  - SSID: look on the ID tag on the Rear Electrical Housing, something like "GVR-BOT-057"
  - Password is "modern0325"
- **Once connected, start your OCU software and plug in the Xbox handset**
- **Left joystick controls vehicle tracks to drive the platform**
- **The GVR-BOT OCU SW has an emergency stop feature implemented**
  - To immediately shut the robot power off via the handset, press down both the Back button and Start button simultaneously



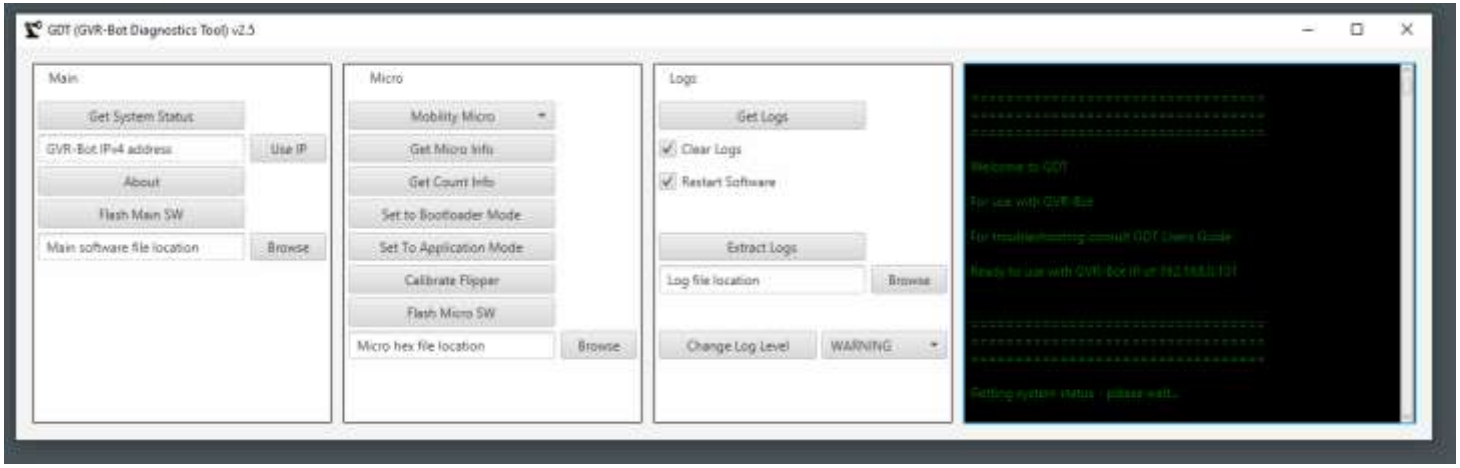
SOMETHING IS WRONG - WHAT NOW?

- **If your GVR-BOT has trouble, you will notice the status LED will no longer be solid green**
  - There may be other symptoms, like the robot no longer moving when commanded
- **Most problems are caused by cabling or connectors, but electrical hardware does fail as well**
- **The Status LEDs are your first indication of what is wrong**

Green Status LED State	Red Status LED State	Meaning	Troubleshooting
Blinking (2 Hz)	Off	Powering Up	Default state of robot is powered on, but not all software is running yet. If this state remains for more than 90 seconds, there is likely a communication issue between Main Processor and Power Mgt Board.
Solid	Off	Normal running operation	None.
Solid	Blinking (2 Hz)	Internal communication error	The main processor has lost communications with an internal component. More in-depth troubleshooting is required.
Fast Blink (5 Hz), alternating with Red LED	Fast Blink (5 Hz), alternating with Green LED	Internal communication error	Pwr Mgt board has exited application code and entered bootloader mode. More in-depth troubleshooting is required.

