

# Cognitive Ability and the Prediction of UAV Team Members' Performance

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# Overview

- Selection and Training issues
- Cognitive Abilities
- Team Members' Performance
- Simulated UAV tasks for AVO & SO
- Predictions for different performance metrics
- Results from a Study
- Some interesting conclusions

# Background

- Selection is an old issue for UAV operators
- Substantial research has been conducted
- Still a question frequently raised for operators
- Practical, conceptual, and theoretical concern
- Do specific cognitive abilities predict general and specific aspects of UAV operators task performance?
- Much evidence to suspect spatial abilities

# Objectives

- Do spatial abilities tests relate to specific and general aspects of UAV operators task performance?
- Are the spatial abilities tests reliable?
- Do tests have differential prediction for criteria?
- Do the tests predict training performance?
- Does training performance predict mission performance?
- How do spatial abilities and training contribute to the prediction of mission performance?

# Spatial Abilities

- Spatial orientation is “the ability to perceive spatial patterns or to maintain orientation with respect to objects in space” (Card Rotations)
- Related to visualization of figures which involves short-term visual memory (Purdue Visualizations of Rotations)
- Spatial orientation involves mental rotation while visualization requires both rotation and performing serial operations.
- Spatial scanning is ability to quickly scan a field and follow correct paths visually before wasting time pursuing incorrect paths (Map Planning)

# Card Rotations Test

- Spatial Orientation from the Kit of Factor-Referenced Cognitive Tests (ETS, 1976)
- 80 items (10 for each of 8 shapes) in 3 minutes

Is the figure on the right the same or different from the figure on the left?



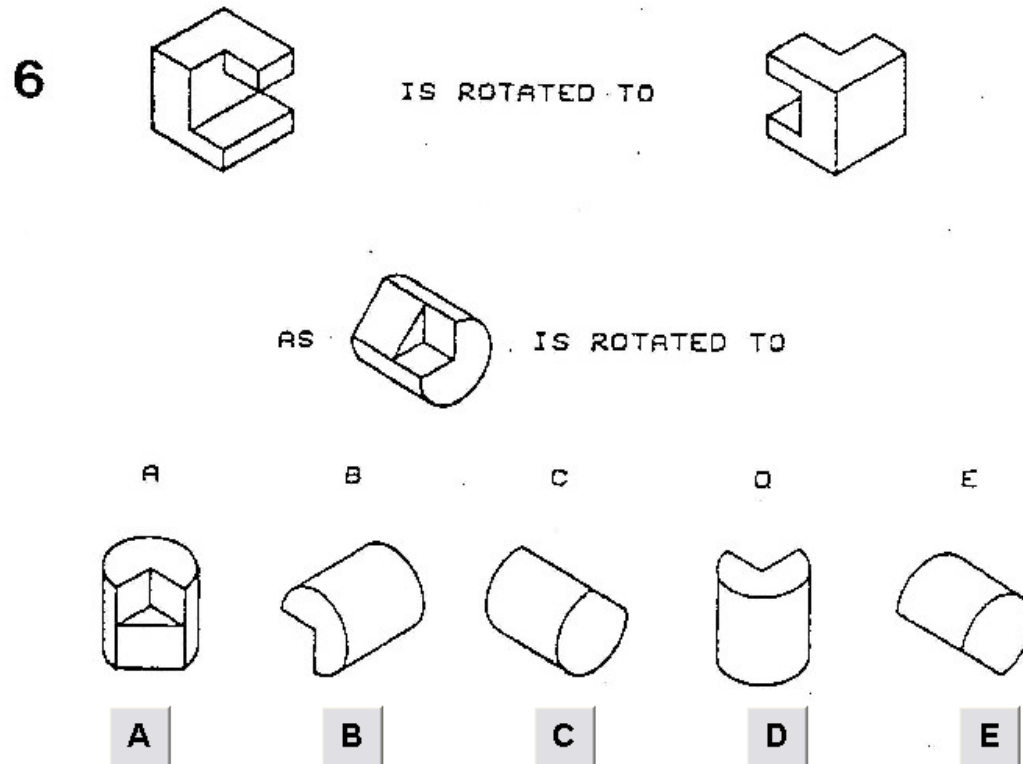
Same



Different

# Purdue Visualization of Rotations Test

- Purdue ROT: 20 items with no time limit



# Map Planning Test

- Spatial Scanning Test from Kit of Factor-Referenced Cognitive Tests

This is a test of your ability to find the shortest route between two places as quickly as possible. The drawing on the next page is a map of a city. The dark lines are streets. The circles are road-blocks, and you cannot pass at the places where there are circles. The numbered squares are buildings. You are to find the shortest route between two lettered points. The number on the building passed is your answer.

