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Aviation Human-in-the-Loop Simulation Studies: Experimental Planning, Design, and Data Management

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16. Abstract Researchers from the NASA Ames Flight Cognition Lab and the FAA's Aerospace Human Factors Research Lab at the Civil Aerospace Medical Institute examined task and workload management by single pilots in very light jets, also called entry-level jets. This exploratory simulation study was also performed to generate baseline data to be used in future NextGen-oriented studies and was conducted in a Level 5 Cessna Citation Mustang flight training device (for simplicity, referred to as a "simulator" throughout the rest of this document). In addition to the use of the simulator, data collection included voice analysis, instantaneous self-assessment of perceived workload, NASA Task Load Index workload measures, researcher observations, final debriefing interviews, Cockpit Set-up Preferences questionnaires, Demographics questionnaires, and Automation Experiences and Perceptions questionnaires. Within the current paper, we describe the process by which we designed our human-in-the-loop (HITL) simulation study and the methodology used to collect and analyze the results. For a summary of the results, please refer to Burian, Pruchnicki, Rogers, et al. (2013). The purpose of this document is to describe much of the work required in the development of HITL simulation study materials, the design of experimental scenarios, and the management and transformation of data required in preparation for analysis.					
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As part of this study, we relied on the expertise and experience of two air traffic control subject matter experts, Art Gilman and Greg Elwood. In addition, we sought guidance during the design of the study and during data analysis from our pilot and G1000/Mustang aircraft subject matter expert, Dave Fry. Their expertise contributed greatly to the success of this project.

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Finally, our sincere appreciation to the Cessna Mustang pilots who completed questionnaires and participated in the simulator portion of the study. Their time and willingness to participate and the insight they so generously shared contributed greatly to the success of this project.

Contents

Aviation Human-in-the-Loop Simulation Studies: Experimental Planning, Design, and Data Management

INTRODUCTION	1
STUDY AND SCENARIO DESIGN	1
Flight Scenarios	1
Background Chatter	2
Study Scripts	2
En Route Weather Information for ATC	3
Task Analyses	4
Concurrent Task Timelines	4
STUDY MATERIALS AND MEASURES	4
Pilot Questionnaires	4
Flight Briefing Material	5
NASA Task Load Index	5
Debriefing Interview	6
DATA COLLECTION EQUIPMENT	6
Cessna Citation Mustang Flight Simulator	6
Video/Audio Recorders	8
Experimenter's Station	9
Pilot Headsets	10
Instantaneous Self-Assessment (ISA) Device	10
DATA EXTRACTION, MANAGEMENT, AND PREPARATION FOR ANALYSIS	11
Simulator Flight Performance Data Extraction Process	12
Data Transformation	13
Extracting Audio and Video Files	13
Extracting Instantaneous Workload Assessments	13
Master Spreadsheet	13
Graphs	13
Google Earth Plots	15
Audio Transcription	17
Preparation for Voice Analysis	18
Preparation for Analysis of Approach and Landing Data	19
CONCLUSIONS	21
REFERENCES	22

LIST OF FIGURES

Figure 1.	Excerpt from the familiarization scenario script-----	3
Figure 2.	Cessna Citation Mustang flight training device (“simulator”) and external visual system -----	7
Figure 3.	Simulator G1000 avionics suite and out-the-window view -----	7
Figure 4.	EMRRS output showing the four camera views -----	8
Figure 5.	Experimenter’s station-----	9
Figure 6.	Researchers and ATC at the experimenter’s station -----	9
Figure 7.	Screen shot view of instructor station map and limited flight parameter display-----	10
Figure 8.	Stacked graphs of simulator data -----	14
Figure 9.	Example flight trajectory plotted in Google Earth-----	15
Figure 10.	Flight path trajectory with additional aircraft data selected -----	16
Figure 11.	Plot of the 1.3 nautical mile obstacle clearance area at Martin State Runway 15 -----	17
Figure 12.	Sample flight communication transcription -----	18
Figure 13.	Touchdown zone-----	21

LIST OF TABLES

Table 1.	Experimental flight NASA TLX task rating events -----	6
Table 2.	Experimental flight ISA rating prompts-----	11
Table 3.	Flight simulator variables-----	12

APPENDICIES

Appendix A.	Air Traffic Controller and Weather Briefing Package -----	A1
Appendix B.	Demographic Data Questionnaire -----	B1
Appendix C.	Advanced Avionics and Automation Questionnaire -----	C1
Appendix D.	Citation Mustang and G1000 Cockpit Set-Up Preference Questionnaire -----	D1
Appendix E.	Pilot Briefing Package -----	E1
Appendix F.	Post-Study Interview Questions -----	F1
Appendix G.	Simulator Lesson Planner Scripts -----	G1
Appendix H.	Visual Basic for Applications Code to Format Google Earth Data-----	H1
Appendix I.	Visual Basic for Applications Code for Creating KML File -----	I1
Appendix J.	Visual Basic for Applications Code for Creating a Fixed Cylinder -----	J1

AVIATION HUMAN-IN-THE-LOOP SIMULATION STUDIES: EXPERIMENTAL PLANNING, DESIGN, AND DATA MANAGEMENT

INTRODUCTION

Human-in-the-loop (HITL) flight simulations are complex endeavors. In conducting such studies, researchers must balance the need to collect many different types of data with the need to maintain the integrity of the simulation. For example, researchers would like to measure workload on the pilot during the flight and how this workload varies as the result of the various tasks imposed, including both routine and non-routine events. Researchers have a need to measure the workload of the pilot during the flight because automation and advanced technology can provide a great benefit to pilots in terms of reducing some types of workload and making increased situation awareness possible, particularly when flying single-pilot operations. Guidance is needed so designers can reduce the cognitive complexity of these systems, to minimize the likelihood of human error, and to better support pilots managing the workload and resources of advanced automation. The implementation of a within-cockpit workload measurement device (the instantaneous self-assessment device) allows the measurement of workload at any pre-determined point during the flight, and post-hoc workload measures can be administered as required.

On the other hand, the presence of a within-cockpit workload measure has the possibility of making the flight seem less real, actually adding to the workload being measured, and potentially interrupting other tasks, essentially changing the way in which the pilot performs the flight when compared to a flight in the real world. Methods of measuring workload after the flight has finished can suffer from the participants' inaccurate memories.

Achieving the necessary balance between gathering the most useful data and maintaining the fidelity of the simulation requires careful planning and execution of the study. There are numerous background materials that must be developed and multiple data sources that must be considered. Each requires its own time investment as researchers prepare for the study and, afterwards, analyze the results. Researchers interested in replicating a realistic flight environment must consider various operational changes that occur simultaneously during the time that they are planning and designing their study (Pruchnicki, Burian, & Christopher, 2011). In this paper, we describe in detail much of the work required in the development of HITL simulation study materials, the design of the experimental scenarios, and the management and transformation of data required in preparation for analysis.

Civil Aerospace Medical Institute (CAMI) and National Aeronautics and Space Administration (NASA) personnel examined the effects of advanced flight deck functionality on single-pilot workload management in very light and entry-level jet aircraft by having pilots fly scenarios in a fixed-base (i.e., no motion), simulated high-performance aircraft. As a result of this exploratory study, we generated baseline data to be used in

future NextGen-oriented research. The study was conducted in a Level 5 Cessna Citation Mustang flight training device (for simplicity, referred to as a "simulator" throughout the rest of this document). This paper describes the process by which we designed our HITL study, developed various study materials and measures, programmed and set up other data collection equipment, and prepared the data in advance of analysis.

STUDY AND SCENARIO DESIGN

Flight Scenarios

Three flight scenarios were developed with the help of an airline pilot and instructor, a Cessna Citation Mustang mentor pilot, and air traffic control (ATC) experts. The first scenario, lasting approximately 30 minutes, allowed the pilot to become familiar with the simulator and measurement equipment. We referred to this as the "familiarization flight," and data from this scenario were not analyzed. The two legs of the experimental flight, each lasting approximately one hour, occurred in day instrument meteorological conditions (IMC) and required the participants to complete a wide range of typical flight tasks. Some examples of these tasks include programming and performing an in-flight reroute, meeting crossing restrictions, responding to a non-normal event (i.e., circuit breaker pop), and conducting precision and non-precision approaches at a non-towered and towered airport, respectively. In the first experimental scenario (i.e., the first leg), pilots departed from Teterboro Airport in New Jersey (KTEB) and landed at Martin State Airport (KMTN) just outside of Baltimore, Maryland. The second leg involved a flight from KMTN to Hot Springs/Ingalls airport (KHSP) in Virginia. More detailed information about the familiarization and experimental flight scenarios can be found in Burian et al. (2013).

As described in Pruchnicki et al. (2011), the development of scenarios is not the first, or even necessarily the most time-consuming task in designing a HITL simulation study. After outlining our research questions (i.e., how do single pilots manage their workload and use the automation when flying entry-level jets?), we determined that we needed to design flight scenarios that would present the pilots with a number of realistic high workload tasks. Our pilot subject matter experts, particularly one who had substantial experience in developing line-oriented flight training (LOFT) scenarios for airline training, were essential in completing this task.

We originally mapped out three experimental scenarios. The first scenario was very similar to the first leg of the experimental flight used in our study. The other two scenarios occurred in California and Colorado and involved dealing with convective weather and an aircraft emergency requiring a diversion, respectively. After outlining these scenarios, study sponsors at the FAA and others in the industry (e.g., Cessna) were consulted. The

scenarios were revised to include specific tasks they requested (e.g., circle to land maneuver). High-level task descriptions for each of the three scenarios were constructed by one of the pilot subject matter experts (SMEs) and used for the later development of detailed task analyses of the experimental scenarios, described below. ATC SMEs reviewed the scenarios to make sure that our routing and planned tasks were generally realistic in today's airspace operations.

Upon checking with members of the team involved in acquiring and programming the simulator, however, we discovered that there would be great expense and delays should we try to use the second and third scenarios. The simulator was not capable of emulating and displaying convective weather conditions, as required in the second scenario, and developing of multiple models for all the airports to which participants might choose to divert to in the third scenario was cost prohibitive. We decided to retain the first scenario, which became our first leg, and develop a second leg of the flight to go with it. We also incorporated as many of the tasks from the original second and third scenarios as we could, particularly those that had been requested by our study sponsors and Cessna.

The scenario for the familiarization flight was designed last and was constructed with the following goals in mind: 1) construct a relatively short instrument flight rules flight with few high workload tasks so as not to add substantially to the length of the day and possibly fatigue the participants, 2) construct a flight long enough to allow participants to get accustomed to the simulator and other data collection equipment (e.g., instantaneous self-assessment of workload device), and 3) construct a flight that included departure and arrival airports that were already modeled and available for use in the simulator. We specifically chose airports for the familiarization flight that were not part of the experimental flights.

Background Chatter

An essential part of pilot workload in busy airspace is attending to background chatter on the radio, in part to monitor for a call from ATC but also to keep abreast of what is going on with surrounding aircraft in case there might be some effect upon one's own flight. An elaborate script of background chatter involving over 100 other aircraft was developed and recorded for use in this study (see Burian, Pruchnicki, & Fry, 2013). Unfortunately, due to unanticipated problems experienced with the simulator audio system, we were unable to use it. We did, however, have a few occasions where "other pilots," such as the "lost pilot" during the second leg of the experimental flight, interacted with ATC and with the study pilots over the radio during the three scenarios. All "other pilot" communications were scripted and performed by members of the research team in real time (i.e., not pre-recorded) as the scenarios unfolded.

Study Scripts

Consistency in the administration of the study is important to ensure that each pilot is subjected to relatively the same conditions during the flights. Detailed scripts were developed for all three study scenarios and were used to guide all communications from ATC and other pilots as well as the triggering of all events, such as the circuit breaker pop during the second leg of the experimental flight. The scripts included the following: aircraft location, active radio frequency, triggers for all ATC calls to the participant pilots (such as the aircraft's location), notes and alternate actions that may be necessary, a description of pilot tasks (to facilitate situation awareness among the ATC and researchers), and all exact communications, excluding communications from the participants. An excerpt of the familiarization scenario script can be seen in Figure 1.

