Human Factors Symposium
October 18 - 21, 2004
Ames Research Center • Army/NASA Rotorcraft Division

Improving the Flight Path Marker Symbol on Rotorcraft Synthetic Vision Displays

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Synthetic Vision
Background

- Most Army & civil rotorcraft cannot operate low-level, off-airfield in poor visibility conditions.

Synthetic Vision
Previous Research - Fixed Wing

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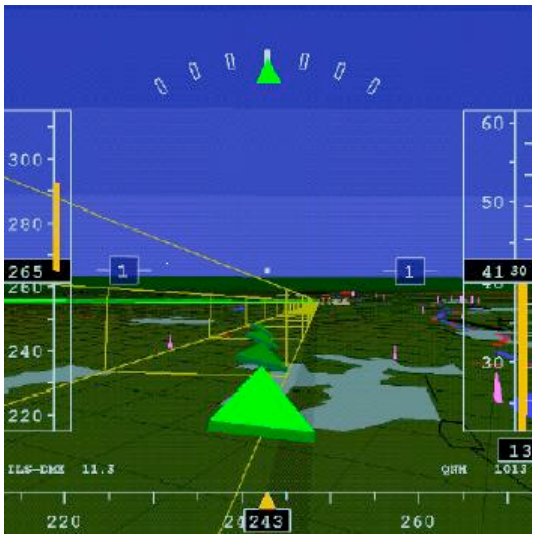
NASA-Langley
Rockwell-Collins

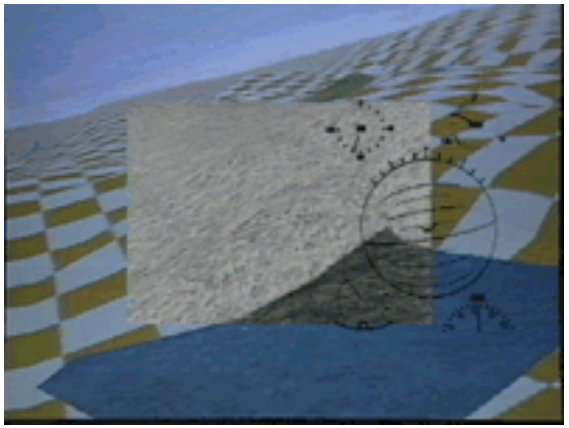
Fixed wing SV:
- Synthetic terrain
- Earth-referenced flight path marker



DLR- German Aerospace Center
Technische Universität Darmstadt
Technische Universität München

Synthetic Vision
Previous Research at NRC

Rotorcraft synthetic vision:
- Wide field-of-view helmet-mounted display
- Imaging sensor inset in synthetic terrain

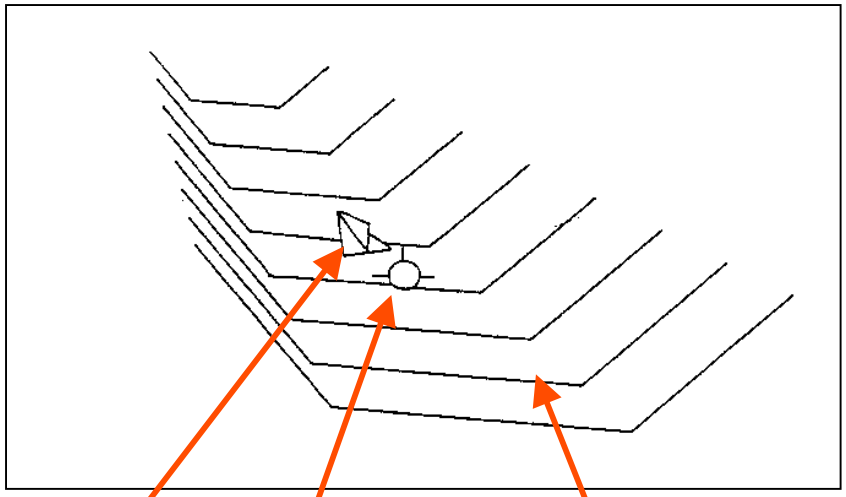


NRC - National Research Council
Canada

Flight Path Marker Guidance
Previous Research at ARC

Computer-Derived Path

Ref. Swenson



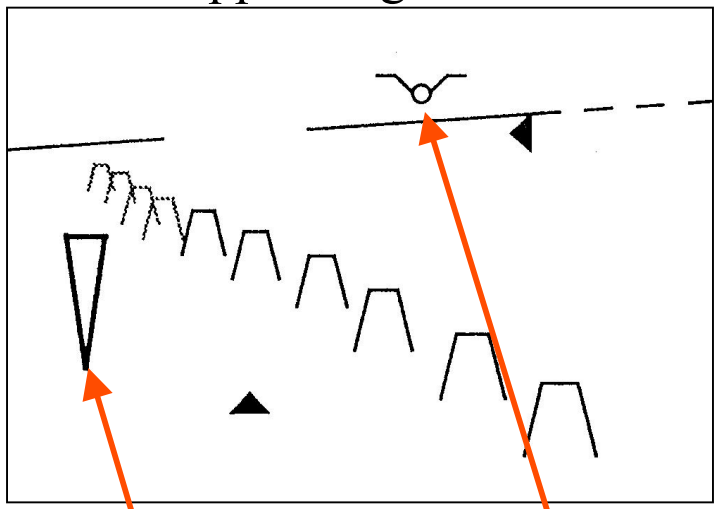
Leader

Flight Path Marker

Path Computed Real-Time
– current position
– destination
– terrain
– aircraft limits

With/Without Path

Ref. Coppenbarger



Reference Point (predicted point on terrain the aircraft will fly over)

Flight Path Marker

Objective of this Research

Develop and test a FPM symbol tailored for the rotorcraft mission

– low level flight

– off a programmed path

– No ground navig. aids

Synthetic Vision Simulation
Rotorcraft Cab

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Synthetic Vision Simulation
Altitude and Ground Track Predicting Flight Path Marker (ATP-FPM)

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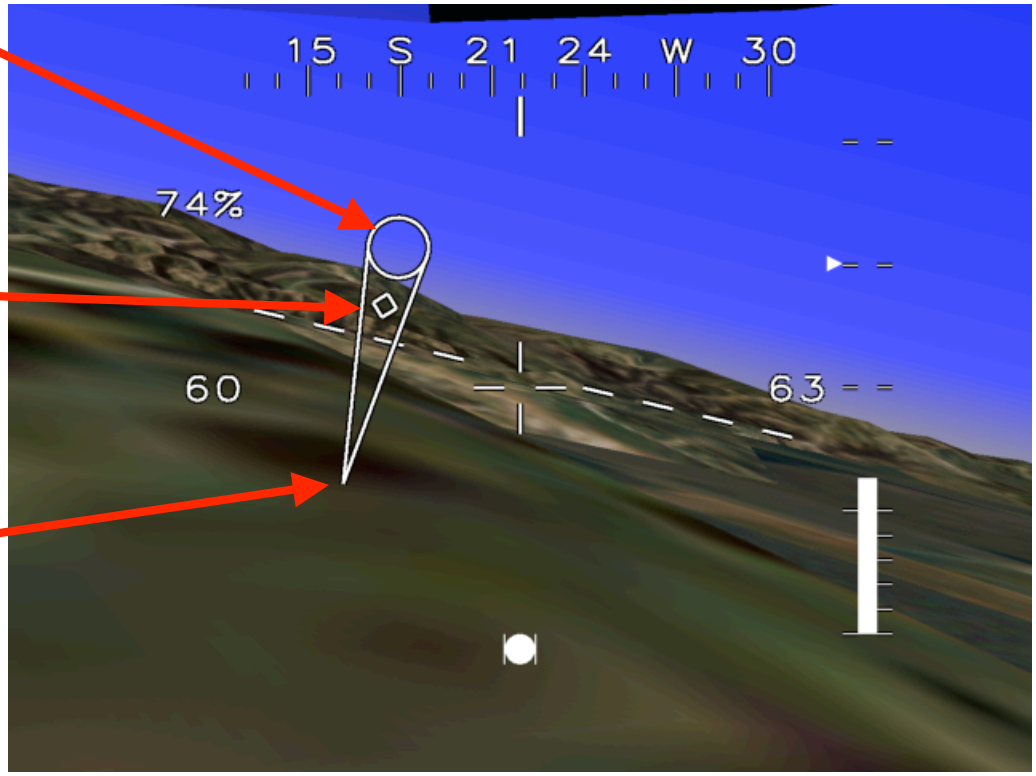
Aircraft Position Predictor (3 sec)

50 ft Target Altitude

Ground Pointer (determined by radar or stored terrain database)



