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CRY HAVOC AND LET $LIP THE BOT$ OF WAR

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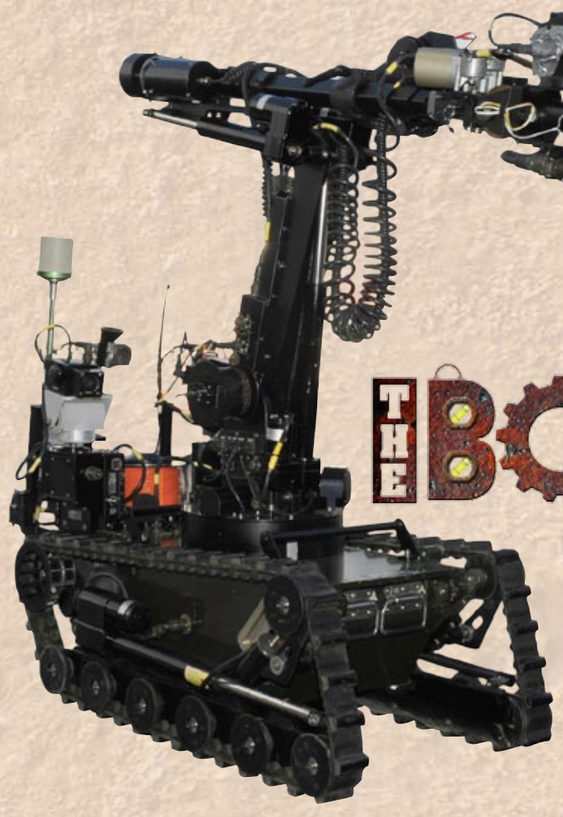


CRY HAVOC AND LET $LIP THE BOTS OF WAR

THE MOTHER OF INVENTION

Unmanned ground vehicles (UGVs) are products born out of the necessity to shelter and protect ground soldiers from the dirty and deadly hazards of war. UGVs operate without an onboard human presence and can be used for many applications where it may be inconvenient, dangerous, or impossible to have a human operator present. Generally, the vehicle will have sensors to observe the environment, and will either make autonomous decisions about its behavior or pass the information to a remote human operator up to 1,000 meters away from the action.

The UGV is the land-based counterpart to unmanned aerial vehicles and remotely operated underwater vehicles. Unmanned robotics serve civilian and military operations to perform a variety of mission-critical assignments. In remote controlled mode, all actions are determined by the operator based upon either direct visual observation or remote use of sensors and digital video cameras.

Military and civilian applications

Remote-controlled unmanned ground vehicles are used to enhance the safety and security of humans engaged in hazardous situations, such as disabling improvised explosive devices (IEDs). Currently, UGVs are being used in Japan to repair dangerous nuclear reactors damaged in the 2011 tsunami and still too radioactive to allow a human presence.

UGVs are also used extensively in ground surveillance, gatekeeper/checkpoint operations, urban street presence, and to enhance police and military capabilities in urban settings. Remote-controlled UGVs can "draw first fire" from insurgents—reducing military and police casualties. Robots of this type have been successfully deployed in rescue and recovery missions, such as in the efforts following 9/11.

A fully autonomous UGV is a robotic device that operates without the need for a human controller. Outfitted with a broad range of sensors and computer-controlled programming, the UGV uses its equipment to develop a limited understanding of the environment, which is then used by control algorithms to determine the next action to take in the context of a human provided mission goal. One example is the "follow-me" capability in which an RF beacon, carried by a soldier or mounting in a lead vehicle, is tracked autonomously by robots following at a predetermined distance.

Going where soldiers don't want to go: the Cobham Telemax UGV is designed for use in confined spaces and/or overcoming tall obstacles and varied terrain.

A fully autonomous robot may have the ability to:

- Collect information about the environment, such as mapping building interiors
- Detect objects of interest such as people and vehicles
- Travel between pre-defined waypoints without assistance
- Work for extended durations without human intervention
- Avoid situations that are harmful to people, property or itself, unless those are part of its design specifications
- Disarm, or remove explosives
- Repair itself without outside assistance

MILITARY ROBOT HISTORY

In the 1930s, the USSR developed Teletanks, machine gun-armed tanks remotely controlled by radio from another tank. These were used in the Winter War (1939-1940) against Finland and at the start of the Eastern Front after Germany invaded the USSR in 1941. During World War II, the British developed a radio control version of their Matilda II infantry tank in 1941. Known as "Black Prince," it would have been used for drawing the fire of concealed anti-tank guns, or for demolition missions.

In 1942, the Germans used the Goliath tracked mine for remote demolition work. The Goliath was a small tracked vehicle carrying 60 kg of explosive charge directed through a control cable. Their inspiration was a miniature French tracked vehicle found after France was invaded in 1940. The combination of cost, low speed, reliance on a cable for control, and poor protection against weapons meant it was not considered a success

For the most part, early efforts to develop remote-controlled weapons of war were focused on guided missile technology. Operation Aphrodite, for example, used stripped-out bombers filled with explosives to attack enemy bunkers and gun emplacements. The operation had a near perfect failure rate and caused more casualties to the test pilots than their targets. These primitive cruise missiles were not what you would call robots, but they represented the first steps toward controlling war machines remotely.

Although the US used remote controlled surveillance drones throughout the Cold War, the Israeli military pioneered the development of modern drone aircraft. However, it was the advent of the Global Position System (GPS) that signaled the true dawn of the Drone Age and the start of the UAV (Unmanned Aerial Vehicle) industry. With GPS, which became fully active in 1994, UAVs could be controlled from vast distances with remarkable accuracy. Today's drone pilots don't "fly" the aircraft by controlling individual flight surfaces. Instead, they assign GPS waypoints for the UAV to follow. The on-board computer handles flight control.

The G-NIUS Guardium MK1 is designed for routine programmed patrols and autonomous reaction to unscheduled events.

The widespread use of military robots in the wars in Iraq and Afghanistan came about due to a combination of technological and logistical factors. A mature and robust GPS system was crucial, allowing pilots to know where their drones were, and the drones to self-locate, at all times. Advances in battery technology increased the energy density of rechargeable batteries and reduced weight, allowing robots to deploy for longer operational periods.

Military robots don't conform to the sci-fi cliché of a walking humanoid machine. A robot's form factor depends on its specific function. UAVs obviously tend to resemble aircraft, and range in size from hand-launchable (like the Lockheed-Martin Desert Eagle) to Israel Aerospace Industries' 79-foot Eitan drone.

Many early US-made unmanned ground vehicles used treads instead of wheels or legs, giving them excellent maneuverability in difficult terrain. The extremely successful PackBot, made by iRobot, is a perfect example. We'll talk more about PackBot later, but it's basically a versatile treaded platform with an auxiliary set of treaded flippers that allow it to climb and right itself if capsized. Mesa Robotics' MATILDA is another example of a treaded military robot.

Some military UGV robots are, at least from a distance, indistinguishable from standard military vehicles. The difference is the potential for robotic vehicles to improve soldier safety and survival. The TerraMax system, is a massive six-wheeled truck that can operate autonomously. The Marine Corps has tested it with manned vehicles in convoys. Transporting supplies and troops has been a major vulnerability in Iraq and Afghanistan due to the use of roadside bombs, so remote control and automation of transport vehicles will continue to be a key focus of robot/remote control development efforts.

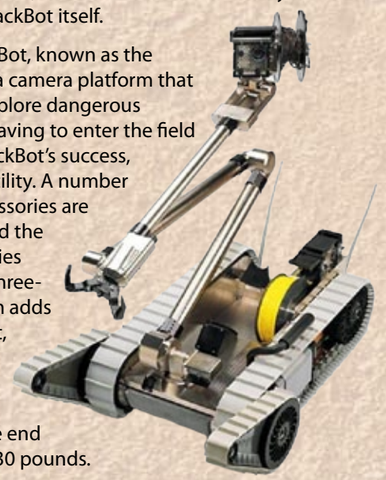
Forward-based Army and Marine reconnaissance teams have made good use of highly maneuverable and portable UGVs.

PACKBOT

Developed in the late 90s, early PackBots were used to search the ruins of the World Trade Center. Like most military equipment, PackBot has evolved and matured, becoming both more durable and more useful in its mission profile.