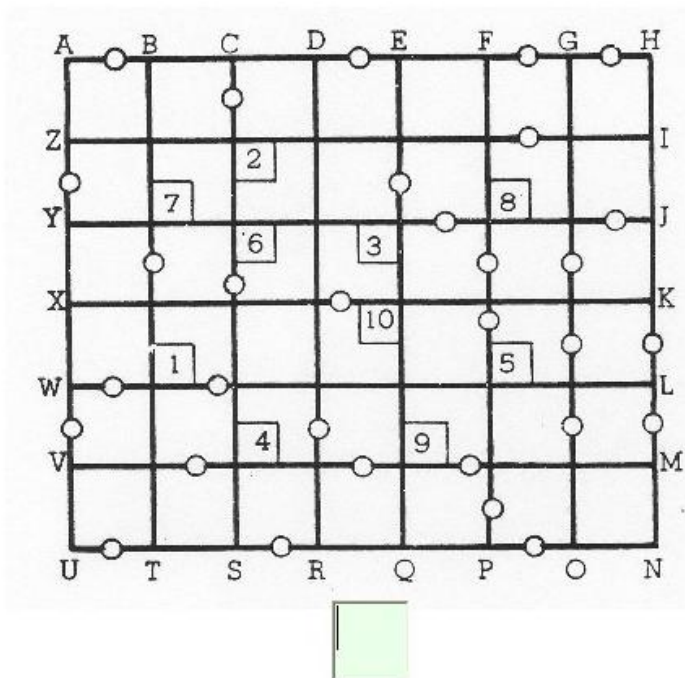
## Rules

- 1). The shortest route will always pass along the side of one and only one of the numbered buildings
- 2). A building is not considered as having been passed if a route passes only a corner and not a side
- 3) The same numbered building may be used on more than one route.
- 4) After 10 questions, the positions of the buildings and roadblocks will be changed

# Map Planning Test

- Two sections of 20 items each with 3 minutes to complete each section (40 items in 6 minutes)

The shortest route from F to I passes by which building?



Press ENTER when you have typed your answer

# Procedure

- 250 university student participants  
in 125 AVO & SO teams
- Initially complete Spatial Abilities Test
- Simulated Task Environment – BRUTE
  - Networked computer workstation environment
  - Not high fidelity, but similar cognitive demands and skill requirements



# AVO / 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

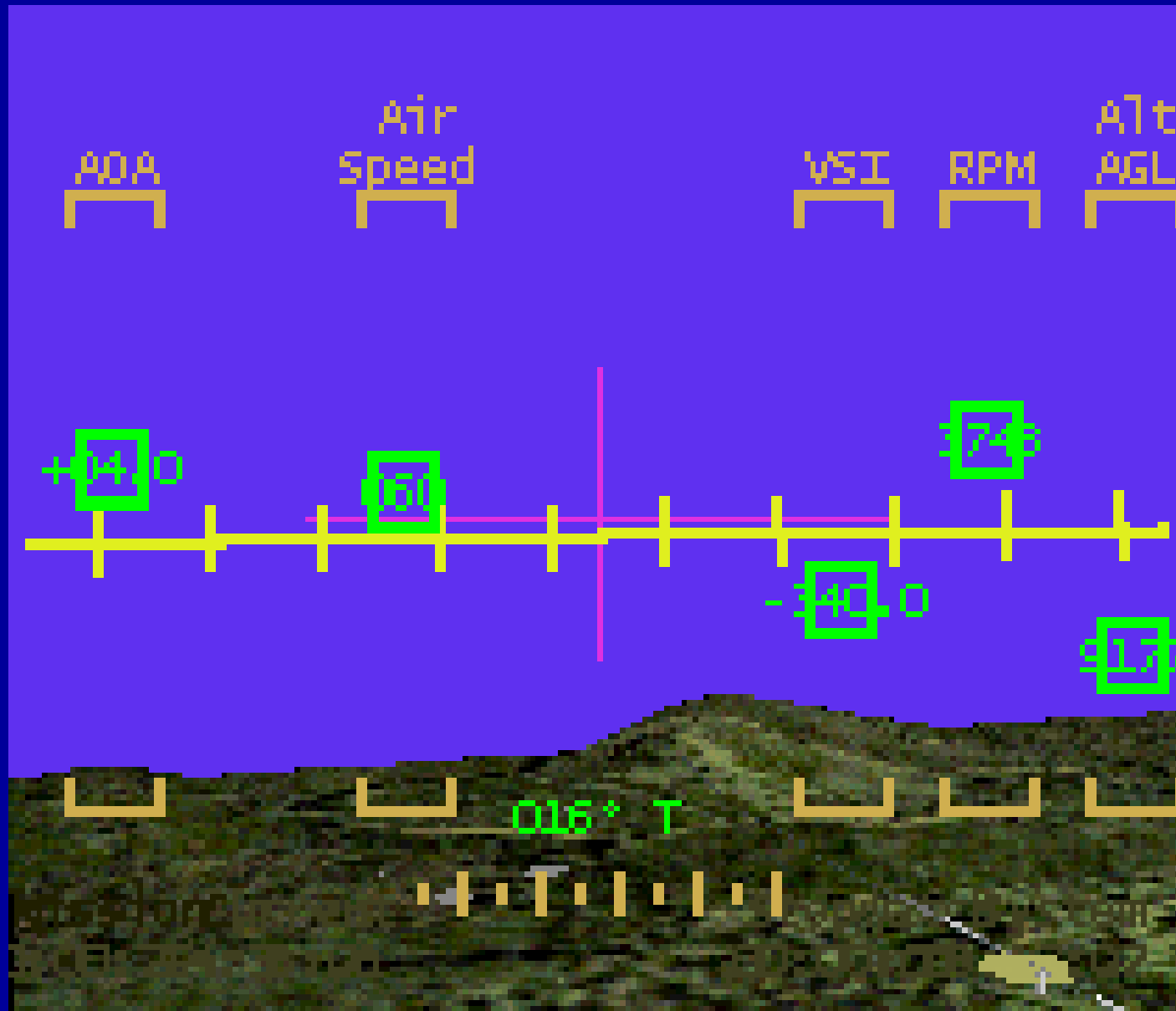
ESC

F1 Heading Hold OFF  
F2 Airspeed Hold OFF  
F3 Altitude Hold OFF  
F4 Weather Scan OFF

