Improved Situational Awareness Produced by the Space Shuttle Cockpit Avionics Upgrade

April 16, 2004

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GENERAL DYNAMICS
Decision Systems

BOEING

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CAU Operational Objective

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COCKPIT AVIONICS UPGRADE

To increase situational awareness and reduce cockpit workload resulting in the execution of more accurate and timely decisions

note: crew error reportedly responsible for the majority of civil and military aeronautical accidents

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Background

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The Shuttle has complex flight regimes:

- Launch rocket for approximately 9 minutes
- Orbital spacecraft for 10-14 days
- Hypersonic plane for an hour
- Subsonic glider about 5 minutes

Large operational flight envelope is further complicated by an extremely large set of monitoring tasks and procedures over 10 major subsystems

- Propulsion, Guidance & Navigation, Flight Control, Hydraulics
- Power, Thermal, Environmental
- Data Processing, Communications
- Payloads

NASA chooses the "Best of the Best" for its astronauts

- Experienced test pilots with thousands of hours in 40+ aircraft

Minimum time required to train a shuttle pilot is 2-3 years!

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Improved Situational Awareness

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- Situational Awareness (SA) is an understanding of the state of the environment
  - It provides the PRIMARY basis for subsequent decision making and performance in the operation of complex, dynamic systems
- What detracts from situational awareness?
  - Too much data
  - Too little time
  - Lack of information
  - High workload
  - Malfunctions
  - Environmental distractions (noise, vibration, visibility, etc.)
- What are the consequences when these come together?

Errors can be, and are, made

- Display navigation/command inputs
- Problem diagnosis and resolution

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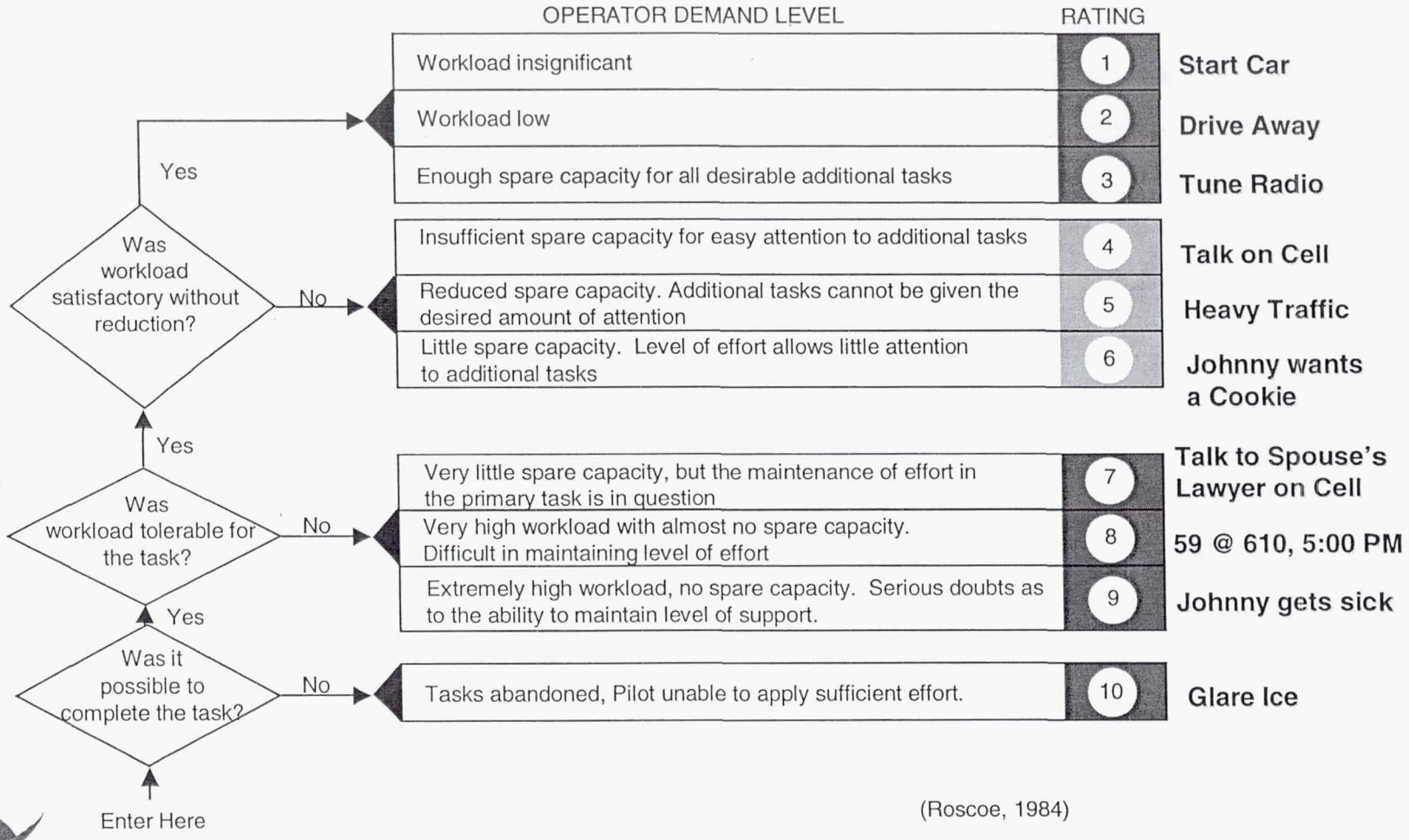
Bedford Workload Scale