The current PackBot is the 510 model. It weighs roughly 24 pounds plus the weight of the batteries, light enough for a single soldier to carry it in a pack (hence the name). The control rig and other gear needed to use a PackBot weighs an additional 15 pounds. The PackBot's sealed hardcase has eight payload bays, GPS, compass, accelerometer, and inclinometer. Its top speed is almost six mph. A single set of lithium-ion batteries allows four hours of continuous use.

PackBot's uses a video game style hand controller, which transmits digital radio signals to the robot. The eyes and ears are provided by a set of high-resolution cameras and a two-way audio system, which allows the operator to both hear what the PackBot "hears," and issue commands to anyone who might be near the PackBot itself.



The most basic PackBot, known as the Scout, is essentially a camera platform that allows soldiers to explore dangerous situations without having to enter the field of fire. The key to PackBot's success, however, is its versatility. A number of add-ons and accessories are available that expand the basic unit's capabilities tremendously. The three-link manipulator arm adds 20 pounds of weight, but it adds over six feet of reach with an extremely agile gripping hand at the end which can lift up to 30 pounds.

PackBot can also be equipped with a suite of powerful sensors, including additional cameras and laser range-finders. A HazMat unit includes sensors that detect the presence of toxic or radioactive materials, while the EOD (explosive ordnance disposal) version of PackBot can detect, remove or defuse explosives. There's a lighter, higher speed version of PackBot, and even one that can zero in on snipers by acoustically analyzing gun fire.

PackBots have become such an integral part of soldier's lives fighting in Iraq and Afghanistan that the robots are given names, honorary ranks, and painted with hash marks for each device they successfully defuse, much like fighter pilots did in World War II. A PackBot named Scooby Doo was destroyed after 19 successful missions, and the soldiers in Scooby's unit were reportedly upset to lose their robotic companion. And no wonder—the explosion that destroyed the robot would surely have killed a human EOD tech.

RANGE OF APPLICATION

It's one thing to say, "Military robots do dangerous jobs so humans don't have to." That's a given. Military robots save lives. They can also boost unit strenght by freeing up troops for more important duties. Imagine a convoy of 30 trucks being driven by 30 Marines. Then think of all the things those Marines could be doing instead if the trucks could drive themselves.

To best understand the direction future robot technology is going to take, we have to look at the specific demands that will be placed on that technology and the trade-offs those demands will require. If we're designing a tank, we have to decide if it's going to be fast, efficient, heavily armored, or packed with technology. It can't be all four. Military robot

The Crusher is a 6,000 kg autonomous off-road UGV developed by Carnegie-Mellon University's National Robotics Engineering Center for DARPA. Optimized for rough terrain, the Crusher can easily overcome vertical walls, wooded slopes, and rocky creekbeds and carry 3,600 kg of armor and cargo.

design faces the same restrictions. Here are some of the capabilities military planners want in future robots:

Toughness – Military robots by nature operate in hostile environments. More robust systems allow UGVs to increase the percentage of time they are operational and increase the range of tasks they are capable of performing. This also means cutting down on operator and equipment failure. As of 2012, UAVs had the highest mishap rate of all planes in the Air Force, but that number has been steadily decreasing.

Efficiency – Most military robots operate on battery power, so increases in battery technology are a high priority. However, robots can also be made more efficient by reducing payload weights. Improving robot efficiency can lead to smaller maintenance crews supporting each mission, effectively freeing up these same soldiers for other work.

Autonomy – The first generations of military robots had little to no autonomy. They were all operated remotely by human controllers. Currently, most robots still act only when a human issues direct commands. However, autonomous operation is a major area of research—dependent upon improvements in sensors and the software that a robot uses to make decisions. Robots that can complete simple tasks on their own increase efficiency and in some situations can react more quickly and accurately than a human controller.

Interoperability – Ideally, multiple types of robots from different military branches should all be able to communicate with each other, creating a single cohesive network of information and command/control. This is why interoperability is a buzzword you'll hear a lot in current discussions of military robotics. Robots built on different platforms using different communication protocols can't share

Sandia Labs' Bob Anderson and robot "M2" at White Sands Missile Range

information or issue/relay commands to each other. Instead of a single network, you have a series of isolated nodes that require subsystems or humans to collect and analyze the data. Open architecture allows designers to share information and build robotic systems on similar platforms using compatible parts and connections, with identical communications protocols. Interconnects play a major role in interoperability. The right connectors can provide seamless communications between systems, harden systems against harsh environments and electromagnetic interference, and simplify operations for human controllers in the field. Currently communication standards vary among military branches and types of robots. Some use the JAUS communication standard, others STANAG 4586.

ROBOTS AT THE CUTTING EDGE

The field of military robotics is not standing still. New robots are being developed, some of them with amazing capabilities that will revolutionize the battlefield.

The new 710 Warrior robot is PackBot's bigger brother. It's similar in form to PackBot, but weighs between 300 and 500 pounds. It has a gripper arm that can lift more than 70 pounds and carry 300 pounds, with a grip strength of 700 pounds. It can handle a wide variety of battlefield conditions. While obviously not portable the way PackBot is, the 710 Warrior is taller, stronger, and more versatile. It even runs advanced 3D visualization software that helps the operator see where the robot, the arm, and the gripping claw are.

Guardbot is a rolling sphere that uses a pendulum to keep an internal spy camera steady. From its origins as a potential surveyor on Mars, it may end up serving with the U.S. Marines.

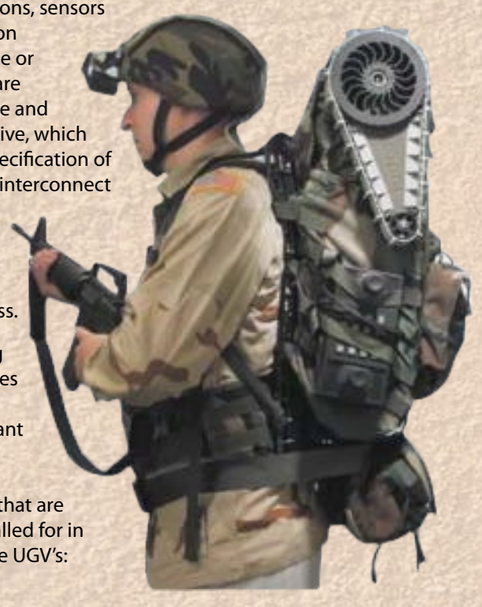
BigDog is a relatively famous robot, a four-legged walker that looks uncanny when it trots along uneven ground and negotiates difficult terrain. It's still a research project (partly funded by DARPA), but it has a lot of potential to serve as a pack mule and even a mobile weapons platform for future soldiers.

INTERCONNECTS AND UGVs

UGV designers, when evaluating long-term, total cost of ownership, as well as the demands of the application environment are compelled to specify high-performance interconnect technologies such as MIL-DTL-38999, The Series 80 Mighty Mouse or other military-grade connectors. These high-performance connectors offer UGV designers such tangible benefits as:

- Improved longevity of service
- Reduced installation and maintenance costs
- Reduced testing and qualification costs
- Improved reliability and safety

But since UGV battery life and range are such critical factors; and since truly "man-portable" vehicles are so important in tactical settings, unmanned system designers are also compelled to minimize interconnect weight and size to free-up "real estate" for vehicle payload technologies, communications, sensors and propulsion systems. Large or small, UGV's are inherently size and weight sensitive, which makes the specification of miniaturized interconnect technologies a critical element in the overall design process.