F5 Video Camera NOSE  
F6 Payload Camera Target AGONE  
F7 Payload Camera Zoomed OUT  
F8 Tell Recon Objective

F9 Satisfy Recon Objective  
F10 Report Camera Problem  
F11 Report Autopilot Problem

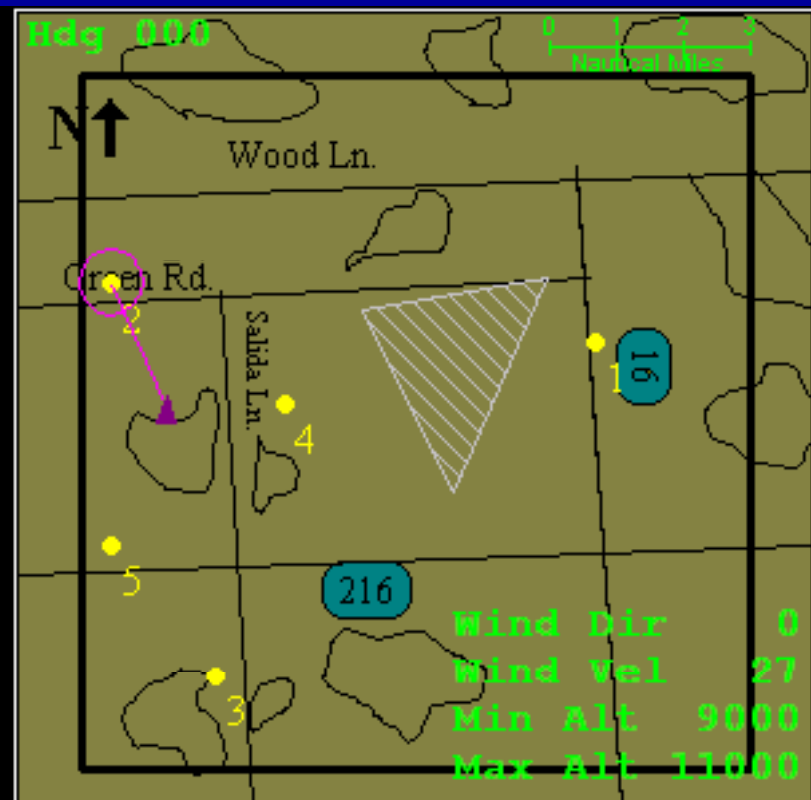
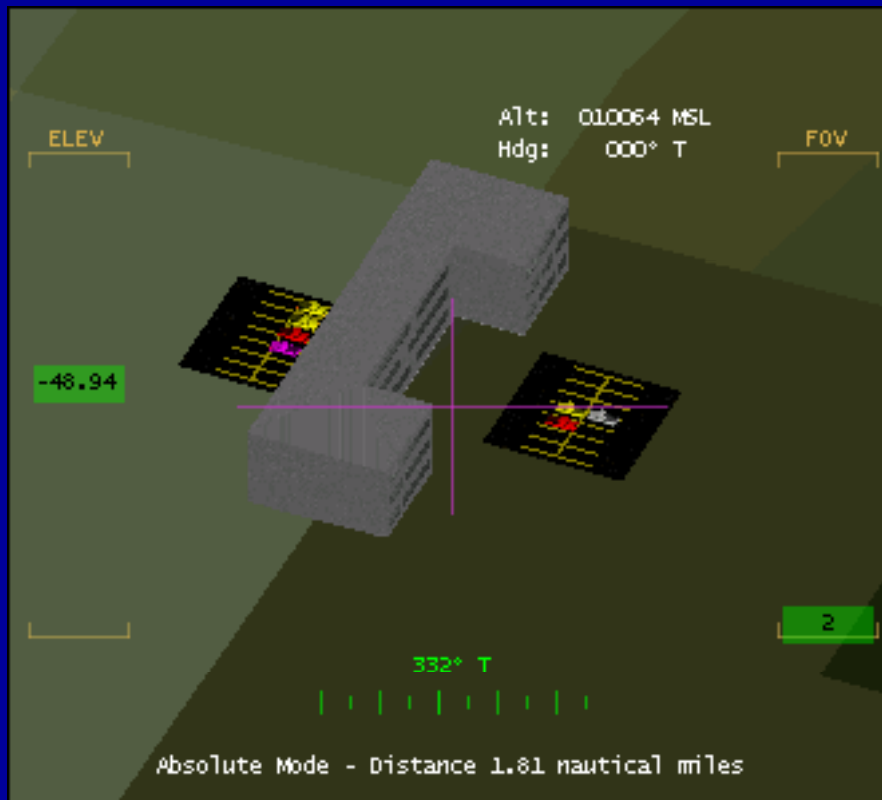
# Nose Camera View



