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## A Validated Task Analysis of the Single Pilot Operations Concept

Cynthia A. Wolter San Jose State University Research Foundation

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### Acronyms

ASLabove sea level
ATC Air Traffic Control
ATIS Automatic Terminal Information Service
CACaptain
CDU computer display unit
ConOps concept of operations
CRM Crew Resource Management
CTACognitive Task Analysis
DA Dedicated Assistance
FDDRLFlight Deck Display Research Laboratory (NASA Ames Research Center)
FOFirst Officer
ft feet
FYfiscal year
GO1 Ground Operator 1
GO2 Ground Operator 2
GO3 Ground Operator 3
ILS Instrument Landing System
NAS National Airspace System
NASANational Aeronautics and Space Administration
NextGenNext Generation Air Transportation System
OBP On-Board Pilot
PFpilot flying
PM pilot monitoring
PNGpilot not flying
SME subject matter expert
SPOSingle Pilot Operations

### A Validated Task Analysis of the Single Pilot Operations Concept

Cynthia A. Wolter<sup>1</sup> and Brian F. Gore<sup>2</sup>

### Executive Summary

The current day flight deck operational environment consists of a two-person Captain/First Officer crew. A concept of operations (ConOps) to reduce the commercial cockpit to a single pilot from the current two pilot crew is termed Single Pilot Operations (SPO). This concept has been under study by researchers in the Flight Deck Display Research Laboratory (FDDRL) at the National Aeronautics and Space Administration's (NASA) Ames (Johnson, Comerford, Lachter, Battiste, Feary, and Mogford, 2012) and researchers from Langley Research Centers (Schutte et al., 2007). Transitioning from a two pilot crew to a single pilot crew will undoubtedly require changes in operational procedures, crew coordination, use of automation, and in how the roles and responsibilities of the flight deck and ATC are conceptualized in order to maintain the high levels of safety expected of the US National Airspace System. These modifications will affect the roles and the subsequent tasks that are required of the various operators in the NextGen environment. The current report outlines the process taken to identify and document the tasks required by the crew according to a number of operational scenarios studied by the FDDRL between the years 2012-2014.

A baseline task decomposition has been refined to represent the tasks consistent with a new set of entities, tasks, roles, and responsibilities being explored by the FDDRL as the move is made towards SPO. Information from Subject Matter Expert interviews, participation in FDDRL experimental design meetings, and study observation was used to populate and refine task sets that were developed as part of the SPO task analyses. The task analysis is based upon the proposed ConOps for the third FDDRL SPO study. This experiment possessed nine different entities operating in six scenarios using a variety of SPO-related automation and procedural activities required to guide safe and efficient aircraft operations. The task analysis presents the roles and responsibilities in a manner that can facilitate testing future scenarios. Measures of task count and workload were defined and analyzed to assess the impact of transitioning to a SPO environment.

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### **1.0 Introduction**

When dealing with complex system redesigns such as the proposed Single Pilot Operations (SPO) in the National Airspace System (NAS) in the United States, it is necessary to evaluate the impact that the redesign will have on the roles and responsibilities of all of the agents operating within the system. This analysis can take many forms, including empirical simulations of the environment experiencing the complex redesign, semi-structured task analyses of the redesigned environment, and / or computational modeling to generate predictions of the impact of the redesigned systems on the baseline operational environment (among other approaches). In order to fully understand the effect that new system designs have on the system performance, and on all of the agents within the system, documenting the tasks that are currently required for the safe operation of the system and comparing this baseline task analysis with the tasks required in the redesigned system provides insight into potential problem areas for the redesigned system. The objective of the current research was to conduct a task analysis (iteratively validate/refine sets of tasks) associated with likely SPO environments to measure the impact of transitioning to SPO from current-day operations based on the simulations being completed out of the FDDRL over the past three years.

The current-day flight deck operational environment consists of a two-person Captain/First Officer (CA/FO) crew. A concept of operations to reduce the commercial cockpit from the current two-pilot crew to a single pilot is termed Single Pilot Operations. This concept has been under study by researchers in the Flight Deck Display Research Laboratory (FDDRL) at the National Aeronautics and Space Administration's (NASA) Ames Research Center (ARC) (Johnson, Comerford, Lachter, Battiste, Feary, and Mogford, 2012) and Langley Research Center (LaRC) (Schutte et al., 2007). The ARC FDDRL research focuses on air-ground integration issues, while the LaRC research focuses on flight deck design issues. Both the ARC and LaRC research teams foresee that transitioning from a two-pilot crew to a single-pilot crew will undoubtedly require changes in operational procedures, crew coordination, in use of automation, and in how the roles and responsibilities of the flight deck and Air Traffic Control (ATC) are conceptualized in order to maintain the high levels of safety expected of the U.S. National Airspace System (NAS). The work consisted of: conducting a detailed task analysis of candidate FDDRL scenarios, refining existing current day approaches to reflect the roles/responsibilities of proposed SPO entities, and augmenting the SPO scenarios to include responses to off nominal scenarios using the full implementation of the augmented number of ground based operators. In performing this work, the task analysis team reviewed relevant literature, interviewed subject matter experts with active commercial aviation

### 1.1 The Task Analysis

A task analysis is the process whereby the tasks to safely fly the aircraft with automation are analyzed, documented and outlined (Kirwan & Ainsworth, 1992). The task analysis is a methodology covering a range of techniques to describe, and in some cases evaluate, the humanmachine and human-human interaction in systems. It is often described as the study of what an operator (or team) is required to do in terms of actions or cognitive processes to achieve a specific system state. Typically, it is characterized by a hierarchical decomposition of how a goal-directed task is accomplished, including a detailed description of activities, task and element durations, task frequency, task allocation, task complexity, environmental conditions, necessary clothing and equipment, and any other unique factors involved in, or required for, one or more people to perform a given task (Kirwan & Ainsworth, 1992).

One type of task analysis, the Cognitive Task Analysis (CTA) identifies all of the critical cognitive tasks that the operator is required to perform with the automation (Diaper, 1989; Zachary, Ryder, &

Hicinbothom, 1998). CTA is a family of methods and tools for gaining access to the mental processes that organize and give meaning to observable behavior. CTA methods describe the cognitive processes that underlie the performance of tasks and the cognitive skills needed to respond adeptly to complex situations. Knowledge is elicited through in-depth interviews and observations about cognitive events, structures, or models. Often the people who provide this information are *subject matter experts* (SMEs)—people who have demonstrated high levels of skill and knowledge in the domain of interest (Klein, 2000). The CTA is a complement to traditional task analysis as it adds the capability for designing for the unanticipated by describing the constraints on behavior rather than solely describing the behavior. These approaches feed into a concept-verification phase, where the research concept is verified by a human-system engineer, and preparations are made to implement the results from the task analyses into a model form (Gore, 2008).

### **1.2 Current Day Operations**

The traditional roles of the cockpit operators are defined as Captain (CA) and First Officer (FO) roles. The CA is the main pilot of the aircraft and the one who remains ultimately responsible for the aircraft, its passengers, and the crew. The CA sits in the left seat of the cockpit. The FO is the second pilot of an aircraft. The FO sits in the right-hand seat in the cockpit. One pilot is designated the "pilot flying" (PF) and the other the "pilot not flying" (PNF), or "pilot monitoring" (PM), alternating during each flight phase as necessary. Even when the FO is the flying pilot, the CA is in command and has legal authority of the aircraft. The amount of time either pilot is in control of the aircraft is near equal in normal operations, as the PF designation is passed back-and-forth throughout any given flight. In typical day-to-day operations, the essential job tasks are distributed fairly equally but final decisions always remains with the CA (pilot-in-command). Some have defined the shared roles in the cockpit as being *Aviate*, *Navigate*, *Communicate*, and *Systems Management* (Billings, 1997). Modifications to the manner that this shared cockpit is implemented might be necessary in SPO.

### **1.3 Single Pilot Operations**

In SPO, it is entirely possible that multiple operators and entities will be required to guide the safe transport of the aircraft (Johnson et al., 2012). In this proposed distribution of roles and responsibilities in the SPO environment, a division of tasks between 9 entities will be explored: an On-Board Pilot (OBP), Ground Operator 1 (GO1), Ground Operator 2 (GO2), Ground Operator 3 (GO3), each with their own operator-specific automation (Flight Deck Automation, Ground Automation 1, Ground Automation 2, and Ground Automation 3), and Air Traffic Control. In this SPO iteration, the GOs would be fully trained pilots capable of flying the aircraft alone in the event that incapacitation of the OBP pilot. Three experiments conducted by the FDDRL will illustrate the basis for the scenario-based tasks that were included in the task analysis and the manner that it was created in an iterative fashion.

### 1.4 Single Pilot Operations Background Research

In the first SPO study conducted by Johnson, Comerford, Lachter, Battiste, Feary, and Mogford (2012), pairs of pilots were asked to complete simulated flight segments in each of two conditions: Co-located, and remote. The pilots were purposely presented with a critical situation that required problem solving. The situation was one in which the crew encountered severe weather during their flight and needed to divert to an alternate airport. Scenarios added complexity to the diversion task, such as the amount of fuel onboard to support planned or unplanned diversions and system failures such as anti-skid that required the crew to recalculate landing weights and distances.

The co-located condition required that pilots work together in a two-person flight simulator, a scenario that corresponded to current-day conditions. The remote condition required that the right and left seats of the cockpit be placed in different rooms, a scenario that represented one version of a SPO concept. The crew in the remote condition version of the SPO concept was allowed to communicate freely, however they could not see each other, observe each others' body language or point to information like weather cells on the navigation display. The interaction of the crew would be impacted by this change to SPO and part of the current task was to identify how the tasks would change as a function of such SPO operations.

A second SPO study evaluated the use of Crew Resource Management (CRM) indicators and shared charts to aid both ground and air-based pilots' communication and to enhance collaboration (Lachter, Brandt, Battiste, Ligda, Matessa & Johnson, 2014). Along with nominal, current-day baseline trials, pilots were separated as a distributed crew, with the CA on the flight deck and the FO on the ground, serving as dispatch with limited support to the OBP for multiple company aircraft. The concept of requesting Dedicated Assistance (DA) was also explored, both with the assistance of automation (CRM tools) and without. This study also presented a situation in which the pilots encountered severe weather that necessitated a diversion to an alternate airport.

A third SPO study focused on the transition between actively controlling multiple aircraft to actively controlling a single aircraft during dedicated assistance (see Johnson et al., in press). Two crew configurations were studied to identify the optimal allocation of responsibilities. In the SPO Hybrid condition, one GO performing dispatch duties to the distressed aircraft, along with other company aircraft, would transition to a dedicated assistant (ground-based FO) when requested by the OBP of the distressed aircraft. Their other nominal aircraft was automatically handed off to other GOs. In the SPO Specialist condition, a Specialist GO was waiting, on call, for a dedicated assistance request by an OBP of any distressed aircraft. The distressed aircraft was then automatically handed off from the "dispatch" GO to the Specialist GO.

### 1.5 Single Pilot Operations Candidate Roles

A review of the requirements in the above-described studies augmented the 2013 task analysis of SPO scenario manipulations (Wolter & Gore, 2013). Finer level of detail and validation came from subsequent interviews and collaboration with SMEs (C. Wolter, B. Gore, V. Battiste & R. Kotesky, personal communication, January 30, 2013, and May 16, 2013; C. Wolter. R. Kotesky & W. Preston, personal communication, April 22, 2014). In this paper, we explore the differences between a nominal SPO flight and off-nominal SPO flights that require DA, all of which begin with the same flight plan into Denver. In nominal operations, the OBP would be in sole control of decision-making and flying tasks, only relying on the GO for dispatch information and communication with maintenance and company personnel. In off-nominal operations, the OBP can request DA where the GO becomes a ground-located FO.

In this case, PF and PNF designations would vary between the OBP and the GO, with possible multiple mid-flight reassignments until the OBP releases DA. Most settings and radio communications would remain solely PNF responsibilities. Current CA specific tasks would remain the same and would always fall to the OBP. Both human operators would continually monitor instruments and radio communications, as well as perform crosschecks when notified of a change via voice or automation, and verify that the environment is consistent with their internal schema.

Due to a "separated cockpit", automation will play a large role in notifying the OBP and GO of any changes so that either could verify without undue radio congestion. The current mode of Dispatch or

DA would determine the type of automation available. In the DA mode, automation would notify a human operator if their ground or air-based counterpart had made changes such as: radio frequency, altitude, heading, speed, altimeters, computer display unit (CDU) inputs/executions, entering/exiting holds, approach mode, speed brake, landing gear, touchdown zone elevation, or flaps. In the Dispatch mode, automation would monitor the GO for conformance and notify if an aircraft needs assistance or has not been checked up on for a specified period of time. Automation will also notify parties of emergency situations when an aircraft reaches flight-based touch-points, such as when an aircraft passes below 18,000 ft. Advancements in automation may relieve the human operators of some tasks such as getting the current Automatic Terminal Information Service (ATIS), setting altimeters, loading expected arrival information and clearances from ATC. A major notable difference between the current day and the SPO environment is the shift to 'communication-cued' crosschecks (verbal or automated) rather than 'movement-cued' crosschecks that occur in a shared cockpit. Automation will need to account for these overt and covert characteristics associated with a human "good crew member." Automation that mimics the characteristics of a "good crew member" can lead to increased efficiencies; which in turn lead to increased spare capacity to deal with unforeseen events.

