An Overview of the Human Systems Integration Division

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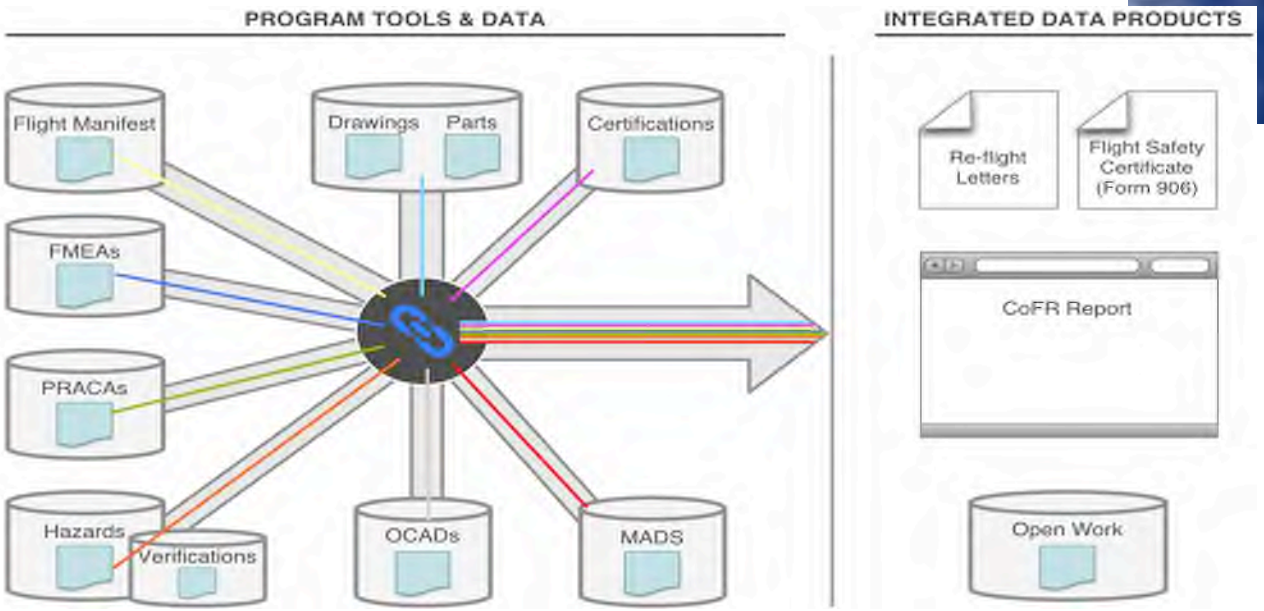
Overview:
Human Systems Integration Division

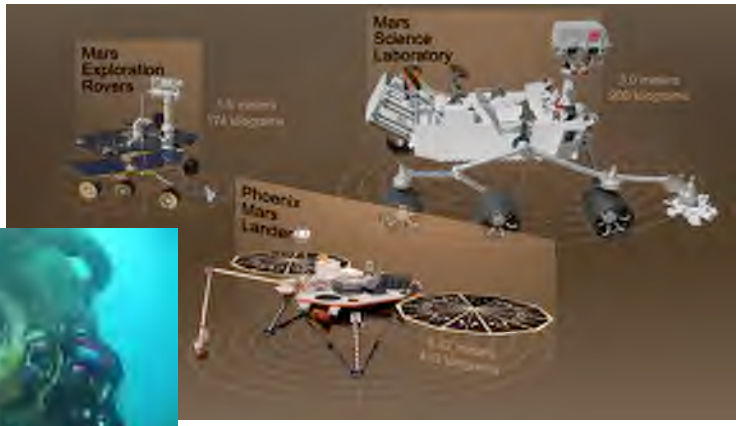
Dr. Alonso Vera!
Division Chief!
!

March 5, 2015

Integrated Information Systems for the International Space Station!

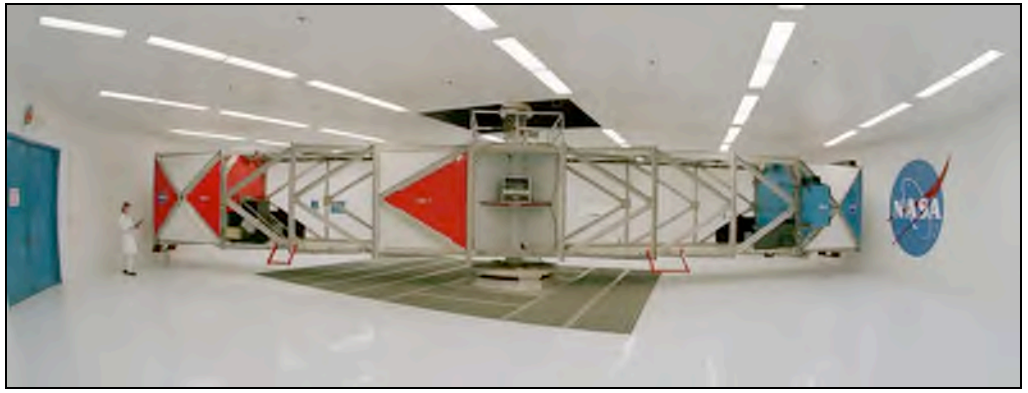


Planning and Scheduling Tools



Mobile Applications for Operations and Systems Engineering!

Vibration Impact on Human Performance!

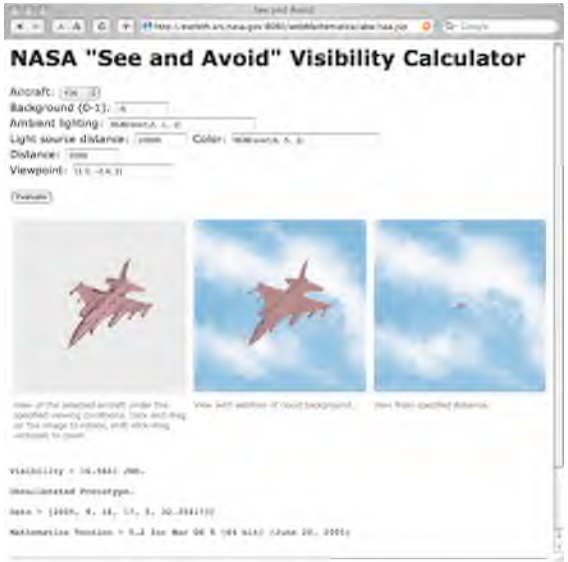


Vision Science and Visual Technologies!

Image Compression, Frame Rates and TBI Assessment

Image compression

Target Identification



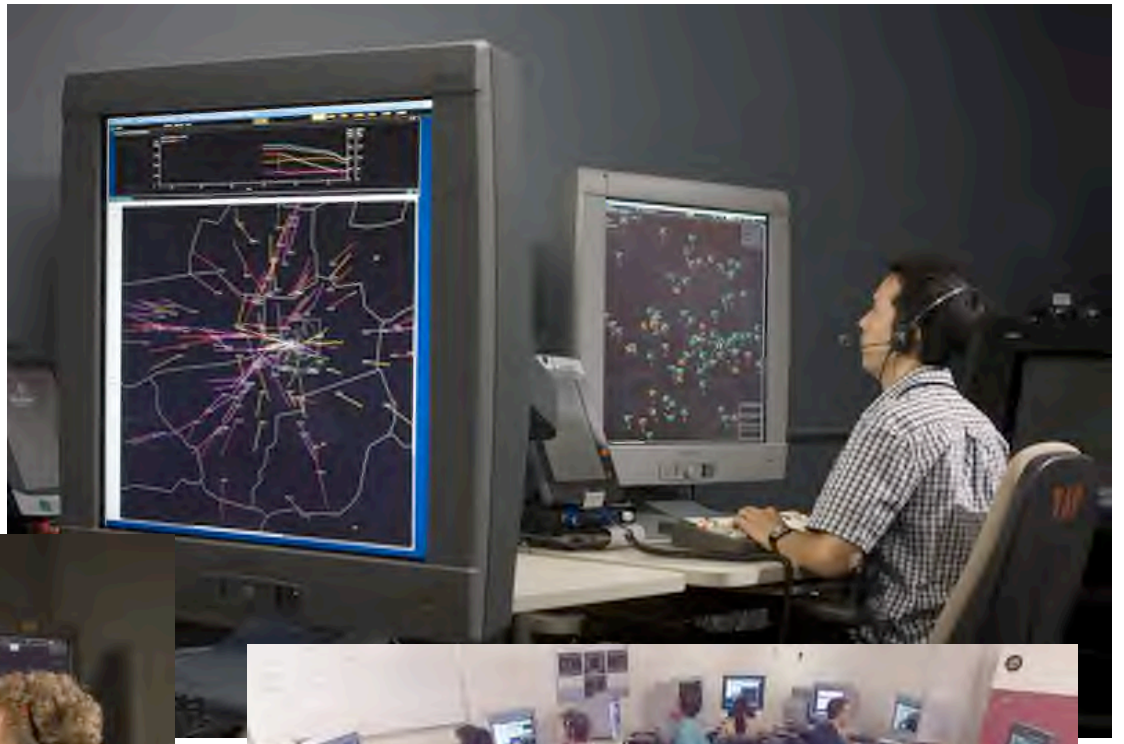
Aircraft/UAV Detection

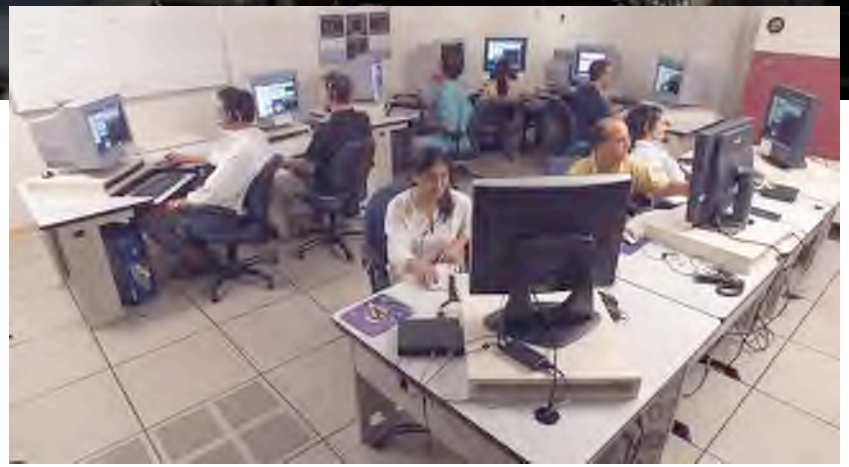
National Aeronautics and Space Administration

Ames

Discovery Innovations Solutions

Airspace Operations Laboratory!