(Roscoe, 1984)

Shuttle Cockpit is a Complex Work Environment

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- 100+ time/safety critical dynamic flight procedures
  - Aborts to KSC, East Coast, Spain, Africa, Orbit
- ~1000 on orbit procedures
  - Systems, Payloads, Mission Objectives
- On orbit in-flight maintenance procedures designed in real-time
  - Problem diagnosis and repair
- Signature Recognition required for almost every procedure
  - Obscure problems are recognized by specific 'Christmas Tree' warning light patterns
- Rote memorization required in display navigation and problem diagnosis
  - Backed up by hundreds of pages of printed manuals

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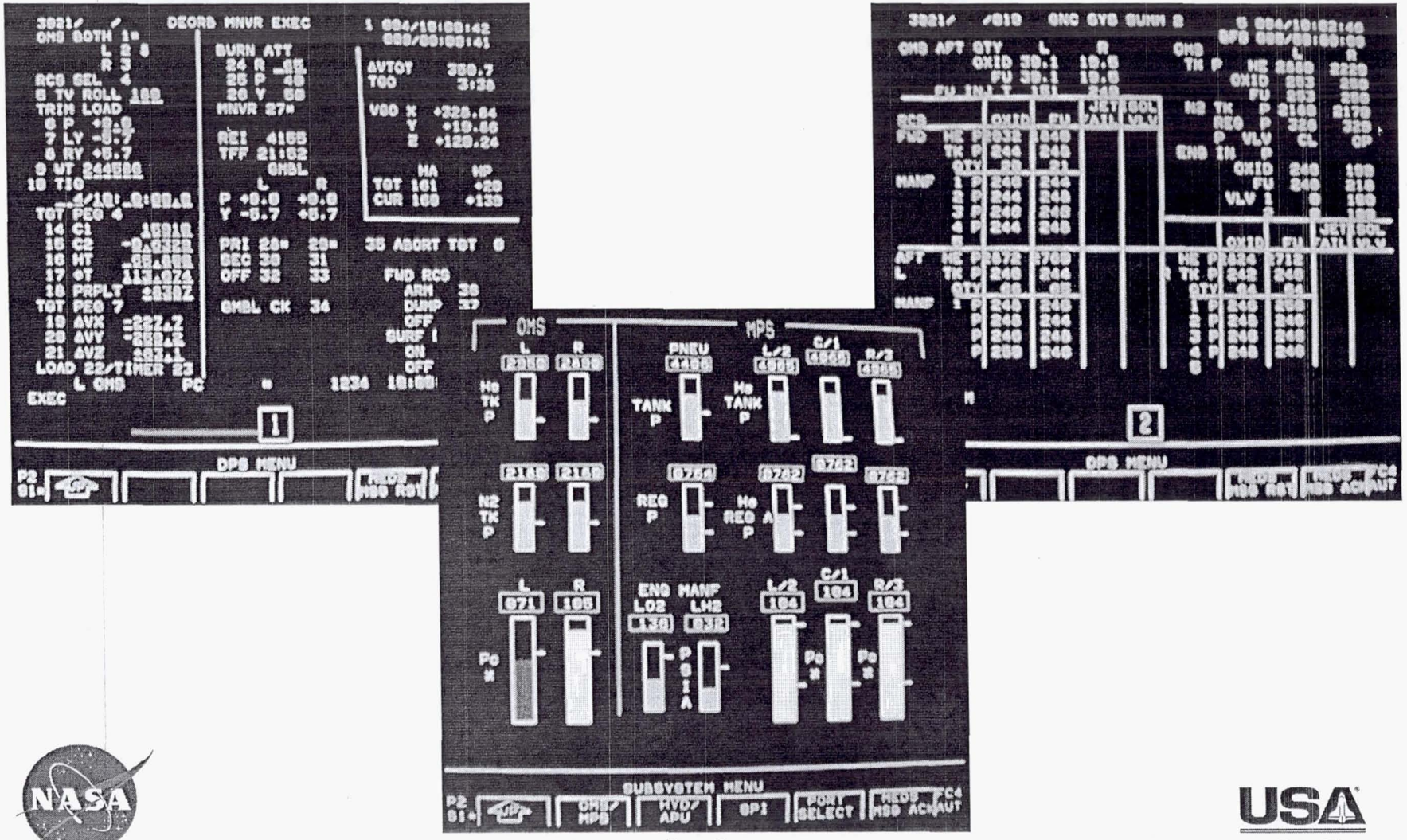
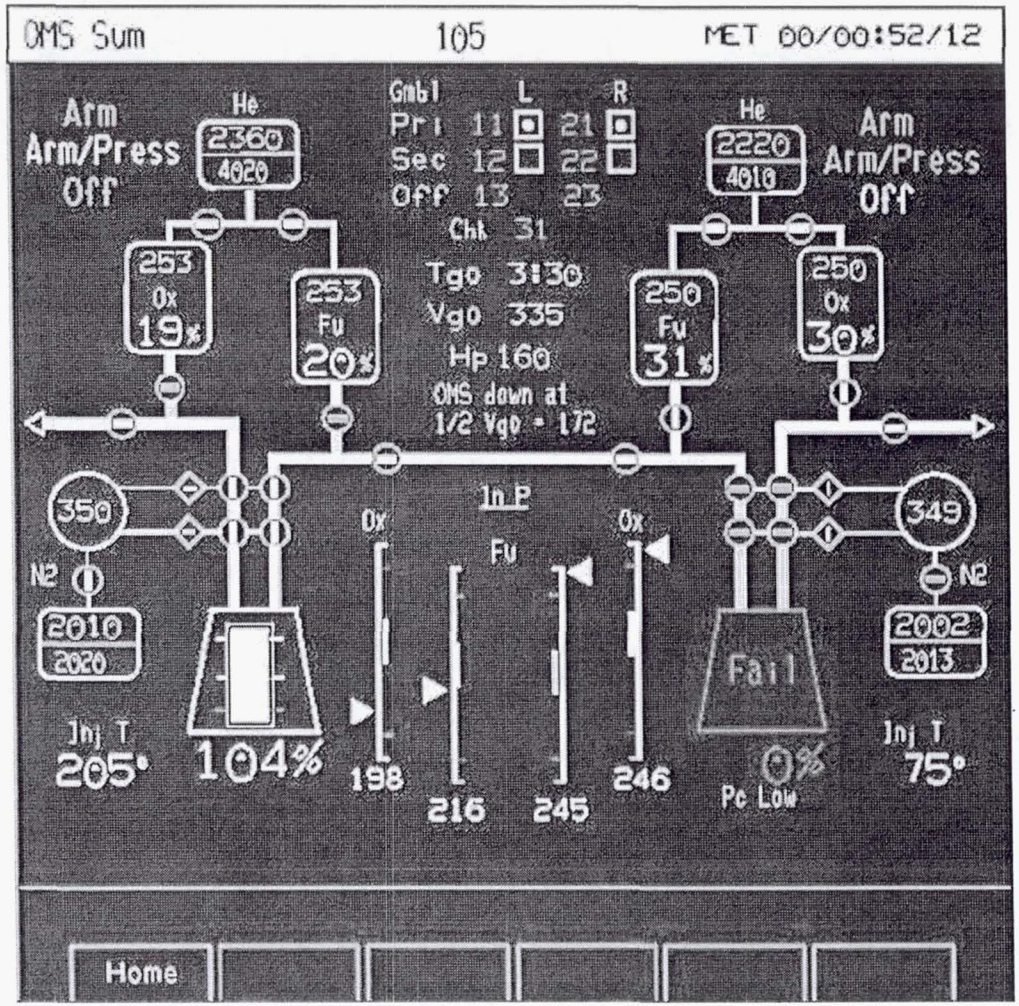
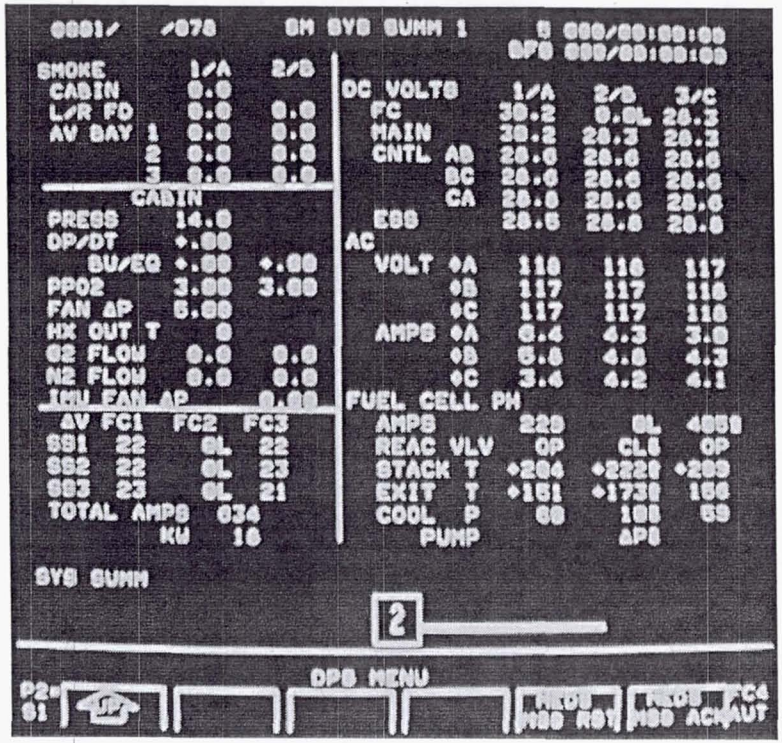
Legacy Displays to support OMS Burn Task

