

# 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
- 
- Demonstration later today

# BRUTE: Basic Research UAV Task Environment

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- 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

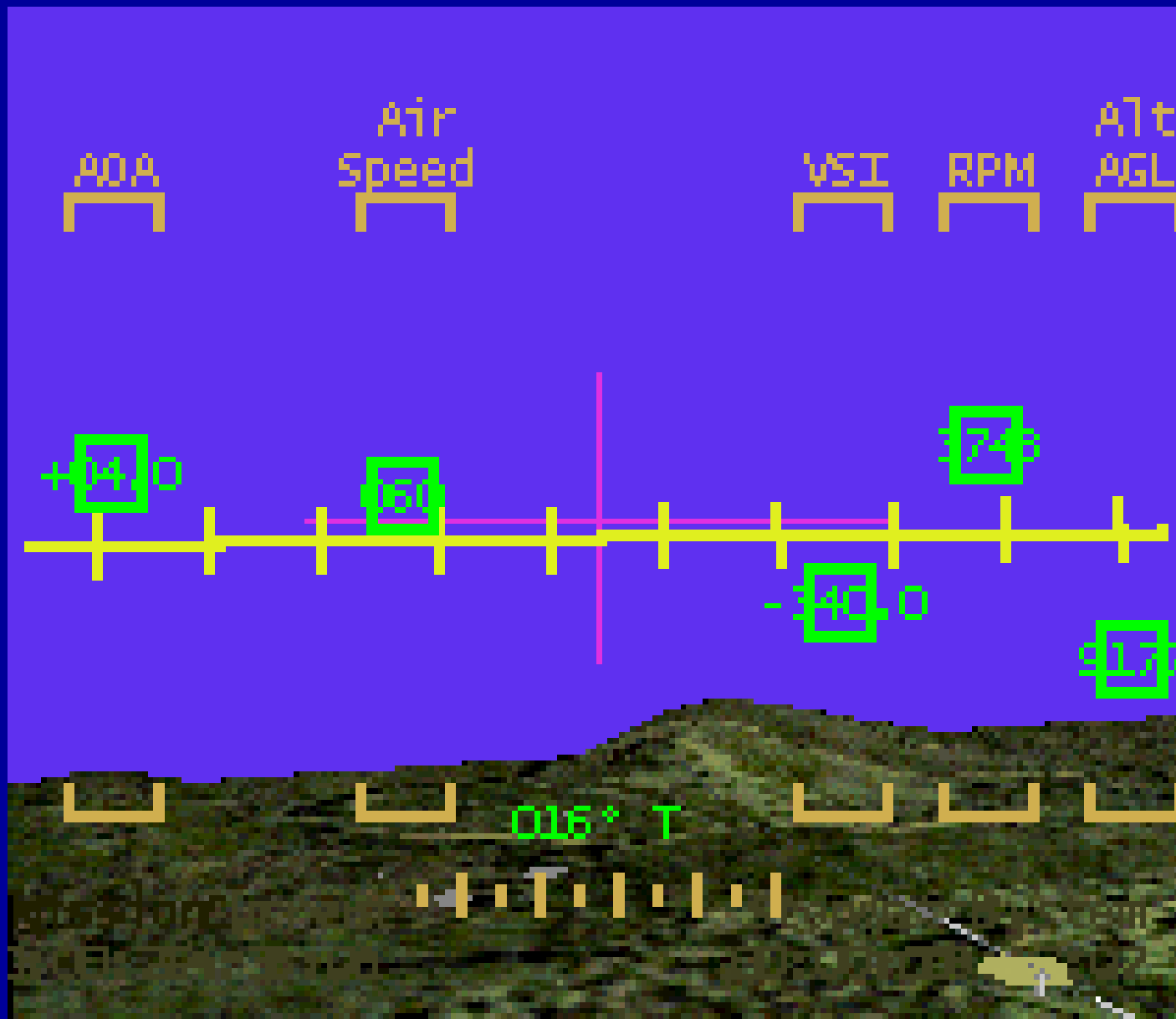
F8  
Tell  
Recon  
Objective

F9  