Synthetic Vision Simulation
ATP-FPM Video

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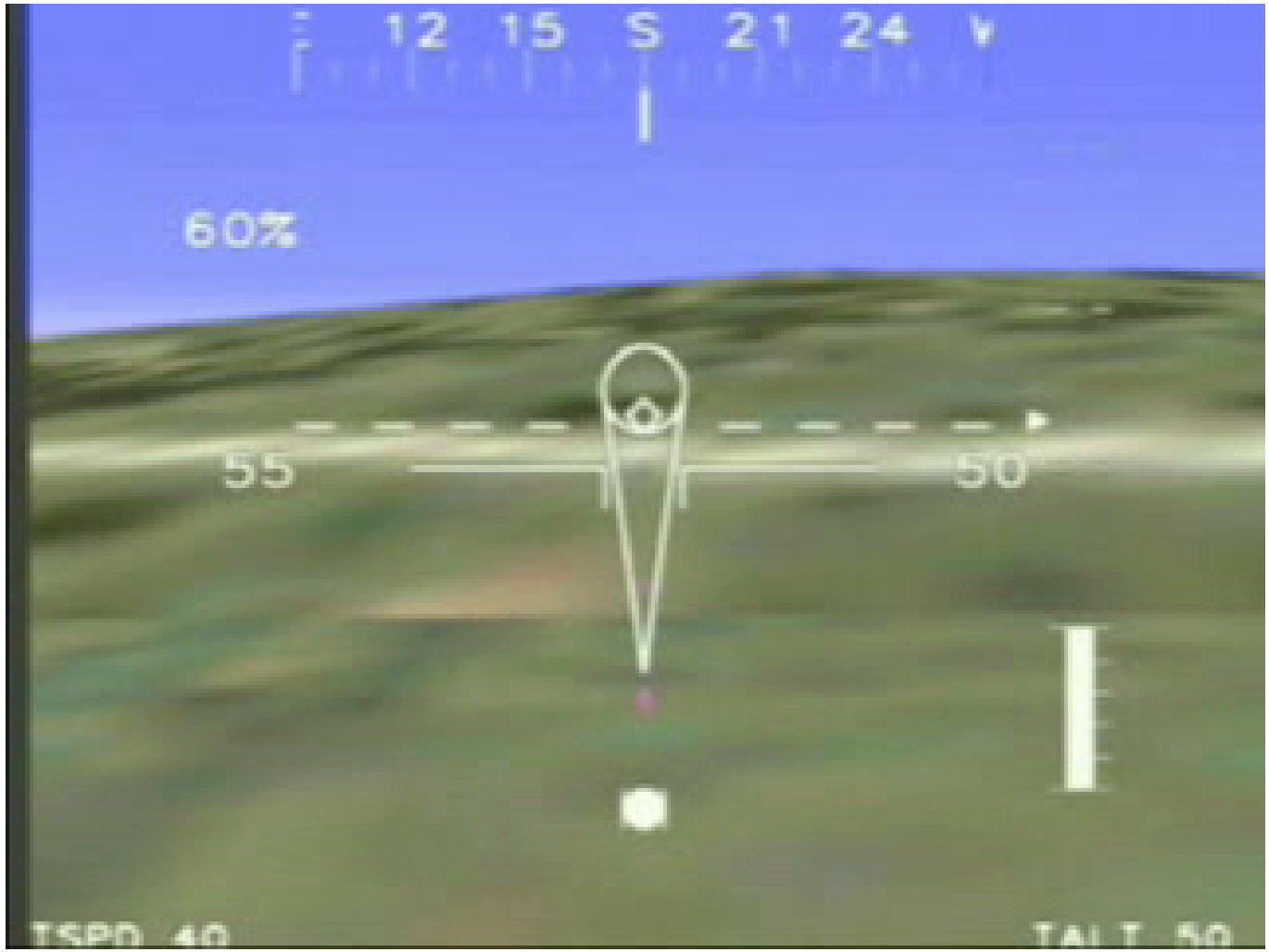

Synthetic Vision Simulation
Test Configurations

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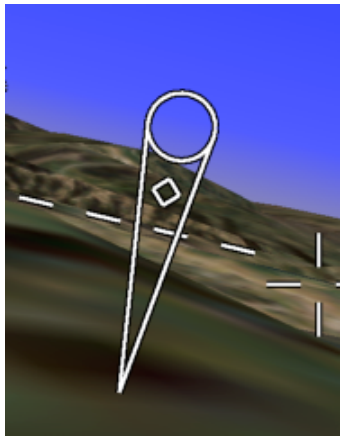
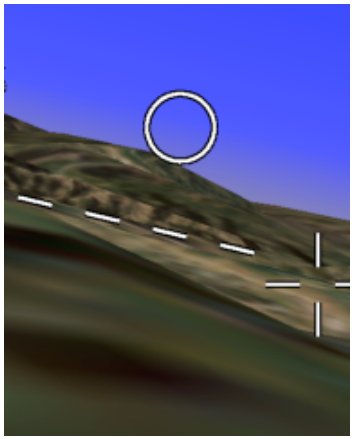


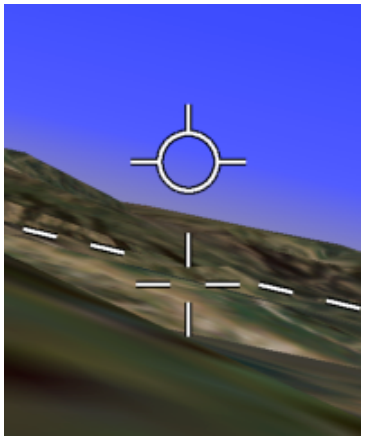
ATP-FPM

Altitude and ground Track Predicting Flight Path Marker



Q-FPM

Quickened Flight Path Marker



I-FPM

Instantaneous Flight Path Marker

Synthetic Vision Simulation
Course

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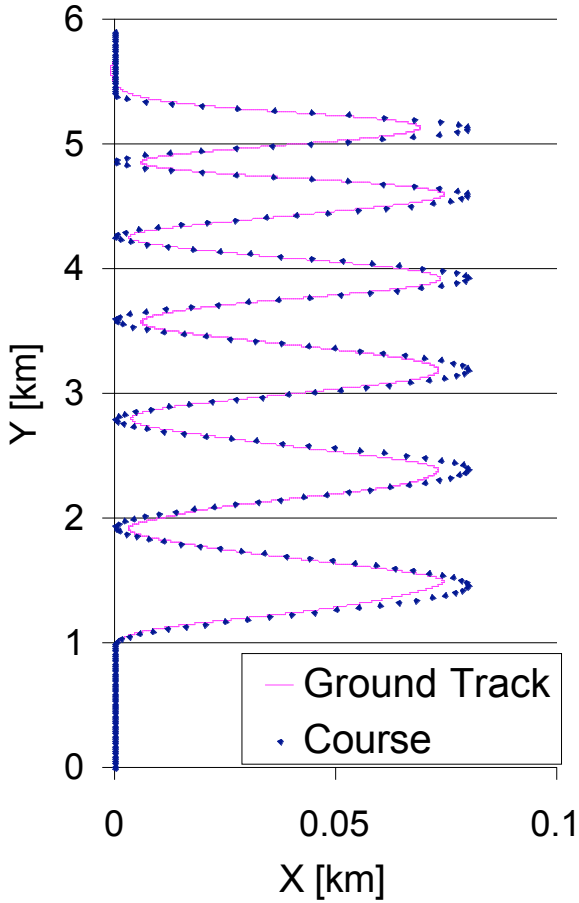
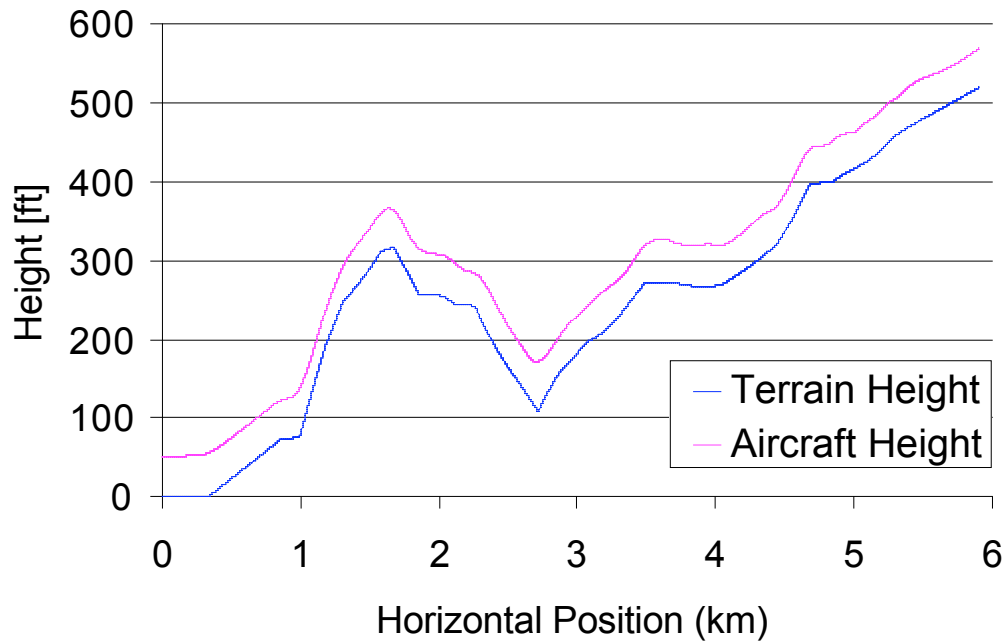
Plan View of Course and Ground Track for a Typical Flight