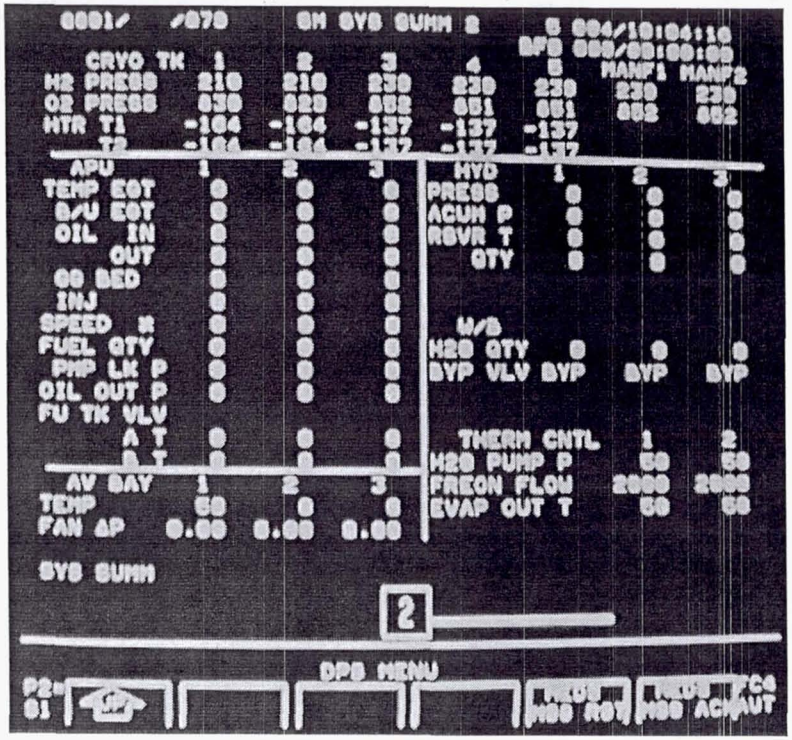


CAU Display to support OMS Burn Task

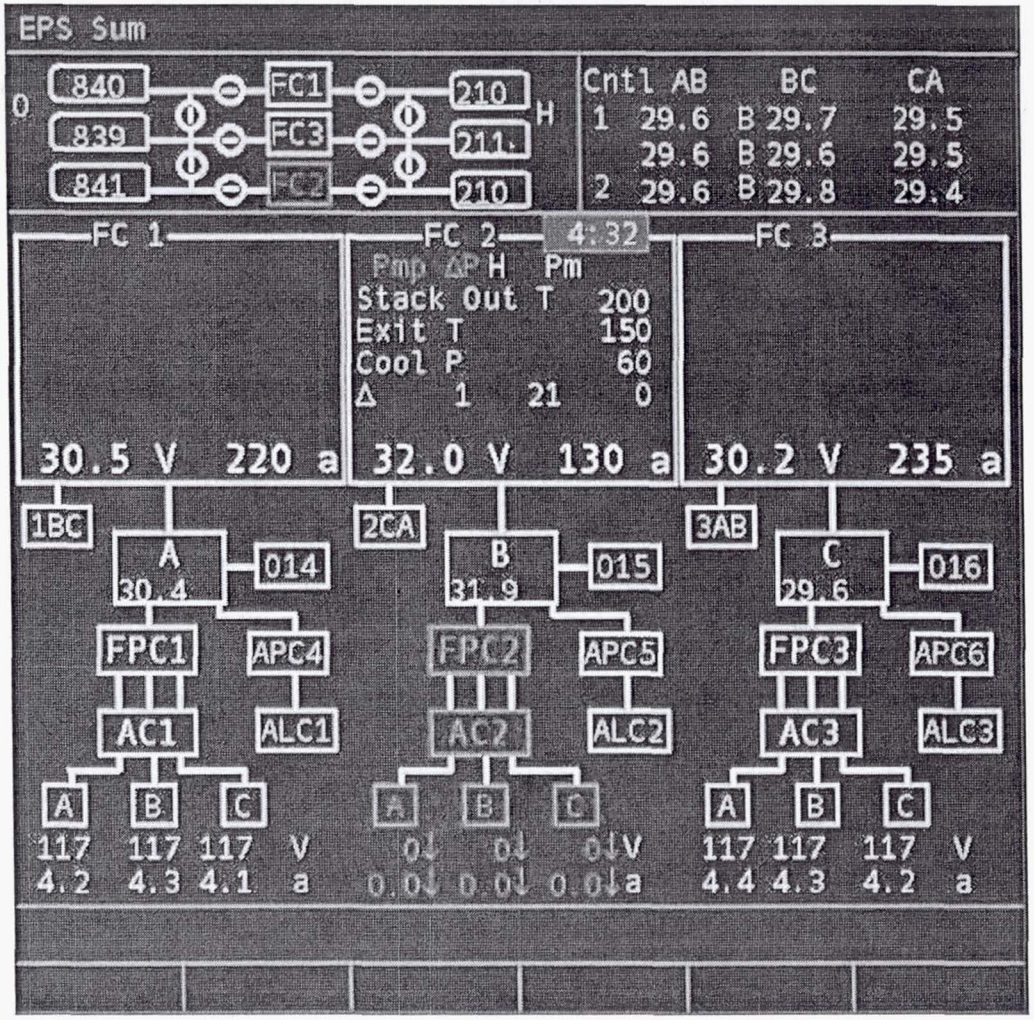


Legacy Electrical Monitoring Displays

