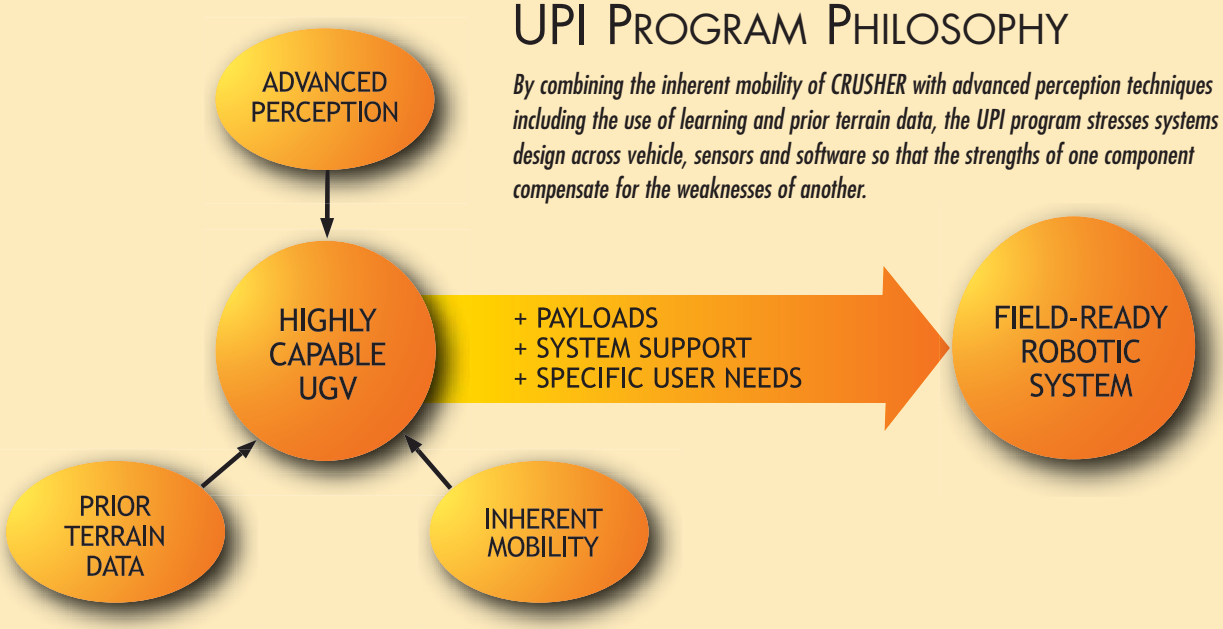
UGCV PerceptOR Integration

Ft. Carson - August 2006

Field test in Somerset, PA, March 2006

UPI Program Philosophy

By combining the inherent mobility of CRUSHER with advanced perception techniques including the use of learning and prior terrain data, the UPI program stresses systems design across vehicle, sensors and software so that the strengths of one component compensate for the weaknesses of another.



UPI

UGCV PERCEPTOR INTEGRATION

Ft. Carson, CO, August 2006

Overhead colorized lidar data from Ft. Hood

The UPI program, initiated July of 2004, extends the UGCV and PerceptOR efforts by integrating these parallel development programs into one. Created as a Future Combat Systems (FCS) technology feed program, test results found on the UPI program are influencing and leading efforts on many military vehicle programs targeting deployment in the near future.

NREC and DARPA are working to create some of the most advanced and intelligent autonomous ground vehicle platforms available today.

Through the UPI program, NREC has designed CRUSHER, featuring a new hull, new suspensions, and many developments and improvements based upon the SPINNER version 1.0 vehicle.

With the addition of two new CRUSHER vehicles, the program is able to conduct parallel field testing agendas in varied terrain sites.

- Building on successful results from PerceptOR, the perception and automation systems are being extended to provide improved automation capabilities at higher speeds. More focus is placed on learning technologies which allow the vehicle to experiment and react to previously untravelled terrains. Technologies that supervise or support off-road navigation in highly varying terrain are a priority.

- Rigorous field testing continues to allow for improvement of endurance, obstacle capability, and payload fraction (the primary goals for the UGCV program). Vehicle performance is analyzed, modified, and tested continuously pushing to maximize inherent terrainability of the CRUSHER platform.

- Payload development, integration and testing are proving out the intended mission scenarios. Leveraging upon unmanned vehicle capabilities and CRUSHER's unique terrain capabilities, these field tests are helping to demonstrate and influence the use of autonomous vehicles in the future.