Elevation Profile for a Typical Flight



Synthetic Vision Simulation
Results

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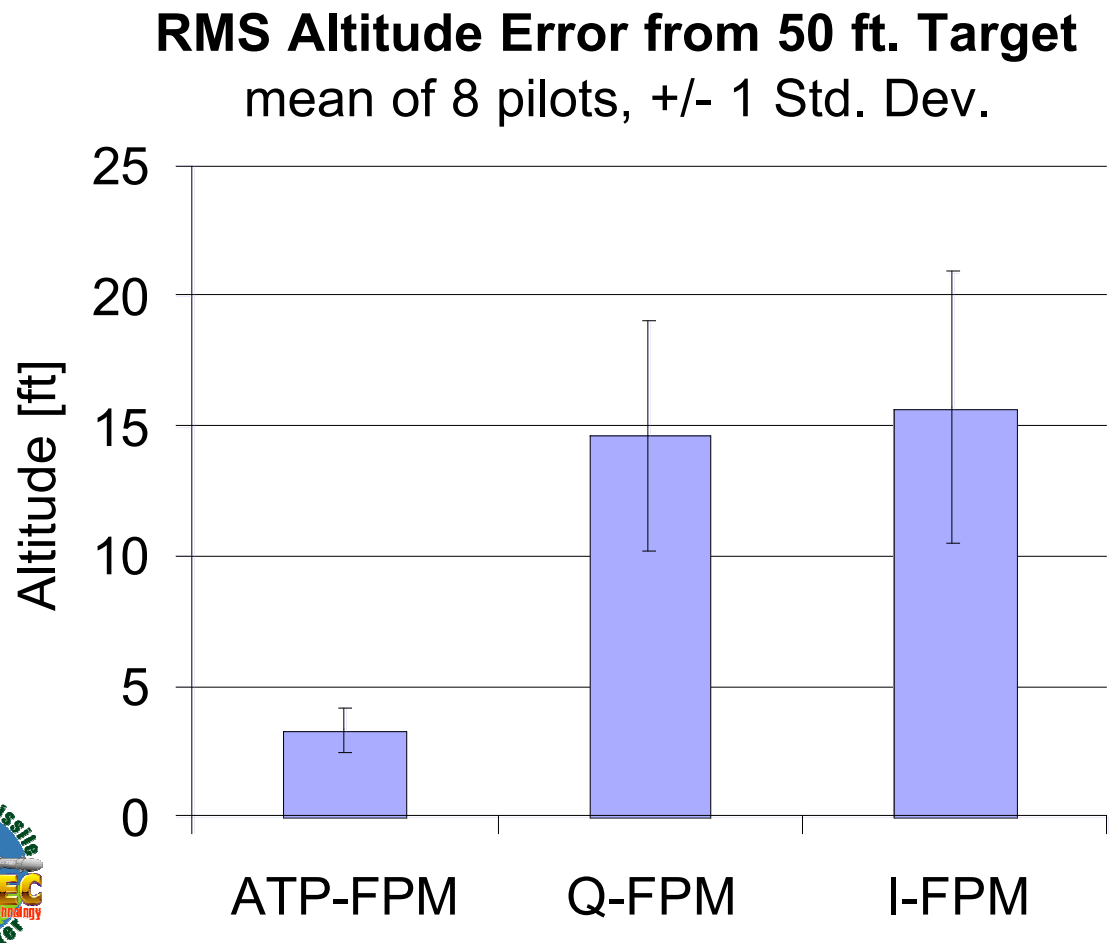

ANOVA

1 vs 2: $F(1,7) = 57.7$, $p<0.01$

1 vs 3: $F(1,7) = 47.7$, $p<0.01$

2 vs 3: $F(1,7) = 1.4$, not signif.

Synthetic Vision Simulation
Results

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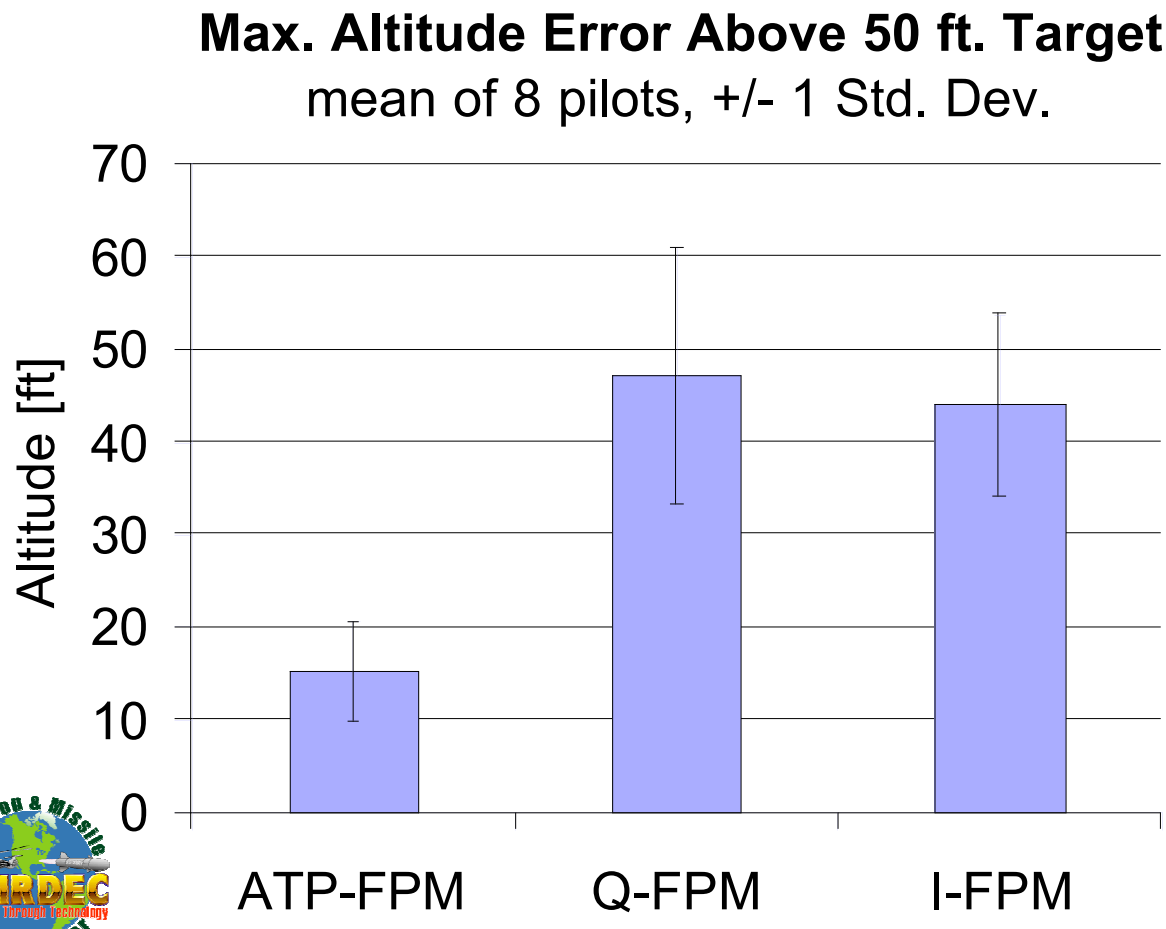

ANOVA

1 vs 2: $F(1,7)=39.7$, $p<0.01$

1 vs 3: $F(1,7)=38.7$, $p<0.01$

2 vs 3: $F(1,7)=0.5$, not signif.

Synthetic Vision Simulation
Results

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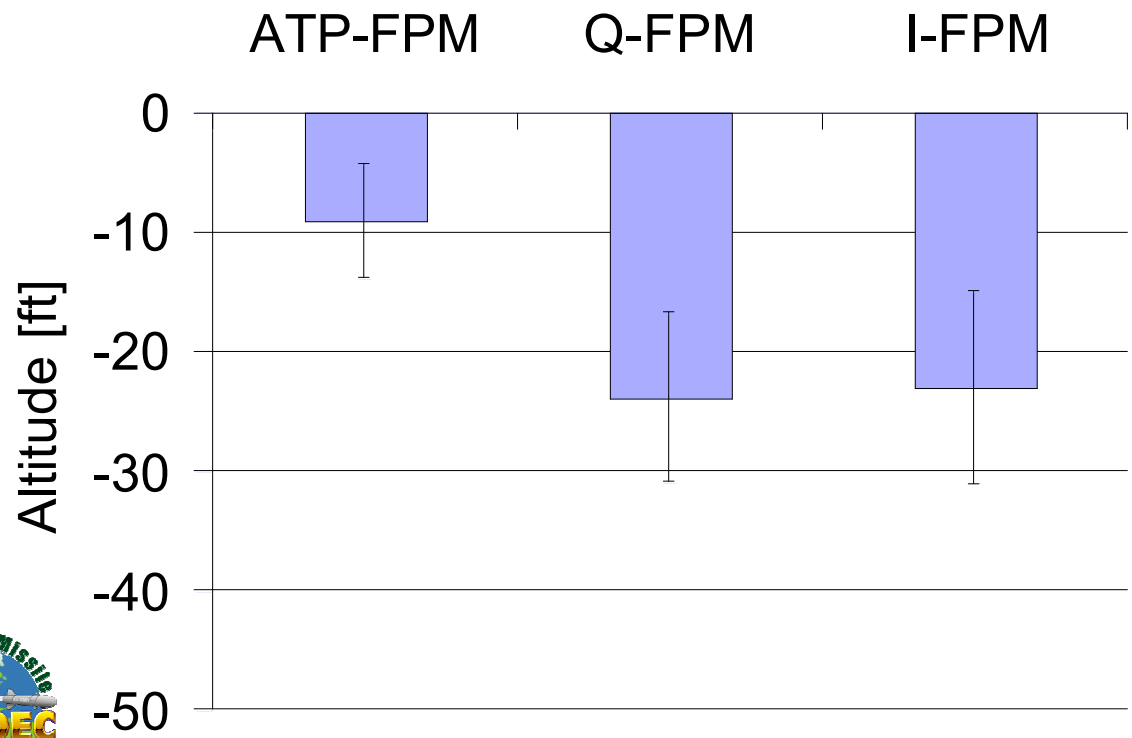
Max. Altitude Error Below 50 ft. Target

mean of 8 pilots, +/- 1 Std. Dev.