# On Screen Tracker Map



# SO / Camera Operator's Screen



00:26:01

Targets

- 15 points
- 10 points
- 5 points
- Completed

Points

Gained 0  
Lost 0  
Total 0

stick controls camera

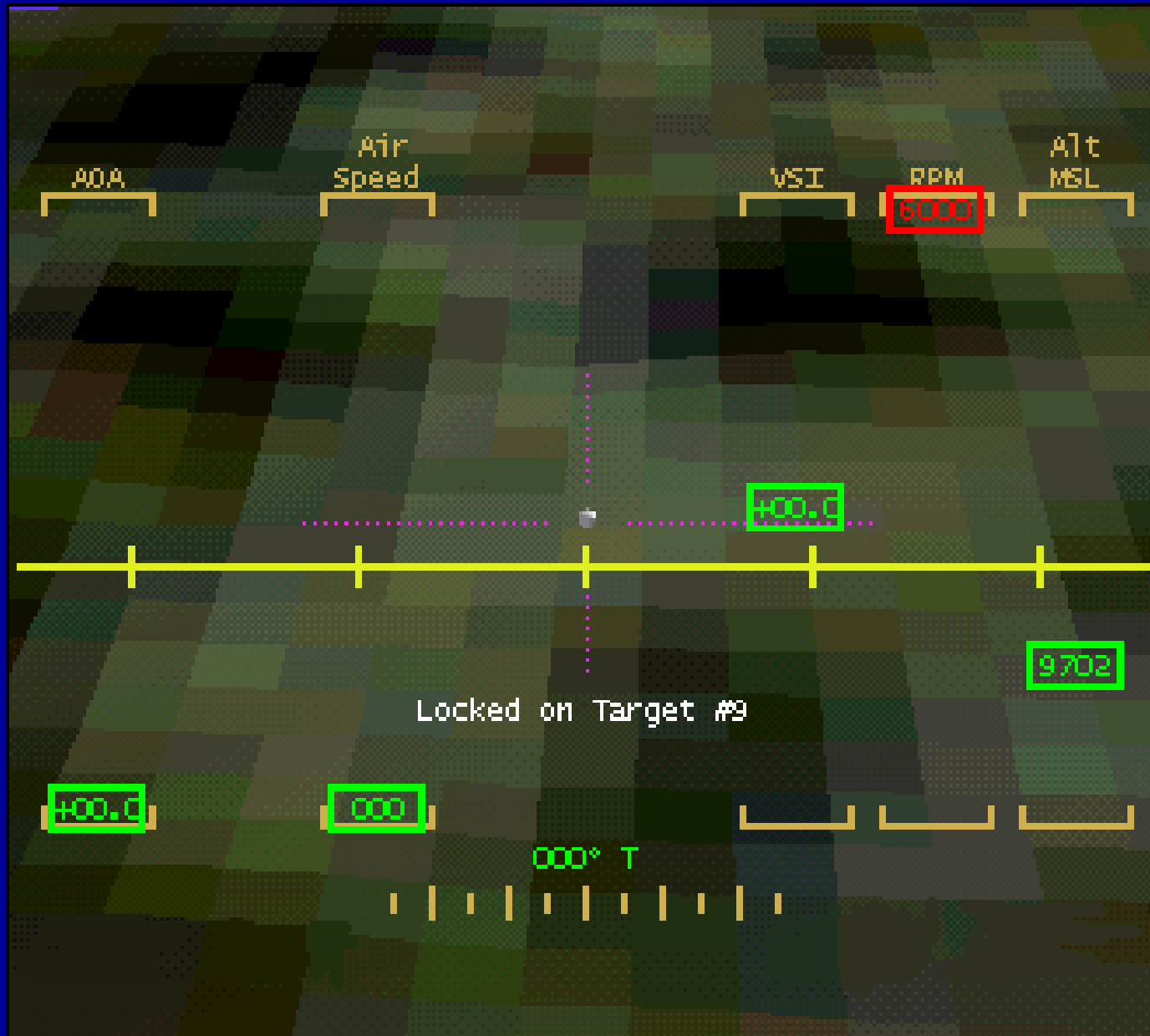
ESC

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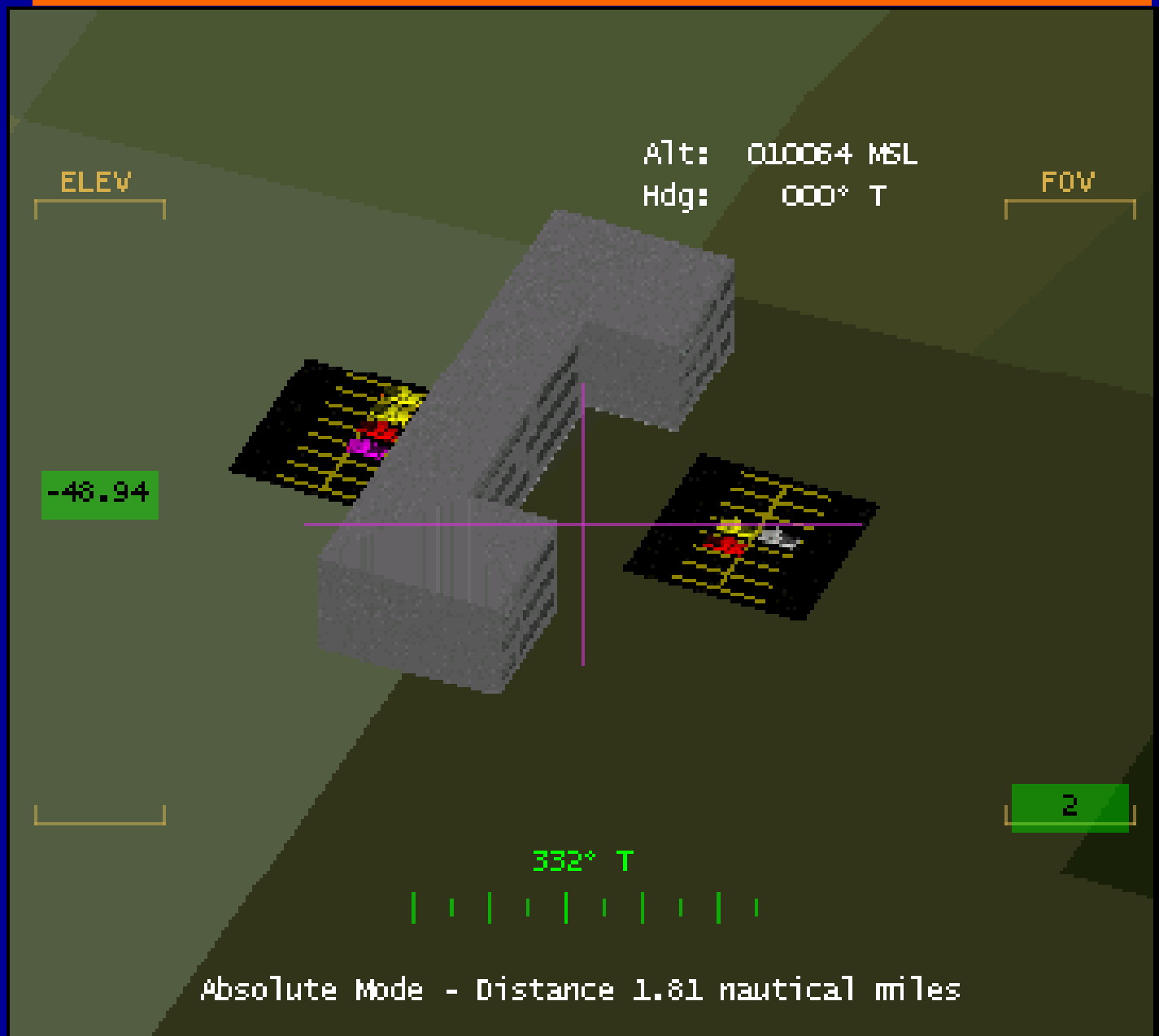
F5 Video Camera Payload	F6 Payload Camera Target 2	F7 Payload Camera Zoomed IN	F8 Tell Recon Objective
