An Overview of the Human Systems Integration Division

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Human Systems Integration Division
NASA Ames Research Center
Moffett Field, CA
Overview:
Human Systems Integration Division

Dr. Alonso Vera!
Division Chief!

March 5, 2015
Integrated Information Systems for the International Space Station!
Planning and Scheduling Tools
Mobile Applications for Operations and Systems Engineering!
Vibration Impact on Human Performance!
Vision Science and Visual Technologies!

Image Compression, Frame Rates and TBI Assessment

Image compression

Original
Compressed 100x

Target Identification

Aircraft/UAV Detection
Airspace Operations Laboratory!
Human Systems Integration for UAS and Single Pilot Operations (or “Reduced Crew Operations”)!
Aviation Safety Reporting System (ASRS)

- Processes voluntarily submitted incident reports from pilots, controllers, flight attendants and others.
- Reports may describe unsafe and hazardous situations.
- Receiving about 10,000 reports per month.
- Established in 1976.
Google SDC Collaboration!
Just-in-Time Crew Training for Long Duration Space Missions!
Modeling and simulation are critical to comprehensively study complex human-system designs.

Many different types of models exist at NASA:
- Human behavioral
- Human performance
- Anthropometric, biomechanic, volumetric
- Information processing
- Vision, auditory, memory, and other human processes
- Task network
- Physical structural (space launch vehicle, aircraft, crewstations, CAD/CAEs)
- Airspace system
- Weather
- Airflow and other CFD
- Physiological
- Robotics and automation
- Oxygen and blood flow
- Scheduling
NASA Ames Human Modeling in System Design

- System and Environment Design
  - "Airspace
  - "Aircraft Trajectories
  - "Illumination
  - "Gravitational forces

- Physical Equipment Design
  - "Crewstation
  - "Flight deck layout
  - "Loads
  - "Manual handling
  - "Fluids and heat transfer models

- Operations Design, Evaluation, and Integration
  - "Procedures
  - "Training
  - "Roles & responsibilities
  - "Scheduling

- Technology Design, Evaluation, and Integration
  - "Displays
  - "Automation
  - "Information Requirements

- ADEPT: Human-Automation Interaction
- JACK: Anthropometric model
- MIDAS-FAST (& BORIS): Robotics Trainer
- Volumetric CFD
- ACES: National Airspace System
- FACET: Air traffic management
- BRAHMS: Agent-based models
- MIDAS: Behavior models
- Cognitive process models: Decisions / response to information
- SPIFe/SCORE: Scheduling and Planning models
- ADEPT: Human-Automation Interaction
- HOP: Human Vision
- Basic Process Models: Audition (e.g. threshold models), MIDAS: Memory & cognitive processing
### NASA Ames HSI Research Areas

*http://humansystems.arc.nasa.gov/techareas/tech_areas.php*

<table>
<thead>
<tr>
<th>Technical Area</th>
<th>Laboratory</th>
<th>Research Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Human Machine Interaction (HCI)</td>
<td>HCI</td>
<td>Contribute to the development of better NASA software through careful application of iterative user research, interaction design, and usability (Curiosity - MSLICE)</td>
</tr>
<tr>
<td>Human Automation Interaction</td>
<td>ADEPT</td>
<td>ADEPT provides a tool for prototyping automation and associated interfaces, in an integrated tool that includes analyses to identify potential HAI vulnerabilities early in the design process.</td>
</tr>
<tr>
<td>Scheduling and Planning</td>
<td>Scheduling and Planning Interface for Exploration (SPIFe) toolkit for space missions that includes human constraints on mission operations.</td>
<td></td>
</tr>
<tr>
<td>Human Performance Research</td>
<td>Advanced Controls and Displays</td>
<td>Research on haptics, speech recognition, visual perception, visual perception in space, adaptation to virtual environments, and acoustics.</td>
</tr>
<tr>
<td>Human Vibration Laboratory</td>
<td>Human Vibration Laboratory</td>
<td>Assesses whole-body vibration impacts on visual, cognitive, and manual performance, understand the mechanisms contributing to vibration-induced performance deficits, and develop countermeasures to mitigate these deficits.</td>
</tr>
<tr>
<td>Flight Cognition Lab</td>
<td>Flight Cognition Lab</td>
<td>Studies the cognitive, team and organizational processes that underlie the performance of pilots, air traffic controllers, and other skilled professionals.</td>
</tr>
<tr>
<td>Psychophysiological Lab</td>
<td>Psychophysiological Lab</td>
<td>Studies altered gravitational effects on human autonomic and central nervous system function to maximize the health, productivity and safety of humans in space.</td>
</tr>
<tr>
<td>Intelligent Systems</td>
<td>Intelligent Systems</td>
<td>Enhance mission safety and crew efficiency in next-generation spacecraft by evaluating the operational impacts of environmental stressors and by developing and testing advanced operations concepts and crew-vehicle interfaces.</td>
</tr>
<tr>
<td>Man-machine Integration Design and Analysis System (MIDAS)</td>
<td>Man-machine Integration Design and Analysis System (MIDAS)</td>
<td>Develop human performance models of human-system interaction to predict operator performance along the measures of task performance and times, visual attention, workload, situation awareness.</td>
</tr>
<tr>
<td>Integration and Training</td>
<td>Integration and Training</td>
<td>Researches roles, responsibilities, and requirements for human operators and automation in future air traffic management (ATM) systems using human in the loop.</td>
</tr>
<tr>
<td>Airspace Operations Laboratory (AOL)</td>
<td>Airspace Operations Laboratory (AOL)</td>
<td>Focuses on mission safety and efficiency by developing innovative display technologies using both HITL and HPM methodologies.</td>
</tr>
<tr>
<td>Flight deck display research</td>
<td>Flight deck display research</td>
<td>Works to increase the capabilities of the flightdeck crew by expanding their roles and responsibilities.</td>
</tr>
</tbody>
</table>
Human Performance Models

