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May 6-10 Reno, Nevada

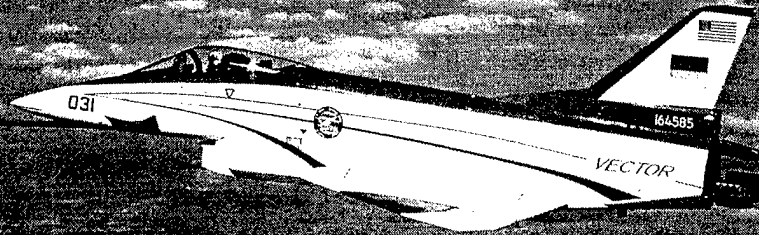
Human Factors Considerations in the X-31 Aircraft

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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



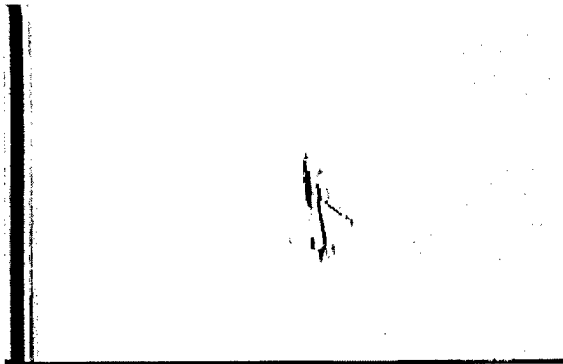
Integration of components from several aircraft

Manoeuvres

Manoeuvres available

Manoeuvres available

1995 Paris Air Show Video

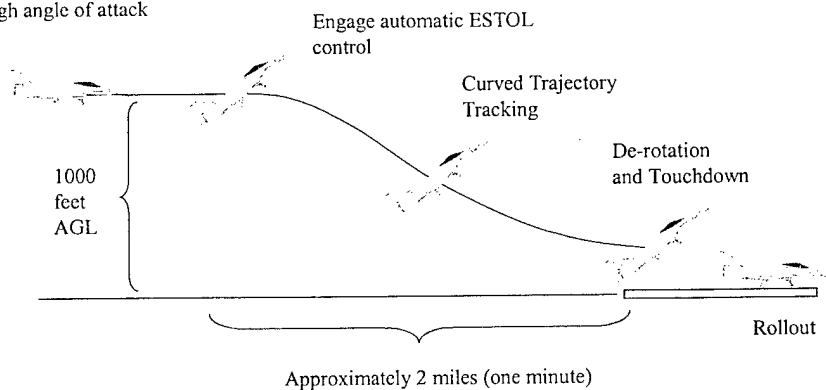


ESTOL Maneuver

- **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

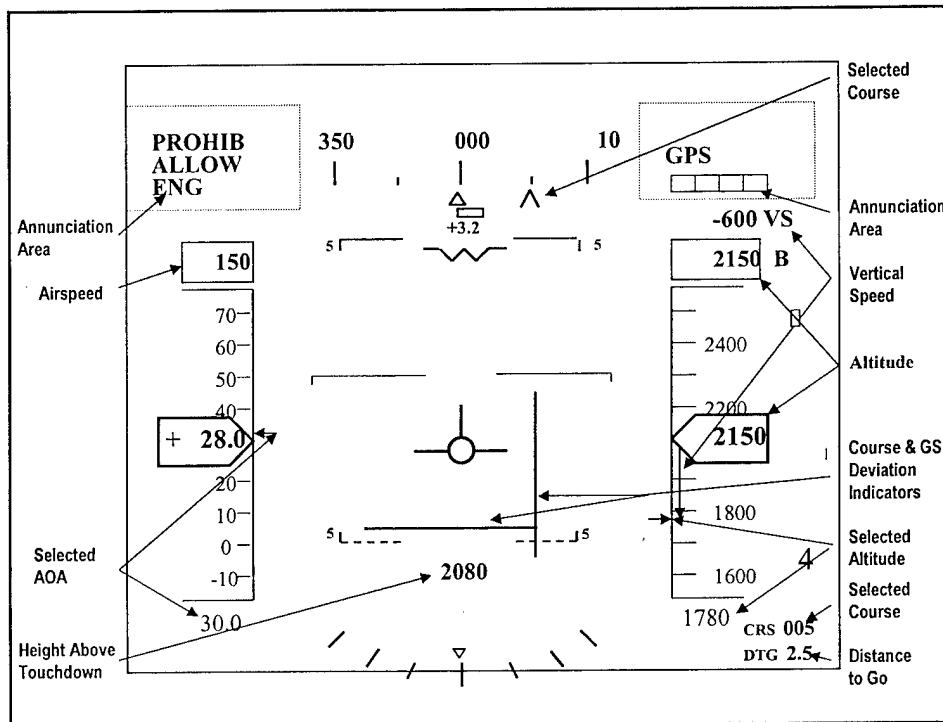
- Display symbology
- Video
- **HOTAS and other pilot controls**
- **Ejection seat**
- **O² regulator**
- **Communications ear plug (CEP)**