Satisfy  
Recon  
Objective

F10  
Report  
Camera  
Problem

F11  
Report  
Autopilot  
Problem

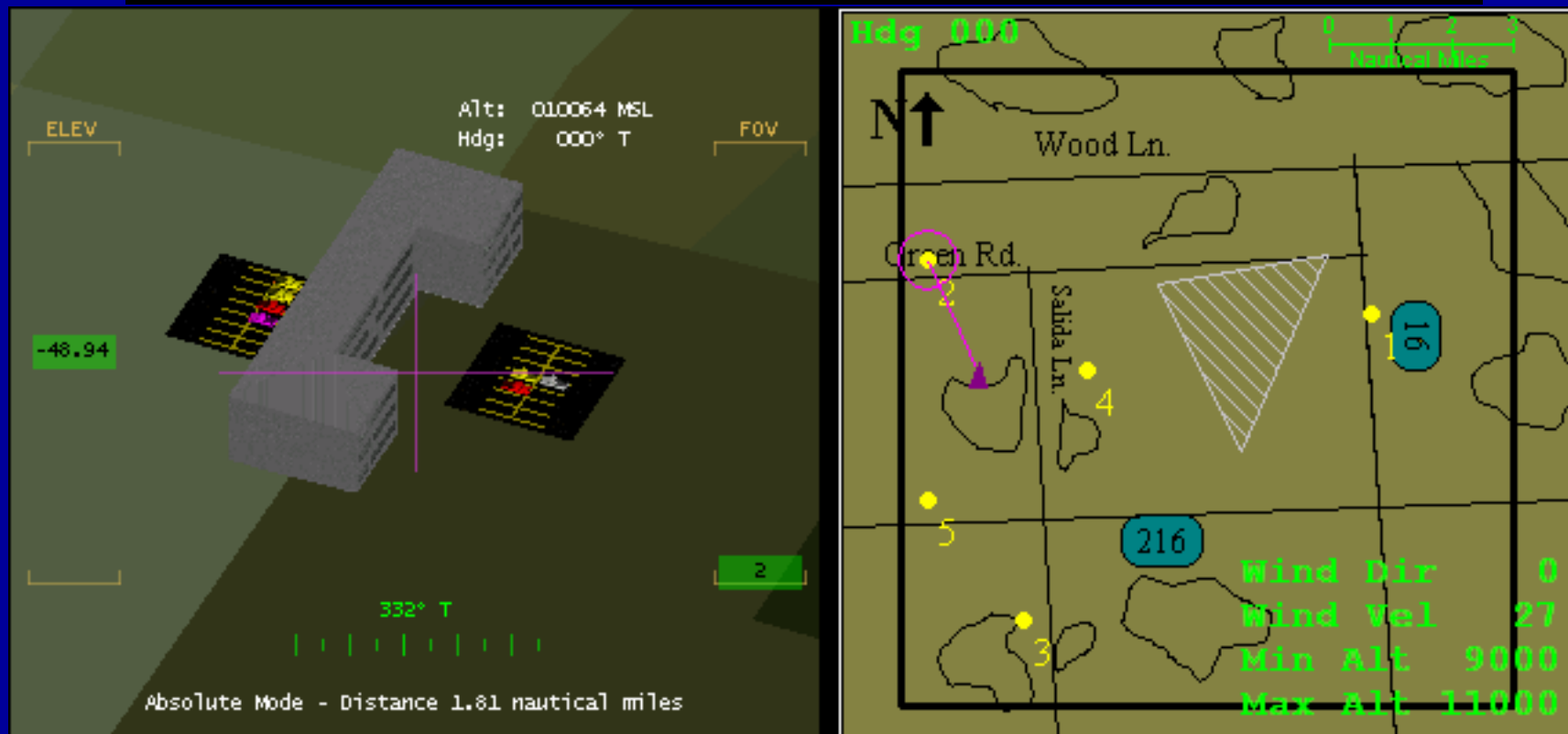