The following list summarizes some of the more important interconnect performance benchmarks that are commonly called for in military-grade UGV's:

Mechanical/Materials Packaging

- 300 g's Weapon Shock
- 20 to 30 g's Vibration
- Thermal Shock per EIA-364-32
- Operating Temperature Range: -55°C to +150°C
- Humidity (Condensation) Resistance
- Keyed High-Performance Contacts
- 22-28 Gage Signal Wire Support
- Up to 12 Gage Wire Support for Power/Battery Systems
- Power, Signal, Coax Layouts

Electrical

- 500 Volts DC
- Minimum 3 AMP Current (Continuous Rating)
- Up to 23 AMP for Power Contacts
- Low Shell-to-Shell Resistance
- Shielded/Grounded
- Compatibility with Balanced Impedance/ High Speed Signals
- Up to 65 dB at 1 MHZ EMI Shielding Effectiveness

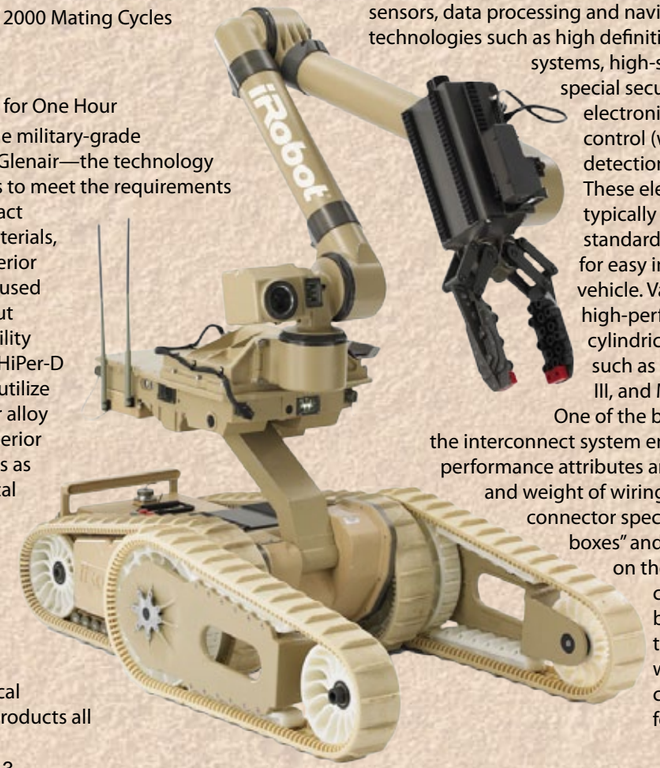
Environmental

- MIL-STD-810F
- Durability: In Excess of 2000 Mating Cycles
- Field Cleanable
- Chemical Resistance
- Immersion: One Meter for One Hour

The core technology in the military-grade connectors produced by Glenair—the technology that enables the products to meet the requirements listed above—is the contact system. Superior base materials, superior plating, and superior fabrication processes are used in the contacts throughout all of Glenair's high-reliability connector products. Our HiPer-D connectors, for example, utilize heavy gold plated copper alloy contacts that provide superior performance in such areas as mating durability, electrical performance, resistance to fretting corrosion and intermittence due to vibration and shock. Our Series 80 Mighty Mouse connectors, Series 89 Nanominiature connectors, and our tactical fiber optic interconnect products all utilize superior contact materials and designs. Incorporated into precisely engineered connector housings, these contact systems insure reliable performance in harsh mechanical, electrical and environmental applications.

Extremely small UGVs are good examples of systems that require design attention to every aspect, including the size and weight of printed circuit boards, connectors and enclosures.

The electronic sub-systems of a typical military-grade UGV served by interconnect cabling include: battery controls, sensors, data processing and navigation, and payload technologies such as high definition infrared camera systems, high-speed image processing, special secured data communication electronics, targeting and fire control (weapons) systems, mine detection, sonar, radar or radios. These electronic sub-systems are typically equipped with military standard receptacle connectors for easy incorporation into the vehicle. Various configurations of high-performance rectangular and cylindrical connectors are specified, such as the MIL-DTL-38999 Series III, and MIL-DTL-83513 (Micro-D).



One of the best opportunities for the interconnect system engineer to improve key performance attributes and/or reduce the size and weight of wiring systems, is to influence connector specifications on payload "black-boxes" and other electronic equipment on the vehicle. Appropriate connector choices on the box will allow the engineer to specify reduced size and weight cable harness, printed circuit boards and enclosures for the many sub-systems.

THE TAXONOMY OF AN UGV

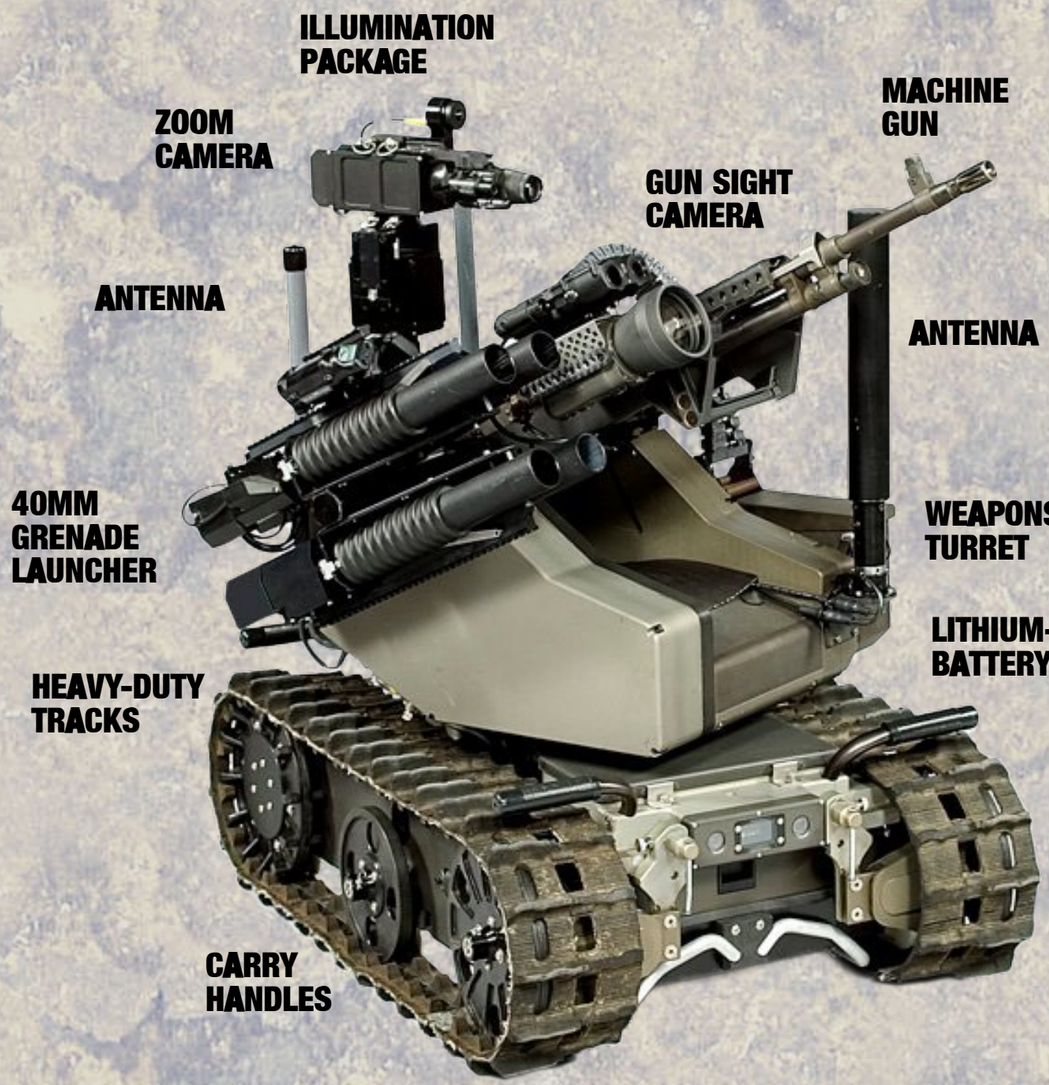
Small UGVs, with their range of application formats, have been the workhorses of unmanned soldier systems, markedly enhancing the impact and role of individual soldiers both when operated as remote controlled devices or in autonomous mode. Typically run on battery power and designed to be man-portable, small UGV's such as the iRobot PackBot are equipped with miniaturized sensors, manipulators, battery power, video and even audio capabilities. Designed mainly for surveillance and reconnaissance, ruggedized robots of this type have already been used in the thousands in Iraq and Afghanistan and have been integral elements in NETT Warrior and legacy future soldier platforms.

UGVs sensors enable the robot to catalog its environment and make basic decisions on surmounting obstacles as it makes its way to a pre-programmed string of way points. Tactical UGVs are generally equipped with a combination of light direction and ranging sensors, called LIDAR as well as miniaturized video cameras, infrared camera, and collision-avoidance radar. LIDAR sensors aid the UGV in creating a 3D picture of the surrounding environment for the purpose of obstacle avoidance and as a guide to assist the robot in returning to its prescribed path after a divergence.

