Cybernet Systems Corporation
3885 Research Park Drive
Ann Arbor, MI 48108

ROBOTICS

Cybernet Systems Corporation (www.cybernet.com) has been a leader in robotics since 1989. It focuses on development and rapid deployment services in *robotics*, *computer vision*, *situational awareness systems* and *software-oriented interoperability*. Our core competences are robotics, sensor systems integration and algorithm development, man-machine interface design, medical devices and applications, modeling and simulation (with focus on *massive multiplayer* scale simulations), and network appliances and security.

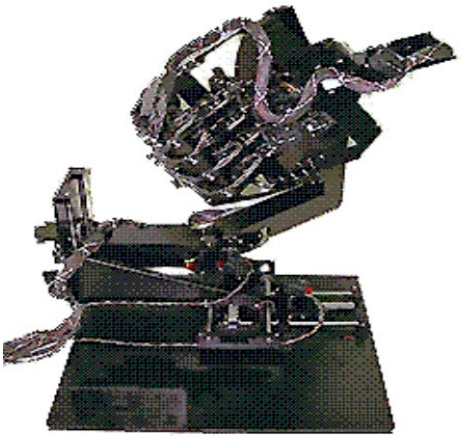
Force Feedback and Consumer Robotics

Our most successful robotics endeavor to date has been force feedback or tactile computer game devices (Figure 1). Shortly after the founding of Cybernet, our staff made a pioneering leap in robotics under NASA funding – we developed the first force feedback joysticks, and later wheels and other gaming appliances, which have gone on to become mass marketed robotic products. Our force feedback spin-off, Immersion Corporation, is the leader in this field and licensor to all of the many device manufacturers. Immersion subsequently went public (NASDAQ: IMMR) and today licenses BMW (iDrive), Logitech (Force Feedback enabled devices like the MOMO Racing Wheel), Microsoft (Xbox and Sidewinder controllers), Sony and many other companies. *These force feedback devices are the LARGEST selling robotic consumer products in the market today, with over 100 million sold since 1997.*

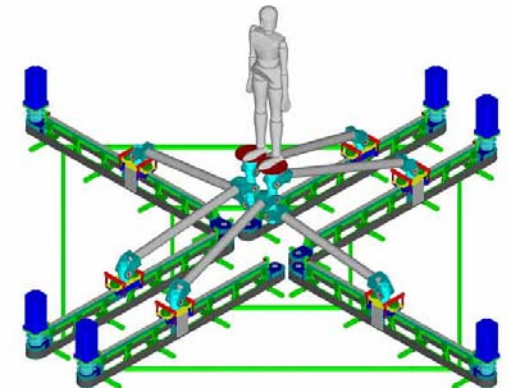
In this period we also developed our first custom, specialized robot arms like the ones shown in Figure 2, delivered to Ford Motor Company and NASA.

Figure 1. Cybernet force feedback device built form NASA (left); Commercial derivatives licensed by Immersion for Cybernet (Right – Logitech products)

Panograph large reach arm (Ford Motor)



Hand exoskeleton hand (NASA)



Three-D Treadmill (PEOSTRI)

Figure 2. Robot arms and platforms

Gesture Recogntion

Cybernet is an early developer of user interfaces to robotic and computerized devices based on detection of motion in video and inertial tracker data steams, recognition of intentional human motion in these motion streams, and conversion of the human intention into machine control or computer control commands. This technology is now being popularized in computer gaming by Microsoft through it's Kinect product. Cybernet began developing this technology in the early 1990s and holds 11 patents[1] (and 11 more patents pending) in this area, with the technology applied to fields ranging from computer gaming to augmented reality training and to human-intention-cued automated multi-camera surveillance.

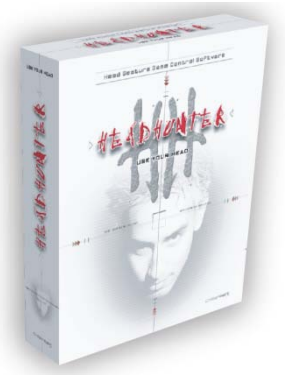


Figure 3. UseYourHead eye/head tracking for PC game control

Figure 4. Augmented reality training

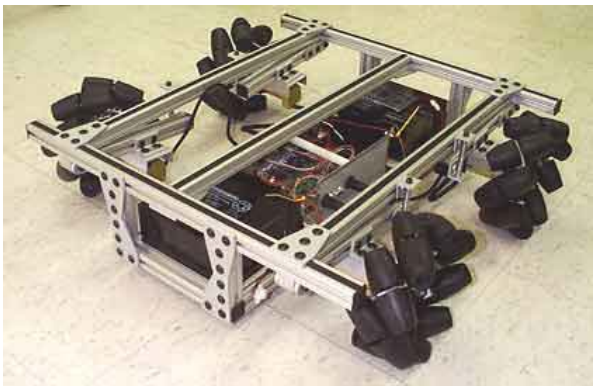
Figure 5. Applying human motion tracking and intention detection to video surveillance