ANOVA

1 vs 2: $F(1,7)=91.0$, $p<0.01$

1 vs 3: $F(1,7)=41.5$, $p<0.01$

2 vs 3: $F(1,7)=0.1$, not signif.

Synthetic Vision Simulation
Results

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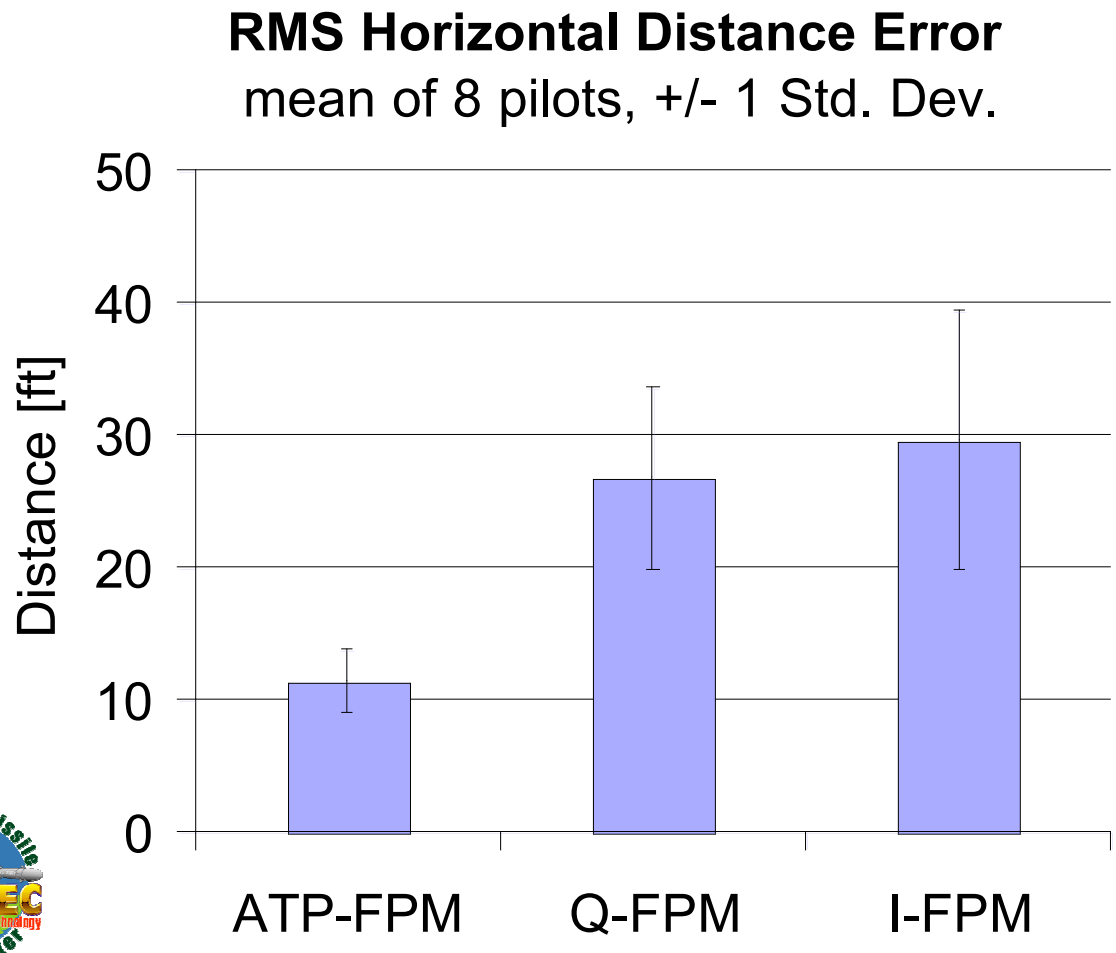

ANOVA

1 vs 2: $F(1,7)=45.8$, $p<0.01$

1 vs 3: $F(1,7)=30.5$, $p<0.01$

2 vs 3: $F(1,7)=0.5$, not signif.

Synthetic Vision Simulation
Results

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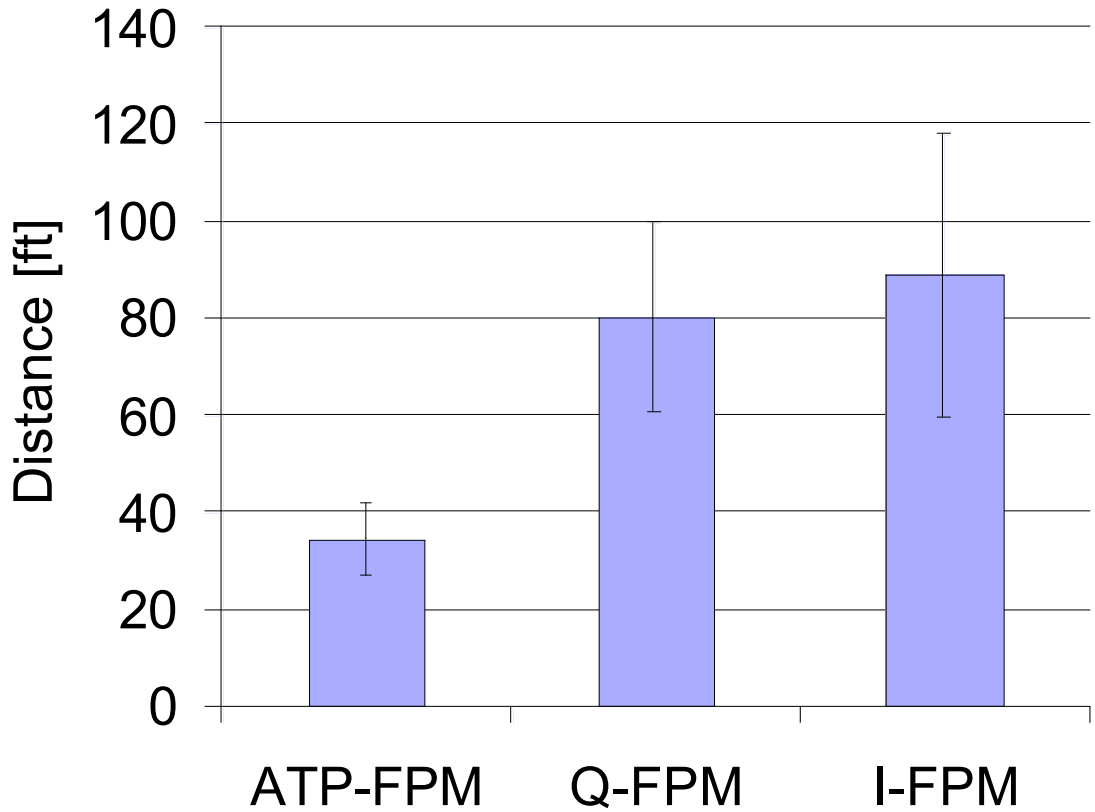
Max. Horizontal Distance from Course

mean of 8 pilots, +/- 1 Std. Dev.



ANOVA

1 vs 2: $F(1,7)=35.9$, $p<0.01$

1 vs 3: $F(1,7)=22.2$, $p<0.01$

2 vs 3: $F(1,7)=0.3$, not signif.

