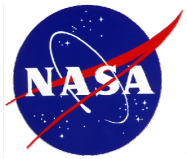
Abstract:

The Glenn Research Center is investigating and developing technologies for communications, avionics, and information systems that will significantly enhance extra vehicular activity capabilities to support the Vision for Space Exploration. Several of the ongoing research and development efforts are described within this presentation including system requirements formulation, technology development efforts, trade studies, and operational concept demonstrations.



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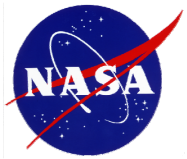
EVA Communications Avionics and Informatics

Presented at the Exploration EVA Conference
Houston, Texas
November 14, 2005

David Carek, P.E.
NASA Glenn Research Center



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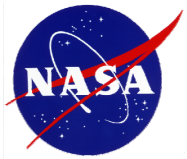
Overview

- Scope of CAI subsystems
- GRC CAI organizational structure
- Current Activities
  - Systems Requirements Formulation
  - Technology Development
  - Trade Studies
  - Ops Concept Evaluation/Demonstration



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CAI Scope

- **Communications**
  - Radio and navigation system and interface with vehicles/relays
  - Voice/audio system for suited crew
  - Interoperable data networking and interface with surface assets/relays
  - Integrated voice, video, and crew/suit health data
- **Avionics**
  - Displays to support text, graphics, and video
  - Biomed system and sensors to monitor crew health
  - PLSS sensor systems to monitor suit health and met-rate
  - Electronics and control systems to interface with various subsystems
  - On suit Informatics processor
- **Informatics**
  - Crew interface (user interface displays, voice activated control)
  - Crew and suit health data monitoring
  - Caution & warning system
  - Software systems to increase productivity and enhance autonomous operations (e.g. voice recognition, procedure check off, suit checkout, navigation, diagnostics, etc.)

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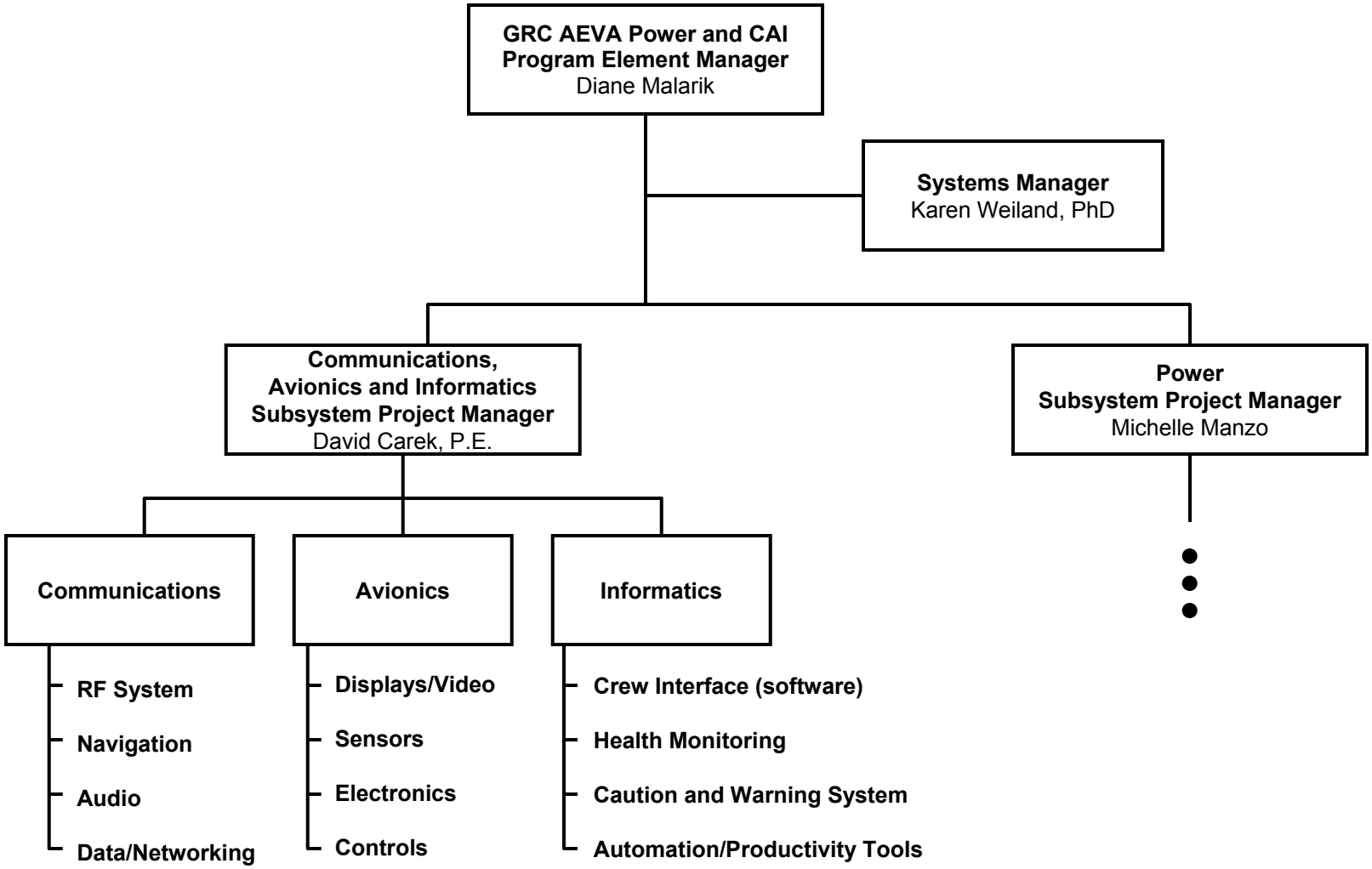
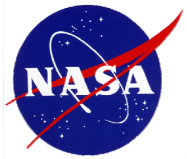
GRC A/EVA Org Chart