GDT

- GVR-BOT Diagnostic Tool (GDT) is included with the robot as well and can be used for more advanced troubleshooting (Linux and Windows)



- **If anything is wrong with your robot, please contact the GVR-BOT team**
  - We can help you with troubleshooting and possible fixes
  - If hardware or cabling is the problem, you'll need to send it back to us for repairs

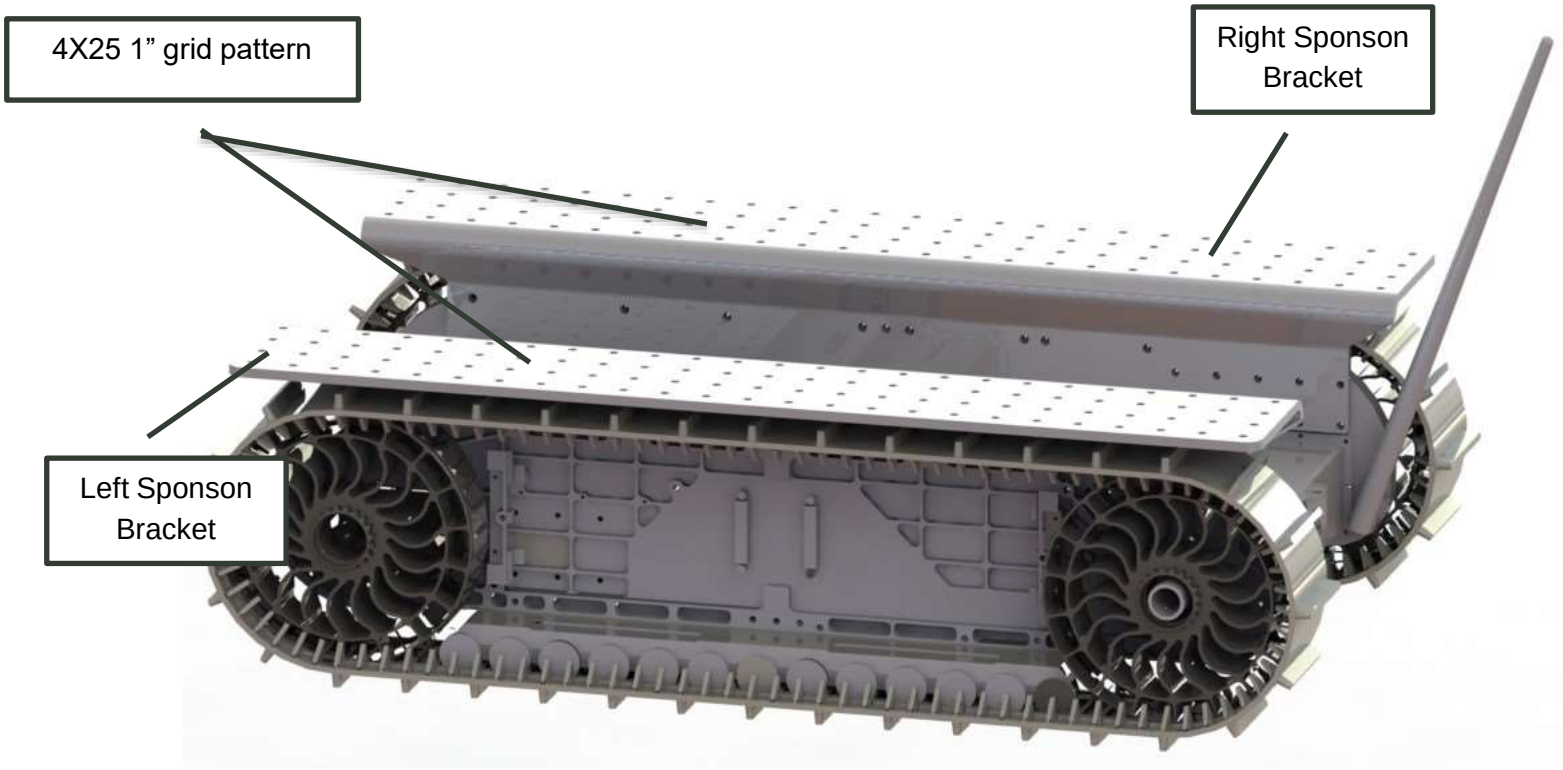
Integration

INTEGRATION

- **Mechanical**
- **Electrical**
- **Software**

MECHANICAL INTEGRATION

- **GVR-BOTs will be shipped with two sponson brackets**
- **¼-20 threaded holes in 4 X 25 pattern on each side**
  - 1” X 1” grid pattern
- **CAD for the robot and Sponson Brackets will be provided**