" Human Performance Models (HPMs) allow system designers the ability to model critical events that cannot be fully studied with empirical simulations.

" Models can be used to provide estimates of human-system performance when the concepts, technologies, or automation are too new, difficult, or dangerous for the human operator.

" Model validity is a paramount concern when predictions are generated to evaluate candidate NextGen operations.
Motivation:
NextGen Technology Design, Evaluation, and Integration

•" NextGen Characteristics:
  –" More data available to the flight deck
    •" e.g., weather, wake, traffic trajectory projections, etc.
  –" More precise and closely coordinated operations
    •" e.g., self-separation, closely spaced parallel operations, RNAV/RNP
  –" More tasks are automated
    •" Pilot increasingly placed in a monitoring role
  –" Potential for increased workload, decreased situation awareness, increased demand for shared attentional resources

•" Evaluating NextGen Concepts:
  –" Must consider pilots’ capabilities when designing / evaluating NextGen procedures, operations, roles / responsibilities and the information requirements
  –" Failure to do so will leave the pilots, and thus the entire aviation system, vulnerable to error
Man-machine Integration Design and Analysis System (MIDAS)

- Validated, first-principle models of human behavior including perception, visual attention, memory, & workload
- 3D CAD models of the environment, the workstation, and the equipment
- Controls a generic, anthropometrically-correct human mannequin (Jack™, 5th percentile female - 95th percentile male)
- Monte carlo simulation capability with stochastic human performance
- Distributed simulation (e.g. Microsaint Sharp)
- Generates realistic task-management behaviors sensitive to task context, environment
- Produces task timelines, workload, and situation awareness profiles and visualization which permits testing of procedure alternatives
MIDAS v5 Structures

**MIDAS Input**
- Tasks and Procedure Lists (activities and sub-activities)
- Microsaint Sharp Mission Models
- Workstation Models
- Anthropometric Models
- Environmental Models
- Dynamic Models
- Flight Profile Models
- Scenario Objects
- Operator Characteristics
- Performance Shaping Factors

**MIDAS Processes**
- Task Manager
  - Schedules
  - Actuates/Triggers
- Commands
- Results
- Physical Simulation
  - Environmental behavior
  - Crewstation behavior
  - Model state movement
  - Model state actions
  - Model state changes
- Library
  - Primitive tasks in human model
- MIDAS Operator Process Models
  - Fitts Law; Perception & Attention (SEEV)
  - Multiple Resource Model; Memory, SA
  - Workload; Operator States (fatigue, gravitational effects)
  - Timeliness

**MIDAS Output**
- Task Network
- Timeline
- Fit/Reach/Vis envelope
- Dynamic Animation
- Mission Risks
- Mission success
- Performance measures

Workload, visual attention
Objective

Develop valid HPMs of approach and land operations, use these models to evaluate candidate NextGen concepts (Closely Space Parallel Operations, CSPO), develop guidelines regarding flight deck displays and pilot roles and responsibilities.

Evaluating NextGen Closely Spaced Parallel Operations Concepts with Validated Human Performance Models

Model Development and Validation
- Develop RNAV model based on task analyses (SME input)
- Validate model inputs, processes and outputs
- Extend RNAV model to two CSPO Concepts
- Evaluate: Pilot-ATC separation responsibility, Wake Information Requirements, Spacing Management Information Requirements
- Implications based on: Pilot workload, visual attention event/alert detection response times

1. Develop and validate model (BRIMS 2010, 2011)
- RNAV scenario + 2 CSPO operational scenarios
- Validated model
  - inputs (Focus groups)
  - processes (Literature)
  - outputs (HITL data)

2. Evaluate off-nominal events (BRIMS 2010, 2011)
- Weather (high wind)
- RNP Loss
- FMS Failure
- Aircraft of runway

3. Evaluate roles and responsibilities (AHFE 2012)
- Pilot-pilot roles (Allocation of task, monitoring workload)
- Pilot-ATC roles (Conflict detection and resolution)

4. Evaluate information requirements
- Flight deck information required to support early conflict detection and safe response
- Wake format and location
- Spacing Automation style and format

MIDAS v5, a human performance model of the flight deck environment, pilots’ workflow and cognitive processes.