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CAI Requirements Formulation

- Prioritize CAI Scope based on ESAS guidance
  - First priority – Stage 1 CEV to ISS by 2012
  - Lunar Surface Suit 2017
- CAI Systems Requirements Formulation
  - Define scope boundaries
  - Collect stakeholder visions and lessons learned
  - Evaluate historical data and designs
  - Generate concept of operations based on ESMD parent needs
  - Identify external subsystem interfaces
  - Develop system requirements
  - Generate/evaluate concepts
  - Perform trade studies
  - Identify technology gaps
- Current Assumptions for CAI
  - Stage1 – In-space contingency only suit
    - Minimal/no technology development
    - Main CAI systems include audio, biomed, C&WS, suit sensors, and vehicle interfaces
  - Stage 2 - Surface Suit – new enabling capabilities
    - Integrated voice, video and data; suit display; sensors to increase autonomous operation
    - voice operated control, productivity software aids, etc.

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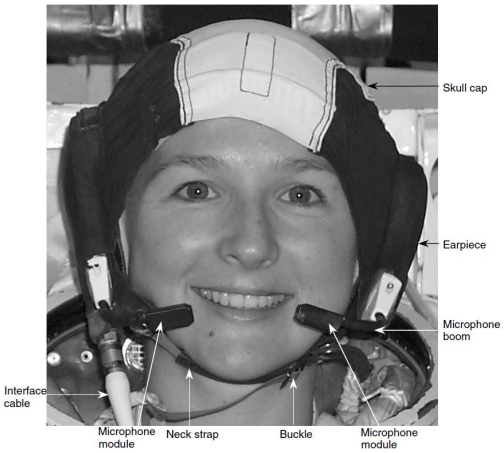
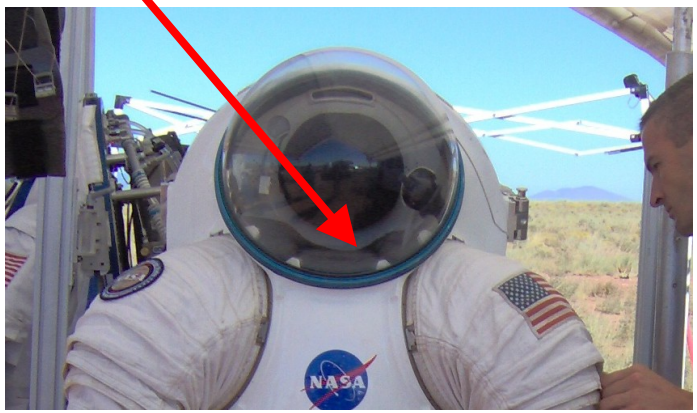
Voice Communications

