

BRUTE: A Versatile Research Platform for Studying UAV Operator Behavior

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Overview

- Description of BRUTE
 - List of BRUTE features
 - Illustrate Capabilities for Research
 - Note some Compatibility Limitations
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- Demonstration later today

BRUTE: Basic Research UAV Task Environment

- Simulated Task Environment
- Remotely Piloted Vehicles – UAVs
(U.S. Air Force Predator)
- Joystick and Keyboard Piloting operations for the Air Vehicle Operator (AVO)
- Joystick and Keyboard Camera operations for the Sensory (Payload: PLO) Operator (SO)
- Off-the-shelf PC hardware requirements
- Not high fidelity, but similar cognitive demands and skill requirements

BRUTE Software Development

- Developed under contract for the Air Force Research Laboratory, work units 2313HM15 and 1123A117
- Based on a Cognitive Task Analysis (Hall & Gugerty, 1997)
- Credit to: Steve Watson, Leo Gugerty, and Scott Chaiken
- Jamie Burns and Rich Walker of CDSI were primary programmers.

Presentation Format

- Critical information is presented in 3-dimensional graphics
- Game-like appearance with a reward-point structure for appropriate responses
- Complex information presented in straight-forward manner

Training

- AVO (piloting) operations
- SO (or PLO) camera operations
- Joystick for piloting or camera movement
- Keystrokes for defining settings
- Informs operators of functions & responsibilities
- Accomplished in about 30 minutes
- Involves knowledge and skill development
- Graphic display of critical information

