NetMAX™ ROBOTICS

NetMAX.com (www.netmax.com) has been a commercial leader in distributed system software and Linux applications since 1999. It licensed robotics products from Cybernet Systems Corporation in April of 2007 to shift its business focus from Linux security servers to embedded and robotics systems. NetMAX Robotics focuses on product sales and commercial development of *robotics*, *situational awareness systems* and *embedded sensor products*. 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 – specialties inherited and influenced by our parent, Cybernet Systems Corporation.

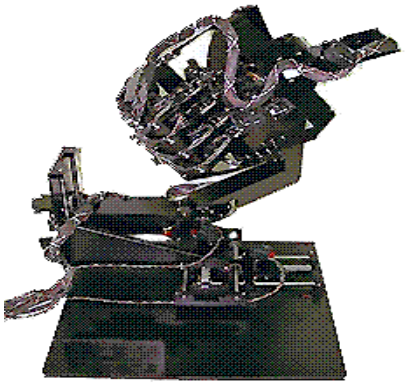
Force Feedback and Consumer Robotics

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

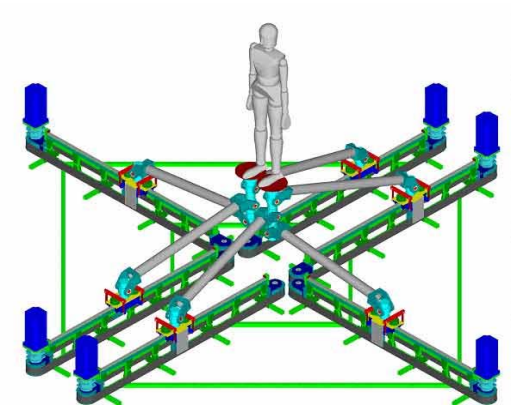
In this period, we also developed our first custom, specialized robot arms (like the ones shown in Figure 2), for Ford Motor Company and NASA. This technology has evolved into products that NetMAX.com sells commercially for Gesture recognition, tracking, and HCIs.

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

Pantograph large reach arm (Ford Motor)



Hand exoskeleton hand (NASA)



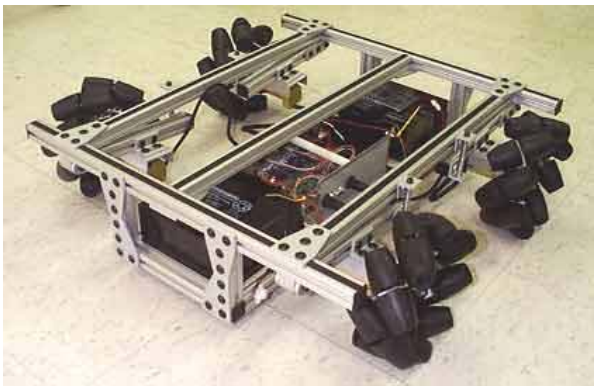
Three-D Treadmill (PEOSTRI)

Figure 2. Robot arms and platforms

Unique Robotic Platforms and User Interfaces

NetMAX builds small robotic platform systems to customer specifications (for examples see Figure 3), and has deep experience developing human-robot interfaces and operator stations (Figure 4) dating back to the earliest DoD development efforts in this area. The core protocol gateway, terrain, map, blue-force tracking technology we developed for robotics is also used for other military and computer game applications. NetMAX staff also actively participate in the JAUS Working Group.

Demo I HMMWV & Controller (Army)



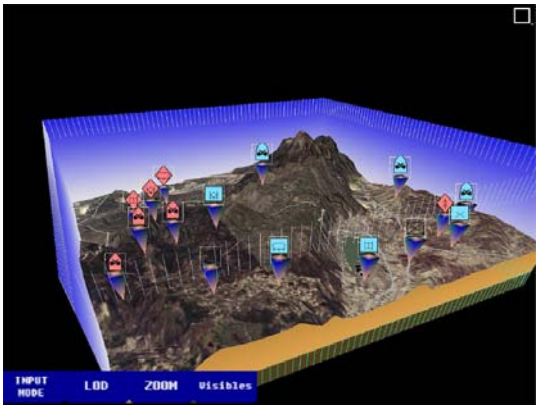
Omnidirectional Platform (Navy)