ACES com cap*

EMU com cap**



Concept suit mounted microphone elements



* Photo from “Crew Escape Systems 21002,” SFOC-FL0236

** Photo from “Extravehicular Mobility Unit Systems Training Workbook,” JSC-19450

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Audio Demonstration and Evaluation Laboratory

- Capability to instrument different spacesuits for characterizing acoustic environment and evaluating voice/audio performance
- Acoustic Head and Torso Simulator
  - Enables unmanned testing within low pressure chamber
  - Characterization of sound levels in ear canal
- Multi-channel, instrumentation-grade transducers for in suit acoustic measurements
- Enables characterization of acoustical environment temporally and spatially
- Enables development and testing of advanced signal processing algorithms for suit audio

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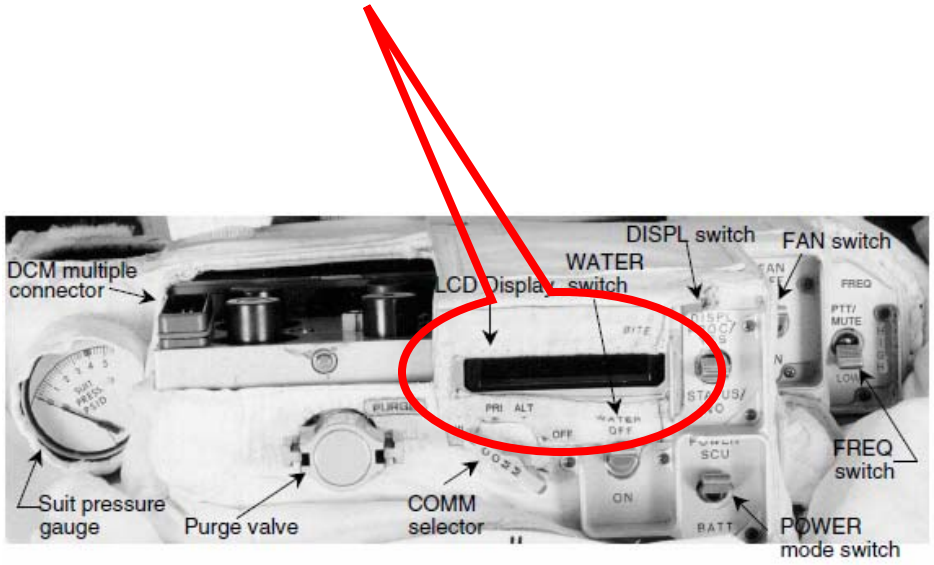
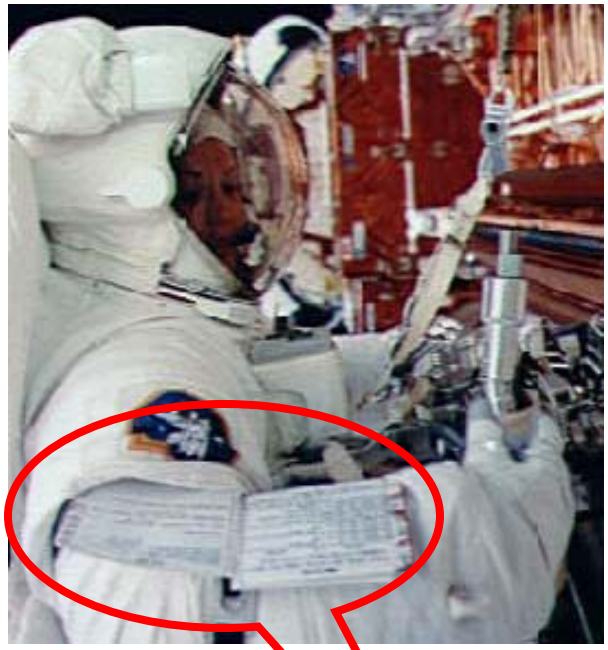
Current EVA Displays