Human Systems Integration for UAS and Single Pilot Operations (or “Reduced Crew Operations”)!

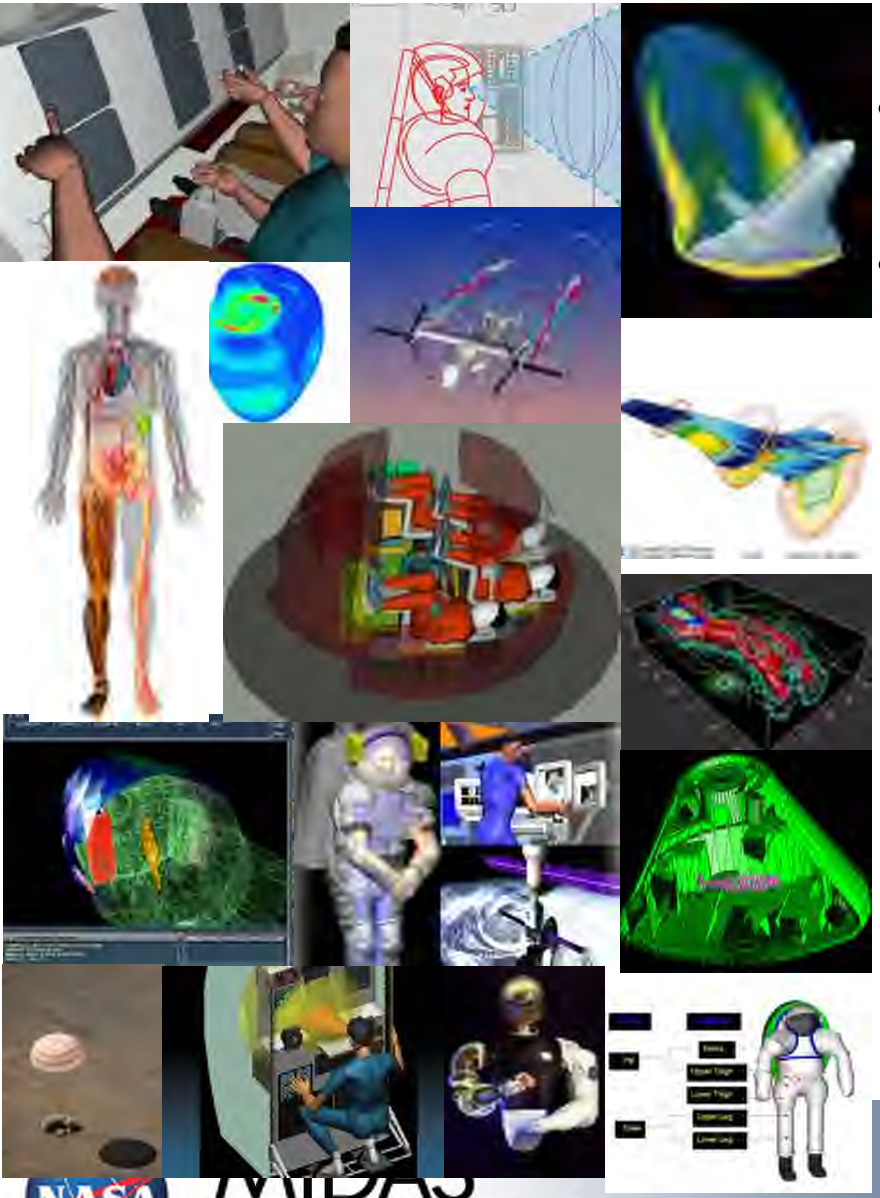
Aviation Safety Reporting System (ASRS)!

- 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!

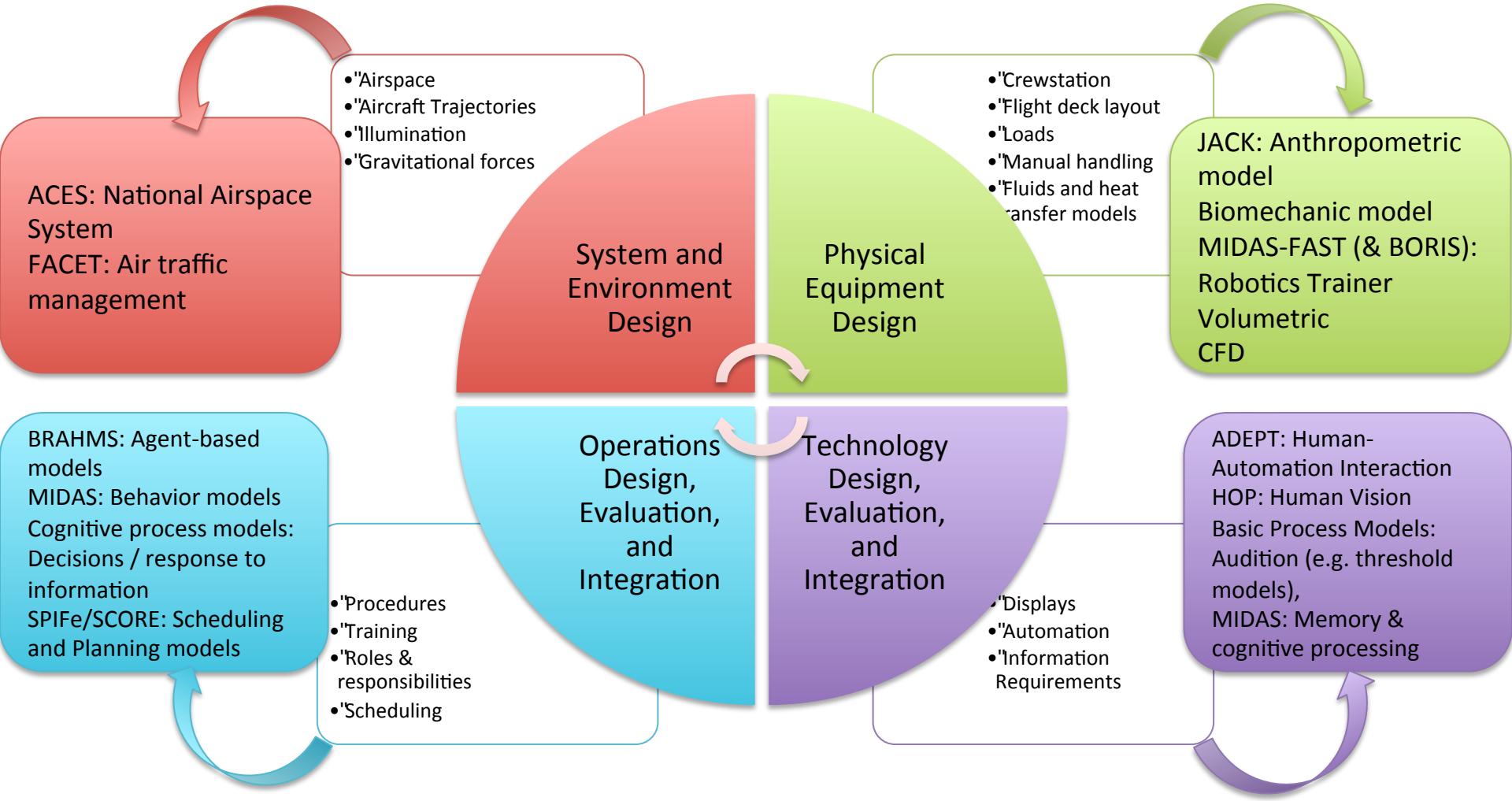
Just-in-Time Crew Training for Long Duration Space Missions!

National Aeronautics and Space Administration



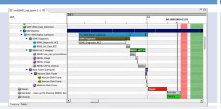
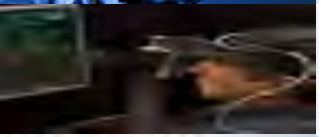
- Modeling and simulation are critical to comprehensively study complex human-system designs
- Many different types of models exist at NASA
  - Human behavioral
  - Human performance
  - Anthropometric, biomechanic, volumetric
  - Information processing
  - Vision, auditory, memory, and other human processes
  - 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



NASA Ames HSI Research Areas

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

Technical Area	Laboratory	Research Area
Human Machine Interaction (HCI)	HCI 	Contribute to the development of better NASA software through careful application of iterative user research, interaction design, and usability (Curiosity - MSLICE)
	Human Automation Interaction	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
	Scheduling and Planning	Scheduling and Planning Interface for Exploration (SPIFe) toolkit for space missions that includes human constraints on mission operations
Human Performance Research	Advanced Controls and Displays 	Research on haptics, speech recognition, visual perception, visual perception in space, adaptation to virtual environments, and acoustics
	Human Vibration Laboratory	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.
	Flight Cognition Lab	Studies the cognitive, team and organizational processes that underlie the performance of pilots, air traffic controllers, and other skilled professionals
	Psychophysiological Lab	Studies altered gravitational effects on human autonomic and central nervous system function to maximize the health, productivity and safety of humans in space.
	Intelligent Systems	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.
MIDAS	Man-machine Integration Design and Analysis System (MIDAS)	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
Integration and Training	Airspace Operations Laboratory (AOL)	Researches roles, responsibilities, and requirements for human operators and automation in future air traffic management (ATM) systems using human in the loop
	Human Centered Systems Laboratory (HCSL)	Focuses on mission safety and efficiency by developing innovative display technologies using both HITL and HPM methodologies
	Flight deck display research	works to increase the capabilities of the flightdeck crew by expanding their roles and