Getting from here to there is the most basic requirement of an UGV. But the real business of these tactical military robots is to aid in the collection of intelligence and reconnaissance data and to pass that information on over a secure internet. To this end, UGV's are equipped not only with tactical payloads that include laser-equipped range finders, laser targeting, video and still cameras, mechanical arms capable of lifting and carrying small objects—such as a C4 charge to detonate an IED.

All the capabilities described above take power—from motive power to operational power for system payloads and data communications. The provision of adequate power is a systemic issue in every battery powered UGV. That UGV's have an operational range limited by its battery life is both a challenge and opportunity for makers of lightweight battery packs and re-charging systems. This is particularly the case when you consider the UGV is just one component in a lager suite of ground soldier electronic gear that also has considerable power requirements.

Much is made of the potential for military robots to be weaponized for operation in combat. Several larger format UGVs, such as the Foster-Miller SWORDS platform and next-generation MAARS (Modular Advanced Armed Robotic System), also from the Foster-Miller group, now part of QinetiQ add both non-lethal and lethal force to the payload of the tactical UGV.



QINETIQ MODULAR ADVANCED ARMED ROBOTIC SYSTEM (MAARS)

QinetiQ MAARS non-lethal weaponry includes mounted loudspeakers, high-powered pulsing laser, 40mm non-lethal ammunition (including bean bags, smoke, star clusters and pepper spray). For lethal action, the remote-controlled MAARS can launch 40mm HE grenades or fire its 7.62mm machine gun.

THE ROBOT BATTLEFIELD

What might the battlefield of the future look like? Here's a hypothetical situation. In this scenario, you have a primary base and a forward base 10 clicks away. The road to the forward base passes through contested territory.

Both bases are patrolled by robotic sentries. Using visual, FLIR, and acoustic sensors, small tracked robots move through randomized patterns to prevent enemies from spotting a pattern. Above, quadrotor robots hover in key locations, keeping a watchful eye on areas below as well as watching for incoming aerial attacks. Meanwhile, nano-sized robots search the perimeter of the base, repairing damage and sniffing for planted explosives.

On the road to the forward base, a convoy of autonomous trucks cruise in close formation. Above, an automated helicopter looks ahead to spot blockages or enemy troops before the trucks can see them.

At the forward base, the sentry bots detect an attack. An explosion at the perimeter wall knocks several robots off line, but other robots quickly rush in to fill the gap. They detect an enemy tank platoon approaching the forward base.

The key here is not simply that robots are guarding the bases and driving the trucks. What happens next is all of this information is immediately available to every robot in the system. Before a human operator could even parse the situational details of the battlefield, the robots react. The trucks slow (but don't stop) while the helicopter moves ahead. An on-board computer analyzes the data and identifies the tanks as enemy combatants. A signal is sent to a drone aircraft that's been cruising at high altitude. It descends and fires several Hellfire missiles at the tanks, delaying their attack on the forward base.

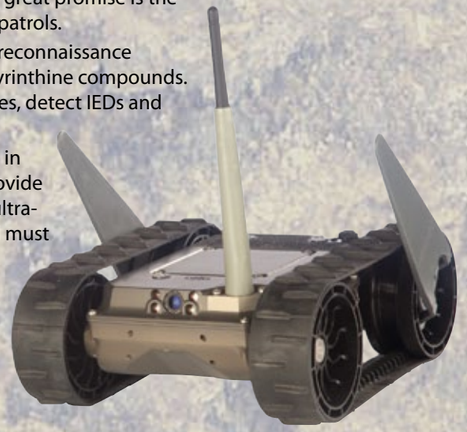
None of this has removed the need for humans on the battlefield, of course, but in the moments it took for this action to evolve, pilots were scrambling jets and preparing to defend the base. Using the network of robots as their eyes and ears, the unit's commanders knew everything the robots did—where the enemy was, what kind of equipment they had, how many of them had been damaged, and even what direction they came from.

This scenario shows why interoperability is so crucial. All of these robotic systems need to communicate instantly to share information and create total battlefield awareness. Beyond communications, standardized connections and cabling systems will increase efficiency. Tomorrow's military robots will come in a targeted range of types and sizes—from throwbots used solely for surveillance and reconnaissance to large, multi-functional vehicles engaged in both transport as well as tactical operations.

RISE OF THE THROWBOTS

Modern ground warfare requires anticipation of roadside bombs, improvised explosive devices (IEDs) and land mines. Remote detonated and pressure triggered IEDs have a kill rate of 40% and a very high rate of amputations. Military leaders sought effective counter measures to protect ground troops. One such method showing great promise is the small, throwable robot and its robotic surveillance system used to augment foot patrols.

Troops face significant challenges in urban warfare, including the difficulty of reconnaissance when buildings feature high, impenetrable mud and brick walls surrounding labyrinthine compounds. Effective use of throwable robots can help illuminate the layout of enclosed spaces, detect IEDs and determine if a person is a friendly soldier, a civilian or an enemy.



Typically weighing less than two pounds, a throwable robots can be deployed in seconds and its video surveillance and sophisticated listening capabilities can provide immediate intelligence to ground troops in urban warfare environments. These ultra-small reconnaissance robots are built for durability and ease-of-deployment, and must be capable of withstanding long distance throws and drops into varied terrain such as a partially destroyed building. Throwable robots are typically equipped with IR optical systems and wireless datacom transmit/receive capabilities. Operators utilize hand-held control units for immediate access to both audio and video output.

The iRobot 110 FirstLook is an ultra-small and lightweight throwable robot designed to provide immediate situational awareness as well as persistent observation in both open terrain and confined spaces. Weighing in at under two pounds, the lithium-ion battery powered FirstLook provides up to six hours of operational endurance and can move at speeds up to 1.5 meters per second. Multiple built-in cameras with zoom features and IR illumination deliver situational video output. The iRobot FirstLook is also equipped with a standard Picatinny rail mount for optional integration of additional sensors or cameras.

MacroUSA Armadillo V2 throwable micro unmanned ground vehicle (NUGV) tactical robot is one of the smallest, lightest and most rugged NUGVs on the market.

ReconRobotics Recon Scout IR tactical robot designed for tactical and SWAT applications, the man-packable and throwable MUGV is equipped with thermal/IR imaging and video broadcast capability.

Throwbot XT from ReconRobotics A video *and* audio reconaissance robot with IR video and throwing handle, shock-tested to 120 feet.

The ECA Inbot is controlled with a PDA or tablet PC and joystick. It is equipped with up to two hours of battery life and a ± 90° rotary head with color day/night as well as infrared video.

Le petit robot Nerva de Nexter est conçu pour évoluer en tout-terrain et sous conditions climatiques difficiles, à la vitesse d'un fantassin au pas de course.

Inspector Bots Toughbot is designed for reconnaissance, security and surveillance. This lightweight UGV features a wide-field video camera, zero turning radius, and an integrated carry handle.