Pilot's Screen View



00:29:57

Targets

- 15 points
- 10 points
- 5 points
- Completed

Points

Gained 0
Lost 0
Total 0

stick controls aircraft

ESC

F1
Heading
Hold
OFF

F2
Airspeed
Hold
OFF

F3
Altitude
Hold
OFF

F4
Weather
Scan
OFF

F5
Video
Camera
NOSE

F6
Payload
Camera
Target
NONE

F7
Payload
Camera
Zoomed
OUT

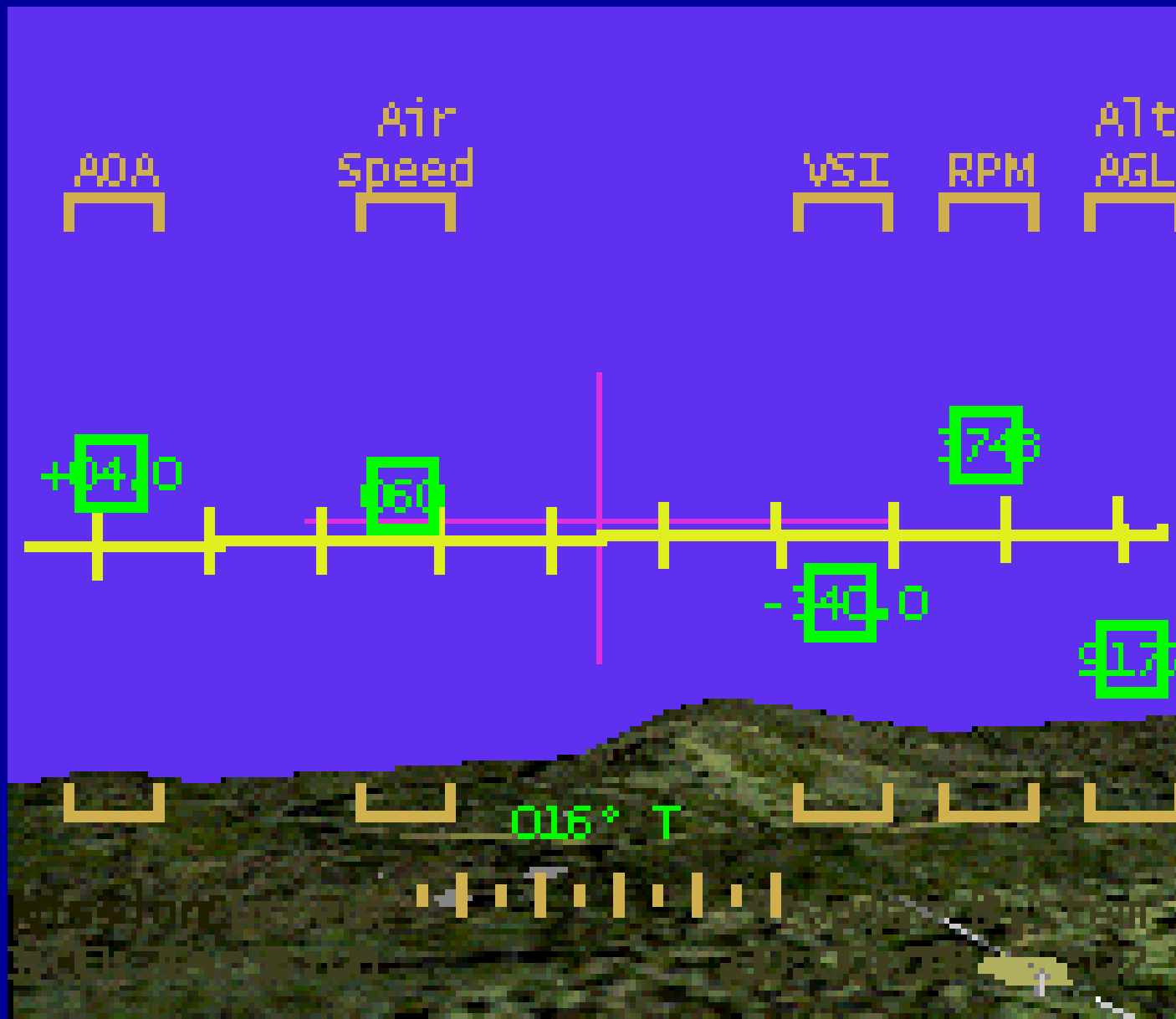
F8
Tell
Recon
Objective

F9
Satisfy
Recon
Objective

F10
Report
Camera
Problem

F11
Report
Autopilot
Problem

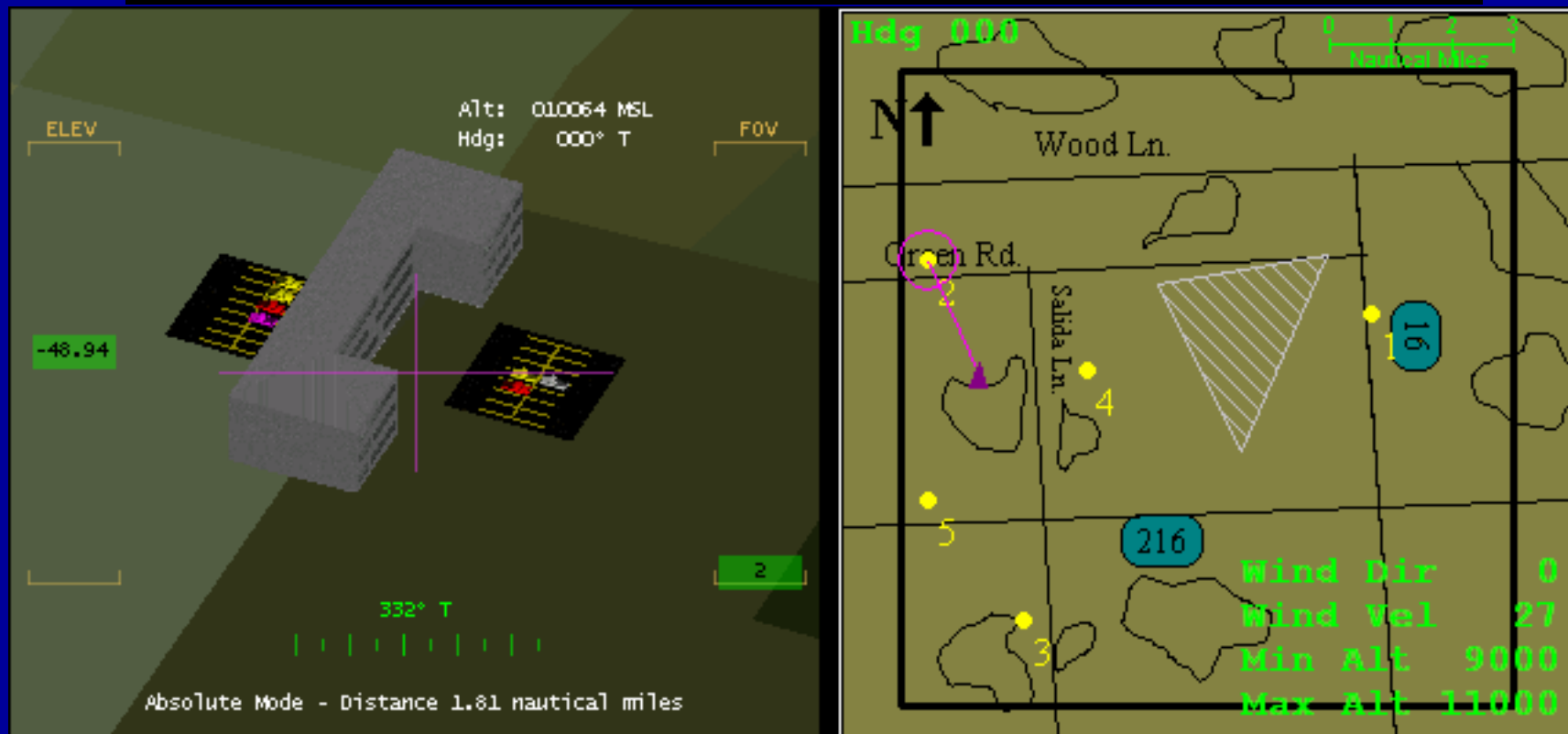