12-character alphanumeric Liquid Crystal Display (LCD)





EVA Cuff Checklist

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Display Concepts

Electronic Cuff Display*

Internal Eyepiece Display

Heads Up Display

* Photo Courtesy of NASA JSC EVADA Project

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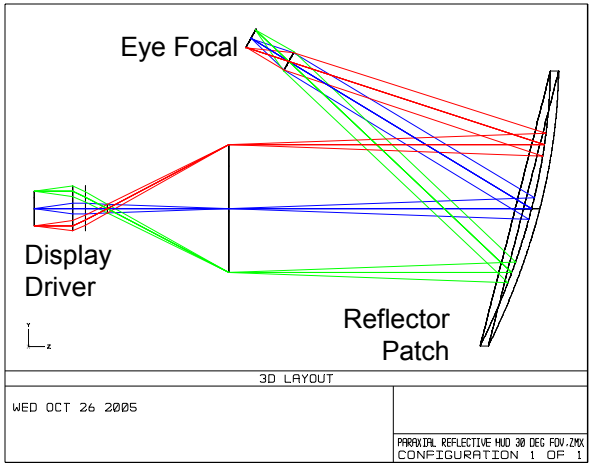
Helmet Mounted Displays

Technology Development Activities

- Concept development and analysis
- Display driver and optics bread boarding
- Engineering prototyping

Monocular Occluded Concept



Technology Challenges

- Long eye relief
- Space constraints
- Low power
- High resolution
- Large field of view
- Display uncoupled from head
- Option for see-thru capability
- Flammability

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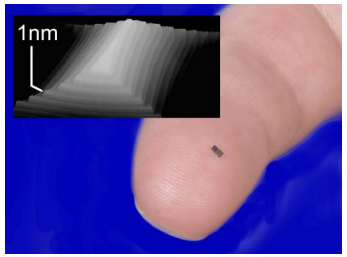
AEVA Sensor Development

- Leverage GRC silicon carbide (SiC) technology and sensor development to provide
  - Enhanced semiconductor radiation tolerance
  - Higher temperature operation
  - Higher reliability
  - Increased sensitivity and detection

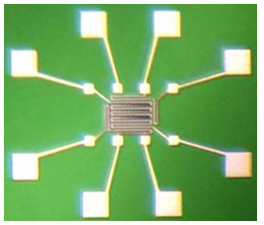
Investigating SiC for Solid-State Personal Dosimetry



2004 R&D 100 Award
SiC Growth Technology for Nanoscale Measurement Standards, NASA GRC

- Leverage GRC sensor technologies for EVA crew health and suit health sensing applications
  - Internal suit CO_2, O_2, temperature, and pressure
  - Internal/external dust conditions, or toxic gas conditions

Leverage world leading development in fire microsensor technology to provide dust and chemical species monitoring for suit applications.



2005 R&D 100 Award: Fire Detection Technologies Microscale Particle Classifier, NASA GRC

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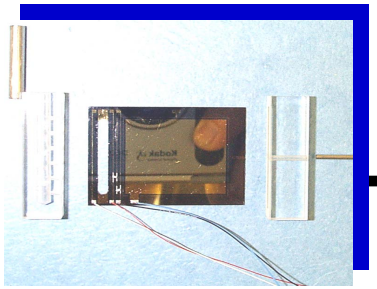
AEVA Sensor Development

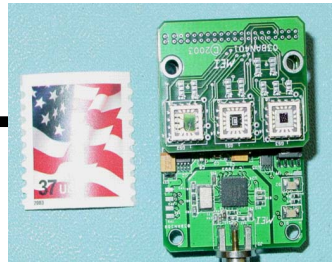
Develop sensor technologies to enable “Smart Suit” monitoring, control, and warning capabilities for both internal and external suit parameters

