ARMY RESEARCH LABORATORY

Robotics Collaborative Technology Alliance (RCTA) 2011 Baseline Assessment Experimental Strategy

by Barry A. Bodt

ARL-TN-457 **September 2011**

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Army Research Laboratory
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REPORT DOCUMENTATION PAGE	Form Approved OMB No. 0704-0188

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1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED (From - To)
September 2011	Final	March 2011–August 2011

4. TITLE AND SUBTITLE
Robotics Collaborative Technology Alliance (RCTA) 2011 Baseline Assessment Experimental Strategy

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Barry A. Bodt

5d. PROJECT NUMBER
1T0ZT2

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Research Laboratory
ATTN: RDRL-CII-C
Aberdeen Proving Ground, MD 21005-5067

8. PERFORMING ORGANIZATION REPORT NUMBER
ARL-TN-457

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The current Robotics Collaborative Technology Alliance (RCTA) has, as an integral part of its program plan, the requirement to conduct periodic assessments on maturing technologies. This report documents the planning process for an initial baseline assessment and presents detailed guidelines for experiment conduct. The snapshot of that process presented here is in the form of a working document produced toward the end of the planning cycle. Its value to the RCTA community is in serving as an example of how the RCTA will approach assessments in terms of formal experimentation. The motivation for releasing it as a working document is to provide greater insight to the development of an experiment than is customarily included in a report documenting the results of the experiment. The intent is that this will be helpful to RCTA members as they plan future assessments of RCTA technologies.

15. SUBJECT TERMS
RCTA, experimental strategy, autonomous, look and move

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Barry A. Bodt
Unclassified	Unclassified	Unclassified	UU	36	19b. TELEPHONE NUMBER (*Include area code*) 410-278-6659

Standard Form 298 (Rev. 8/98)
Prescribed by ANSI Std. Z39.18

Contents

Preface **iv**

Acknowledgments **v**

1. Purpose **1**

2. Scope **1**

3. Objective **1**

4. Background **1**

5. Experimental Site **2**

6. Platform/Configuration **2**

7. Challenges Addressed **3**

7.1 Surfaces 3

7.2 Structure 3

7.3 Situations 4

7.4 Tasks 4

7.5 Summary of Challenges 4

8. Experiment **5**

9. Robotics Collaborative Technology Alliance Resources **15**

10. Other Topics **15**

Appendix. Runs and Locations **17**

Distribution List **27**

Preface

The current Robotics Collaborative Technology Alliance (RCTA) has, as an integral part of its program plan, the requirement to perform periodic assessments on maturing technologies. This report documents the planning process for an initial baseline assessment and presents detailed guidelines for experiment conduct. The challenging and complex research areas of perception, intelligence, human-robot interaction, and dexterous manipulation and unique mobility provide a commensurate challenge in the assessment of their performance. This assessment challenge was even more acute in that it represented the first assessment of the program and involved platforms and mission considerations different than those of the previous RCTA. The snapshot of that process presented here is in the form of a working document produced toward the end of the planning cycle. Its value to the RCTA community is in serving as an example of how the RCTA will approach assessments in terms of formal experimentation. The motivation for releasing it as a working document is to provide greater insight to the development of an experiment than is customarily included in a report documenting the results of the experiment. The intent is that this will be helpful to RCTA members as they plan future assessments of RCTA technologies.

Because this was a working document, the actual experiment details differed in some ways from this initial plan, even though the general strategy remained intact. For example, the side-slope approach to a drop-off was abandoned at the test site because an important, limiting feature of the intended course segment was not discernable from the aerial photograph used in planning but was immediately obvious when viewed in person. Other differences are present, but we will leave those discussions to the final report for the experiment. In general, however, the details of the experiment outlined here were implemented.

Acknowledgments

Without a collaborative effort from many individuals, this strategy for experimentation would not have been possible. The principal contributors were Marshal Childers (U.S. Army Research Laboratory); Rick Camden and Craig Trice (MPRI); Robert Mitchell, Brad Stuart, Robert Dean, and Stacey Cape (General Dynamic Robotic Systems); Alberto Lacaze, Karl Murphy, and Nenad Uzunovic (Robotic Research); Mark Del Giorno (Del Services LLC); and Justin Teems (QinetiQ-NA).

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1. Purpose

This report outlines the 2011 baseline assessment experimental strategy to be conducted at Fort Indiantown Gap (FTIG), PA, in the Combined Arms Collective Training Facility (CACTF) 1–3 August. The purpose of the baseline assessment is to initiate the experimental component integral to the Robotics Collaborative Technology Alliance (RCTA) and focus on behavior primitives necessary to achieving autonomous "look" and "move"—two of the RCTA vision components of "think," "look," "move," "talk," and "work" (TLMTW) identified in the FY 2011 Annual Program Plan (APP).