Hybrid Mobility EOD Robot (IR&D)

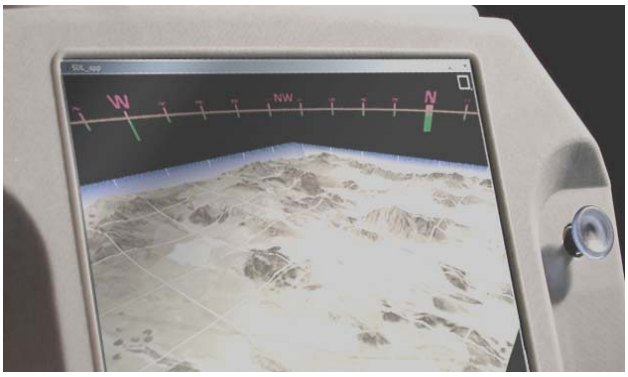
Surveillance Robot (JPO)

Figure 3. NetMAX small robot platforms

POCS OCU Built for Demo I and II



Blue Force Tracking Displays

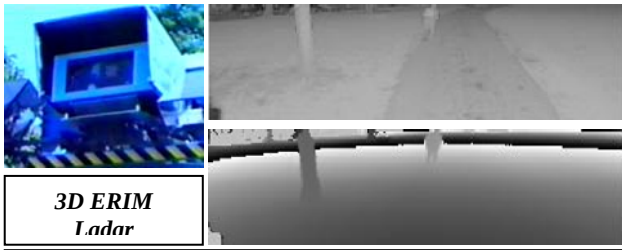


Hand-held Portable Operator Controllers for Smaller Robots

Figure 4. NetMAX operator stations and planning/execution monitoring software

Navigation, Rendezvous & Docking

The NetMAX 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 5 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 6 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 5. ERIM LADAR for DARPA ALV & Navlab

Figure 6. IBEO LUX Distributed by Cybernet

applications – the LUX in Figure 6 is presently being quoted into major automotive applications in volume for several hundred Euro per unit (two orders of magnitude lower than R&D LADARs that have been used in previous robotics programs).

Team Cybernet (which included NetMAX.com team members) was chosen, as the only small business-led Michigan-based team, to participate as a semifinalist in the 2007 DARPA Urban Challenge. Our 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 NetMAX, Cybernet, and its teammates have done for over twenty years).

Figure 7. Cybernet Automated Minivan "Cybervan" (www.cybernet.com/urbanchallenge).

Figure 8 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 NetMAX technical team, for 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 licensed NetMAX several patented methods[1] for accomplishing these types of computer vision tasks as well as a wealth of industrial and military experiences performing similar machine vision controlled robotic operations.

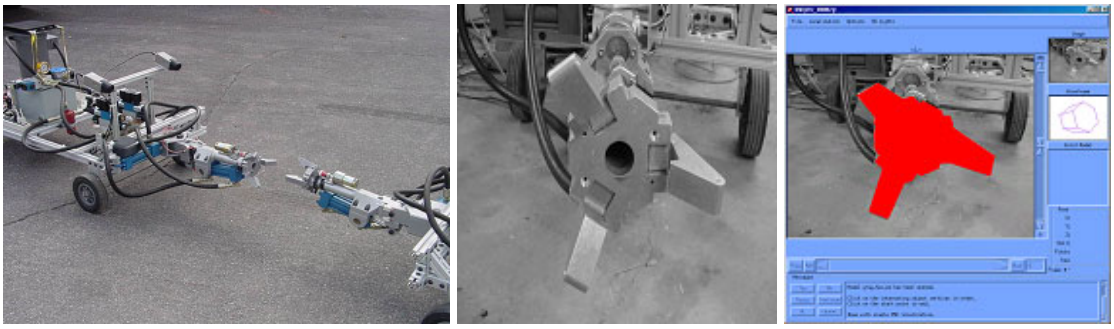


Figure 8. A coupling rendezvous and docking demonstrator.