[1] 7,852,262 Wireless mobile indoor/outdoor tracking system
7,684,592 Realtime object tracking system
7,668,340 Gesture-controlled interfaces for self-service machines and other applications
7,460,690 Gesture-controlled interfaces for self-service machines and other applications
7,121,946 Real-time head tracking system for computer games and other applications
7,050,606 Tracking and gesture recognition system particularly suited to vehicular control applications
7,036,094 Behavior recognition system
6,950,534 Gesture-controlled interfaces for self-service machines and other applications
6,801,637 Optical body tracker
6,299,308 Low-cost non-imaging eye tracker system for computer control
6,173,066 Pose determination and tracking by matching 3D objects to a 2D sensor

Unique Robotic Platforms and User Interfaces

Cybernet has built a number of small robotic platform systems over the years (Figure 6), and has deep experience developing human-robot interfaces and operator stations (Figure 7) dating back to the earliest DoD development efforts in this area. The core protocol gateway, terrain, map, and blue-force tracking technology we developed for robotics is also used for other military and computer game applications. Cybernet staff are also active participants in the JAUS Working Group.

Demo I HMMWV & Controller (Army)



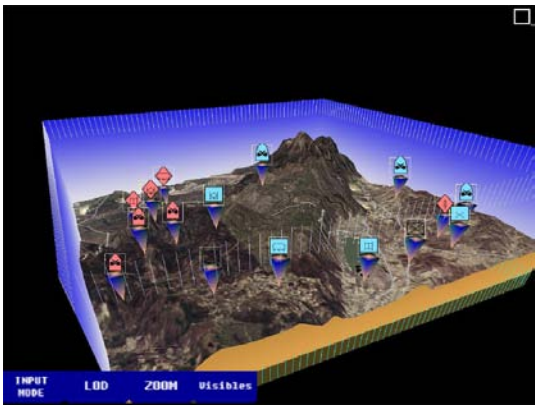
Omnidirectional Platform (Navy)

Hybrid Mobility EOD Robot (IR&D)

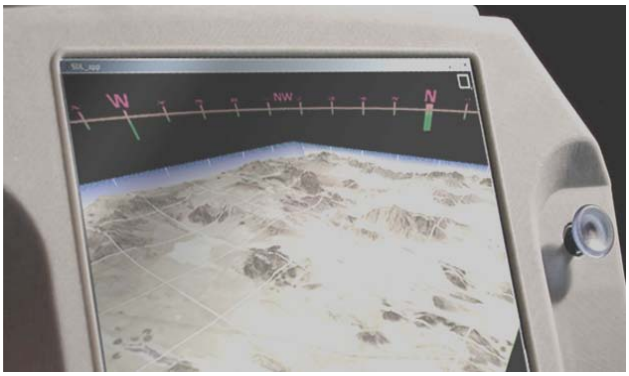
Surveillance Robot (JPO)

Figure 6. Cybernet small robot platforms

POCS OCU Built for Demo I and II



Blue Force Tracking Displays

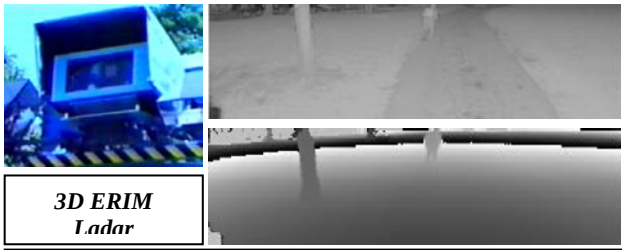


Hand-held Portable Operator Controllers for Smaller Robots

Figure 7. Cybernet operator stations and planning/execution monitoring software

Navigation, Rendezvous & Docking

The Cybernet team's experience with 3D optical radar systems traces back to the first ERIM 3D optical radars that were deliverable to the Autonomous Land Vehicle program, and later to the U.S. Postal Service. We also have a strong practice in vehicle embedded computer vision applications (ATR, inspection, and navigation/docking) and miniature pointing and location solutions (video trackers and gesture recognition systems, MEMs INS-augmented GPS, parachute descent tracking systems, and GPS/compass combinations). Figure 8 shows the first Optical LADAR our team built (while at the Environmental Research Institute of Michigan, in Ann Arbor, Michigan, as part of the DARPA Autonomous Land Vehicle Program). Figure 9 shows a LUX sensor we integrate and distribute to civilians and military programs in the U.S. for IBEO, a division of SICK. IBEO is the leading company building LADARs for automotive



3D ERIM Ladar

Figure 8. ERIM LADAR for DARPA ALV & Navlab

Figure 9. IBEO LUX Distributed by Cybernet

applications – the LUX in Figure 8 is presently being quoted into major automotive applications in volume for several hundred Euros per unit (two orders of magnitude lower than R&D LADARs that have been used in previous robotics programs).