MULES: ROBOT BEASTS OF BURDEN

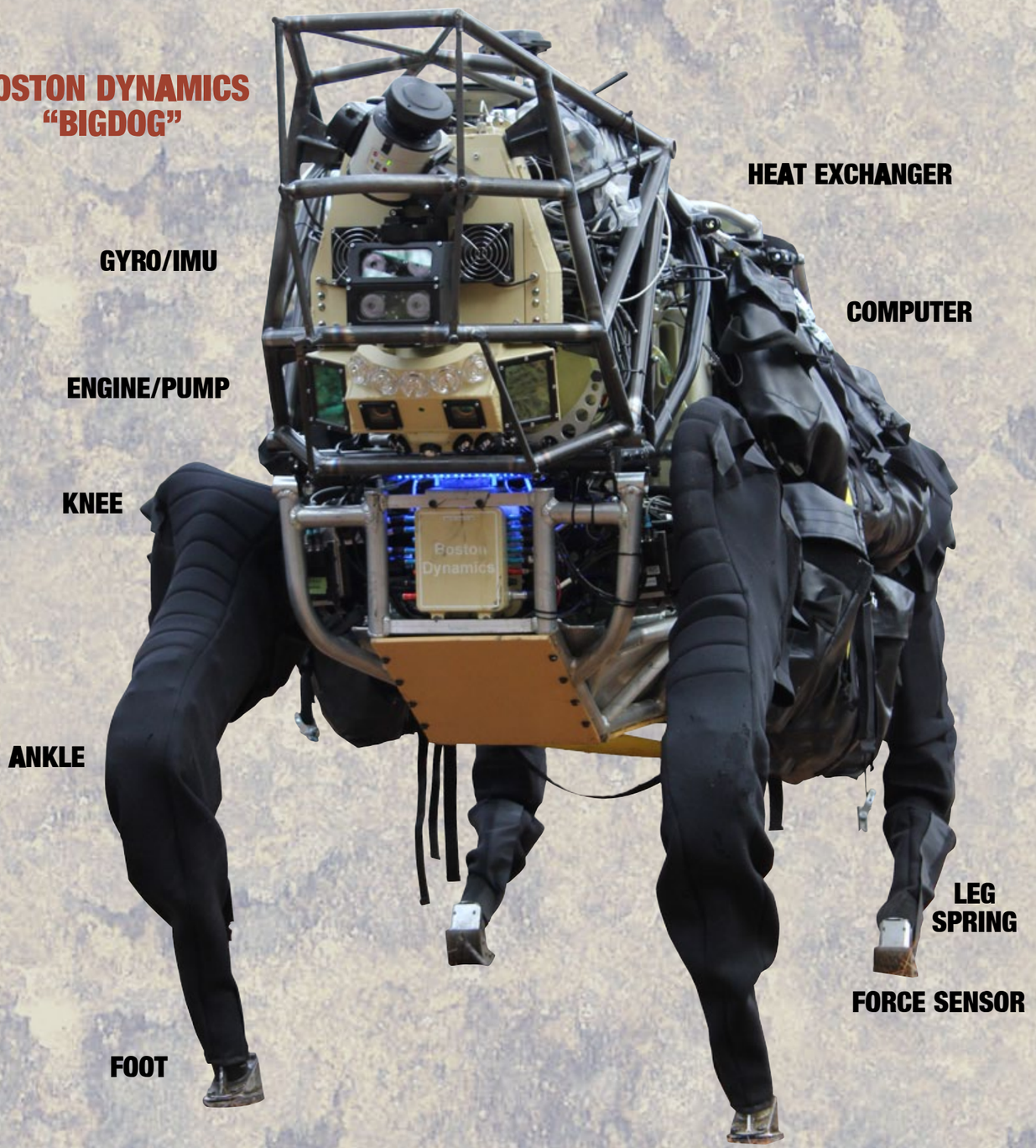
Robotic mules are designed to carry loads for ground troops in support of tactical missions. One of the most advanced US-based projects is the DARPA-sponsored Legged Squad Support System (LS3). Built by Boston Dynamics, and nicknamed "BigDog," the LS3 carries 400 pounds of warfighter equipment, walks 20 miles at a time, and acts as an auxiliary power source to recharge troops' battery-driven devices. Mules can solve the very real problem of transporting the sizeable load of equipment required to wage modern warfare.

The LS3 has sensors to enable autonomous navigation around obstacles during daylight or at night. It can also respond to voice commands, determine distances and directions, and distinguish between types of vegetation and terrain.

In late 2012, the LS3 underwent two weeks of field testing as the first in a series of trials which could lead to a place in the Marine ground arsenal within a couple of years. Ultimately, the goal is for the LS3 to act like a well-trained (autonomous) pack animal so that troops will not have to spend valuable resources "driving" the robot.

More conventional mules resemble standard off-road vehicles or trucks or the ubiquitous armored HUMVEE. Outfitted with ample room for the transportation of weapons, ammunition, communications gear, water, food and other essential supplies, autonomous or semi-autonomous robotic vehicles may play an increasingly important role in ground warfare, given that today's modern soldier is now called upon to carry a huge burden into battle—sometimes in excess of 140 pounds.

The Mira MACE 2 (Mira Autonomous Control Equipment 2) is designed for load carriage, IED disposal, casualty evacuation and perimeter control. The autonomous controlled vehicle is equipped with a land rover caliber power train and transmission to enhance speed and load-carrying capacity.



The IAI Rex Field Porter is an autonomous "follow me" vehicle, designed to support infantry units with up to 400 pounds of equipment and supplies.

Lockheed-Martin Squad Mission Support System (SMSS), designed for transport and logistics support, is the largest UGV ever deployed with US forces.

The Thales R-Trooper is a 6X6 wheeled, multipurpose UGV designed for area control, perimeter surveillance, and IED clearance, and can transport multiple small UGVs.

Kinder, Gentler Robots

Search and Rescue

Search and rescue robots, such as the "survivor buddy" shown here—a technology development project funded the National Science Foundation and researchers at Stanford University and Texas A&M—are optimized for human interaction through the use of attributes deemed soothing and supportive of individuals in high-stress rescue scenarios. The Survivor Buddy incorporates simulated eye-contact, music and other social graces to reduce stress and prevent shock in victims.

Firefighting

QinetiQ's Firefighting robots are employed by the London Fire Brigade to fight fires in dangerous conditions.

Mine Rescue Robot

Developed at Sandia Labs, the Gemini-Scout Mine Rescue Robot is equipped with gas and thermal sensors and the strength to drag a wounded miner to safety.

Vehicle Checkpoint Inspection

Spector is an innovative under-vehicle inspection system designed by Autonomous Solutions, Inc. (ASI). The versatile robot is designed to perform under-vehicle visual inspections to ensure safety at border crossings and customs stations.

Agricultural / Farming

As robotic technology spreads from homes to offices to factories, a logical step is to design robots to assist humans in agriculture. Crop-scouting robots like AgBo, developed by guest professor and researcher Yoshi Nagasaka at the University of Illinois' department of Agricultural and Biological Engineering utilizes laser scanning for guidance, and sophisticated steering mechanisms to navigate through crop fields—reporting soil conditions and alerting farmers of problems like weeds or insect infestations. Multiple wheel sizes have been tested for both dry and wet soil conditions. The experimental robot weighs in at 165 lbs., and is programmed to operate autonomously, or via remote control.

Domestic Robots

Samung's new Smart Tango Corner Clean robotic vacuum is equipped with unique oscillating brushes that extend beyond the cylindrical vacuum to suck up spills and debris from hard-to-reach corners. The advanced navigation system incorporates mapping technology, which records an image of the area before cleaning. The image is used as a virtual map of the cleaning zone for purposes of calculating efficient routes and ensuring all areas are methodically cleaned.

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gasp

gasp

Gun Jr.

One Another

One Another

One Another

One Another

One Another

One Another

ANSWERS: www.glenair.com/qwikconnect (available August 15th)

QwikConnect

UGV LINE CARD

High-Reliability/Lightweight Interconnect Solutions for Unmanned Ground Vehicles

GLENAIR CAPABILITIES:

From discrete components…

…to turnkey assemblies

DESIGN GOALS:

- Optimize interconnect system reliability
- Ensure electromagnetic compatibility and environmental sealing
- Reduce weight through miniaturization and material selection
- Reduce assembly labor and maintenance
- Maximize high-speed data throughput and bandwidth

Glenair®

For more information contact Glenair at **818-247-6000** or visit our website at **www.glenair.com**
U.S. CAGE code 06324

UGV LINE CARD

High-reliability/lightweight interconnect solutions For Unmanned Ground Vehicles

SELECTED CATEGORIES OF GLENAIR INTERCONNECT TECHNOLOGIES WITH PROVEN PERFORMANCE ON UNMANNED GROUND VEHICLES

INTERCONNECT SOLUTIONS

Series 970 PowerTrip™

Series 80 Mighty Mouse (low-profile Cobra shown)

Series 88 SuperFly™ connectors

SuperSeal™ RJ45 and USB field connectors

Fiber Optics

Series 79 Micro-Crimp

Series 28 HiPer-D High Performance M24308

Micro-D and Nanominiature

INTERCONNECT ACCESSORIES

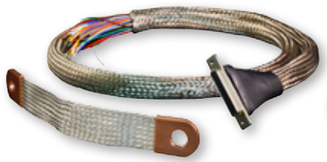
Band-Master™ ATS Advanced Termination System