2. Scope

This report (1) identifies and gives the rationale for individual tests within the overall experiment, (2) provides a description of each test, (3) suggests the analysis to be performed, and (4) notes procedural and logistical issues to be addressed. This report does not constitute the detailed test plan/sequence, which will follow after the strategy outlined within is agreed upon. It should, however, provide sufficient detail that developers can plan for the experiment.

3. Objective

This report synthesizes the discussions, demonstrations, visitations, and explorations over the past few months and molds them into a sensible starting point for RCTA experimentation. A sufficient level of detail is provided on the rationale and conduct of each test to provide a basis upon which the community can accept, decline, or accept with modification each test within the overall initial experimental strategy.

4. Background

The APP submitted in March 2011 reaffirms the RCTA intent to include frequent experimentation on developing technologies. RCTA leadership stressed the need to begin that process early in the RCTA, with the understanding that in this initial year technology development was just beginning. Additional direction suggested the initial experimental focus be on small unmanned ground vehicle (SUGV) performance within the TLMTW vision. Visitations, notably with the 20th Support Command at Aberdeen Proving Ground, discussions

within the RCTA, and explorations using the Robotic Research–fitted Talon helped forge notions of primitive behaviors deemed important to the TLMTW vision and raise genuine questions on performance capabilities, the pursuit of which would contribute to RCTA research.

5. Experimental Site

The site of the experiment is the CACTF at FTIG. The CACTF offers an urban terrain consistent with a mission profile envisioned for an SUGV and many fixed structural components that serve to stress behavior primitives.

Other sites were considered: the U.S. Army Research Laboratory/Human Research and Engineering Directorate (ARL/HRED), ARL/Vehicle Technology Directorate (VTD), U.S. Army Aberdeen Test Center (ATC), and National Institute of Standards and Technology (NIST)/Nike. ARL/HRED has sufficient ground to support an experiment but has limited existing course structure to leverage, and scheduling was a problem. ARL/VTD has sufficient ground to support an experiment but has no existing course structure. Also, potential hurdles associated with gaining approval for testing behind the fence in the time window available made it impracticable. The ATC site is an SUGV course constructed to test SUGV mobility in operator-controlled environments, but its configuration does not support the range of autonomous behaviors to be considered. The NIST/Nike site was used by the previous RCTA and offers an adequate test location. Logistical preference and urban terrain backdrop favored the CACTF for this initial investigation.

6. Platform/Configuration

The platform will be the Robotic Research–fitted Talon, with a fixed baseline configuration (hardware/software) for the experiment. To the extent possible, parameters will be fixed throughout the nine experimental vignettes identified in this report; that is, avoid fine tuning for a specific vignette within the range of nine challenges to preserve the sense that the collective of behavior primitives could be robustly achieved. (Absolutely avoid changing parameter settings within a vignette according to different factor levels to prevent confounded results.) However, across vignettes the desire for robustness must be balanced with the need to collect meaningful data; a parameter setting that virtually guarantees failure for all runs within a vignette demonstrates only that the space for experimentation (parameter settings and challenge conditions) was poorly chosen. The experimental space should span easy-to-hard (or impossible), so that something can be learned. Consequently, we recognize that to ensure meaningful data is collected, certain parameters may have to be adjusted according to the

challenge of the vignette. Ultimately, a goal of the program is to autonomously make necessary parameter adjustments.

As an artifact of the experimental design, some parameters may be adjusted to channel the robot down a path to ensure it interacts with a challenge.

The platform is to be moving forward in all runs of this experiment.

7. Challenges Addressed

Many mobility/perception challenges and SUGV tasks linked to envisioned operations have been discussed in the RCTA community. At this early stage of technology development, there is no need to associate challenges or tasks within a specific scenario context; rather, we should examine performance with an eye toward general applicability. For this discussion, we draw soft distinctions between inherent mobility of the platform, autonomous mobility, and intelligent control or higher-level planning activities.

7.1 Surfaces

Traversal over different surfaces—climbing stairs, negotiating ditches, etc.—is an inherent mobility concern. The platform capability of moving over pavement, concrete, gravel, stone, grass, mud, etc., can be explored in an operator-controlled setting and is not within the scope of this experiment. However, surfaces, combined with slopes, could also induce slippage, affecting the NAV solution, or present challenges to perception depending on the coarseness of the surface (or in the case of grass, the height of perceived obstacles). In that sense, surfaces present an autonomous mobility challenge. To detect slippage, real time would require a ground truth capability that we will not have for this experiment; however, a differential GPS reading will be taken at the beginning and end of each run and compared with the Talon NAV solution. The perception challenge may be indirectly assessed by measuring speed over course segments of available surfaces.

7.2 Structure

Common fixed structures and free obstacles must be negotiated by an autonomous SUGV. Specific to an urban setting, there are, for example, cones, vehicles, trash barrels, doorways, stairs, slopes, drop-offs, and narrow alleys. These challenges are immediate impediments to the progress of the SUGV, requiring it to negotiate around them, through them, or over them. Other impediments to progress might be dynamic, such as with people or vehicles. The challenge with movers is for the SUGV to appropriately update the map to account for position changes and to incorporate the dynamic obstacles in its route planning.