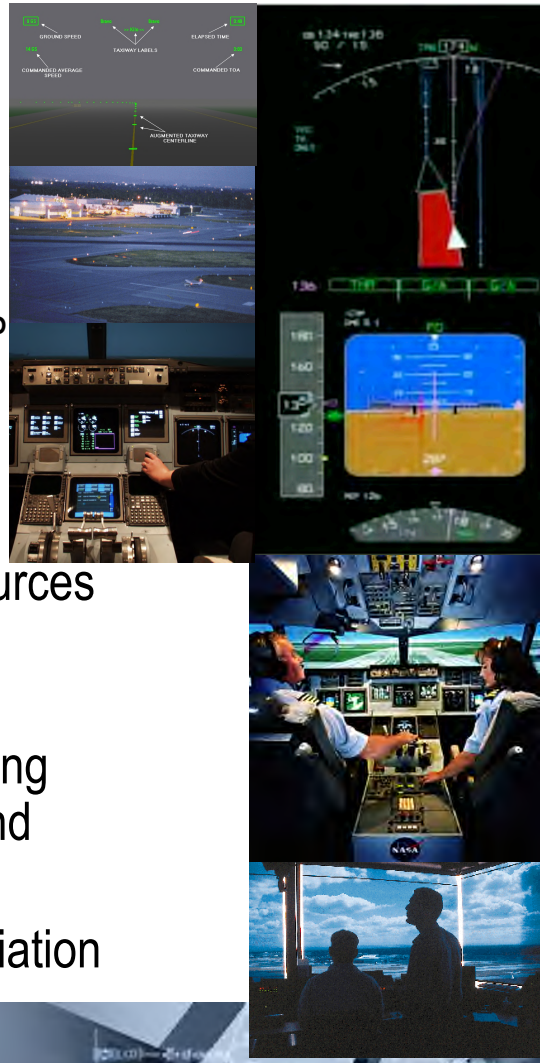
Human Performance Models

- 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:

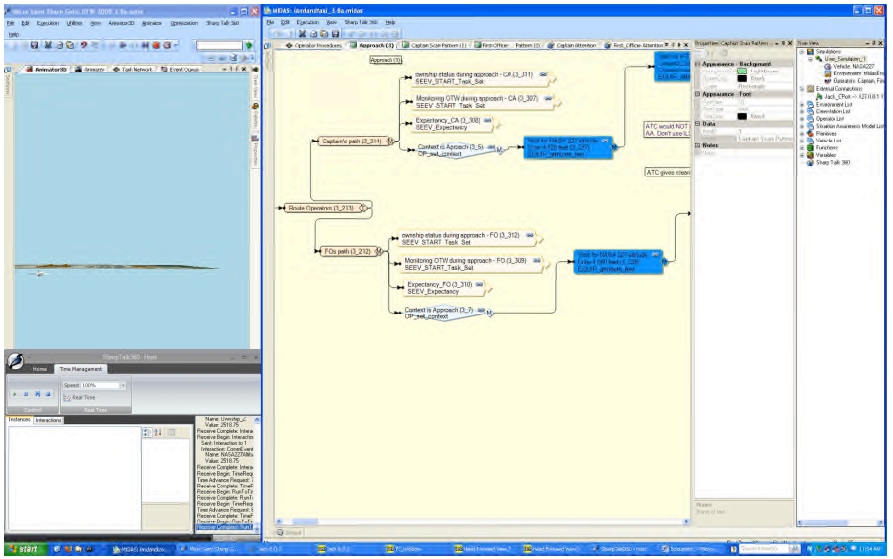
NextGen Technology Design, Evaluation, and Integration

- 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



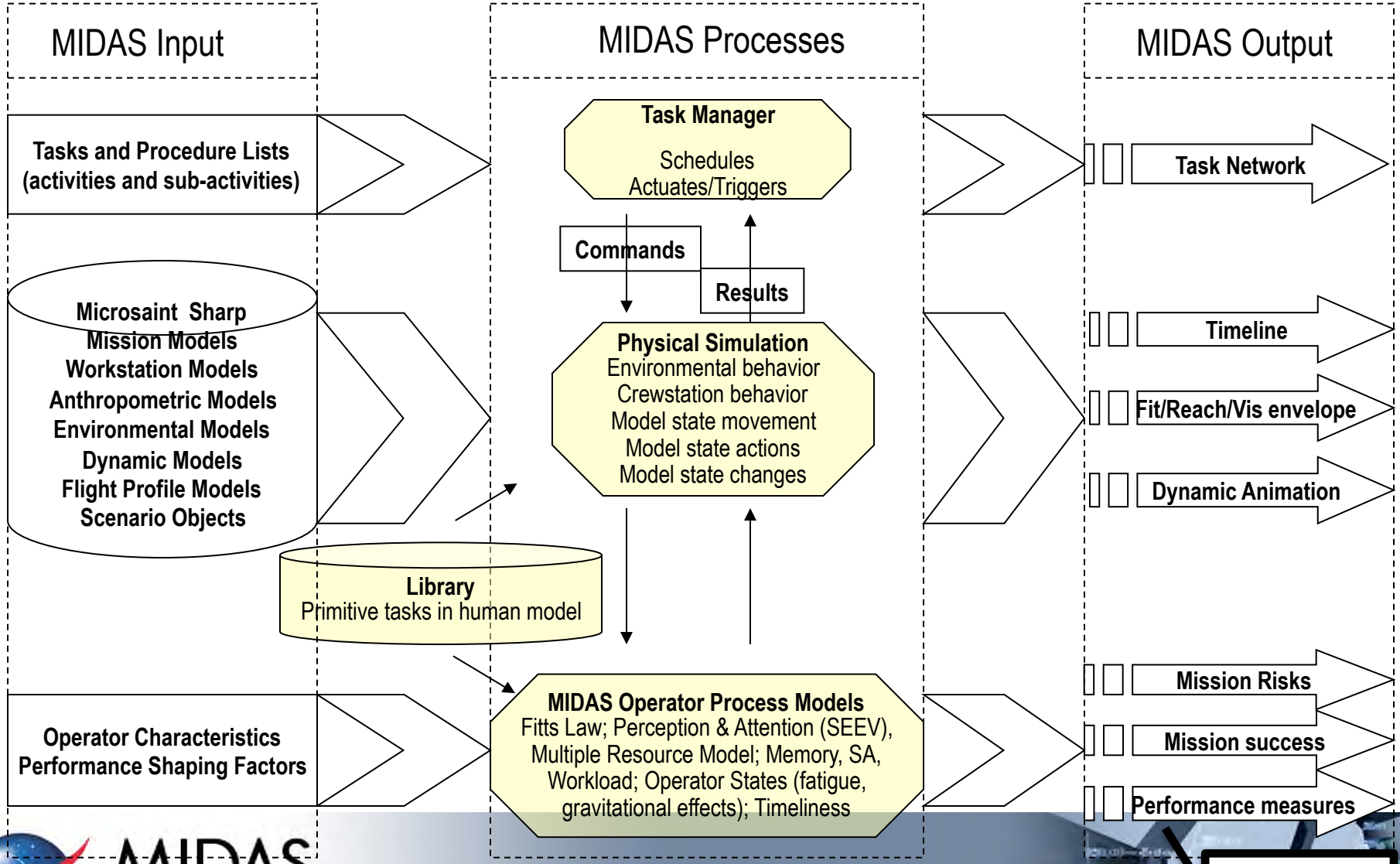
Man-machine Integration Design and Analysis System (MIDAS)

- ✓" 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



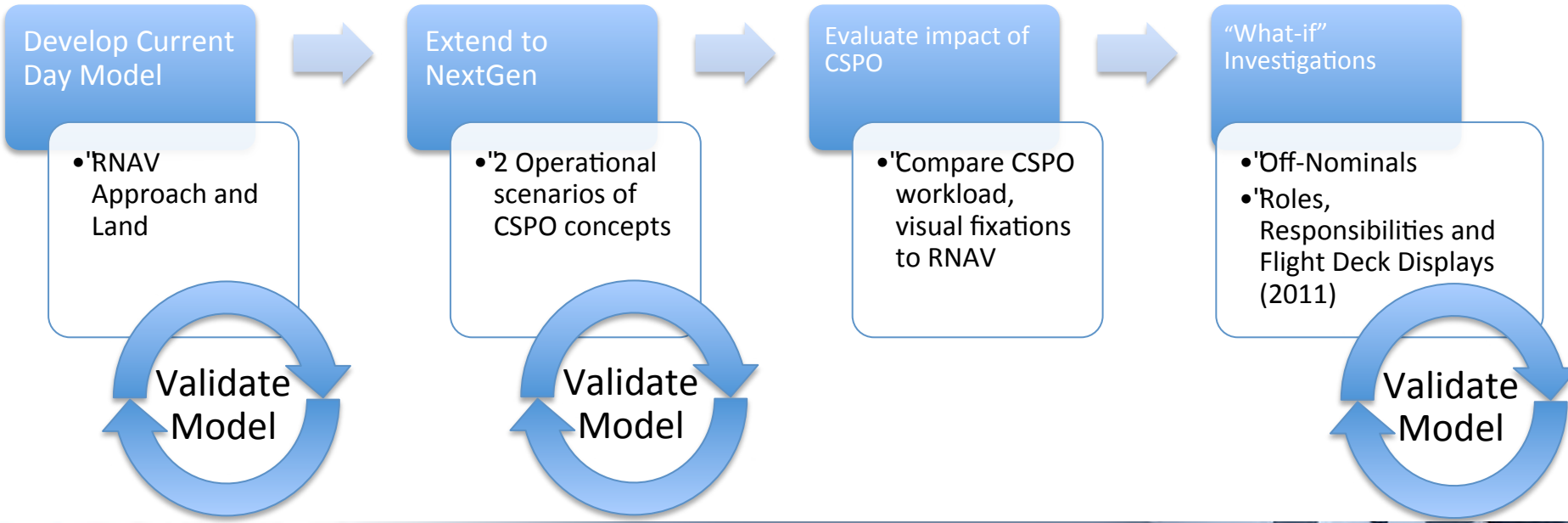
- ✓" Distributed simulation (e.g. Microsaint Sharp)
- ✓" Generates realistic task-management behaviors sensitive to task context, environment
- ✓" Produces task timelines, workload, and situation awareness profiles and visualization which permits testing of procedure alternatives

MIDAS v5 Structures



CSPO Project Overview

- 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



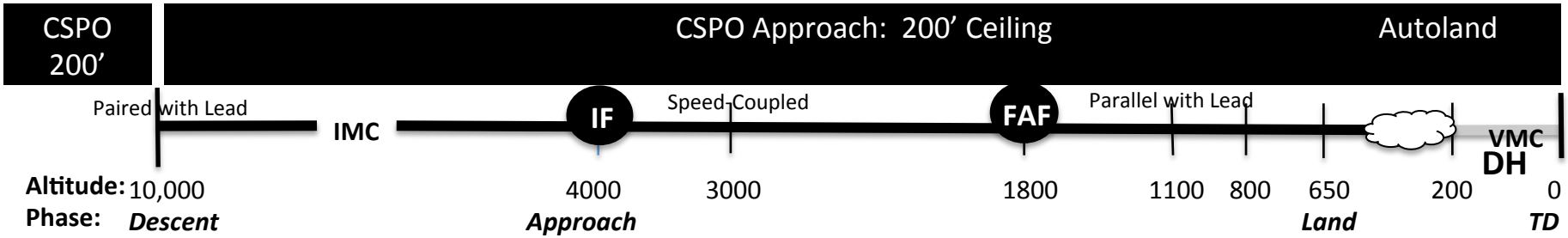
Gore, B.F., Hooey, B.L., & Foyle, D.C. (BRIMS 2011, March 21-26).