ELECTRICAL INTEGRATION

- **There are 4 payload connectors, each provides**
  - Raw battery power (25 – 34 VDC @ ~10.0 A)
  - Gigabit Ethernet
  - USB 2.0 (including 5 VDC @ 0.5 A)
- **Payload connectors are DB-25 connectors in a 17W2 pin configuration**

PAYLOAD CABLE

- **Two (2) payload breakout cables will be provided with the robot that convert the mating DB-25 connector into standard connectors for Ethernet, USB, and Power**
- **A wiring diagram & pinout is provided in the Users Manual if you wish to make more**
  - Parts are inexpensive, less than $30

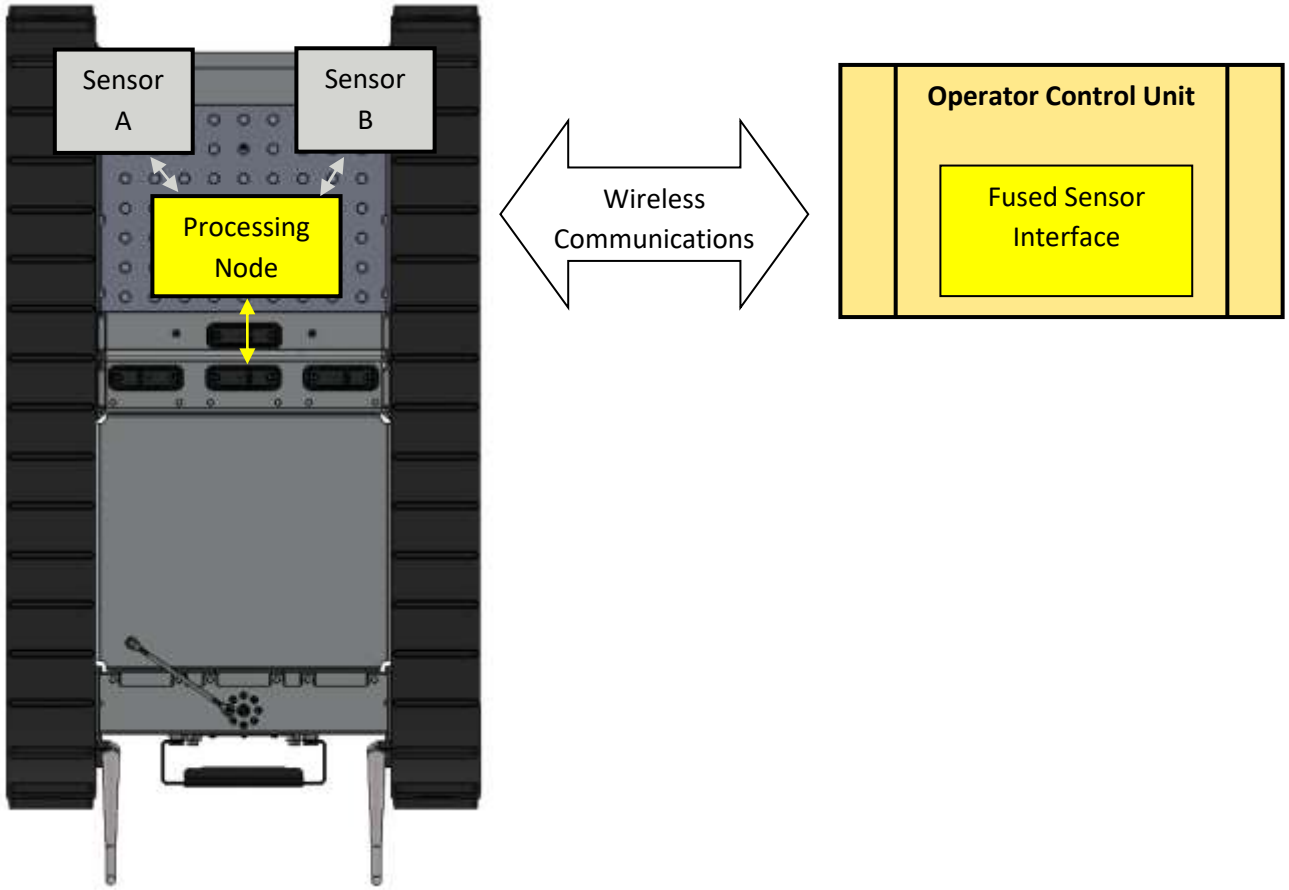
ADDING ELECTRONICS

- **It is not recommended to modify the platform's software**
  - If the OS or certain driver files are damaged, the robot must be disassembled to reflash
- **Preferred methods of control for LINC are**
  - Modify or create your own OCU software to send twist commands to the platform and receive feedback from the platform
  - Add an external processing payload and / or sensors to the robot using a payload port
    - These can be powered by the robot and communicate over the wired Ethernet, or they can have their own wi-fi

- **IMPORTANT: the robot's power source is not regulated and drops in voltage as the batteries are depleted**
  - Battery power could be between 34 and 25 VDC, with momentary spikes and drops (for example, when the motors are actuated)
  - **DC-DC converter in-line with the power is strongly recommended, properly sized for your hardware**

PREFERRED SYSTEM DESIGN

- **The recommended system design is shown below**
- **More details are provided in the GVR-BOT Users Guide**