Familiarization Flight - Comms									
	Aircraft Location	Active Radio Freq.	Trigger	Alternate/ Notes	Pilot Task	ATC/ Flight Watch Comms	Mustang Pilot (Study Participant) Comms	Other Pilots - Live Comms	Recorded Comms (ATIS, AWOS, Background Chatter)
	AXODY, climbing to 11,000 ft.	128.4 (Fort Worth Center)	Aircraft is at AXODY		Respond to ATC Traffic Call	"Citation 510C You have crossing traffic at 4000, right to left, 2 o'clock and ten miles, a Citation Sovereign."			
				exact comms will vary depending upon if pilot sees traffic			(pilot acknowledges traffic call - looks for traffic)		
						"Sovereign 36V, You have crossing traffic at XXXX feet climbing, crossing left to right 10 o'clock and ten miles, a Citation Mustang"			
								36V has traffic	
					monitor level off at 11,000 ft				
Cruise									
	on assigned route, 11,000 ft.		Aircraft is 15 nm before LIONS		Respond to ATC Traffic Call	"Citation 510C You have crossing traffic at 8000, right to left 2 o'clock and five miles, an A320"			
				exact comms will vary depending upon if pilot sees traffic			(pilot acknowledges traffic call - looks for traffic)		
						"Frontier 1449, you have crossing traffic at 11,000, left to right at 10 o'clock and 4 miles, a Citation Mustang"			
								"Lookin' for the little fella, Frontier 1449"	
									Will Rogers Oklahoma City Airport Information BRAVO 1855 Zulu automated weather, wind is 230 at 5 gusting to 14, visibility 10 miles, 25,000 few, temperature 30, dew

Figure 1. Excerpt from the familiarization scenario script

The study scripts were developed using the following materials: 1) the high level overviews of the scenario tasks, 2) detailed task analyses of the experimental flights, described below, 3) communication from a "lost pilot" developed for use in the experimental flight, and 4) weather information developed for Automated Terminal Information System (ATIS) and Automated Surface Observation System (ASOS) recordings. ATC SMEs reviewed all scripted ATC communications, including those from Flight Watch briefers, to make sure they were realistic and consistent with standard phraseology. The complete scripts developed for the familiarization flight and both legs of the experimental flight can be found in Burian et al. (2013).

En Route Weather Information for ATC

As with any simulation, part-task or full-mission, researchers need to determine the level of realism or fidelity required. Because the main focus of the study was pilot workload management, we made significant efforts to keep realism as high as possible

within the limits of the hardware. We wanted to provide an immersive environment so that pilots would feel comfortable assuming their normal flying behaviors in the simulator. One area that required significant attention was the development of the weather in which the scenarios took place and the en route and airport weather information available to both the pilots and air traffic controllers.

One challenge we faced was not knowing when or how pilots might try to seek weather updates while en route. For example, during the en route phase of both experimental legs, there was a wide range of possible strategies regarding how pilots could gather weather information for both their current airspace and that of the destination. For example, they could contact flight watch or get AITS information from airports that were passed while en route. We had to be ready to accommodate any approach chosen by the participants lest we lose the level of realism desired in the study.

Once we knew the type of weather needed at all three airports included in the two experimental legs, we drafted a more global-scale weather picture of the east coast that would support those local weather observations. We crafted frontal locations and movements with corresponding winds aloft to provide ATC and the subject pilots a better understanding of the atmosphere that they would be flying through. We developed the local ATIS for each of the three airports in the scenarios as well as for any airports passed en route. This was done to support the experiment's realism in case pilots chose to check weather while en route by tuning any ATIS or ASOS/Automated Weather Observation System (AWOS) stations close to them. It was important that this information was immediately available for both our ATC assistants as well as the researchers that would be functioning as the automated stations (i.e., reading any requested ATIS & ASOS/AWOS information).

Because there were a tremendous number of stations along the route of flight for both legs, we had to evaluate the potential benefit of creating weather for every possible station on the east coast or being selective in our choice of stations. We decided to include every possible source of ground-based automated weather for 20 nm on either side of the route of flight (see Appendix A). We were also aware that some pilots might seek a more detailed weather update and choose to leave the frequency to contact the nearest flight service station. To accommodate any such potential request, the ATC SMEs assisting with data collection were provided a weather briefing packet that contained not only current automated observations, but also synoptic descriptions, satellite pictures (captured on a real day when conditions matched our virtual environment), airmen meteorological information (AIRMETS), significant meteorological information (SIGMETS), pilot reports (PIREPS), freezing levels, notices to airmen (NOTAMS), winds aloft, and terminal area forecasts (TAFS). By doing this, we were assured we would be able to help both the pilot and ATC SMEs stay in role. We were even cognizant that the automated stations could not report the weather unless the pilot had tuned in the correct frequency. As such, we listed each frequency with the weather report so that the researcher would not only choose the correct weather to read but also would only do so if the frequency was correctly tuned in the cockpit. All of these data were presented in a flight-time chronological format enabling the researchers and ATC SMEs to follow the list of reporting stations that the pilot was approaching so as to be ready should a request be made.

Task Analyses

During the study design phase of this research, high level outlines of the two experimental flights were constructed (Burian, Christopher, Fry, 2013). These outlines included all the major tasks to be completed by the participants during those flights. Detailed task analyses were then conducted with the assistance of a subject matter expert who serves as an instructor and mentor pilot in the Cessna Citation Mustang. In these task analyses, the major tasks were broken down into subtasks, sub-sub-tasks, and so on until each step for the completion of

a task was identified down to the level of pressing a button or turning a knob. To the extent possible, cognitive tasks associated with some of the physical tasks (e.g., "recall that ATC gave direction to report when reaching assigned altitude") were also included. These analyses were developed to identify the correct way in which each task must be completed or—when multiple ways of accomplishing a task exist—one way of accomplishing the scripted tasks that represents correct action and a superior approach to workload management, as determined by our subject matter expert. The task analyses were used during data analysis when reviewing approaches to task completion and workload management employed by the study participants. The task analyses for the two experimental flights can be seen in their entirety in Burian et al. (2013).

Concurrent Task Timelines

Task analyses can be quite helpful in decomposing the various actions and cognitive demands associated with the completion of flight deck tasks. However, written in a spreadsheet/tabular format, as we did with our task analyses, it appears as though all tasks are to be completed in a sequential and linear way. Tasks which are performed concurrently, as so many are during flight operations, cannot easily be depicted relative to the others, nor can a table easily depict how long it is expected (or permitted) for each task to be completed. Therefore, using the task analyses, we developed concurrent task timelines (CTTs) in which bars (or lines) representing the first three levels of tasks and sub-tasks included in the analyses were drawn relative to each other (the horizontal axis on the page indicated time). Again, our Cessna Citation Mustang SME assisted in the development of these timelines, and they were used by researchers during the data analysis phase of the study for identifying and evaluating participant performance and workload management strategies. The complete CTTs for both experimental flights can be seen in Burian (2013).

STUDY MATERIALS AND MEASURES

Pilot Questionnaires

Background information was solicited from potential participants through the use of a demographic questionnaire (Appendix B). This questionnaire was used to screen for pertinent flight certification and history that was essential for the study. A portion of this information was used to identify potential participants who represented the population of interest (Mustang owner-operators) as well as others (i.e., professional pilots) who flew the experimental scenarios in the simulator.

An advanced avionics and automation questionnaire was designed to gather information with regard to participant attitudes toward advanced technologies such as glass cockpits/primary flight displays and multifunction displays (Appendix C). The participants were polled on which features they preferred most and least, as well as on their thoughts regarding advanced avionics and automation design, functionality, use, training, and maintaining proficiency, among other things.

There are a wide variety of G1000 settings available to pilots to support their preferred information needs such as map orientation, de-cluttering options, and temperature units. Therefore, the pilots who participated in the simulator portion of the study also completed a Citation Mustang and G1000 cockpit set-up preference questionnaire to indicate their preferred Garmin G1000 settings (Appendix D). This allowed us to configure the simulator to closely replicate the real aircraft flown by each participant prior to the start of data collection and minimize the amount of time they would need to configure the simulator during preflight activities. The questionnaire was developed using information from the Mustang owner's manual and the G1000 integrated flight deck cockpit reference guide for the Cessna Citation Mustang. This information was then used to set up the G1000 in the study simulator prior to their session to match those settings in the actual aircraft that they flew.

Flight Briefing Material

The purpose of the flight briefing material was to draw the pilot into the scenario as much as possible. It included much of the same information that would be used by pilots when planning and executing an actual flight, in addition to background information about the purpose of the flight, current date, proposed times of departure, and the like. Detailed information regarding the scenarios and flight briefing material can be found in Burian et al. (2013).

We prepared all of the flight briefing material for each participant in a similar method as would be done for a real flight in an aircraft of this type. Because this was a simulation, we also needed to include a small amount of additional information to help provide more realism and offer positional awareness regarding their starting and finishing locations on the airport surface. We started each Pilot Briefing Package (see Appendix E) with an introduction section where we covered the purpose of the flight, departure and destination airports, date/time of day, and aircraft location on the airport surface. Aircraft location was further clarified with the addition of an airport surface map noting both the location of the parked aircraft and the intended departure point on the runway.

We did not want the participants to be consumed with flight planning duties, so information such as the trip navigation log was created using a free on-line flight planning program (FlightPlan.com). The real weather captured through the online

flight planner was altered to match the scripted weather in the scenarios. An FAA flight plan form (7233-1) was also prepared. We also created a spreadsheet for all of the weight and balance information that would be required for each flight. Weight limitations, co-located with weight calculations in the spreadsheet, indicated that the aircraft would be operating the entire time within all weight and center-of-gravity constraints. Furthermore, we included the center-of-gravity graph from the aircraft flight manual with both the take-off and landing values depicted.

We also constructed a complete weather briefing package, including an area forecast and synopsis, current satellite conditions, SIGMETs and AIRMETs, weather and sky conditions, PIREPS, meteorological aerodrome reports (METARs) and TAFs and radar returns for departure and destination airports, winds aloft forecast for the route of flight, en route METARs and terminal area TAFs, and a complete set of (NOTAMs). To develop this weather package, we used real east coast weather data on a day very similar to the planned simulated flight. Some of this material was downloaded (and modified as necessary) from the National Oceanic and Atmospheric Administration (NOAA) Aviation Weather Center Aviation Digital Data Service (ADDs) (see <http://www.aviationweather.gov/adds/>) as well as from other on-line aviation weather providers. Although this resulted in a large amount of information for our participants to review, we felt that it was very representative of the types and quantity of information most pilots flying this type of aircraft would likely review. Where we could, such as with the number and types of NOTAMS, we trimmed the amount of information presented so as to decrease the amount of time the pilot had to spend reviewing the material. All of the above briefing packet material was developed for both legs of the flight and placed in briefing packets in a logical sequence.

NASA Task Load Index

Paper and pencil versions of the NASA TLX (Hart, 2006) were used as a subjective, retrospective, multidimensional assessment of perceived workload on six different subscales: mental demand, physical demand, temporal demand, performance, effort, and frustration. Immediately after Leg 1 and again after Leg 2, pilots were asked to give ratings on each of the subscales for the flight, overall, as well as for specific high workload tasks or phases of flight. The events for which participants completed a TLX for both legs of the experimental flight are shown in Table 1.

Table 1. Experimental flight NASA TLX task rating events

Leg 1	Leg 2
Leg 1 Flight Overall	Leg 2 Flight Overall
TEB 6 Standard Instrument Departure	KMTN Radar Vector Departure
Build Course to Intercept Broadway (BWZ) 208° Radial	Immediate Descent for Another Aircraft With an Emergency
VNAV Path for Descent to Meet a Crossing Restriction	Circuit Breaker Pop Event
Hold at JUGMO Waypoint	Facilitate ATC Communication With Lost VFR Pilot
RNAV (GPS) Rwy 33 Approach and Circle to Land Runway 15 KMTN	Meet Crossing Restriction Before Montebello (MOL) VOR
	ILS Approach to KHSP
	Deal With Disabled Aircraft on the Runway and Complete Landing at KHSP

Debriefing Interview

After a short break following the second leg of the experimental flight, researchers conducted a semi-structured debriefing interview with the participants. We asked pilots about their overall impression of their experience for the day and if there were any tasks during the flights that increased their workload. In addition, we asked how they felt they managed their workload during the flights. For a complete description of the specific questions that were asked during the semi-structured interviews, see Appendix F. These interviews were recorded as digital audio wav files on a digital audio recorder and were transcribed for later analysis.