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F9 Satisfy Recon Objective	F10 Report Camera Problem	F11 Report Autopilot Problem
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# Camera Zoomed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



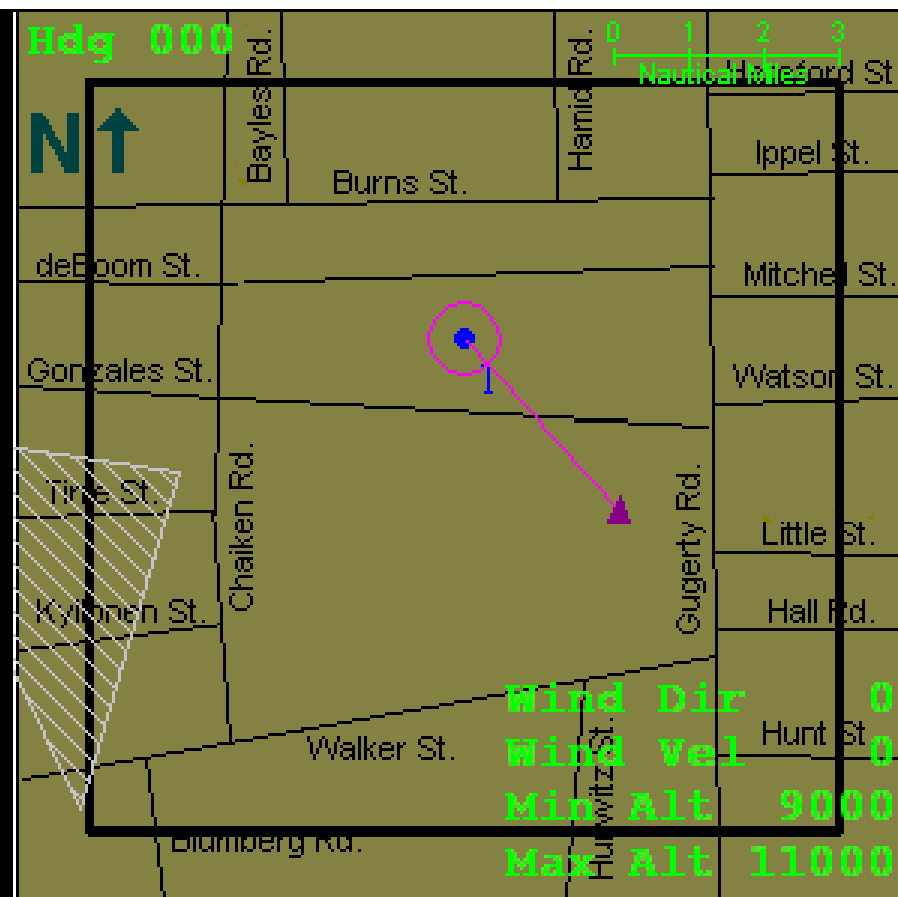
# Camera Zoom In Feature



# 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
- Followed by a Training Scenario that tests the skills of operators on various performance skills