[1] 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.

Automatic 3-D Structure Creation and Target Identification, U.S. Air Force.

Semi-Autonomous Telemaintenance of Robotic Platforms, U.S. Army.

Dynamic Modelbase from Motion Vision, US Army.

An Articulated Joint for the High-Mobility, Articulated, All-Wheel Drive, Modular Vehicle (HAAMR), US Army.

Dead Reckoning and Position Determination Systems

NetMAX has accumulated substantial 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 9 measure airborne soldier jump exit, static line release, parachute opening, and descent from the jump exit through to ground touchdown.

Figure 9. 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. The best system yet built was used in our 2007 Grand Challenge vehicle (Figure 11). This system achieved nominally 10 cm accuracy with GPS and maintained this accuracy for up to a mile when GPS was denied – for only $5000 of sensor and computation equipment.

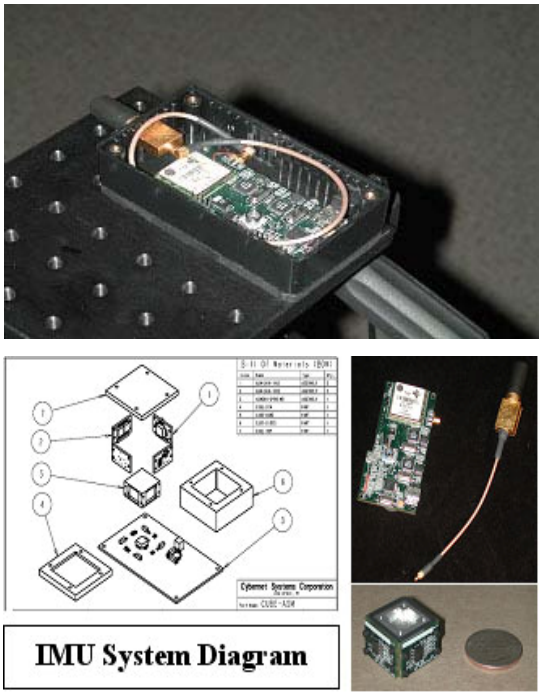


Figure 10. 6 axis solid state inertially compensated magnetometer

Related Projects Completed:

GPS Denied Precision navigation, DARPA Grand Challenge.

Scalable Geo Telemetry Networks, US Army.

Wearable Wireless Fall Event Detector, NIH.

NLOS Pointing Device For OneTESS Application, AT&T for PEOSTRI.

Enhanced GPS/INS Tracking and Vehicle Dynamics Monitoring System.

Low-Cost Navigation System to Augment GPS Receivers in General Aviation Aircraft, DOT.

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

Parachute Automatic Activation Device (AAD) for Low Altitude Jumps.

Ammunition Peculiar Equipment: Ordnance ID and Inspection

Army Tactical Ammunition Classification System (ATACS)

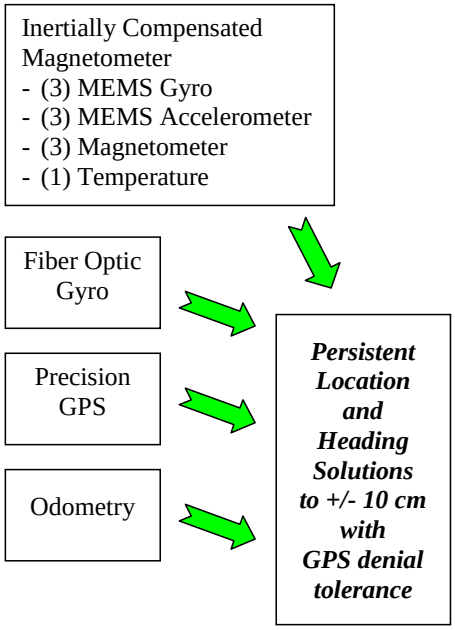


Figure 11. DARPA Grand Challenge Dead Reckoning System

ATACS is an automated ammunition identification, inspection, and sorting system that separates good rounds from bad, rounds by type, 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 50 cal 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 transshipment. These ATACS types are currently operating in Kuwait and at the National Training Center for three shifts per day.