Nose Camera View



On Screen Tracker Map



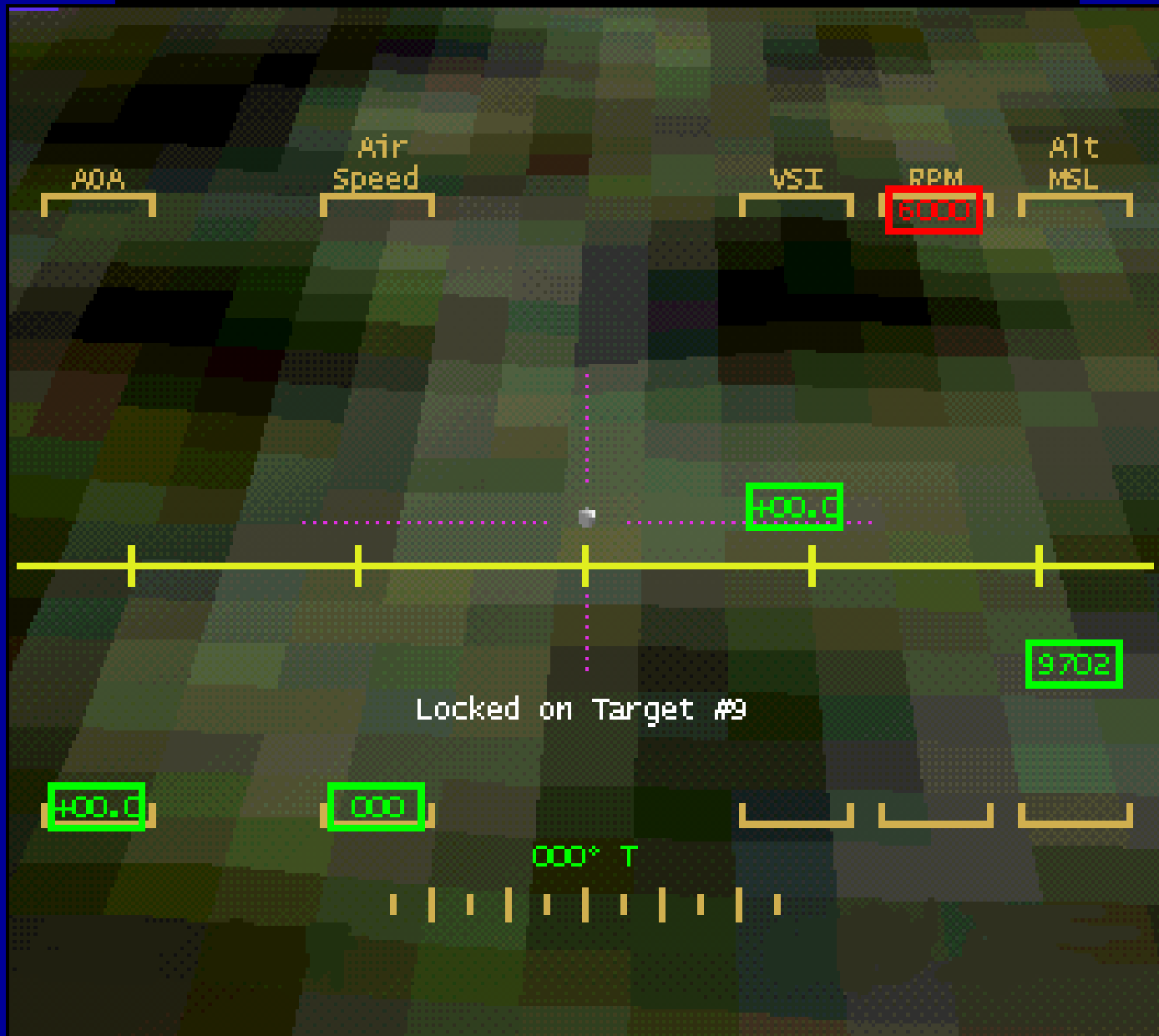
Camera Operator's Screen



stick controls camera

ESC	F1 Heading Hold OFF	F2 Airspeed Hold OFF	F3 Altitude Hold OFF	F4 Weather Scan OFF	F5 Video Camera Payload	F6 Payload Camera Target 2	F7 Payload Camera Zoomed IN	F8 Tell Recon Objective	F9 Satisfy Recon Objective	F10 Report Camera Problem	F11 Report Autopilot Problem
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Camera Zoomed Out

