



Joint Ground Robotics Enterprise



Ground Robotics Test and Evaluation: Are We Ready?

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Agenda



- **If Past is Prologue.....Then Robotics are ‘Coming to a Theater Near You’**
- **Where are We Headed? (and Are We Ready?)**
- **Thoughts on What is Needed to be Ready to Test**
- **Hopeful Signs of Progress**
- **Conclusions**



Ground Robots Proving Their Worth...



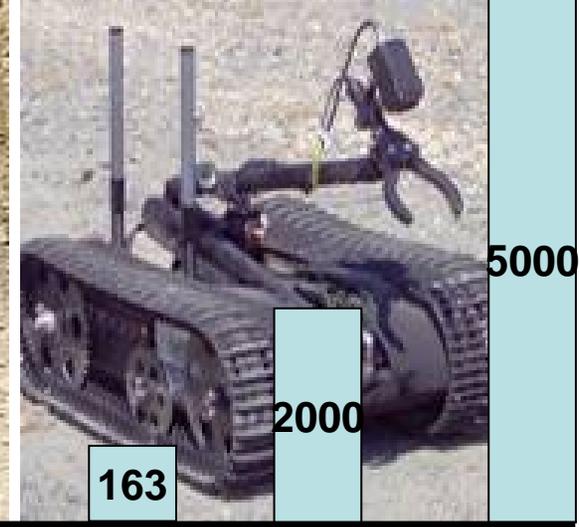
Vietnam
- Four Decades Ago -



Afghanistan
- Four Years Ago -



Iraq
- Today -



2002 2003 2004 2005 2007



Joint Robotics Program

Joint Ground Robotics Enterprise



Progress in Autonomy and Cognition



Million instructions/second

Key Challenges

- **High speed mobility**
 - Improved perception
 - Reliable data fusion
- **Safe operations**
 - Detect & classify stationary people & objects
 - Collision avoidance
- **Design for tactical behavior flexibility**
 - Understand environments
 - Decision processing
 - React appropriately to contact
- **Collaboration**
 - Conduct collaborative missions with mixed manned/unmanned force
 - Collaborative air-ground operations