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

Contracts: ATACS Logistical Support, US Army; TACS (Army Corps of Engineers Purchase Order), US Army.

Contact: US Defense Ammunition Center

Figure 12. (a) Bulk turn-in ammunition (b) ATACS bulk ammunition inspect and sort

Projectile IDentification System (PIDS)

NetMAX has also licensed Cybernet technology that demonstrates identification and inspection sensors for large caliber ammunition developed for Picatinney Arsenal to support future force mortars. This device uses an inspection and identification technology similar to that proven on the ATACS, can ID 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, US Army.

Contact: TACOM-ARDEC

(a) (b)

Figure 13. (a) Concept future force mortar with PIDS system inline with loading port. (b) PIDS ID and inspect 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 throughout the world in harsh environments. NetMAX engineers have experience integrating these complex automation systems into standard form factors, such as within ISO containers. This supports PLS integration and trans-shipment 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).

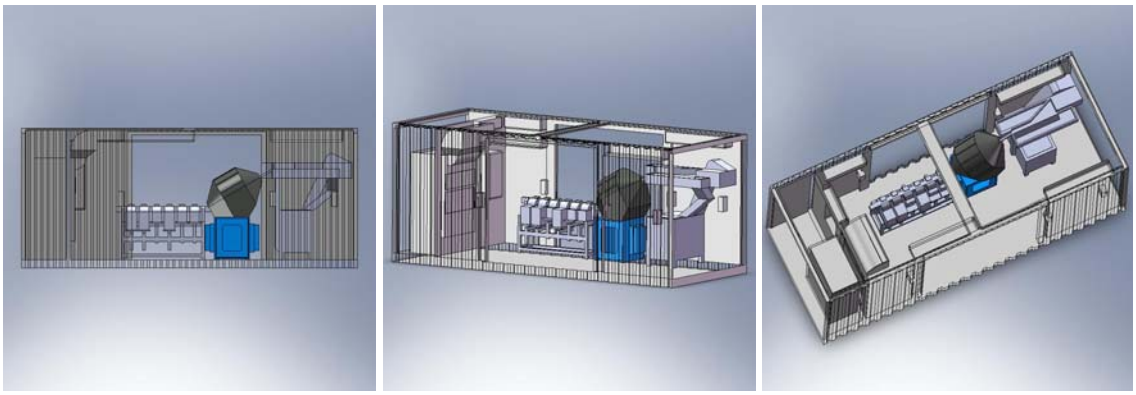


Figure 14. ATACS packaged in an ISO container form factor

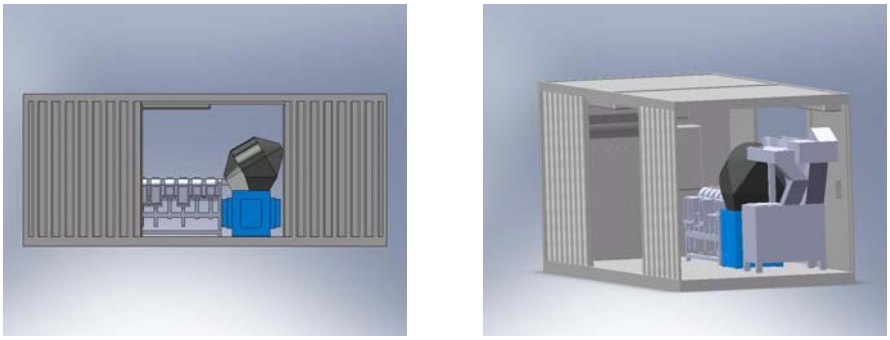


Figure 15. More views of the ISO container form factor

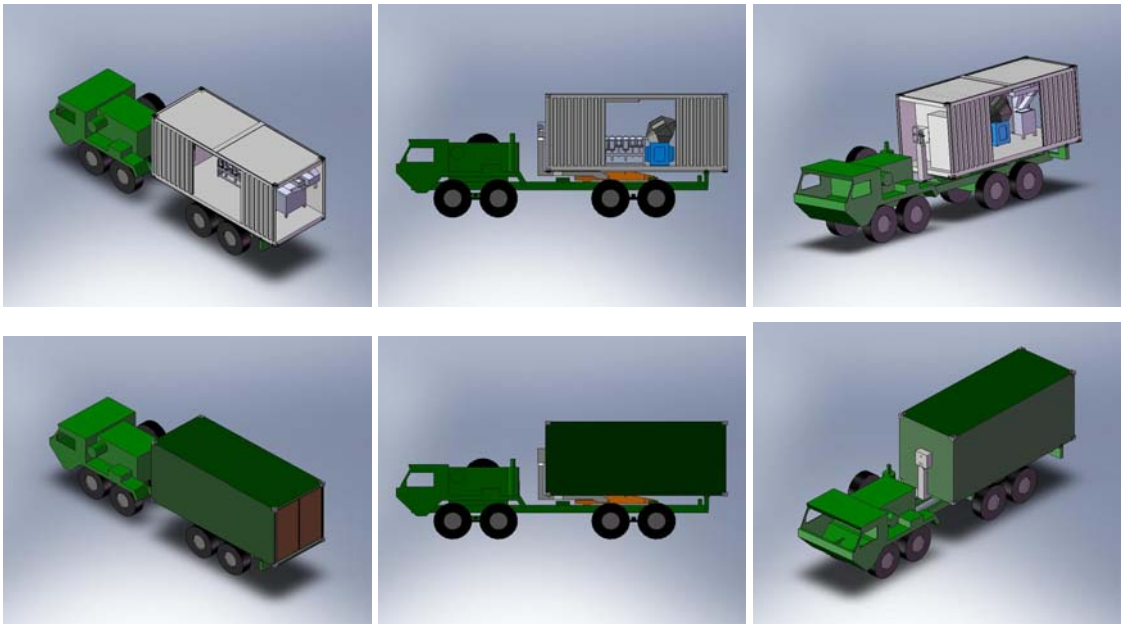


Figure 16. ATACS ISO containers integrated with HEMTT/PLS

Robotic & Material Handling

NetMAX staff began by developing and supporting robotic flexible manufacturing systems in 1979 by developing the material handling systems used by Texas Instruments in its semiconductor packaging production lines worldwide, and while at the Environmental Research Institute of Michigan, developed the technology that now sorts the U.S. 1st class mail stream on a daily basis. 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, with error rates of less than 1%.

Figure 17. USPS letter and flats sorting machines using handwritten and machine print OCR automation developed by Cybernet/NetMAX staff while they worked at the Environmental Research Institute of Michigan, 1987-1990.

As summarized previously, NetMAX 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, NetMAX works with a number of Detroit-based non-traditional robotics applications and manufacturing companies so we can bring mature automotive-derived experience to our military customers for tactical and field applications.

Figure 18. Some NetMAX partner automation deployments to automotive

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

Figure 19. NetMAX leverages industrial material handling expertise when it builds tactical automation solutions for DoD customers.

Vehicle Integration

NetMAX has integrated vehicle systems, vehicle simulations, and vehicle automation. Presently we are deeply committed to productize our DARPA Urban Challenge technology in standardized kit forms. All automation systems in the challenge vehicle shown in Figure 7 were built or integrated by NetMAX and Cybernet engineering staff, including 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.

