TEAM OVERBOT

Briefing book

DARPA Site Visit
May 4, 2005

DARPA Team ID: A133

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Team Identification Information

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Silicon Valley Overland Robotics Association

DARPA Team ID: A133

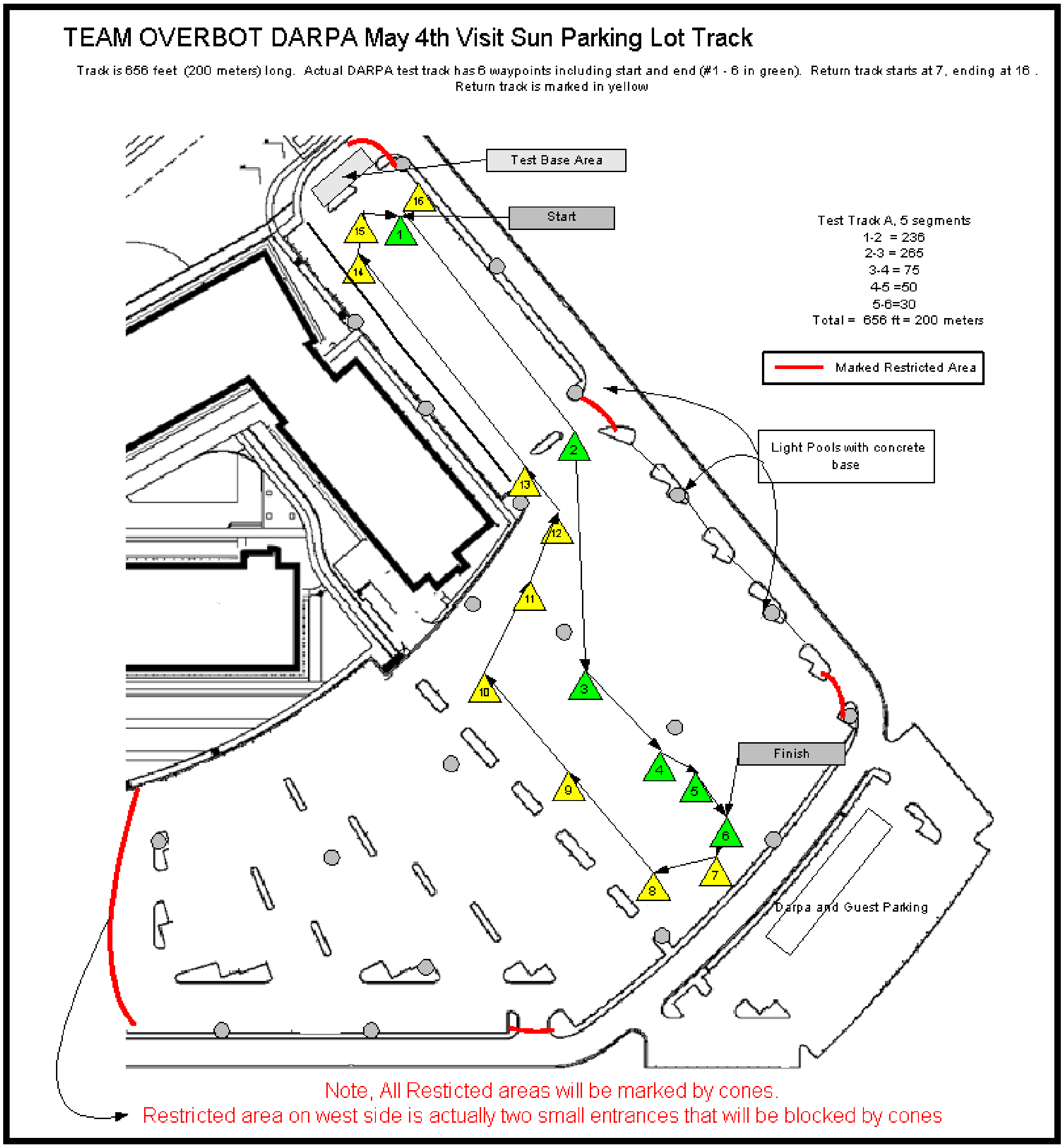
The Overbot

TEAM OVERBOT

Today's agenda

- Introduction
- Safety briefing
- Vehicle tour
- Questions
- Vehicle runs course with no obstacles.
- Vehicle runs course with DARPA-placed obstacles.
- Longer closed-loop course with display of map afterward.
- Wrap up.

The course today



Test specifications

- Flat course with two turns, per DARPA specifications.
- No driver in the vehicle.
- The vehicle has no advance information about the course – just the waypoints.
- The DARPA-specified waypoints are part of a closed course, so we can return the vehicle to the starting point automatically.
- The vehicle will map the terrain, and the map can be viewed after each run.

Safety briefing

- When the yellow strobe light is flashing, the vehicle can move by itself.
- All vehicle travel along the DARPA-specified course is away from the viewing location.
- The big red buttons on either side of the vehicle and at the rear will stop the vehicle, cut the throttle, and lock the brakes.
- Our emergency stop radio system is an industrial emergency stop system used in heavy industrial applications. Pressing the big red button on the remote will stop the vehicle. Loss of communication for two seconds will stop the vehicle.
- If any part of the vehicle goes beyond the course boundaries, or we lose the high-precision GPS signal, the vehicle will shut down as a safety measure.
- A hardware timer will stop the vehicle if the computers do not reset it every 125ms.
- We will not exceed 15MPH today.