# Nose Camera View



# On Screen Tracker Map



# Camera Operator's Screen

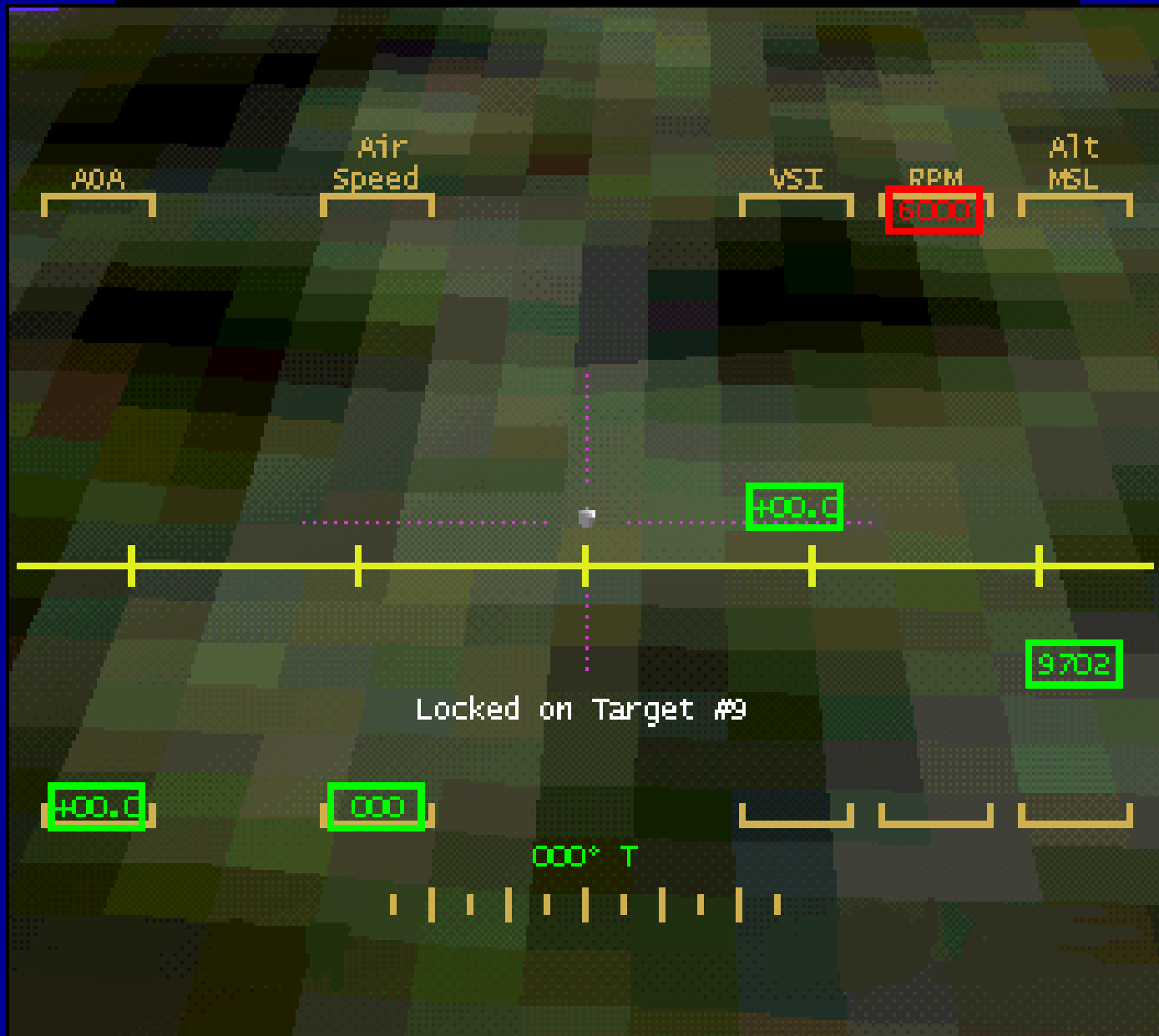


00:26:01

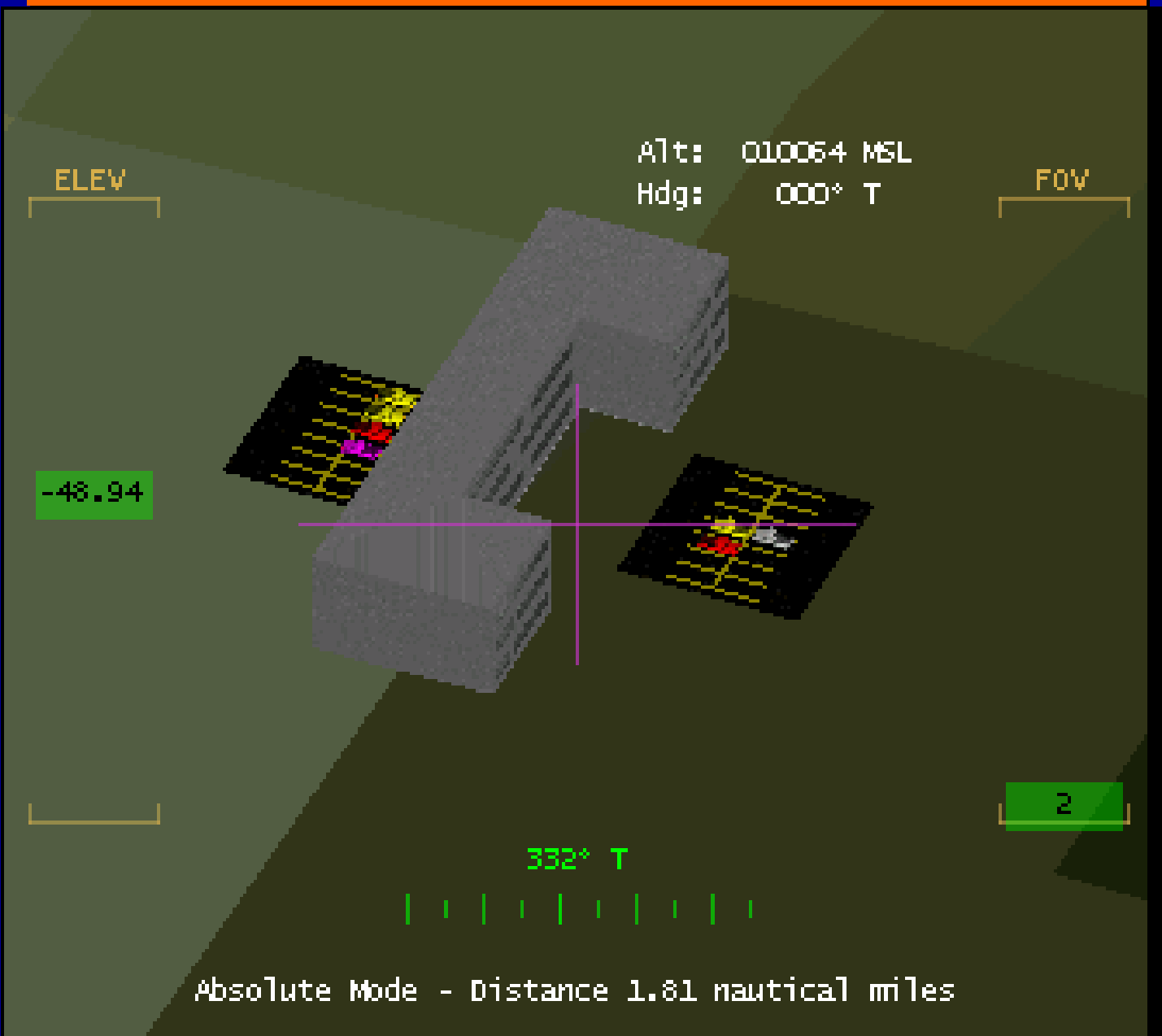
stick controls camera