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

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



1. Develop and validate model (BRIMS 2010, 2011)	2. Evaluate off-nominal events (BRIMS 2010, 2011)	3. Evaluate roles and responsibilities (AHFE 2012)	4. Evaluate information requirements
-" RNAV scenario + 2 CSPO operational scenarios -"Validated model - **inputs** (Focus groups) - **processes** (Literature) - **outputs** (HITL data)	- Weather (high wind) - RNP Loss - FMS Failure - Aircraft of runway	-"Pilot-pilot roles (Allocation of task, monitoring workload) -"Pilot-ATC roles (Conflict detection and resolution)	-"Flight deck information required to support early conflict detection and safe response -"Wake format and location -"Spacing Automation style and format

- " Insert MIDAS TOGA movie

CSPO Findings and Implications

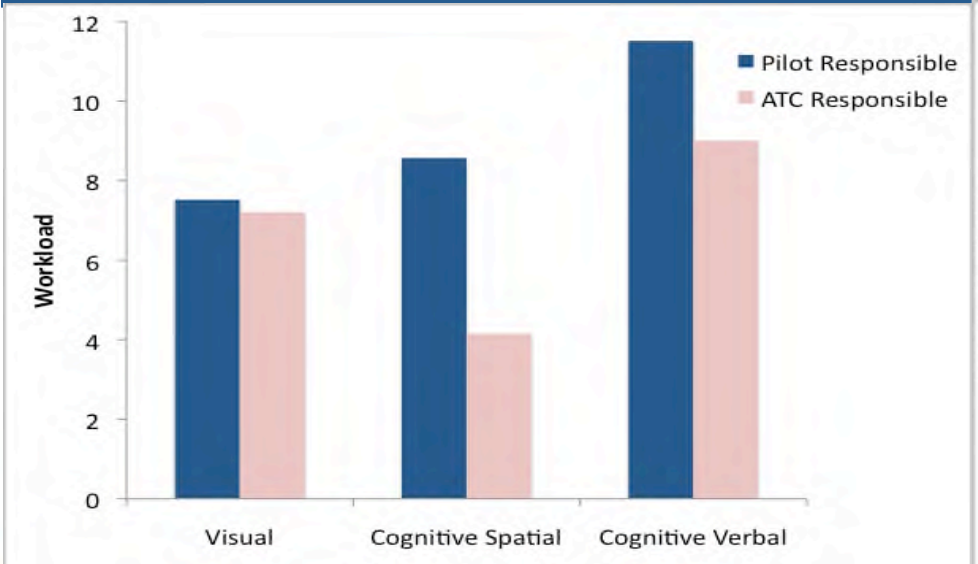
Flight Deck Requirements for:

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)

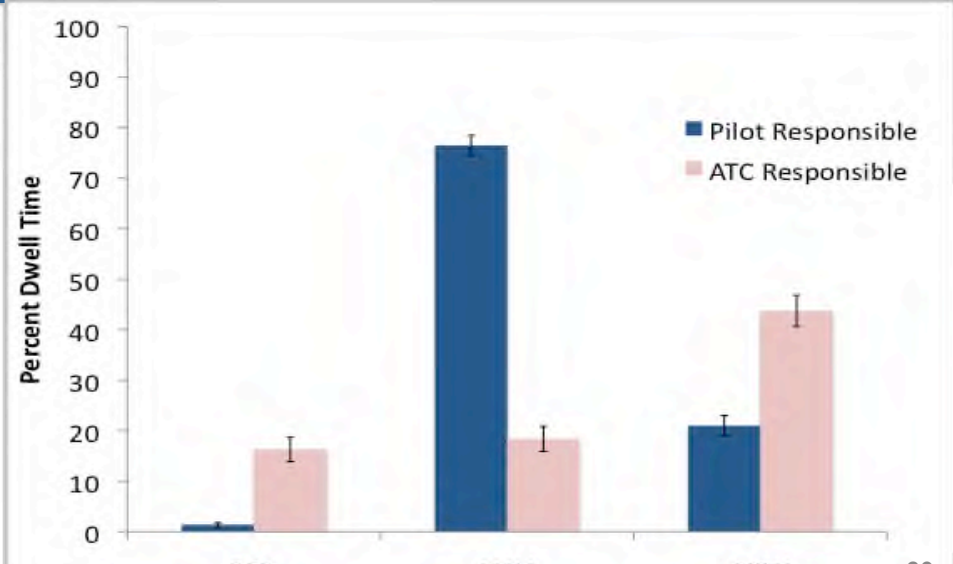
Evaluating ATC-Pilot Roles and Responsibility: Separation Delegation

-" 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

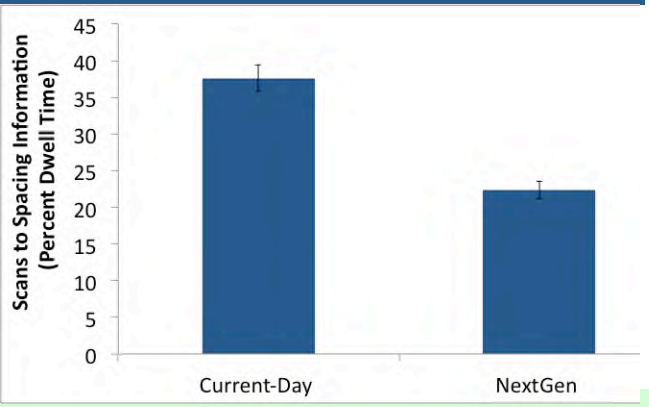
Flight Deck Requirements for:

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)

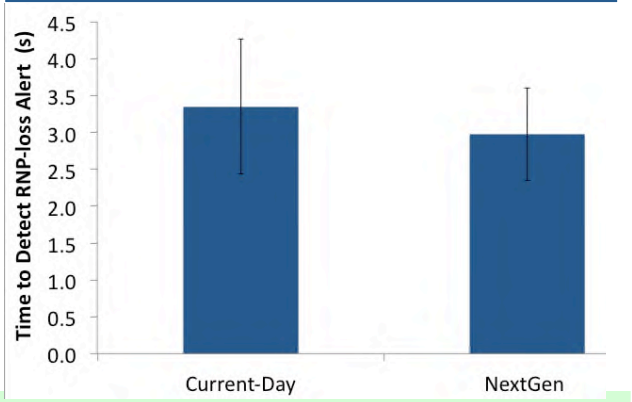
Flight deck requirements for spacing management automation style

- 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

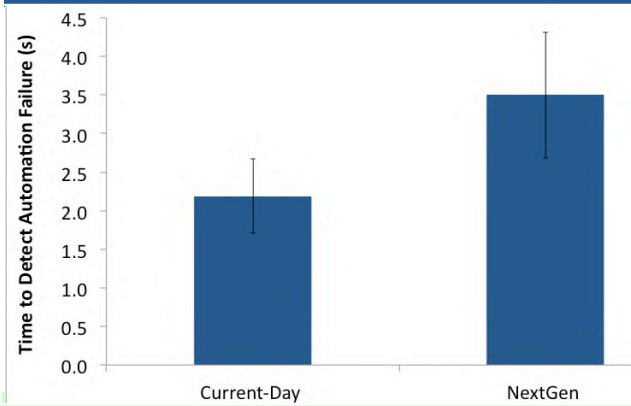
Less time monitoring spacing with NextGen Automation