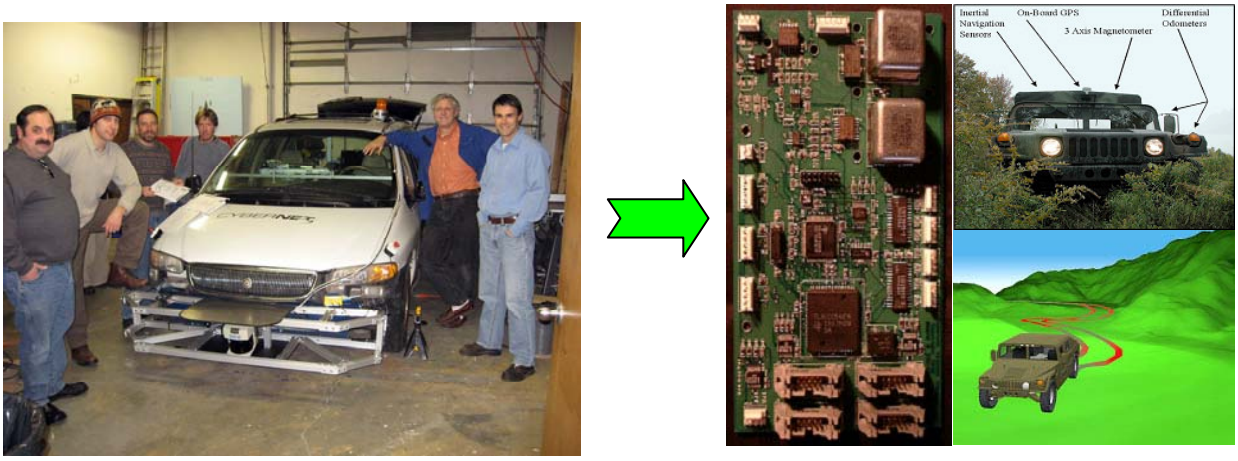


Figure 20. Transition of kit robotics to fieldable applications

Vehicle Systems Design and Test

NetMAX engineers have developed whole vehicle concepts. Shown in Figure 21 is a small V-22 size compatible four wheel drive and steer concept vehicle we developed for the Special Forces command.

Figure 22 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 feasibility for using high-powered microwave (HPM) devices to soft-kill cars and trucks in pursuit situations.

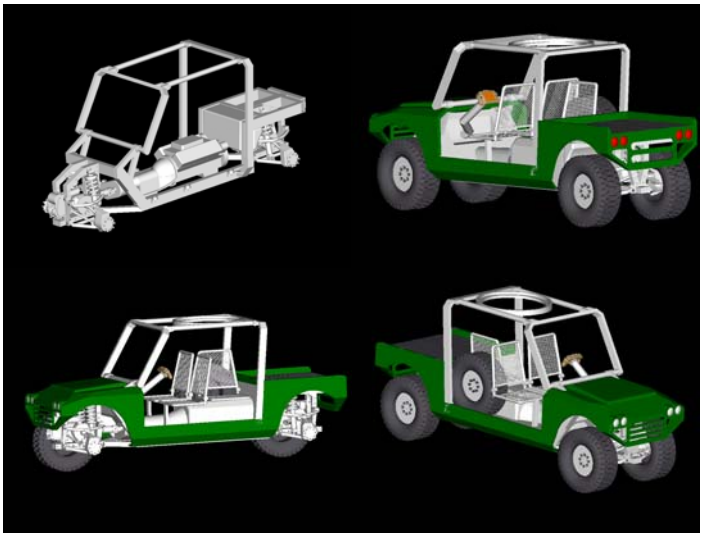


Figure 21. A small, V-22 size compatible, four wheel drive and steer concept vehicle.

Figure 22. The 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)

Special Facilities

NetMAX.com's main development facilities are at 727 Airport Boulevard, 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

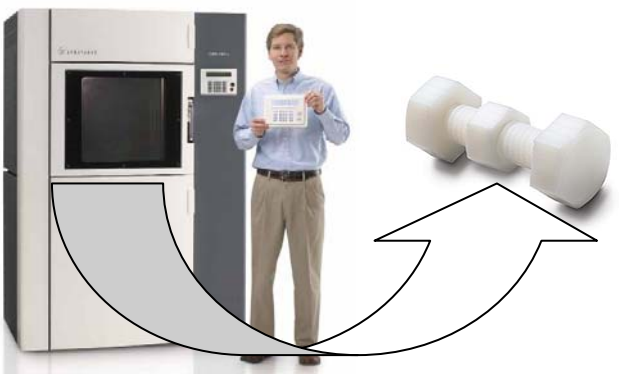


Figure 23. Cybernet FDM Machine and Sample Part

prototyping for complex usable plastic part shapes, light electronics assembly lab, 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.).

NetMAX.com 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.

Think of NetMAX.com for your challenging commercial robotics systems integration and unique robotic sensor and system requirements.

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