For the all SPO flights analyzed, there is a task decomposition of two candidate roles and responsibilities for the ground operators. In the Hybrid off-nominal condition, a GO who is serving as dispatcher with limited OBP support to 10 aircraft, will hand-off 9 of their aircraft to other GOs when DA is requested by an OBP of a distressed aircraft. They will then perform both dispatch tasks and FO tasks for the distressed aircraft. In the Specialist off-nominal condition, a GO who is serving as dispatcher with limited OBP support to 10 aircraft, will hand-off a distressed aircraft to a specialist GO when DA is requested by the OBP of that aircraft. The specialist GO will then perform both dispatch tasks and FO tasks for the distressed aircraft to a specialist GO when DA is requested by the OBP of that aircraft. The specialist GO will then perform both dispatch tasks and FO tasks for the distressed aircraft.

### **1.6 Research Objectives**

The objective of this research was to iteratively validate/refine sets of tasks associated with likely SPO environments to measure the impact of transitioning to SPO from current day operations. The tasks identified in the task analysis are linked together in a string of both sequential and parallel nodes. These nodes represent networks that can then be used to analyze different scenarios and task assignments for their impact on workload, efficiency, and safety. Possessing such task analyses allows researchers to explore the degree to which the location and roles of pilots (co-located or remote) impact the ability of the crew to work as an effective, separated, two-person crew as compared to a co-located two-person crew. Potential SPO ConOps were measured by task count and task workload to assess the impact of the transition.

### 2.0 Method

For the current research, task decompositions that included both the task analysis and a semistructured CTA of six scenarios (described below) of a planned approach into Denver starting at 37,000 ft Above Sea Level (ASL) with the crew operating under (a) current-day rules, (b) SPO Hybrid rules, or (c) SPO Specialist rules, were completed. Each rule set was tested in either nominal approach to land or an off-nominal condition requiring the dynamic replanning of an alernate airport was completed. The task network analyses are represented with task decomposition spreadsheets and task networks.

### 2.1 Scenarios

*Scenario 1a.* Current Day Nominal: Instrument Landing System (ILS) approach into Denver runway 16L.

The first task analysis scenario began before the top of descent at 37,000 ft ASL, near the YANKI waypoint. The crew included a CA and a FO. For this flight, the CA had the role of PF and the FO that of the PNF. CA/FO specific tasks are noted (see Figure 1a and Appendix A).

*Scenario 1b.* Current Day Off-Nominal: Planned ILS approach into Denver runway 16L with a diversion to Cheyenne runway 27L.

The second task analysis began before the top of descent at 37,000 ft ASL, near the YANKI waypoint. During the descent into Denver, a severe weather hold was initiated at LANDR at 17,000 ft and the crew discussed and decided on their alternate landing points. The crew included a CA and a FO. For this flight, the CA had the role of PF and the FO that of the PNF. CA/FO-specific tasks are noted (see Figure 1b and Appendix B).

Scenario 2a. SPO Hybrid Nominal: ILS approach into Denver runway 16L.

The third ask analysis began before the top of descent at 37,000 ft ASL, near the YANKI waypoint. The crew included an OBP, a company GO (GO1), flight deck automation, and ground automation. Two additional GOs, their ground automations, and ATC are also represented in the analysis. The OBP was always the CA of the flight. The GOs each monitored 10 aircraft, provided limited support, and primarily performed dispatch duties for their assigned aircraft. The GOs were available for DA support but DA was not initiated in this scenario (see Figures 1a, 2a, and Appendix C).

*Scenario 2b.* SPO Hybrid Off-Nominal: Planned ILS approach into Denver runway 16L with a diversion to Cheyenne runway 27L.

The fourth task analysis began before the top of descent at 37,000 ft ASL, near the YANKI waypoint. During the descent into Denver, a severe weather hold was initiated at LANDR at 17,000 ft and the crew discusses and decides on their alternate. The crew included an OBP, a company GO (GO 1), flight deck automation, and ground automation. Two additional GOs, their ground automations, and ATC are also represented in the analysis. The OBP was always the CA of the flight. The GOs each monitored 10 aircraft, provided limited support, and primarily performed dispatch duties for their assigned aircraft. The GOs were available for DA support, which was requested by the OBP of "NASA01." GO 1 then released their other aircraft to the other GOs and offered dedicated support to NASA01 until DA was no longer needed and released by the OBP. During DA, GO also performed dispatch duties for NASA01 (see Figures 1b, 2b, and Appendix D).

Scenario 3a. SPO Specialist Nominal: ILS approach into Denver runway 16L.

The fifth task analysis began before the top of descent at 37,000 ft ASL, near the YANKI waypoint. The crew included an OBP, a company GO (GO 1), a Specialist GO, and their automations. One additional GO, their ground automation, and ATC are also represented in the analysis. The OBP was always the CA of the flight. The GOs each monitored 10 aircraft, provided limited support, and primarily performed dispatch duties for their assigned aircraft. The Specialist GO was "offline" and available for DA support but DA was not initiated in this scenario (see Figures 1a, 2a, and Appendix E). Because DA was not initiated here, the task assignments for this scenario are fundamentally the same as Scenario 1b above.

*Scenario 3b.* SPO Specialist Off-Nominal: Planned ILS approach into Denver runway 16L with a diversion to Cheyenne runway 27L.

The sixth task analysis began before the top of descent at 37,000 ft ASL, near the YANKI waypoint. During the descent into Denver, a severe weather hold was initiated at LANDR at 17,000 ft and the crew discusses and decides on their alternate. The crew included an OBP, a company GO (GO 1), a Specialist GO, and their automations. One additional GO, their ground automation, and ATC are also represented in the analysis. The OBP was always the CA of the flight. The GOs monitored 10 aircraft, provided limited support, and primarily performed dispatch duties for their assigned aircraft. The Specialist GO was "offline" and available for DA support, which was requested by the OBP of "NASA01." The GO then released NASA01 to the Specialist GO but retained their other aircraft. The Specialist GO offered dedicated support to NASA01 until DA was no longer needed and released by the OBP back to the GO. During DA, the Specialist GO would also perform dispatch duties for the distressed aircraft (see Figures 1b, 2c, and Appendix F).

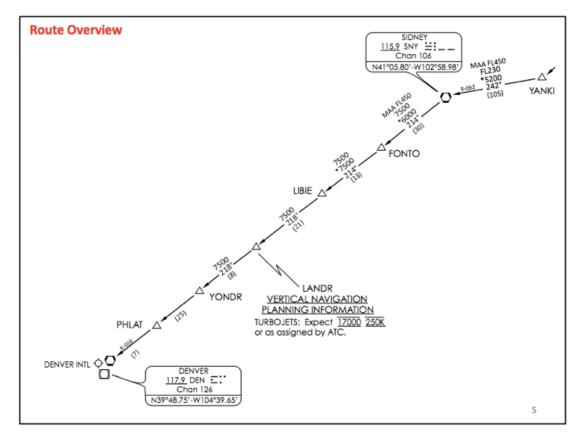


Figure 1a. Denver approach (nominal).

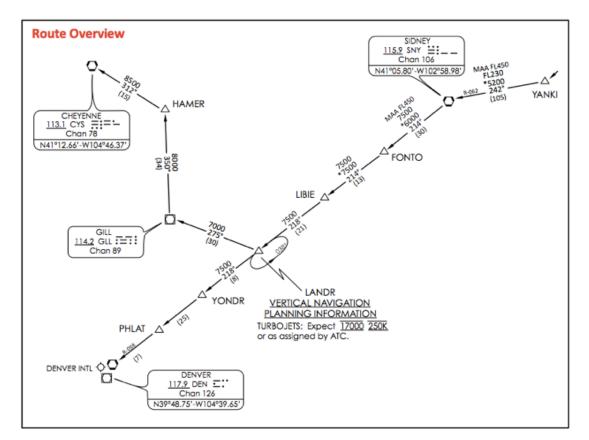


Figure 1b. Divert to Cheyenne approach (off-nominal).

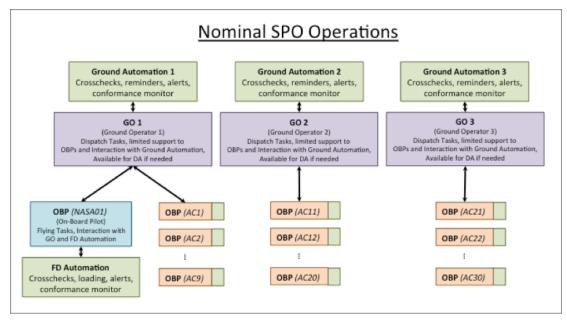


Figure 2a. Nominal SPO operations.

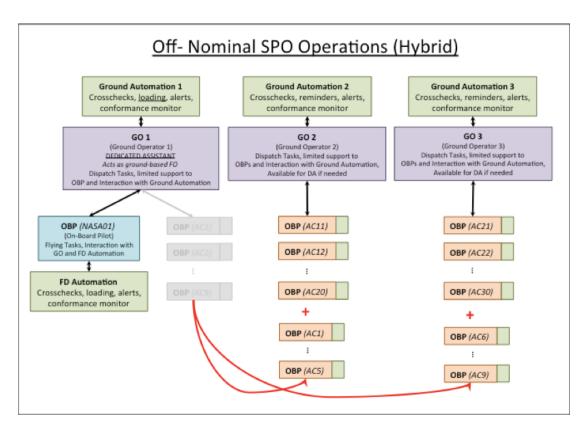


Figure 2b. Off-nominal SPO hybrid operations.

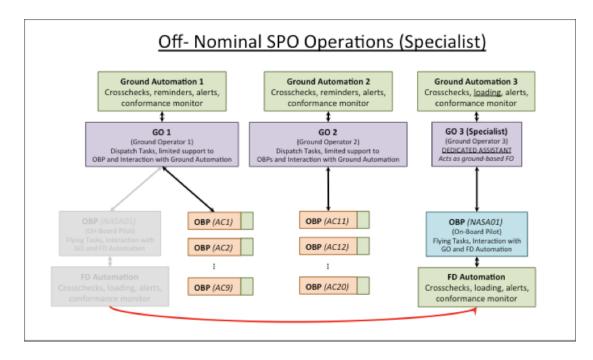


Figure 2c. Off-nominal SPO specialist operations.

### 2.2 Task Representations

Due to the complexity of the operational domains, two task representations were created to convey the details associated with each approach-to-land rule set. This breakdown was necessary given the complexity of the tasks required to safely land an aircraft and to illustrate the tasks that shifted from the well-established and safe concept of operations to the new concept of operations. Possessing such a breakdown allows a baseline operational standard to be compared with a next generation set of tasks. These representations of the tasks include a task decomposition spreadsheet and a task network model representation.

- 1. *Task decomposition spreadsheet.* The task decomposition spreadsheet is an Excel<sup>™</sup> listing of the tasks and their sequential location per entity. The task decomposition was created to describe each task and operator roles in a more detailed, organized, in-depth manner to illustrate the task flow and the operator responsibilities. This complex representation of the task network allows for a more evolved understanding of both the malleable and rigid associations between tasks (see Figure 3a).
- 2. *Micro Saint Sharp task network*. Micro Saint Sharp<sup>™</sup> is a platform for visualizing the task network linearly and identifying trouble spots where there is an increased task load due to the proposed SPO environment. By creating validated task groups, a fluid reorganization of task orders for analysis based on a given scenario can be developed. A difficulty level to each task could be assigned to better understand which tasks are suitable for redistribution to another human operator or to automation (see Figure 3b).

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		Essenia Altitude	Send to ground auto		18985998698698608998	0005000056555556600	Sont Schott, Tally Webs	Cyster Init- (NANAMI)		
		Lieux te AZC	Pre-load ATC infe	Sap "NASA00 contact Deriver Contact, 133-00"			Son Senim: Tally Management			
		Say "NASAH, Davier Center, 133.82"			1		Linen		1	
		Consultants anto only					Result or CONF ()		1	
		Rafe Ingence		1			Discours Wheel chairs			
		Energia radio Imperior					Find Getz Information ()			
		Say "Denver Cantus, NASAM					Spoak w/ Currented Care Team			
		docending through 240°					Datas: Wheekdam ()			
		Linux to ATC Crosscheck	Pro-load ATC info	Say "NASAHI; Denver Contex, doward and maintain 17 threased, Expect ILS RW 16L; Denver allowing 25.57			Spaals to 'OSP'. Ballay excelution			
		C4 creatiants Il Suberta not correct, get ATIS & amend Approach bracing checklist. Say "SAEAH descending to 17					Beven Fuel levels ()		]	
		Say "NAXAIII descending to 17 Bosciend, 29:37"	Set 3 Alteration Natify				Raviow Weather ()	Uplau Inli- (NAMME)		
		Crosscheck anio info: Altimeters					Nam Netters: Tails Names		1	
		Esecus Alterators	Send to ground satu				Scat Screet: Tails Management		1	
		Crosscheck acts info: Altituda			()4)		Ravide Faal lands ()		1 0	
		Easenty Altikule	Send to ground auto Law Alert	-			Review Neether () Scar Screen, Taily Netus	Uples his (NANAR)	-	
		Speak w GO					Linter			
		"forward lawsakey is fasting"					1.0628			

Figure 3a. Task decomposition spreadsheet example.

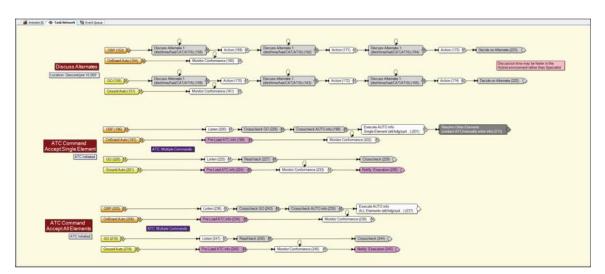


Figure 3b. Micro Saint Sharp task network example.