DATA COLLECTION EQUIPMENT

In addition to all of the materials that were developed for the study, a number of pieces of equipment were used to collect and record the flights. The following items were used during the study.

Cessna Citation Mustang Flight Simulator

The flight simulator used in this study is a Frasca level 5 flight training device that features a realistic Mustang flight deck with an actual Garmin G1000 avionics suite, digital electric control loaders, and a high-fidelity digital surround sound system that accurately replicates flight, engines, system, and environmental sounds.

The FAA requested two modifications at the factory to make the training simulator more suitable for human factors research. The software was modified to allow access to 5,159 recorded simulator variables for analyzing subject flight performance. Also, the flight instructor cab that typically comes attached to the back of training simulators was removed. The cab gives a training instructor the convenience of sitting close to the pilot for easy instructional communication and control of the simulator operations at the same time. However, the desire in the human factors research studies is to isolate the pilot by placing the research operator stations several feet away in an attempt to make the cockpit environment as realistic as possible. Additionally, removing the cab allows easier installation of recording devices such as cameras and eye tracking systems.

The simulator is surrounded by a high-fidelity 225 degree (lateral angle), floor-to-ceiling, spherical projection screen that gave the pilot a realistic field-of-view. The projection screen uses embedded sensors to detect the alignment and quality of the projected images. The system consists of six Wide Quad Extended Graphics Array (WQXGA) (1920x1200) projectors that are driven from six high-end Intel server-class computers that maintain 60 Hz update rates to the visual scene. Pictures of the simulation environment can be seen in Figures 2 and 3.

The simulator data stream variables are recorded at a rate of 5 times per second. Each sample constitutes a sequentially numbered “frame” in the data stream. These data include latitude, longitude, and altitude information, the status of cockpit controls and displays, simulated weather settings, aircraft attitude and airspeed, and the activation and values of specific G1000 settings (e.g., barometric pressure). Following the completion of each scenario, the data stream recording was stored in a proprietary data format on the local simulator drive.



Figure 2. Cessna Citation Mustang flight training device (“simulator”) and external visual system

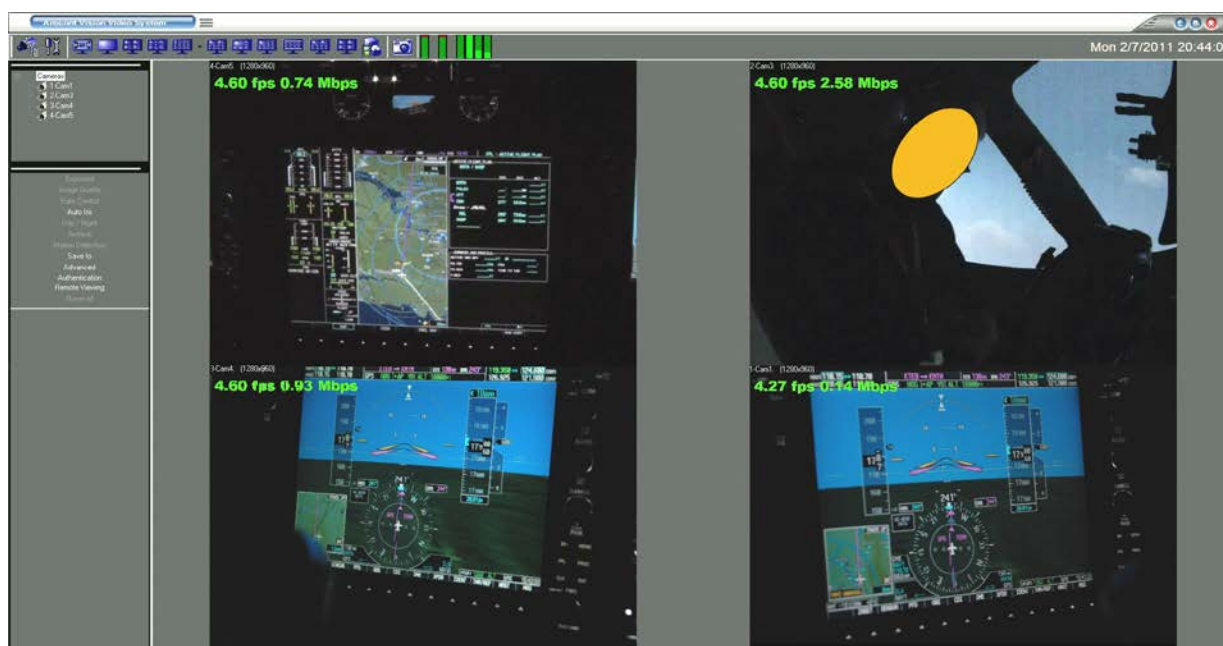


Figure 3. Simulator G1000 avionics suite and out-the-window view

Flying a repeatable scenario in the simulator required the use of a software package to create a structured set of features for the simulation. These features included wind and weather settings, and the triggering of events at specific points in the flight. These events could be changes in wind, weather, or the appearance of aircraft traffic. The triggering of events also could be based on a variety of conditions within the simulation such as the aircraft descending below a specific altitude or reaching a particular latitude or longitude. The software used to create a scenario is called “Lesson Planner.®”

Depending on the number of events required for the simulation and the number of changes in conditions, the development of a scenario script in Lesson Planner® can be simple or complex. For the current experiment, developing the scenario script took several weeks. Most of this complexity was centered on the appearance of traffic at the precise points where they would have an effect on the experimental flight. The scripts developed for the experiment are listed in Appendix G.

Video/Audio Recorders

Audio and video recordings were achieved through a high-fidelity digital video and audio recording system, which employed several devices that were networked together in a Local Area Network (LAN). There were three major components to this network: the cameras, a digital media encoder and server, as well as a mixing board.

A Zoom H4n Handy Recorder™ was used to record and store high-fidelity audio recordings of communications between the cockpit and the operator station as well as the post-flight debriefing interviews that were conducted with each participant.

The recorder stores audio information in 96 Khz, 24-bit, MP3 digital audio files onto standard Secure Digital High Capacity (SDHC) memory cards.

Four Arecont Vision IR™ video cameras were specifically selected for their high-resolution color image streams. Two of the cameras were mounted on tripods placed on each side of the simulator cockpit. The camera on the pilot side recorded the pilot’s G1000 Primary Flight Display (PFD). The camera on the co-pilot side recorded the pilot so participant well-being could be monitored, as required by FAA and NASA Institutional Review Board protocols. A third camera was mounted at the aft of the simulator cab to record the G1000 Multi-Function Display (MFD). The fourth camera was mounted inside the cockpit on the co-pilot’s window pillar and recorded the co-pilot’s PFD. All four cameras operated at 60hz NTSC signal and were IR-sensitive.

A Plexsys™ data recording system, called the Enhanced Mission Record and Review System (EMRRS™), was used to record, process, and store high-quality digital video streams. EMRRS was used to combine multiple audio, video, and data streams and store them on a media storage server. The video cameras and sound mixer were connected to the Plexsys recording system through a network hub. EMRRS synchronized all the recorded streams for accurate time-stamped playback and real-time analysis. Additionally, it provided real-time observation of pilot activity during the recording, including pausing, rewinding, and replay of the media without disturbing the recording. A Windows 7 media client was the EMRRS primary user and administration interface for the server computer. An example of the output from EMRRS is shown in Figure 4.

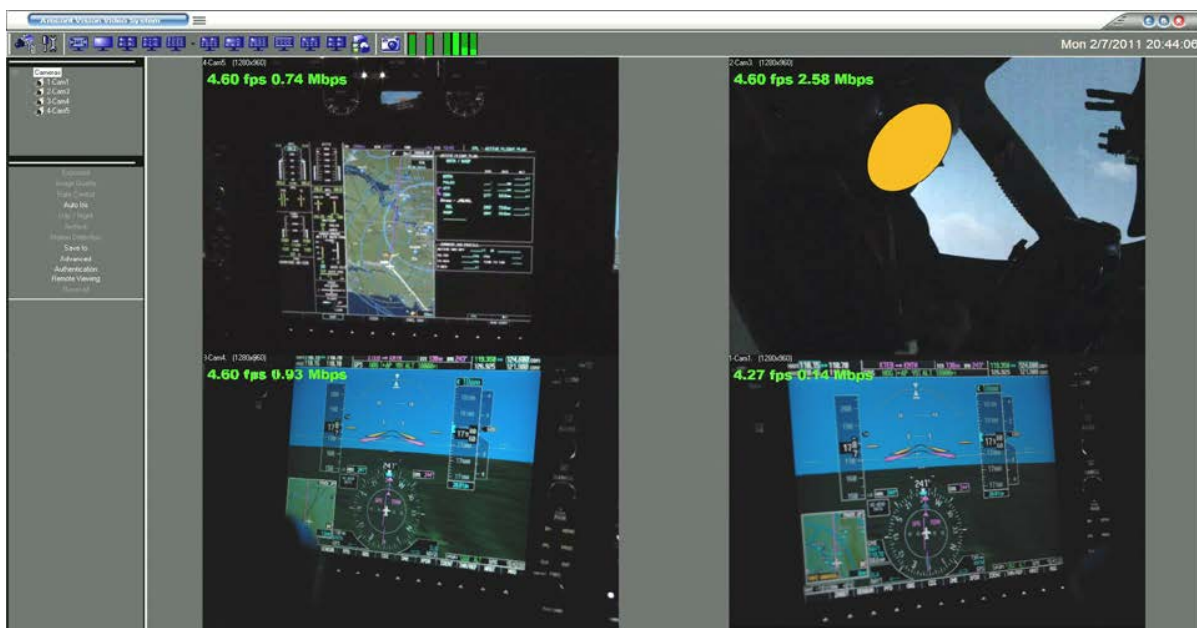


Figure 4. EMRRS output showing the four camera views. Starting from top left rotating clockwise – MFD, view of pilot, pilot’s PFD, co-pilot’s PFD

Although post-collection examination of the video revealed degraded video quality, the video still served as a valuable source to confirm simulator flight parameter data by helping to place raw data in context. Despite the limited resolution, the usefulness of fast-forward or fast-reverse made reviewing videos easy. We found this to be especially helpful when choosing to examine events that occurred later in the flights or when a replay of an event was desired. When the fast-forward icon was selected once, the recording would advance by 30 seconds, and selection of the fast-reverse icon would reverse the video in 10-second increments. One particular challenge we faced when using the video recordings together was their lack of synchronization. An

additional difficulty was that the voice recording of the pilots and all others on a given frequency were collocated with the moving map/flight parameter video only. Given these constraints, it was necessary to play the map recording, as well, when audio analysis was desired and required an awareness that fast-forwarding or reversing either video feed would result in de-synchronization.

Experimenter's Station

Researchers and air traffic controllers sat at the experimenter's station (see Figures 5 and 6) situated approximately 20 feet behind the simulator. Several monitors at the station allowed the researchers and ATC to monitor the progress of the flight



Figure 5. Experimenter's station. (The simulator and visual system can be seen in the background.)



Figure 6. Researchers and ATC at the experimenter's station

and the feed from the video recorders in the cockpit. Researchers playing the role of “other pilots” and ATC wore headsets at the station and spoke on the radios by pressing a push-to-talk switch on the headset or audio system panel. All data recording systems were managed and controlled at the experimenter’s station. In addition, there was a dynamic display of a navigation map including ownship position in relation to navigational fixes, airports, and airways, which was only available at the experimenter’s station. This screen also functioned as a radar screen for ATCs who assisted with data collection (see Figure 7). As with the cockpit videos, these recordings were reviewed during data analysis.

Pilot Headsets

Participants were invited to bring and use their own headset or to use the headset that came with the simulator. These headsets have soft foam buttons that sit on the ear, and have a boom microphone, and are very light. They were not noise-cancelling, however, and participants had difficulty hearing ATC instructions. To compensate, a Bose A20 noise-cancelling headset was purchased by the researchers and used by all but the first participant.