UPI brings together technologies and people to produce autonomous platforms capable of conducting missions with minimal intervention.

Fort Carson, CO, August 2006

UGCV

Unmanned Ground Combat Vehicle

March 2004: SPINNER completes 100 miles of extreme terrain testing at Yuma Proving Grounds.

Created in 2001, the UGCV Program developed vehicle prototypes that exhibit advanced performance in endurance, obstacle negotiation, and payload capability based on novel designs unrestrained by the need to accommodate human crews. The reduced logistical footprint resulting from high fuel economy, high payload fraction, and simplified transportability offers excellent deployability for the Future Combat Systems (FCS) program . DARPA and the Army evaluated UGCVs against three primary metrics:

1. Endurance (14-day missions; 450 km range without refueling),
2. Obstacle Capability (1m+ positive, 2m negative, 35° slopes), and
3. Payload Fraction (>25%).

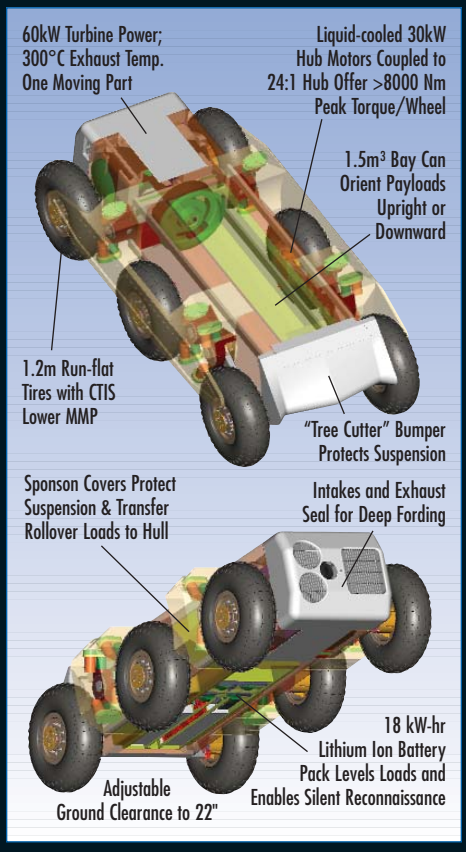
In the UGCV program, NREC led a four-member team [Boeing, Timoney Technology, DRS-TEM] to build an innovative unmanned vehicle, "SPINNER," that couples extreme terrainability with fuel efficiency, survivability and payload flexibility to deliver the long-range capability required by FCS missions. SPINNER is a highly durable, invertible, 6WD hybrid powered vehicle that responds to the need of a UGCV to surmount challenging terrain obstacles, be easily teleoperated, and withstand an occasional moderate crash and rapidly recover. SPINNER takes maximal advantage of the uncrewed UGCV aspect through its inverting design as well as the unique hull configuration that offers a large continuous payload bay that is rotatable to position payloads upright or downward. It also has incredible stealth qualities derived from its low profile and quiet hybrid operation.

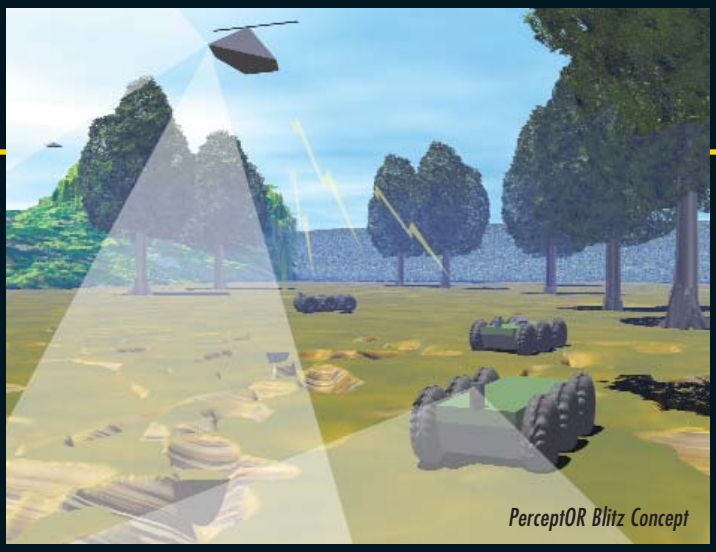
SPINNER has completed two years of intense testing to fully assess its capability in a variety of terrains, weather conditions and operational scenarios. Results continue to show SPINNER as a viable option for UGCV technology in the future.