7.3 Situations

The overcoming of immediate obstacles does not have to drastically change the route of the SUGV; it overcomes or bypasses the obstacle and continues. However, certain situations create major route disruptions that require the SUGV to effectively establish a new route segment over a portion of the initial route or provide constraints on how the route is executed. These challenges suggest a need for higher-level intelligent control. For example, outside cul de sacs or dead ends within buildings require a substantive departure from the initial route. A maze of street clutter might have the same effect, as would interaction with buildings. Further, the SUGV may seek to minimize line of sight to an enemy location or prefer a surface (e.g., sidewalks) when operating in a busy urban setting. Additional constraints provide a challenge to perception and planning.

7.4 Tasks

The SUGV will have certain tasks to perform on its route. It could be carrying tools or supplies, identifying key objects, interacting with those objects, performing recon on an area, etc. At this stage in the program, the SUGV available has a capability for mapping that can be used toward the "look" component of TLMTW. The SUGV also has the capability to record video as it passes through an area, but there are no perception algorithms on board currently to dissect that information into objects of interest (OOIs). For example, in an urban setting we would expect the SUGV to perceive people in various settings: moving, stationary, prone, crouched, standing, partially obscured, etc. Other OOIs could also be targeted, for example, cars, furniture, walls, barrels, windows, and suspended objects. In this initial experiment, a baseline will be established by having analysts interpret the video. As perception capabilities come online, the completely automated parsing of OOI can be compared.

7.5 Summary of Challenges

A summary of the challenges considered is listed as follows:

A. Surfaces
    1. Pavement
    2. Gravel
    3. Grass (various heights)

B. Structure
    1. Doorway
    2. Slope
    3. Stairs

4. Drop-offs
5. Alley
6. People

C. Situations
    1. Cul de sac, dead end, maze
    2. Street clutter
    3. Room clutter
    4. Building exterior/interior

D. Tasks
    1. Mapping
    2. OOI video

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8. Experiment

The experiment is parsed into a surfaces study and then a series of vignettes to address the challenges listed in section 7.5. Each is presented in outline form with regard to goal, location, conduct, measurement, and analysis. Test conduct will include setup, execution, and special considerations, such as test apparatus or obstacles.

A. Surfaces Study: Surfaces will be examined in a two-factor 4 × 4 design with surface acting as a block.
    1. Goals: To establish baselines on speed over surfaces and different horizons allowed by autonomous mobility, especially perception, and assess the quality of the route taken.
    2. Factors
        a. Surface (pavement, gravel, low grass, high grass)
        b. Horizon (uphill, downhill, side hill, level)
    3. Conduct: Send the SUGV on an A/B route over nominally 50–75 ft.
    4. Responses

a. Time will be computed from when the treads start moving to when the robot reaches the end point.

b. A/N path ratio will be taken as the ratio of the actual (A) path length to the nominal (N) straight line, A/B path length. (It is important to note that there is no implied expectation that the SUGV will travel in perfect linear fashion even in an open course; however, this measure may provide some additional insight to developers on how route costs are influenced by various surface conditions.)

c. Displacement will be taken as the difference between the NAV solution at end point and a differential GPS solution. Responses will be based on the same distance A/B route if possible, but normalized to the distance possible for different locations if necessary.

5. Replications: (2)

6. Randomization: Refers to order of experimentation. TBD.

7. Locations: Various locations are required throughout the CACTF. The exact runs are TBD.

   a. Pavement

      (1) Level: in front of police station

      (2) Uphill: in between police station and hotel

      (3) Downhill: in between police station and hotel

      (4) Sidehill: in between police station and hotel

   b. Gravel

      (1) South of two-story office building

      (2) Uphill: southwest approach to church intersection

      (3) Downhill: southwest approach to church intersection

      (4) Sidehill: southwest approach to church intersection

   c. Low grass

      (1) Level: across the circle

      (2) Uphill: next to southwest approach to church intersection

      (3) Downhill: next to southwest approach to church intersection

      (4) Sidehill: courtyard next to southwest approach to church intersection

d. High grass

(1) Level: southern (upper) end of courtyard

(2) Uphill: courtyard

(3) Downhill: courtyard

(4) Sidehill: courtyard

8. Considerations

a. Parameter settings (cell size, corridor) should be held constant.

b. Course preparation for grass runs. Grassy areas may contain solid obstacles, such as rocks, bricks, cement blocks, etc.

c. An adequate run length must be established to account for location tolerances at the end of the run. Side hill runs will be reduced to one rep.

9. Analysis

a. Supports estimation of speeds and displacement for a variety of surfaces.

b. Supports investigation of differences among surfaces using Analysis of Variance (ANOVA).