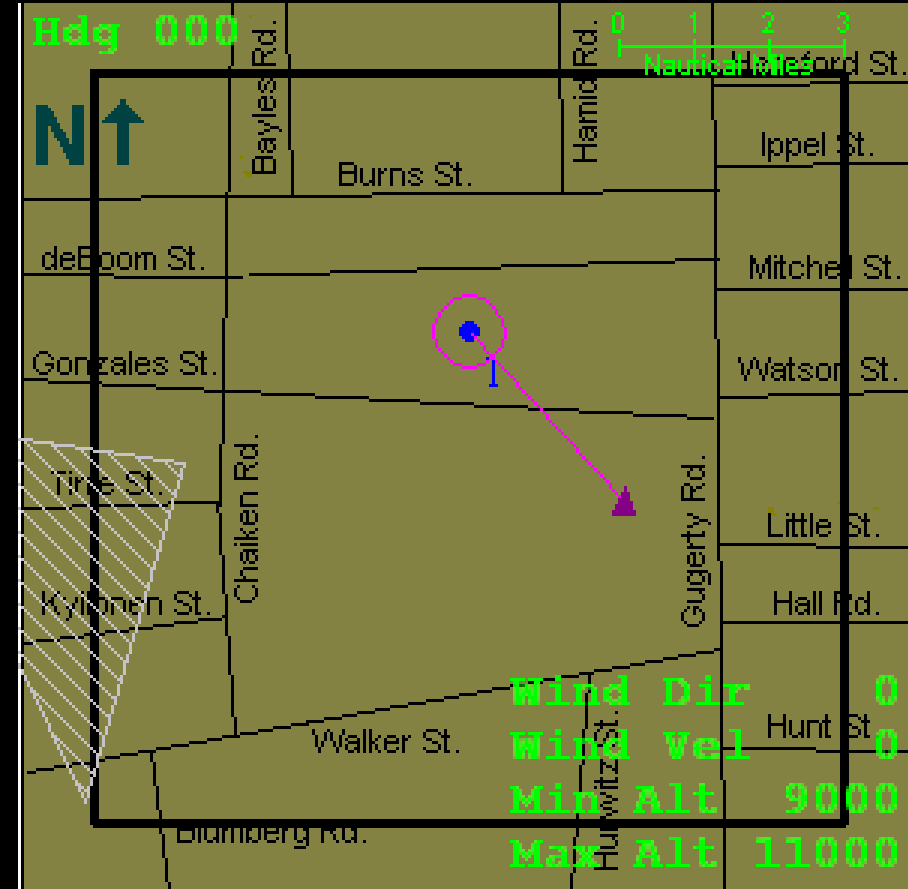


Camera Zoom In Feature



Types of Tutorials

- BRUTE can be configured for one player to perform both pilot and camera functions
- BRUTE can be set up in 'network' mode in which one player performs pilot tasks and another performs the camera operations.
- Tutorials exist for both forms of operation



1. Make sure the camera is zoomed out (use F7 if necessary)
2. Use the stick to control the camera and point it at target #1
(Make sure that the target is centered in the cross-hair)
3. Press F7 to zoom the camera in
4. Press F8 to find out the recon objectives for the target
5. Use the stick to look at different parts of the target
6. Press F9 to satisfy recon objective