Faster to detect RNP-Loss (EICAS) with NextGen



Slower to detect Automation Failure (PFD) with NextGen



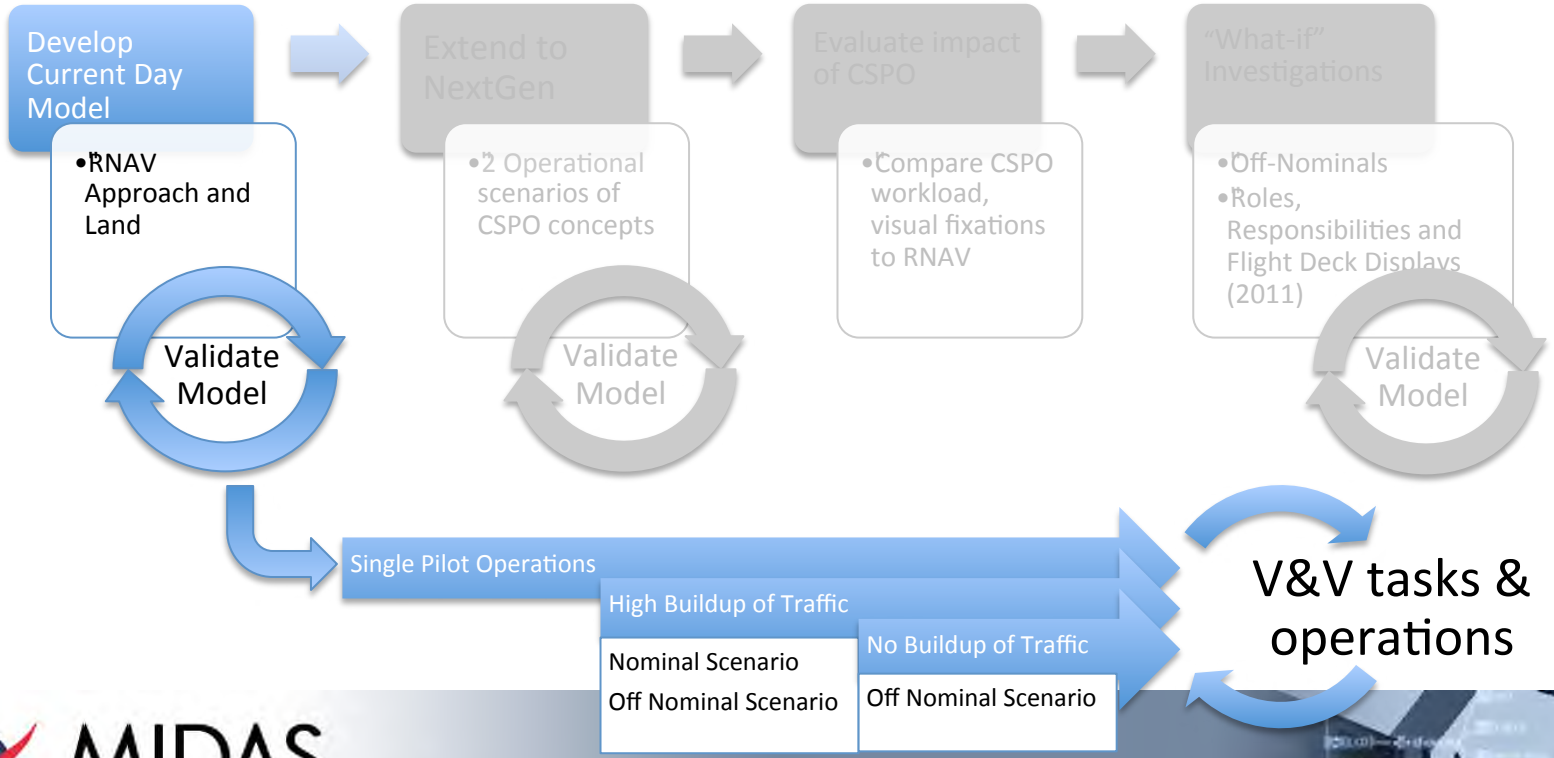
Current-day speed-management resulted in: increased pilot scans to spacing displays, faster detection of RNP-loss alert (on EICAS)

NextGen speed-management slowed time to detect automation failure on PFD (complacency)

Hooey, Gore, Mahlstedt, & Foyle (2012)

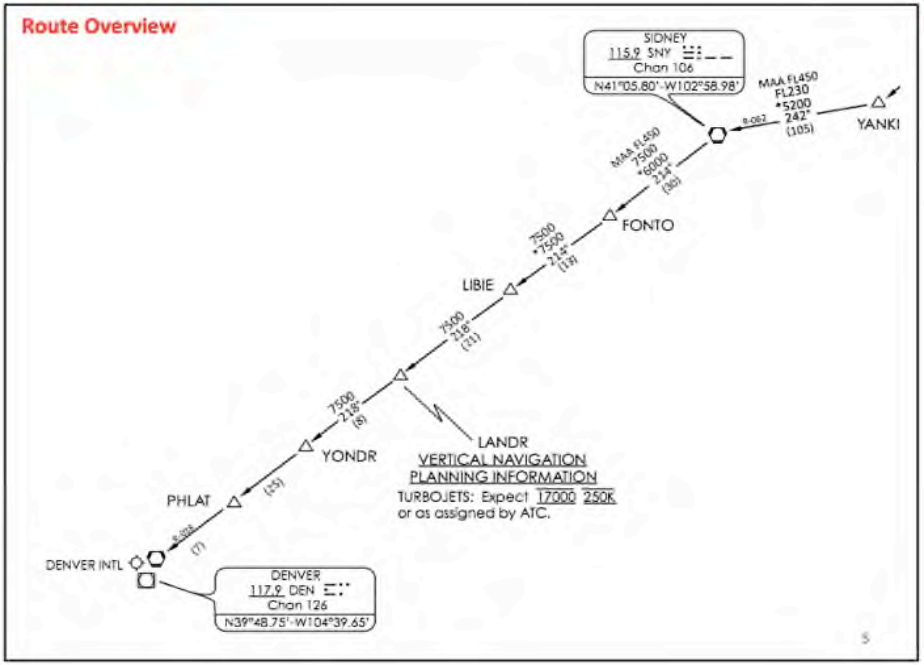
SPO Project Overview

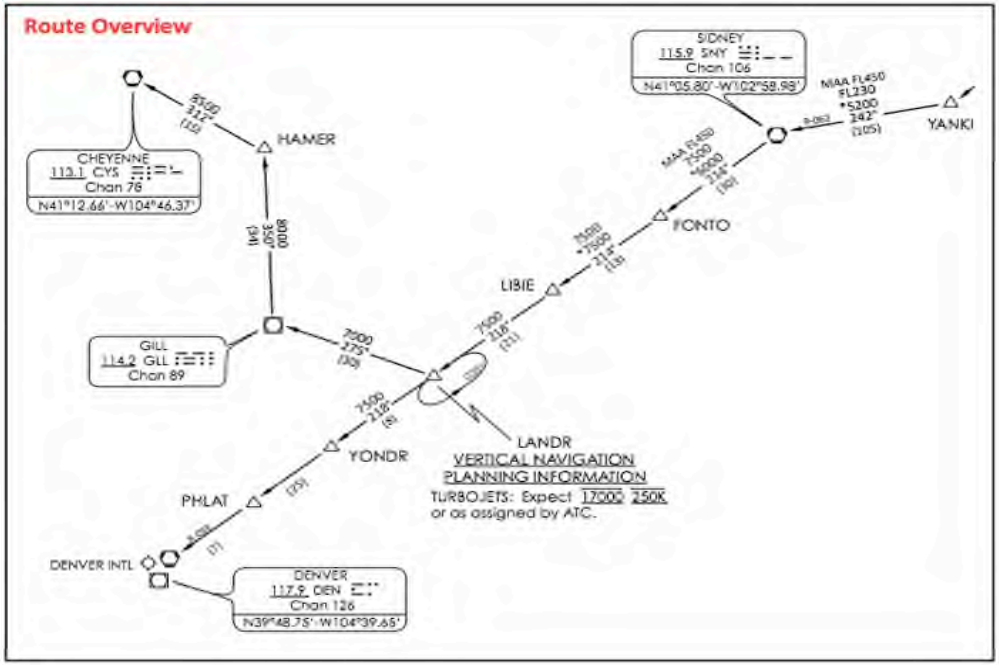
- Objective
  - Complete a task analysis of the Pre-TOD to TOD tasks required in candidate Operational scenarios (Single Pilot Operations; SPOs)

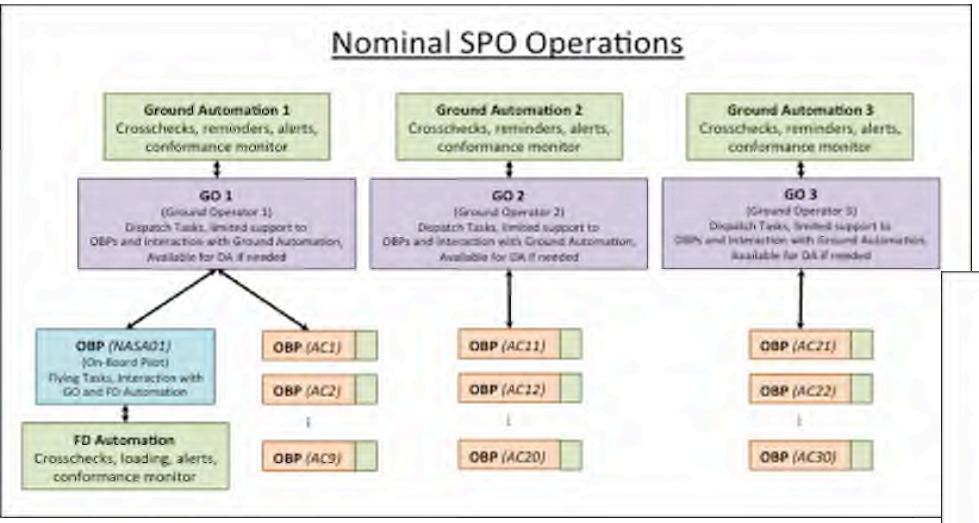


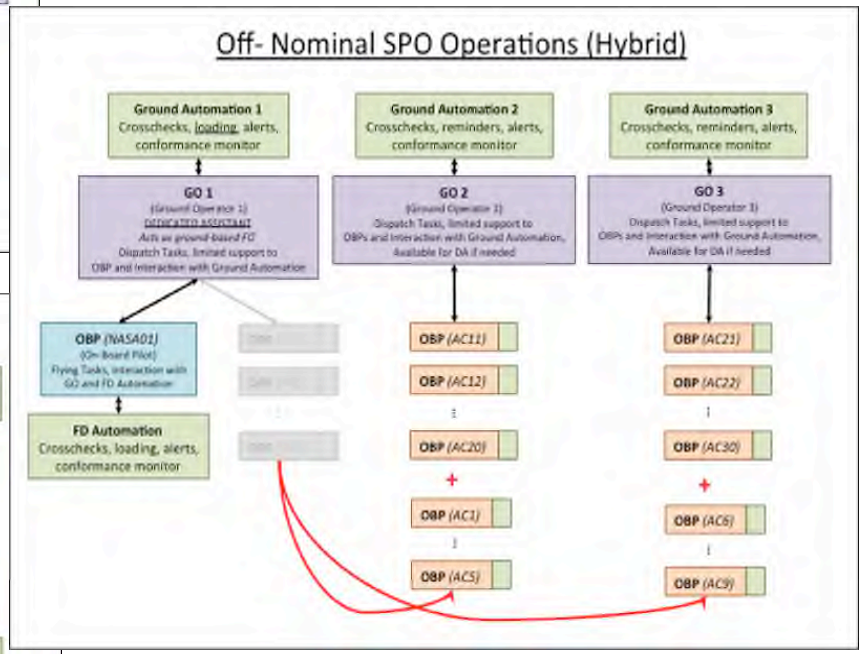
Denver Arrival Approach Plate

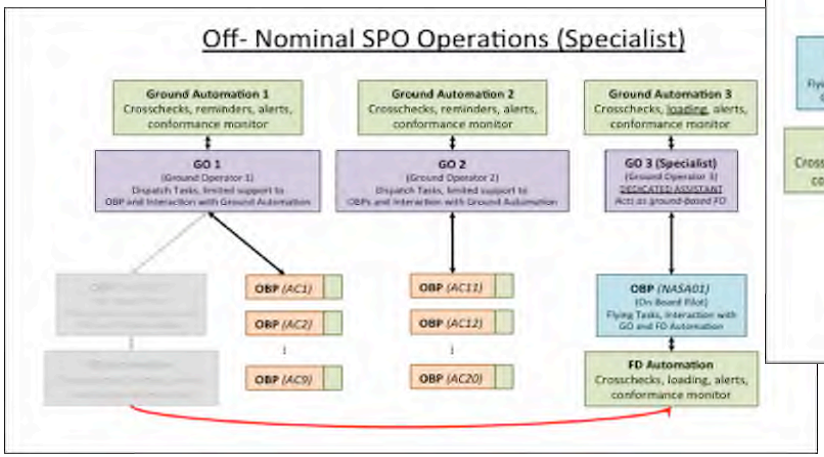
- Nominal Approach plate to DIA
- Off-Nominal (Divert Approach plate to Cheyenne)