## 2.3 Concept Verification and the Impact of SPO on Operator Roles and Responsibilities

The task analyses were performed to determine the task differences between the current day and the proposed SPO descent and approach to land phases of flight, in addition to the changes in procedures when the crew is given divert commands from ATC regarding specific significant events (e.g., airport closure). Specific variables of interest included the number of communications, amount/role of automation, number of crosschecks and their impact on crew coordination. The analysis process began with a pre-existing current-day task analysis of a descent into Denver as well as a Divert to Cheyenne due to weather including entering and exiting a hold, deciding to divert to Cheyenne, and to safely land the aircraft. This was altered to represent the tasks required when operator roles are modified in the SPO environment with an OBP, GOs, operator-specific automation, and sometimes a Specialist GO (see Figures 2a, 2b, and 2c). This preliminary representation of significant event scenarios was populated through direct observation of the first and second SPO studies (Johnson et al., 2012; Lachter et al., 2014), observation of, and participation in, the creation of the third SPO study (see Johnson et al., in press), SME evaluations and interviews (C. Wolter, B. Gore, V. Battiste & R. Kotesky, personal communication January 30, 2013 and May 16, 2013; C. Wolter. R. Kotesky & W. Preston, personal communication April 22, 2014) and published reports of anticipated NextGen tasks and operator errors (Gore, Hooey, Mahlstedt, & Foyle, 2013; Gore, Hooey, Haan, Socash, Mahlestedt, & Foyle, 2013; Gore, Hooey, Haan, Bakowski, & Mahlstedt, 2011).

The most insight into the NextGen SPO ConOps was gained through active participation in the third SPO study design meetings. The ideas developed through this iterative simulation development process were fed into the task analysis. Reactions to the Hybrid and Specialist roles from the participants from the third SPO study were also used to further refine the analysis. The task analysis completed in FY14 follows the proposed ConOps from the third SPO study, and presents the roles and responsibilities in a manner that can facilitate generating future FDDRL testing scenarios as well as provide insight into the most efficient use of the crew resource as roles are reassigned. Specifically, the 2013 task analysis was augmented to include a more complex divert scenario based on a specific scenario also used in the third SPO study (see Johnson et al., in press). The previously explored single pilot-on-board role and responsibilities built upon the SPO first-of-its-kind task decomposition (Wolter & Gore, 2013) to define and incorporate a completely new entity (operator and operator role) based upon current dispatch operations.

Gaps identified in previous task analyses were filled by first creating new task analysis spreadsheets, including new entities, tasks, roles, and responsibilities being explored by the FDDRL lab. Multiple iterations of the analyses revealed potential for improvement through task allocation to a different entity. After final scenarios were chosen and populated with high-level tasks, the tasks were refined and decomposed through comparison with SPO-concept reports, and a series of SME interviews. There were three interview sessions conducted where three SMEs (one current CA, one former air traffic controller, and an ATC specialist) reviewed six spreadsheets of very detailed tasks and task orders to represent each scenario. The spreadsheets were organized by altitude and airport distance for the primary aircraft (NASA01), human operator tasks (PNF and PF) with CA assignment, automation tasks, and ATC communications. Using SME input, the task decomposition spreadsheet was modified to be more representative of the proposed SPO environment (see Figure 3a and Appendices A, B, C, D, E, and F).

An alternate set of roles and responsibilities for the crew, that focused on the impact of greater reliance on automation, both on the flight deck, and on the ground was created through SME

interviews. The preliminary analysis revealed a large increase in the number of tasks to be completed in the newest proposal of SPO ConOps, which indicated that on-board pilots and ground operators would need extra assistance from automation if they were to maintain a similar level of workload as previously proposed in the SPO ConOps.

Both representations went through a series of edits to create both an accurate representation of a current-day environment, and a task distribution capable of representing a future SPO concept. The tasks were expanded into higher-level task groups or events such as Weather Rerouting, Maintenance Issues, and Gate Connections. These tasks groups were then entered into the Micro Saint Sharp program as individual networks, providing a flexible means to create new scenarios and identify problem areas by evaluating the task count and the workload (defined below) associated with the group (see Figure 3b and Appendices G, H, and I).

A number of operator specific task groups for the GO are addressing maintenance issues, delays, security threats, customer care, and the complex dedicated assistance change in role. The nominal handoffs during a shift change, off-nominal Hybrid handoffs, off-nominal Specialist handoffs, as well as the handoff that occurs once dedicated assistance is released has been represented in the present analysis. In this representation, automation has been delegated the following tasks; crosschecks, notifications (for both OBP and GO if there is an issue detected such as non-compliance with the issued clearance), reminding (e.g., complete landing checklist at a certain altitude, execute new clearance, check on aircraft passing 18,000 ft, or "have you checked on this aircraft lately?"), and logging flight deck activity to continuously create briefing packages to ease handoffs.

### 2.4 Role and Responsibility Considerations

A review of previous SPO studies revealed that when separated, the aircraft's crew performs additional communications to preserve a consistent mental map of the approach and the candidate divert options (Lachter et al., 2014). These additional communications highlighted a potential area of concern implementing a SPO-like condition; if the crew needed to take immediate action, fewer cognitive, attentional, or even coordinated resources to safely land the aircraft may be available for the crew as they are occupied getting to a consistent mental map. As the crew work to become coordinated, their attentional resources are occupied to a greater extent than if they were already coordinated. This suggests that additional tasks cannot be added to the crew. To alleviate extra communications and radio congestion, the use of CRM tools and shared displays were analyzed (Lachter et al., 2014). Although the automation support was helpful for preserving a consistent mental map, even more automation in different forms may be required. Exploring dedicated assistance revealed potential problem areas for the GO during the transition from handling multiple aircraft to handling one distressed aircraft. The method for the transition would need to be streamlined and defined in detail to ensure the distressed aircraft would receive the level of assistance required.

Automation tasks were based on theoretical advancements in technology currently being tested in a laboratory setting for this task analysis. Here, automation has delegated many typical FO tasks as well as "good crew traits" such as crosschecking. The OBP/CA needs to be able to maintain ultimate control of the aircraft, yet have enough confidence to only crosscheck and execute the information that the flight deck automation has supplied.

A specific SPO ConOps-related gap and research issue was identified for the Ground Operator and a problem aircraft's dispatch tasks. There has been a lack of information on the impact on the dispatch

tasks once dedicated assistance is initiated. Based on our observations and task counts, the optimal role allocation may be for the original GO to retain their dispatch duties for the DA aircraft, assuming there is a moderate- to high-level of automation available to provide some task relief. This can alleviate some of the issues relating to "coming-in-cold" in the Specialist conditions by retaining an operator already familiar with the distressed aircraft.

### 2.5 Task Count and Workload

The task count and the workload associated with the tasks identified through a task analysis can be easily generated once a vetted set of tasks has been created. The task count is simply the number of tasks that the entity is responsible to complete, while the workload associated with the task is related to the attentional load required by the task.

To measure workload in the six scenarios described, each task was described as having low-, medium-, or high-workload demands. The task-analyst classified the workload classifications using the task analysis and workload as a basis for the categorizations (Hamilton, Bierbaum, & McAnulty, 1994; Hamilton, Bierbaum, & Fulford, 1990; McCracken & Aldrich, 1984). Low-workload tasks have been defined as tasks that are either very short in duration and/or require less attention (i.e., listening tasks, executing tasks, or any task performed by automation). Medium-workload tasks have been defined as tasks that occupy more attentional resources, but are normal tasks that are performed often (i.e., speaking and crosschecking). High-workload tasks have been defined as tasks that are unfamiliar and/or very demanding of attentional resources (i.e., discussing, deciding, and final manual landing). Every task in each scenario was given a corresponding workload level and then counted and recorded (see Figures 4a, 4b, 4c, 4d, 4e, and 4f). For the purposes of relevancy, GO and GO Automation tasks were only counted if they directly related to the flight of NASA01. GO tasks outside of the primary flight have not been adequately discussed at this point to confidently measure their shift from beginning to end.

For a nominal approach into Denver, the task count revealed that the total task number is reduced from 175 tasks performed by three entities to 160 tasks performed by four entities for both the SPO Hybrid and SPO Specialist Nominal condition compared to current day (Figure 4a, 4b, and 4c). The number of tasks performed by the CA/OBP remains at 85 tasks in both current day and SPO, 48.57% & 53.13% of the task total respectively. The workload for the CA/OBP also dropped from current day to SPO: High-workload tasks decreased from 16.47% to 11.76%; medium-workload tasks dropped from 62.35% to 54.12%; and, low-workload tasks increased from 21.18% to 34.12%. Across all entities, the same trend can be seen: High-workload tasks decreased from 11.43% to 7.5%; medium-workload tasks dropped from 66.86% to 33.75%; low-workload tasks increased from 21.71% to 58.75%.

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

Figure 4a. Current day nominal task count.

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

Figure 4b. SPO hybrid nominal task count.

			SPO	) Specia	list	N	on	ninal	
		OBP	FD AUTO	GO1	Sp	ec	GO	GO AUTOS	ALL
Low Workload	Total Low	29	42	8				15	94
Tasks	Percent Low	34.12%	100.00%	44.44%	Ш	Ш		100.00%	58.75%
Med Workload	Total Medium	46	0	8				0	54
Tasks	Percent Medium	54.12%	0.00%	44.44%		Ш		0.00%	33.75%
High Workload	Total High	10	0	2				0	12
Tasks	Percent High	11.76%	0.00%	11.11%				0.00%	7.50%
Total Tasks	Total Tasks	85	42	18				15	160
Total Tasks	Percent Entity	53.13%	26.25%	11.25%				9.38%	100.00%

Figure 4c. SPO specialist nominal task count.

For an off-nominal approach into Denver with a diversion to Cheyenne, the total tasks increased when comparing current day (237; Figure 4d) to the SPO Hybrid condition (318; Figure 4e) and the SPO Specialist condition (343; Figure 4f.) The number of tasks performed by the CA/OBP increased in both the SPO Hybrid (141, 44.34%) and SPO Specialist (146, 42.57%) conditions as compared to current day (118, 49.79%). The workload intensity trends were similar between all three conditions; High-workload tasks for current day, SPO Hybrid, and SPO Specialist made up 22.88%, 28.37%, and 30.82% of the total CA/OBP tasks respectively; Medium-workload tasks for current day, SPO Hybrid, and SPO Specialist made up 59.32%, 49.65%, and 47.26% of the total CA/OBP tasks respectively; and, Low-workload tasks for current day, SPO Hybrid, and SPO Specialist made up 17.8%%, 21.99%, and 21.92% of the total CA/OBP tasks respectively. The increase in task number between SPO Hybrid and SPO Specialist is notable for future SPO ConOps development.

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

Figure 4d. Current day off-nominal task count.

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

Figure 4e. SPO hybrid off-nominal task count.

			SPO S	Specialis	t Off-No	minal	
		OBP	FD AUTO	GO1	Spec GO	GO AUTOS	ALL
Low Workload	Total Low	45	54	9	12	46	166
Tasks	Percent Low	30.82%	100.00%	29.03%	18.18%	100.00%	48.40%
Med Workload	Total Medium	69	0	19	46	0	134
Tasks	Percent Medium	47.26%	0.00%	61.29%	69.70%	0.00%	39.07%
High Workload	Total High	32	0	3	8	0	43
Tasks	Percent High	21.92%	0.00%	9.68%	0.00%	0.00%	12.54%
Total Tasks	Total Tasks	146	54	31	66	46	343
Total Tasks	Percent Entity	42.57%	15.74%	9.04%	19.24%	13.41%	100.00%

Figure 4f. SPO specialist off-nominal task count.

### 3.0 Conclusion

It is certainly a challenge to develop a set of tasks for concepts that are just in their infancy as is the case with the SPO concept. The task analyses completed as part of the present research produced a detailed and verified set of tasks representing a nominal, current-day approach into Denver. This task network is the necessary first step for any NextGen SPO approach scenario development process as it illustrates the most likely baseline task set upon which modifications could be proposed and evaluated for moving from a two-person crew to a single pilot being responsible for the operations of the aircraft. It is imperative that this baseline task analysis be accurate so that incremental changes can be proposed and evaluated in subsequent scenario considerations and an informed decision can be made about the costs and benefits of a next generation concept. Two reasonable and plausible SPO scenarios were defined and populated with detailed tasks, operator assignments, and task orders through a series of SME interviews, reviews of published reports, and participation in ongoing SPO experiments conducted in the FDDRL at NASA Ames Research Center.

Based on SPO concept reports, studies conducted in the FDDRL lab, and task analyses performed thus far, a clearer picture of future NextGen SPO ConOps has been formed. To avoid overloading any single human operator during the approach phase of flight, there is an identified need for more reliance on automation to at minimum perform crosschecks and load flight settings. The approach phase of flight is densely populated with tasks from the top of descent to touchdown, requiring input from multiple operators to safely land the aircraft. If tasks currently being performed by two co-located pilots are all assigned to a single OBP, the task load on that operator becomes too great to reliably perform. With two operators collaborating remotely, communication between them presents an obstacle to overcome. Without the physical cues from being co-located, all communications could be made verbally but would add an impractical amount of additional tasks.

The solution in these analyses was to provide support for crew crosschecks through automated notifications of any operator-initiated changes of the aircraft and shift routine setting tasks to automation. Automation would also act as a "good crew member" by reminding the human operators to attend to items that automation recognizes have not been attended to for a period of time. ConOps specifically relating to DA handoffs and DA changes in roles need to be firmly defined to increase the effectiveness of a ground-based FO. Along with some projected advancements in automation to perform basic uploading from ATC functions, tasks being assumed by all three entities (OBP, GO, and automation) rather than just the OBP alone, will help to alleviate task overload on any single operator—especially in the case of any significant and/or unexpected event. The data derived from these task analyses support these conclusions.