Targets

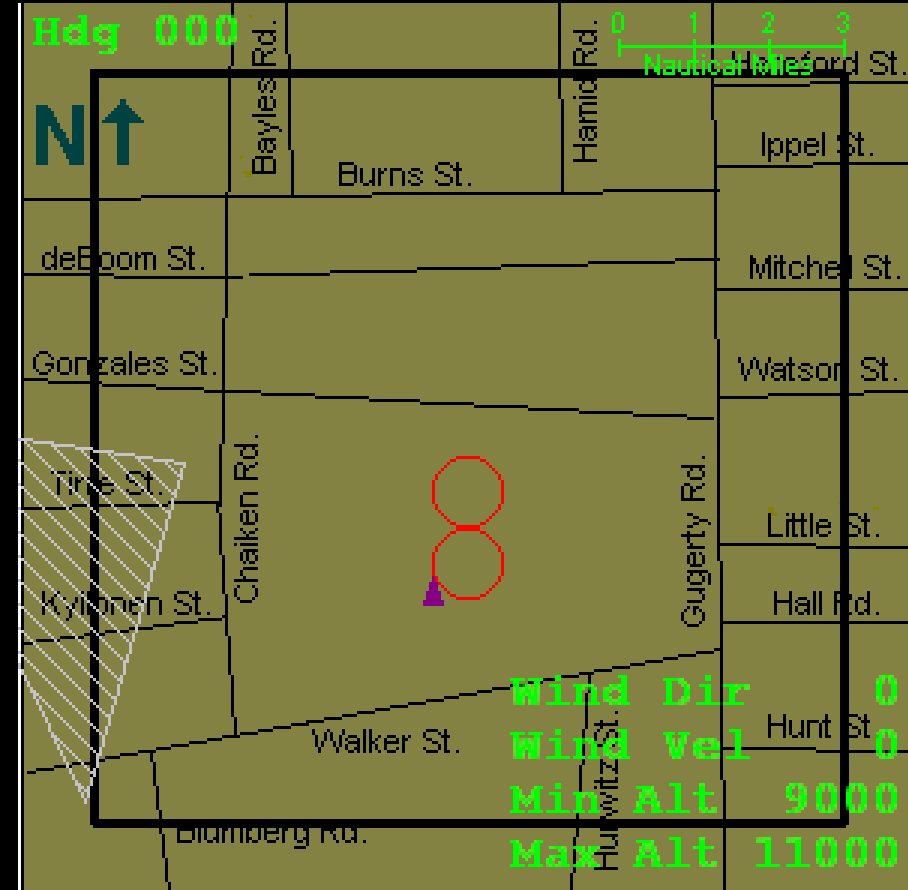
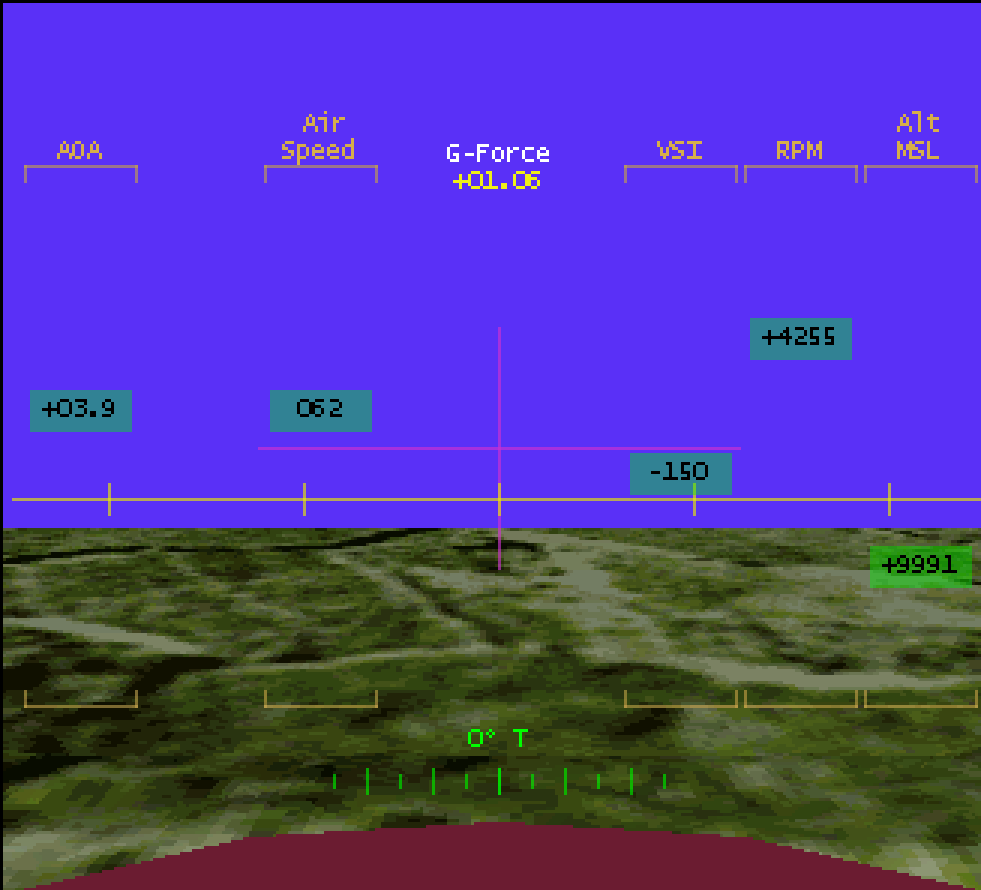
- 15 points
- 10 points
- 5 points
- Completed

Points

Gained 0
Lost 0
Total 0

stick controls camera





Practice flying along the figure-8 for three minutes.