<table>
<thead>
<tr>
<th>CSPO 200’</th>
<th>CSPO Approach: 200’ Ceiling</th>
<th>Autoland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paired with Lead</td>
<td>Speed-Coupled</td>
<td>Parallel with Lead</td>
</tr>
<tr>
<td>IMC</td>
<td>FAF</td>
<td>DH</td>
</tr>
</tbody>
</table>

Altitude: 10,000
Phase: Descent

<table>
<thead>
<tr>
<th>Approach</th>
<th>4000</th>
<th>3000</th>
</tr>
</thead>
<tbody>
<tr>
<td>FAF</td>
<td>1800</td>
<td>1100</td>
</tr>
<tr>
<td>Land</td>
<td>800</td>
<td>650</td>
</tr>
<tr>
<td>TD</td>
<td>200</td>
<td>0</td>
</tr>
</tbody>
</table>

Descent
Approach
Land
TD

IMC
VMC
IF
FAF
DH
"Insert MIDAS TOGA movie"
**Flight Deck Requirements for:**

1. ATC-Pilot Roles and responsibilities: ATC vs Pilot responsibility for separation
2. Alert styles for wake and blunder threats: One-stage vs two-stage alerts
3. Wake display technology: Format (predicted vs real-time), Location (PFD, Nav Display, or Both)
4. Spacing management automation: Style (Current vs NextGen), Location (PFD, Nav Display, or Both)

**Evaluating ATC-Pilot Roles and Responsibility: Separation Delegation**

- Compared Current-day (ATC responsible for separation) with NextGen (Pilot responsible for separation)
- Model predicted slightly faster emergency escape maneuvers when Pilot’s are responsible (.3 sec), BUT...

Higher workload when pilots are responsible for separation

Less balanced pilot scan when pilots are responsible for separation

Hooey, Gore, Mahlstedt, & Foyle, (2012); Gore, Hooey, Mahlstedt, Foyle (in process)
CSPO Findings and Implications

**Flight Deck Requirements for:**
1. " ATC-Pilot Roles and responsibilities: ATC vs Pilot responsibility for separation
2. " Alert styles for wake and blunder threats: One-stage vs two-stage alerts
3. " Wake display technology: Format (predicted vs real-time), Location (PFD, Nav Display, or Both)
4. " Spacing management automation: Style (Current vs NextGen), Location (PFD, Nav Display, or Both)

**Flight deck requirements for spacing management automation style**
- " Compared Current-day spacing management (MCP) with NextGen Automation (e.g. Airborne Spacing for Terminal Arrival Routes (ASTAR) algorithm; Murdoch, 2009)
- " Extend Lozito et al. HITL results to assess pilot scan and response to off-nominal events

<table>
<thead>
<tr>
<th>Less time monitoring spacing with NextGen Automation</th>
<th>Faster to detect RNP-Loss (EICAS) with NextGen</th>
<th>Slower to detect Automation Failure (PFD) with NextGen</th>
</tr>
</thead>
</table>

Current-day speed-management resulted in: increased pilot scans to spacing displays, faster detection of RNP-loss alert (on EICAS)
NextGen speed-management slowed time to detect automation failure on PFD (complacency)

Hooey, Gore, Mahlstedt, & Foyle (2012)
SPO Project Overview

"Objective"

- Complete a task analysis of the Pre-TOD to TOD tasks required in candidate Operational scenarios (Single Pilot Operations; SPOs)

Develop Current Day Model

- RNAV Approach and Land

Extend to NextGen

- 2 Operational scenarios of CSPO concepts

Evaluate impact of CSPO

- Compare CSPO workload, visual fixations to RNAV

“What-if” Investigations

- Off-Nominals
- Roles, Responsibilities and Flight Deck Displays (2011)

Validate Model

Validate Model

Validate Model

Single Pilot Operations

High Buildup of Traffic

Nominal Scenario

Off Nominal Scenario

No Buildup of Traffic

Off Nominal Scenario

V&V tasks & operations
Denver Arrival Approach Plate

•" Nominal Approach plate to DIA

•" Off-Nominal (Divert Approach plate to Cheyenne)
Single Pilot Operations Task Analysis

2013
- 4 entities
  - Pilot on Board
  - Ground Operator
  - Automation
  - ATC

- 4 Scenarios
  - Current Day
    - Nominal
    - Off-Nominal
  - SPO
    - Nominal
    - Off-Nominal

2014
- 9 entities
  - Onboard Pilot
  - FD Automation
  - Ground Operator 1
  - Ground Automation 1
  - Ground Operator 2
  - Ground Automation 2
  - Ground Operator 3
  - Ground Automation 3
  - ATC

- 5 Scenarios
  - Current Day
    - Nominal
    - Off-Nominal
  - SPO High Build-up
    - Nominal
    - Off-Nominal
  - SPO No Build-up
    - Nominal
    - Off-Nominal
  - DISPATCH TASKS
Generating the 2014 Task Analysis