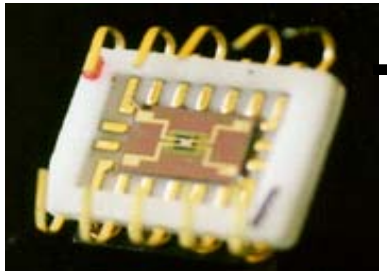
Concept suit sensor examples

Micro Particulate Classifier

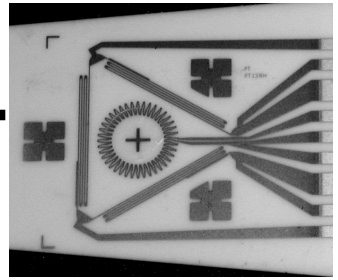


Self Contained wireless MicroSensor System

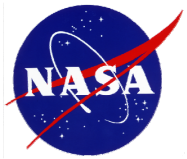




Micro Chemical Sensor



Multifunctional Physical Sensor



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CAI Trade Studies

- Sensor/Communications Architecture Study
  - Determine most advantageous configuration for interfacing and networking various EVA suit sensors
  - Evaluate wired and wireless power and data configurations
  - Consider criticality level of sensor

- AEVA Processor Trade Study
  - Characterize the space-radiation environment for various scenarios
  - Analyze commercially available CPUs for rad-hard environments
  - Examine current and projected technologies for rad-hard/tolerant processors
  - Identify prospective technologies for on-suit CAI processor

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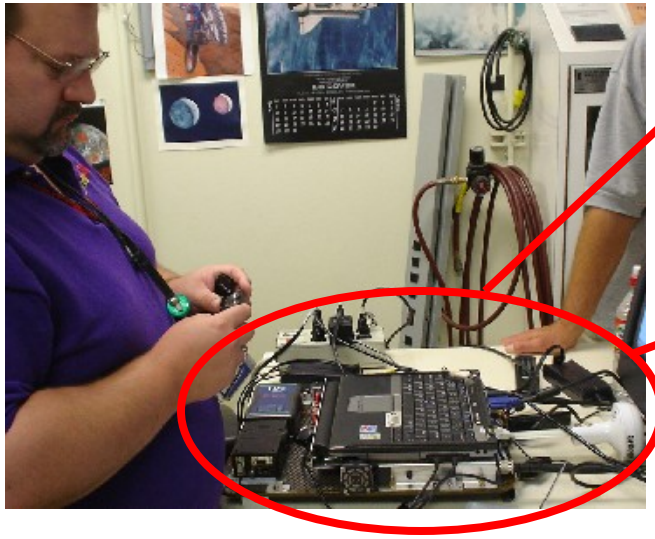
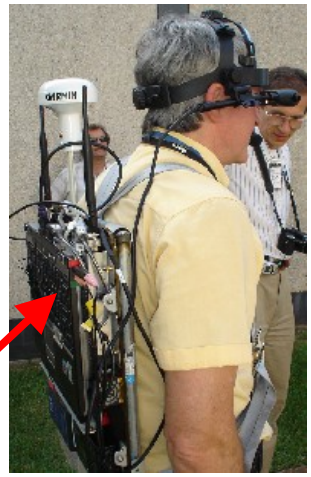
Ops Concept Demo/Eval

2005 Dessert RATS Support

- Utilize operational analogs to evaluate/demonstrate potential EVA technologies
- Develop inexpensive commercial hardware (NOT flight) to evaluate operational concepts



CAI Pack



Demonstrate integrated communications, voice, display, and information systems (shown demonstrating advanced ARC informatics software)

Evaluate in field outings (Dessert RATS 2005)