Targets

- 15 points
- 10 points
- 5 points
- Completed

Points

Gained	0
Lost	0
Total	0

stick controls aircraft

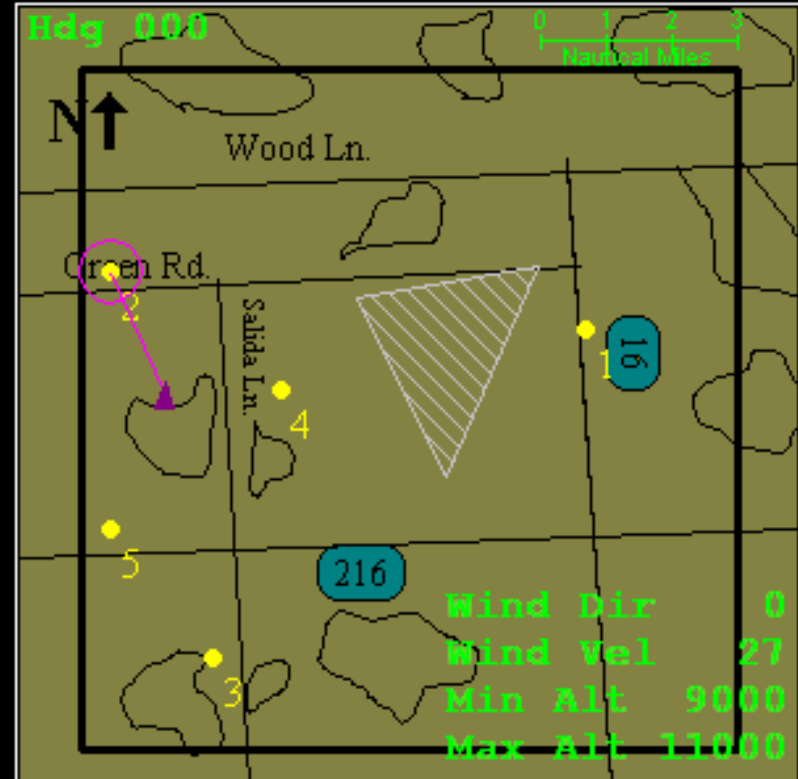
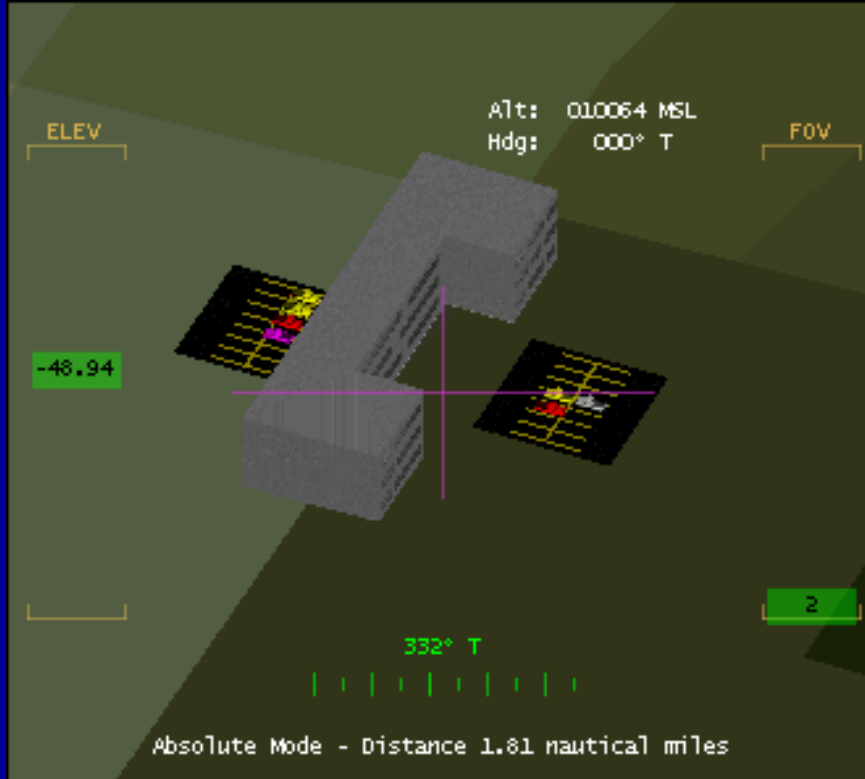
ESC	F1 Heading Hold OFF	F2 Airspeed Hold OFF	F3 Altitude Hold OFF	F4 Weather Scan OFF	F5 Video Camera NOSE	F6 Payload Camera Target NONE	F7 Payload Camera Zoomed OUT	F8 Tell Recon Objective	F9 Satisfy Recon Objective	F10 Report Camera Problem	F11 Report Autopilot Problem
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Training Test Scenario

- A simple training scenario is provided to test the skills of players as an assessment of operator performance upon completion of the training.
- We use a separate Operator Knowledge test

Which of the following will result in a violation?

- A** flying within the threat zone
- B** flying within the restricted operating zone (ROZ box)
- C** flying at 10,500 feet
- D** all of the above