### 4.0 Future Research

The SPO scenarios defined thus far represent two flight conditions and two potential ways of assigning tasks between entities in a SPO environment. Next steps could include refinement of the existing task analysis based on additional SME evaluations, as well as extending the task analysis to better define the GO roles and responsibilities. A GO-centric analysis may reveal needs that have not yet been defined. The GO-as-dispatch and GO-as-ground-based-FO tasks have not been adequately defined for analysis as they are entirely new roles, and never before studied. Modifications to the existing scenarios include dissecting the FY14 GO tasks to a finer level of detail, and possibly the impact of requesting DA at the beginning of the GO shift, or shift-start compared to DA at when crew are in the middle of their shift, or mid-shift. To accomplish this, a shift-based task analysis of the GO that includes likely tasks, task allocations, and task workloads for a specific period of time would need to be created. The tasks in the FY15 will be designed to parallel future FDDRL studies via communication/collaboration between teams. There will be an impact assessment of required and time-critical flight crew and ATC tasks under SPO technologies and procedures. Impact will be measured by task count and associated task workload changes and the number of task conflicts.

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		Listen	Listen		Speak w/ FO (NASA01) Confirm request: Maintenance Problem
		Listen	Listen		Speak w/ FO ( <b>NASA01</b> ) Safety inquiry: Maintenance Problem "Do you have any safety concerns?"
			Speak w/ Dispatch "No, have maintenance ready on the ground at DEN."		Listen
					Speak w/ Maintenance (NASA01)
		Listen	Listen		Speak w/ FO ( <b>NASA01</b> ) Relay Resolution: "Maintenance will you meet you at the gate"
18,000' 12,650' AGL	74 nm	Crosscheck.	Turn on exterior lights		
		Crosscheck.	Check Pressurization.		
		Listen.	Check Altimeters as completed on approach descent checklist. If 777/787 observe ECL items are green. Say "Altimeters are set to 29.57. Approach descent checklist complete"		
11,650' AGL	61 nm	Listen to ATC	Listen to ATC	Say "United 573, Fly heading 218, cleared direct PHLAT, direct KIPPR, direct Denver, descend and maintain 10,000, expect runway 16L ILS approach to Denver."	
		Crosscheck.	Say "Roger, United 573, 218, direct to PHLAT, direct DEN, descend and maintain 10,000, expect runway 16L approach."		
		Crosscheck.	Set Altitude.		
		Listen to ATC	Listen to ATC	Say "United 573 contact Denver Approach on 119.3."	
		Crosscheck	Say "Roger, United 573, 119.3."		
		Crosscheck.	Set radio frequency to 119.3 for Denver Approach		
		Crosscheck.	Say "Denver Approach, United 573, one zero thousand with Alpha."		
4,650' AGL	40 nm	Listen to ATC	Listen to ATC	Say "Roger, United 573. descend and maintain flight level 8000"	
		Listen	Say "Roger, 8000 for United 573"		
		Crosscheck.	Set Altitude		
		Listen to ATC	Listen to ATC	Say "United 573, turn left heading 270, base leg."	
		Listen.	Say "Roger, heading 270, base leg, United 573"		
		Crosscheck.	Set Heading		
		Command "Flaps 1"	Listen.		
		Crosscheck.	Reach flap lever. Set flaps to 1.		
		Speed set (210)	Speed confirm (210)		
		Command "Flaps 5"	Listen.		

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	Crosscheck.	Reach flap lever. Set flaps to 5.			
	Listen to ATC	Listen to ATC		Say "United 573, turn left heading 200, maintain 7,000 until established. Maintain 180 kts to LEETS, contact tower on 135.3"	
	Listen.	Say "Roger, left 200, 7,000 until established and 180 until LEETS, contacting Tower at 135.3, United 573"			
	Crosscheck.	Set Heading			
	Crosscheck.	Set Altitude.			
	Crosscheck.	Arm Approach Mode			
	Crosscheck.	Confirm FMA display reads expected			
	Crosscheck.	Set radio frequency to 135.3 for Denver Tower			
2,650' AGL 32 nm	Command "Flaps 15"	Listen.			
	Crosscheck.	Reach flap lever. Set flaps to 15.			
	Speed set (180)	Speed confirm (180)			
	Listen.	Say "Denver Tower, United 573 turning Final for the ILS 16L approach."			
	Listen to ATC	Listen to ATC		Say "United 573, cleared for the ILS 16L approach."	
	Listen.	Say "Roger, cleared for ILS 16L, United 573"			
	Disconnect autopilot.		Aural alert.		
	Command "Gear Down, Landing checklist"	Listen.			
	Crosscheck.	Set landing gear			
	Speed set (146)	Speed confirm (146)			
	CA Arm speed brake.	FO Crosscheck.			
	Contirm "TDZE set"	Set TDZE Listan			
	Command "Flaps 20"	Listen.			
	Crosscheck.	Reach flap lever. Set flaps to 20.			
1,650' AGL 7 nm	Glideslope capture	Confirm capture			
	Crosscheck.	Confirm FMA display reads: LOC & G/S			
	Command "Flaps 25"	Listen.			
	Crosscheck.	Reach flap lever. Set flaps to 25.			
	Command "Flaps 30"	Listen.			
	Crosscheck.	Reach flap lever. Set flaps to 30.			
	Crosscheck.	Complete landing checklist. Sav "Landing Checklist complete"			
	Crosscheck.	Say "Tower, United 573 for RWY one six left"			
	Listen to ATC	Listen to ATC		Say "United 573 cleared to land RWY one six left"	
	Listen.	Say "Roger, cleared to land RWY one six for United 573"			
1,000' AGL 3.9 nm	Listen.	Say "1000 feet"			
	Check stabilize	Check stabilized approach status			
	Acquire runway Sav "Runwav in sight"	Confirm.			
	were in fairman fac				

	Listen.	Say "Approaching DH"	
500' AGL ~1.5nm	Listen.	"500 feet"	
	Recheck stabilize	Recheck stabilized approach status	
	Listen.		
	Listen.	"50"	
	Listen.	"30"	
	Listen.	"20"	
*	Listen.	.01	
Touchdown			

	C Dispatch 1	Continuous Tasks: Maintain           ks: Maintain         company schedule efficency. POC           tion         between AC and other entities.           Route adjustments and reroutings.										contact Denver 33.95"				Denver Center, ain 17 thousand; 16L; Denver 29.57"							
	ATC	Continuous tasks: Maintain separation										Say "United 573 contact Denver Center, 133.95"				Say "United 573; Denver Center, descend and maintain 17 thousand; Expect ILS RW 16L; Denver altimeter 29.57"							
Current Day - Off-Nominal Divert to: CYS ILS RWY 27L 800' Cloud Ceiling Category D	FD Automation																					Lav Alert	
Current Divert to: 800' C	Pilot NOT Flying (FO)	Continuous tasks: Build a common schema - mainly at cross checks. Auditory and Instrument Monitor (continue to TD)	Monitor PF Pre-Arrival Briefing. Crosscheck.	Listen.	Say "Roger"	Get ATIS. Load expected approach/arrival info (Airport, runway, altimeter, target speed, landing flaps, DH, frequencies.) Notify.	Set radio and navigation frequencies and final course		If good captain & threat is evident Crosscheck. Say "Roger."	Read: Approach descent checklist	Set Altitude.	Listen to ATC	Say "United 573, Denver Center, 133.95"	Set radio frequency to 133.95 for Denver Center	Say "Denver Center, United 573 descending through 240"	Crosscheck.		Listen to ATC command.	Say "United 573 descending to 17 thousand, 29.57"	Set 1 Altimeter.	Crosscheck.		
	Pilot Flying (CA)	Continuous tasks: Build a common schema - mainly at cross checks. Auditory and Instrument Monitor (continue to TD)	Pre-Arrival briefing. (Taxi Chart, taxi route, gate, flaps, target landing speed, descent speed, brake settings, time of year, geographic position)	Briefs GSO about procedures and techniques. Say "I'm going to use full reverse on this landing."	Listen.	Crosscheck.	Crosscheck.	If good captain & threat is evident	If good captain & threat is evident Preload CYS into FMS. Say "Preloading Cheyenne into FMS."	Crosscheck.	Crosscheck.	Listen to ATC	Crosscheck.	Crosscheck.	Crosscheck.	Crosscheck.	CA crosscheck. If Schema not correct, get ATIS & amend Approach briefing.	Listen to ATC command.	Crosscheck.	Set 2 Altimeters.	Crosscheck.		
	Altitude Airport Distance	Prior to Final Descent								~110nm TOD	37,000' 104 nm SIDNEY					<u> </u>	<u> </u>						

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		Listen	Listen		Speak w/ FO ( <b>NASA01</b> ) Confirm request: Maintenance Problem
		Listen	Listen		Speak w/ FO ( <b>NASA01</b> ) Safety inquiry: Maintenance Problem "Do you have any safety concerns?"
			Speak w/ Dispatch "No, have maintenance ready on the ground at DEN."		Listen
					Speak w/ Maintenance (NASA01)
		Listen	Listen		Speak w/ FO ( <b>NASA01</b> ) Relay Resolution: "Maintenance will you meet you at the gate"
18,000' 11,879' AGL	74 nm	Crosscheck.	Turn on exterior lights		
		Crosscheck.	Check Pressurization.		
		Listen to ATC	Listen to ATC	Say "All aircraft, Microburst alert at Denver, approaches are temporally discontinued, expect holding for all runways"	
		Crosscheck.	Load primary alternate Airport (CYS).		
		Discuss probable hold locations & pa	Discuss probable hold locations & pattern. Discuss fuel state and calculate		
		Crosscheck.	Pre-load probable hold into CDU		
		Locate all alternate approach plates.			
		Discuss Alternate 1 (CYS) (distance/time/fuel/CAT/ATIS) (x2)	ance/time/fuel/CAT/ATIS) (x2)		
		Action.	Antion		
		Discuss Alternate 2 (distance	Discuss Alternate 2 (distance/time/filel/CAT/ATIS) (x2)		
		Action.			
			Action.		
		Discuss Alternate 3 (distance/time/fuel/CAT/ATIS) (x2)	e/time/fuel/CAT/ATIS) (x2)		
		Action.			
			Action.		
		Listen to ATC	Listen to ATC	Say "United 573, hold North of LANDR on 216 radial, left-hand turns. Maintain one seven thousand, expect further clearance in one zero (10) minutes"	
10,879' AGL	61 nm	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.)	rmate. Discuss fuel state and calculate tew destination. (Find burn to CYS. ht burn rate. Time/fuel remaining. heck.)		
		Listen.	Say "United 573 maintaining 17,000', will hold at LANDR"		
		Crosscheck.	Say "Denver Center, United 573 at LANDR, time 15, 17,000"		
		Crosscheck.	Execute hold.		
		Listen to ATC	Listen to ATC	Say "All aircraft, Tower evacuated due to funnel cloud sighting, divert to other airports."	
		Decide to divert to CYS (the Decide			
		CA: Validates / in agreement with mental map			
_					

		Action.			
			Action.		
		Listen.	"Denver Center, United 573 request IFR clearance to Cheyenne via direct"		
		Listen to ATC	Listen to ATC	"United 573 standby" "United 573 cleared to Cheyenne via direct GILL, direct Cheyenne"	
		Listen.	Say "Roger, direct GILL, direct Cheyenne, United 573."		
		Crosscheck.	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/NNAV.		
		CA: Validates / in agreement with mental map			
		Monitor PF Pre-Arrival Briefing. Crosscheck.	Pre-Arrival briefing. (Taxi Chart, taxi route, gate, flaps, target landing speed, descent speed, brake settings.		
		Listen to ATC	Listen to ATC	Say "United 573 Fly heading 281 GILL, maintain one seven thousand"	
		Crosscheck.	Say "Roger, United 573, 281 to GILL, maintaining 17,000."		
		Listen to ATC	Listen to ATC	Say "United 573, Fly heading 350, Cleared direct HAMER, direct CYS, descend and maintain 10,000, expect runway 27 approach to CYS; Cheyenne altimeter 28.15"	
		Crosscheck.	Say "Roger, United 573, 350, direct to HAMER, direct CYS, descend and maintain 10,000, expect runway 27 approach; altimeter 28.15"		
		Crosscheck.	Execute route.		
		Crosscheck.	Exit hold.		
		CA crosscheck. If Schema not correct, get ATIS & amend Approach briefing.			
		Set 2 Altimeters.	Set 1 Altimeter.		
		Crosscheck.	Crosscheck.		
10,879' AGL	~70 nm	Listen.	Say "Denver Center, United 573, Unable, minimum fuel. Request emergency clearance to"		
		Listen to ATC	Listen to ATC	Say "United 573 cleared to Descend and maintain 10,000'. Contacton ###,##"	
		Crosscheck.	Say "Roger, United 573, cleared to descending to 10,000', ###.##"		
3,879' AGL 4	49 nm	Listen to ATC	Listen to ATC	Say "United 573 contact Cheyenne Approach on 124.55"	
		Crosscheck.	Say "Roger, United 573, 124.55"		
		Crosscheck.	Set radio frequency to 124.55 for Cheyenne Approach		
		Listen.	Say "Cheyenne Approach, United 573, one zero thousand with Alpha."		

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Off-Day Nominal)
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Appendix B.