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

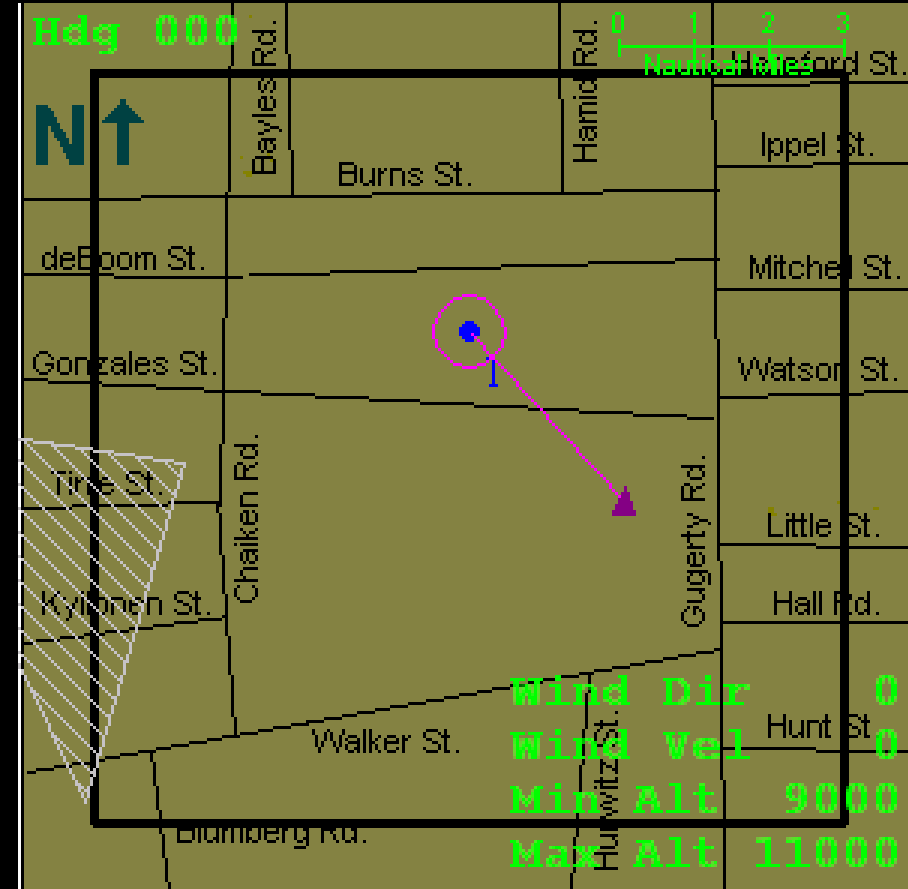


# Camera Zoom In Feature



# 