Instantaneous Self-Assessment (ISA) Device

A five-point ISA rating system was used to evaluate pilot workload in real-time. The ISA device consisted of a small rectangular box with a red light at the top and five numbered buttons arranged vertically below it. Pilots were prompted to perform an instantaneous self-assessment of workload by pressing one of the numbered buttons (5 meaning very high workload and 1 meaning very low workload) when the red light was illuminated. Researchers controlled when the light would illuminate through a software interface at the experimenter’s station. Once illuminated, the light would stay on for up to 60 seconds or until the participant pressed one of the numbered buttons. Prior to the familiarization flight, pilots were briefed on the use of the ISA rating system and were provided a printed card for reference during flight, if necessary, which explained how the ISA was to be used and described the rating scale. Pilots were also informed verbally and in writing that making an ISA rating when prompted was secondary to any other task and to only make the rating when they were able to or not at all if there was no break in their primary task during the 60 seconds that the ISA light was illuminated.

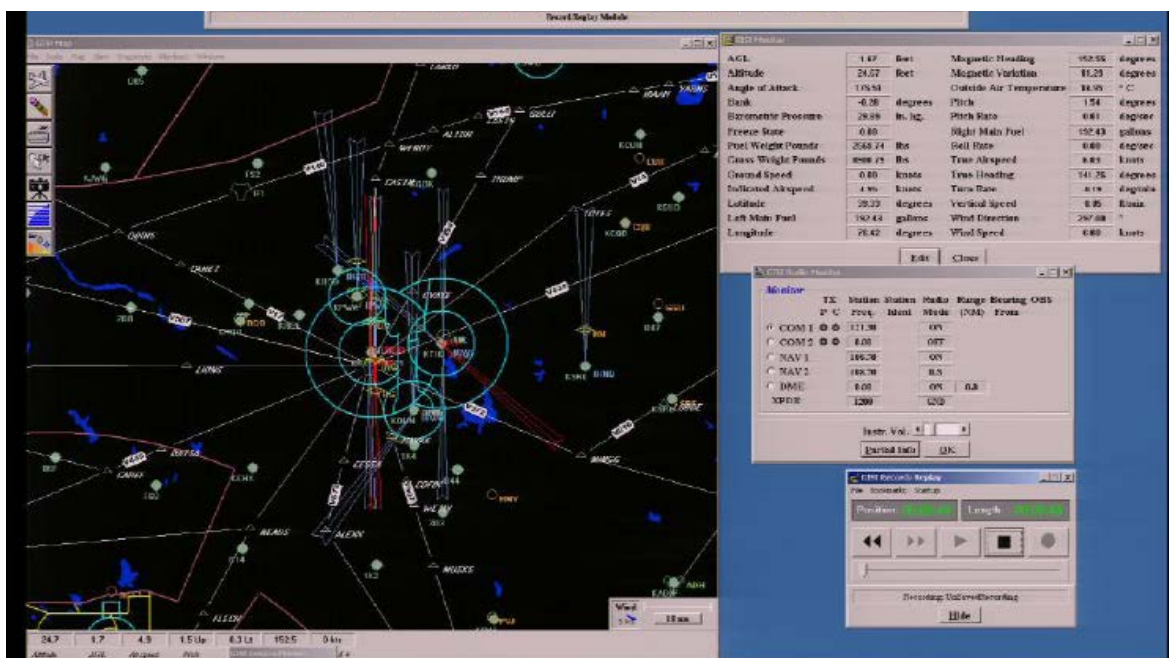


Figure 7. Screen shot view of instructor station map and limited flight parameter display

Participants were given an opportunity to practice responding to ISA rating prompts during the familiarization flight. Following this flight, participants were asked if they had any questions with regard to how and when ISA ratings were to be made and were reminded that they would be asked to continue to make ISA ratings during both legs of the experimental flight. Table 2 lists where participants were prompted to make an ISA workload rating during the two legs of the experimental flight.

Data Extraction, Management, and Preparation for Analysis

CAMI collaborators spent two months downloading and organizing data from the simulator itself, the audio/video recorder, the ISA tool, and the eye tracker. We saved this data on external hard drives and distributed them to the researchers at NASA and CAMI for analysis. We also transcribed the recorded debriefing interviews.

NASA collaborators shared updated documents outlining data to be analyzed and research questions to be answered and constructed databases with data from the simulator, the audio/visual recorder, information from questionnaires and NASA TLX workload measures, and the ISA tool. Biweekly and then weekly teleconferences were held to discuss data analysis plans, findings, and milestones for reporting findings. Because of the qualitative nature of much of the data and the large and distributed nature of the research teams, much more coordination and communication with regard to the approach to data analysis was needed than is typically the case (Pruchnicki et al., 2011).

Table 2. Experimental flight ISA rating prompts

Leg 1	Leg 2
2,000ft level off plus 60 seconds	Aircraft reaches 2,000ft plus 60 seconds
Heading change for BIGGY waypoint plus 60 seconds	Aircraft reaches 6,000ft after expedited descent
Aircraft reaches COPES waypoint	Aircraft reaches FL200 plus 60 seconds
Initiation of descent from FL 200	Aircraft turns over CSN VOR plus 60 seconds
Aircraft descends through 12,000ft	Aircraft reaches MOL VOR
Aircraft turns outbound after crossing JUGMO waypoint in the hold	Aircraft turns inbound over AHLER waypoint on the approach plus 15 seconds

Simulator Flight Performance Data Extraction Process

To extract the simulator flight performance data, a separate software package, Frasca Flight Recording Exporter,[™] was used to gather specific variables from the data stream for analysis.

This software package created a comma-separated value (CSV) text file that could be easily imported into Microsoft Excel.[™] Table 3 shows all of the flight parameters, units of measure, and variable names used for analysis.

Table 3. Flight simulator variables

Parameter	Units	Variable Name
Aircraft Heading	Degrees Magnetic	MagneticHeadingExpression_Deg
Altitude (AGL)	Feet	AltitudeAGLExpression_Ft
Altitude (MSL)	Feet	AltitudeMSLExpression_Ft
Autopilot engagement	Enum	AUTOPILOT1:DOIOP_C_AFCS_1_ANNUNC.AP_ENGAGESTATE
Autopilot lateral mode	Enum	AUTOPILOT1:DOIOP_C_AFCS_1_ANNUNC.ROLLCOUPLEDMODE
Autopilot vertical mode	Enum	AUTOPILOT1:DOIOP_C_AFCS_1_ANNUNC.PITCHCOUPLEDMODE
Barometric Setting in Aircraft	mmHg	BaroSetting_InHg
Barometric Setting in Sim. Environment	mmHg	DEBRIEFOUTPUTS:ALTIMETER1_PRESSURE_INHG
Engine One Interstage Turbine Temperature	Degrees Celsius	GIA1_429_FROM_MUSTANGFADEC1:DOIOP_C_EAU_ENG_1_ITT.TEMPERATURE_C
Engine Two Interstage Turbine Temperature	Degrees Celsius	GIA1_429_FROM_MUSTANGFADEC1:DOIOP_C_EAU_ENG_2_ITT.TEMPERATURE_C
Engine One Thrust	% N ₁ Fan Speed	GIA1_429_FROM_MUSTANGFADEC1:DOIOP_C_EAU_ENG_1_N1.PERCENT
Engine Two Thrust	% N ₁ Fan Speed	GIA1_429_FROM_MUSTANGFADEC2:DOIOP_C_EAU_ENG_2_N1.PERCENT
Flap Selection	Degrees	GIA1_GEA1:DOIOP_C_EAU_FLAPS_POSITION.POSITION_DEG
Fuel Level Left Tank	Gallons	GIA1_429_FROM_MUSTANGLEFTFUELQUANTITY:DOIOP_C_EAU_FUEL_ALT_L_1.FUELVOLUME_GALS
Fuel Level Right Tank	Gallons	GIA2_429_FROM_MUSTANGRIGHTFUELQUANTITY:DOIOP_C_EAU_FUEL_ALT_R_1.FUELVOLUME_GALS
Glide Slope Deviation	Dots on Indicator	GLIDESLOPERECEIVER2:DOIOP_B_GS_DATA.DEVIATION_DOTS
Heading Bug Setting	Degrees Magnetic	DEBRIEFOUTPUTS:HSI1_HEADINGBUG_DEG
Indicated Airspeed	Knots	IndicatedAirspeedExpression_Kts
Landing Gear Position (nose)	True or false	MISCOUTPUTS:NOSELDGGEARDOWNANN
Localizer Deviation	Dots on Indicator	DEBRIEFOUTPUTS:HSI1_LATERALDEVIATION_DOTS
Location Latitude	Radians	LatitudeExpression_Rad
Location Longitude	Radians	LongitudeExpression_Rad
Pitch	Degrees	PitchExpression_Deg
Pressure Differential	PSI	GIA1_429_FROM_PRESSURIZATIONSYSYEM:DOIOP_C_EAU_CABIN_DIFF_PRESS.PRESSURE_PSI
Speed Brake Deployment	True or false	GIA1_GEA1:BOIOP_C_EAU_LH_SPEED_BRAKE_EXTEND.EXTENDED
Vertical Speed	Feet per Minute	VertSpeed_Fpm
Wind Direction	Direction From in Degrees	WindTruDirection_Deg
Wind Speed	Feet per Second	WindSpeed_FtSec

Data Transformation

Before we were able to examine these flight parameters, adjustments were required to both heading values (heading bug and aircraft heading) and geographical location. The extracted heading values from the Frasca simulator software were reported 180 degrees greater or less than zero degrees. Therefore, all negative values were actually numbers between 181 and 359 degrees magnetic. For example, a magnetic heading value of -90 degrees corresponds to a heading of 270 degrees and a heading value of -170 degrees corresponds to a heading of 190 degrees. Using Microsoft Excel, we converted all negative heading values to their corresponding positive heading values between 181 and 359 degrees, resulting in values that were consistent with magnetic headings such as those seen on approach charts, runway headings, and vectors issued by ATC.

A second value transformation required was that of geographical location. The Frasca Simulator software package yields location values in radians. Using Microsoft Excel, we converted all latitude and longitude radian values into degrees where needed.

Extracting Audio and Video Files

High-fidelity audio recordings were played back and analyzed through a variety of commonplace devices and software using an MP3 format (e.g., Windows Media Player). Video Recordings were extracted from the Plexsys digital media server to a Windows 7 computer where it was viewed through the EMRRS playback system and exported to a proprietary format that is portable and can be used on personal computers outside of the simulator lab. All recorded data were transported via a LAN. To combine the video and audio from the communication streams, a Loud Technologies, Inc. 802-VLZE Premium Mic/Line audio mixer was used to balance the quality of the audio communications streams prior to combining those streams with the video streams in the EMRRS.

Extracting Instantaneous Workload Assessments

In addition to pilots' subjective workload ratings, the ISA device also captured the time delay in milliseconds of the pilot's response from the time of the cue presentation (i.e., the illuminated red light on the ISA device prompting the pilot to make a rating). Data points also included the local clock time and the timing of each cue from the start of the ISA device. The data were saved to a CSV file that was subsequently imported into Microsoft Excel for analysis. The data were then manually synchronized with the remainder of the simulator data through a computation of the simulator frame number when each ISA cue was presented. The primary workload metric was the subjective rating, and the response delay was analyzed as a secondary metric.