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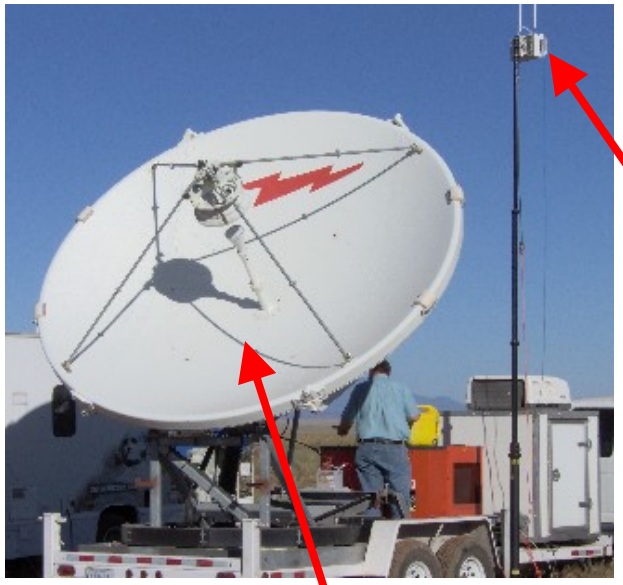
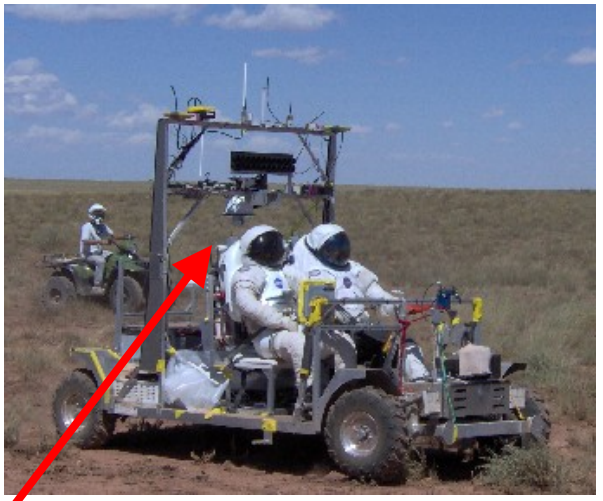
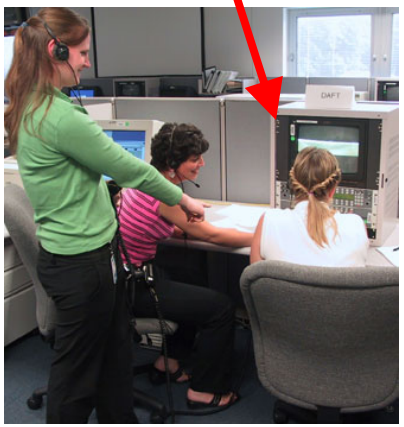
Ops Concept Demo/Eval

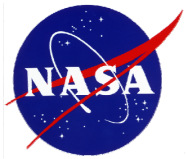
2005 Dessert RATS Support



Integrated voice and data networking operational concepts







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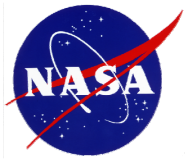
CAI Technology Challenges

- Rad-Hard communications system that supports integrated voice video and data streams that can operate within the limitations of power, frequency, bandwidth, and radiation patterns
- High speed avionics data bus to allow data aggregation (voice, video, data)
- Integrated communications/navigation capability
- Comfort base audio systems that work over a range of operating environments
- Display technology
  - Internal helmet display that meets flammability requirements for 4.3 psia O_2 suit
  - External display that can survive thermal environment
- Low power/mass radiation tolerant computing for enhanced informatics capabilities (e.g. voice recognition, navigation aids, procedure readers)
- Low power, high reliability miniaturized sensor systems
  - Accurate metabolic rate sensor system
  - High reliability CO_2 sensor
- Computationally efficient voice recognition software system
- …



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Concluding Remarks

Many new and varying CAI desires and visions - however - new functionality must be balanced against cost, schedule, and system complexity

"Design strategy should be marked by *simplicity* and also *reliability*. The design should address only reasonably anticipated task requirements and should try to neither include capabilities that are not needed nor events that are unlikely to occur"*

- To be affordable - future NASA technology development needs to flow from solid mission requirements
- Concept evaluations will help rank and determine future investment areas

* Quotation from "Interviews with the Apollo Lunar Surface Astronauts in Support of Planning for EVA Systems Design," NASA TM 108846