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

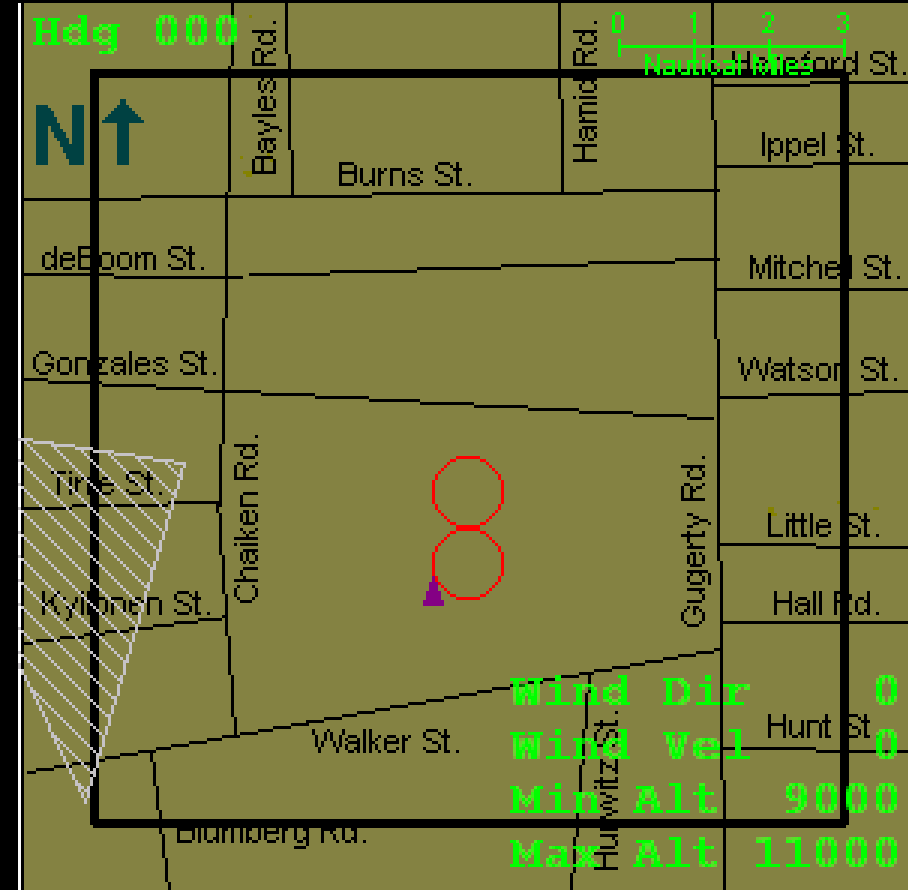
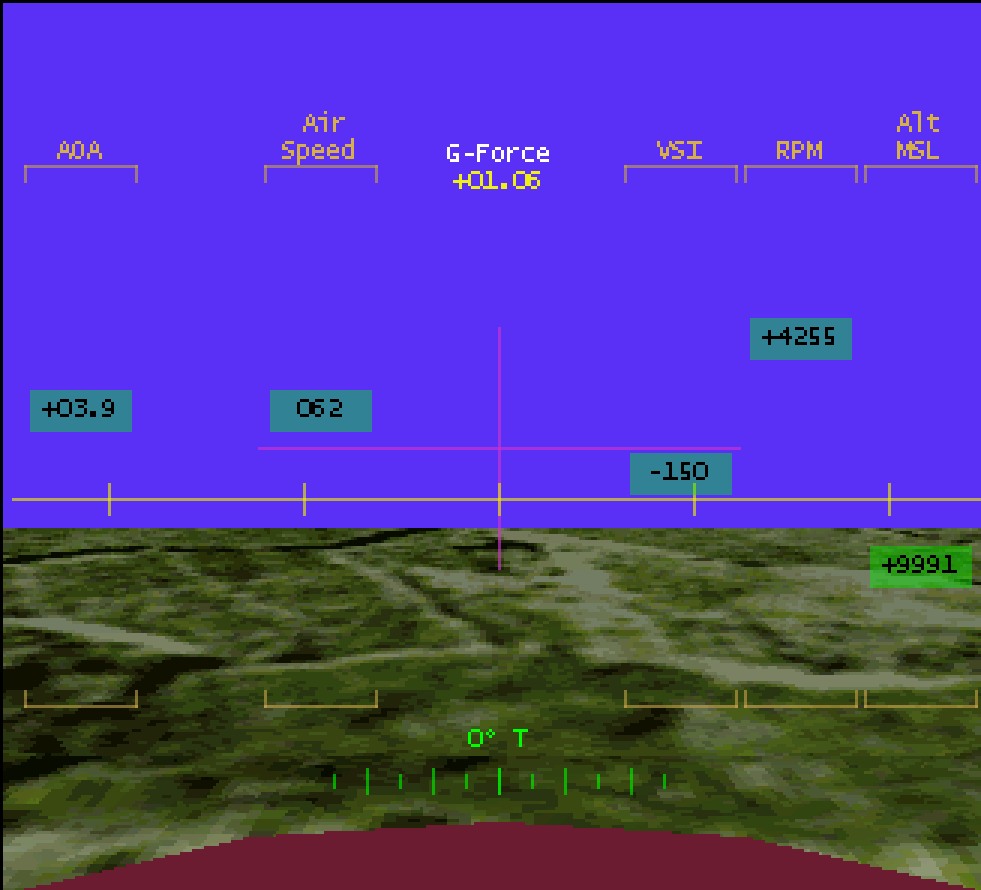
- 15 points
- 10 points
- 5 points
- Completed