Master Spreadsheet

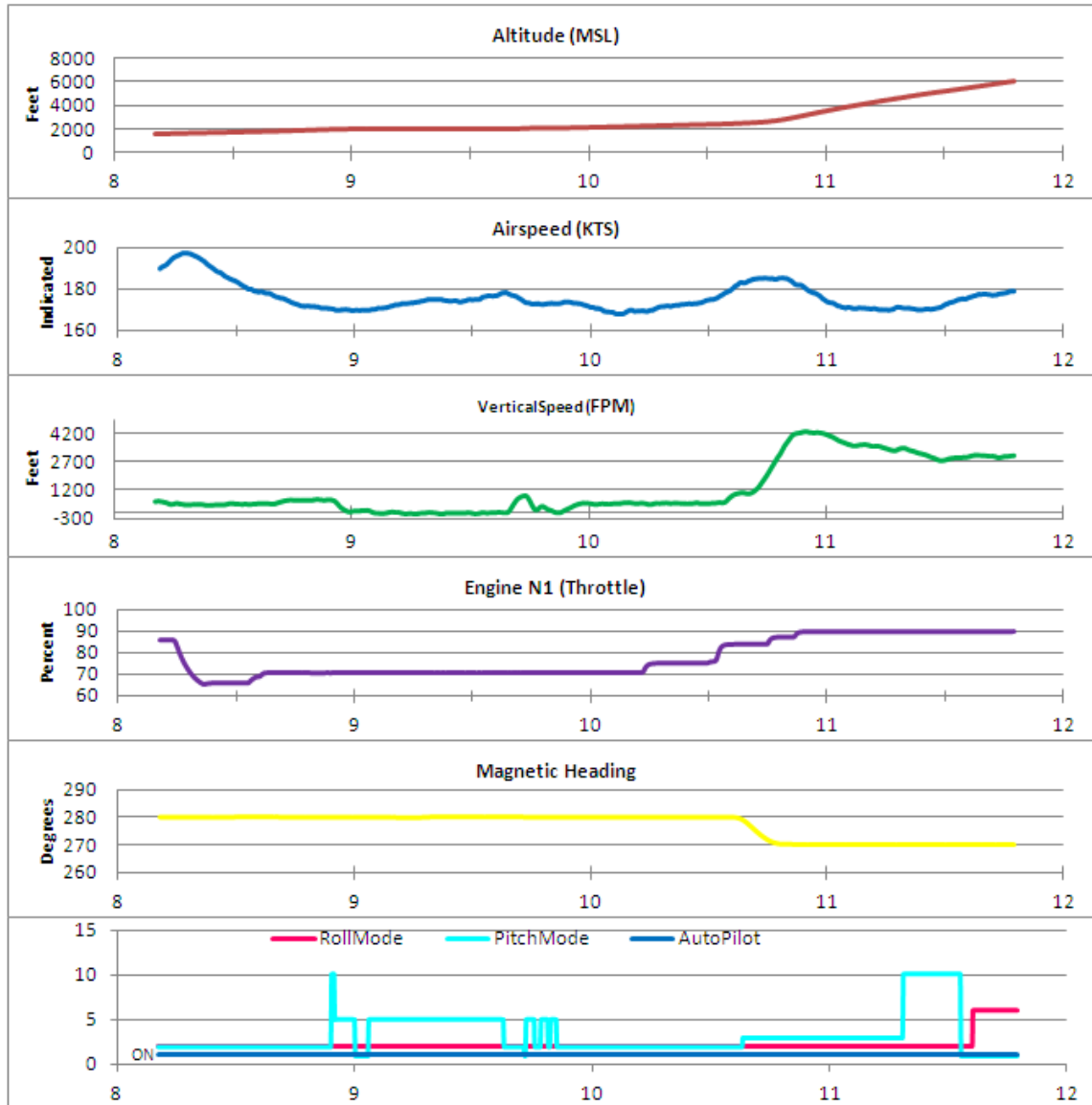
As mentioned earlier, a master spreadsheet of data was constructed using Microsoft Excel for managing a wide variety of data and discrete variables taken from the various measures, questionnaires, and data collection equipment used in this study. Data fields in the spreadsheet included information such as demographic data, TLX ratings for approaches at KMTN and KHSP, audible warnings, if any (e.g., "pull up, pull up"), aircraft configuration and completion of approach and landing checklist items, V_{ref} speeds, duration of exceedances, if any (e.g., airspeed, bank angle), threshold crossing height, and touchdown airspeed and location, among many others.

Graphs

Using extracted simulator data, graphs of several variables were created in Microsoft Excel for each participant (see Figure 8). The following variables were graphed: altitude, airspeed, vertical speed, engine power, magnetic heading, and autopilot modes. The x-axis of all graphs was expressed as time in minutes. The y-axis was indicated by a scale appropriate to each variable. Multiple graphs for each participant were constructed for the specific sections of flight under analysis.

Engine power, expressed as a percentage of maximum power, was graphed along with the mean power setting across the flight. Included on the magnetic heading graph, when appropriate, was a horizontal dotted line indicating runway heading.

To facilitate the comparison of multiple variables simultaneously, the graphs were stacked on top of each other, aligning time markers along the x-axis. Vertical lines were sometimes created through all graphs indicating when specific events such as the autopilot being switched off or the aircraft initially reaching a specific altitude during the approach. Figure 8 shows an example of some of the graphs used to analyze a portion of the climbout and en route phase of flight for one participant during the second leg of the experimental flight.



Pitch Modes			Roll Modes		
0	None		0	None	
1	Pit	Pitch	1	Roll	Roll
2	VS	Vertical Speed	2	HDG	Heading
3	FLC_IAS	Flight Level Change – Indicated Air Speed	3	APR_GPS	Approach - GPS
4	FLC_Mach	Flight Level Change – Mach	4	APR_LOC	Approach – Localizer
5	ALT	Altitude hold	5	APR_VOR	Approach – VOR
6	VPTH	Vertical Path	6	NAV_GPS	NAV mode - using GPS
7	GS	Glide Slope	7	NAV_LOC	NAV mode - using localizer
8	GA	Go Around	8	NAV_LOC_BC	NAV mode - using localizer back course
9	ALTS	Selected Altitude Capture	9	NAV_VOR	NAV mode - using VOR
10	ALTV	Vertical Path Capture	10	GA	Go Around

Figure 8. Stacked graphs of simulator data

Google Earth Plots

To assist in the analysis of the data, the flight path trajectories were plotted in the Google Earth™ software package. The creation of a Google Earth plot provided a three-dimensional representation of the flight path for review and study. The view of the plot could be manipulated by the researchers as necessary to focus on the entire flight or any particular portion of it. An example flight trajectory at cruise and initial descent plotted in Google Earth is shown in Figure 9.

Google Earth plots require the creation of OpenGIS® KML Encoding Standard data files (KML files). Details of the KML file standard are available from the maintainers of the specification, Open Geospatial Consortium, Inc. at <http://www.opengeospatial.org/standards/kml/>

Creating the KML files was a two-step procedure. The end result of both procedures was the creation of a list of placemarks that denoted the three-dimensional location of the aircraft during the entire flight as sampled every 0.2 seconds. The first step involved taking the CSV data files from each simulator run, extracting the information required to build the KML file, and creating a new Excel file with the data formatted such that the information required for each placemark within the KML file was available. This required identifying specific events during the flight such as the retraction and extension of the landing gear, flap setting changes, and the use of the autopilot. Identification of these events allowed certain placemarks to be formatted uniquely so they could be easily distinguished within the flight path trajectory. Appendix H contains a listing of the Excel Visual Basic for Applications (VBA) code that accomplished the first step.



Figure 9. Example flight trajectory plotted in Google Earth



Figure 10. Flight path trajectory with additional aircraft data selected

The second step in the procedure required the actual construction of the KML file using the data organized in the first step. The code for constructing this KML file is listed in Appendix I. The code created a placemark for each point in the flight trajectory. In addition, information regarding the aircraft status at that point, such as altitude and airspeed, was included so that a user could select any of the points along the trajectory and retrieve that status information. Figure 10 shows a Google Earth plot of the trajectory with one of the placemarks selected, showing the additional information available.

In addition to the flight path depictions, there was a need to identify a 1.3 nautical mile radius cylinder around the runway threshold at Martin State runway 15 as an obstacle clearance safe area for analysis of participants' performance of a circle-to-land maneuver. To accomplish this, the lead author wrote a VBA program to create a KML file that would plot the cylinder. The program required a formula to compute a destination latitude/longitude point given a bearing and distance from an initial point. The formula is (MTS, 2011):

$$\text{Formulae: } lat_2 = \sin^{-1} \left(\sin(lat_1) \times \cos\left(\frac{d}{R}\right) + \cos(lat_1) \times \sin\left(\frac{d}{R}\right) \times \cos(\theta) \right)$$

$$lon_2 = lon_1 + \tan^{-1} 2 \left(\sin(\theta) \times \sin\left(\frac{d}{R}\right) \times \cos(lat_1), \cos\left(\frac{d}{R}\right) - \sin(lat_1) \times \sin(lat_2) \right)$$

where: θ is the bearing (in radians, clockwise from north);

$\frac{d}{R}$ is the angular distance (in radians), where d is the distance travelled and R is the earth's radius

A listing of this program is provided in Appendix J. Figure 11 shows the plotted cylinder, along with one of the flight path trajectories.

To assist in future analyses, the code was written so that the radius, location, and height of the cylinder could be changed as required. Various units could be used to specify the cylinder radius, including feet, meters, kilometers, statute miles, and nautical miles. The values required can be entered into an Excel spreadsheet and the VBA code will then create a new cylinder KML file.

Audio Transcription

The audio files of the flight communications were transcribed into Excel files. Transcriptions of the experimental flights were completed with the use of Start Stop Universal™ software. This enabled the extraction of start and stop times to be entered for each ON-frequency transmission. ON-frequency transmissions were communications between ATC and the participant or other aircraft pilots, played by the researchers, included in the scenarios. ON-frequency transmissions included ATC instructions, advisories, weather information, pilot's readback and



Figure 11. Plot of the 1.3 nautical mile obstacle clearance area at Martin State Runway 15

requests. The participant's cockpit headset included a "hot" mic (on and recording continuously). Communications between experimenters and participants during simulation setup or in preparation for flight were considered OFF-frequency transmissions. OFF-frequency transmissions also included experimenter interjection due to equipment issues, when a participant was recorded thinking aloud, and the simulator voice aural alerts heard in the cockpit. Since OFF-frequency transmissions were not flight-related communications between ATC and the participant, they were transcribed with start times only. Each transcribed file started at zero hours, minutes, and seconds (00:00:00) (see Figure 12).

The aircraft identifiers (AC_ID) were entered for ON-frequency transmissions. However, OFF-frequency AC_ID remained blank. When more than one AC_ID was involved in a transmission, both AC_IDs were shown. The AC_ID aided in the examination of transmissions by aircraft.

To distinguish between the experimenters, the Speaker ID and Receiver ID variables included individuals' initials and their related task role (e.g., JB/ATC, BR/PILOT2). Unrecognizable voices were entered as unknown (UNK). "Participant" identified the participant transmissions. Also, when a participant transmit-

ted to the experimenters as a whole, "GROUP" was entered. In addition, when the simulator voice aural alert sounded, the Speaker ID was coded "SIMULATOR." Any participant transmissions regarding automated services were noted by the designations ATIS or AWOS.

Transmissions that could not be understood were entered as "[UNINTELLIGIBLE]." The line number (LINE) variable is a count of the transmissions. Each line represents a single transmission. This variable may be used to determine the sequence of transmissions and the total transmission lines per transcribed file.

In addition to the flight communications files, the debriefing interviews were transcribed as well. These transcriptions were placed into Microsoft Word files for review.

Preparation for Voice Analysis

Previous research has found a relationship between different vocal qualities and stress or workload. For example, it has been found that speech fundamental frequency (pitch) and vocal intensity (loudness) increase significantly as workload increases and tasks become more complex (Brenner, Doherty, & Shipp, 1994; Griffin & Williams, 1987). Speech or articulation rate has also been shown to increase when the speaker is under stress