B. Structure

1. Drop-off or negative obstacle: Negative obstacles can be explored in a three-factor $3 \times 3 \times 2$ factorial design, with location serving as a blocking factor.

a. Goal: To establish a baseline for the drop-off the SUGV will attempt to negotiate.

b. Factors

(1) Start surface (level concrete, level grass, side hill grass)

(2) Drop height (high [15 in], medium [10 in], low [5 in])

(3) Landing surface (plywood, sod on plywood)

c. Conduct: Send the SUGV on an A/B route with a tight corridor parameter setting through a scheduled drop-off to the B waypoint beyond the challenge. A line will be attached to the SUGV to prevent it from incurring damage on the most difficult drops. Record GPS location at end of run.

d. Responses

(1) Run time will be recorded as the time from when the SUGV starts moving to when it stops for "no plan," remains inactive for 30 s, or clears the challenge and reaches the goal.

(2) Decision will be recorded as attempted or not attempted to step down.

(3) Outcome will be recorded in two parts: as a data-collector decision on the level of success of the movement past the challenge and, conditional on getting past the drop, if it reached the goal.

(4) Displacement is the difference between the NAV-indicated location and GPS location at the end of the run.

e. Replications: (2)

f. Randomization: TBD

g. Locations: Business 1 across from the townhouse toward the cemetery (level concrete porch), two-story office building (side hill grass), police station (grass to retaining wall drop-off).

h. Considerations

(1) Need a landing platform with adjustable height. I suggest two half-sheets of 7/16-in plywood joined by two or three door hinges along with a number of bricks. We would rest the landing on bricks to a predetermined height and let the other 1/2 sheet of plywood ramp to the ground for flat landing runs.

(2) Need a few pieces of sod to provide a different surface for the landing.

(3) Either corridor setting or physical barriers (plywood) will be needed to force Talon to interact with the drop-off for the side hill location and police station retaining wall.

i. Analysis will be descriptive/exploratory. Where appropriate, ANOVA will be performed.

2. Stairs: Stairs can be explored in a four-factor 3 × 3 × 2 × 2 design, not run in a factorial manner.

a. Goal: To establish a baseline for the height and type of stairs the SUGV is willing to climb.

b. Factors: Treatment combinations will be formed from these four factors, but not in a factorial structure. We are trying to take into account the ~34-in length of the Talon and the ~10-in tread height.

(1) Three riser heights (12, 8, and 4 in)

(2) Tread width (96, 24, 12, and 8 in)

(3) Riser could be open (as in a fire escape) or closed like concrete steps

(4) No. of steps (one or two)

(5) Combinations have been chosen (1) to facilitate modular construction using 1/2 plywood and standard framing lumber to achieve nominal heights /widths and (2) to challenge the robot in realistic stair conditions for humans. Notation (riser height × tread width) for the one-step case and (riser height × tread width × riser height × tread width) for the two-step case. Run each combination with open risers and closed risers. Combinations in inches are as follows: (4 × 96), (8 × 96), (12 × 96), (4 × 8 × 4 × 96), (4 × 12 × 4 × 96), (4 × 24 × 4 × 96), (8 × 8 × 8 × 96), (8 × 12 × 8 × 96), (8 × 24 × 8 × 96), (12 × 12 × 12 × 96), (12 × 24 × 12 × 96).

c. Conduct: Send the robot on a path with a tight corridor parameter to engage steps.

d. Responses

(1) Run time will be recorded as the time from when the SUGV starts moving to when it stops for "no plan," negotiates the climb, or remains inactive for 30 s upon reaching the challenge.

(2) Decision will be recorded as attempted or not attempted to climb.

(3) Outcome will be recorded as a data-collector decision on the level of success of the movement past the challenge.

e. Replications: (2)

f. Randomization: TBD

g. Location: Barn (constructed steps) and townhouse opportunities as appropriate.

h. Considerations

(1) We may be able to vary the riser height (within existing steps) by considering fractions of the riser using framing lumber (4 × 4, 2 × 4, 2 × 2, etc.) to soften the perceived climb. The softening would impact both the riser and the tread.

(2) It is likely that bricks or block support of plywood landings and treads with some combination of lumber may be required to completely simulate steps for some conditions, but the townhouse steps should be incorporated if feasible.

(3) Bricks on the end of the steps, with 2 × 4 spanning, might be able to give the effect of open risers.

i. Analysis will be descriptive/exploratory.

3. Doorway: Doorways can be explored in a two-factor 3 × 3 × 2 factorial design.

a. Goal: To establish a baseline for the opening and angle of approach needed to pass through a doorway.

b. Factors: Factors take into account the ~22-in platform width.

(1) Three common door widths: 24, 30, and 36 in.

(2) Angle of approach 90°, 45°, and 0° from opening.

(3) Door ajar away from approach in degrees (180 and 60). (Note: The 24-in door at 60° would require the SUGV to nudge the door to pass through.)

c. Conduct: The robot travels an A/B route through a door.

d. Responses

(1) Run time will be recorded as the time from when the SUGV starts moving to when it stops for "no plan," negotiates the door and fully enters the room, or remains inactive for 30 s.

(2) Decision will be recorded as attempted or not attempted to pass through.