Team Cybernet was chosen, as the only small business-led Michigan-based team, to participate as a semifinalist in the 2007 DARPA Urban Challenge. Cybernet's team placed in the Grand Challenge using the modified COTS vehicle shown below. Our approach with minimal cost controls, driver fusion systems, and industrial LADAR foreshadowed future cost-sensitive Convoy Autonomous System Technology (CAST) needed in the U.S. Army by providing the full strap-on Grand Challenge-capable driving kit for less than $35,000 per vehicle (and only $250,000 in non-recurring team development cost that leveraged the innovative work Cybernet and its teammates have done for over twenty years).

Figure 10. Cybernet Automated Minivan "Cybervan" (www.cybernet.com/urbanchallenge).

Figure 11 shows an example of the three-dimensional vision work that has been a Cybernet technology development focus for over 25 years (and for key members of the Cybernet technical team, over 30 years). This application is a proof of concept demonstrator for FCS refueling and reloading automation systems like the Large Caliber Automated Re-Supply (LCAR) system presently under preliminary design for FCS by a Cybernet team. Cybernet has several patented methods[2] for accomplishing these types of computer vision tasks as well as a wealth of industrial and military experience performing similar machine vision controlled robotic operations.

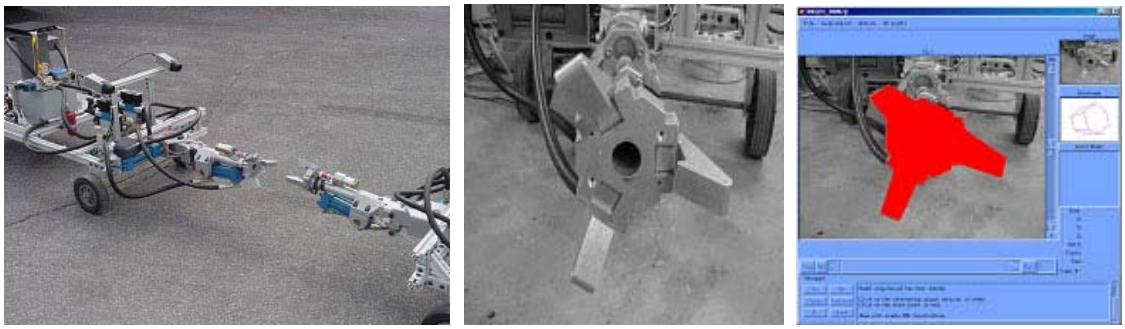


Figure 11. A coupling rendezvous and docking demonstrator (TACOM DAAE07-99-C-L045)

[2] 7,050,606 Tracking and gesture recognition system particularly suited to vehicular control applications
7,036,094 Behavior recognition system
6,950,534 Gesture-controlled interfaces for self-service machines and other applications
6,173,066 Pose determination and tracking by matching 3D objects to a 2D sensor

Some Computer Vision-based Projects Completed:

Autonomous Rendezvous and Docking Techniques, NASA, NAS8-03028
Automatic 3-D Structure Creation and Target Identification, U.S. Air Force, F33615-02-M-1210
Semi-Autonomous Telemaintenance of Robotic Platforms, U.S. Army, DAAB07-02-C-P618
Dynamic Modelbase from Motion Vision, U.S. Army, DAAH01-00-C-R010
An Articulated Joint for the High-Mobility, Articulated, All-Wheel Drive, Modular Vehicle (HAAMR), U.S. Army, DAAE07-99-C-L045

Dead Reckoning and Position Determination Systems

Cybernet has accumulated over 8 years of experience implementing miniature inertial and GPS-based guidance and tracking systems. This area of expertise was initiated in 1999 when our engineers built the first electronic Automated parachute Activation Devices (AAD) to enhance airborne soldier safety. The AAD devices shown in Figure 12 measure airborne soldier jump exit, static line release, parachute opening, and descent from the jump exit through to ground touchdown.

Figure 12. MEMS GPS/INS AAD units

From this project starting point we have miniaturized and improved accuracy for magnetometer, inertial measurement, and GPS-fused navigation solutions in applications focused on vehicle, personnel, and other object tracking. One system built by Cybernet was used in its 2007 Grand Challenge vehicle (Figure 14). This system achieved nominally 10 cm accuracy with GPS and maintained this accuracy for up to a mile when GPS was denied, using only $5000 of sensor and computation equipment.