Synthetic Vision Simulation
Results

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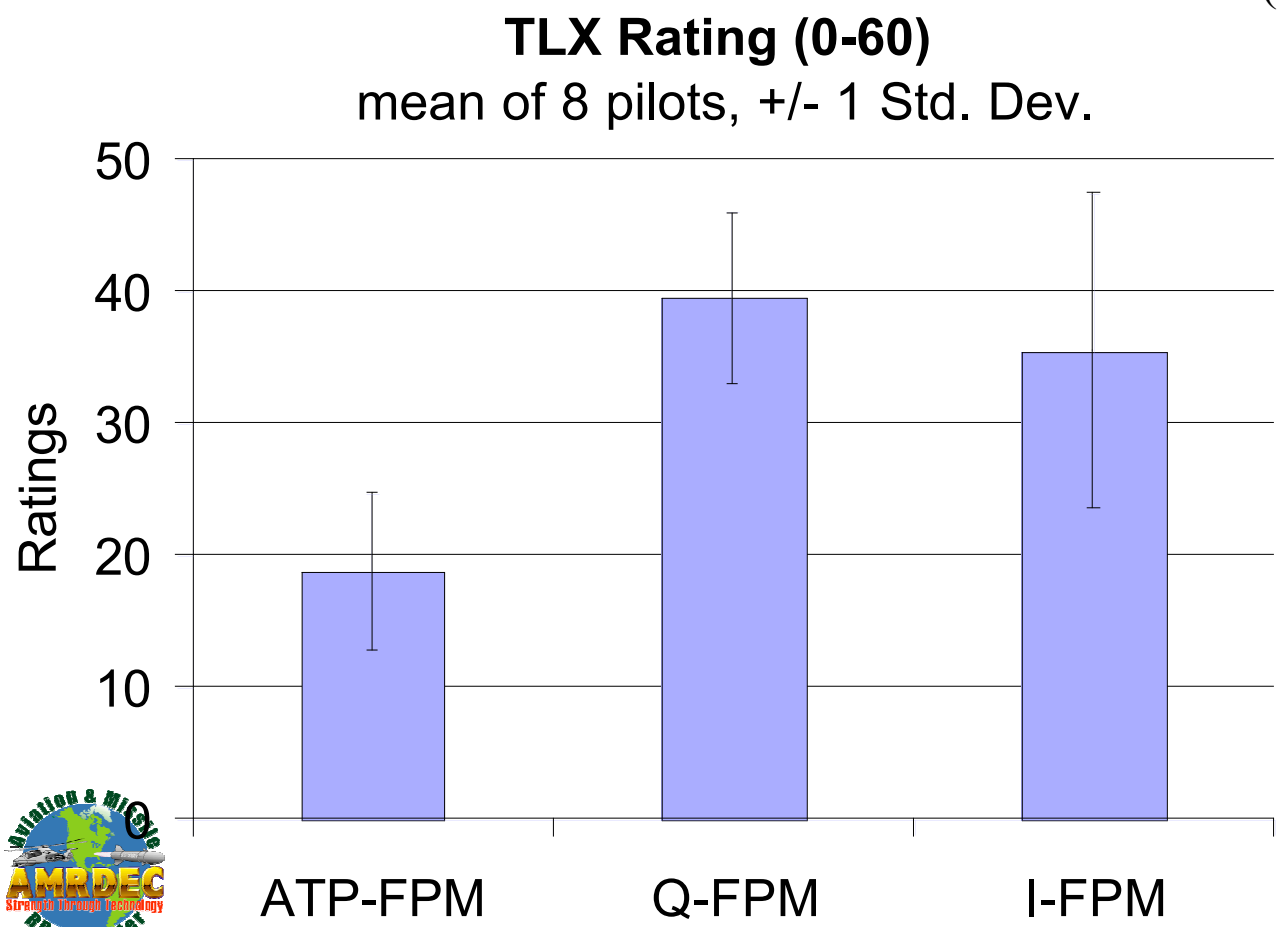

NASA Task Load Index
(lower is better)

- Mental Demand
- Physical Demand
- Temporal Demand
- Effort
- Performance
- Frustration

ANOVA

1 vs 2: $F(1,7)=37.3$, $p<0.01$
1 vs 3: $F(1,7)=14.2$, $p<0.03$
2 vs 3: $F(1,7)=2.5$, not signif.

Synthetic Vision Flight Test

RASCAL UH-60

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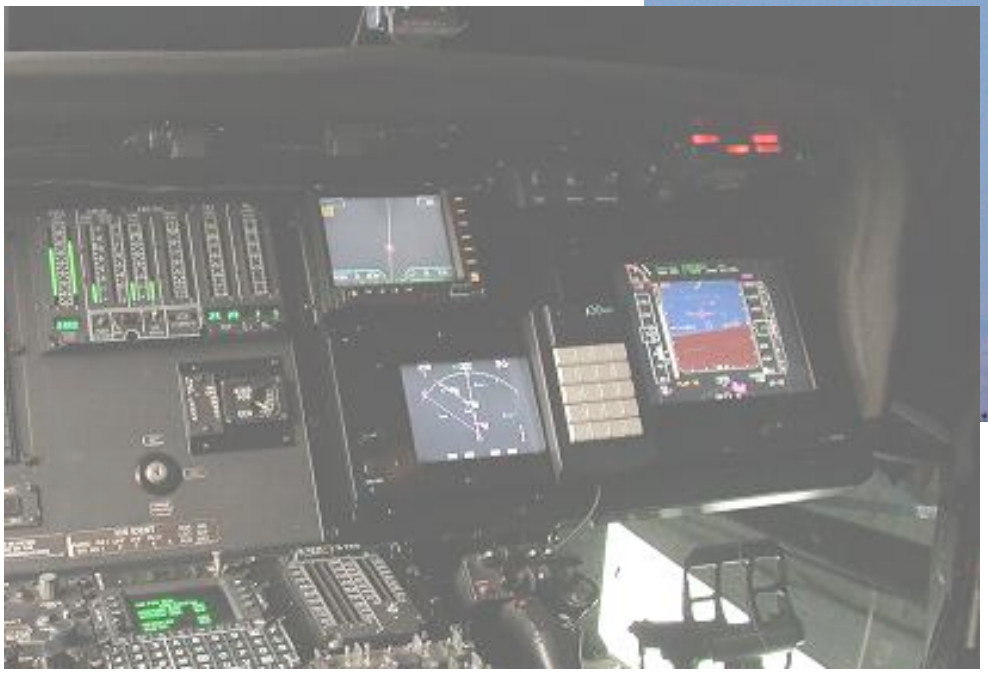

Synthetic Vision Flight Test

ATP-FPM

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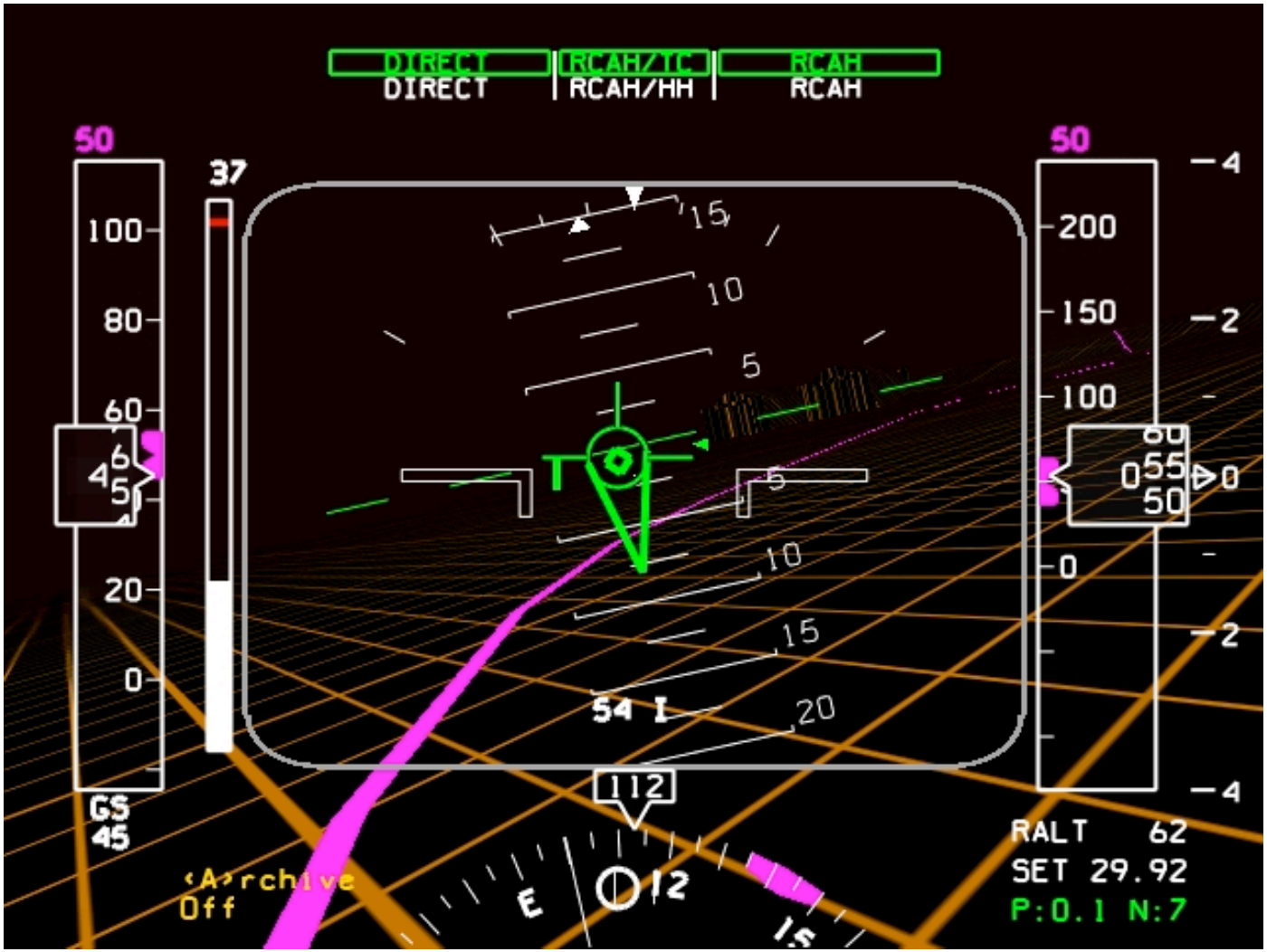