1,000'AGL 3.9 nm
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	Ground Automation 3	Continuous tasks: Off-Nominal Attern Monitor task adherence. Transiti information packages. Transfer notification.															GO Jasks (Other AC)													
	Filot NOT Flying Ground Operator (Hybrid) 3	Continuents taoks: Audincy & Ater Munitur. Maintain a common schema. Maintain common schema. Maintain common schema. Maintain common schema schema Maintain and schema schema Maintain schema schema Maintain schema schema Maintain schema Maintain Maint																												
	Ground Automation 2	Continuous tasks: Off-Nominal Alerts, Monitor conformance, Trannit information packages, Transfer information packages, Transfer				Remind GO:	Attend to AC #								Update Info (NASA01)								Update Info (NASA01)	Remind GO: Amond to AC O	Update Info (NASA01)	Undate Info (NASA01)	francescol our sundo			
	Filet NOT Flying Ground Operator (Hybrid) 2	Continuous taaks: Auditory & a der Moniter. Maintaine examon schema. Maintaine examon schema. Maintaine examon schema. Maintaine examon schema schema information. A limited support to to OBP (Oher), Available for DA if requested.	Pre-Sluth Flight Boerlogs	Renter handoff packages (NASA0E ACLACLAC4 AC3	Listen Scan Screen: Tails Status	Scan Screen: Tails Management	Review Fuel levels ()	Review Weather () Paulour Evol Levole ()	Review Weather ()	Review Fuel levels () Review Weather ()	Review Fuel levels ()	Review Weather ()	Review Fuel levels (NASA01)	Review Weather (NASA01)	Scan Screen: Tails Status	Scan Screen: Tails Management	Listen	Speak w/ OBP () Discuse Wheel chairs	Find Gate Information ()	Speak w/ Customer Care Team Disense: Wheelchairs ()	Speak w/ OBP: Relay resolution	Review Fuel levels ()	Review Weather ()	Scan Screen: Tails Status	Scan Screen: Tails Management	Review Fuel levels () Review Weather ()	Scan Screen: Tails Status	Listen	Speak w/ OBP (NASA01) Confirm request: Maintenance Problem	Speak w/ OBP (NASA01) Safety inquiry: Maintenance Problem "Do you have any safety concerne?"
SPOILI Hybrid - Nominal NASA01 DEN ILS RWY 16 807 Cloud Celling Cregory D NASA01 Per (YO) - TD GOH 1(x) - 1(y)	Ground Automation 1	Continuous tacks: Off-Nominal Attents: Monitor task adhreneses. Transfer netification. packages. Transfer netification.																			Other AC)									
SPC SAN AS	Pilot NOT Flying Ground Operator (Hybrid) 1	Continuous tasks: Auditory & herr Menitor. Matatalia common schema. Allatalia common schema. Allatalia compary schedule efficeres, Provide ligatich information & limited support to DBP (NAXM). Available for DAM	Prepare briefing package for Handoff (NASA01)								Execute handoff (NASA01)	Disconnect (NASA01)									GO Tasks (Other AC)									
	ATC (cues)	Continuous tasks: Maintain separation														Say "NASA01 contact Denver Center, 133.95"					Say "NASA01; Denver Center, descend and maintain 17 thousand; Expect ILS RW 16L; Denver altimeter 29.57"									
	Flight Deck Automation (NASA01)	Continuous node: Off-Nominal Aterts, Phase of flight alerts, Monibe conformance. Notification of non self-initiated system changes.		Get ATIS. Uplink to FD: expected approacharrival info (Airport, runway, altimeter, target speed, landing Inps, DH, frequencies,) Nocify.										Remind: Approach descent checklist	Send to ground auto	Pre-load ATC info					Pre-load ATC info		Set 3 Altimeters Notify.	1 Commission 1	Send to ground auto	Send to eround auto	Lav Alert			
	Pilot Flying On-Board Pilot NASA01 (CA)		Pre-Arrival brieflag/checklist (Taxi Chart, taxi route, gate, flaps, target landing speed, descent speed, beake settings, time of year, geographic position?		Crosscheck auto info Execute auto info							If most contain & threat is existent	Preload alternatives into FMS. Say "Preloading alternateinto FMS."	Approach descent checklist	Execute Altitude.	Listen to ATC	Say "NASA01, Denver Center, 122.04"	Crosscheck auto info: Radio frequency	Execute radio frequency	Say "Denver Center, NASA01 descending through 240"	Listen to ATC Crosscheck.	CA crosschock. If Schema not correct, get ATIS & amend Approach briefing/checklist.	Say "NASA01 descending to 17 thousand. 29 57*	Crosscheck auto info: Altimeters	Execute Altimeters	Crosscheck auto info: Altitude Execute Altitude	TOWNER TRANSPORT	Speak w/ GO "Forward lavratory is leaking"	Listen	Listen
	NASA01 NASA01 Altitude Distance													~110nm TOD	37,000' 104 mm SIDNEY															

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Notity: Below 18,000 (XXXAB)							
Listen Listen Speak wi Maintenneer (MAM) Padi through maintenneer toidiatenneer Speak wi OBP (MAM) Speak wi OBP (MAM) Maintenneer wil year merk you at Review Ted Laptor Review	Scan Screen: Tails Status Scan Screen: Tails Management Review Abitude & Heading ()	Review Fuel Lavels () Review Worther () Speak w (OBP () Discuss: Arpest inboard delays Speak w (Customer care ream Discuss: Delays () Speak w Reservation conditator Discuss: Delays ()	Scan Screen: Tails Status Scan Screen: Tails Management Review Altitude & Heading () Review Fuel Ievels ()	Review Wenther () Review Attinues: & Heading () Review Venether () Review Wenther () Review Wenther () Scan Screen: Tails Stama	Scan Screee: Tails Management Review Altitude & Hending () Review Fuel levels () Review Wenther ()	Scan Screen: Tails Staten Scan Screen: Tails Management Discuss Fuel Funderatures ()	Som Screen: Lans same Som Screen Tails Management Review Fuel levels () Review Wenther () Som Screen: Tails Status

GO Tasks (Other AC)

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Appendix

																GO Tasks (Other AC)																		
			Update Info (NASA01)										Update mao (NASAUI)	Attend to AC ()											Notify: Below 1.0007 (NASA01)	Undate Indo (NASA01)								
Review Fuel levels ()	Review Weather ()	Receive and Understand message (ATC1* *	Identify relevant AC	Scan Screen: Tails Status	Scan Screen: Tails Management	Speak w/ 08P ()	Con Const Tab Contraction	Son Screen Talk Manadement	Listen	Speak w/ OHP ()	Discuss: Fuel temp test	Calculate fuel temp	Send lest results min taci lemp ()	Scan Screen: Tails Status	Scan Screen: Tails Management	Prepare Outbound for release	Check weather () Prepare Outbound for release	Check flight plan ()	Scan Screen: Tails Status	Scan Screen: Tails Management	Review Weather ()	Review Altitude & Heading ()	Review Fael levels ()	Review Weather ()	Review Altitude & Beading	(NASA01) Review Finel Invels (NASA01)	Review Weather (NASA01)	Scan Screen: Tails Status	Scan Screen: Tails Management	Review Fuel levels ()	Review Weather ()	Review Altitude & Heading ()	Speak w/ 0BP () Discuss: Delays	: Find Gate Information ()
	Say "NASA0), chaned for the ILS 16L approach."															GO Tacks (Other AC)							Say "NASA01 cleared to land RWY one six left"											
	Say "N the II		Aural alert. Send to ground auto	Remind: Landing gear						Remind	Flaps 20		Send to ground auto		Remind: Flans 25		Remind:	Flaps 30		Remind: Landing checklist			, And		"1.000 feet"	Send to enound auto	"Amenachine DH"	"500 feet"		-100-	-50*	"30"	"20"	-10-
turning Final for the ILS 27L approach."	Lister to ATC	Say "Roger, cleared for ILS 271., NASA01"	pilot	Listen	Set landing gear	Set speed (146)	Cd. Acres assessed branches	Set TDZE	1000	listen		Reach and set flaps to 20.	Conference of A discharge	Continuity may apply reads: LOC & G/S	Listen	Reach and set flags to 25.		Liston	Reach and set flaps to 30.		Indicate landing checklist complete	Say "Tower, NASA01 for RWY two seven left"	Listen to ATC	Say "Roger, cleared to land RWY two seven for NASA01"	Listen	Accessing numbers	atten .	Laten	Recheck stabilized approach status	Listen	Listen	Latton	Listen	Letten
													1,050' AGL 7 100												1.000' AGL 3.9 mm			S07 AGL -Inm	1					

	Filet NOT Flying and Operator (Hybrid) 2 Ground Automation 2 Ground Operator (Hybrid) 3 Ground Automation 3	Confinence nacks:         Confinence nacks:         Confinence nacks:           A left Monter:         Confinence nacks:         Autificity & left Monter.           atoms of comparison stores.         Confinence nacks:         Autificity & left Monter.           atoms of comparison stores.         Confinence stores.         Confinence stores.           atoms of comparison stores.         Confinence stores.         Confinence stores.           consort stores.         Confinence storestor.         Confinence storestore. <t< th=""><th></th><th>seen: transfer produces 00. AC2_AC3_AC3_AC50</th><th>Listen Canada Control Control</th><th>Screen Tails Management Remind GO:</th><th>Periors Wenther 0 Antend to AC ()</th><th>Review Fuel Levels ()</th><th>Review Wenther () Review Fuel levels ()</th><th>Review Wenther () Review Finel Involution</th><th>Review Wenther ()</th><th>tere Fuel levels (XASA01)</th><th>view Weather (NASA01)</th><th>icam Screen: Tails Status Update Info (NASA01)</th><th>Screen: Tails Management</th><th>Listen GO Tasks (Other AC)</th><th>Speak w/ OBP () Discuss: Wheel churis</th><th>ind Gate Information ()</th><th>Npeak w. Caustenne Care Taam Discuss: WheekEans ()</th><th>Speak w. OBP. Reday resolution</th><th>Review Fuel hereis ()</th><th>Review Wenther () Update Info (XASA01)</th><th>ican Screen: Tails Status Screen: Tails Management Update Info (NASMI)</th><th></th><th>H</th><th>Listen</th><th>peak w (DBP (AAMU)) fitm request Maintenace Probatin</th><th>Slicy VagAN Slicy VagAN Universure Problem</th><th>Liter</th></t<>		seen: transfer produces 00. AC2_AC3_AC3_AC50	Listen Canada Control	Screen Tails Management Remind GO:	Periors Wenther 0 Antend to AC ()	Review Fuel Levels ()	Review Wenther () Review Fuel levels ()	Review Wenther () Review Finel Involution	Review Wenther ()	tere Fuel levels (XASA01)	view Weather (NASA01)	icam Screen: Tails Status Update Info (NASA01)	Screen: Tails Management	Listen GO Tasks (Other AC)	Speak w/ OBP () Discuss: Wheel churis	ind Gate Information ()	Npeak w. Caustenne Care Taam Discuss: WheekEans ()	Speak w. OBP. Reday resolution	Review Fuel hereis ()	Review Wenther () Update Info (XASA01)	ican Screen: Tails Status Screen: Tails Management Update Info (NASMI)		H	Listen	peak w (DBP (AAMU)) fitm request Maintenace Probatin	Slicy VagAN Slicy VagAN Universure Problem	Liter
ensinal VWY 27L G	Ground Automation 1 Ground Operator (Hybrid) 2	iter. rema. edule atch sport to r DA if		Research Instance Franksons NNSN01, NCC ACC ACCA ACCA	Listen Scan Screen: Tails Status	Scan Screen: Tails Management	Review Worther ()	Review Fuel levels ()	Review Weather () Review Fuel levels ()	Review Wenther () Review Faul Levels ()	Review Weather ()	Review Fuel levels (NASA01)	Review Weather (NASA01)	Scan Screen: Tails Status	Scan Screen: Tails Management	Listen	Speak w/ OBP () Discuss Wheel chairs	Find Gate Information ()	Speak w/ Customer Care Team Discuss Wheelchairs ()	Speak w/ OBP; Relay resolution	Review Fuel levels ()	Review Weather ()	Scan Screen: Tails Status Scan Screen: Tails Management	Review Fuel levels ()	Scan Screen: Tails Status	Listen	Speak w/ OBP (NASA01) Confirm request: Maintenance Problem	Speak w/ OBP (MASA01) Safety inquiry: Maintenance Problem "Do vou have any safety conceme?"	Listen
SPOIII Hybrid - Off-Neminal OS Diverte CS ILS RWY 271. OS Diverte Canod Calling Marcare D NASAH Pre TOD - TD OG H(3) - HD	Eround Operator (Hybrid) 1 Ground A	Continuous tasks: Autlitry & Aret Mennier. Mattrini or cummon sterma. Matatrini compary schedule Off-Somiau AM Matatrini compary schedule of Disk and effectory. Provide digatch andremation & limited support to DBP (xXXM). Available for Dixit requested.	Prepare briefing package for Handoff (NASA01)							Execute handloff (NASA01)	Disconnect (NASA01)									GO Tasks (Other AC)									
	ATC (cues)	Continuous tusks: Maintain separation													Say "NASA01 contact Denver Center, 133.95"					Say "NASA01; Denver Center, descend and maintain 17 thousand; Expect ILS RW 16L; Denver altimeter 29.57"									
	Flight Deck Automation (NASA01)	Continuous tasks: Off-Nominal Alerts, Phase of flight alerts, Monite conformance, Notification of non self-initiated system changes.		Get ATIS. Uplink to FD: expected approach/arrival info (Airport, runway, altimeter, larget speed, landing Raye, DH, frequencies, ) Metify.									Remind: Approach descent checklist	Send to ground auto	Pre-load ATC info					Pre-load ATC info		Set 3 Altimeters Notify.	Send to ground auto		COM OF BUILDING WITH				
	Dn- Board Pilot NASA01 (CA)	Continuous tacks: Auditory and lastrument Monitor. Maintain a common schema.	Pre-Arrival briefing/checklist (Taxi Chart, taxi routs, gats, flaps, tragst landing speed, descent speed, brake settings, time of year, geographic settings, time of year, geographic		Crosscheck auto info Execute auto info							If good captate & threat is evident_ Preload alternatives into FMS. Say "Preloading alternate into FMS."	Approach descent checklist	Execute Altitude.	Listen to ATC	Say "NASA01, Denver Center, 133.95"	Crosscheck auto info: Radio frequency	Execute radio frequency	Say "Deriver Center, NASA01 descending through 240*	Listen to ATC Crosscheck.	CA crosscheck. If Schema net correct, get ATIS & amend Approach briefing/checklist.	Say "NASA01 descending to 17 thousand, 29.57"	Crosscheck auto info: Altimeters Execute Altimeters	Crosscheck auto info: Altitude Breeute Aleitede	ENCOUR CONTINUES	Speak w/ GO "Forward lavratory is leaking"	Listen	Listen	Speak w/ GO *No, have maintenance ready on the ground at DEN.*
	NASA01 NASA01 Altitude Distance												~110nm TOD	37,000' 104 mm SIDNEY															

