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May 6-10 Reno, Nevada

Human Factors Considerations in the X-31 Aircraft

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Patuxent River, Maryland

Introduction

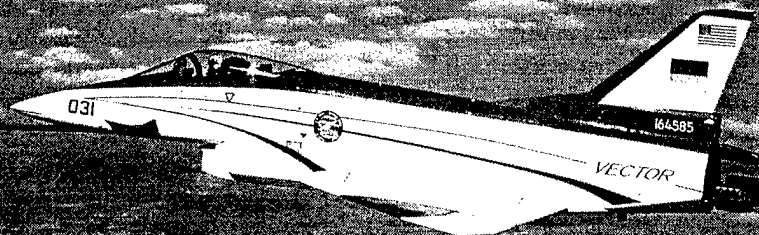
- **Purpose**

- Provide an insight to human factors issues that are relevant to the X-31 ESTOL maneuver

- **Background**

- US Navy Crew System Department human factors lead engineer for the Vectoring ESTOL Control Tailless Operation Research (VECTOR) Program

Aircraft Description



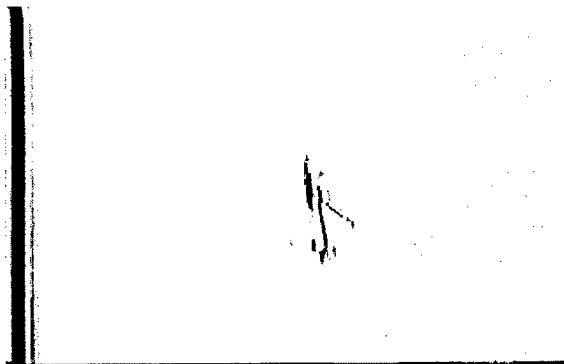
Integration of components from several aircraft

Canards

Variable geometry

Engine: Allison

1995 Paris Air Show Video

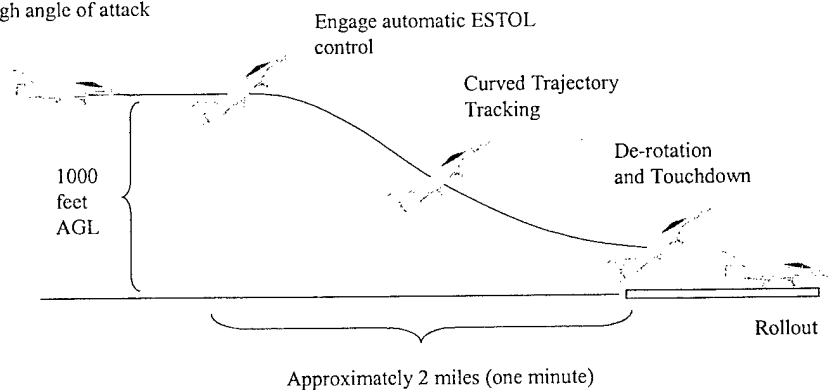


ESTOL Maneuver

- **High alpha approach with derotation just prior to touchdown**
 - Design goal 40° alpha
 - Best payoff 25°
 - Automatic (hands off) approach and touchdown
 - Integrated Beacon Landing System (IBLS)
- **Pilot will not have direct view of runway environment**
 - Specialized display symbology
 - Indirect view of runway environment
 - Reduced workload
 - HOTAS controls
 - Location of other cockpit controls

ESTOL Approach Profile

Manually enter window and transition to high angle of attack



Human Factors Issues

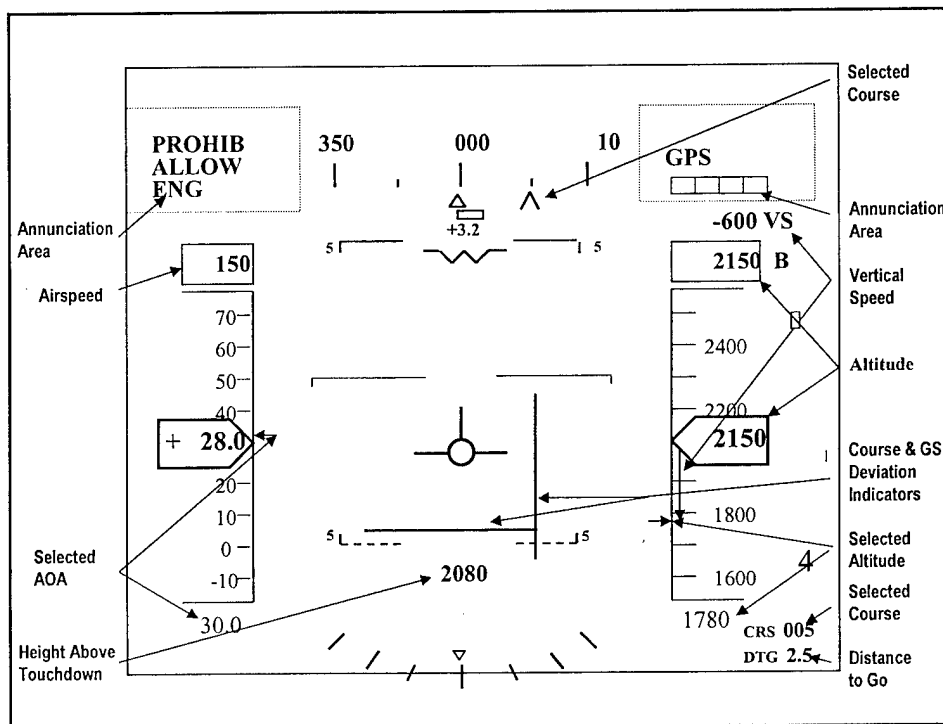
- Display symbology
- Video
- HOTAS and other pilot controls
- Ejection seat
- O² regulator
- Communications ear plug (CEP)