Molded shapes and shrink boots (shielded piggyback boot shown)

Swing-Arm backshells with and without shield socks (shown with Do-Drop-In fitting)

440-069 aluminum and stainless steel banding adapters

WIRE PROTECTION SOLUTIONS



Lightweight EMI/RFI braided shielding and ground straps

TurboFlex High-Durabiltiy/ High Flexibility Power Cable

Tubular braided Fabric sleeving (fiberglass shown)

Easy-to-assemble conduit wire protection tubing and fittings

SERIES 970
PowerTrip™

The power connector for extreme environments

Lightweight plug with ratcheting coupling nut and LouverBand contacts

Keyed receptacle with superior sealing and EMI shielding

- **Fast, easy mating with triple-start ACME thread: 360° turn for full mating**
- **Reduced size and weight compared to MIL-DTL-5015**
- **LouverBand sockets for improved current ratings and longer life, up to 2000 mating cycles**
- **Splined backshell interface for improved backshell attachment and EMI shielding**
- **Ratcheting coupling nut for secure mating**
- **Operating temperature -65° C to +200° C**

MIL-DTL-5015 contact arrangements

+

MIL-DTL-38999 triple-start coupling

+

MIL-DTL-28840 splined backshell interface

=

Series 970 PowerTrip™

Series 970 PowerTrip™ Connector Styles

Plug
970-001

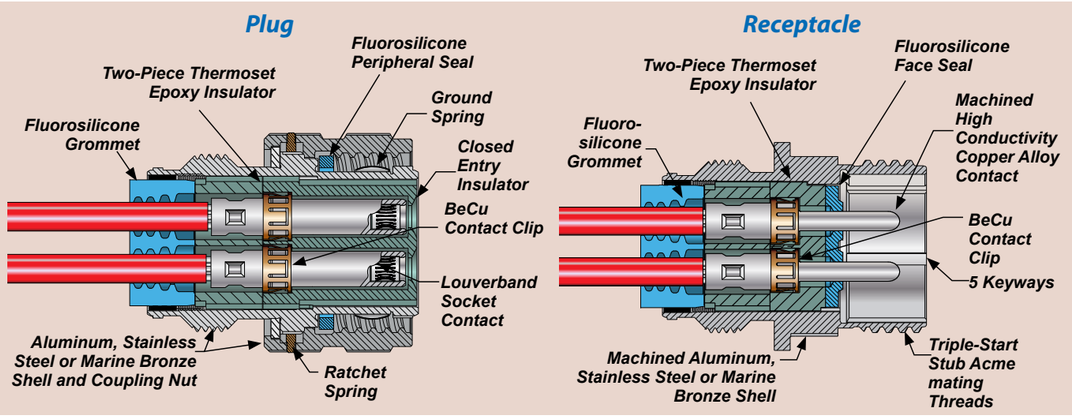
Square Flange Receptacles
970-003

Jam Nut Receptacles
970-004

Cable Receptacles
970-005

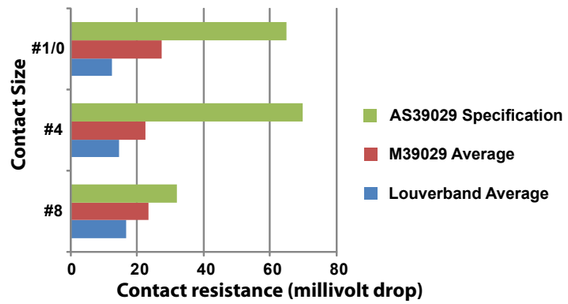
Feed-Thru Bulkhead
970-006

Hermetic Feed-Thru Bulkhead
970-007



Series 970 PowerTrip™ Specifications	
Current Rating	Up to 225 A.
Dielectric Withstanding Voltage	2000 VAC
Insulation Resistance	5000 megohms minimum
Operating Temperature	-65° C. to +200° C.
Shock	300 g.
Vibration	37 g.
Shielding Effectiveness	65 dB minimum from 1GHz to 10GHz.
Durability	2000 mating cycles

CONTACT RESISTANCE AFTER 1000 MATING CYCLES



TurboFlex is available in a broad range of gages, 12 AWG to 450 MCM

Rugged Duralectric™ jacketing is available in a broad range of colors

PowerTrip™ connectors are designed for use with TurboFlex™ power distribution cable, the ultra-flexible, ultra-durable power cable solution. All TurboFlex™ conductor materials deliver maximum flexibility and ability to handle the high voltage and temperature ranges inherent in such applications as military vehicles, aerospace ground support systems, and UGV charging stations. Duralectric™, the TurboFlex jacketing delivers superior flexibility and durability compared to other high-performance jacket materials.

SIZE AND WEIGHT REDUCTION

QwikConnect

ULTRAMINIATURE

Circular Connectors

Series 80 Mighty Mouse and the new nanominiature SuperFly™

Size and weight comparison of Series 801 Mighty Mouse (7 Contacts)…

…to MIL-DTL-38999 (6 Contacts) Up to 71% weight savings and 52% size savings

MICRO crimp

Rectangular versions of the Mighty Mouse (Series 79 Micro-Crimp) are also available

Series 80 Mighty Mouse: The new industry standard for high-performance, ultraminiature connectors

- **Over 50 tooled LCP contact arrangements ranging from 1 – 130 contacts**
- **MIL-DTL-38999 caliber environmental, mechanical, and electrical performance**
- **Ultraminiature #23 contacts set on .076" centers**
- **Size #20HD, #16, #12, #8 signal, power, fiber optic and shielded contact layouts**
- **Discrete connectors and turnkey cable assemblies**

Introducing the new Mighty Mouse Series 824 *Locking* Push-Pull Connector: All the familiar size, weight and performance advantages of the industry-standard Mighty Mouse with revolutionary low-profile *locking* push pull mating. Finally, mil-spec caliber performance comes to locking push-pull applications.

ULTRAMINIATURE

Circular connectors

For soldier systems and man-packable UGVs

Series 80 Mighty Mouse *Environmental* Connectors

Series 800	Series 801	Series 802	Series 803	Series 804	Series 805
					
Light-Duty UNF Thread	Rugged Double-Start ACME Thread	3500 PSI AquaMouse	Fast-Mate Bayonet Coupling	Quick-Disconnect Push-Pull	Ratcheted Triple-Start

Series 80 Mighty Mouse *Hermetic* Receptacles

Series 800	Series 801	Series 802	Series 803	Series 804	Series 805
					
•Vitreous glass sealing •1X10^{-7} cc/sec maximum helium leak rate	•Solder-cup and PC tail terminations •304L stainless steel shells			•Alloy 52 iron alloy contacts •Solder-mount, square flange or jam nut	

Available with threaded or quick-disconnect mating

SUPERFLY

ULTRAMINIATURE CONNECTORS

Compact, ultralightweight SuperFly connectors feature threaded or push-pull coupling, EMI shielding and IP67 ingress protection. Available in a variety of layouts and sizes for audio, video, comms and data applications, Series 88 connectors are ideal for man-portable electronics where size and weight are prime considerations. Available in ready-to-use cordsets and single-ended pigtails, Series 88 SuperFly assemblies ship with ultra-flexible high-speed cabling in contact arrangements from 3–44 contacts.