(3) Outcome will be recorded as a data-collector decision on the level of success of the movement past the challenge.

e. Replications: (2)

f. Randomization: TBD

g. Location: Entering the police station from the outside patio.

h. Considerations

(1) Use one 1/2 sheet of plywood with right-angle support to make it perpendicular to the floor/ground. Slide it as we wish to vary the width of the door opening.

(2) An excursion might be to have the door only partially open, much less than 60°, with one of the wider door openings.

(3) Angles considered are 90° from straight through the doorway, 45°, or 0°. Intermediate angles could be considered also, but would be excursions.

i. Analysis will be descriptive/exploratory.

4. Alley: A narrow passageway can be explored in a single-factor design at three levels.

a. Goal: To establish a baseline for time to pass through a narrow passage.

b. Factor: Passage width (full alley, tight to robot, in between).

c. Conduct: Send the robot on an A/B route along a narrow passage.

d. Responses

(1) Time to achieve route will be recorded as the time from when the SUGV starts moving to when it stops for "no plan," reaches the B waypoint, or remains inactive for 30 s.

(2) Outcome will be recorded as a data-collector decision on the level of success of the movement past the challenge.

e. Replications: (2)

f. Randomization: TBD

g. Location: Alley north side of police station

h. Considerations

(1) Need plywood to narrow alley.

(2) Cell size fixed or varied in a structured manner as part of the experiment.

i. Analysis will be descriptive/exploratory.

5. People: Dynamic obstacles on the map to be explored in a two-factor 5 × 2 factorial design.

a. Goal: To establish a baseline for whether persistence of dynamic obstacle tracks on the map impede robot progress.

b. Factors

(1) Dynamic obstacle path (front [perpendicular], front [parallel], side [perpendicular], side [parallel], orbit)

(2) Speed of obstacle (walk, jog)

(3) Proximity (3–4 m)

c. Conduct: Have the robot proceed on an A/B route with no dynamic obstacle. Or, start a dynamic obstacle in front, beside, or around the robot in close proximity.

d. Responses

(1) Time to achieve route will be recorded as the time from when the SUGV starts moving to when it stops for "no plan," reaches the B waypoint, or remains inactive for 30 s.

(2) Outcome will be recorded as a data-collector decision on the level of success of the movement past the challenge.

e. Replications: (2)

f. Randomization: TBD

g. Location: Street in front of the townhouses

h. Considerations

(1) Appropriate "proximity" to interact with route should be inside and outside planning horizon of 5 m.

(2) Consider capturing a decay time of the mover on the map, but that is probably a setting.

(3) Orbit path will be in the same direction as the sensor rotation.

i. Analysis will be descriptive/exploratory.

C. Situations/Tasks

1. Cul de sac/dead end: A cul de sac and other major route disruptions can be explored in a two-factor 3 × 3 factorial design.

a. Goal: To establish a baseline for how well route adjustments are implemented to overcome major route disruptions.

b. Factors

(1) Disruptions (cemetery cul de sac, the two-story office building next to the small alley, and a cone maze in the courtyard)

(2) Severity adjusts route to reflect (full, moderate, slight) interaction with disruption

c. Conduct: Have the robot proceed on an A/B route to the obstacle.

d. Responses

(1) Time to achieve route will be recorded as the time from when the SUGV starts moving to when it stops for "no plan," reaches the B waypoint, or remains inactive for 30 s.

(2) Outcome will be recorded as a data-collector decision on the level of success of the movement past the challenge.

e. Replications: (2)

f. Randomization: TBD

g. Location: Cemetery, two-story office building, street between business 1 and the church

h. Considerations: Eliminate grass as a factor (short grass).

i. Analysis will be descriptive/exploratory.

2. Marketplace: Run a busy street scene, one-factor design in three levels

a. Goal: To establish a baseline for a busy marketplace route.

b. Factors: Scene

(1) Clear, no obstacles (or to the side)

(2) Static obstacles

(3) Static and dynamic obstacles (people on controlled routes)

c. Conduct: Have the robot proceed through the main street.

d. Responses

(1) Time to achieve route

(2) Obstacle challenges met

(3) Obstacle challenges overcome

e. Replications: (2)

f. Randomization: TBD

g. Location: Center north/south run

h. Considerations

(1) Some obstacles can be suspended

(2) OOI will be present and named ahead of time

(3) 360° video capture of the runs by robot

(4) Video capture of the runs by CACTF

i. Analysis

(1) Primarily descriptive.

(2) Individuals from a three-person analyst team will use a Likert scale to score the visibility of specific OOI along the route.