SPINNER's range of operation is not limited to open terrain.

Key team members & vendors: Boeing (hull), Timoney Technology (suspensions and hubs), DRS-TEM (hybrid control), UQM (traction motors), Capstone (turbine), SAFT (battery pack), Novatel (positioning), SBS (computing).

SPINNER's suspension provides excellent terrainability to overcome challenging obstacles.





PerceptOR Blitz Concept

PerceptOR

Perception for Off-road Robotics

Automated Flying Eye with LADAR

During Phase II, the NREC team conducted rigorous tests at the Yuma Proving Ground.

Started in 2001, the PerceptOR program was created to develop perception and autonomous navigation capabilities for ground vehicles operating in complex, off-road environments and to test and evaluate these capabilities on a variety of terrains in an unrehearsed manner.

The NREC led a four-member team (with Sarnoff Corporation, Boeing, and Robotics Engineering Excellence) in the PerceptOR program. The team's innovative "Blitz" concept included a dedicated unmanned air vehicle - a "Flying Eye" (FE) - that flies ahead of the UGV to detect holes and other hazards before the onboard UGV sensors would otherwise be able to detect them. The UGV itself carries its own extensive sensor suite to address the broad range of operating conditions at slower speeds and to confirm the hazards seen from the air. Both systems can operate fully autonomously or with several levels of operator involvement.

During Phase II (2002), the NREC team successfully completed evaluation experiments of unrehearsed courses located in four terrains: Virginia forests, Arizona desert, California alpine and Louisiana forested lowland. The team demonstrated fully-integrated unmanned air/ground sensing to detect and avoid negative obstacles and other hazards. In addition, the vehicles negotiated complex terrain using only passive sensing, identified and negotiated difficult terrain types (ground cover, meter-high vegetation, desert scrub) by fusing geometric and color sensor data, and overcame brief periods of GPS dropout with tight integration of GPS and odometry.

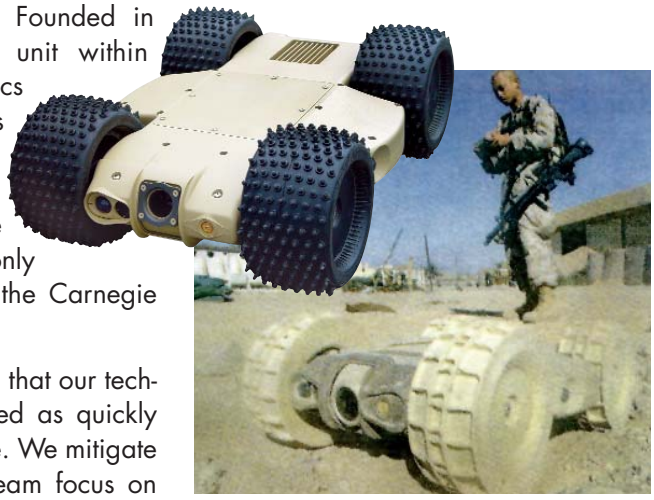
In Phase III (2003/2004) the team matured UGV autonomous capabilities through further development and field trials. Improvements included dynamically increasing UGV speed when appropriate, classifying a broader range of objects and surfaces, and operating with degraded GPS and communications.

NREC

National Robotics Engineering Center

The National Robotics Engineering Center (NREC) develops and delivers leading edge automation technology to industry and government to enable new products and capability. Founded in 1995 as an operating unit within Carnegie Mellon's Robotics Institute, NREC employs over 125 scientists, technical staff, graduate students and support personnel. The 100,000 sq. ft. facility is only a ten minute drive from the Carnegie Mellon campus.

We partner with clients so that our technology can be transitioned as quickly and effectively as possible. We mitigate client risk by continual team focus on measurable project objectives, accelerated product development, reuse of core NREC technologies and extensive field testing under real-world conditions.



(Above) Gladiator, an unmanned robotic vehicle that exhibits high mobility and advanced robotic scouting capabilities required for the Ground Combat Element of the United States Marine Corps.

(Left) Dragon Runner™, developed for the US Marine Corps Warfighting Laboratory, is a small, man-portable robot, capable of inverted operation and designed to increase situational awareness.

UPI CRUSHER

Government Sponsors

DARPA

Office of the Assistant Secretary of the Army — Acquisition, Logistics & Technology

PROGRAM MANAGER FCS BRIGADE COMBAT TEAM
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