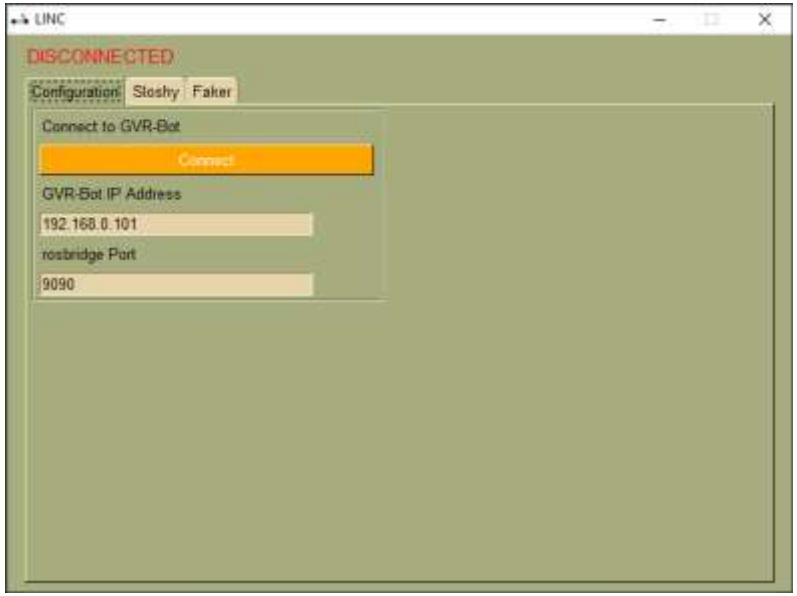
LINC Payloads

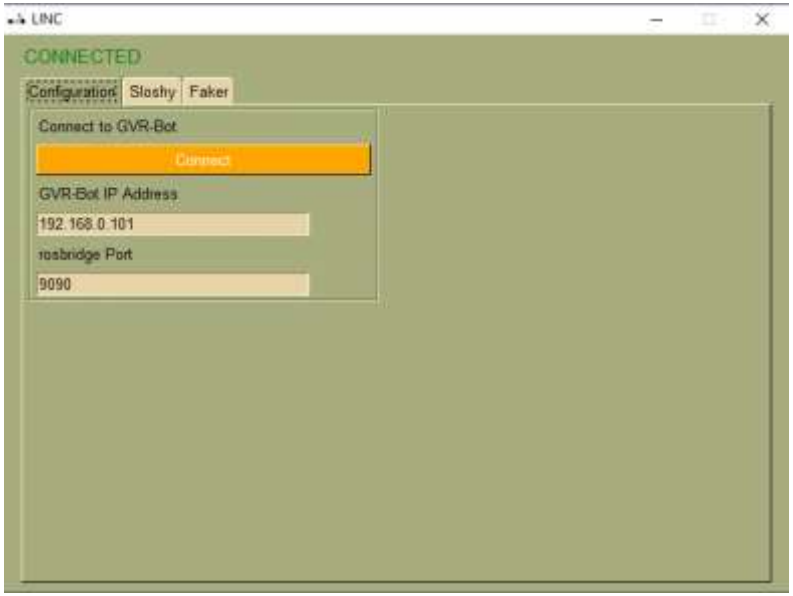
LINC PAYLOADS

- **LINC User Interface**
- **Sloshy Payload**
- **Sail Payload**
- **Faker (simulated faults & failure) software**

LINC USER INTERFACE

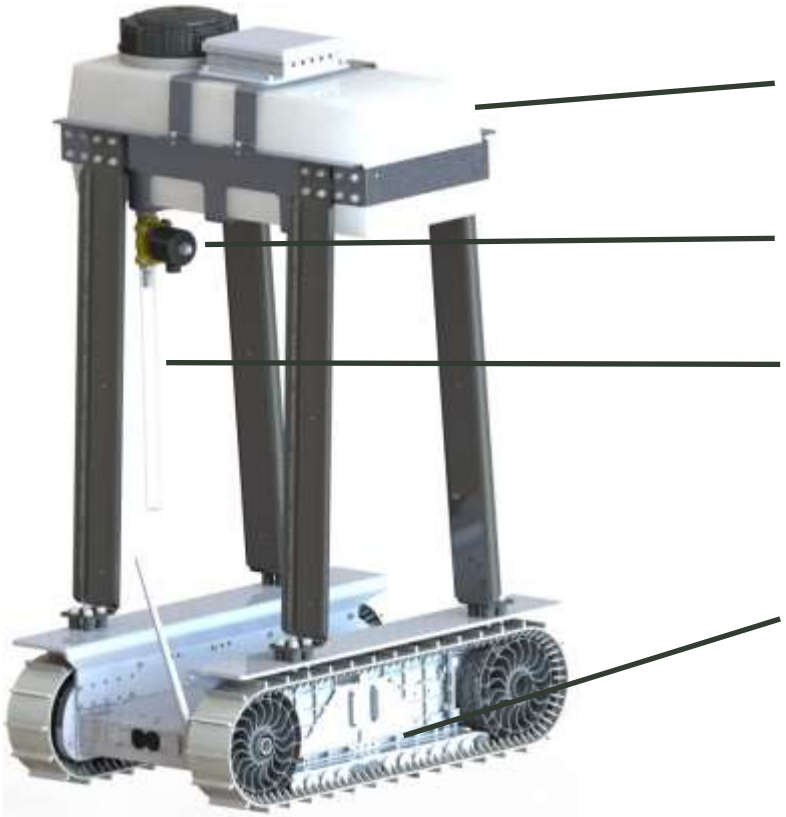
- **LINC Software is available for Linux or Windows**
  - Connects to the robot over wi-fi
  - Used to control the payloads
  - The default IP address and port is already set
  - Press “Connect” button to connect to the LINC software onboard the robot