3. Building mapping: Mapping a building can be explored in a two-factor 2 × 3 factorial design.

a. Goal: To establish a baseline for interior mapping capabilities.

b. Factors

(1) Obstacles (clear, room obstacles)

(2) Buildings (three buildings)

c. Conduct: Have the robot proceed through a building, and map the location of walls and furniture (if it sees furniture).

d. Responses: A number of fiducial marker positions will be compared with actual locations in a post-run analysis to determine offset distances; letters placed at different heights and of different heights will be scattered in the area to provide a camera baseline.

e. Replications: (2)

f. Randomization: TBD

g. Location: Police station, restaurant, second-floor two-story office building

h. Considerations

(1) Some obstacles can be suspended

(2) OOI, including people, will be present and named ahead of time

(3) 360° video capture of the runs by robot

(4) Video capture of run by CACTF

i. Analysis

(1) Primarily descriptive.

(2) Individuals from a three-person analyst team will use a Likert scale to score the visibility of specific OOI along the route.

9. Robotics Collaborative Technology Alliance Resources

RCTA will provide the following:

- Two Talons with control stations and operators
- Communications/radios to operate in the CACTF
- Safety officers as required
- Differential GPS (portable)
- Formal definition of mapping a room or area (partial response already provided)
- Identification of all failure modes to prescribe appropriate responses during run (working on this issue)
- Automated data collection to support responses in experiment vignettes
  - Coordinates of the start point, end point, and any waypoints for any plan generated during any run
  - Video file from the three cameras for runs involving OOI identification
  - File containing Talon coordinates (x,y,z, roll, pitch, azimuth) vs. time vs. status (moving, stopped, etc.), vs. vehicle direction (forward or backward)
  - A file including experimental conditions, date, time, run number, etc.
  - A map on mapping missions

10. Other Topics

This section lists a few general topics for discussion.

- Do we need some kind of periodic calibration? Data collectors will record start and end points on each run using a portable GPS unit. (There will be a calibration prior to each run. The RCTA will provide the timing and method.)

- Can we lock and report the values of key parameters? (Agreed to not vary parameters within vignettes.)
- Should key parameters be varied within the design other than what was mentioned above? (Some exploratory varying of parameters at the end of the test may be tried for certain vignettes.)
- Are there other responses that could be considered? (Holding with these.)
- We need to tighten the failure mode. Time was mentioned, but what about retries within a run? Should there be some repositioning opportunity and retry for some of the tests? (No interventions in the initial baseline test. The Talon will succeed or fail on its own. However, some excursions may be run where interventions and parameter changes are permitted.) (I recommend allowing 15 excursions during the test at the request of the developers and with approval of the test director. A maximum of four will be allowed for any one vignette. Prior to moving to a new vignette, but at the conclusion of the current vignette, the developer can call for excursion or exploratory runs [analogous to throwing a football challenge flag] where they feel there is information to be gleaned from a change in parameters, intervention, etc. By incorporating the challenges in the design as opposed to waiting to the very end, there will be better flexibility to pursue important questions when they arise.)
- When is a run invalid and a rerun appropriate? (Admin stops and reruns will be allowed in certain situations [e.g., electronic or mechanical failure, operator error in setup configuration, serious loss of comms, inadvertent interloper on the course, failure to collect files with robot data/video].)
- We need two Talons for this effort. Both will be used fully in the plan. However, if one fails, we will have to prioritize on the fly what portions of the remaining experiment will be performed. (We will have two Talons.)
- Who is responsible for test setup items (static obstacles [cones, vehicles, barrels, mannequins], plywood for door widths, platform and ramp, blocks/bricks to adjust heights of platforms)? (GDRS will handle this.)
- Do we want to add something like bags of mulch as steps for the robot to climb or descend? (No.)
- What operating conditions would lead to an e-stop (e.g., too big of a drop-off, too much of a roll)? (A safety line will be used to protect the robot from damage in runs pushing the operating limits.)

Appendix. Runs and Locations

This appendix appears in its original form, without editorial change.

RCTA 2011 Baseline Assessment
Appendix A: Runs & Locations
Surfaces Vignette

Runs 1-2 (Low Grass x Level)

Runs 3-8 (Low Grass x [uphill, downhill, side hill])
Runs 9-14 (Gravel x [uphill, downhill, side hill])

Runs 15-16 (Gravel x Level)

Runs 17-24 (Pavement x [uphill, downhill, side hill, level])

Runs 25-32 (High Grass x [uphill, downhill, side hill, level])

Notes
- Alpha Team
- Grass cut on approach south of church
- 32 (28) Scheduled runs, randomized within location, except side hill runs which come last; 1 side hill run per location
- Excursions (maximum 4)

RCTA 2011 Baseline Assessment
Appendix A: Runs & Locations
Cul de Sac Vignette

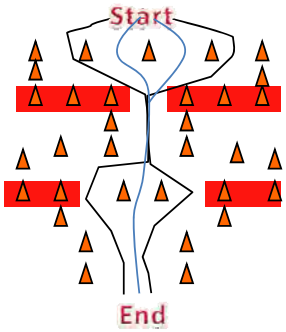
Runs 33-38 (2 Story Office Building x Severity)

Runs 39-44 (Cemetery x Severity)