# Training Slide



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

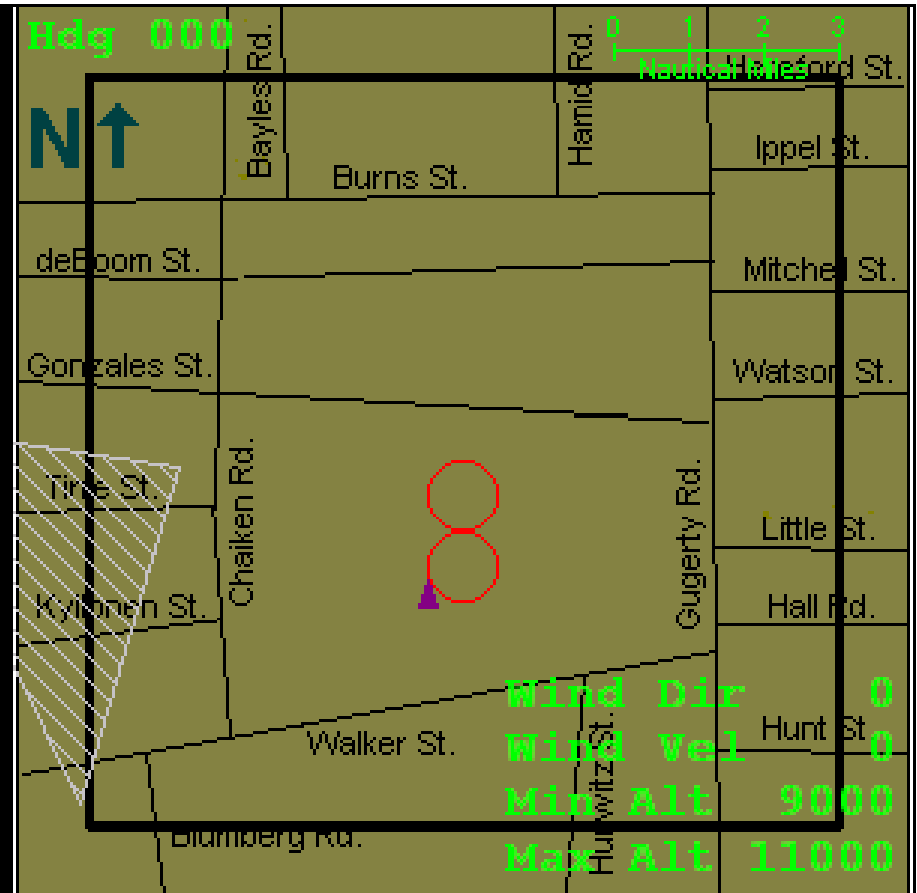
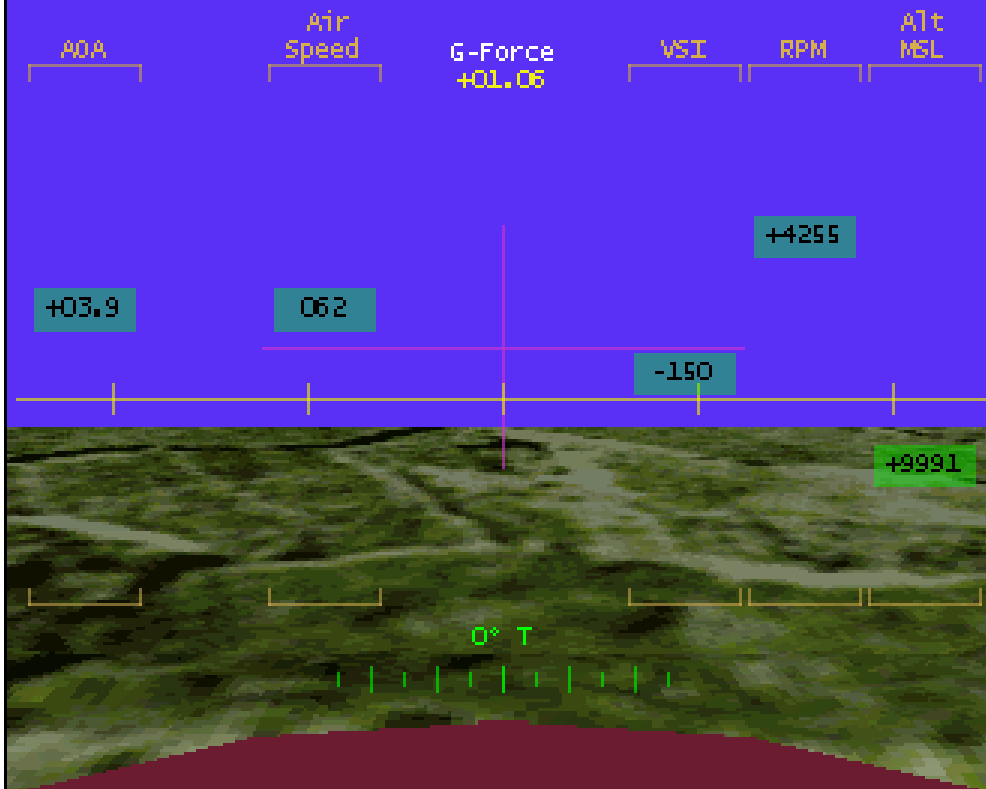
## Points

Gained 0  
Lost 0  
Total 0

# stick controls camera



# Training Slide



Practice flying along the figure-8 for three minutes.