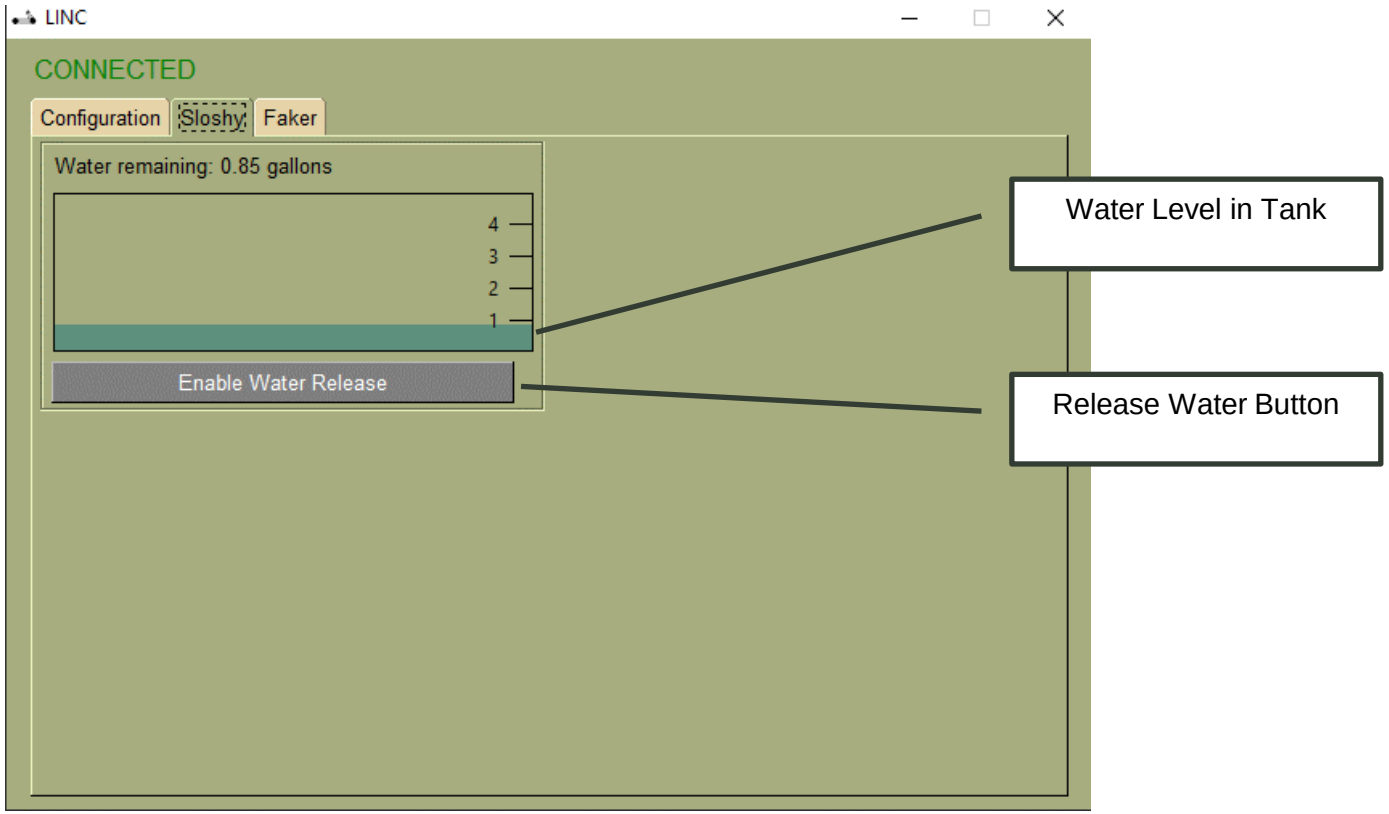
SLOSHY PAYLOAD

- **Four gallons of water sitting above the robot**
- **Remote actuated control valve to dump water during a test run and change the control characteristics of the system**
- **Water level sensor will keep a real-time estimate of water in the tank**