• "Modified a verified set of flying tasks completed
• "No FO/Limited FO
• "New dispatch tasks added (including handoffs)
• "Redistribution of tasks among 9 operators
• "All tasks must be assigned
• "Greater delegation to automation
  – "When tasks were moved to automation, new crosschecking tasks arose for the human operators
## 2014 Task Analysis Output #1

### Prior to Final Descent

|----------|------------------|------------|-------------------|-----------|-----------------------------------|-------------------|-------------------------------------|--------------------|-------------------------------------|--------------------|

### Other ROIs

- **500 nm**
  - **MNT1**: Send to ground auto
  - **MNT2**: Send to ground auto

### Ground Automation

- **MNT1**: Review Fuel levels (I)
- **MNT2**: Review Fuel levels (I)
- **MNT3**: Review Fuel levels (I)
- **MNT4**: Review Fuel levels (I)
- **MNT5**: Review Fuel levels (I)
- **MNT6**: Review Fuel levels (I)
- **MNT7**: Review Fuel levels (I)
- **MNT8**: Review Fuel levels (I)
- **MNT9**: Review Fuel levels (I)
- **MNT10**: Review Fuel levels (I)

### Continuous tasks

- **ACC**: Uplink to FMS; expected approach controller (Airspace, runway, altimeter, takeoff speed, landing gear, EELs, (seasonal)) Note.
- **Crewmiss addition info**
- **Executive extras info**
- **Lions**
- **S답**: Speak to OBP (NASAMS) "Climbing in-bonded to OOB, have a 米878 flight!" (Seasonal) (NASAMS)
- **Taps, loud addled, goodnight**
- **Before capture & threat is confirmed**
  - **Climb and route into the FMS:** "(Seasonal) (NASAMS)" (Seasonal)
  - **Approach during checklist**

### Other ROIs

- **MNT1**: Send to ground auto
- **MNT2**: Send to ground auto
- **MNT3**: Send to ground auto
- **MNT4**: Send to ground auto
- **MNT5**: Send to ground auto
- **MNT6**: Send to ground auto
- **MNT7**: Send to ground auto
- **MNT8**: Send to ground auto
- **MNT9**: Send to ground auto
- **MNT10**: Send to ground auto

### Human Systems

- **FSE**: Send to ground auto
- **HSCP**: Send to ground auto
2014 Task Analysis

•" Focused on defining task groups (for flexibility)
  −" Dispatch
    •" Scans for off-nominal situations
    •" Addresses maintenance issues
    •" Reroutes
    •" Complies to Company standards
    •" Liaison between OBP and outside entities

−" OBP
  •" Flying tasks (addresses clearances, executes clearances, communicates w/ ATC & GO)
  •" Continuous Tasks- Crosschecks flight against CA’s mental map

−" Automation
  •" Ground- Notifications: flight conformance, off-nominals, and reminders to act or check. Collect and organize flight information (handoff packages).
  •" FD- Notifications, Reminders, and Loads of clearances
  •" Communicate between Ground & FD Automations
### 2014 Task Analysis Spreadsheet (Groups)

#### Nominal Handoff: Giving 1, Getting 5

<table>
<thead>
<tr>
<th>GOH1</th>
<th>Ground Auto 1</th>
<th>GOH2</th>
<th>Ground Auto 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tr>
<tr>
<td>Prepare briefing package for Handoff (NASA01)</td>
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<tr>
<td>Scan Screen: Tails Status</td>
<td></td>
<td></td>
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<tr>
<td>Scan Screen: Tails Management</td>
<td></td>
<td></td>
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<tr>
<td>Speak w/ OBP ()</td>
<td></td>
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</tr>
<tr>
<td>Review Fuel levels ()</td>
<td></td>
<td></td>
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<tr>
<td>Review Weather ()</td>
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<td>Review Weather (NASA01)</td>
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<tr>
<td>Handoff &amp; Disconnect</td>
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</tr>
<tr>
<td>GOH1</td>
<td>Ground Auto 1</td>
<td></td>
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<tr>
<td>Prepare briefing package for Handoff ()</td>
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<tr>
<td>Review Weather ()</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Listen</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Speak OBP ()</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Going to handoff to GOH2, have a nice flight&quot;</td>
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<tr>
<td>Listen</td>
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<tr>
<td>Review Handoff Package ()</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Execute handoff ()</td>
<td></td>
<td></td>
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<tr>
<td>Disconnect ()</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Connect &amp; Multiple Handoffs</td>
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</tr>
<tr>
<td>GOH2</td>
<td>Ground Auto 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Review handoff packages (NASA01, AC2, AC3, AC4, AC5)</td>
<td></td>
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<td></td>
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<tr>
<td>Scan Screen: Tails Status</td>
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<td>Scan Screen: Tails Management</td>
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</tr>
<tr>
<td>Review Fuel levels (NASA01)</td>
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<tr>
<td>Speak w/ OBP ()</td>
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</tbody>
</table>
### Nominal Flight Review