Symbology

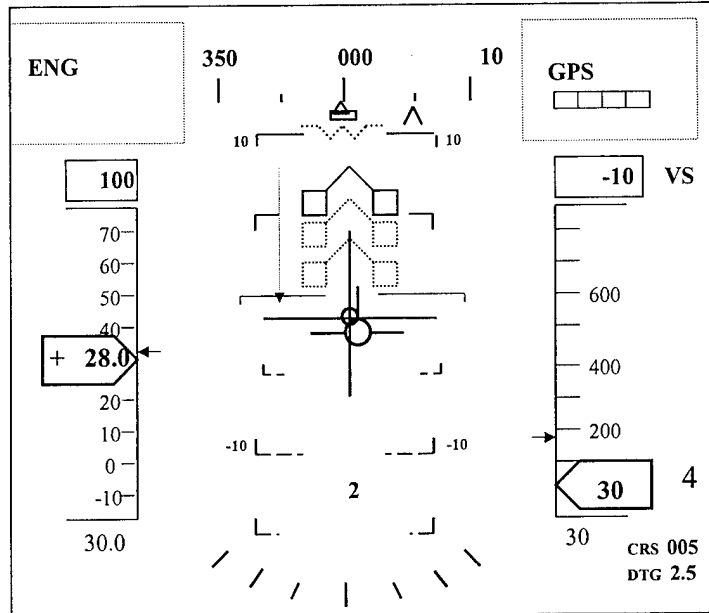
- **Modified to meet ESTOL flight profile**
 - ESTOL-specific symbology
 - Declutter during standard operations
 - Centralized scan of display
- **Primary flight display during approach**
 - HUD vs DDI
 - Opto-Kinetic Cervical Reflex
 - Difficult to assess in simulator
 - Display symbology in both displays
 - Ease of transition from DDI to HUD
 - A/C vs VV centered displays

ESTOL-Specific Symbolology

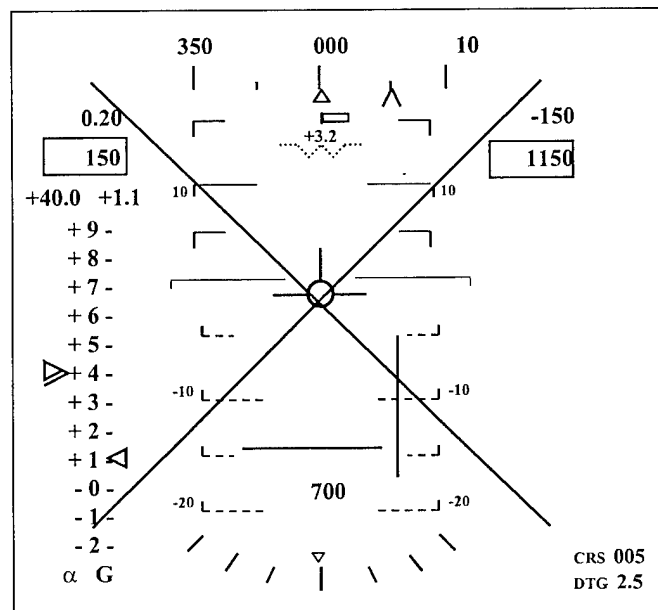
- Annunciator boxes
- Selected heading
- Commanded AOA pointer
- Commanded altitude pointer
- Needles
- Height above touchdown (HAT)
- Selected course
- Selected course
- Distance to go (DTG)
- Acceleration caret
- Derotation cue
- Wave-off X