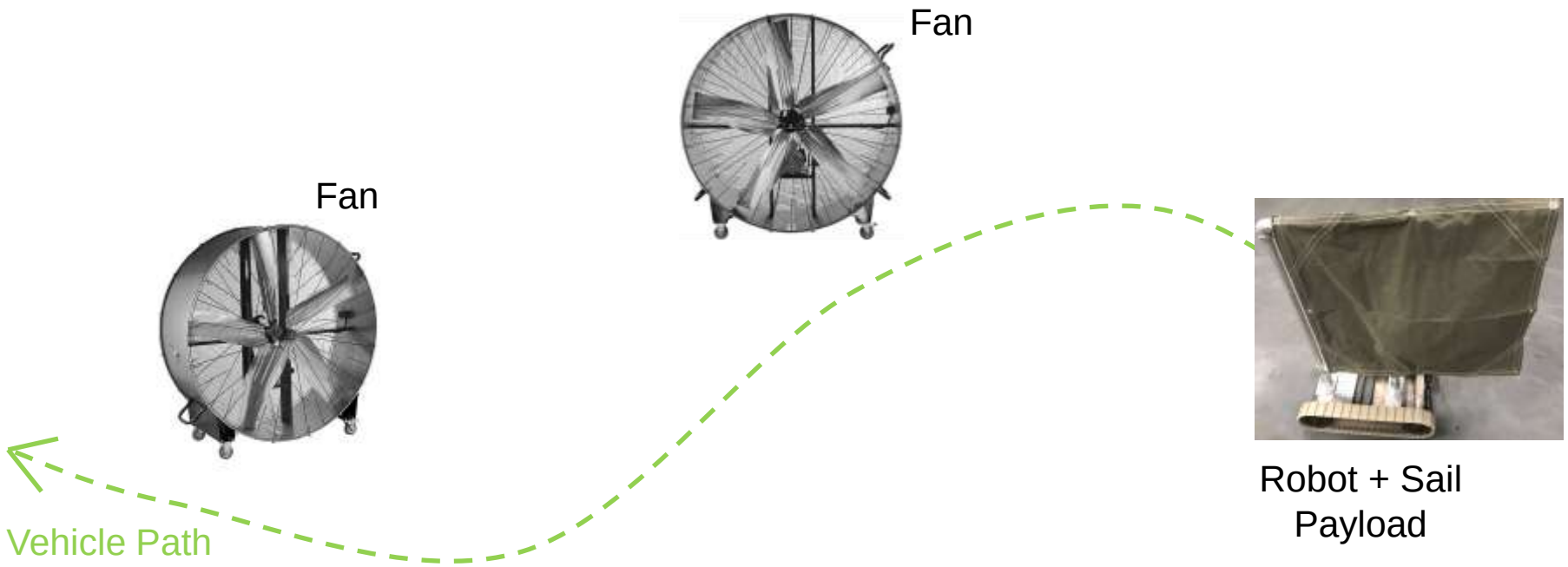
SLOSHY CONTROLS

- **Water can be dumped from the LINC User Interface**
  - Use “Enable Water Release” button
- **Real-time estimate of water level**