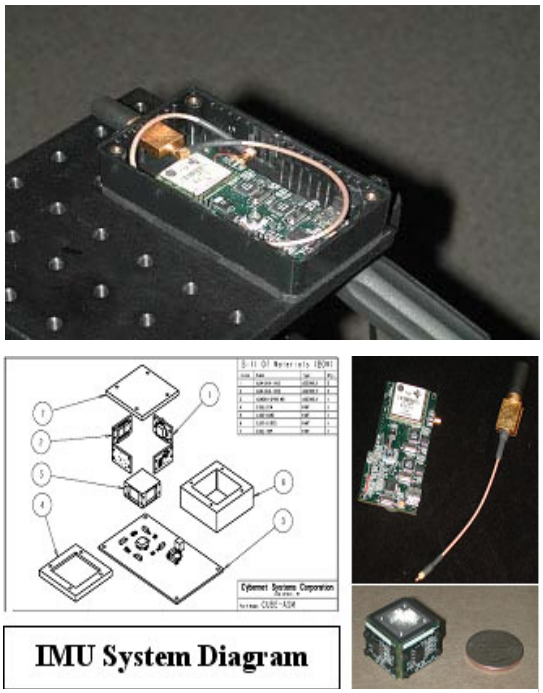


Figure 13. 6 axis solid state inertially compensated magnetometer

DARPA Grand Challenge GPS Denied Precision navigation, 2007
Scalable Geo Telemetry Networks, U.S. Army, W9132V-05-C-0011, 2005-2007
Wearable Wireless Fall Event Detector, NIH, 2005-2007
NLOS Pointing Device For OneTESS Application, AT&T for PEOSTRI, 2005
Enhanced GPS/INS Tracking and Vehicle Dynamics Monitoring System, 2005
Low-Cost Navigation System to Augment GPS Receivers in General Aviation Aircraft, DOT, 2002

Enhanced Accuracy INS/GPS System Utilizing Low-Cost Sensors and Geophysical Models, U.S. Army, 2002

Parachute Automatic Activation Device (AAD) for Low Altitude Jumps, 1999-2003

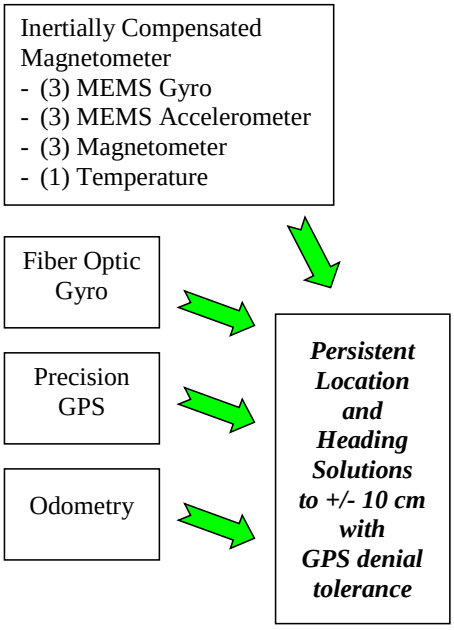


Figure 14. DARPA Grand Challenge Dead Reckoning System

Ammunition Peculiar Equipment: Ordnance ID and Inspection

Cybernet's Automated Tactical Ammunition Classification System (ATACS) is an automated ammunition identification, inspection, and sorting system that separates good rounds from bad, round types, and round calibers based on comparing as-built inspection criteria with inspection for surface damage and corrosion. The system separates bulk turn-in ammunition from 9mm to 50cal at a rate of approximately 100,000 rounds per day, saving the Army approximately $25 million in labor avoidance costs per machine per quarter. Early versions were built to operate in normal desert particulate and temperature ranges (up to 140 degrees F) and break down into four shipping containers for flexible system transport. These ATACS types are operating in Kuwait and at the National Training Center, three shifts per day.