Nominal SPO Operations
Ground Automation 1
Crosschecks, reminders, alerts, conformance monitor
Ground Automation 2
Crosschecks, reminders, alerts, conformance monitor
Ground Automation 3
Crosschecks, reminders, alerts, conformance monitor
GO 1
(Ground Operator 1)
Dispatch Tasks, limited support to OBPs and interaction with Ground Automation, Available for DA if needed
GO 2
(Ground Operator 2)
Dispatch Tasks, limited support to OBPs and interaction with Ground Automation, Available for DA if needed
GO 3
(Ground Operator 3)
Dispatch Tasks, limited support to OBPs and interaction with Ground Automation, Available for DA if needed
OBP (NASA01)
(On-Board Pilot)
Flying Tasks, Interaction with GO and FD Automation
FD Automation
Crosschecks, loading, alerts, conformance monitor
OBP (AC1)
OBP (AC2)
OBP (AC9)
OBP (AC11)
OBP (AC12)
OBP (AC20)
OBP (AC21)
OBP (AC22)
OBP (AC30)


Off- Nominal SPO Operations (Hybrid)
Ground Automation 1
Crosschecks, loading, alerts, conformance monitor
Ground Automation 2
Crosschecks, reminders, alerts, conformance monitor
Ground Automation 3
Crosschecks, reminders, alerts, conformance monitor
GO 1
(Ground Operator 1)
DEDICATED ASSISTANT
Acts as ground-based FD
Dispatch Tasks, limited support to OBP and interaction with Ground Automation
GO 2
(Ground Operator 2)
Dispatch Tasks, limited support to OBPs and interaction with Ground Automation, Available for DA if needed
GO 3
(Ground Operator 3)
Dispatch Tasks, limited support to OBPs and interaction with Ground Automation, Available for DA if needed
OBP (NASA01)
(On-Board Pilot)
Flying Tasks, Interaction with GO and FD Automation
FD Automation
Crosschecks, loading, alerts, conformance monitor
OBP (AC11)
OBP (AC12)
OBP (AC20)
OBP (AC1)
OBP (AC5)
OBP (AC21)
OBP (AC22)
OBP (AC30)
OBP (AC6)
OBP (AC9)


Off- Nominal SPO Operations (Specialist)
Ground Automation 1
Crosschecks, reminders, alerts, conformance monitor
Ground Automation 2
Crosschecks, reminders, alerts, conformance monitor
Ground Automation 3
Crosschecks, loading, alerts, conformance monitor
GO 1
(Ground Operator 1)
Dispatch Tasks, limited support to OBP and interaction with Ground Automation
GO 2
(Ground Operator 2)
Dispatch Tasks, limited support to OBPs and interaction with Ground Automation
GO 3 (Specialist)
(Ground Operator 3)
DEDICATED ASSISTANT
Acts as ground-based FD
OBP (AC1)
OBP (AC2)
OBP (AC9)
OBP (AC11)
OBP (AC12)
OBP (AC20)
OBP (NASA01)
(On-Board Pilot)
Flying Tasks, Interaction with GO and FD Automation
FD Automation
Crosschecks, loading, alerts, conformance monitor

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

SPOHI III - Off-Nominal
O/S Divert to: CYS ILS RWY 27L
900' Cloud Ceiling
Category D
NASA01 Pre TOD - TD
GO t(x) - t(y)

Altitude	Airport Distance	Pilot Flying On- Board Pilot NASA01 (CA)	NASA01 Automation	ATC (cues)	Pilot NOT Flying Ground Operator (Hybrid) 1	Ground Automation 1	Pilot NOT Flying Ground Operator (Hybrid) 2	Ground Automation 2	Pilot NOT Flying Ground Operator (Hybrid) 3	Ground Automation 3
Prior to Final Descent		*Continuous tasks:* Auditory and Instrument Monitor. Maintain a common schema.	*Continuous tasks:* Off-Nominal Alerts. Phase of flight alerts. Monitor task adherence. Notification of non self-initiated system changes.	*Continuous tasks:* Maintain separation	Continuous tasks: Auditory & alert Monitor. Maintain a common schema. Maintain company schedule efficiency. Provide dispatch information & limited support to OBP (NASA01). Available for DA if requested.	*Continuous tasks:* Off-Nominal Alerts. Monitor task adherence. Transmit information packages. Transfer notification.	*Continuous tasks:* Auditory & alert Monitor. Maintain a common schema. Maintain company schedule efficiency. Provide dispatch information & limited support to OBP (Other). Available for DA if requested.	*Continuous tasks:* Off-Nominal Alerts. Monitor task adherence. Transmit information packages. Transfer notification.	*Continuous tasks:* Auditory & alert Monitor. Maintain a common schema. Maintain company schedule efficiency. Provide dispatch information & limited support to OBP (Other). Available for DA if requested.	*Continuous tasks:* Off-Nominal Alerts. Monitor task adherence. Transmit information packages. Transfer notification.
					Prepare briefing package for Handoff (NASA01)		Pre Shift Flight Briefings		Performs GO tasks	
		Pre-Arrival briefing/checklist (Taxi Chart, taxi route, gate, flaps, target landing speed, descent speed, brake settings, time of year, geographic position)					Review handoff packages (NASA01, AC2, AC3, AC4, AC5)			
							START SHIFT	START SHIFT		
							Scan Screen: Tails Status			
			Get ATIS. Uplink to FMC: expected approach/arrival info (Airport, runway, altimeter, target speed, landing flaps, DH, frequencies.) Notify.				Scan Screen: Tails Management			
		Crosscheck auto info					Speak w/ OBP ()			
		Execute auto info					Review Fuel levels ()			
							Review Weather ()			
							Speak w/ OBP ()			
							Review Fuel levels ()			
							Review Weather ()			
							Speak w/ OBP ()			
							Review Fuel levels ()			
		Listen			Speak w/ OBP (NASA01) "Going to handoff to CO2, have a nice flight"		Review Weather ()			
		Speak w/ CO "Roger, handoff initiated, goodnight"			Listen		Speak w/ OBP ()			
					Execute handoff (NASA01)		Review Fuel levels ()			
					Disconnect (NASA01)		Review Weather ()			
		Speak w/ CO			Continues GO tasks		Speak w/ OBP (NASA01)			
		If good captain & threat is evident... Preload alternatives into FMS. Say "Preloading alternate ___ into FMS."					Review Fuel levels (NASA01)			
	~110nm TOD	Approach descent checklist					Review Weather (NASA01)			
37,000'	104 nm SIDNEY									
		Execute Altitude.	Send to ground auto				BEGIN SPO III scenario events			
		Listen to ATC command		Say "NASA01 contact Denver Center, 133.95"			Scan Screen: Tails Status			
		Say "NASA01, Denver Center, 133.95"					Scan Screen: Tails Management			

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			
GOH1	Ground Auto 1	GOH2	Ground Auto 2
Prepare briefing package for Handoff (NASA01)		Pre-Shift Flight Briefings	
		Review handoff packages (NASA01 AC2, AC3, AC4, AC5)	
		START SHIFT	START SHIFT
		Scan Screen: Tails Status	
		Scan Screen: Tails Management	
		Speak w/ OBP ()	
		Review Fuel levels ()	
		Review Weather ()	
		Speak w/ OBP ()	
		Review Fuel levels ()	
		Review Weather ()	
		Speak w/ OBP ()	
		Review Fuel levels ()	
Speak w/ OBP (NASA01) "Going to handoff to GOH2, have a nice flight"		Review Weather ()	
Listen		Speak w/ OBP ()	
Execute handoff (NASA01)		Review Fuel levels ()	
Disconnect (NASA01)		Review Weather ()	
		Speak w/ OBP (NASA01)	
		Review Fuel levels (NASA01)	
		Review Weather (NASA01)	

Handoff & Disconnect	
GOH1	Ground Auto 1
Scan Screen: Tails Status	
Scan Screen: Tails Management:	
Prepare briefing package for Handoff ()	
Review Fuel levels ()	
Review Weather ()	
Interact OBP ()	
"Going to handoff to GOH2, have a nice flight"	
Listen	
Review Handoff Package ()	
Execute handoff ()	
Disconnect ()	

Connect & Multiple Handoffs	
GOH2	Ground Auto 2
Review handoff packages (NASA01, AC2, AC3, AC4, AC5)	
Scan Screen: Tails Status	
Scan Screen: Tails Management	
Review Fuel levels (NASA01)	
Review Weather (NASA01)	
Speak w/ OBP (NASA01)	
Review Fuel levels ()	
Review Weather ()	
Speak w/ OBP ()	
Review Fuel levels ()	
Review Weather ()	
Speak w/ OBP ()	
Review Fuel levels ()	
Review Weather ()	
Speak w/ OBP ()	
Review Fuel levels ()	
Review Weather ()	
Speak w/ OBP ()	

2014 Task Analysis Spreadsheet (Groups)

Nominal Flight Review	
GOH2	Ground Auto 2
Scan Screen: Tails Status	
Scan Screen: Tails Management	
Review Altitude & Heading ()	
Review Fuel levels ()	
Review Weather ()	

New Outbound	
GOH2	Ground Auto 2
Scan Screen: Tails Status	
Scan Screen: Tails Management	Notify: New Outbound ()
Prepare Outbound for release Check weather ()	
Prepare Outbound for release Check flight plan ()	