<table>
<thead>
<tr>
<th>GOH2</th>
<th>Ground Auto 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scan Screens: Tail Status</td>
<td></td>
</tr>
<tr>
<td>Scan Screens: Tail Management</td>
<td></td>
</tr>
<tr>
<td>Review Altitude &amp; Heading ()</td>
<td></td>
</tr>
<tr>
<td>Review Fuel Levels ()</td>
<td></td>
</tr>
<tr>
<td>Review Weather ()</td>
<td></td>
</tr>
</tbody>
</table>

### New Outbound

<table>
<thead>
<tr>
<th>GOH2</th>
<th>Ground Auto 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scan Screens: Tail Status</td>
<td></td>
</tr>
<tr>
<td>Scan Screens: Tail Management</td>
<td></td>
</tr>
<tr>
<td>Pressure (if needed; file release)</td>
<td>Notify: New Outbound ()</td>
</tr>
<tr>
<td>Clock weather ()</td>
<td></td>
</tr>
<tr>
<td>Pressure (if needed; file release)</td>
<td>Check flight plan ()</td>
</tr>
</tbody>
</table>

### Single Handoff

<table>
<thead>
<tr>
<th>GOH2</th>
<th>Ground Auto 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prepare briefing package for Handoff ()</td>
<td></td>
</tr>
<tr>
<td>Speak with OHP (&quot;Going to handoff to GOH2, have a safe flight&quot;)</td>
<td></td>
</tr>
<tr>
<td>Login</td>
<td></td>
</tr>
<tr>
<td>Execute handoff ()</td>
<td></td>
</tr>
<tr>
<td>Disconnect ()</td>
<td></td>
</tr>
</tbody>
</table>

### Fuel Temperatures

<table>
<thead>
<tr>
<th>GOH2</th>
<th>Ground Auto 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scan Screens: Tail Status</td>
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<tr>
<td>Scan Screens: Tail Management</td>
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<tr>
<td>Discuss Fuel Temperatures ()</td>
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<tr>
<td>Send fuel results from fuel temp ()</td>
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### Security Information

<table>
<thead>
<tr>
<th>GOH2</th>
<th>Ground Auto 2</th>
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<tbody>
<tr>
<td>Scan Screens: Tail Status</td>
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<tr>
<td>Scan Screens: Tail Management</td>
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<tr>
<td>Receive and Understand message (ATC):</td>
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<tr>
<td>Speak w/ OHP ()</td>
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<tr>
<td>Discuss Security Information</td>
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# 2014 Task Analysis Spreadsheet (Groups)

## Delays

<table>
<thead>
<tr>
<th>GOH2</th>
<th>Ground Auto 2</th>
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<tbody>
<tr>
<td>Reserve and understand message (ATC) &quot;Delays at ORD due to weather.&quot;</td>
<td>Reserve and understand message (ATC) &quot;Delays at ORD due to weather.&quot;</td>
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<tr>
<td>Scan Screen: Tail Status</td>
<td>Scan Screen: Tail Status</td>
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<tr>
<td>Scan Screen: Tail Management</td>
<td>Scan Screen: Tail Management</td>
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<tr>
<td>Review Alternate &amp; Handling ()</td>
<td>Review Alternate &amp; Handling ()</td>
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<tr>
<td>Review Fuel Levels ()</td>
<td>Review Fuel Levels ()</td>
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<tr>
<td>Review Weather ()</td>
<td>Review Weather ()</td>
</tr>
<tr>
<td>Speak w/ DIIP ()</td>
<td>Speak w/ DIIP ()</td>
</tr>
<tr>
<td>Discuss: Airport/aboard delays</td>
<td>Discuss: Airport/aboard delays</td>
</tr>
<tr>
<td>Speak w/ Customer care team</td>
<td>Speak w/ Customer care team</td>
</tr>
<tr>
<td>Discuss: Delays ()</td>
<td>Discuss: Delays ()</td>
</tr>
<tr>
<td>Speak w/ Reservation coordinator</td>
<td>Speak w/ Reservation coordinator</td>
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<tr>
<td>Discuss: Delays ()</td>
<td>Discuss: Delays ()</td>
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## Weather Rerouting

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<td>Scan Screen: Tail Status</td>
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<td>Scan Screen: Tail Management</td>
<td>Scan Screen: Tail Management</td>
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<tr>
<td>Reserve and understand message (ATC) &quot;Converge on weather problem between HOU - DAL.&quot;</td>
<td>Reserve and understand message (ATC) &quot;Converge on weather problem between HOU - DAL.&quot;</td>
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<tr>
<td>Review Fuel levels ()</td>
<td>Review Fuel levels ()</td>
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<tr>
<td>Review Weather ()</td>
<td>Review Weather ()</td>
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<tr>
<td>Interact DIIP ()</td>
<td>Interact DIIP ()</td>
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<tr>
<td>Discuss: Weather rerouting</td>
<td>Discuss: Weather rerouting</td>
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## Maintenance