Synthetic Vision Flight Test

ATP-FPM (video)

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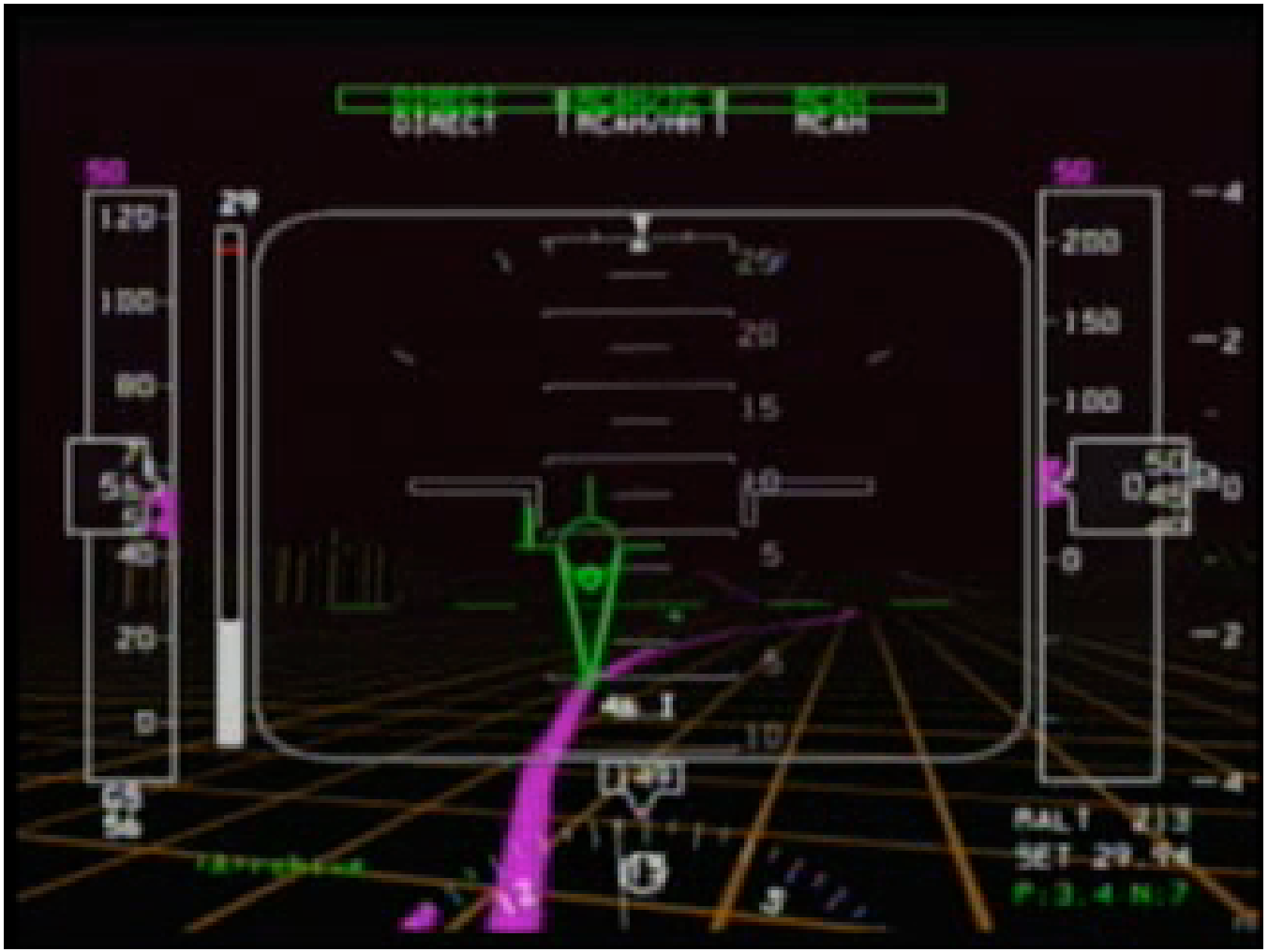

Synthetic Vision Flight Test

Q-FPM (video)

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Synthetic Vision Flight Test

Course - Plan View

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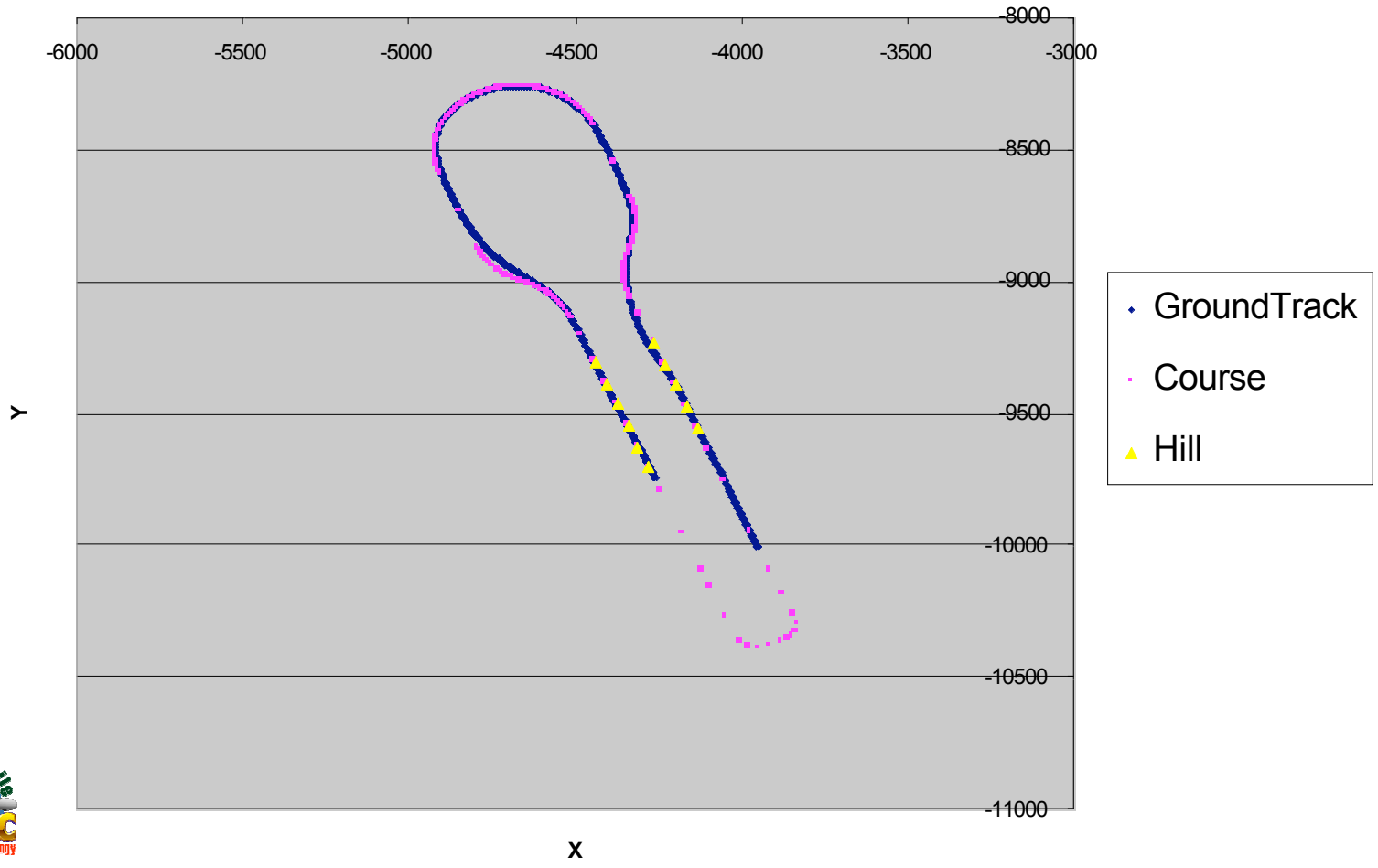
Ground Track