Single Handoff	
GOH2	Ground Auto 2
Prepare briefing package for Handoff ()	
Speak w/ GDP () "Going to handoff to GOH2, have a nice flight"	
Listen	
Execute handoff ()	
Disconnect ()	

Fuel Temperatures	
GOH2	Ground Auto 2
Scan Screen: Tails Status	
Scan Screen: Tails Management	
Discuss: Fuel Temperatures ()	
Send fuel request/note fuel temps ()	

Security Information	
GOH2	Ground Auto 2
Scan Screen: Tails Status	
Scan Screen: Tails Management	
Receive and Understand message (ATC) " "	
Speak w/ GDP () Discuss: Security information	

Before Takeoff	
GOH2	Ground Auto 2
Review Altitude & Heading ()	Notify: Ready (GDP) ()
Review Fuel levels ()	
Review Weather ()	

2014 Task Analysis Spreadsheet (Groups)

Delays	
GOH2	**Ground Auto 2**
Receive and Understand message (ATC) "Delays at ORD due to weather"	
Scan Screen: Tails Status	
Scan Screen: Tails Management	
Review Altitude & Heading ()	
Review Fuel Levels ()	
Review Weather ()	
Speak w/ DXIP () Discuss: Airport/inbound delays	
Speak w/ Customer care team Discuss: Delays ()	
Speak w/ Reservation coordinator Discuss: Delays ()	

Weather Rerouting	
GOH2	**Ground Auto 2**
Scan Screen: Tails Status	
Scan Screen: Tails Management	
Receive and Understand message (ATC) "Convective storm cell between HOU – DAL"	
Review Fuel levels ()	
Review Weather ()	
Interact OBP () Discuss: Weather rerouting	

Gate Connections	
GOH2	**Ground Auto 2**
Scan Screen: Tails Status	
Scan Screen: Tails Management	
Speak w/ OBP () Discuss: Gate Connection Problem	
Speak w/ OBP () Discuss: Gate Connection Solution	
Contact: Reservation coordinator Discuss: Gate Connections ()	

Maintenance	
GOH2	**Ground Auto 2**
Listen	
Speak w/ OBP () Discuss: Maintenance Problem "Do you have any safety concerns?"	
Listen	
Speak w/ OBP () Discuss: Maintenance Solution "Roger, contacting maintenance"	
Speak w/ Maintenance () Patch through maintenance (collaboration possible)	
Speak w/ OBP () "Maintenance will you meet you at the gate"	
Review Fuel levels ()	
Review Weather ()	

and analysis system

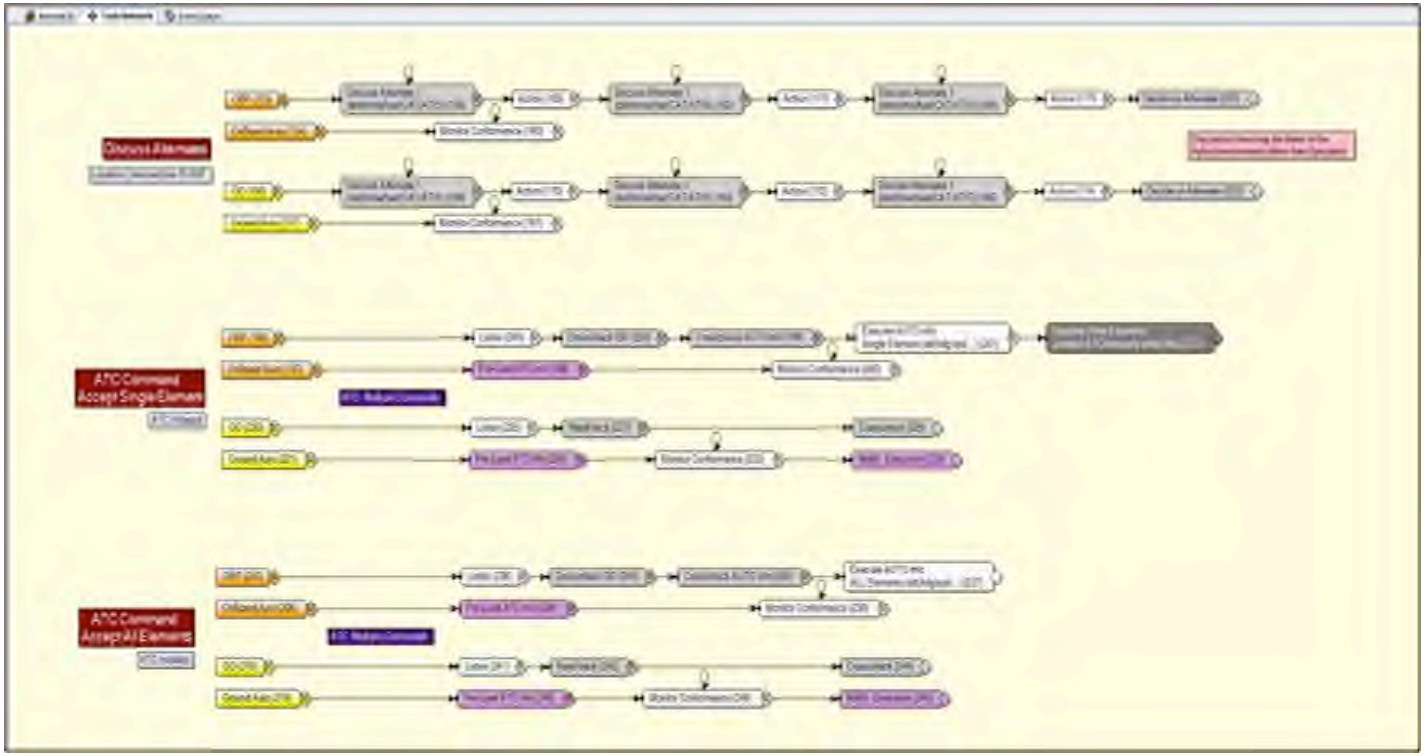
2014 Task Analysis Spreadsheet (Groups - DA)

Dedicated Assistance	
GOH2	**Ground Auto 2**
Notified of wx at DEN, possible hold and divert (NASA01)	Notify: Wx @ DEN
Review Fuel levels (**NASA01**)	
Review Weather (**NASA01**)	
Listen DA request (**NASA01**)	
Review Altitude & Heading (**NASA01**)	
Confirm DA request (**NASA01**)	
Handoff other AC - No briefing	
Speak w/ OBP (**NASA01**): "How can I help?"	
Listen	
"Roger, locating."	
Locate approach plates (CYS/EGE/COS/GJT/PUB)	
Send plates to **NASA01**	Send plates to **NASA01** auto
Review weather (CYS/EGE/COS/GJT/PUB)	
Send weather to **NASA01**	Send weather to **NASA01** auto
Discuss current state	
Agree on preliminary best alternate (CYS)	
Listen	
Confirm duties	
Load primary alternate Airport (CYS)	Notify **NASA01** auto
Discuss probable hold locations & pattern. Discuss fuel state and calculate endurance for a hold. (Find burn to DEN. Desired DEN landing fuel. Current burn rate, Time/fuel remaining. Crosscheck.)	
Pre-load probable hold into CDU	Notify **NASA01** auto
Discuss Alternate 1 (CYS) (distance/time/fuel/CAT/ATIS) (x2)	
Action	
Discuss Alternate 2 (EGE) (distance/time/fuel/CAT/ATIS) (x2)	
Action	
Discuss Alternate 3 (COS) (distance/time/fuel/CAT/ATIS) (x2)	
Action	

Listen to ATC command. Decide on Cheyenne (CYS) as the alternate. Discuss fuel state and calculate endurance for a hold with CYS as new destination. (Find burn to CYS. Desired CYS landing fuel. Current burn rate. Time/fuel remaining. Crosscheck.)	
Say "NASA01 maintaining 17,000', will hold at LANDR"	
Say "Denver Center, NASA01 at LANDR, time 15, 17,000"	
	Notify GO
Crosscheck OBP	
Listen to ATC	
Listen to ATC command. Decide to divert to CYS (the Decide piece requires that alternates are removed from consideration by a process of elimination - weather, distance to land, and fuel - OTHERS?). Execute Alternate 1 Plan.	
Action	
"Denver Center, NASA01 request IFR clearance to Cheyenne via direct"	
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.
Crosscheck AUTO info	
Monitor PF Pre-Arrival Briefing. Crosscheck	
Listen to ATC	
Say "Roger, NASA01, 281 to GILL, maintaining 17,000."	
Listen to ATC	

Say "Roger, NASA01, 350, direct to HAMER, direct CYS, descend and maintain 10,000, expect runway 27 approach; altimeter 28.15"	
	Notify GO
Crosscheck OBP	
	Notify GO
Crosscheck OBP	
	Set 1 ground Altimeter Notify GO & NASA01
Crosscheck 3 Altimeters	
Listen to ATC	
Say "Roger, NASA01, 124.55"	
Say "Cheyenne Approach, NASA01, one zero thousand with Alpha."	
Listen to ATC	
Say "Roger, 9000 for NASA01"	
Notified	Notify GO
Crosscheck OBP	
Listen	
Speak w/OBP: "Roger, releasing dedicated assistance"	
Listen	
Interact NASA01: "No problem, goodnight."	
Notified	Notify GO