Air/Ground Collaboration



Crusher/DARPA

On-road convoy operations



Armed Reconnaissance Vehicle—RSTA



Near autonomous team members



Demo IIIa



True follower—follows in tracks of manned leader

1B

10M

100K

1K

1999

2005

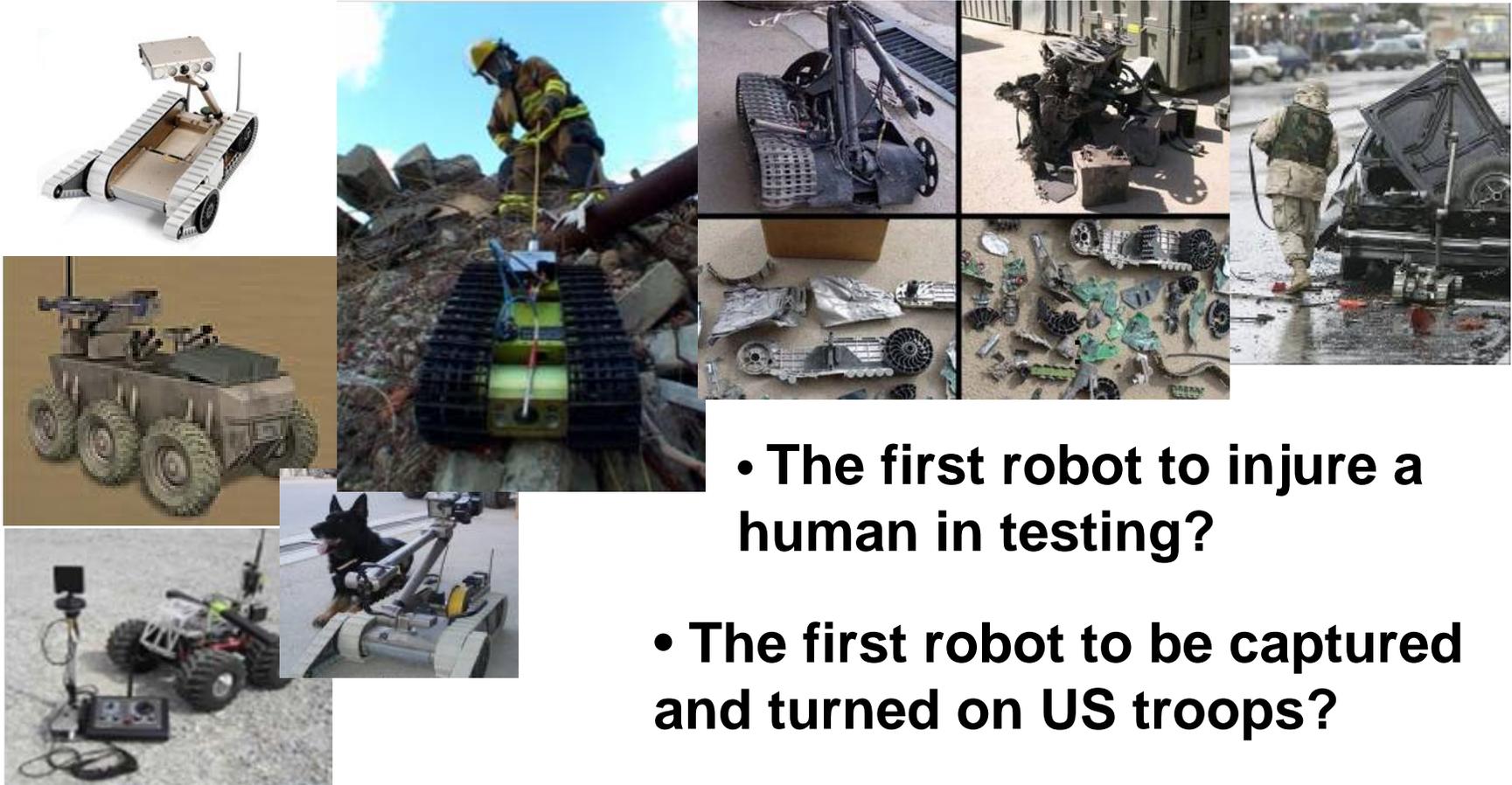
2008

2011

2015...



Ground Robotics are Saving Lives, But How Do We Test to Avoid:



- The first robot to injure a human in testing?

- The first robot to be captured and turned on US troops?

- The first robotic friendly fire incident?



What's on the Horizon?



Snakebot



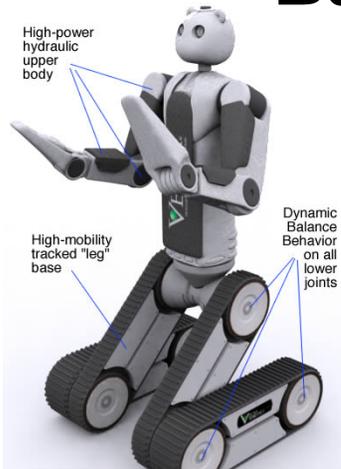
- Provides the ability to navigate over rough, steep terrain where a wheeled robotic vehicle would likely get stuck or topple over
- Recon in severely restricted terrain
- Future software will allow the Snakebot to learn on its own by experience



What's on the Horizon?



Battlefield Extraction-Assist Robot (BEAR)



- Currently in the proof-of-concept development phase for US Army's Telemedicine and Advanced technology Research Center
- Designed to find, pick up and rescue people without risking additional human life
- Upper body controlled by hydraulics
- A mobility platform that features two independent sets of tracked "legs"
- Features dynamic balancing behavior (DBB) while on its "ankles", "knees" or "hips"



What's on the Horizon?



Little Dog

- Developed under the Defense Advanced Research Projects Agency's (DARPA) Learning Locomotion program

- Goal is to learn how to traverse large, irregular obstacles with a high degree of freedom robot

- Expected Locomotion Strategy:

- Develop a library of moves to traverse terrain elements
- Recognize similar, already learned elements and modify as required in real time
- Best results will be ported to Big Dog



Boston Dynamics

Big Dog



What's on the Horizon?



- Developed by Carnegie Mellon University to assess the capabilities of large, unmanned ground vehicles operating autonomously in a wide-range of complex, off-road terrains
- Made of high-strength aluminum and titanium to withstand below-hull strikes from boulders and tree stumps, and a nose designed to absorb the impact of major collisions.

Crusher





Lessons from SWORDS Safety Testing?



- The SWORDS Spiral 1 was subjected to testing for a total of 1,111 operational hours at Aberdeen Proving Ground
- The following design changes were made solely to increase safety. In most cases performance is slightly degraded due to the design change. All design changes were included in the final System Safety testing.
 - Increased number of steps in firing sequence
 - Limit operation of the system to ranges where the operator can see the vehicle line of sight
 - Loss and regain of communications between the OCU and vehicle will cause the operator to re-run arming and firing sequence, regardless of ready state prior to communications loss
 - Weapon cannot be fired while platform is moving (Weapon firing is inhibited while joystick is engaged to move vehicle)
 - Vehicle “Kill Switch” added





Thoughts on What May Be Needed to Test Successfully...



- Performance adjudication: wheels, tracks, legs, snake motion...which one more operationally effective?
- Definition of levels of autonomy and standard performance metrics for each...how do you verify that you have achieved the desired level of autonomy?





Thoughts on What May Be Needed to Test Successfully...