### Targets

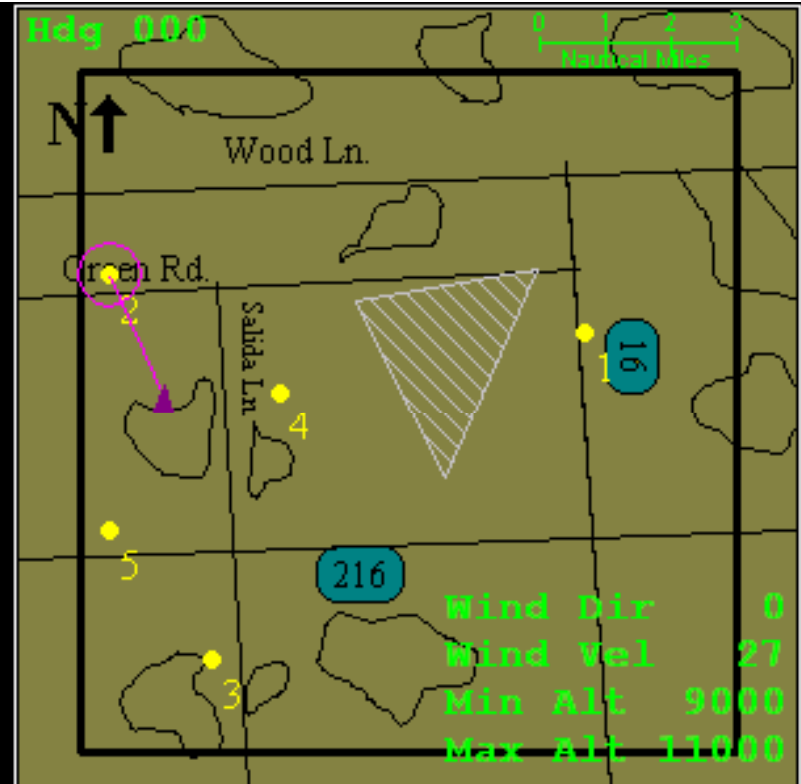
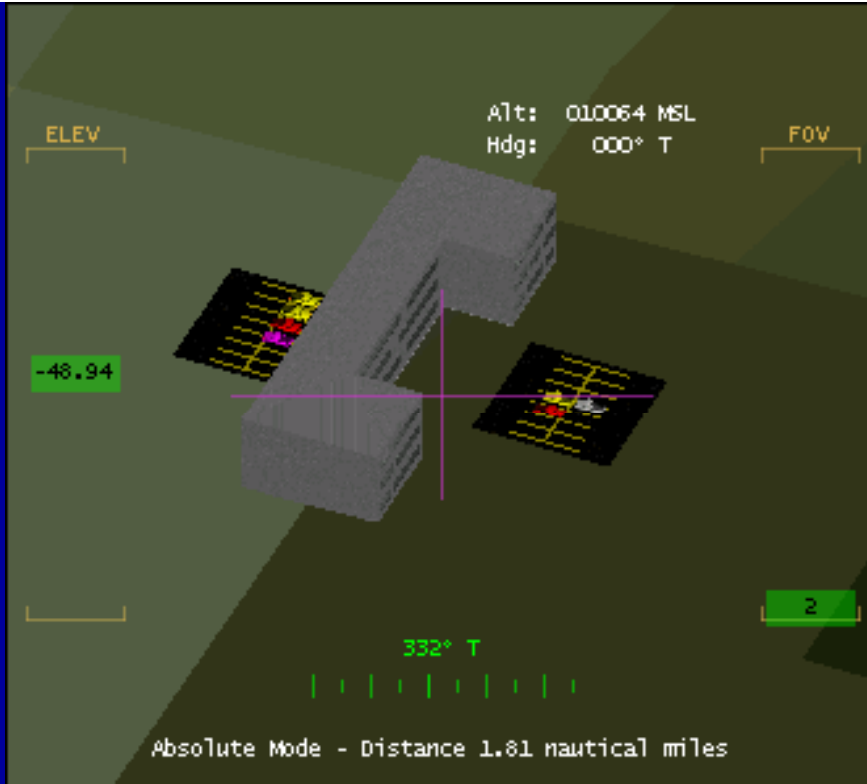
- 15 points
- 10 points
- 5 points
- Completed

### 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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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

- Violations of various restrictions
- Questions answered correctly
- Time taken to respond to all targets

## Missions

- Training mission with 2 initial targets & 2 ad hoc
- Three missions of increasing complexity
  - Mission 1: 4 initial targets and 2 ad hoc targets
  - Mission 2: 3 initial targets and 4 ad hoc targets
  - Mission 3: 8 initial targets and 2 ad hoc targets

# Reliabilities and Intercorrelations of the Three Spatial Tests

	Card Rotations	Purdue (ROT) Visualizations of Rotations	Map Planning
Card Rotations	<b>.97</b>		
Purdue (ROT) Visualizations of Rotations	<b>.45**</b>	<b>.81</b>	
Map Planning	<b>.43**</b>	<b>.49**</b>	<b>.76</b>

\*\* denotes correlation is significant  $p < .01$  two-tailed.  $N \geq 233$  for each correlation

# Prediction of Training Performance with the Spatial Tests (multiple R)

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	Violations	# Correct Answers	Time to Completion
Card Rotations	.41**	.24*	.27*
Purdue ROT	.48**	.40**	.30**
Map Planning	.34**	.25*	.22

**Multiple R:** Performance =  $a + b_1 \cdot \text{AVO Test Score} + b_2 \cdot \text{SO Test Score}$

\* denotes correlation is significant  $p < .05$  two-tailed.