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<td>Listen</td>
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<tr>
<td>Speak w/ DIIP ()</td>
<td>Speak w/ DIIP ()</td>
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<tr>
<td>Discuss: Maintenance Problem</td>
<td>Discuss: Maintenance Problem</td>
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<tr>
<td>&quot;Do you have any safety concerns?&quot;</td>
<td>&quot;Do you have any safety concerns?&quot;</td>
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<tr>
<td>Listen</td>
<td>Listen</td>
</tr>
<tr>
<td>Speak w/ DIIP ()</td>
<td>Speak w/ DIIP ()</td>
</tr>
<tr>
<td>Discuss: Maintenance Solutions</td>
<td>Discuss: Maintenance Solutions</td>
</tr>
<tr>
<td>&quot;Roger, contacting maintenance.&quot;</td>
<td>&quot;Roger, contacting maintenance.&quot;</td>
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<tr>
<td>Speak w/ Maintenance ()</td>
<td>Speak w/ Maintenance ()</td>
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<tr>
<td>Patch through maintenance (collaboration possible)</td>
<td>Patch through maintenance (collaboration possible)</td>
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<td>Speak w/ ODP ()</td>
<td>Speak w/ ODP ()</td>
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<tr>
<td>&quot;Maintenance will you meet you at the gate?&quot;</td>
<td>&quot;Maintenance will you meet you at the gate?&quot;</td>
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<tr>
<td>Review Fuel levels ()</td>
<td>Review Fuel levels ()</td>
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<tr>
<td>Review Weather ()</td>
<td>Review Weather ()</td>
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## Gate Connections

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<td>Scan Screen: Tail Management</td>
<td>Scan Screen: Tail Management</td>
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<tr>
<td>Speak w/ DIIP ()</td>
<td>Speak w/ DIIP ()</td>
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<tr>
<td>Discuss: Gate Connection Problem</td>
<td>Discuss: Gate Connection Problem</td>
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<tr>
<td>Speak w/ DIIP ()</td>
<td>Speak w/ DIIP ()</td>
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<td>Discuss: Gate Connection Solution</td>
<td>Discuss: Gate Connection Solution</td>
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<tr>
<td>Contact: Reservation coordinator</td>
<td>Contact: Reservation coordinator</td>
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<td>Discuss: Gate Connections ()</td>
<td>Discuss: Gate Connections ()</td>
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<td>Dedicated Assistance</td>
<td>Ground Auto 2</td>
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<tr>
<td><strong>GOH2</strong></td>
<td><strong>Notify: Wa &amp; DEN</strong></td>
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<tr>
<td>Notified of weather at DEN, possible hold and divert (NASA01)</td>
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<tr>
<td>Review fuel levels (NASA01)</td>
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<td>Review weather (NASA01)</td>
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<tr>
<td>Listen DA request (NASA01)</td>
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<tr>
<td>Review altitude &amp; heading (NASA01)</td>
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<td>Confirm DA request (NASA01)</td>
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<tr>
<td>Handoff other AC - No briefing</td>
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<td>Speak w/OBP (NASA01): &quot;How can I help?&quot;</td>
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<td>Listen</td>
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<tr>
<td>&quot;Roger, locating.&quot;</td>
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<tr>
<td>Locate approach plates (CYSE/EG/US/GT/PUB)</td>
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<tr>
<td>Send plates to NASA01</td>
<td>Send plates to NASA01 auto</td>
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<tr>
<td>Review weather (CYSE/EG/US/GT/PUB)</td>
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<tr>
<td>Send weather to NASA01</td>
<td>Send weather to NASA01 auto</td>
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<tr>
<td>Discuss current status</td>
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<tr>
<td>Agree on preliminary best alternate (CYSE)</td>
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<td>Listen</td>
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<tr>
<td>Confirm duties</td>
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<tr>
<td>Load primary alternate Airport (CYSE)</td>
<td>Notify NASA01 auto</td>
</tr>
<tr>
<td>Discuss probable hold locations &amp; patterns. Discuss fuel state and calculate endurance for a hold. (Find DENT to DENT, Desired DENT landing fuel, Current burn rate, Time/Trip remaining, Crosscheck.)</td>
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<tr>
<td>Pre-load probable hold into CDU</td>
<td>Notify NASA01 auto</td>
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<tr>
<td>Discuss Alternate 1 (CYSE) (distance/time/fuel/CAT/ATIS) (A2)</td>
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<tr>
<td>Action</td>
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<tr>
<td>Discuss Alternate 1 (EG/US/GT/PUB) (distance/time/fuel/CAT/ATIS) (A2)</td>
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<tr>
<td>Discuss Alternate 3 (CO/COS) (distance/time/fuel/CAT/ATIS) (A2)</td>
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<tr>
<td>Action</td>
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### Action:

- **Listen to ATC:**
  - Listen to ATC: Load CYS as new destination in CDU. Get ATIS. Build a route. Load expected Approach/Arrival Information: Airport, Runway, Altimeter, Speed changes, landing flaps, DH, frequencies. Load LNAV/VNAV. Notify GO.
  - Notify GO.

- **Crosscheck OBP:**
  - Notify GO.

- **Crosscheck 1:**
  - Notify GO.

- **Crosscheck 2:**
  - Notify GO.

- **Crosscheck 3:**
  - Notify GO.

- **Crosscheck 4:**
  - Notify GO.