Derotation Cue



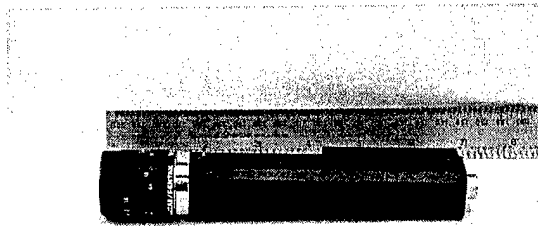
Go Around



Video

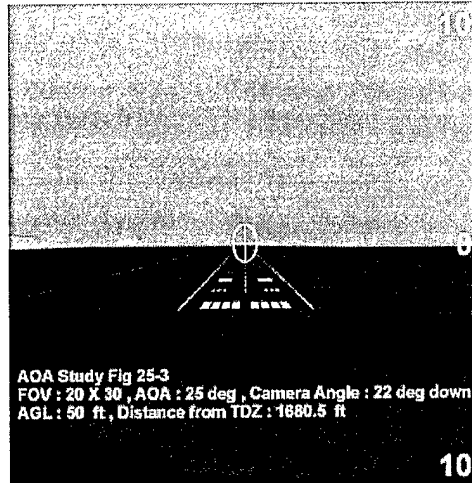
- **Provides indirect view of runway during approach**
 - Runway FOD
 - Gross alignment
 - No symbology overlay of touchdown point
- **Camera mounted internally in lower aspect of nose**
 - High alpha view of runway
 - No obstructions from nose gear
- **Display located on instrument panel behind stick**
 - Easy to scan with DDI and HUD
 - Daylight readability issues
 - Potential obstructions due to stick
- **Flight testing prior to ESTOL flights**

Camera

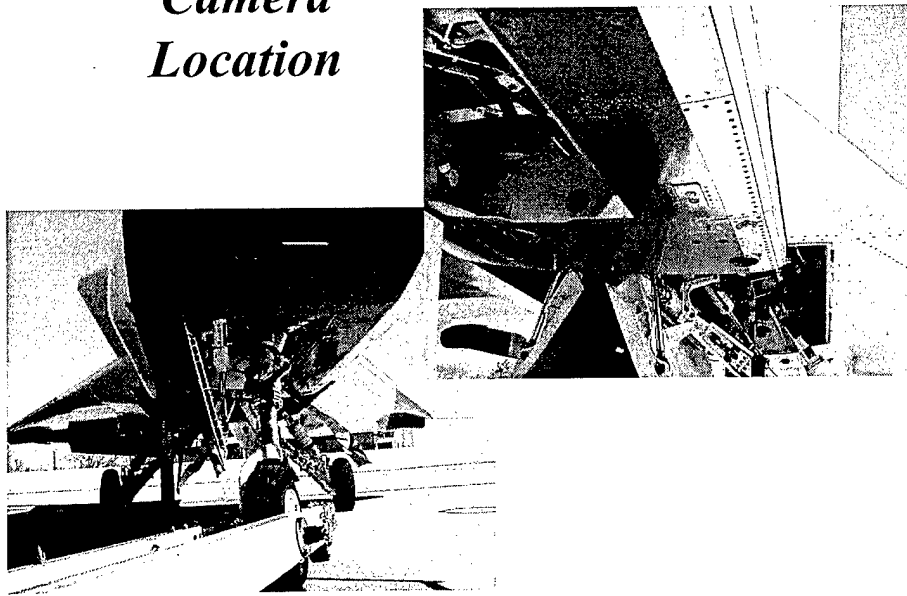


- **Ground tests to evaluate FOV of various lens**
- **Use of simulations to determine mounting angles**
- **Mounting location to provide clear view**
- **Flight tests to verify design concepts**

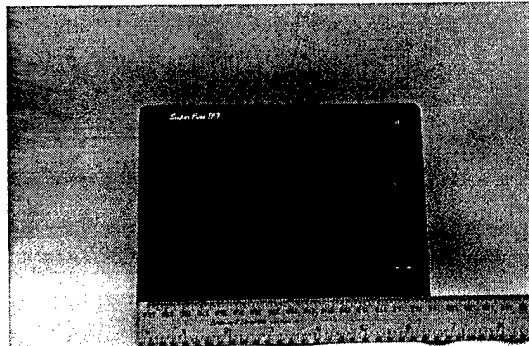
Simulated Video Image



Camera Location

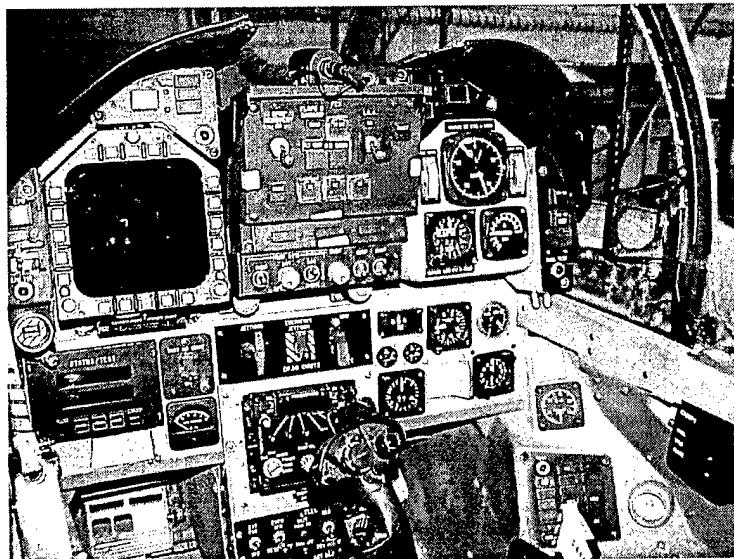


Display



- Video on DDI not feasible
- Ground tests to compare off-the-shelf displays
- Flight tests to evaluate display location and video quality
 - Camera positioning, daylight readability, etc.

Video Display Location



Summary

Application of human factors design concepts will enhance the safety and effectiveness of the VECTOR program.