Implementing Task Analysis Output #1: Task Representation and Coding



2014 Task Analysis Spreadsheet (w/**DA** Dispatch)

Altitude	Airport Distance	Pilot Flying On- Board Pilot NASA01 (CA)	NASA01 Automation	ATC (cues)	Pilot NOT Flying Ground Operator (Hybrid) 1	Ground Automation 1	Pilot NOT Flying Ground Operator (Hybrid) 2	Ground Automation 2	Pilot NOT Flying Ground Operator (Hybrid) 3	Ground Automation 3
		Speak w/ GO; Discuss Gate connection problem					Speak w/ OBP (NASA01) Discuss: Gate Connection Problem			
		Speak w/ GO; Discuss Gate connection solution					Speak w/ OBP (NASA01) Discuss: Gate Connection Solution			
		Listen					Speak w/ Reservation coordinator Discuss Gate Connections (NASA01)			
		Speak w/ GO; Discuss Wheelchairs					Speak w/ OBP (NASA01) Discuss: Wheel chairs			
							Find Gate Information ()			
		Listen					Speak w/ Customer care team Discuss: Wheelchairs (NASA01)			
		Pre-Arrival briefing, (Taxi Chart, taxi route, gate, flaps, target landing speed, descent speed, brake settings.					Monitor PF Pre-Arrival Briefing Crosscheck			
		Listen to ATC command	Pre-load ATC info	Say "NASA01 Fly heading 281 GILL, maintain one seven thousand"			Listen to ATC			
		Crosscheck GO					Say "Roger, NASA01, 281 to GILL, maintaining 17,000."			
		Listen to ATC	Pre-load ATC info	Say "NASA01, Fly heading 350, Cleared direct HAMER, direct CYS, descend and maintain 10,000, expect runway 27 approach to CYS; Cheyenne altimeter 28.15"			Listen to ATC			
		Crosscheck GO					Say "Roger, NASA01, 350, direct to HAMER, direct CYS, descend and maintain 10,000, expect runway 27 approach; altimeter 28.15"			
		CA crosscheck. If Schema not correct, get ATIS & amend Approach briefing.								
		Execute route	Send to ground auto					Notify GO		
							Crosscheck OBP			
		Exit hold	Send to ground auto					Notify GO		
							Crosscheck OBP			
			Set 2 cockpit Altimeters Notify NASA01 & GO					Set 1 ground Altimeter Notify GO & NASA01		
		Crosscheck 3 Altimeters					Crosscheck 3 Altimeters			
5,879'	49 nm	**Approaching GILL (IAF) at 10000'**								
		Listen to ATC	Pre-load ATC info	Say "NASA01 contact Cheyenne Approach on 124.55"			Listen to ATC			
		Crosscheck GO					Say "Roger, NASA01, 124.55"			
		Execute frequency 124.55 for Cheyenne Approach								
		Speak w/ GO "Forward lavatory is leaking"					Listen			
		Listen					Speak w/ OBP (NASA01) Discuss: Maintenance Problem "Do you have any safety concerns?"			
		Speak w/ GO "No, have maintenance ready on the ground at DEN "					Listen			
		Listen					Speak w/ OBP (NASA01) Discuss: Maintenance Solution "Roger, contacting maintenance"			
							Speak w/ Maintenance (NASA01) Patch through maintenance (collaboration possible)			
		Listen					Speak w/ OBP (NASA01) "Maintenance will you meet you at the gate"			

Dispatch tasks

Dispatch tasks

Continues GO tasks

Continues DO tasks

2014 Task Analysis Spreadsheet (w/GO Dispatch)

Altitude	Airport Distance	Pilot Flying On- Board Pilot NASA01 (CA)	NASA01 Automation	ATC (cues)	Pilot NOT Flying Ground Operator (Hybrid) 1	Ground Automation 1	Pilot NOT Flying Ground Operator (Hybrid) 2	Ground Automation 2	Pilot NOT Flying Ground Operator (Hybrid) 3	Ground Automation 3
		Speak w/ GO: Discuss Gate connection problem					Listen & Crosscheck Route/Arrival		Speak w/ OSP (NASA01) Discuss: Gate Connection Problem	
		Speak w/ GO: Discuss Gate connection solution					Listen & Crosscheck Route/Arrival		Speak w/ OSP (NASA01) Discuss: Gate Connection Solution	
		Listen					Listen & Crosscheck Route/Arrival		Speak w/ Reservation coordinator Discuss Gate Connections (NASA01)	
		Speak w/ GO: Discuss Wheelchairs					Listen & Crosscheck Route/Arrival		Speak w/ OSP (NASA01) Discuss: Wheel chairs	
							Crosscheck Route/Arrival		Find Gate Information ()	
		Listen					Listen & Crosscheck Route/Arrival		Speak w/ Customer care team Discuss: Wheelchairs (NASA01)	
		Pre-Arrival briefing, Class Chart, taxi route, gate, flaps, target landing speed, descent speed, brake settings.					Monitor PF Pre-Arrival briefing Crosscheck		Receive and Understand message (ATC) "Delays at ORD due to weather."	
		Listen to ATC command		Say "NASA01 Fly heading 281 GILL, maintain one seven thousand"			Listen to ATC		Scan Screen: Tails Status	
		Crosscheck GO					Say "Roger, NASA01, 281 to GILL, maintaining 17,000."		Scan Screen: Tails Management	
		Listen to ATC	Pre-load ATC info	Say "NASA01, Fly heading 350, Cleared direct HAMER, direct CYS, descend and maintain 10,000, expect runway 27 approach to CYS; Cheyenne altimeter 28.15"	Continues GO Tasks		Listen to ATC		Review Altitude & Heading ()	
		Crosscheck GO					Say "Roger, NASA01, 350, direct to HAMER, direct CYS, descend and maintain 10,000, expect runway 27 approach; altimeter 28.15"		Review Fuel Levels ()	
		£4 crosscheck If Schema not correct, get ATIS & amend Approach briefing.							Review Weather ()	
		Execute route	Send to ground auto					Notify GO	Speak w/ OSP () Discuss: Airport/inbound delays	
							Crosscheck OBP		Speak w/ Customer care team Discuss: Delays ()	
		Exit hold	Send to ground auto					Notify GO	Speak w/ Reservation coordinator Discuss: Delays ()	
							Crosscheck OBP		Scan Screen: Tails Status	
			Set 2 cockpit Altimeters Notify NASA01 & GO					Set 1 ground Altimeter Notify GO & NASA01	Scan Screen: Tails Management	
		Crosscheck 3 Altimeters					Crosscheck 3 Altimeters		Review Altitude & Heading ()	
5,879'	49 nm	Approaching GILL (IAF) at 10000'								
		Listen to ATC	Pre-load ATC info	Say "NASA01 contact Cheyenne Approach on 124.55"			Listen to ATC		Review Fuel levels ()	
		Crosscheck GO					Say "Roger, NASA01, 124.55"		Review Weather ()	
		Execute frequency 124.55 for Cheyenne Approach							Scan Screen: Tails Status	
		Speak w/ GO "Forward lavatory is leaking"					Listen & Plan		Listen	
		Listen					Listen & Plan		Speak w/ OSP (NASA01) Discuss: Maintenance Problem "Do you have any safety concerns?"	
		Speak w/ GO "Yes, have maintenance ready on the ground at DEN."			Continues GO Tasks		Listen & Plan		Listen	
		Listen					Listen & Plan		Speak w/ OSP (NASA01) Discuss: Maintenance Solution "Roger, contacting maintenance"	
		Listen					Say "Cheyenne Approach, NASA01, one zero thousand with Alpha."		Speak w/ Maintenance (NASA01) Finish through maintenance (collaboration possible)	
		Listen					Listen & Plan		Speak w/ OSP (NASA01) "Maintenance will you meet you at the gate"	

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			
		CA	FO	GO	ALL
Low Workload	Total Low	18	18	2	38
	Percent Low	21.18%	21.43%	33.33%	21.71%
Medium Workload	Total Medium	53	61	3	117
	Percent Medium	62.35%	72.62%	50.00%	66.86%
High Workload	Total High	14	5	1	20
	Percent High	16.47%	5.95%	16.67%	11.43%
Total Tasks	Total Tasks	85	84	6	175
	Percent Entity	48.57%	48.00%	3.43%	100.00%

	Current Day Off-Nominal			
	CA	FO	GO	ALL
Total Low	27	24	2	53
Percent Low	22.88%	21.24%	33.33%	22.36%
Total Medium	70	78	3	151
Percent Medium	59.32%	69.03%	50.00%	63.71%
Total High	21	11	1	33
Percent High	17.80%	9.73%	16.67%	13.92%
Total Tasks	118	113	6	237
Percent Entity	49.79%	47.68%	2.53%	100.00%

		SPO Hybrid Nominal				
		OBP	FD AUTO	GO	GO AUTO	ALL
Low Workload Tasks	Total Low	29	42	8	15	94
	Percent Low	34.12%	100.00%	44.44%	100.00%	58.75%
Med Workload Tasks	Total Medium	46	0	8	0	54
	Percent Medium	54.12%	0.00%	44.44%	0.00%	33.75%
High Workload Tasks	Total High	10	0	2	0	12
	Percent High	11.76%	0.00%	11.11%	0.00%	7.50%
Total Tasks	Total Tasks	85	42	18	15	160
	Percent Entity	53.13%	26.25%	11.25%	9.38%	100.00%

	SPO Hybrid Off-Nominal				
	OBP	FD AUTO	GO	GO AUTO	ALL
Total Low	40	58	24	37	159
Percent Low	28.37%	100.00%	29.27%	100.00%	50.00%
Total Medium	70	0	47	0	117
Percent Medium	49.65%	0.00%	57.32%	0.00%	36.79%
Total High	31	0	11	0	42
Percent High	21.99%	0.00%	13.41%	0.00%	13.21%
Total Tasks	141	58	82	37	318
Percent Entity	44.34%	18.24%	25.79%	11.64%	100.00%

		SPO Specialist Nominal					
		OBP	FD AUTO	GO1	Spec GO	GO AUTOS	ALL
Low Workload Tasks	Total Low	29	42	8		15	94
	Percent Low	34.12%	100.00%	44.44%		100.00%	58.75%
Med Workload Tasks	Total Medium	46	0	8		0	54
	Percent Medium	54.12%	0.00%	44.44%		0.00%	33.75%
High Workload Tasks	Total High	10	0	2		0	12
	Percent High	11.76%	0.00%	11.11%		0.00%	7.50%
Total Tasks	Total Tasks	85	42	18		15	160
	Percent Entity	53.13%	26.25%	11.25%		9.38%	100.00%

	SPO Specialist Off-Nominal					
	OBP	FD AUTO	GO1	Spec GO	GO AUTOS	ALL
Total Low	45	54	9	42	46	166
Percent Low	30.82%	100.00%	29.03%	18.18%	100.00%	48.40%
Total Medium	69	0	19	46	0	134
Percent Medium	47.26%	0.00%	61.29%	69.70%	0.00%	39.07%
Total High	32	0	3	8	0	43
Percent High	21.92%	0.00%	9.68%	0.00%	0.00%	12.54%
Total Tasks	146	54	31	66	46	343
Percent Entity	42.57%	15.74%	9.04%	19.24%	13.41%	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

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