- **Crosscheck 5:**
  - Notify GO.

- **Crosscheck 6:**
  - Notify GO.

- **Crosscheck 7:**
  - Notify GO.

- **Crosscheck 8:**
  - Notify GO.

- **Crosscheck 9:**
  - Notify GO.

- **Crosscheck 10:**
  - Notify GO.

- **Crosscheck 11:**
  - Notify GO.

- **Crosscheck 12:**
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- **Crosscheck 13:**
  - Notify GO.

- **Crosscheck 14:**
  - Notify GO.

- **Crosscheck 15:**
  - Notify GO.

- **Crosscheck 16:**
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- **Crosscheck 17:**
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- **Crosscheck 18:**
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- **Crosscheck 19:**
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- **Crosscheck 20:**
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- **Crosscheck 21:**
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- **Crosscheck 22:**
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- **Crosscheck 23:**
  - Notify GO.

- **Crosscheck 24:**
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- **Crosscheck 25:**
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- **Crosscheck 26:**
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- **Crosscheck 27:**
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- **Crosscheck 28:**
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- **Crosscheck 29:**
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- **Crosscheck 30:**
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- **Crosscheck 31:**
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- **Crosscheck 32:**
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- **Crosscheck 33:**
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- **Crosscheck 34:**
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- **Crosscheck 38:**
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- **Crosscheck 39:**
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- **Crosscheck 41:**
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- **Crosscheck 42:**
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- **Crosscheck 44:**
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- **Crosscheck 45:**
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- **Crosscheck 46:**
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- **Crosscheck 47:**
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- **Crosscheck 61:**
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- **Crosscheck 63:**
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- **Crosscheck 64:**
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- **Crosscheck 65:**
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- **Crosscheck 66:**
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- **Crosscheck 67:**
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- **Crosscheck 70:**
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- **Crosscheck 71:**
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- **Crosscheck 72:**
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- **Crosscheck 73:**
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- **Crosscheck 74:**
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- **Crosscheck 75:**
  - Notify GO.

- **Crosscheck 76:**
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- **Crosscheck 77:**
  - Notify GO.

- **Crosscheck 78:**
  - Notify GO.
Implementing Task Analysis Output #1: Task Representation and Coding
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<th>Plan NPTI Phase 3</th>
<th>Plan NPTI Phase 4</th>
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<td>Ground Automation</td>
<td>Ground Automation 1</td>
<td>Ground Automation 2</td>
<td>Ground Automation 3</td>
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</table>
| October 26, 2014 3:10:00 PM

Note: The table above outlines the sequence of tasks and dialogues between different automation systems and ATC, focusing on the process of NASAMI in GO Dispatch. Each row represents a step in the procedure, with the columns indicating different systems or contexts (e.g., AFT case, Ground Automation). The interactions include activation of NASAMI, communication with ATC, and other procedural steps to manage the flight. The dates and times in the image indicate the specific timeframe for these procedures.
2014 Task Analysis

"Included:
- Nominal “shift change” handoff as one of the first task groups
- Nominal ramp-up
- Off-Nominal handoff
- Off-Nominal ramp-up
- "End-of-DA” handoff
- "End-of-DA ramp-up
- Dispatch tasks

"Discovered:
- Greater reliance on automation
- Ground Automation (new)
- “Dispatch” Automation (new)
- New Relationships
  - GO > GO, GO > FD, FO > GO, OBP > GO, CA > FO
- What happens during a DA handoff?
  - Who is responsible for the dispatch tasks?
  - Should a Ground FO in DA have assigned duties, or are they determined by the CA > FO relationship?
# Task Analysis Output #2

## Current Day Nominal

<table>
<thead>
<tr>
<th>Workload</th>
<th>Total Low</th>
<th>Percent Low</th>
<th>CA</th>
<th>FO</th>
<th>GO</th>
<th>ALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>18</td>
<td>21.18%</td>
<td>18</td>
<td>21.43%</td>
<td>33.33%</td>
<td>38</td>
</tr>
<tr>
<td>Medium</td>
<td>53</td>
<td>53.42%</td>
<td>61</td>
<td>3</td>
<td>117</td>
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<tr>
<td>High</td>
<td>21</td>
<td>16.47%</td>
<td>5</td>
<td>11.11%</td>
<td>16.67%</td>
<td>20</td>
</tr>
<tr>
<td>Total Tasks</td>
<td>85</td>
<td>48.57%</td>
<td>84</td>
<td>5</td>
<td>6</td>
<td>175</td>
</tr>
</tbody>
</table>

| Workload | Percent Entity | 48.00% | 3.43% | 100.00% |

## Current Day Off-Nominal

<table>
<thead>
<tr>
<th>Workload</th>
<th>Total Low</th>
<th>Percent Low</th>
<th>CA</th>
<th>FO</th>
<th>GO</th>
<th>ALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>27</td>
<td>22.88%</td>
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<td>33.33%</td>
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<tr>
<td>Medium</td>
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<td>69.03%</td>
<td>50.00%</td>
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<tr>
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<td>11</td>
<td>9.73%</td>
<td>16.67%</td>
<td>33</td>
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<tr>
<td>Total Tasks</td>
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<td>49.79%</td>
<td>113</td>
<td>6</td>
<td>237</td>
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| Workload | Percent Entity | 47.68% | 2.53% | 100.00% |