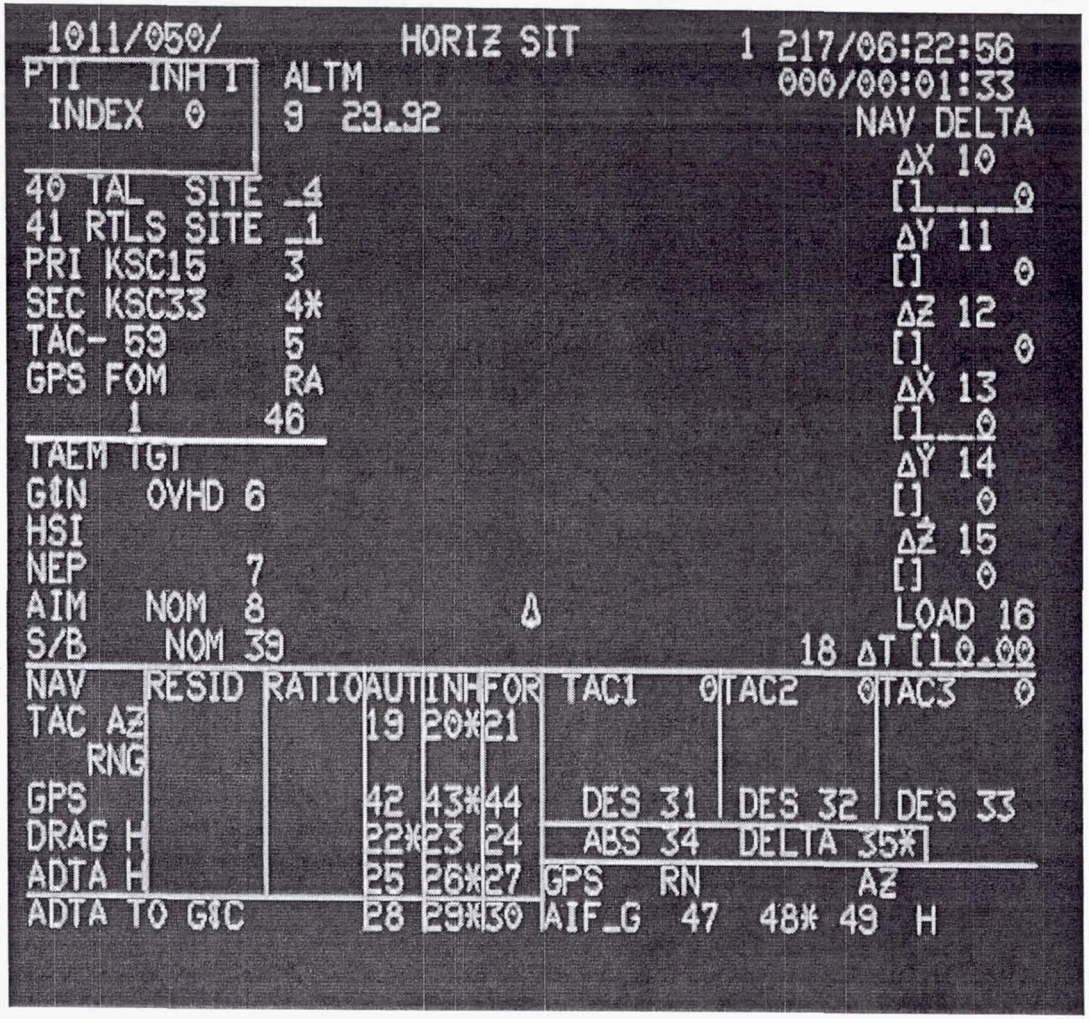




CAU Electrical System Summary Display



Legacy Ascent Horizontal Situation Display



CAU Ascent Horizontal Situation