#### 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

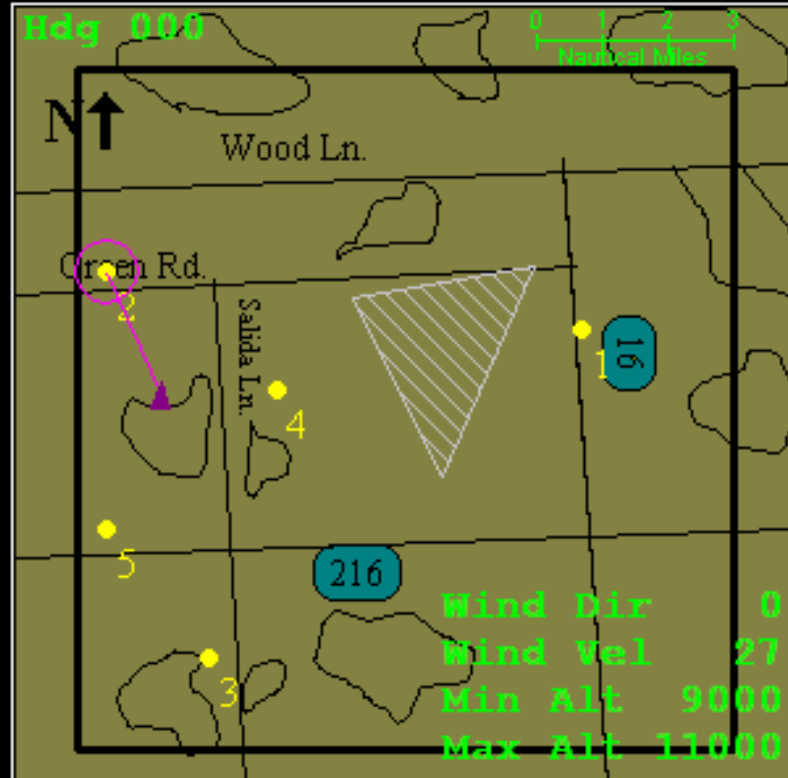
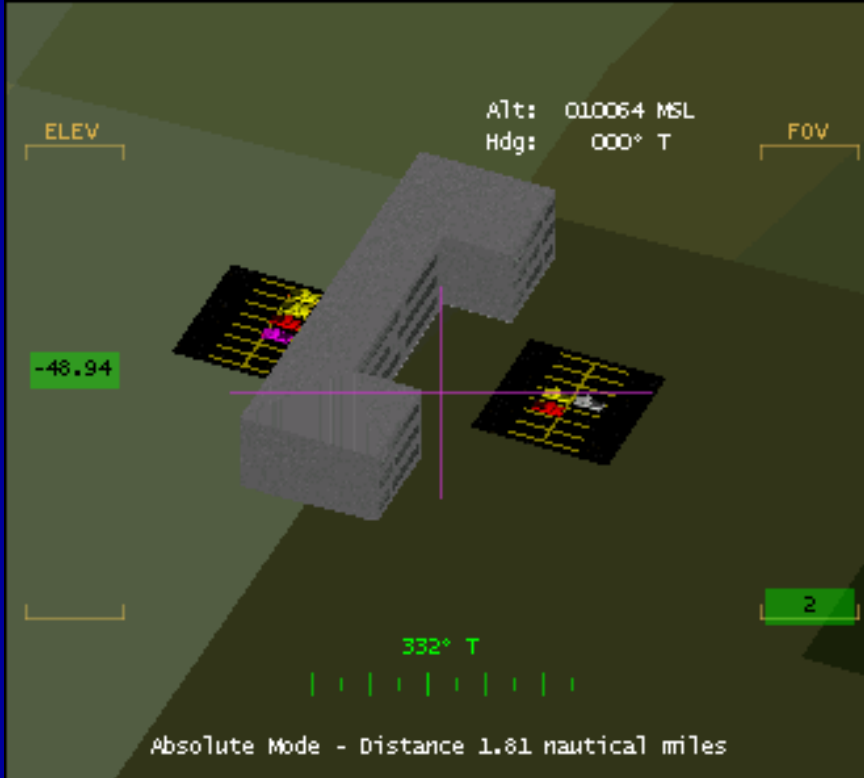
ESC	F1 Heading Hold OFF	F2 Airspeed Hold OFF	F3 Altitude Hold OFF	F4 Weather Scan OFF	F5 Video Camera NOSE	F6 Payload Camera Target NONE	F7 Payload Camera Zoomed OUT	F8 Tell Recon Objective	F9 Satisfy Recon Objective	F10 Report Camera Problem	F11 Report Autopilot Problem
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# 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		Points	
● 15	points	Gained	0
● 10	points	Lost	0
● 5	points	Total	0
●	Completed		