Synthetic Vision Flight Test
Course - Elevation View

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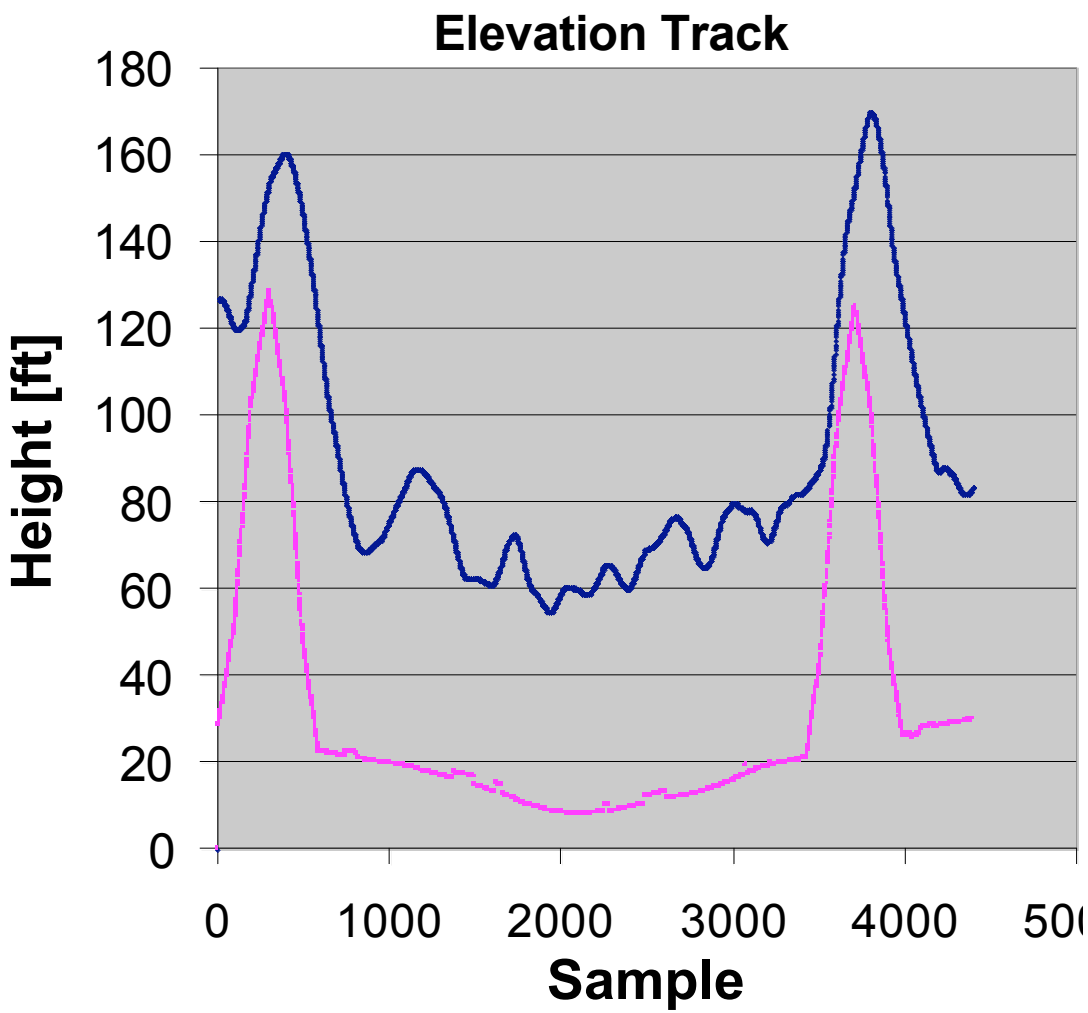

Synthetic Vision Flight Test
Results

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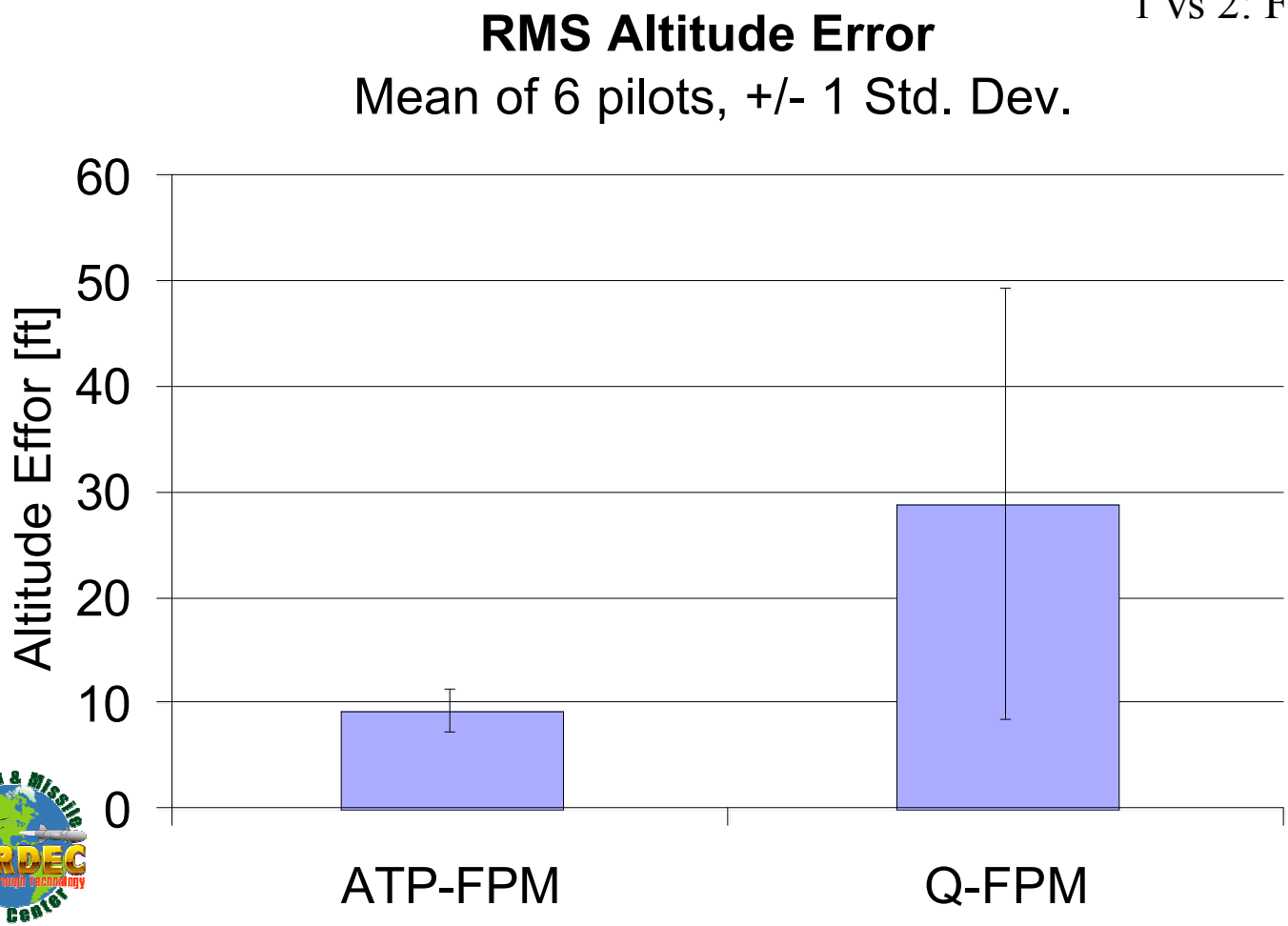
ANOVA
1 vs 2: F(1,5)=5.0, not signif.



Synthetic Vision Flight Test
Results

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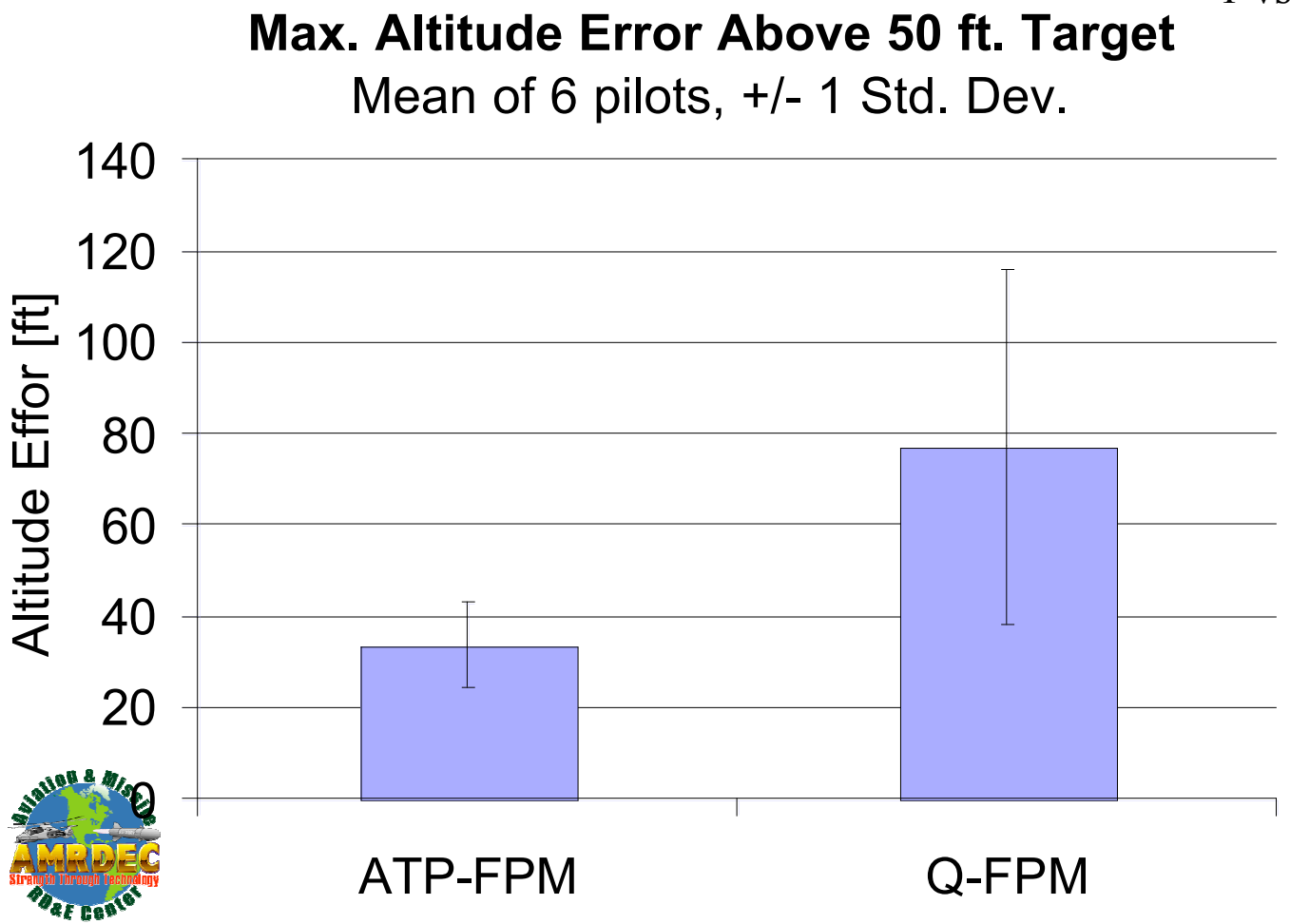
ANOVA
1 vs 2: F(1,5)=5.9, not signif.