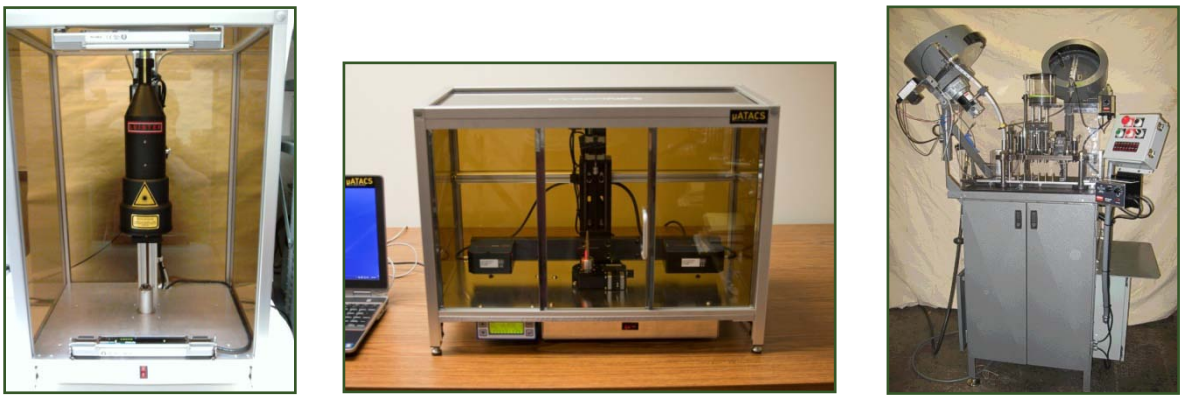
Because there is a need for ammunition identification, inspection, and reclamation in less improved environments, current generation ATACS machines are being packaged into ISO containers – with self-contained power and facilities in the container so that a flat area is all that is needed to set-up shop.

Contracts: ATACS Logistical Support, U.S. Army, W912DY-06-D-0008
ATACS (Army Corps of Engineers Purchase Order), U.S. Army, W912DY-05-P-0112

Contact: U.S. Defense Ammunition Center

Figure 15. (a) Bulk turn-in ammunition (b) ATACS bulk ammunition inspect and sort

The Cybernet team is also integrating these technologies into full ammunition manufacturing lines, to support new types of specialized ammunition (Figure 16). The resulting line of ammunition inspection and manufacturing products is listed at atacs.cybernet.com.



(a) (b) (c)

Figure 16. (a) Ammunition case welding machine; (b) Ammunition case measurement machine; (c) Automatic munitions assembly line machine

Cybernet's Projectile IDentification System (PIDS) was developed and demonstrated as an identification and inspection sensor for large caliber ammunition to Picatinny Arsenal, in order to support future force mortars. This device uses an inspection and identification technology similar to that proven on the ATACS, can identify and inspect ordnance based on color, shape, and OCR/bar-coded identifiers inline as the ordnance is loaded, and is fully field-ruggedized for rapid deployment.

Contracts: Optical Projectile Identification and Inventory System, U.S. Army, DAAE30-03-C-1060, Contact: TACOM-ARDEC

(a) (b)

Figure 17. (a) Concept future force mortar with PIDS system inline with loading port; (b) PIDS identification and inspection system as implemented for port inline application

ISO Containerization

Part of the effort for Tactical Automation systems like LCAR or ATACS is packaging them for use in harsh environments. Cybernet engineers have experience integrating these complex automation systems into standard form factors, like within ISO containers. This supports PLS integration and transport through other multimodal means. Below we show a number of views

of the ISO-containerized ATACS presently being readied for fielding (under the ATACS contracts already summarized).