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

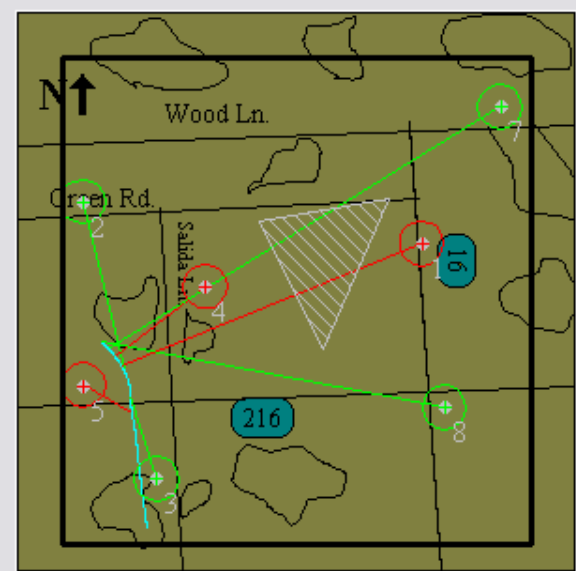
# Performance on Targets



# 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:

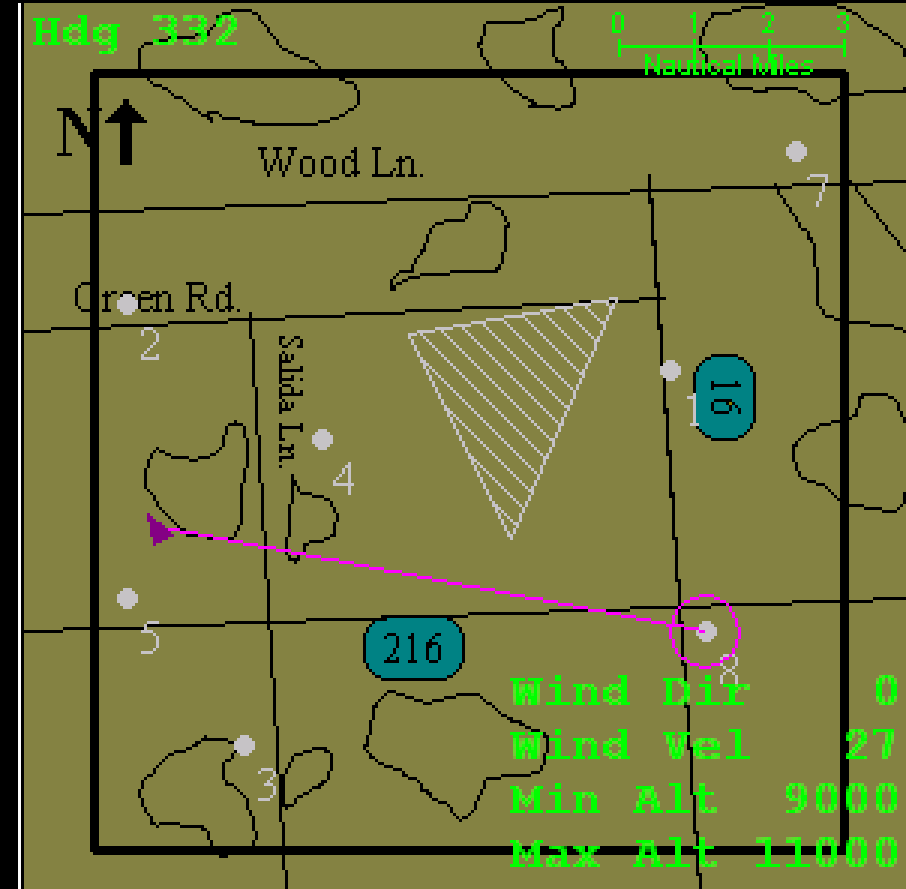
4 completed correctly  
3 completed incorrectly  
0 not completed

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

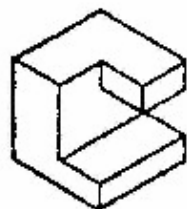
# Single or Team Operator Modes

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

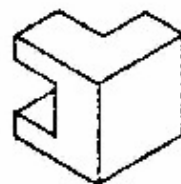
# Robust Testbed of Operator Behavior

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

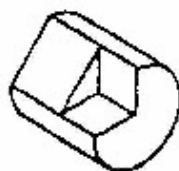
6



IS ROTATED TO



AS



IS ROTATED TO

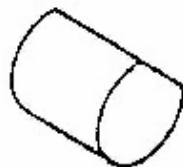
A

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