	A	B	C	D	E	F
1	Line	STRT_TIME	STOP_TIME	SPKR_ID	RCVR_ID	Transcription
2	40	0:23:56	0:24:05	ATC	Participant	CITATION SEVEN QUEBEC FOXTROT CLIMB AND MAINTAIN FLIGHT LEVEL TWO ZERO ZERO, LEAVING ONE SEVEN THOUSAND CONTACT WASHINGTON CENTER ON ONE THREE THREE POINT NINER.
3	41	0:24:13	0:24:19	Participant	ATC	CLIMB AND MAINTAIN FLIGHT LEVEL TWO ZERO ZERO LEAVING ONE SEVEN THOUSAND CONTACT WASHINGTON ON ONE THREE THREE DECIMAL NINER, FIVE SEVEN QUEBEC FOXTROT.
4	42	0:26:32	0:26:37	Participant	ATC	UH WASHINGTON CITATION FIVE SEVEN QUEBEC FOXTROT PASSING THROUGH ONE SEVEN THOUSAND FOR FLIGHT LEVEL TWO ZERO ZERO.
5	43	0:26:40	0:26:46	ATC	Participant	CITATION FIVE SEVEN QUEBEC FOXTROT WASHINGTON CENTER ROGER. PLEASE VERIFY THE REST OF YOUR ROUTING AND YOUR SQUAWK.
6	44	0:26:48	0:27:26	Participant	ATC	UH SQUAWK IS ONE SIX TWO THREE. AND UH MY ROUTING FROM UH MY ROUTING IS UH FROM NOTTINGHAM TO CASANOVA J48 TO MONTEBELLO, THEN DIRECT HOT SPRINGS, FIVE SEVEN QUEBEC FOXTROT
7	45	0:27:27	0:27:28	ATC	Participant	SEVEN QUEBEC FOXTROT ROGER.
8	46	0:30:19	0:30:52	ATIS	Participant	INGALLS FIELD AIRPORT AUTOMATED WEATHER OBSERVATION ONE FOUR TWO TWO ZULU WEATHER. WIND TWO TWO ZERO AT FIVE, VISIBILITY SIX MILES, NINE HUNDRED OVERCAST. TEMPERATURE ELEVEN DEGREES CELSIUS, DEW POINT SEVEN DEGREES CELSIUS, ALTIMETER TWO NINER POINT EIGHT FOUR. INGALLS FIELD AIRPORT AUTOMATED WEATHER OBSERVATION ONE...
9	47	0:34:13	0:34:19	ATC	Participant	CITATION SEVEN QUEBEC FOXTROT FOR TRAFFIC DESCEND AND MAINTAIN ONE SIX THOUSAND, CULPEPER ALTIMETER TWO NINER EIGHT SIX.
10	48	0:34:21	0:34:26	Participant	ATC	ONE SIX THOUSAND, SEVEN QUEBEC FOXTROT.
11	49	0:38:59		Participant	Participant	Okay, one oh eight dess seven, and uh center one three four four, and uh uni one two three zero. Flaps
12	50	0:40:09		Participant	Participant	And checklist complete.
13	51	0:41:48		Participant	Participant	Okay, eleven degrees. Okay, landing weight - seven and a half - and two thousand four hundred and eighty - pounds.
14	52	0:42:09	0:42:16	ATC	Participant	CITATION FIVE SEVEN QUEBEC FOXTROT DESCEND PILOT'S DISCRETION, CROSS ONE FIVE NORTHEAST OF MONTEBELLO AT ONE ZERO THOUSAND, TEN THOUSAND.

Figure 12. Sample flight communication transcription

associated with high workload (Ruiz, Legros, & Guell, 1990). Therefore, we decided to conduct various voice analyses as possible objective indicators of participant workload in this study.

To prepare each participant's audio files for the fundamental frequency (F_0) and articulation rate analyses, audio files containing the flight communications of each participant were exported into Sound Forge Audio Studio (Version 10). Sections of communication for each participant to be used in the analyses, described later, were identified and labeled; all audio of ATC, experimenters, other pilots (played by the researchers), and simulator noises were deleted from the file. Each identified section of communication was then pasted into a single WAV file so that each participant had one audio file containing all audio sections to be analyzed.

F_0 was calculated at a rate of 0.01 s using WaveSurfer™ (Version 1.8.8p4). The average articulation rate per section was then calculated using Praat™ software (Version 5.3.22; Boersma & Weenink, 2012; de Jong & Wempe, 2009). Articulation rates were then calculated by dividing the number of syllables uttered by the total speaking time.

Preparation for Analysis of Approach and Landing Data

The analysis of flight performance data during the approach and landing phases of flight required taking the raw position data extracted from the flight simulator and using that data to measure deviation from an expected path or from nominal

flight performance. We began by transferring simulator flight data - airspeed, vertical speed, altitude (MSL & AGL) and aircraft configuration (flaps and gear) to the master spreadsheet, described earlier. These data were compared to the plots created in Google Earth and the graphs, also discussed earlier, to enhance our understanding of the dynamics seen during these phases of flight. They were also evaluated relative to the audio component of the cockpit videos to determine when aural annunciations and warning indications such as gear horns, altitude call-outs, and terrain warnings, such as "sink rate" and "pull-up," were provided. This contributed to our evaluation of whether stabilized approach and landing criteria had been met.

We wanted to determine how far the aircraft deviated from an extended centerline of the runway, if at all, during the final approach. Additionally, as part of the effort to analyze landing performance, a number of potential performance metrics were required such as the height of the aircraft when it crossed the runway threshold, the speed of the aircraft at the threshold, as well as at the touchdown point, and the aircraft distance from the runway centerline when crossing the threshold and at the touchdown point. Although aircraft airspeed and altitude were recorded, there was no indication within the data stream of the position of the aircraft relative to the runway threshold and centerline. These positions had to be computed based on the identification of latitude/longitude points representing the runway threshold and centerline.

Using the flight simulator, we identified two latitude and longitude points that corresponded to the corners of the runway thresholds of both the Martin State runway 15 and Hot Springs runway 25; two other latitude and longitude points were also found that corresponded to positions along these runway centerlines. With these points for reference, aircraft distance to the threshold and centerline were computed using a cross-track error formula found online at the Movable Type Scripts website (MTS, 2011). The cross-track error formula is as follows:

$$d_{xt} = \sin^{-1} \left(\sin \left(\frac{d_{13}}{R} \right) \times \sin(\theta_{13} - \theta_{12}) \right) \times R$$

where:

d_{xt} is cross-track error

d_{13} is distance from start point to third point

θ_{13} is (initial) bearing from start point to third point

θ_{12} is (initial) bearing from start point to end point

R is the earth's radius

For our calculations, the radius of the earth was denoted in kilometers and equal to 6,371. To compute the distance between two latitude and longitude points, we used the spherical law of cosines formula (MTS, 2011).

Spherical law of cosines:

$$d = \cos^{-1} ((\sin(lat_1) \times \sin(lat_2)) + \cos(lat_1) \times \cos(lat_2) \times \cos(lon_2 - lon_1)) \times R$$

The computation for bearing (MTS, 2011) is given as:

$$\theta = \tan^{-1} \frac{2(\cos(lat_1) \times \sin(lat_2) - \sin(lat_1) \times \cos(lon_2 - lon_1))}{\sin(lon_2 - lon_1) \times \cos(lat_2)}$$

These formulae were used to determine the distance from the runway threshold and allowed for the distance from the centerline to be computed for any desired point during the flight. A sign change in the threshold distance indicated when the aircraft crossed the threshold. Because the data were generated every 0.2 seconds, the aircraft typically travelled about 30 feet between samples during the landing phase of flight. This meant that there was no single point that corresponded exactly to the runway threshold. Instead, the points immediately preceding and following the crossing of the threshold were identified. The altitudes of these points were used to compute the height of the aircraft at the threshold by assuming a linear trajectory (constant descent rate) between the altitudes.

One of the items of interest for this particular analysis was the landing distance for each flight. However, because the simulator program model for handling the aircraft on the ground was poor, actual landing distances observed during the study were not accurate reflections of what could be expected

in real-world landings. To compensate for the poor ground model, we decided to calculate the expected landing distance for each flight. A table of predicted landing distances for a nominal airspeed was available from Cessna that was based on the weight of the aircraft, the temperature, airport elevation, and the wind speed and direction. How much more (or less) runway participants would need over the landing table distance was derived by dividing their indicated (actual) airspeed by the nominal touchdown airspeed and then squaring that value—thus yielding the percent of landing distance needed. That percentage was then multiplied by the landing distance derived from the tables to get the computed landing distance. The landing table distance was subtracted from this computed landing distance to get the number of feet over (or under) the amount specified in the landing tables which the pilot would have needed to land. This length was used to plot the expected stopping point for each flight in Google Earth.



Figure 13. Touchdown zone (green rectangle) along with initial (green) and projected final (red) landing points

Figure 13 presents the TDZ for Hot Springs Runway 25 (the green rectangle). The green icons represent the touchdown point for sample flights. The red icons represent the projected stopping point for each sample flight based on the initial touchdown point and airspeed.

The construction of this picture required manually inputting the latitude and longitude points individually, along with identifying and computing the four points representing the touchdown zone.

CONCLUSIONS

Compared to the amount of time required to plan a HITL flight simulation study and analyze and report the results, the amount of time actually spent conducting the study was quite small. This type of research collects literally thousands of variables, many times a second over the duration of a flight that could last several hours. Ensuring that the data are valid requires careful planning and execution. It also involves people working as a team. In addition to providing detailed information about how data were prepared for analysis in this study, the purpose of this report is to communicate to the reader much of the work that is required to perform this type of research, both in the planning stage and in the post-experimental stage.

When pilots perform flights in the real world, they do not simply show up at the airport, jump in the plane, start the engine, and takeoff. There are many steps involved in planning and executing the flight. The safety of the flight depends critically on the performance of these steps. When conducting a flight simulation study, one intention of the researcher is to make the flight experience as realistic as possible so that the performance and decision-making activities of pilots match what would be found if they were flying an actual aircraft. The presence of preflight planning data assists in the overall flight experience.

At the same time, even though the researcher attempts to make the flight experience realistic, the researcher needs to collect relevant data. While some data collection activities are transparent to the pilot, others involve some intrusion into the cockpit. Workload measures and eye-tracking data can detract from the realism, but careful planning and execution can minimize the interference.

After the last pilot has flown the simulation, the work is far from over. Given the complexity of the data, there is much work to be accomplished even before the analyses can begin. Extracting and organizing all of the data requires much time and effort. A plan to organize the data will greatly decrease the workload involved with processing it.

After extracting and organizing, there is much work involved in presenting the data in such a way that it can be understood. The construction of task analyses and concurrent task timelines will assist in focusing the data analyses in specific directions. Some types of data, such as video feeds from inside the cockpit, can be viewed without much processing. Other data, however, is in a numeric or other format that is not easily understood. The development of plots and graphs of the data assist researchers in understanding what happened during the flight. And, when combined with video and audio data, these plots and graphs allow a much more complete understanding of what actually occurred. The advent of Google Earth technology adds greatly to the toolbox of aviation researchers, allowing three-dimensional representations of the flights to be depicted and viewed from every conceivable angle and distance.

There are numerous flight deck issues needing to be investigated. Human in the loop (HITL) flight simulation studies are an important part of this research. If our readers are able to use the material presented here as a resource for planning and conducting their own flight research and preparing data for analysis, then this report will have succeeded.

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APPENDIX A

AIR TRAFFIC CONTROLLER & FLIGHT SERVICE STATION PERSONNEL WEATHER BRIEFING PACKAGE

Leg 1 TEB-MTN

Introduction

This weather package is designed to acquaint you with the weather conditions that will be simulated during leg one of this study. We have tried to emulate real world conditions as much as possible. As such we have probably provided more information than you need to accomplish your task.

With any study as compared to real life flight conditions, there may always be situations for which no data is provided. To help mitigate the awkwardness of these events we fully support your professional judgment in attempting to maintain as much realism as possible. For example, in an effort to support this idea, we have included a generic METAR for a situation where a pilot may ask for weather at a location that we have not provided. Study personnel will always be available during the scenarios to help you if needed.

To ensure sufficient realism during the study and when functioning as a flight service station (FSS) personnel i.e. Flight Watch – please remember to gather the following information should a pilot contact you for weather.