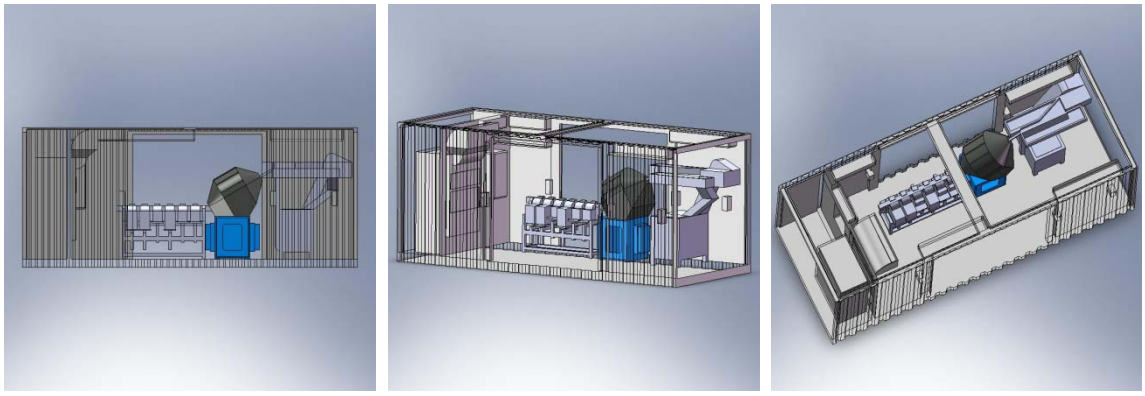


Figure 18. ATACS packaged in an ISO container form factor

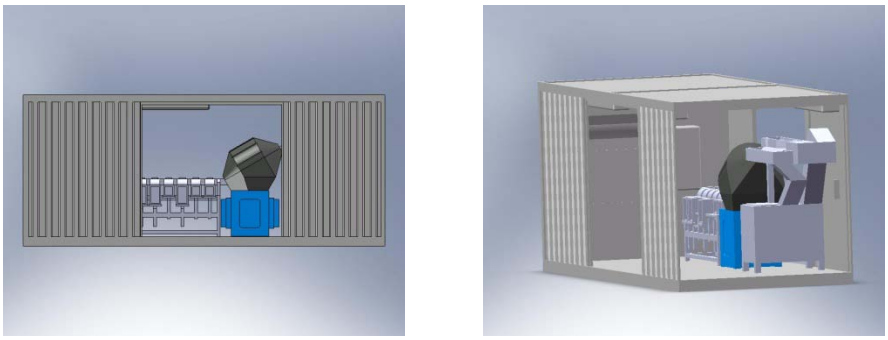


Figure 19. More views of the ISO container form factor

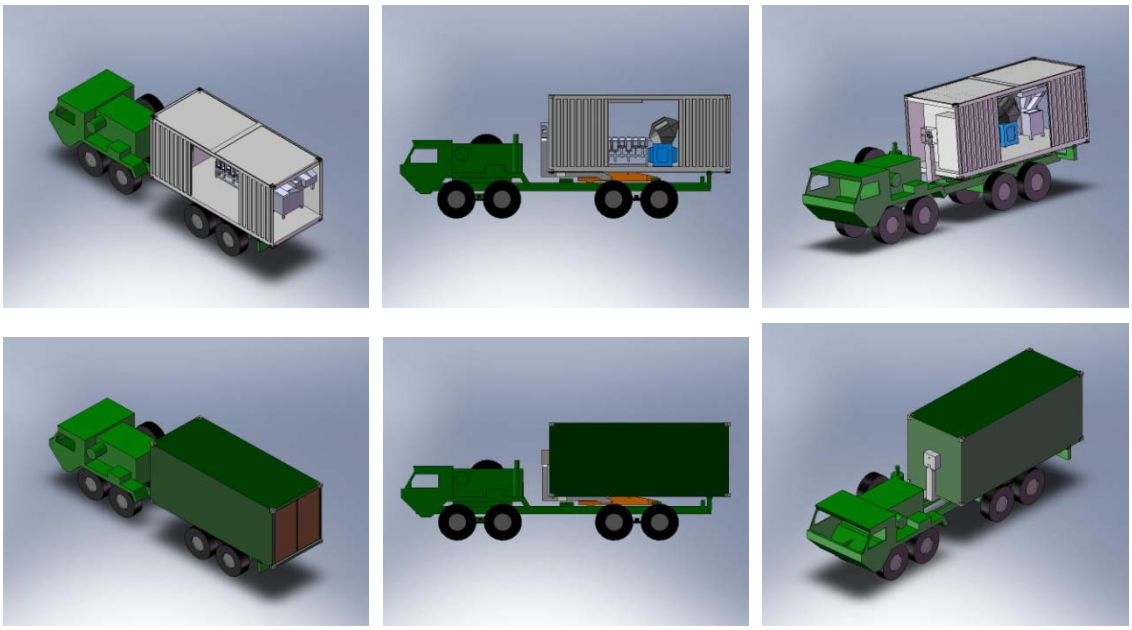


Figure 20. ATACS ISO containers integrated with HEMTT/PLS

Robotic & Material Handling

Cybernet staff began developing and supporting flexible robotic manufacturing systems in 1979, and thereafter developed the material handling systems used by Texas Instruments in its semiconductor packaging production lines worldwide. While at the Environmental Research Institute of Michigan, current Cybernet staff developed the technology that currently sorts the daily U.S. 1st class mail stream. In 1990 this was a very demanding application, requiring identification of 5 and 9 digit zip codes for both hand-written and machine-printed mail pieces, at a rate of nominally 10 per second and error rates of less than 1%.

Figure 21. USPS letter and flats sorting machines using handwritten and machine print OCR automation developed by Cybernet staff while they worked at the Environmental Research Institute of Michigan, 1987-1990

Figure 22. Some Cybernet partner automation deployments to automotive

As summarized previously, Cybernet staff is now applying its expertise in material handling and robotics to unmanned vehicle systems and robotic ammunition peculiar equipment – as far as we know we are *THE ONLY FIELD ROBOTIC AMMUNITION PECULIAR EQUIPMENT MAKER IN THE WORLD.*

To integrate complex automation systems, Cybernet works with a number of Detroit-based non-traditional robotics applications and manufacturing companies, allowing us to bring mature automotive-derived experience to our military customers for tactical and field applications.

Leveraging material handling expertise available from this mature manufacturing sector, we use our military expertise to modify the designs of various COTS material handling systems to support our soldiers' needs in the field.

Figure 23. Cybernet leverages industrial material handling expertise when it builds tactical automation solutions for DoD customers.