00:26:01

Targets

- 15 points
- 10 points
- 5 points
- Completed

Points

- Gained 0
- Lost 0
- Total 0

stick controls camera

ESC	F1 Heading Hold OFF	F2 Airspeed Hold OFF	F3 Altitude Hold OFF	F4 Weather Scan OFF	F5 Video Camera Payload	F6 Payload Camera Target 2	F7 Payload Camera Zoomed IN	F8 Tell Recon Objective	F9 Satisfy Recon Objective	F10 Report Camera Problem	F11 Report Autopilot Problem
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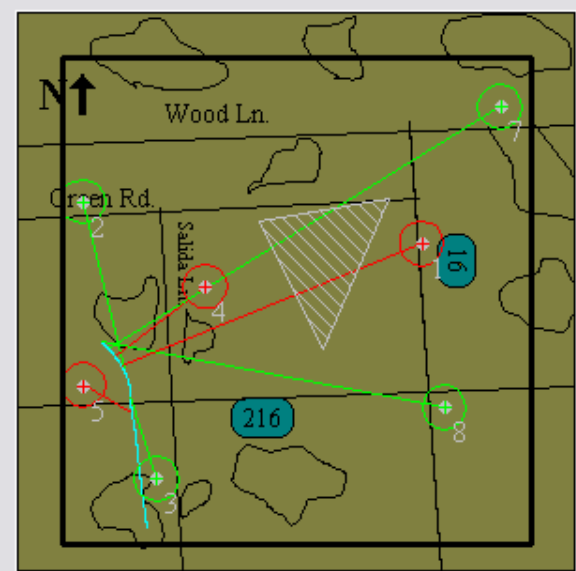
Performance on Targets



Performance Metrics

- Various performance metrics can be assessed from output file and 'slime' trail

C:\brute3d_cd\BDEM\bdem\Brute3D\MISSION3B.SLM



- Select Files
- First Subject
- Next Subject
- Same Subject
- All Subjects

Scores

Points:
 Gained: 40
 Lost: 0
 Total: 40

Targets:
 Satisfied: 4
 Attempted: 7

Violations:
 ROZ: 0
 TZ: 0
 Alt: 0
 AOA: 0
 Total: 0

Failures:
 Camera Drift: 0/0
 Wrong Target: 0/0

Targets

Targ	TX	TY	TZ	AX	AY	AZ	Time	Key	Resp	RW
1:	14150	5582	0	-19798	-8183	10162	10	5	4	0
2:	-24130	10200	0	-19245	-9249	10121	20	3	3	1
3:	-15861	-20906	0	-18842	-11658	10043	15	6	6	1
4:	-10422	560	0	-20453	-7251	10200	33	Y	N	0
5:	-24130	-10480	0	-18587	-13569	9964	36	6	4	0
7:	22968	20856	0	-21279	-6297	10241	16	NE	NE	1
8:	16691	-12840	0	-22026	-5551	10274	15	8	8	1
D:								0		
W:								0		
*								219		

```
00059016: AircraftStateMsg
Position=-17559.31,-21587.
Heading=0.00
GForce=1.20
ClimbRate=-0.31
Airspeed=155.66
AOA=2.00
Pitch=-4.97
Roll=0.00
Yaw=0.00
Throttle=1.00
JoyX=0.0000
JoyY=0.3890
00059016: CameraStateMsg
Heading=330.90
Pitch=-33.29
FOV=2.29
```

Performance Metrics (cont.)

- Self-report of performance (e.g., morale, satisfaction with partner, viability of team)

I was very satisfied with the way my team functioned during the missions

- 1 strongly disagree
- 2 disagree
- 3 slightly disagree
- 4 neither
- 5 slightly agree
- 6 agree
- 7 strongly agree

Performance Metrics (cont.)

- Add behavioral coding from interactions for additional performance components

Your score:

Gained	Lost	Total
+40	0	+40

Best score:

Gained	Lost	Total
+70	0	+70

Targets:

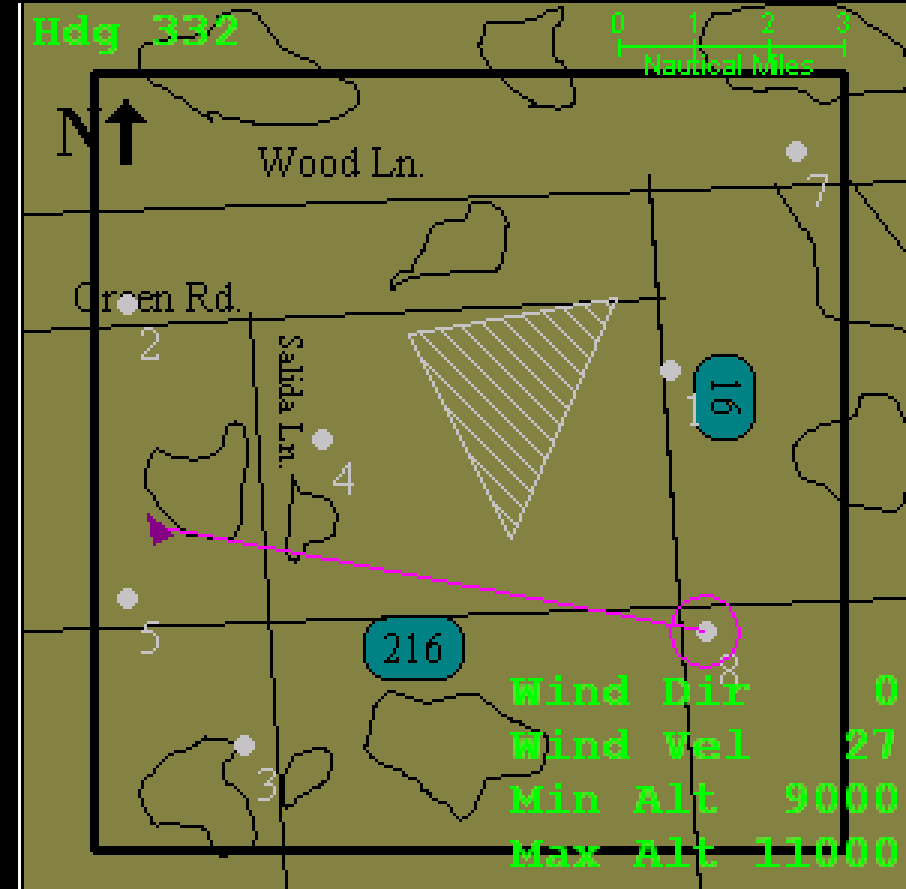
4 completed correctly
3 completed incorrectly
0 not completed