Aircraft Identification

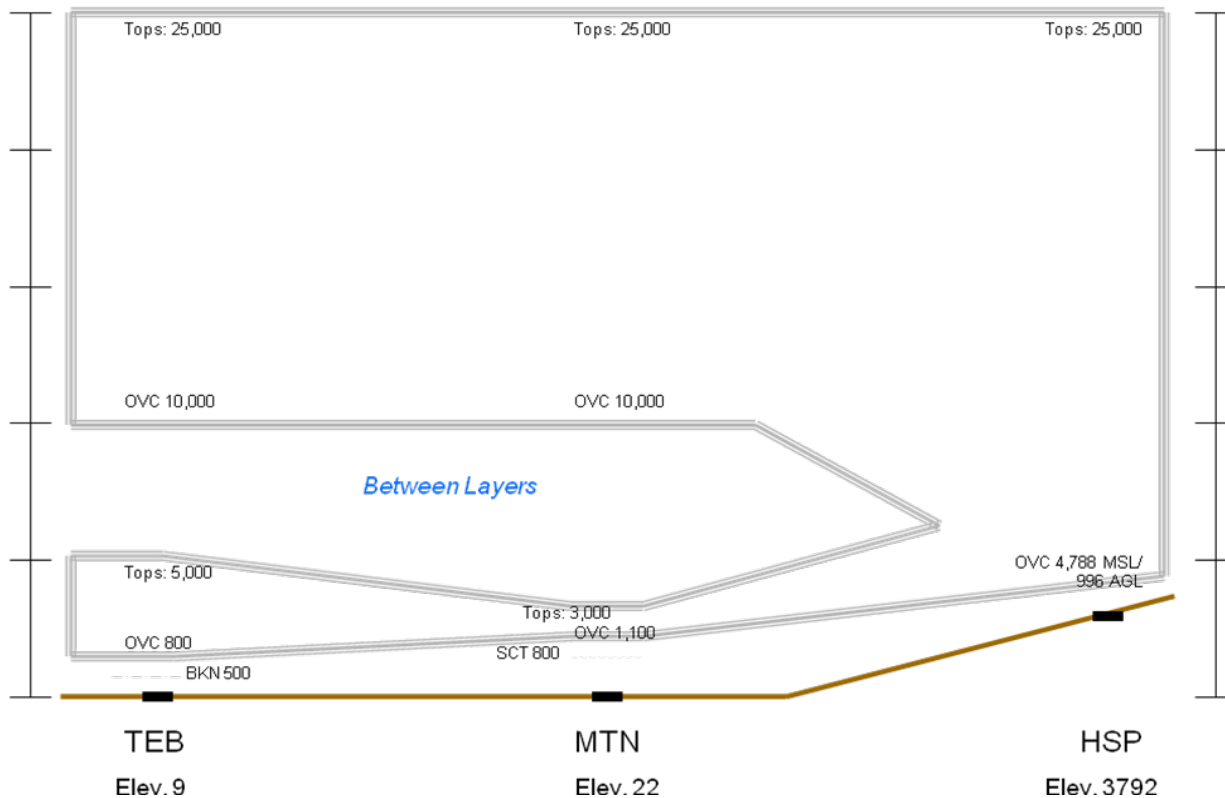
Aircraft Type

Aircraft Position

Altitude

Destination

This chart below provides a graphic representation of the cloud coverage for both legs 1 and 2. The purpose of this chart is to offer you a global understanding of these conditions that the subject pilots will experience. Later in this package, the details of weather for numerous stations along the route are provided.



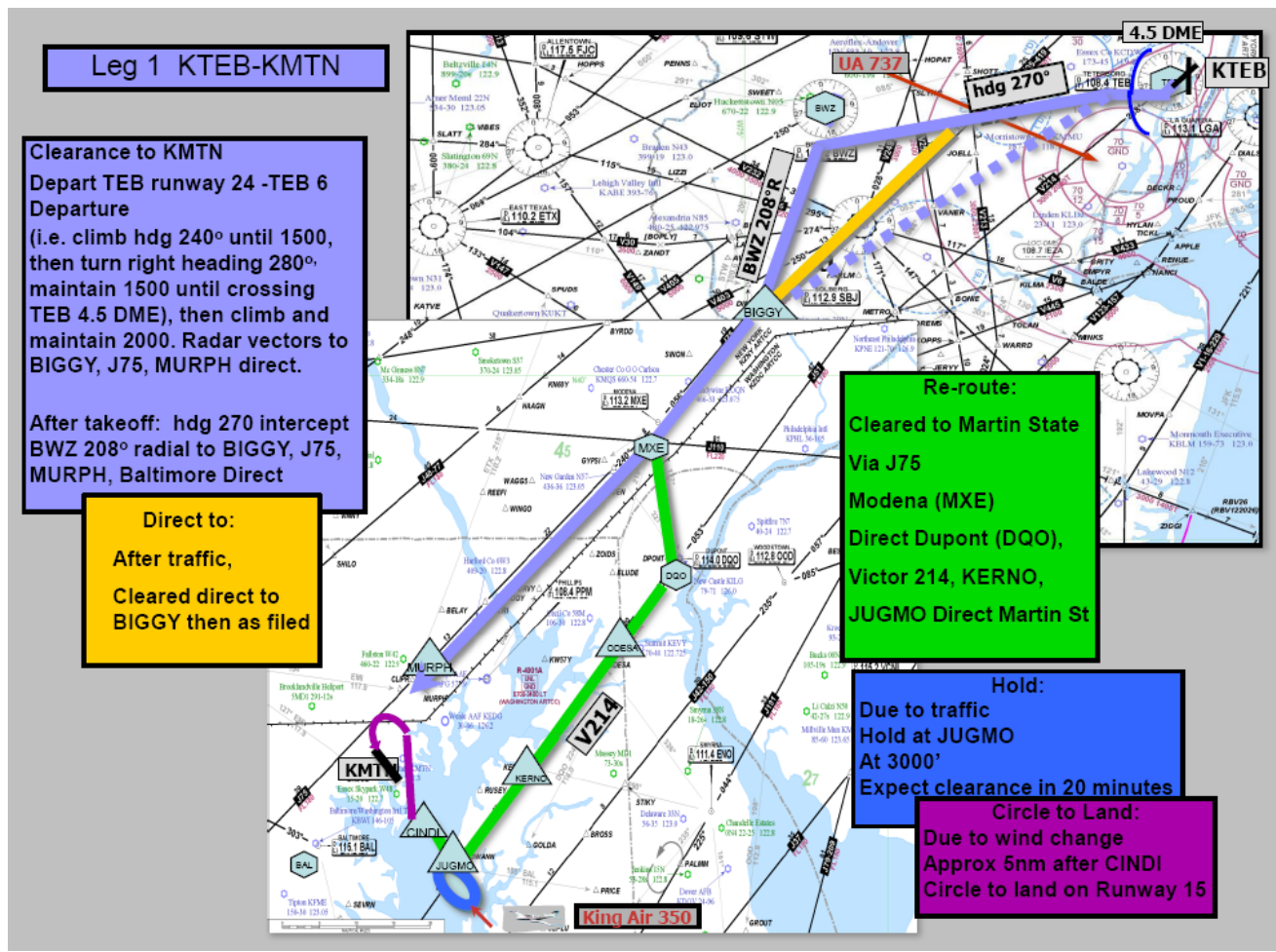
Leg 1 KTEB-KMTN

Flight Plan

U.S. DEPARTMENT OF TRANSPORTATION FEDERAL AVIATION ADMINISTRATION		(FAA USE ONLY) ☐ PILOT BRIEFING ☐ VNR			TIME STARTED		SPECIALIST INITIALS	
FLIGHT PLAN		☐ STOPOVER						
1. TYPE ☒ VFR ☐ IFR ☐ DVFR	2. AIRCRAFT IDENTIFICATION NS10C	3. AIRCRAFT TYPE / SPECIAL EQUIPMENT C510/L	4. TRUE AIRSPEED 240 KTS	5. DEPARTURE POINT KTEB	6. DEPARTURE TIME PROPOSED (Z) 1300 ACTUAL (Z)		7. CRUISING ALTITUDE FL200	
8. ROUTE OF FLIGHT TEB6.TEB BIGGY J75 MURPH								
9. DESTINATION (Name of airport and city) Baltimore Martin State KMTN			10. EST. TIME ENROUTE HOURS 0 MINUTES 41		11. REMARKS			
12. FUEL ON BOARD HOURS 3 MINUTES 30		13. ALTERNATE AIRPORT(S)		14. PILOT'S NAME, ADDRESS & TELEPHONE NUMBER & AIRCRAFT HOME BASE Mustang Pilot (On file)			15. NUMBER ABOARD 1	
16. COLOR OF AIRCRAFT White with blue strip		17. DESTINATION CONTACT/TELEPHONE (OPTIONAL)						
CIVIL AIRCRAFT PILOTS. FAR Part 91 requires you file an IFR flight plan to operate under instrument flight rules in controlled airspace. Failure to file could result in a civil penalty not to exceed \$1,000 for each violation (Section 901 of the Federal Aviation Act of 1958, as amended). Filing of a VFR flight plan is recommended as a good operating practice. See also Part 99 for requirements concerning DVFR flight plans.								

FAA Form 7233-1 (8-82)
Electronic Version (Adobe)

CLOSE VFR FLIGHT PLAN WITH _____ FSS ON ARRIVAL



Area synopsis

SYNOPSIS..BROAD UPR TROF CONTS FM THE MID/LWR MS VLY INTO THE GLFMEX. TROF WL SHFT SLOLY EWD. STNR FNT CONTS FM THE MD/VA CSTL WTRS-VA/NC BORDER-ERN TN-SRN MS. BY 12Z WK LOW WL BR OVR SWRN NC WITH STNR FNT ENEWD TO MD/VA CSTL WTRS. WK CDFNT WL EXTND FM THE LOW SWWD TO SRN AL. DEEP MOIST AIRMASS EXTDS FM THE MID ATLC RGN TO THE SERN US. MSTR WL SPRD SLOLY NWD INTO PA/NJ-EXTRM SE NY AFT 06Z.

Area forecast

PA NJ

SERN PA/SRN NJ..SCT010-020 OVC030. TOPS FL200. WDLY SCT -SHRA. BECMG 1218 BKN010-020 OVC030. OCNL VIS 3-5SM -RA BR. OTLK..IFR CIG RA BR.

NERN PA/NRN NJ..SCT010 BKN CI. BECMG 0306 BKN010. TOPS FL200. OTLK..VFR BECMG MVFR CIG SHRA AFT 11Z.

SWRN PA..BKN040-050. TOPS 080. BKN CI. BECMG 0306 BKN030 OVC100. TOPS FL220. OCNL VIS 3-5SM -SHRA BR. OTLK..IFR CIG SHRA BR.

NWRN PA..SCT050-060 BKN CI. 05Z SCT-BKN040-050. TOPS 080. BKN CI. OTLK..MVFR CIG.

MD DC DE VA

WRN MD/NWRN VA..OVC020-030 LYRD TO FL250. OCNL VIS 3-5SM -RA BR.OTLK..IFR CIG RA BR.

SWRN VA..BKN010-020 OVC030. TOPS 250. SCT -SHRA/-TSRA. CB TOPS FL420. BECMG 0003 OVC030-040 LYRD TO FL250. OCNL VIS 3-5SM -SHRA BR. OTLK..IFR CIG SHRA BR.

FAR S CNTRL/SERN VA..BKN020 BKN100. TOPS 150. SCT -SHRA/-TSRA. CB TOPS FL420. BECMG 1218 BKN010-020 OVC100. TOPS FL240. OCNL VIS 3-5SM -SHRA BR. OTLK..IFR CIG SHRA BR. RMNDR

ERN VA/ERN MD/DC/DE..BKN-OVC010-020 LYRD TO FL250. OCNL VIS 3-5SM -RA BR. OTLK..IFR CIG RA BR.

CSTL WTRS

S OF CYN..BKN010-020 BKN-OVC100. TOPS FL200. SCT -SHRA. OTLK..IFR CIG SHRA BR. BTN CYN AND ACK..BKN015-025 OVC100. TOPS FL200. WDLY SCT -SHRA. OTLK..MVFR CIG SHRA BR.

N OF ACK..SCT-BKN010-020. TOPS 040. OTLK..IFR CIG OFSHR.VFR NEARSHR.

AIRMET

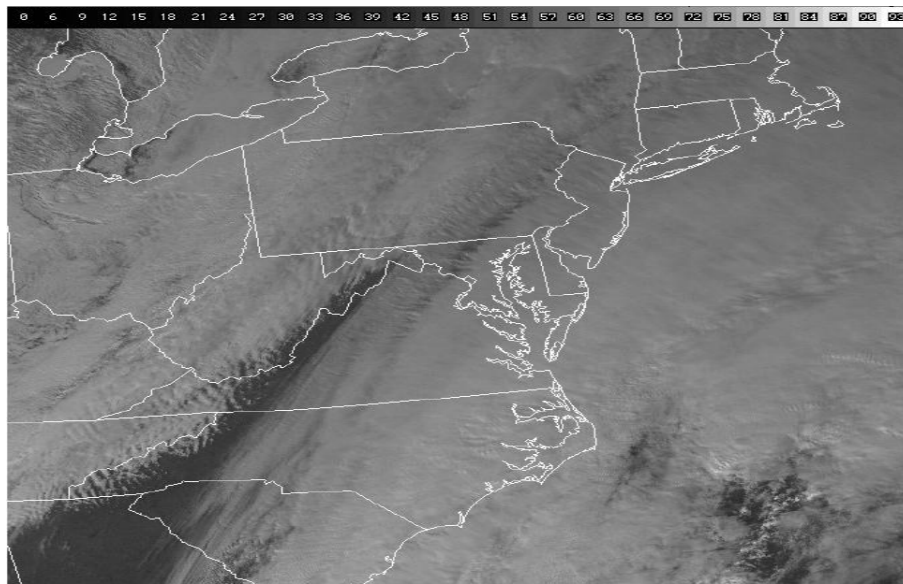
AIRMET MTN OBSCN..PA WV MD VA FROM HAR TO 40SSE PSK TO HNV TO 40S HNN TO 40SE AIR TO HAR MTNS OBSC BY CLDS/PCPN/BR. CONDS CONTG BYD 21Z.