Vehicle Integration

Cybernet has integrated vehicle systems, vehicle simulations, and vehicle automation. Presently we are deeply committed to productize the DARPA Urban Challenge technology in standardized kit forms. All automation systems in the challenge vehicle shown in Figure 10 and 24 were built or integrated by Cybernet engineering staff. This includes novel navigation, self-location, road finding, and motion range detection technology as well as an AI-based intelligent vehicle control system. Our goal is to move this kit technology rapidly forward for deployment in automated convoying (CAST), automated vehicle-to-vehicle maneuvers (LCAR), mine clearing, and other high value applications of ground robotics.

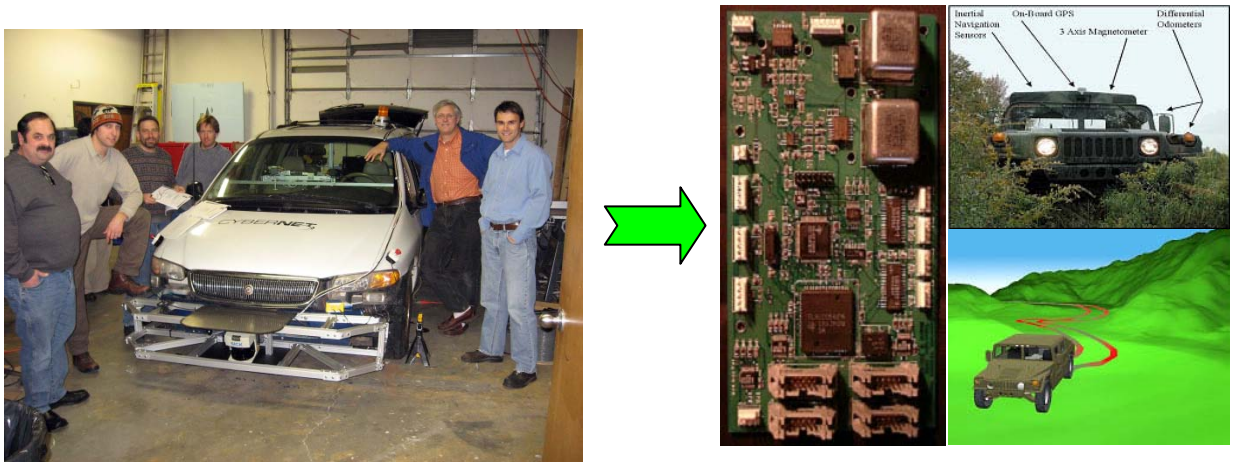


Figure 24. Transition of kit robotics to fieldable applications

Automation for Material Handling and Combat Robotics

Cybernet is making automatic forklift and material handling a reality for U.S. Army ARDEC (customer: CASCOM). We are translating the technology of the Urban Challenge to forklifts that handle transport of dangerous ammunition into and out of specialized store houses called igloos. The effort develops closely-packed warehouse material handling vehicle technology and standard material handler automatic driving kits. These kits are also being refitted to the Gladiator, a mid-sized robotic recognizance-in-force vehicle capable of 8-10 hour missions that involve mobility, Reconnaissance, Surveillance and Target Acquisition (RSTA), and armed assault.

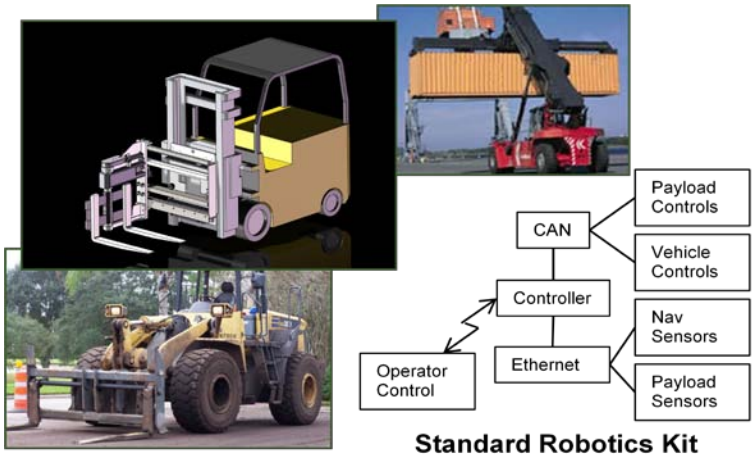


Figure 25. Robotic Forklifts/Material Handing

Figure 26. Gladiator Combat Robot

Vehicle Systems Design and Test

Cybernet engineers have also developed whole vehicle concepts. Figure 27 shows utilization of the General Motors Electromagnetic susceptibility testing laboratory to determine how much EM radiation is required to stop a commercial vehicle (shown mounted on a turntable dynamometer within an anechoic chamber large enough to accommodate a semi-truck and trailer). This work is being done for the DHS and TSWG to prove the feasibility of using high-powered microwave (HPM) devices to soft-kill cars and trucks.