Symbology

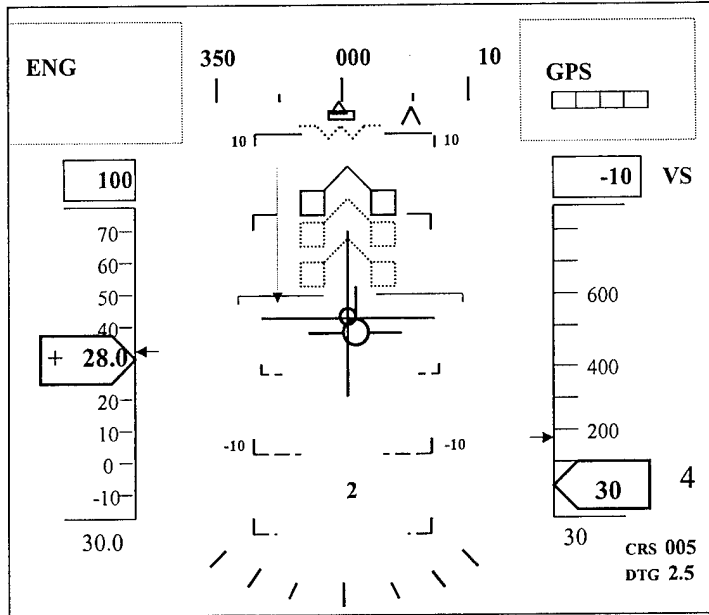
- **Modified to meet ESTOL flight profile**
 - ESTOL-specific symbology
 - Declutter during standard operations
 - Centralized scan of display
- **Primary flight display during approach**
 - HUD vs DDI
 - Opto-Kinetic Cervical Reflex
 - Difficult to assess in simulator
 - Display symbology in both displays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

ESTOL-Specific Symbolology

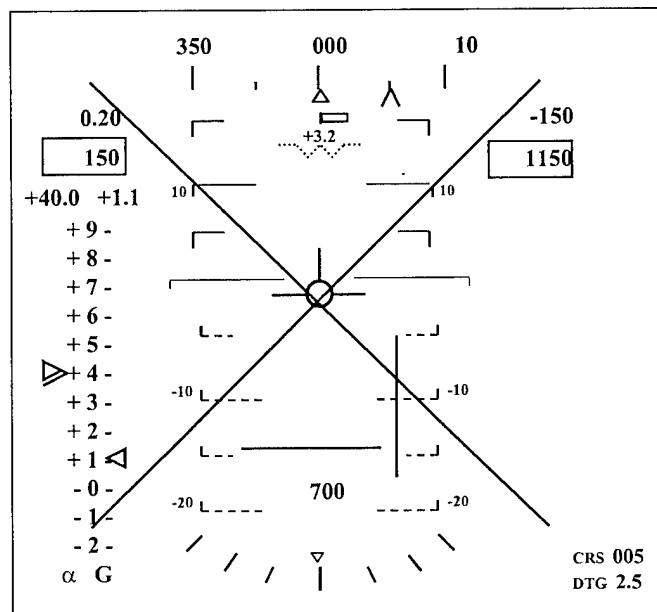
- Annunciator boxes
- Selected heading
- Commanded AOA pointer
- Commanded altitude pointer
- Needles
- Height above touchdown (HAT)
- Selected course
- Selected course
- Distance to go (DTG)
- Acceleration caret
- Derotation cue
- Wave-off X



Derotation Cue



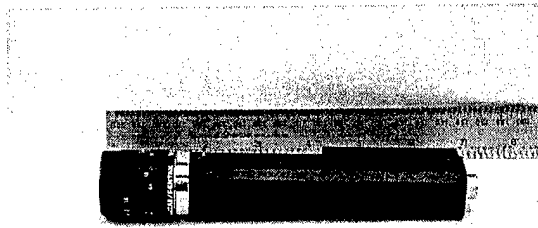
Go Around



Video

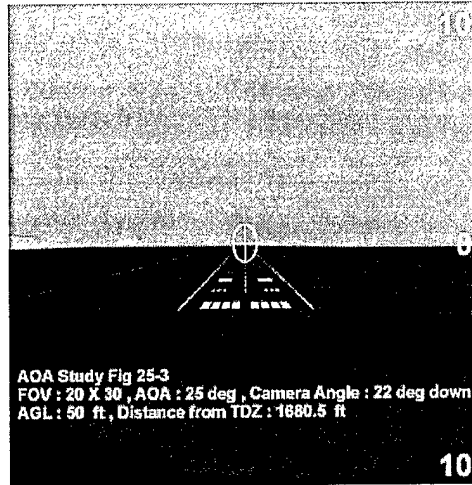
- **Provides indirect view of runway during approach**
 - Runway FOD
 - Gross alignment
 - No symbology overlay of touchdown point
- **Camera mounted internally in lower aspect of nose**
 - High alpha view of runway
 - No obstructions from nose gear
- **Display located on instrument panel behind stick**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