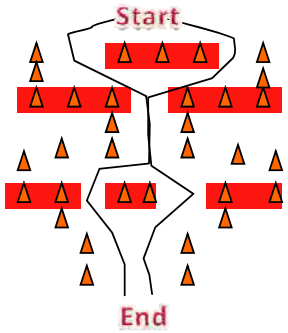
Runs 44-50 (Maze x Severity)

Notes
- Bravo Team
- Grass cut in cemetery and out
- Severity reflects full interaction with cul de sac or glancing blow
- Maze severity will be based on obstacle density and the directness of a path through (diagram below)
- 18 Scheduled runs, randomized within location, except the maze which follows easy to hard, 2 reps each
- Corridor setting wide, except for maze which should be maze width
- Excursions (maximum 4)

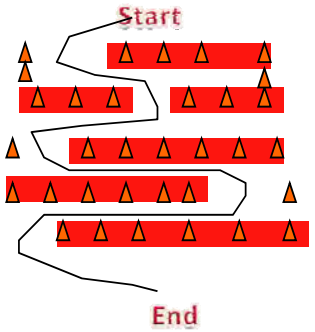
Easy



Medium



Hard



RCTA 2011 Baseline Assessment
Appendix A: Runs & Locations
Alley Vignette

Runs 51-56 (3 Alley widths)

Notes
- Bravo Team
- Enter alley from the street
- Vary narrowness of alley using plywood on the north side of alley to full alley (no plywood) and two other widths TBD
- 6 Scheduled runs, sequence wide to narrow alley, 2 reps each
- Excursions (maximum 4)

RCTA 2011 Baseline Assessment
Appendix A: Runs & Locations
Doorway Vignette

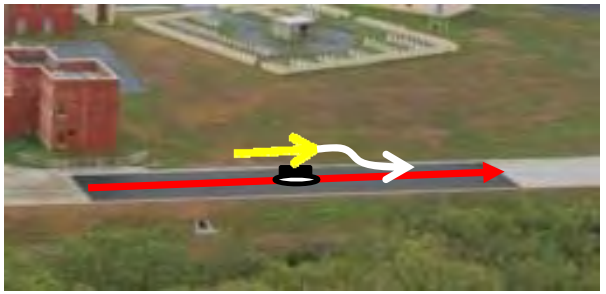
Runs 57-92 (3 Door widths x 3 Angles of approach x Door Ajar/Not)

Notes

- Bravo Team
- Enter door from patio area attached to south end of police station.
- Vary door width with plywood and angle of approach by initial position. Door ajar at 60 degree open or not.
- 36 Scheduled runs, randomized across factors, but within a rep
- Excursions (maximum 4)

RCTA 2011 Baseline Assessment
Appendix A: Runs & Locations
People Vignette

Runs 93-112 (Path x Speed)



Runs 93-112 (Path x Speed)

Runs 93-112 (Path x Speed)

Runs 93-112 (Path x Speed)

Runs 93-112 (Path x Speed)

Notes
- Alpha Team
- Two baseline runs (no people) from the surfaces vignette
- Paths (yellow [walk], yellow continuation white [jog])
- Proximity of movers to TALON (3-4 m)
- Orbit path in same direction as sensor rotation
- Corridor setting to keep TALON on street
- 20 Scheduled runs, randomized
- Excursions (maximum 4)

RCTA 2011 Baseline Assessment
Appendix A: Runs & Locations
Building Mapping Vignette

Runs 113-120 (Police station (left) and 2-story Office Bldg (right, 2nd floor) x obstacles)

Runs 121-124 (Restaurant x obstacles)

Notes
- Bravo Team
- Obstacle condition (clear, furniture + OOI)
- 360 Video captured for later analyst review in identifying OOI
- A class of OOI will be numbers on the wall to establish a baseline on the camera.
- 12 Scheduled runs, 2 reps after each set-up/location
- Excursions (maximum 4)

RCTA 2011 Baseline Assessment
Appendix A: Runs & Locations
Drop-off Vignette

Runs 125-136 (Level Concrete x 3 Heights x 2 Landings)

Run E1 (Excursion [angled approach to drop-off])

Runs 137-148 (Side Hill Grass x 3 Heights x 2 Landings)

Runs 149-160 (Level Grass x 3 Heights x 2 Landings)

Notes
- Alpha Team
- Heights: 15", 10", 5"
- Landings: plywood, sod
- Need to have the door open and start from within Business 1
- 36 Scheduled runs, sequenced within each location, varying height (5" to 15") with plywood first, then sod, 2 reps each
- Excursions (maximum 4)
- Excursion run conditions (Height & Landing) TBD

RCTA 2011 Baseline Assessment
Appendix A: Runs & Locations
Market Place Vignette

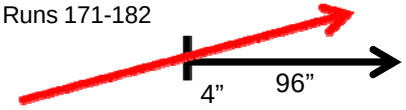
Runs 161-170 (Market Place with [clear, static obstacles, static and dynamic obstacles])