- **Safety Releases-** Are we ready for armed autonomous robots (e.g. SWORDS limitations)?
- **The TRUST Factor-** If humans do not trust robot to perform, then inherent capability may not be achieved...how do we measure?





Test Standards and Instrumentation



- E-Stops, data logging, position
- How much latency is too much?

- Standard Test Methods, Metrics





Effective Tests



Computer vision may not be as good as thought, according to MIT study

Cathryn M. Delude, McGovern Institute
January 24, 2008

- Apparent success may be misleading because the tests being used are inadvertently stacked in favor of computers
- Caltech101 database, intended to test computer vision algorithms against the variety of images seen in the real world
- Caltech101 'natural' images fail to adequately capture real-world variability

The human brain easily recognizes that these cars are all the same object, but the variations in the car's size, orientation and position are a challenge for computer-vision algorithms.
Image / Nicolas Pinto



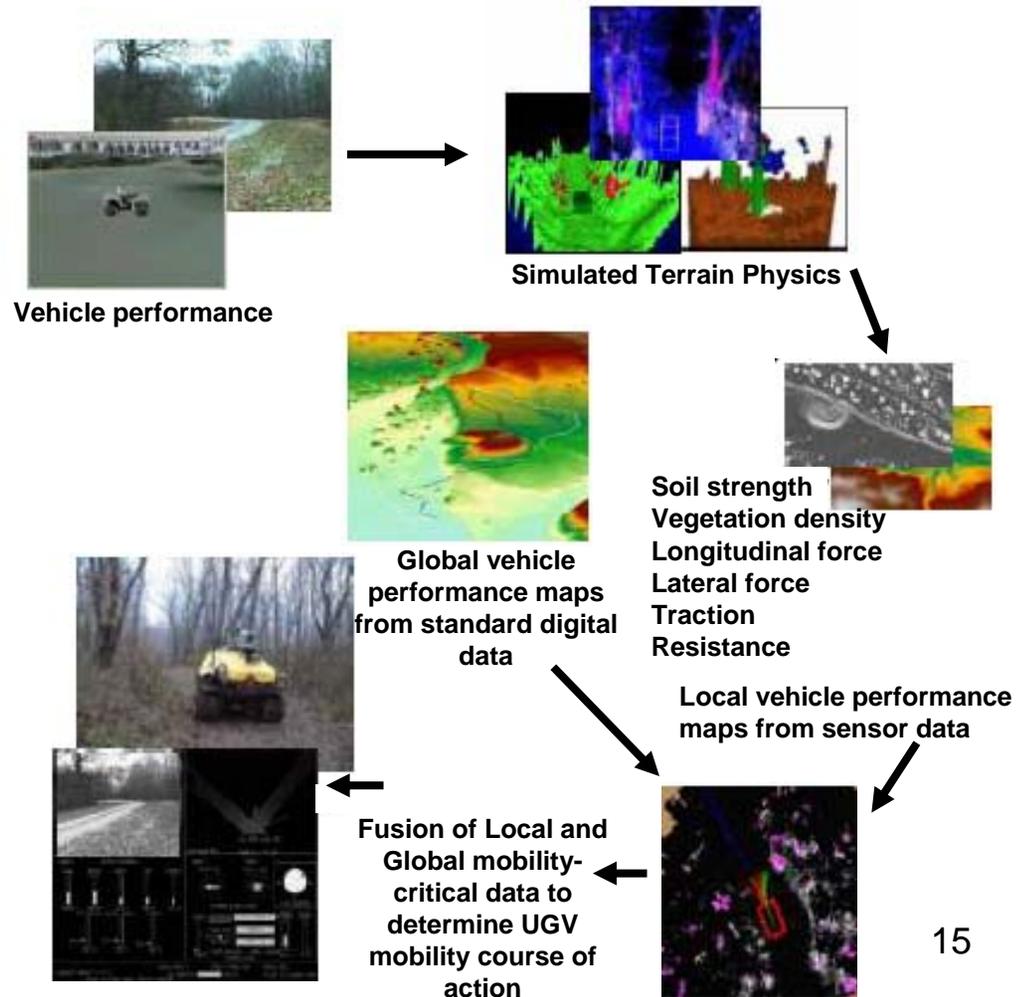


One Possible Answer



Virtual Autonomous Navigation Environment (VANE) – Testbed Process

- Provides controlled data for autonomous navigation algorithm development
- Provides a systematic process to investigate fusion of local and global mobility data
- Brings an understanding of how complex environments effect UGV autonomous operations
- Mission planning functions based on sensor perceptions





Conclusions



- **It is not a matter of 'If', but 'When'**
- **The Test Community has work to do to ensure we are ready for the challenges...**
 - TOPS
 - Metrics
 - Infrastructure
 - Modeling & Simulation

One Additional Thought...

Robots are coming to the fight...are we capitalizing on them in supporting our testing, e.g. targets, nodes on the network, etc...