				GO Tasks (Other AC)								Receives AC Roon GO2															GO Tasks (Other AC)													
	Neifly: Below 18,000 (NASAB1)				Notify Wx (§ DEN						0	Handoff all scher AC	Neetly: DA MODE						Send plates to NASA01 auto	Contraction W10100 and	Schil weather to NASAUL auto							Notely NASA01 auto			Notify NASARI anto	THE TWO AND								12
Speak or Manternater (NASAB1) Parch function framework (collaboration possible) Speak woll Speak woll and Maintenneer of Upyan meet you at Maintenneer of Dynamic and Speak at Review Huller (NASAB1) Review Welder (NASAB1)	Scan Screen: Tails Status	Scan Screen: Tails Management Speak w/ OHP ()	Speak w/ OHP () Speak w/ OHP () Discuss Gate Connection Solution	Comm: Reservation coordinator Discuss Gate Connections ()	Notified of wx at DEN, possible hold and divert (NASA01)	Review Fuel levels (NASA01)	Scan Screen: Tails Status	Listen DA request (NASA01) Review Althouts	(NASA01) Review Heading	(NASA01) Societ w/ OBP: Confirm DA realised	(NASA01)	Cunfirm handoff	Listen	Speak w/ OBP (NASA01): "How can 1 help?"	Listen	"Roger, locating."	Identify alternate atports	(CYS/EGE/COS/GIT/PUB)	Send planes to NASA01 Locate weather	(CYSEGECOS/GITPUB)	Send weather to XASAUI Review plates	Review weather	Agree on preliminary best alternate	(CYS)	Listen.	Confirm during	CONTINUE (LINES)	Load permary amemate Aurport (C.Y.S)	Wenter and the hold location &	concease protectors to an accuration or potente. Discussi field state and calculate endurance for a hold, (Find hum to DEN: Desired DEN inading fuel. Current hum rate. Tumoflud	remaining, Crosscheck.) Bee-load reobable hold into ("Dtl	Arry only seed support seed-stri	(distance/time/fuel/CAT/ATIS) (x2)	Action	Discuss Alternate 2 (EGE)	(distance/time/fuel/CAT/ATIS) (x2)		Discuss Alternate 3 (COS) (distance/time/fuel/CAT/ATIS) (x2)	Action	
				GO Tasks (Other AC)								Receiver AC-from-GO2															GO Tasks (Other AC)													
					Say "All attenti, Microburat alert at Denver, approaches are temporally facontinued, expect holding for all numeays.	Contraction of the second seco																																		
	Remind: Presentization	Turn on exterior lights	Árnew'										"Dedicated Assistance"						Load plates	T and another the	Load weather						And a state of the	Netry OBP			And Ality	2006 2006								
Lister		Check pressurpation	Crosscheck Lights		Lister to ATC	Review weather	Review options Decide DA is needed	Say: "DA Request"			Listen		Listen	Listen	Speak w/ GO: "Locate relevant alternate approach plates and check	Listen				Review plates	Review weather	Distant states state	Agree on preliminary best alternate	(CVS)	review, ATC communication,	decision support	Latera .		Creating to Construct OO	posters proteins consideration as posters. Discuss facel vate and calculate entirrance for a bold. (Find burn to DEN Desired DEN hading fact. Current burn rate. Time/fuel	remaining. Crosscheck.)	Croacheck GO	Discuss Alternate 1 (CYS) (distance/time/fuel/CAT/ATIS) (x2)		Discuss Alternate 2 (EGE)	(distance/time/fuel/CAT/ATIS) (x2)	Action	Discuss Alternate 3 (COS) (distance/time/fuel/CAT/ATIS) (x2)		Action
	18,000' 74 nm																																							

	1																				
Say "NASA01, hold North of LANDR, on 216 radial, Jefb-hand turns. Matintan one seven thousand, creper further clearance in one zero (10)					Say "All aircraft, Tower evacuated due to furnel cloud sighting, divert to				"NASA01 standby" "NASA01 cleared to Cheyenne via direct GilL1, direct Cheyennae"					Say "NASA01 Fly heading 281 GILL, maintain one seven thousand"			Say "MAKAOI, Fly heading 359, Cleared direct IAMEB, direct CYS, descend and mattain 10,000, expect rearway 25, 159 26,154				
Pre-based ATC info				Send to eround auto					Pre-load ATC info	Load CYS as new destination in CDU, Get ATS Bulla a route, Load expected Approach/Artival Information: Aspoot, Runwey, Altimeter, Seede Anaryss, Landing flags, DR, frequencies, Load LAAN/VSAN? Notify GBP	Good to amond with			Pre-load ATC info		Send to ground auto	Pre-based ATC info			Send to ground auto	Send to ground auto
Later to ATC	Decide on Cheyenne (CYS) as the advance. Discuss first state and calculate enderates for a hold with CYS as now detanation. (Find burn to CYS As norted CYS and any field Current hum rate. Time/field remaining. Crosscheck.)	Listen	Croscheck GO	Crosscheck ATC info Execute hold	Listen to ATC	Decide to divert to CYS (the Decide piece requires that alternates are removed from consideration by a precess of elimination - weather, distance to land, and hiely. Execute Alternate 1 Plan.	CA: Validates / in agreement with mental map Action	Listen. Creasehoot GD			Croscheck AUTO info Events suits	CA: Validates / in agreement with mental map	Pre-Arrival briefing. (Taxi Chart, taxi route, gate, flaps, target landing speed, descent speed, brake settings.	Listen to ATC	Listen Crosscheck GO	Crosscheck AUTO info Execute Neading	Lister to ATC	Listen Cresscheck GO	CA crosscheck. If Schema not correct, get ATIS & amend Approach briefing.	Execute reate	Exit hold
	10,879° AGL 61 mm																				

Pre-load ATC info			Update Info (NASA01) / Notify GO					Pre-load AFC info	Load CVS as new destination in CDU. Get ATIS. Build a route. Load expetted Approach Arrival Information: Auport, Ranway, Altimeter. Speed changes, landing flap, DH frequencies. Load LNAXVXXXX Statis GO.	Undate Info (NASA01) / North GO	carb freedon : d cartoron on th child harmadon		Pre-load ATC info		Update Info (NASA01) / Noilly GO	Pre-load ATC info		Update Info (NASA01) / Notify GO
Lister to ATC	Detaile on Chayome (CYS) as the alminum (Distorts that state and calculate enhance for a hold with CYS as new destantion. (Find burn CYS as new destantion of Find burn Courter burns rate. Then find remaining Crosselveck) syrViASAD maniforming Crosselveck) and bud a LANDPC	Say "Denver Center, NASA01 at LANDR, time 15, 17,000*	Crosscheck hold	Listen to ATC	Decide to divert to CYS (the Decide piece requires that hiermakes are removed from consideration by a process of elimination - weather, distance to land, and facf). Execute Alternate 1 Plan.	Action	"Denver Center, NASA01 request FR clearance to Cheyenne via direct"	Lister to ATC		Crosscheck AUTO info	Crusscheck route	Monitor PF Pre-Arrival Briefing. Crosscheck	Listen to ATC	Say "Roger, NASA01, 281 to GHJ., maintaining 17,000,"	Crosscheck Heading	Lister to ATC	Say "Roger, NASA01. 350, direct to HAMEB, direct CYS, descend and maintain 10,000, expect narway 27 approach, altimeter 28.15"	

GO Tasks (Other AC)

GO Tasks (Other AC)

						GO Tasks (Other AC)								Give AC to GO2												GO Tasks (Other AC)														
Set 1 ground Altimeter Notify GO & NASA01		Pre-load ATC info				Pre-load ATC info		Update Info (NASA01) / Nonfy GO					Update Info (NASA01) / Notify GO				Update Info (NASA01)						Remind GO: Amend to AC ()		Update Info (NASA01)		Update into (NASA01)	Update Info (NASA01)			Update Info (NASA01)						Update Info (NASA01)			
	Crosscheck AUTO info Execute Altimeter	Listen to ATC	Say "Roger, NASA01, 124.55"	Crusscheck AUTO info Execute radio frequency	Say "Cheyenne Approach, NASA01, one zero thousand with Alpha."	Listen to ATC	Say "Roger, 9000 for NASA01"		Crosscheck Allitude Listen	Speak w/OBP. "Canfirming Dedicated Assistance release"	Listen	Interact NASA01: "No problem, secondicited "	Ħ	Request AC return	Roceive other AC	Scan Screen: Tails Status	Scan Streem Tails Management	Review Fael levels ()	Scan Screen: Tails Status	Scan Screen: Tails Management	Review Fuel levels ()	Review Weather ()	Scan Screen: Tails Status	Scan Screen: Tails Management	Review Fael levels ()		Review Weather ()	Scan Screen: Tails Status	Scan Screen: Tails Management	Review Fuel levels ()	Review Weather ()	Scan Screen: Tails Status	Scan Screen: Tails Management Review Fuel levels ()	Review Weather ()	Review Altitude & Heading ()	Receive and Understand message (ATC)*	Identify relevant AC	Scan Screen: Tails Status	Scan Screen: Tails Management Speak w/ 08P ()	Discuss: Security information
						GO Tasks (Other AC)								Gives AC in GO2												GO Tados (Other AC)														
		Say "NASA01 contact Cheyenne Approach on 124 55"	- 10.45 a 49 b			Say "Roger, NASA01. descend and maintain flight level 9000*								Say "NASA01, turn left heading 350, base les."								Say "NASA01, turn left besiding 280, maintain 7,800 until established Maintain 180 kts to ZUNUG, contact tuvert on 118.7*													Say "NASA01, cleared for the ILS 27L approach."					
Set 2 cockpit Altimeters Notify NASA01 & GO		Pre-load ATC info				Pre-load ATC info		Send to ground auto					Send to ground auto	Pre-load ATC info			Send to ground auto Remind	Flaps 1		Remind: Flave 4		Pre-load ATC Info			Send to ground auto		Send to ground auto Remind	Arm approach mode Send to ground auto			Send to ground auto Remind	Flaps 15					Aural alert. Send to ground mito	Remind: Landing gear		
	Crosscheck AUTO info Execute Altimeters	Lister to ATC	Listen Crosscheck GO	Crusscheck AUTO info	Listen. Cresscheck GO	Listen to ATC	Listen. Crosscheck GO	Crosscheck AUTO info Execute Altinude	Speak w/ GO: "I am ready to refease Dedicated Accorded."	Listen	Speak w/ GO: "Thanks for the assistance"	Listen	Execute DA release	Listen to ATC	Say "Roger, heading 350, base leg. NA 5 A01"	Crosscheck AUTO info	Execute Meading	Leton	Reach and set flaps to 1 Set speed (210)	Listen	Reach and set flaps to 5.	Listen to ATC	Say "Roger, left 280, 7,800 until established and 180 until ZUNUG, contacting Tower at 118.7, xxx s.xviv	Crosscheck auto info: Altitude	Execute Alfinade	Crossefreek auto info: Heading	Execute Heading Listen	Arm Approach Mode	Confirm FMA reads as expected	Crossences ano mos Radio frequency	Execute radio frequency		Reach and set flaps to 15. Set speed (180)	Say "Cheyenne Tower, NASA01 turning Final for the ILS 27L approach."	Listen to ATC	Say "Roger, cleared for ILS 27L, NAS AD1*	Ħ		Set landing gear Set speed (146)	double to sandle use
		3,879' AGL 49 mm												2,879' AGL 15 nm						4											10000	1,679' AGL. 15 mm								

Off-Hybrid Nominal)	
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Appendix	