Synthetic Vision Flight Test
Results

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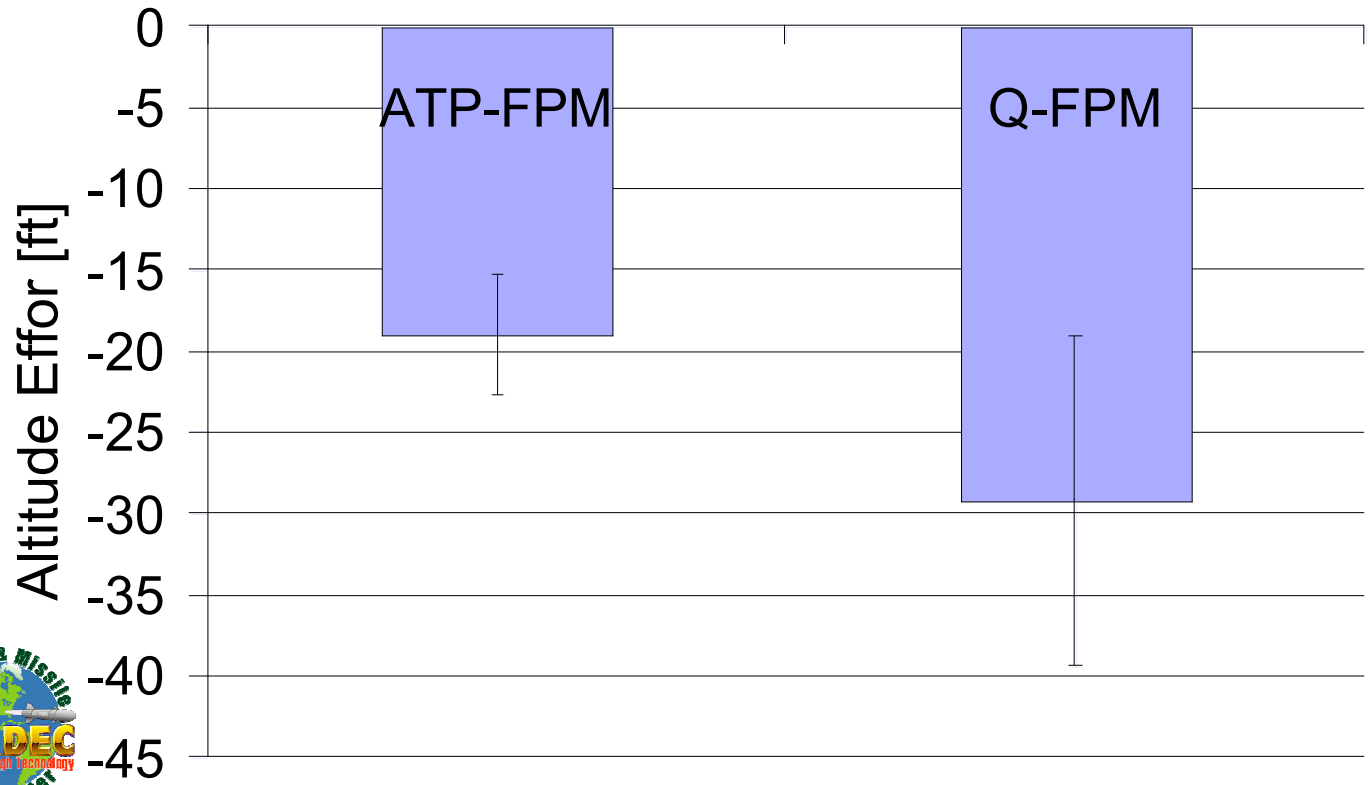
ANOVA
1 vs 2: F(1,5)=3.9, not signif.

Max. Altitude Error Below 50 ft. Target
Mean of 6 pilots, +/- 1 Std. Dev.



Synthetic Vision Flight Test
Result

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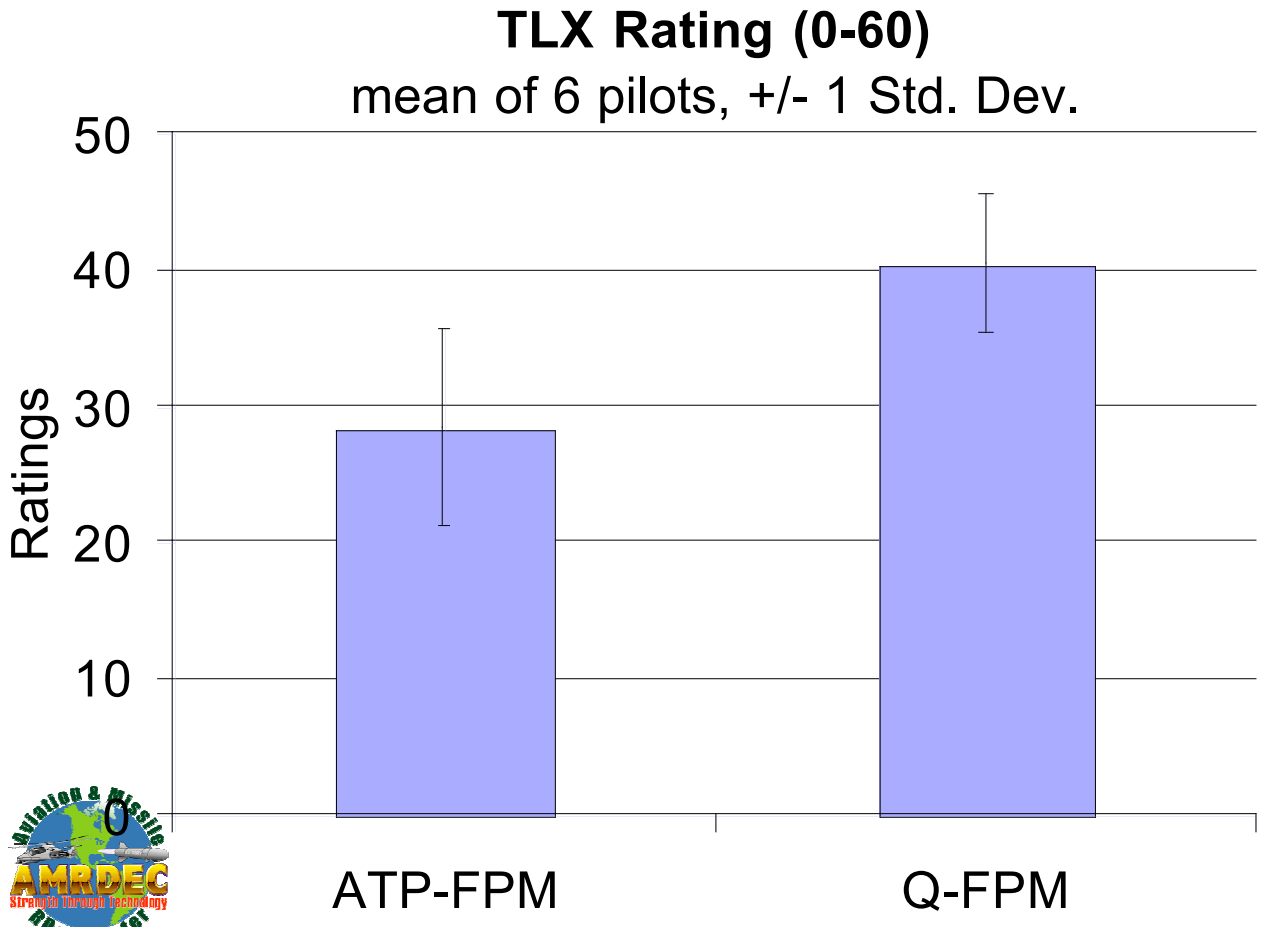

NASA Task Load Index
(lower is better)

- Mental Demand
- Physical Demand
- Temporal Demand
- Effort
- Performance
- Frustration

ANOVA

1 vs 2: $F(1,5)=12.3$, $p<0.02$

Questions?

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