\*\* denotes correlation is significant  $p < .01$  two-tailed.  $N \geq 113$  for each correlation

# Mission 1 Performance Predicted by the Spatial Tests

	Violations	# Correct Answers	Time to Completion
Training	.55**	.44**	.39**
Card Rotations	.39**	.36**	.15
Purdue ROT	.41**	.37**	.37**
Map Planning	.42**	.37**	.27*

zero-order correlation

multiple R – AVO & SO scores

\* denotes correlation is significant  $p < .05$  two-tailed.

\*\* denotes correlation is significant  $p < .01$  two-tailed.  $N \geq 113$  for each correlation

# Mission 2 Performance Predicted by the Spatial Tests

	Violations	# Correct Answers	Time to Completion
Training	.47**	.38**	.42**
Card Rotations	.31**	.26*	.21
Purdue ROT	.30**	.38**	.27*
Map Planning	.32**	.24*	.19

zero-order correlation

multiple R – AVO & SO scores

\* denotes correlation is significant  $p < .05$  two-tailed.

\*\* denotes correlation is significant  $p < .01$  two-tailed.  $N \geq 113$  for each correlation

# Mission 3 Performance Predicted by the Spatial Tests

	Violations	# Correct Answers	Time to Completion
<b>Training</b>	<b>.30*</b>	<b>.33**</b>	<b>.39**</b>
Card Rotations	.16	.21	.23*
Purdue ROT	.21	.33**	.15
Map Planning	.08	.14	.16

zero-order correlation

multiple R – AVO & SO scores

\* denotes correlation is significant  $p < .05$  two-tailed.

\*\* denotes correlation is significant  $p < .01$  two-tailed.  $N \geq 113$  for each correlation

# Comparisons of AVO and SO Predictions of Overall Performance Criteria

Cell entries are standardized Bs

	Violations		# Correct Answers		Time to Completion	
	AVO	SO	AVO	SO	AVO	SO
Card Rotations	-.28**	-.18*	.15	.24*	-.08	-.18*
Purdue ROT	-.28**	-.29**	.07	.42**	-.12	-.25**
Map Planning	-.32**	-.13	.18*	.18*	-.13	-.19*

\* denotes  $\beta$  is significant  $p < .05$  two-tailed.

\*\* denotes  $\beta$  is significant  $p < .01$  two-tailed.  $N \geq 113$  for each regression

# Overall Mission Performance Predicted by the Spatial Tests

	Violations	# Correct Answers	Time to Completion
Training	.58**	.46**	.50**
Card Rotations	.36**	.31**	.22
Purdue ROT	.43**	.43**	.29**
Map Planning	.36**	.27*	.25*

zero-order correlation

multiple R – AVO & SO scores

\* denotes correlation is significant  $p < .05$  two-tailed.

\*\* denotes correlation is significant  $p < .01$  two-tailed.  $N \geq 113$  for each correlation

# Comparisons of AVO and SO Predictions of Overall Performance Criteria

Cell entries are standardized Bs

	Violations		# Correct Answers		Time to Completion	
	AVO	SO	AVO	SO	AVO	SO
Card Rotations	-.13	-.08	.13	.07	.004	-.10
Purdue ROT	-.13	-.29**	-.06	.42**	-.08	-.16
Map Planning	-.19 <sup>+</sup>	-.03	.14	-.05	-.10	-.09

R<sup>2</sup>

.25

.23

.11

+  $p = .07$

\*  $p < .05$  two-tailed.

\*\*  $p < .01$  two-tailed.  $N \geq 113$  for each regression

# Overall Mission Performance Predicted by Training and the Three Spatial Tests

Cell entries are standardized Bs	Violations	# Correct Answers	Time to Completion
Training	.45**	.36**	.44**
Card Rotations	-.10	.14	-.10
Purdue ROT	-.16	.16	-.09
Map Planning	-.09	.03	-.10
$R^2$	.39	.27	.27

\* denotes standardized B is significant  $p < .05$  two-tailed.

\*\* denotes standardized B is significant  $p < .01$  two-tailed.  $N \geq 113$  for each regression

# Some Conclusions and Implications

- Spatial abilities tests were reliable and related
- Spatial abilities predict training on tasks
- Training had stronger influence than tests
- Tests weaker relation over time (training too)
- Differential prediction of criteria for AVO & SO
- Some value to a multiple metric perspective
- Differential prediction of criteria for spatial tests
- Unique view of prediction of team performance
- Spatial ability and training in combination contribute to prediction of team performance but training is stronger and longer sustained under the specific conditions of this study

# Some Caveats

- Limitations of this sample of participants
- Use of this particular UAV simulation
- With these defined mission parameters
- Examining the selected performance metrics
- Limited to these spatial abilities tests

# Assistants

- John Urbanec
- Marina Serdiouk
- Ryan Pillatzki
- Andrea Rooney
- Alice Scharnweber
- Jonathan Pikalek

Thank You !