														GO Tasks (Other AC)													
						Update Info (NASA01)		Notify: New Outbound ()			Remind GO: Attend to AC ()						Notify: Below 1,000' (NASA01)	Update Info (NASA01)									
Scan Screen: Tails Status	Scan Screen: Tails Management	Listen	Speak w/ OBP ()	Discuss: Fuel temp test	Calculate fuel temp	Send test results/min fael temp ()	Scan Screen: Tails Status	Scan Screen: Tails Management	Prepare Outbound for release Check weather ()	Prepare Outbound for release Check flight plan ()	Scan Screen: Tails Status	Scan Screen: Tails Management	Scan Screen: Tails Status	Scan Screen: Tails Management	Speak w/ OBP () Discuss: Gate Connection Problem	Speak w/ OBP () Discuss: Gate Connection Solution	Comm: Reservation coordinator Discuss Gate Connections ()	Review Altitude & Heading (NASA01)	Review Fuel levels (NASA01)	Review Weather (NASA01)	Scan Screen: Tails Status	Scan Screen: Tails Management	Review Fuel levels ()	Review Weather ()	Speak w/ OBP () Discuss: Airnort/inhound delays	Speak w/ Customer care team	Discuss: Letays ()
														GO Tasks (Other AC)													
															Say "NASA01 cleared to land RWY two seven left"												
			Remind:	Flaps 20		Send to ground auto		Remind: Flaps 25		Remind: Flaps 30		Remind: Landing checklist					"1,000 feet"	Send to ground auto	"Approaching DH"	"500 feet"		001.	-50*	-30*	"20"	_10_	
C4 Arm speed brake	Set TDZE		Listen		Reach and set flaps to 20.	Glideslope capture	Confirm FMA display reads: LOC & G/S	Listen	Reach and set flaps to 25.	Listen	Reach and set flaps to 30.		Indicate landing checklist complete	Say "Tower, NASA01 for RWY two seven left"	Listen to ATC	Say "Roger, cleared to land RWY two seven for NASA01"	Listen	Acquire runway	Listen	Listen	Recheck stabilized approach status	Listen	Listen	Listen	Listen	Listen	
					- 1	1,670° AGL 5.1 nm											1,000' AGL 3.9 nm			500' AGL ~Inm							Touchdown

	Ground Automation 3	Continuous tacks: Off-Numinal Atterns. Parase of flight alterns. Monitor taxa andirereace. Notification of non self-initiated system changes. Transfer notification.														Other AC)													
	Pilot NOT Flying Ground Operator (Hybrid) 3	Continuous tacks: Auditory & alert Monitor. Maintain a comton schema. Act a First Officer to DA aircraft &provide dispatch information.														GO Tasks (Other AC)													
	Ground Automation 2	Continuent tasks: Off-Nominal Alerts, Monitor conformance. Transmit information packages. Transfer notification.			Renind GO:	Vietna to ALC U								Update Info (NASA01)								Update Info (NASA01)			Update Info (NASA01)				
	Pilot NOT Flying Ground Operator (Hybrid) 2	Continuous taols: Auditory & alter Monitor. Maintain e common schema. Maintain e common schema. Maintain e compasy schedule efficiency. Provide dispatch information & lumited sigpatch information & number for DA if requested.	Pyce Shift Flight Brochiges	Review handoff packages (SASA01, AC2, AC3, AC4, AC5)	Listen Scan Screen: Tails Status	Scan Screen: Tails Management	Review Fuel levels ()	Review Fuel levels ()	Review Weather ()	Review Fuel levels () Review Weather ()	Review Fuel levels ()	Review Weather () Review Fuel levels (NASA01)	Review Weather (NASA01)	Scan Screen: Tails Status	Scan Screen: Tails Management	Listen	Speak w/ OBP ()	Find Gate Information ()	Speak w/ Customer Care Team Discuss: Wheelebairs ()	Speak w/ OBP: Relay resolution	Review Fuel levels ()	Review Weather ()	Scan Screen: Tails Status	Scan Screen: Tails Management Review Fuel levels ()	Review Weather ()	Listen	Speak w <sup>1</sup> OBP (NASA01) Confirm request: Maintenance Problem	Speak w/ OBP (NASA01) Safety inquiryt: Maintenance Problem "Do you have any safety concerns?"	Listen
SPOIII Specialist - Nominal NASA01 DEN ILS RWY 16 800 Cloud Celing Ortegory D NASA01 Pre TOD - TD GOH 1(x) - 1(y)	Ground Automation 1	Continuous tacks: Off-Nominal Alexts: Monitor tack adhrenees. Transfer notification.																		Other ACI									
SVN NVS	Pilot NOT Flying Ground Operator (Hybrid) 1	Continuous tasks: Auditory & Aster Meanitor. Maintain economous sciencia. Maintain economous sciencia. Maintain economous de la contra efficiency. Provide dispatch information & limited support to OBP (NASMI), resultable for DA if requested.	Prepare briefing package for Handoff (NASA01)								Execute handoff (NASA01)	Disconnect (MSM01)								GO Tasks (Other AC)									
	ATC (cues)	Continuous tacks: Maintain separation													Say "NASA01 contact	LIGHTER CONCE 133:32				Say "NASA01; Denver Center, descend and maintain 17 thousand; Expect ILS RW 161.; Denver altimetor 29.57"									
	Flight Deck Automation (NASA01)	Continuous tasks: Off-Nominal Aterts, Phase of flight alerts. Monibe confirmance. Notification of non self-initiated system changes.		Get ATIS. Uplink so FD: expected approach/arrival info (Aipport, runvay, altimeter, target speed, landing flaps, DH, frequencies.) Notify.									Remind:	Send to ground auto	Pre-load ATC info					Pre-load ATC info		Set 3 Altimeters Novito	1 MARIN'	Send to ground auto	Send to ground auto				
	Ou-Board Filet NASA01 (CA)		Pre-Arrival brieflag/checklist (Taxi Chart, taxi route, gate, flaps, target landing speed, descent speed, beake settings, time of vear, geographic position)		Crosscheck auto info Execute auto info							If good captate & threat is evident Preload alternatives into FMS. Say "Preloading alternateinto	Approach descent checklist	Execute Altitude.	Listen to ATC	Say "NASA01, Denver Center,	Crosscheck auto info:	Radio frequency Execute radio frequency	Say "Deriver Center, NASA01 descending through 240"	Listen to ATC Crosscheck.	CA crosschock. If Schema not corroct, get ATIS & amend Americach beiefine/checklist.	Say "NASA01 descending to 17 shourand 20.57"	Crosscheck auto info: Altimeters	Execute Altimeters Crosscheck auto info: Altitude	Execute Altitude	Speak w/ GO "Forward lavratory is leaking"	Listen	Listen	Speak w/ GO *No, have maintenance ready on the ground at DEN.*
	NASA01 NASA01 Altitude Distance												~110mm	37,000' 104 mm	L'IVIIIC														

				Say "NAKA01. Fly bauling 25, denoid direct PHLAY, direct KIPPR, direct Denoe; KIPPR, direct Denoe; descend and maintain 10,000, expect transay 164. LLS approach to Denore;			Say "NASA01 contact Denver Approach on 110.2 °	111			Say "Roger, NASA01. descend and maintain flight level 8000"		Say "NASA01, turn left	T					D	say 'NASA01, mu bett beeding 200, maintain 7,000 until established. Maintain 180 kts to LEETS, contact tower on 185 ve										
	Remind: Pressurization	Turn on exterior lights	Notefy	Pre-load ATC info		Send to ground muto Send to stround auto			Send to ground auto		Pre-load ATC info		Send to enound acto	Rentado	Flaps 1		Remind: Flaps 5	Pre-load ATC info	Pre-load ATC info			Send to ground auto		Send to ground auto	Remind: Arm approach mode	Send to ground auto		Send to ground nuto Remind:	Flaps 15	
Later		Check pressurization	Crosscheck Lights	Lister to ATC	Say "Roger, United 573, 218, direct to PHLAT, direct DEN, descend and maintain 10,000, expect nurway 161. approach.*	Execute Alimitede Execute Reading	Listen to AFC	Say "Roger, United 573, 119.3,"	Execute Radio	Say "Denver Approach, United 573, one zero thousand with Alpha."	Listen to AFC	Say "Roger, heading 350, hase leg. NASA01" Chorobook A1700.066	Execute Mealine	Gamma a concession	Listen Reach and set flans to 1	Set speed (210)	Listen	Reach and set flaps to 5. Listen to ATC	Listen to ATC	Say "Roger, heading 270, base log, United 573"	Crosscheck auto info: A binde	Execute Altitude	Crosscheck auto info: Heading	Execute Heading	Listen	Arm Approach Mide Centium FMA reads as expected	Crosscheck auto info: Radio frequency	Execute radio frequency	Reach and set flaps to 15.	Set speed (180) Say "Cheyenne Tower, NASA01 turning Final for the ILS 27L approach."
	18,000' 61 nm 11,659' AGL 61 nm										4,650° AGL 40 mm																	2.650' AGL 327 nm		

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	Notify: Below 18,00			Remind GO Amend to AC								Notify: Autopilot d													
Speak wi Matteriner (NAMM) Pach Intength mainteastore (cellaboration possible) Relag Resolution Mainteastore will you meet you at Amatterastore will you meet you at Review Pull Ford (NAMM) Review Pull Ford (NAMM)	Scan Screen: Tails Status	San Serece Taih Anagement Discuss Gare Connection Problem Speak vol 2019 () Discuss Gare Connection Solution Discuss Gare Connection Solution Comm. Reservation coordinator Discuss Gate Connections ()	Receive and Unlexisted 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/ OBP () Discuss: Aspertinbound delays Speak w/ Cutiones care team Discuss Delays ()	Speak w/ Reservation coordinator Discuss: Delays ()	Scan Screen: Tails Status	Review Altitude &	Review Fael levels ()	Review Weather () Review Altitude & Heading ()	Review Fuel levels ()	Review Weather () Review Weather () Scan Screen: Tails Status	Scan Screen: Tails Mattagement	Review Altitude & Heading ()	Review Fuel levels ()	Review Weather ()	Scan Screen: Tails Management Scan Screen: Tails Management	Discuss: Fuel Temperatures () Scan Screen: Tails States	Scan Screen: Tails Management	Review Pael levels ()	Review Weather ()	Scan Screen: 14115 Auragement Scan Screen: Tails Management	

GO Tasks (Other AC)

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Appendix E.

														GO tasks (Other AC)															
the ILS 16L approach."																			Say "NASA01 cleared to land RWY one six left"										
		Aural alers. Send to ground auto	Remind: Landing gent					Remind:	Flaps 20	Could to another meter	COLUMN OF RECORDS	Remind: Flags 25		Remind: Flags 30		Remind: Landing checklist					"1,000 feet"	Send to ground auto	"Approaching DH"	"300 feet"	-100	-30*	~30%	=07=	-10-
Listen to ATC	Say "Roger, cleared for ILS 271., NASA01"	Disconnect autopilot	Listen	Set landing gear	Set speed (146)	C4 Arm speed brake	Set TDZE	Listen		Reach and set flaps to 20.	Confirm PMA display reade LOC & G/S	Listen	Reach and set flaps to 25.	Listen	Reach and set flaps to 30.		Indicate landing checklist complete	Say "Tower, NASA01 for RWY two seven left"	Listen to AFC	Say "Roger, cleared to land RWY two seven for NASA01"	Listen	Acquire ranway	Listen	Listen Bacheels stabilized measured status	PLOCIDENT MADULECU ALL'ANDRE MADULE	Lasten	Listen	Liston	Laton
										1 440' AC1 7											1,000' AGL 3.9 nm			S02'AGL -Imm					

															GO Tasks (Other AC)															
			Remind GO: Attend to AC ()																			Notify: Below 1,000 (NASA01)								
Review Weather ()	Receive and Understand message (ATC)*	Identify relevant AC	Scan Screen: Tails Status	Scan Screen: Tails Management	Speak w/ 08P () Discuss: Security information	Scan Screen: Tails Status	Scan Screen: Tails Management	Liston	Speak w/ OBP () Discuss: Fuel temp test	Calculate fuel temp	Send test results min fuel temp ()	Scan Screen: Tails Status	Scan Screen: Tails Management	Prepare Outbound for release Check weather ()	Prepare Outbound for release Check flight plan ()	Scan Scrotn; Tails Status	Scan Screen: Tails Management	Review Weather ()	Review Altitude & Heading ()	Review Fael levels ()	Review Weather ()	Review Altitude & Heading (NASA01)	Review Fael levels (NASA01)	Review Weather (NASA01)	Scan Screen: Tails Status	Scan Screen: Tails Management	Review Fuel levels () Review Weather ()	Review Altitude & Heading ()	Speak w/ OBP () Discose Palace	L'aitement Louisja