with Shuttle Abort Flight Management Application

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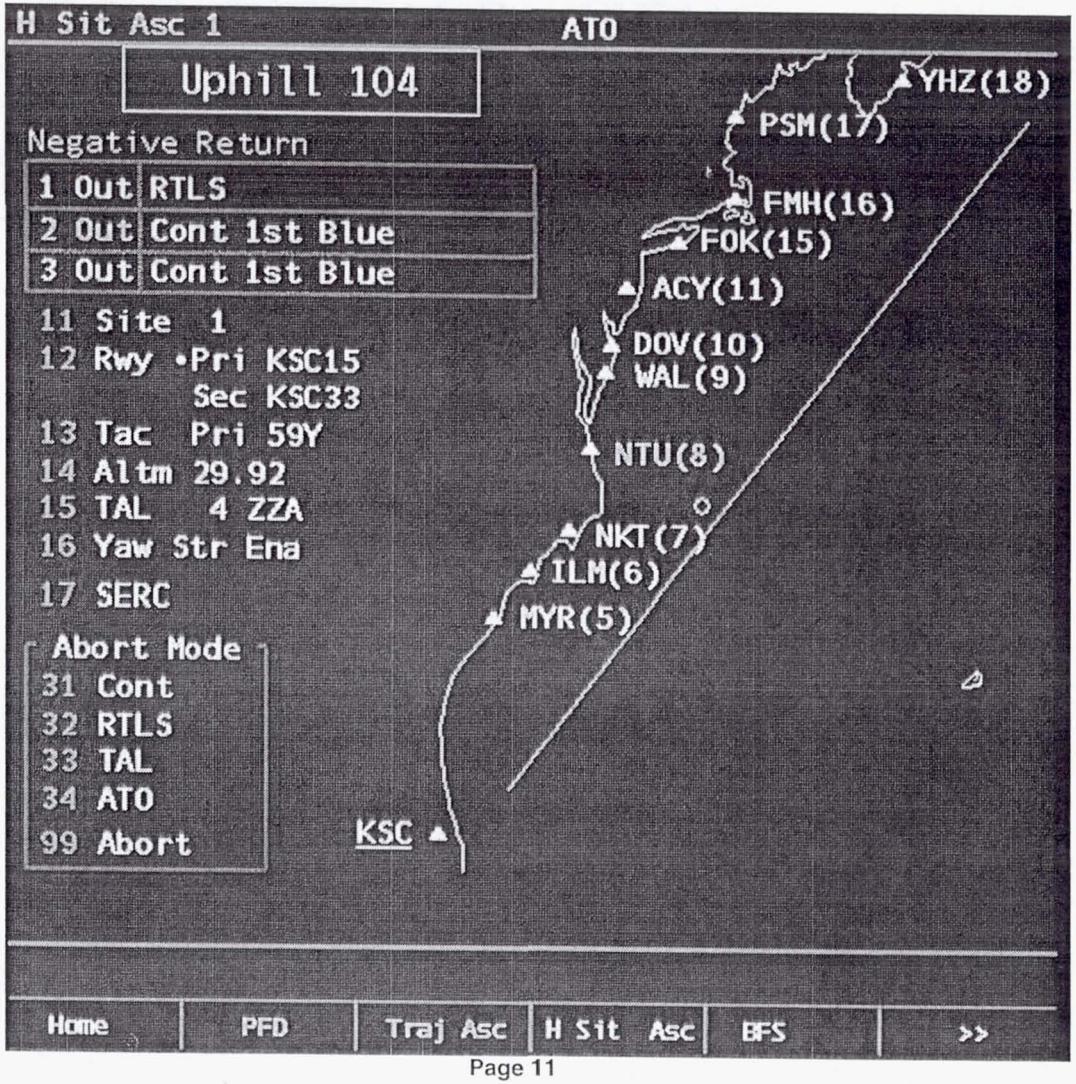