Shown in Figure 28 is a small V-22 size compatible four wheel drive and steer concept vehicle we developed for the special forces command.

Figure 27. The Cybernet Grand Challenge Vehicle under test at the General Motors Electromagnetic Test Facility for determination of microwave weapon assault susceptibility (projects for the Dept. of Homeland Security and TSWG)

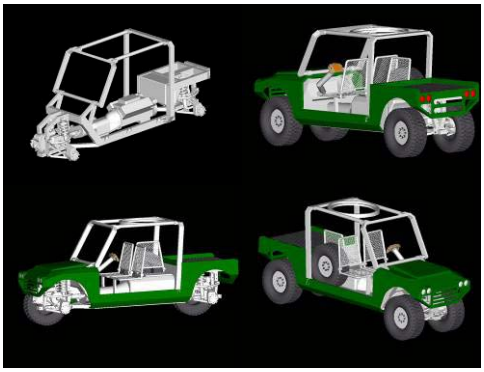


Figure 28. A small V-22 size compatible four wheel drive and steer concept vehicle

Special Facilities

Cybernet System Corporation's main development facilities are at 3885 Research Park Drive, Ann Arbor, Michigan. These facilities include project management, CPA-level financial accounting, purchasing, administration, quality control, publication services, engineering office space and meeting rooms, system-level testing, a metal working machine shop, in-house plastic FDM (Fused Deposition Modeling) machine rapid prototyping for complex usable plastic part shapes, a light electronics assembly lab, an optics lab, ProEngineer, AutoCAD, and SolidWorks CAD, OrCAD circuit design tools, and supporting software development (Windows, Windows CE/mobile, Linux, various embedded) and hardware development tools (spectrum analyzers, scopes, logic analyzers, magnetometer and IMU calibration, etc.).

Cybernet also takes advantage of pre-qualified out-sources for parts fabrication and electronic board and module assembly when volume demands become high enough. Our facilities meet the environmental laws and regulations of federal, state, and local governments for airborne emissions, waterborne effluents, external radiation levels, outdoor noise, solid and bulk waste disposal practices, and handling and storage of toxic and hazardous materials.

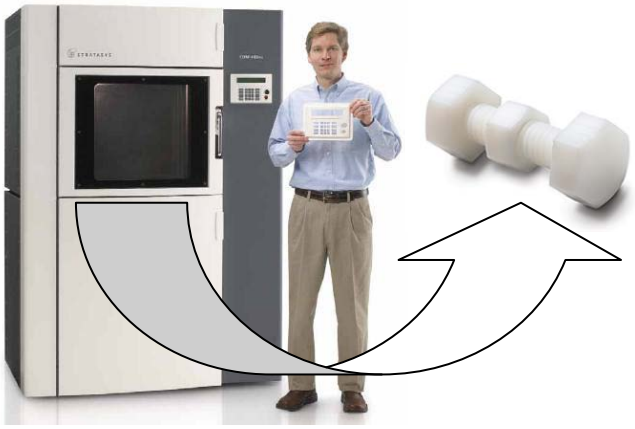


Figure 30. Cybernet' FDM Machine and a Sample

In addition to the Ann Arbor headquarters, Cybernet operates small office facilities in Orlando, FL, the Washington DC area, San Diego, CA, and Johnstown, PA – supporting the USMC, Navy, Army, SOCOM, and prime contractors. Cybernet is a Mentor-Protégé company related to SAIC, is certified as an 8(a) firm by the SBA (SBA Case # 111553), and has been in continuous positive cash-flow operation since 1988 (23 years). **Cybernet facilities are cleared through DoD Secret Level, with key personnel and staff members currently maintaining clearances for work performance.**

Ann Arbor Facility Front Aerial

Figure 31. Cybernet Integration Facilities in Ann Arbor, MI

DoD Field Support

Cybernet supports ATACS robotic equipment to the U.S. Army worldwide, including in OIF, through 24/7 phone support, rapid response logistics, and when needed field support engineering.

Our main development facility offers 45,000 sq. ft of space including 5 vehicle highbays, light machine shop & rapid prototyping, software development, seating for over 150 engineers and staff, and proximately roadway test and off-road test areas. We also have access to the Chelsea Proving Ground and the Ford Romeo Proving Ground.

Mechanical Highbay

Electronics & Test

Vehicle Highbay #1

Vehicle Highbays #2 &3

Vehicle Highbay #4

Demo Highbay #5

Open Office & Experiment space

Open office space

Think of Cybernet for your challenging systems integration and unique robotic sensors and systems development requirements.

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