- **Ultraminiature Packaging**
- **IP67 Immersion Rated**
- **Quick-disconnect (QDC) or Threaded Coupling**
- **High Shock and Vibration**
- **5 Amp, 3 Amp, and 1 Amp High Reliability Contacts**
- **Robust EMI Shielding**
- **Designed for High Speed Data Applications**
- **Pre-Wired, Epoxy-Sealed**
- **Pigtails and Overmolded Cordsets**
- **21 Contact Arrangements**
- **Front or Rear Panel Mounting**
- **Accepts #22 to #32 AWG Wire**

SERIES 050 Harsh-Environment

Opto-Electronic Interconnect Solutions

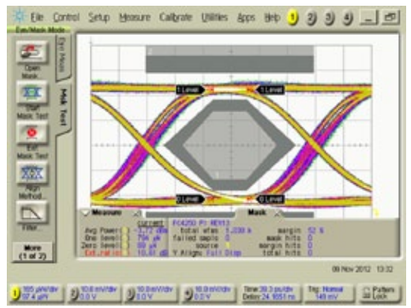
Opto-electronic media converters and active components for Ethernet, high-speed digital data, video media, and signal aggregation

- **Significant performance advantages over electrical copper including expanded bandwidth, reduced size and weight, increased distance, and improved electromagnetic compatibility**
- **Take advantage of fiber optic virtues, while reducing complexity and maintenance of fiber optic systems**
- **Size #8 Opto-Electronic contacts for singlemode and multimode optical fiber**

SIZE #8 CAVITY OPTO-ELECTRONIC CONTACTS AND ACTIVE CONNECTORS

- **Fast and Gigabit Ethernet, DVI, HDMI capable transmitter and receiver-equipped contacts**
- **ARINC 664, 801, 803, 804 and 818 standard compliant**
- **Link distances up to 550 meters, multimode**
- **Single, 3.3 V power supply**
- **Wave-solderable termination with RoHS-compliant solders**

Mighty Mouse receptacle incorporating size #8 opto-electronic contacts



4.25 Gbps / +25°C

FIBER OPTIC, HYBRID AND ACTIVE

Connectors and opto-electronic media solutions

For onboard and umbilical UGV applications

SIZE #16 FIBER OPTIC TERMINI

181-057
Pin Terminus

181-075
Socket Terminus

Termini Type	Optical Fiber Type	Part Number	A Ferrule I.D.	Fiber Size Core/Cladding
Pin	Multi Mode	181-057-126	126.0 microns	50/125, 62.5/125
	Single Mode	181-057-125	125.5 microns	9/125
Socket	Multi Mode	181-075-126	126.0 microns	50/125, 62.5/125
	Single Mode	181-075-125	125.5 microns	9/125
*Consult factory for additional sizes				

Series 801 9-4 with size #16 fiber optic termini vs. equivalent functionality D38999

Series 801
Shell size 9, 4 channel
6 Grams (less contacts)

D38999 Series III
Shell size13, 4 channel
27 Grams (less contacts)

SIZE #20HD FIBER OPTIC TERMINI

181-084
Pin Terminus

181-085
Socket Terminus

Termini Type	Optical Fiber Type	Part Number	A Ferrule I.D.*	Fiber Size Core/Cladding
Pin	Multi Mode	181-084-126	126.0 microns	50/125, 62.5/125
	Single Mode	181-084-1255	125.5 microns	9/125
Socket	Multi Mode	181-085-126	126.0 microns	50/125, 62.5/125
	Single Mode	181-085-1255	125.5 microns	9/125
*Consult factory for additional sizes				

Series 801 8-8 with size #20 HD fiber optic termini vs. equivalent functionality D38999

Series 801
Shell size 8, 8 channel
8 Grams (less contacts)

D38999 Series III
Shell size 17, 8 channel
40 Grams (less contacts)

SIZE #23 FIBER OPTIC TERMINI

181-063
Pin Terminus

181-064
Socket Terminus

Termini Type	Optical Fiber Type	Part Number	A Ferrule I.D.	Fiber Size Core/Cladding*
Pin	Multi Mode	181-063-126	126.0 microns	50/125, 62.5/125
	Single Mode	181-063-1255	125.5 microns	9/125
Socket	Multi Mode	181-064-126	126.0 microns	50/125, 62.5/125
	Single Mode	181-064-1255	125.5 microns	9/125
*Consult factory for additional sizes				

Series 801 6-4 with size #23 fiber optic termini vs. equivalent functionality D38999

Series 801
Shell size 6, 4 channel
5 Grams (less contacts)

D38999 Series III
Shell size 13, 4 channel
21 Grams (less contacts)

Ruggedized RJ-45 and USB Connectors for Field Applications

SuperSeal™

MIL-DTL-38999 Series III with sealed RJ-45

MIL-DTL-5015 with sealed RJ-45

MIL-DTL-38999 Series III with USB jack and jumper

High-capacity, high-speed USB data stick

Plug-and-Play Micro-USB Plug and Receptacle

Plug-and-Play Micro-USB Booted Cordset

Spring-Loaded cover for Series 804 SuperSeal USB

HIGH-PERFORMANCE

Rectangular Connectors

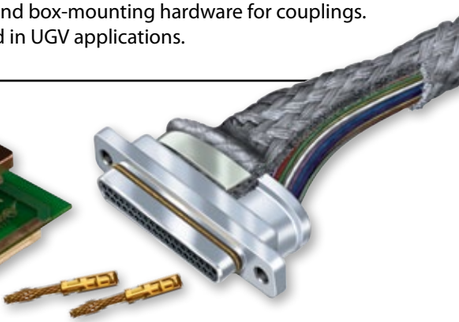
High density solutions for signal, data, RF and power

Rectangular Connectors

Rectangular connectors are typically used in applications where a large number of circuits are accommodated in a single mated pair. They are available with a wide variety of contacts, including hybrid signal, data, RF, and power types. Coupling is accomplished with integral guide pins that ensure correct alignment, and/or jackscrews that can both align and lock the connectors. Rack and panel versions use integral or rack-mounted pins for alignment and box-mounting hardware for couplings. Glenair manufactures all of the popular industry-standard rectangular connectors used in UGV applications.

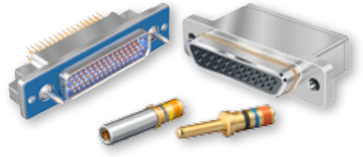
MIL-DTL-83513 QPL AND COMMERCIAL MICRO-D CONNECTORS

MICRO–D



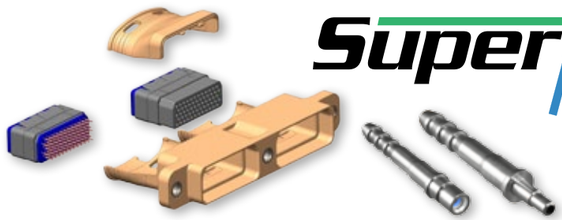
OUR VERSATILE ULTRAMINIATURE SERIES 79 MICRO-CRIMP CONNECTOR

MICRO crimp



OUR REVOLUTIONARY NEW MODULAR COMPOSITE RACK-AND-PANEL SERIES 20 SUPER TWIN

SuperTwin™



OUR SPECIAL HIGH-PERFORMANCE VERSIONS OF THE M24308 D-SUB, THE SERIES 28 HIPER-D

Series 28 HiPer-D features advanced watertight sealing: Rear triple-ripple grommet is sealed with a special compound. Mating interface utilizes a cork-and-bottle flourosilicone interfacial seal

Integrated EMI ground spring improves shell-to-shell grounding

HiPer D MIL-DTL-24308™

CONNECTOR ACCESSORIES

EMI shielding, strain relief and environmental solutions

Rugged metal and lightweight composite backshells and accessories for every application requirement

- Tens of thousands of popular part numbers in inventory ready for same-day shipment
- Fast turnaround on non-standard and made-to-order accessories, typically only two to three weeks
- RoHS compliant plating options

Band-Master™ ATS
Advanced Termination System

Wired, terminated and tested composite junction boxes

Ultra Low-Profile EMI/RFI Backshells

StarShield "Zero Length" Individual Shield Termination Backshells

Self-Locking and Standard Protective Covers

High-Performance Banding Backshells

EMI shielding, strain relief and environmental solutions

Complete range of rugged/lightweight boots and backshells

Conductively-plated composite accessories: Outstanding corrosion resistance, weight reduction, and durability

- High temperature, high strength engineering composite thermoplastics for maximum strength and durability
- Total immunity to galvanic corrosion
- Up to 70% weight reduction compared to standard metal connectors and accessories
- Hundreds of innovative, tooled designs
- All popular part numbers in stock and ready for immediate, same-day shipment
- Conductive platings including RoHS versions

SWING ARM™
COMPOSITE THREE-IN-ONE BACKSHELL

Composite Piggyback Shrink Boot

Standard Lipped or Lipless Boots

Transitions

Convoluted Boots

GLENAIR SHRINK BOOTS ARE NOW QUALIFIED AND APPROVED FOR USE BY THE US ARMY TANK-AUTOMOTIVE COMMAND (TACOM)

Glenair composite interconnect components are manufactured from 30% glass fiber polyetherimide (PEI), an amorphous thermoplastic with outstanding heat and chemical resistance and high strength.