	cround Automation 3 Specialist)	take Cartonovor totake Annune Cartonovor totake Annune Art as Moniber totak andrerenee. Norditensino of non-sof-initiated vareredin. ysteren changes. Transfer formation.															OBhe												
	Etlot NOT Flying Ground Operator (Specialist)	Continuours tasks: Auditory & alert Manitor. Maintain a common schema. Act as Frast Officer to DA aircraft & provide dispatch information.																1											
	Ground Automation 2	Continuous tasks: Off-Nominal Arter: Monitor task adhrenses. Transfer aoffication. packages. Transfer aoffication.			Remind GO: Attend to AC ()								Update Info (NASA01)							Remind GO: Anend to AC ()		Update Info (NASA01)							Notify: Below 18,000' (NASA01)
	Filet NOT Flying Ground Operator (Assistant) 2	Continuous tasks: Auditory & alert Monitor. Maintain a cosmoon schema. Maintain acquery schedule efficiency. Provide dispatch information & lumited support to Other, Available for DA if requested.	Pro-Shift Pight Briefregs	Review Standoff packages (NAS A01, AC2, AC3, AC4, AC5)	Lästen Scan Screen: Tails Status	Scan Screen: Tails Management Review Fuel levels ()	Review Weather ()	Review Fuel levels () Review Weather ()	Review Fuel levels () Review Weather ()	Review Fuel levels () Review Wordow ()	Review Fuel levels (NASA01)	Review Weather (NASA01)	BEGIN SPO III scenario events	Scan Screen: Tails Status	Scan Screen: Tails Management	Speak w/ OBP () Discuss: Wheel chairs	Find Gate Information () Comm: Customer care team	Discuss: Wheekenairs () Review Fuel levels ()	Review Weather ()	Scan Screen: Tails Status	Scan Screen: Tails Management Review Fuel levels ()	Review Weather ()	Speak w/ OBP (NASA01) Discuss: Maintenance Problem	Do yee nave any succy concerns : Listen	Speak w/ OBP (NASA01) Discuss: Maintenance Solution "Doors consection meiotrenance"	Speak w/ Maintenance (NASA01) Speak w/ Maintenance (NASA01) Patch through maintenance (collaboration nossible)	Speak w/ OBP (NASA01) "Maintenance will you meet you at	Review Fuel levels (NASA01) Review Worther (NASA01)	Scan Screen: Tails Status
SPOIII Specialist - Off-Nominal SPOIII Specialist - Off-Nominal OS Divert to: CYS1LS RWY 27 880° Choud Ceiling Category D NAS401 Pre 1000 - 110 GO 1(1) - 1(1)	Ground Automation 1	Continuous tacks: Continuous tacks: Off-Nominal Attents: Monitor task adherence. Transfer notification. packages. Transfer notification.																		Other AC)									
III04S	Pilot NOT Flying Ground Operator (Assistant) 1	Continuous tasks: Auditory & alert Menitor. Maintain eromon schema. Maintain eromon schema. Alfarens: Provide dispatch information & limited support to OBP (AXSA0), Available for DA if requested.	Prepare briefing package for Handoff (NASA01)							Execute handoff (NASA01) Disconnect (NASA01)										GO tasks (Other AC)									
	ATC (cuts)	Continuous tasks: Maintain separation												Say "NASA01 contact Denver Center, 133.95"				Say "NASA01; Denver Center, descend and maintain 17 thousand; Expect ILS RW 161; Denver altimeter 29.57"											
	Flight Deck Automation (NASA01)	Continuous tasks: Ott-Sominal Arets, Phase of flight alerts, Monitor task adherenes, Notification of non self-initiated system changes.		Get ATIS. Uptimk to FD: expected approacharival info (Airport, runway, altimeter, target speed, landing flaps, DM, frequencies.) Notify.								Remind: Approach descent checklist	Send to ground auto					Pre-load ATC info		Set 3 Altimoters Notify.		Send to ground auto							
	Pilot Flying Ou-Board Pilot NASA01 (CA)	Continuous tasks: Auditery and lastrument Monitor. Maintáin a common schema.	Pre-Arrival briefing/checklist (Taxi Chari, taxi routs, gate, flaps, larget landing speed, descerti speed, beake settings, time of year, geographic position)		Crosscheck auto info Execute auto info						If good captain & threat is evident_ Preload alternatives into FMS. Say "Preloading alternate into FMS."	Approach descent checklist	Execute Altitude.	Listen to ATC	Say *NASA01, Denver Center, 133.95*	Set Radio.	Say "Denver Center, NASA01	descending through 240° Listen to ATC Crosscheck.	CA crosseheck. If Schema not correct, get ATTS & amend Amerosch briefing/checklist.	Say "NASA01 descending to 17 thousand, 29.57"	Crosscheck 3 Altimeters. Crosscheck Altitude	Execute Altitude. Speak w/ GO	"Forward lavratory is leaking" Listen	Speak w/ GO "No, have maintenance ready on the mound at DEM *	Listen		Listen		
	NASA01 NASA01 Altitude Distance	Prior to Final Descent										~110nm TOD	37,000' 104 mm SIDNEV																10,879' AGL 74 mm

																		GO tasks (Other AC)																				
		 Say "All aircraft, Microburst alert at Denver, approaches are temporally discontinued, expect holding for all runage"																																				Say "NASA01. Isold North of LANDR on 216 radial, left-hand turns. Maintain one aeron thousand, expect further clearance in one zero (10)
	Turn on exterior lights Notify								Todicated Assistance									Load plates		Load woather							Notify OBP			Notify OBP								Pre-load ATC info
Cook meanington		Lister to ATC	Review weather	Review options	Sector DA to needed Sec. "DA Regiss?"		Listen		Liston	Listen	Introduce.	And Andrews	Problem (Multiple Cycles)	Alter Alteration of	Lasten	Speak w/ GO: "Locate relevant alternate approach plates and check weather"	Liston		Review plates		Review weather	Discuss current state	Agree on preliminary best alternate	(CYS) Assien duties: Chart set un weather	review, ATC communication,	decision support Listen		Crosscheck GO	Discuss probable hold locations & pattern Discuss for data and calcular endurance for a hold. (Find burn to DEN. Desend DEN landing fuel. Current harn rate. Transfried	remaining. Crossence, J	Crosscheck GO	Discuss Alternate 1 (CVS) (distance/time/file(/CAT/ATIS) (x2)	Action Risease Alternate 3 (EGE)	(distance/time/fuel/CAT/ATIS) (x2)	Action	Discuss Alternate 3 (COS) (distance/time/fuel/CAT/ATIS) (x2)	Action	Listen to ATC

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	Neity: Wx (8 DRN	Notified of D. Review R	Reserve t' confirmation         Reverve t' confirmation           Handerfe all cherk AC         Sold           Handerfe all cherk AC         Confirmation           Handerfe all cherk AC         Receives AC           Handerfe all c	

Pre-load ATC info

Listen to ATC

											GO tasks (Other AC)														
				Say "All aircraft, Tower evacuaned due to furmel cloud sighting, divert to other agrnets."					"NASA01 standby" "NASA01 cleared to Cheyenne via direct GILL, direct Cheyennee"				Say "NASA01 Fly heading 281 GRLL, maintain one seven theusand"			Say "NASA01, Fly heading 350, Cheared direct HAMER, direct CTS, discend and mantani 10,000, expect reasway 27 approach to CTS, CDS-repeat dimeter 28.15*							Say "NASA01 contact Cheyenne Approach on 124.55"		
			Send to ground auto						Pre-load ATC info	Land CYS as new destination in CDU, Get ATIS Build a rotat, Load expected Approach/Arrival Information: Anpron, Russway, Attimer, Speed changes, Ianding flags, DH, frequencies: Load LXAN/VNAN: Netris (DBP	Schill for ground auto.		Pre-load ATC info		Send to ground auto				Send to ground auto	Send to ground auto	Set 2 cockpit Altimeters Notify NASA01 & GO		Pre-load ATC info		
Decide on Choyenne (CVS) as the alternate. Discuss fuel state and calculate enhances for a hold with CVS as new decisation. (Find hum to CVS. Desired CVS landing feel Current hum nor Timochid	Listen	Crosscheck GO	Crosscheck ATC info Execute hold	Listen to ATC	Listen to ATC. Decide to divert to CYS for backing process requires that alternates are entroved from consideration by a process of climitation "weather, distance to land, and fast-OTHERS"). Excent Alternate 1 Plan.	CA: Validates / in agreement with mental map	Action	Listen. Crosscheck GO	Listen to ATC		 CA: Validates / in agreement with	Pre-Arrival briefing. (Tao) route, gate, flaps, target landing secoel, descent secoel, brake settines.	Lister to ATC	Listen. Crossrbork GD	Crosscheck AUTO info Execute Heading	Lines to ATC	Listen Crosscheck GO	C4 troacheck. If Schema net correct, get ATIS & amend Anorosch brieffing.	Execute route	Exit hold		Crosscheck AUTO info Execute Altimeters	Listen to ATC	Listen Crosscheck GO Crosscheck AUTO info	Linten Crosscheck GO
ļ																kan 2							40 mm		
10,879° AGL																							3,879' AGL		

	Say "Cheyenne Approach, NASA01, one zeo thousand with Alpha,"
	Crosscheck AUTO info Crosscheck AUTO info Execute radio frequency
Pre-load ATC info	Listen to ATC
	Crosscheck AUTO info Exocute Altimeter
Set 1 ground Altimeter Notify GO & NASA01	
Update Info (NASA01) / Notify GO	Crosscheck OBP
Update Info (NASA01) / Notify GO	Crosscheck OBP
	Say 'Roger, NASA01, 350, direct to HAMER, direct CVS, dissecred and manimum 10,000, expect manway 27 approach, altimeter 28, 15°
Pre-based ATC mfs	Listen to ATC
Update Info (NASA01) / Notify GO	Crosscheck Heading
	Say *Roger, NASA01, 281 to GILL, maintaining 17,000.*
Pre-load ATC info	Listen to ATC
	Monitor PF Pre-Arrival Briefing. Crosscheck
	Crosscheck route
expected reprotest Arrival Information: Anjpost, Runway, Altimeter, Speed changes, landing flaps, DR, frequencies, Load LNAVVNAN, Netify GO.	Crosscheck AUTO info
Pre-load ATC info	Listers to ATC
	"Denver Center, NASA01 request IFR clearance to Cheyenne via direct"
	Action
	Listern to ATC command. Decide to divert no CYS the Decide piece requires that alternatics are removed from consideration by a process of diminations. venther, datance to hand, and thet. OTHERS1). Execute Alternate 1 Plan.
	Listen to ATC
Update Info (NASA01) / Notify GO	Crosscheck hold
	Say "Denver Center, NASA01 at LANDR, time 15, 17,000"
	Say "NASA01 maintaining 17,000'. will hold at LANDR"
	Detect on Cheryware (CVS) as the alternate. Discuss facel starts and calculate endurance for a hold with CVS as new dostination. (Find hum to CVS. Desired CVS landing fact Current hour new Tranchod current hour new Tranchod
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GO tasks (Other AC)

																					GO tasks (Other AC)																							
Say "Roger, NASA01, descend and maintain flight level 9000"											Say "NASA01, turn left heading 350,	- hase reg.							Say "NASA01, turn left heading 280, maintain 7,800 urail established. Maintain 180 kts to ZUNUG, contact tower on 118.7°													Say "NASA01, cleared for the ILS 27L approach."												
Pre-load ATC info		Send to eround auto	CONTRACT IN STOCKED MINOR					Coul to oround auto	ACHI NO STOURD DIRO		Pre-load ATC info			Send to ground auto	Remnd: Flaps 1		Remind		Pre-load ATC info			Send to ground auto		Send to ground auto Remind	Arm approach mode	Send to ground auto		Send to ground auto	Remind: Flags 15					Aural alert. Send to ground auto	Remind: Landing gear				Remind:	Flaps 20	Send to ground auto		Remind: Flaps 25	
Lister to ATC	Listen. Cresscheck GO	Crosscheck AUTO info Execute Altimate	Applicate Contractor	peak wi GO. T am ready to research Dedicated Assistance"	Listen	Speak w/ GO: "Thanks for the	assistance	Freeute DA release	Listen	Speak w/ GO: DA resolved	Listen to ATC	Say "Roger, heading 350, base leg.	NASA01* Crosscheck AUTO info	Execute Heading	Listen	Reach and set flaps to 1 See anoted (210)	Listen	Reach and set flaps to 5.	Listen to ATC	Say "Roger, left 280, 7,800 until established and 180 until ZUNUG, contacting Tower at 118.7, NASA01*	Crosscheck auto info: Attitude	Execute Altitude	Crosscheck auto info: Heading	Execute Heading	Liston	Arm Approach Mode Confirm FMA reads as expected	Crosscheck auto info: Radio frequency	Execute radio frequency		Reach and set flaps to 15. Set upeed (180)	Say "Cheyenne Tower, NASA01 turning Final for the ILS 271, approach."	Listen to ATC	Say "Roger, cleared for ILS 27L, NASA01"	Disconnect natopilot	Liston	Set landing gear	C4 Arm speed brake	Set TDZE	Listen	Reach and set flaps to 20.	Glideslope capture	Confirm FMA display reads: LOC & G/S	Listen	Reach and set flaps to 25.
										1	2,879' AGL. 15 nm						1	_	1	1									1,679° AGL 15 mm					I					1		1,670' AGL 5.1 nm			

CO tasks (Other AC)           Review MASHI from GOI           Space (MASHI from GOI)           Review from from (MASHI from GOI)           Review from (MASHI from GOI)	Say "Reage: 9000 for NASA01 + Conscheck Almate Conscheck Almate Example Beneficial to COC Beneficial t	Update Info (NASA01) / Notify CO Nmfry EA Released Update Info (NASA01) / Notify CO
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Review Weather ()		
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Scan Screen: Tails Statuss Update Info (NASA01)	urbound () XASA01)	
Scan Screen: Tails Management		

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Prepare Outbound for release Check weather () Prepare Outbound for release Check flight plan ()

## Appendix F. Task Decomposition Spreadsheet (SPO Specialist Off-Nominal)

Remind GO: Attend to AC ()							Notify: Below 1,000 (NASA01)	Update Info (NASA01)									
Scan Screen: Tails Status	Scan Screen: Tails Management	Scan Screen: Tails Status	Scan Screen: Tails Management	Speak w/ 08P () Discuss: Gate Connection Problem	Speak w/ OBP () Discuss: Gate Connection Solution	Comm: Reservation coordinator Discuss Gate Connections ()	Review Altitude & Heading	Review Fael Jevels (NASA01)	Review Weather (NASA01)	Scan Screett: Tails Status	Scan Screen: Tails Management	Review Fuel levels ()	Review Weather ()	Speak w/ OBP () Discuss: Aimort/inhound dolaxe	Speak w/ Customer care team	Discuss: Delaya ()	Speak w/ Reservation coordinator
							GU (2016) AU										
					Say "NASADI cleared to had RWY two security												
Remind: Flags 30		Kernind: Landing checklint			Say "XAXA01 cleared to back RWY to accur RWY			Send to ground auto	"Approaching Dif"				-30°				

Appendix G. Micro Saint Sharp Task Groups (OBP-Centric Nominal Mode)

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Appendix G. Micro Saint Sharp Task Groups (OBP-Centric Nominal Mode)

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Appendix H. Micro Saint Sharp Task Groups (GO-Centric Nominal Mode)

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