The Overbot Approach

- **Full automation – no manual preplanning**
  - No aerial data will show every pothole.
  - Terrain may change after data collection.
  - Manual preplanning failed last year.

- **Profile terrain, don't just sense "obstacles"**
  - The Overbot can detect negative obstacles and sloped terrain.
  - We can avoid falling into a ditch, unlike two entries last year.

- **Don't outdrive the sensors**
  - Drive only over terrain that has been profiled.
  - We expect to average around 20mph. Faster on long straight sections, slower in tough sections.

- **Modest sized, rugged vehicle.**
  - Big enough to go the distance
  - Narrow enough to fit comfortably on dirt roads.

The Overbot Approach - Mapping

- **Build local map using LIDAR line scanner**
  - 20cm cells.
  - Cells classified as UNKNOWN, GREEN (passable), YELLOW (possibly passable), or RED, by measuring local roughness using two successive LIDAR scan lines. This minimizes the effect of scanner movement.
  - Absolute elevation data is kept for use in evaluation of YELLOW areas, but is not used at high speed, because it becomes too noisy as the scanner bounces around. At high speed, we drive on GREEN terrain only.

- **Put scanner up high, on a tilt mount**
  - Profile terrain, see potholes and ditches.
  - No single position scanner can reliably fill the map.
  - A tilt head gives full 3D capability if needed.
  - A 3-axis gimbal is too big for this vehicle. 1 axis gives 80% of the capability with less machinery.
  - Tilt is servoed to keep the map filled.

The Overbot Approach - Scanning

- **Correct for scanner vibration**
  - Map building is based on comparing successive scan lines taken at 75Hz.
  - Scanner is on shock mounts with a frequency cutoff around 20Hz.
  - Scanner is balanced on tilt head axis to reduce angular error from linear vibration
  - Sensor data is corrected for scanner position, as measured with inertial system, tilt head feedback, and GPS.

- **Provide "sweep" capability.**
  - When sensor data is unusable, we can stop the vehicle and sweep out the area ahead of the vehicle with the tilt head. This gives us a near-perfect 3D image. In tough spots and tight turns, this gets us out of many problems.

- **Provide a scanner cleaning system**
  - LIDAR with "pollution" detection.
  - Scanner tilts down to cleaning position. Compressed air and washer fluid clean window.
  - Equipment used on heavy mining trucks.

The Overbot Approach – driving

- **Use reactive control against a local map**
  - Pure reactive systems, with no world model, are too dumb.
  - Not enough information for full preplanning

- **Assist reactive planning with a true planner.**
  - Used only in tough spots, at very slow speeds, to get out of problem areas.
  - Can drive in reverse.
  - Can deal with dead ends, vehicle at bad angle.

- **Visual road follower**
  - Recognizes linear features going away from vehicle, not road edges.
  - Suitable for dirt roads.
  - Used as “hint” to find most road-like area.
  - Only used to choose between areas LIDAR maps as passable.

The Overbot Approach – software

- Programmable controllers run the low-level servo loops.
- Higher level processing runs on industrial x86 machines using the QNX real-time operating systems
- System organized as multiple intercommunicating processes on multiple CPUs.
- Everything talks over an Ethernet
- Software written in C++.
- All new software.
- Up to 3 Pentium 4 CPUs can be installed, but today we only have one on board, because we're only at 25-50% CPU utilization and don't need more.

Appendix

Team leader passport
(as required for citizenship verification)

*The Secretary of State
of the United States of America
hereby requests all whom it may concern to permit the citizen/
national of the United States named herein to pass
without delay or hindrance and in case of need to
give all lawful aid and protection.*

*Le Secrétaire d'Etat
des Etats-Unis d'Amérique
prie par les présentes toutes autorités compétentes de laisser passer
le citoyen ou ressortissant des Etats-Unis titulaire du présent passeport
sans délai ni difficulté et, en cas de besoin, de lui accorder
toute aide et protection légitimes.*

John Nagle
SIGNATURE OF BEARER/SIGNATURE DU TITULAIRE

NOT VALID UNTIL SIGNED

UNITED STATES OF AMERICA

PASSPORT
PASSEPORT
USA

Type/Catégorie: P
Code of issuing State / code du pays émetteur: USA
PASSPORT NO./NO. DU PASSEPORT: 152320144
Surname / Nom: NAGLE
Given names / Prénoms: JOHN BENNETT
Nationality / Nationalité: UNITED STATES OF AMERICA
Date of birth / Date de naissance: 12 JUL/JUI 48
Sex / Sexe: M
Place of birth / Lieu de naissance: ILLINOIS, U.S.A.
Date of issue / Date de délivrance: 11 FEB/FEV 95
Date of expiration / Date d'expiration: 10 FEB/FEV 05
Authority / Autorité: PASSPORT AGENCY
NATIONAL PASSPORT CTR 24
Amendments/Modifications SEE PAGE

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