## SPO Hybrid Nominal

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<tr>
<th>Workload</th>
<th>Total Low</th>
<th>Percent Low</th>
<th>OBP</th>
<th>ED AUTO</th>
<th>GO</th>
<th>GO/AUTO</th>
<th>ALL</th>
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</thead>
<tbody>
<tr>
<td>Low</td>
<td>29</td>
<td>54.12%</td>
<td>42</td>
<td>100.00%</td>
<td>8</td>
<td>100.00%</td>
<td>94</td>
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<tr>
<td>Medium</td>
<td>46</td>
<td>54.12%</td>
<td>0</td>
<td>0</td>
<td>8</td>
<td>0</td>
<td>54</td>
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<tr>
<td>High</td>
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<td>11.76%</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Total Tasks</td>
<td>85</td>
<td>53.13%</td>
<td>42</td>
<td>26.25%</td>
<td>18</td>
<td>15</td>
<td>160</td>
</tr>
</tbody>
</table>

| Workload | Percent Entity | 25.79% | 11.64% | 100.00% |

## SPO Hybrid Off-Nominal

<table>
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<tr>
<th>Workload</th>
<th>Total Low</th>
<th>Percent Low</th>
<th>OBP</th>
<th>ED AUTO</th>
<th>GO</th>
<th>GO/AUTO</th>
<th>ALL</th>
</tr>
</thead>
<tbody>
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<td>Low</td>
<td>40</td>
<td>28.37%</td>
<td>58</td>
<td>100.00%</td>
<td>24</td>
<td>100.00%</td>
<td>139</td>
</tr>
<tr>
<td>Medium</td>
<td>70</td>
<td>49.63%</td>
<td>0</td>
<td>0</td>
<td>17</td>
<td>0</td>
<td>117</td>
</tr>
<tr>
<td>High</td>
<td>31</td>
<td>21.99%</td>
<td>0</td>
<td>0</td>
<td>12</td>
<td>0</td>
<td>12</td>
</tr>
<tr>
<td>Total Tasks</td>
<td>141</td>
<td>44.34%</td>
<td>58</td>
<td>18.24%</td>
<td>82</td>
<td>37</td>
<td>318</td>
</tr>
</tbody>
</table>

| Workload | Percent Entity | 25.79% | 11.64% | 100.00% |

## SPO Specialist Nominal

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<th>Total Low</th>
<th>Percent Low</th>
<th>Spec GO</th>
<th>Spec GO/AUTO</th>
<th>ALL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>29</td>
<td>54.12%</td>
<td>42</td>
<td>31.25%</td>
<td>15</td>
</tr>
<tr>
<td>Medium</td>
<td>46</td>
<td>54.12%</td>
<td>0</td>
<td>31.25%</td>
<td>15</td>
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<tr>
<td>High</td>
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<td>11.76%</td>
<td>0</td>
<td>31.25%</td>
<td>15</td>
</tr>
<tr>
<td>Total Tasks</td>
<td>85</td>
<td>53.13%</td>
<td>42</td>
<td>26.25%</td>
<td>15</td>
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</table>

| Workload | Percent Entity | 26.25% | 9.38% | 100.00% |

## SPO Specialist Off-Nominal

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<th>Workload</th>
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<th>Percent Low</th>
<th>Spec GO</th>
<th>Spec GO/AUTO</th>
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<td>9.04%</td>
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<tr>
<td>Medium</td>
<td>69</td>
<td>47.20%</td>
<td>34</td>
<td>9.04%</td>
<td>46</td>
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<tr>
<td>High</td>
<td>31</td>
<td>21.92%</td>
<td>34</td>
<td>9.04%</td>
<td>46</td>
</tr>
<tr>
<td>Total Tasks</td>
<td>141</td>
<td>42.37%</td>
<td>34</td>
<td>9.04%</td>
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</tbody>
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| Workload | Percent Entity | 15.74% | 9.04% | 100.00% |
Summary

1. HPMs such as MIDAS can be used to evaluate:
   – Pilot/ATC tasks, roles and responsibilities, and function allocation
   – Technology development and integration
   – Error or safety vulnerabilities
   – Procedures and training needs

2. HPMs and the modeling approach can be applied to other:
   – Phases of flight, (e.g. aviation - arrivals, enroute, departures, taxi and their transitions; space - ascent, descent; ISS operations)
   – Flight deck technologies (e.g., SVS/EVS; CDTI; EFBs; MFDs; )
   – Information requirements manipulations
   – Concept of Operations evaluations (e.g. Single Pilot Operations)
   – Space operations (e.g. ISS and CEV/SLS procedure design and evaluation)
   – Human-automation interaction domains
NASA’s use of human behavior models for concept development and evaluation

Brian F. Gore
Human Systems Integration Division
NASA Ames Research Center
Moffett Field, CA