Violations:

0 stalls
0 altitude too low or high
0 exited ROZ box
0 entered threat zone

Undetected equipment failures:

0 camera on wrong target
0 camera drifted
0 autopilot malfunctioned



Press the SPACEBAR to go on

Adaptive Scenario Generator

- A set of existing scenarios exist
- A flexible generator to create one's own
- Direct to specific research purposes
- An example, change the time in flight
- Features from the cognitive task analysis
- Isn't in programming language, but in a script file that is easily adapted

Scenario Generator Script Topics

- Mission Time in minutes and seconds
- Question Types: Yes/no, Number, Direction
- Wind Change
- Total Number of Targets
- Number of Ad hoc Targets
- Inclusion of Clouds
- Failures of the Camera or Autopilot
- Manual or Auto Camera control
- Enable/Disable: Weather Scan, Autopilot Report, Camera Report

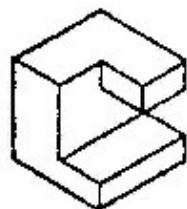
Single or Team Operator Modes

- A team of operators in networked mode
- A single operator that combines AVO and SO functions

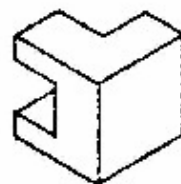
Robust Testbed of Operator Behavior

- Individual or team performance on tasks
- individual differences measures as predictors of performance (e.g., selection)

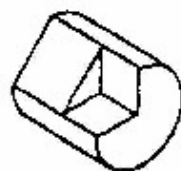
6



IS ROTATED TO



AS



IS ROTATED TO

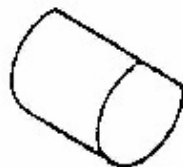
A

B

C

D

E



A

B

C

D

E

Robust Testbed of Operator Behavior

- decision making in determining the routing of targets to be addressed
- communication between operators
- training effectiveness of various components
- strategy development in teams
- memory for details of screen, targets, etc.
- situation awareness for critical incidents

At the start of the mission, which target was located closest to the UAV?

- A** Counting how many hangers had planes in them (Target 1)
- B** Counting trucks in a parking lot surrounded by a fence (Target 3)
- C** Identifying whether or not there was a plane in a hanger (Target 4)
- D** Counting trucks around a building (Target 5)

The maximum level of wind velocity during the mission was

- A** 35
- B** 31
- C** 29
- D** 27

Ease of Set Up

- BRUTE is 'relatively' easy to set up
- Need a PC computer with an appropriate type of processor and operating system
- A standard monitor
- A keyboard and mouse
- A joystick (not advanced version)



Affordable and Flexible OS

- BRUTE is very affordable because it operates on PCs with many operating systems
- Windows 95, but limited to Pentium 3 or lower
- Windows 98, but limited to Pentium 3 or lower
- Windows XP, but requires changes to .dlls
- Did not work with hyperthreaded processors
- Works with AMD processors (e.g. Opteron)
- Programmed in Delphi (4.0) with Direct X (4.0)
- Adapted to XP, Delphi 7.0 and Direct X (9.0?)

BRUTE Software is FREE!

- Because the software was developed as a research testbed under government contract, it is not proprietary and available for free.
- The initial version is available on a CD
- However, there is no support for it because the project that funded its development was cancelled.

Illustration with Team Structure

- BRUTE is being used at NDSU to study coordination and collaboration among UAV pilot and camera operators
- Training and three different scenarios made
- Situations included that require or are best resolved based on collaboration and/or coordination
- Interested in whether errors are corrected or compounded in team performance



Summary

BRUTE is a versatile synthetic task environment for studying dynamic individual and team performance.

Collaborators and Assistants

- Jared Ladbury
- John Urbanec
- Ernest Park
- Ryan Pillatzki
- Chrissy Thorsen
- Dana Lawrence
- Renee Magnan
- Jordan Henkel
- Jonathan Pikalek