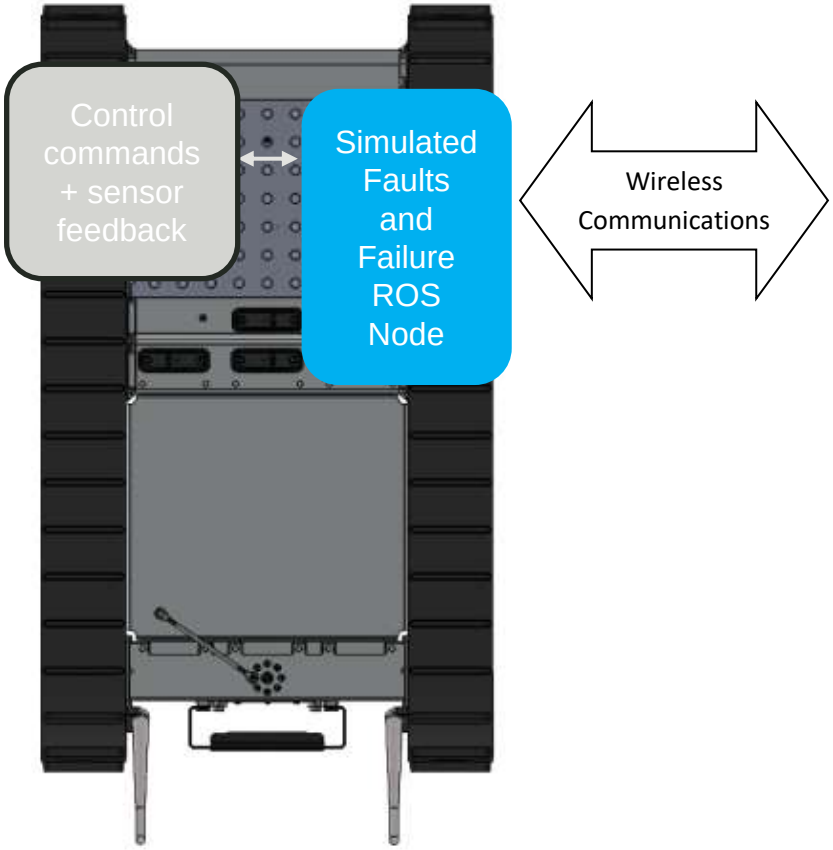
SAIL PAYLOAD – FIRST CONCEPT

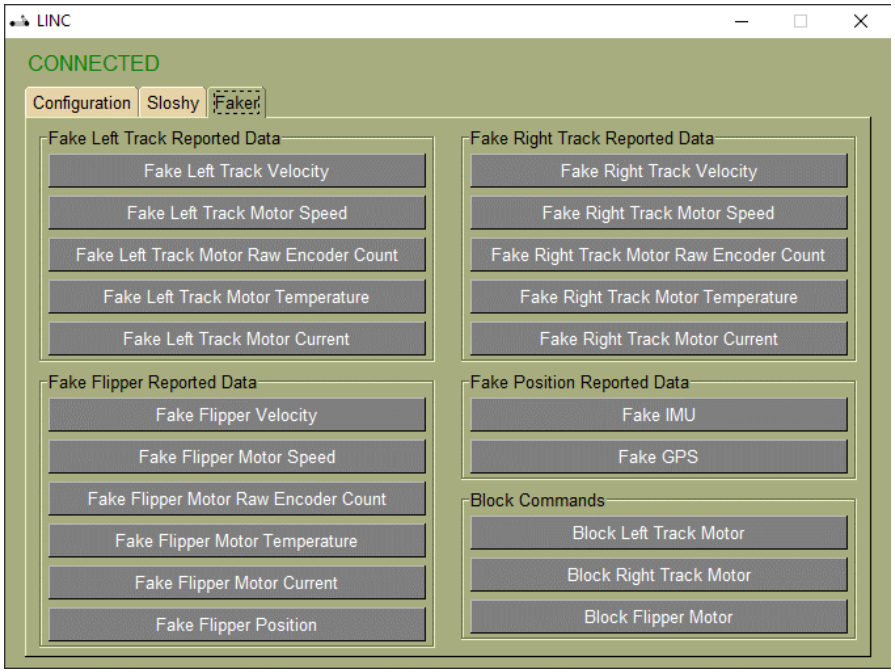
- **A large sail will be attached to the robot**
- **Barn fans along the test route will induce rotational and sideways motion in the vehicle as it is driven along**



SIMULATED FAULTS & FAILURE SOFTWARE

- **ROS node on the vehicle that can be sent messages to shut off sensor outputs or cause unexpected actuator “failures” (simulated, of course)**





Questions?

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Backup Slides

WHY NOT JUST USE PACKBOTS?

Design of the system is closed and proprietary
- Integration of new payloads and behaviors is difficult and costly
- Technical information is closely held by the supplier, even within their own company

The design is “semi-modular” – payloads can be installed to the base chassis, but they can only be installed in specific locations, and the system must have the proper software installed and configured with any new payload
- Not “plug and play”

PackBot platform is expensive to purchase and expensive to maintain

Reliability has been a challenge

The design hasn’t changed significantly in more than two decades