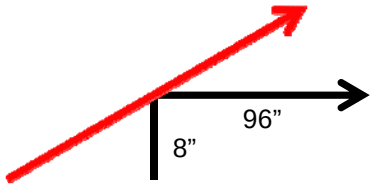
Notes
- Bravo Team
- Two baseline runs with no obstacles and then 4 each with static or static & dynamic
- Paths of dynamic obstacles (people, vehicles) TBD
- Dense collection of obstacles (cones, barrels, vehicles)
- 360 Video will be recorded for later OOI identification by analysts
- Ideal opportunity for video from the hotel window
- 10 Scheduled runs, reps after each set-up
- Excursions (maximum 4)

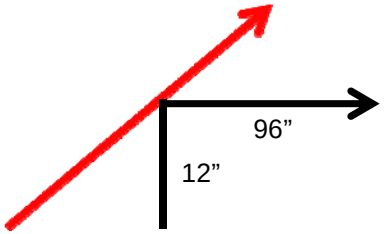
RCTA 2011 Baseline Assessment
Appendix A: Runs & Locations
Stairs Vignette

1 Step

Runs 171-182

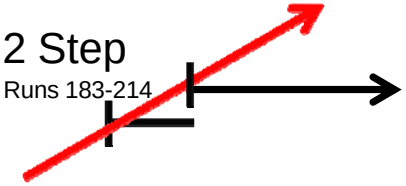


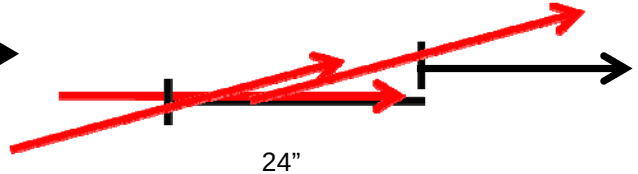


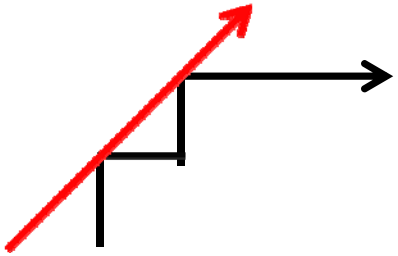


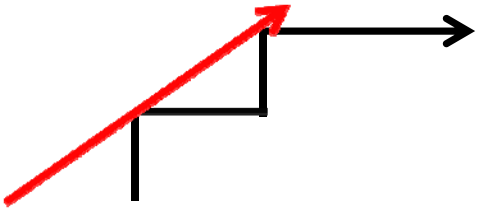
2 Step

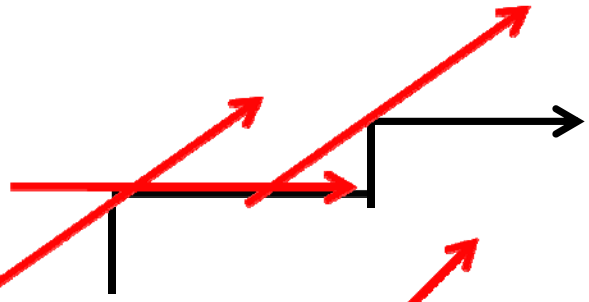
Runs 183-214

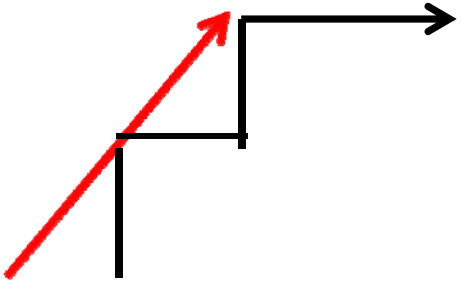


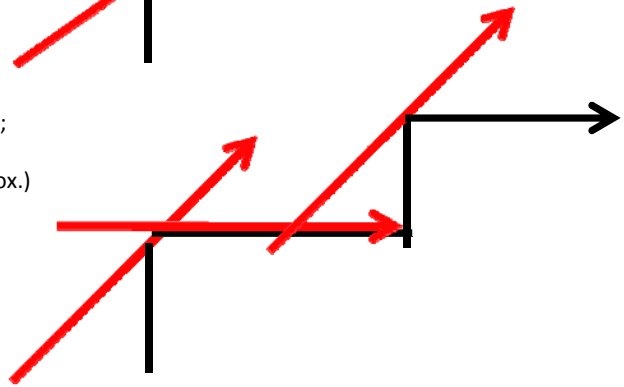












Notes

- Alpha & Bravo Teams
- Riser (4”, 8”, 12”); Tread (8”, 12”, 24”); Run (96”); 11 combinations
- To scale (1/4” = 4”, except 96” run, TALON approx.)
- Riser is open (e.g., fire escape) or closed
- Townhouse steps (~6 runs if feasible, TBD)
- ARL Facility (barn) for remainder of runs
- Safety line to prevent rolling backwards
- Red signifies nominal climb
- 44 Scheduled runs, 1 step first, 2 step ordered by riser,open/closed, then tread
- Excursions (maximum 4)

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