Camera

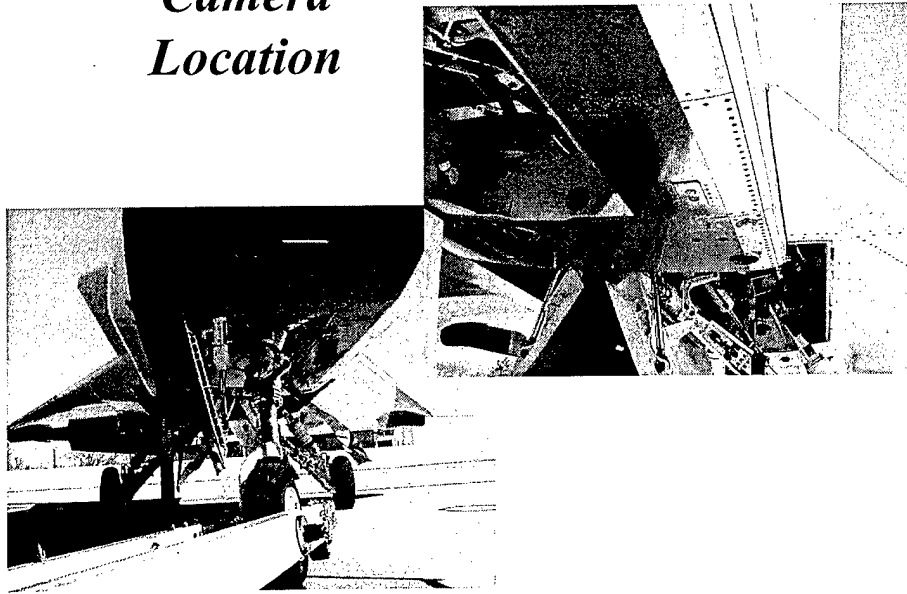


- **Ground tests to evaluate FOV of various lens**
- **Use of simulations to determine mounting angles**
- **Mounting location to provide clear view**
- **Flight tests to verify design concepts**

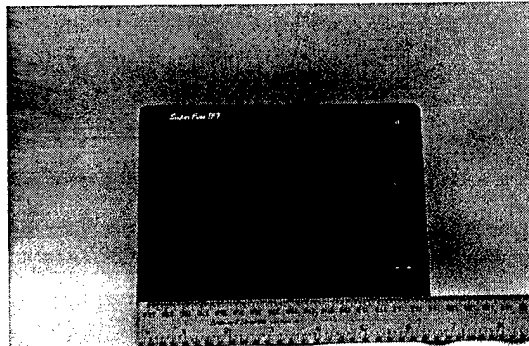
Simulated Video Image



Camera Location

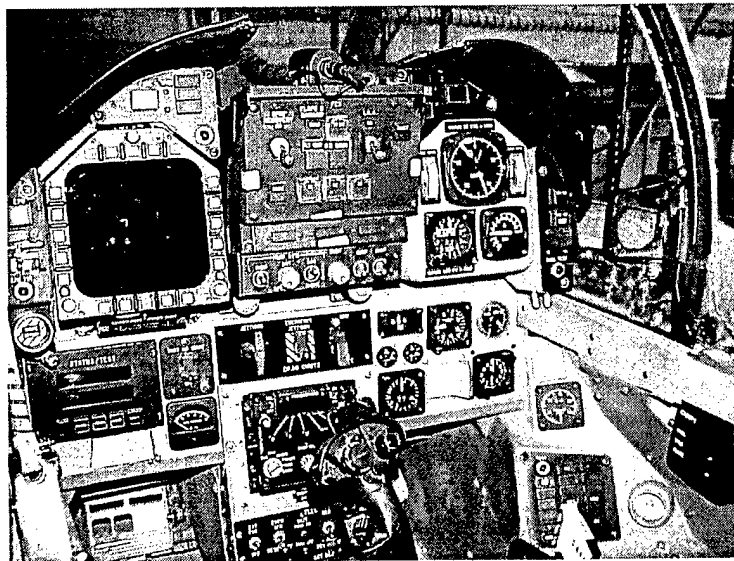


Display



- 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.