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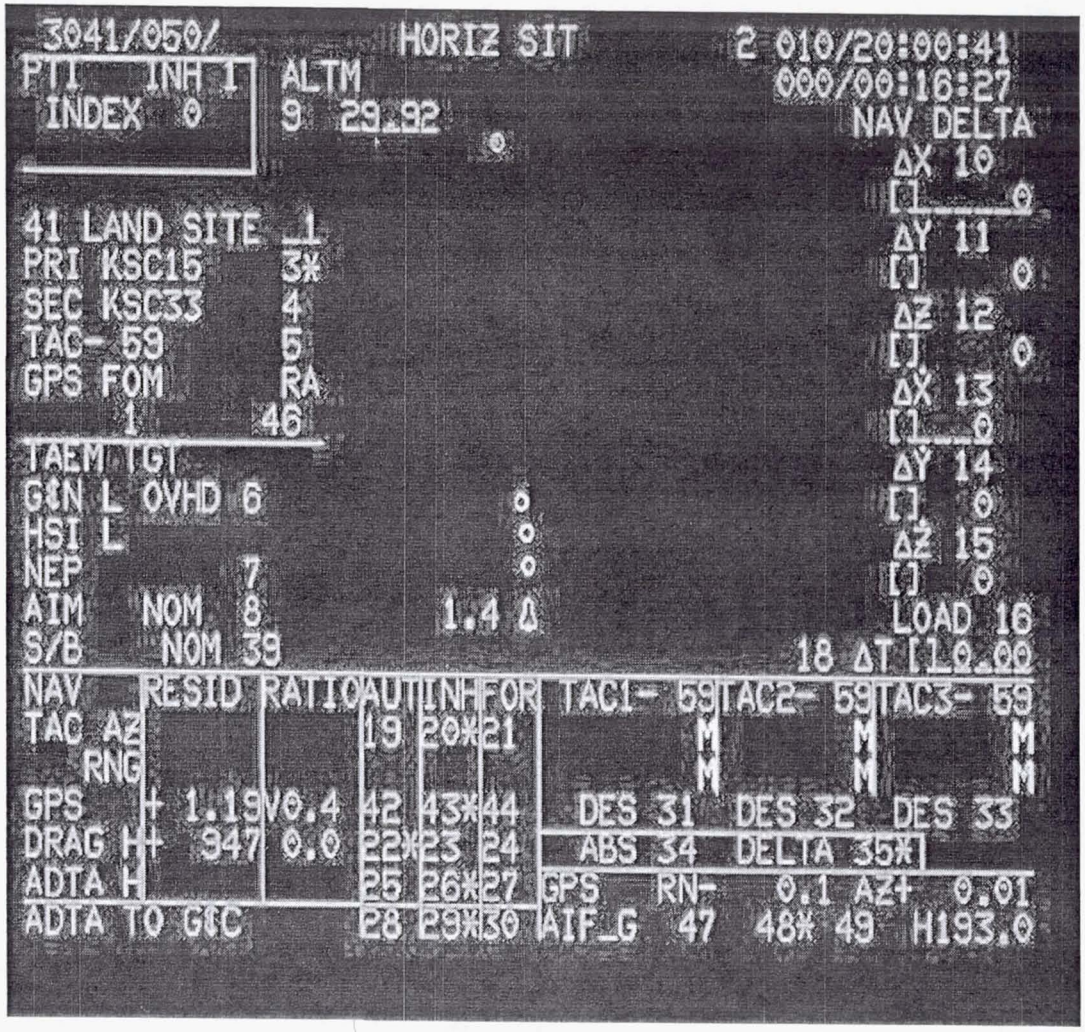
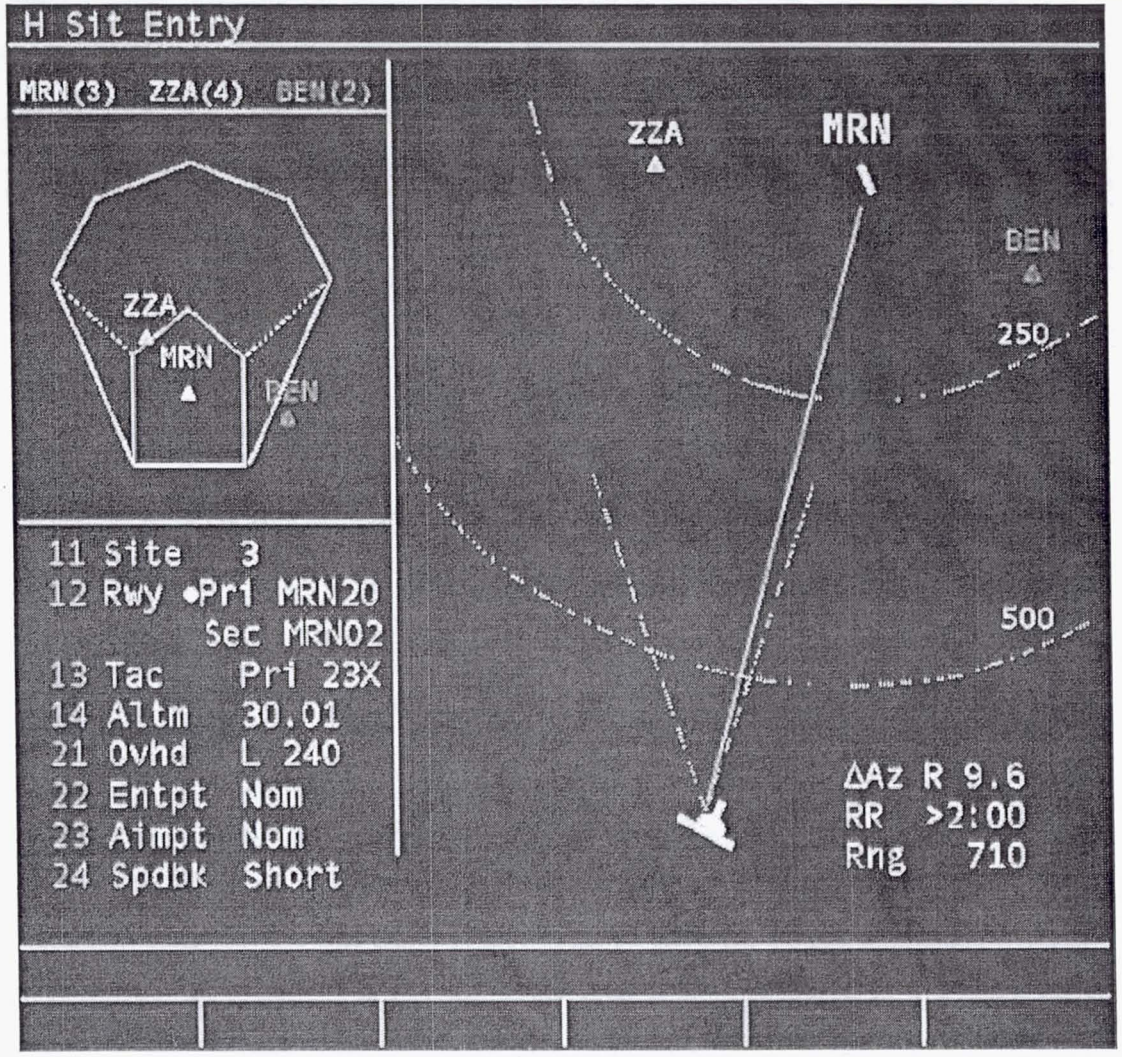
Legacy Entry Horizontal Situation Display



CAU Entry Horizontal Situation Display



The CAU Safety Payback

Decisions and actions are more timely and accurate

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COCKPIT AVIONICS UPGRADE

- Improved crew interface for display navigation and vehicle command and control
  - Execute commands from any display via the existing keyboards
  - Consolidate information from / commanding to multiple sources on single display
  - Fewer keystrokes, less rote memorization, and better encoding of display parameters
  - New mobile scratchpad and improved keyboard
  - Generate multi-color graphics and logical information & command groupings on any display format

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