SemperTan
CONNECTORS, CABLES AND ACCESSORIES

QUALIFIED NI-PTFE NICKEL FLUOROCARBON POLYMER PLATING

The MIL-DTL-38999 Rev L detail specification lists Nickel Fluorocarbon Polymer as a qualified Cadmium free plating alternative. Glenair's qualified, highly conductive, RoHS compliant plating formula is now available on composite interconnect products from Glenair and offers the following benefits in harsh-environment applications:

- 2000+ hour salt spray
- Cadmium free
- Outstanding mating lubricity
- Hexavalent Chromium free
- 500+ mating cycles
- Non-Magnetic

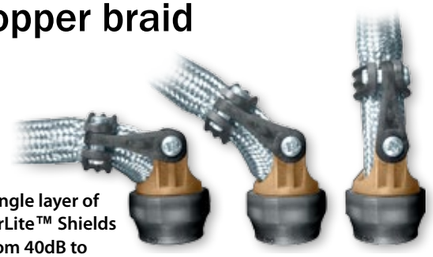
Glenair®

For more information contact Glenair at **818-247-6000** or visit our website at **www.glenair.com**
U.S. CAGE code 06324

ARMORLITE

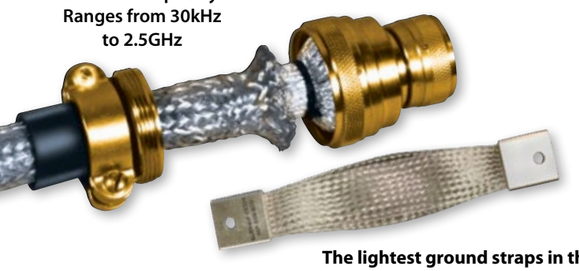
Ultra-Lightweight, flexible microfilament braided shielding

ArmorLite™ microfilament stainless steel braid saves pounds compared to standard QQ-B-575/A-A-59569 copper braid

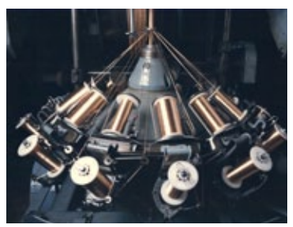


A single layer of ArmorLite™ Shields from 40dB to 80dB in Frequency Ranges from 30kHz to 2.5GHz

- **Ultra-lightweight EMI/RFI braiding for high-temperature applications -80°C to +260°C**
- **Microfilament stainless steel: 70% lighter than NiCu A-A-59569**
- **Outstanding EMI/RFI shielding and conductivity**
- **Reduce shielding weight up to 70% and more**
- **Superior flexibility and "windowing" resistance: 90 to 95% optical coverage**
- **220,000 psi (min) tensile strength**



The lightest ground straps in the industry: Silver or nickel plated



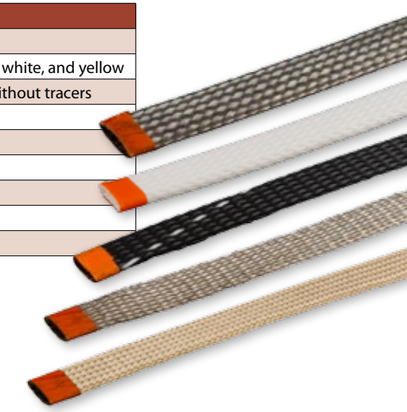
Glenair can also offer ArmorLite™ users direct factory overbraiding services for both point-to-point as well as multi-branch assemblies.

EMI/RFI BRAIDED SHIELDING AND WIRE PROTECTION

Lightweight, harsh-environment solutions

Flexible alternatives to standard cables and shielding

Other non-environmental fabric braided sleeving types available from Glenair	
Series No.	**Type**
102-001 and -002	Polyethelene expandable fabric tubular braided sleeving—black, green, red, white, and yellow
102-020, -021, -022 and -023	Halar expandable fabric tubular braided sleeving, white or black, with and without tracers
102-073	Dacron tubular braid, black
103-013	Nomex tubular braid—black, white, red, green, gray, and desert tan
102-051	PEEK tubular braid, black
102-061	Teflon tubular braid, clear and natural
102-071	Kevlar tubular braid, natural
102-072	Nylon tubular braid, black



Blue, Yellow, Red, Desert Tan, and Orange Annular Polymer-Core Tubing

- **Lightweight, flexible polymer core materials and easy-to-install fittings, transitions and adapters**
- **Choice of three tubing materials: Kynar, PVDF and G-FLEX Siltem**
- **A wide range of colors including desert tan**
- **Choice of turnkey, factory-terminated assemblies or user-installable configurations**
- **All popular part numbers in stock and ready for same-day shipment**
- **Rugged, environmental, chemical and temperature resistant**

Shielded convoluted tubing provides an economical, lightweight and flexible enclosure for interconnect wiring

Part Number 121-190

For non-environmental EMI/RFI applications

Annular conduit tubing with braided shield for EMI/RFI protection and additional structural integrity, particularly pull (tensile) strength.

Part Number 121-191

For environmental EMI/RFI applications

Annular conduit tubing with braided shielding for EMI/RFI protection and a ruggedized jacket for environmental protection against dust, dirt, and moisture incursion.

Outlook

Actively Engaged

A recent headline in the Los Angeles Times caught my eye, ***Most Workers Hate Their Jobs or Have "Checked Out" According to Gallup***. The poll found that of the 100 million Americans who have full-time jobs only 30% are "actively engaged" in their work. The rest either hate their jobs, wish they were someplace else or just don't care anymore.

Well all I can say is that the Gallup pollsters didn't spend much time talking to folks at Glenair. I have personally never witnessed a time when our team was more energized and engaged in serving our customers. Visitors to the factory repeatedly remark on the high-morale of the Glenair team and wonder aloud how we do it. Well I'm happy to share three of our secrets.

First of all, we put our customers first. Our team is laser focused on our customers and the marketplace we serve. Now you may ask, isn't every business? To which I would answer with a resounding no. For many enterprises the focus has shifted to the metrics of their business plan—their forecasts, budget initiatives, quarterly reports and the expanding rules and regulations of their bureaucracy. A quick and nimble response to a customer requirement is a foreign concept to such outfits, many of which have more in common with the business of accounting than they do with the business of manufacturing.

Second, we work hard. We have a simple, flat organization. We don't go in for a complex hierarchical pyramid like most organizations. Our managers are engaged at the shirtsleeve level. At Glenair you're just as likely to see an executive crawling under a conference table to fix an Ethernet cable as you are a young product manager giving an important briefing to a key customer. Our team is motivated to step in and get every job done that needs doing without worrying about whose turf it might be on or what their relative rank is in some org-chart.

Third, we believe in trust and "win-win". Our team operates in an atmosphere of trust because we make it a practice to be straight shooters with every stake-holder in our universe—from employees to suppliers, customers to owners, and the communities we operate in. Some organizations have a "see you in court" approach to resolving problems. At Glenair, one of our mottos is "me and you against the problem." That's a big difference, and it sure helps keep our morale and productivity high. Bottom line, sustainability comes from "win-win".

So like I said, the Gallup people must have skipped our street when they were conducting that survey, because with rare exception our folks are all in that magic 30% who are "actively engaged" in their work. For our country's sake I wish that were true in every organization. But the way a lot of businesses are run I guess I can understand why it is not.

QwikConnect

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Publisher
Christopher J. Toomey

Executive Editor
Marcus Kaufman

Managing Editor
Carl Foote

Editor/Art Director
Mike Borgsdorf

Graphic Designer
George Ramirez

Guest Writer
Ed Grabianowski

Technical Consultant
Jim Donaldson

Issue Contributors
Lisa Amling
Ken Cerniak
Brendan Dempsey
Mike Ghara
Christian Koppe
Ron Logan
Greg Noll
Jim Plessas

Distribution
Terry White

GLENAIR, INC.
1211 AIR WAY
GLENDALE, CA 91201-2497
TEL: 818-247-6000
FAX: 818-500-9912
E-MAIL: sales@glenair.com
www.glenair.com

Glenair®