AIRMET TURB..VT NY LO PA OH LE WV
FROM YSC TO 20SSW ALB TO 30SSW PSB TO HNN TO CVG TO FWA TO DXO TO MSS TO YSC
MOD TURB BLW FL180. CONDS CONTG BYD 21Z THRU 03Z.

Freezing Level

FRZLVL..RANGING FROM 120-140 ACRS AREA
120 ALG 40S FWA-20ENE ERI-MSS-40NE MSS
140 ALG 30S HNN-30W SAX-20SSE MLT-30ENE HUL

Satellite view of area



Winds aloft

DATA BASED ON 181200Z

VALID 181200Z FOR USE 1200-1900Z. TEMPS NEG ABV 24000

	3000	6000	9000	12000	18000	24000	30000	34000
BDL	2328	2330+09	2435+05	2542+01	2647-13	2548-25	275740	287451
JFK	2325	2430+09	2435+04	2344+01	2546-12	2544-24	264840	276150
AVP	2219	2125+09	2236+04	2340+01	2348-13	2444-24	255740	246950
ACY	1928	1934+10	2045+04	2148+00	2247-11	2344-24	244140	254950
EMI	1829	1946+10	2045+04	2239-01	2259-11	2349-23	245440	244650
RIC	1727	1843+11	1845+05	1848+01	1852-12	1949-23	193539	202749

Route PIREPs

TEB UA /OV LGA270025 /TM 1150 /FL080 /TP PA28 /TA 04 /TB SMOOTH DURC

JFK UA /OV JFK180030 /TM1052 /FL050 /TP MD81 /WV 24030/RM TOPS AT 050 OVC ABV

NOTAMS**KTEB**TEB 11/031 **TEB** AD ALL IN PAVEMENT LGTS AND ELEVATED GUARD LGTS OTSTEB 04/069 **TEB** RWY 1 REIL CMSNDTEB 07/065 **TEB** RWY 1 PAEW 1300 S AER 1030-2100 MON-FRI WEF 1007191030TEB 02/065 **TEB** OBST BRIDGE UNKN (624 AGL) 5 E (4051N7357W) LGT OTS WEF 0902231208TEB 11/006 **TEB** OBST CRANE 237 (230 AGL) 1 S AER 6 FLAGGED/LGTDTEB 11/032 **TEB** OBST CRANE 65 (60 AGL) .6 SSW AER 1 LGTD/FLAGGED 1200-2100 DLY TIL 1011122100TEB 11/030 **TEB** NAV RWY 19 ILS LLZ OTS WEF 1011101139UAR 04/009 **TEB** AIRSPACE JAIKE TWO ARRIVAL.. EXPECT TO CROSS JAIKE WAYPOINT AT 13,000 FEET.USD 07/209 **TEB** AIRSPACE TETERBORO SIX DEPARTURE CHANGE RWY 24 DEPARTURE ROUTE DESCRIPTION TO READ: TAKE-OFF RWY 24: CLIMB HEADING 240 TO 1500, THEN RIGHT TURN VIA HEADING 280, CROSS TEB 4.5 DME AT 1500 (NON-DME AIRCRAFT CROSS COL R-011 AT 1500), CLIMB AND MAINTAIN 2000, THENCE..TEB 05/146 **TEB** TWY K NONMOVEMENT AREA BOUNDARY NONSTD MARKINGTEB 11/020 **TEB** TWY B EDGE LINES W RWY 1/19 NONSTDTEB 08/037 **TEB** RAMP ATLANTIC AVIATION RAMP FENCING 56 FT LONG BY 160 FT WIDE ADJ HANGER 3 LGTED**KMTN**MTN 03/004 **MTN** RWY 33 VASI OTSMTN 04/002 **MTN** RWY 33 REIL OTSMTN 07/007 **MTN** NAV GBT OTSMTN 09/011 **MTN** AIRSPACE TFR SEE FDC 0/9463 ZDC 99.7MTN 08/001 **MTN** TWY T PAEW ADJMTN 09/013 **MTN** Airspace R4001B active 15000200 EFC 1009281100**Restricted Airspace in MTN area****R-4001A**

GND-UNL 0700-2400LT

GND-*10,000 0000-0700LT

*Higher alt by NOTAM ZDC

It is not active during this flight.

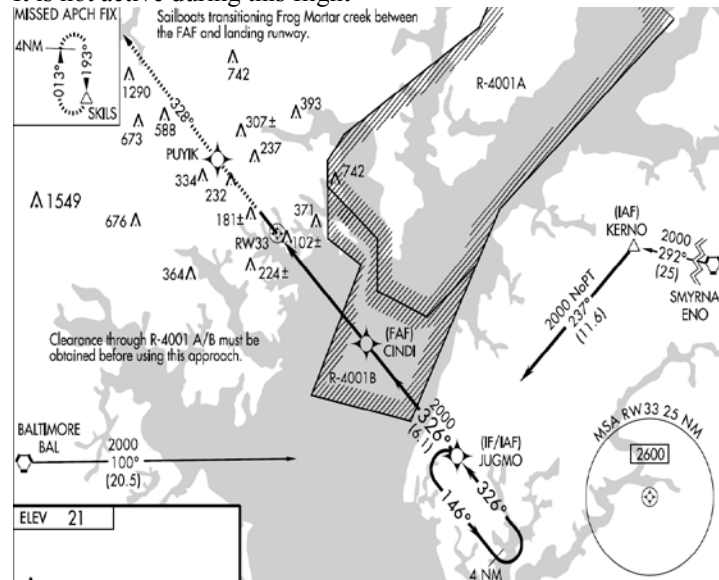
R-4001B

GND-*10,000 0000-0700LT

*Higher alt by NOTAM ZDC

Intermittent by NOTAM ZDC

It is not active during this flight



METARs

These are in approximate geographical order to follow the route of flight. Report times for non-ATIS (ASOS or AWOS) data is missing. Please insert current simulator time minus a few minutes to ensure realism.

- Teterboro , NJ KTEB ATIS 132.02 Information ALPHA @ 1253Z
KTEB 181253Z 22009G15KT 2SM -RA BKN005 OVC008 20/17 A29.85
- Caldwell, NJ KCDW ATIS 135.50 Information ALPHA @ 1253Z
KCDW 181253Z 23010G14 3SM -RA BKN006 OVC009 20/16 A2984
- Morristown, NJ KMMU ATIS 124.25 Information ALPHA @ 1253Z
KMMU 181253Z 22010G14 2SM RA BKN006 OVC007 19/16 A2985
- Newark, NJ KEWR ATIS 134.82 Information ALPHA @ 1253Z
KEWR 181253Z 21015 1SM RA BKN004 OVC006 19/16 A2983
- Linden, NJ KLDJ AWOS 124.025
KLDJ18XXXXXZ 21015 1SM RA BKN004 OVC006 19/16 A2983
- Sommerville, NJ KSMQ ASOS 120.6
KSMQ 18XXXXXZ 22010KT 4SM SCT020 BKN030 21/16 A2985 RMK AO2
- Allentown, PA KABE ATIS 126.97 @ 1253Z Information ALPHA
KABE 181253Z 24005KT 5SM SCT020 BKN060 20/16 A2989
- Quakertown, PA KUKT AWOS 119.47
KUKT 18XXXXXZ 24010KT 5SM SCT025 BKN040 21/15 A2990 RMK AO3
- Doylestown, PA KDYL ASOS 118.875
KDYL 18XXXXXZ 210KT 4SM RA SCT010 BKN030 OVC040 20/15 A2985
RMK AO2
- Perkasio, PA KCKZ AWOS 126.32
KCKZ18XXXXXZ 24010KT 5SM SCT020 BKN050 20/15 A2989 RMK AO3
- Trenton, NJ KTTN ATIS 126.77 @ 1253Z Information ALPHA
KTTN 181253Z 20009KT 2SM BR BKN007 OVC015 18/16 A2988
- Philly NE, PA KPNE ATIS 121.15 @ 1253Z Information ALPHA
KPNE 181253Z 22010KT 3SM BR BKN007 OVC015 19/15 A2987
- Pottstown, PA KPTW ASOS 119.425
KPTW 18XXXXXZ 00000KT 1SM OVC008 15/14 A2984 RMK AO2
- Mount Holly, NJ KWAY ASOS 119.32
KWAY18XXXXXZ 17005KT 3SM BR OVC010 17/15 A2990 RMK AO2
- Philadelphia, PA KPHL ATIS 133.40 @ 1253Z Information ALPHA
KPHL181253Z 17010KT 4SM BR BKN009 OVC020 20/15 A2990
- Coatsville, PA KMQS AWOS 126.25
KMQS 18XXXXXZ 16015KT 5SM FEW035 OVC040 15/09 A2990 RMK AO2

- West Chester, PA KOQN AWOS 121.4
KOQN 18XXXXZ 17010KT 4SM FEW025 OVC030 19/15 A2988 RMK AO3
- Wilmington, DE KILG ATIS 123.95 @ 1253Z Information ALPHA
KILG 181253Z 14009KT 2SM BR BKN005 OVC015 18/16 A2985
- Middletown, DE KEVY AWOS 132.32
KEVY18XXXXZ 15008KT 2SM BR BKN004 OVC010 17/16 A2986 RMK
AO3
- Aberdeen, MD KAPG ATIS 108.4 @ 1253Z Information ALPHA
KAPG 181253Z 14009KT 2SM BR BKN005 OVC015 18/16 A2985
- Martin State, MD KMTN ATIS 127.92 @ 1253Z Information HOTEL
KMTN 181253Z 12013KT 3SM BR SCT008 OVC011 19/17 A29.90
- Baltimore, MD KBWI ATIS 127.80 @ 1253Z Information ALPHA
KBWI 181253Z 13013KT 3SM BR SCT008 OVC010 18/16 A2989
- Gaithersburg, MD KGAI AWOS 128.27
KGAI 181253Z 20013KT 3SM BR SCT009 OVC011 19/16 A2989 RMK AO3
- Ft. Mead, MD KFME AWOS 123.92
KFME18XXXXZ 13010KT 3SM BR SCT008 OVC010 18/16 A2989 RMK
AO3
- College Park, MD KCGS AWOS 121.22
KCGS18XXXXZ 13010KT 3SM BR SCT008 OVC010 18/16 A2989 RMK
AO3
- Washington, DC KIAD ATIS 134.85 @ 1253Z Information ALPHA
KIAD 181253Z 20015KT 5SM BR SCT020 OVC030 19/15 A2991
- Washington, DC KDCA ATIS 128.80 @ 1253Z Information ALPHA
KDCA 181253Z 14008KT 4SM BR SCT009 OVC011 17/13 A2989
- *Generic ASOS for area when they ask for a location we do not have.*

East of the route of flight (east of the stationary front)

18XXXXZ14010KT 3SM BR SCT008 OVC010 19/16 A2990 RMK AO2

West of the route of flight (west of the stationary front)

18XXXXZ21010KT 4SM BR SCT015 OVC030 17/14 A2988 RMK AO2

TAF

- KTEB - KCDW - KMMU
KTEB 181200Z 1812/1912 23009KT 2SM -RA BKN005 OVC008
FM181500 23012KT 5SM -RA SCT010 OVC020
FM190100 24010KT 5SM BKN010 OVC020
FM190800 26015KT P6SM BKN010 OVC020
- KEWR - KLDJ
KEWR 181200Z 1812/1912 22010KT 3SM -RA BKN006 OVC010

FM181500 23012KT 5SM -RA SCT012 OVC020
FM190100 24010KT 5SM BKN015 OVC030
FM190800 26015KT P6SM BKN010 OVC020

- KABE - KUKT - KCKZ

KABE 181200Z 1812/1912 24010KT 5SM BKN020 OVC060
FM181500 23012KT P6SM BKN030 OVC070
FM190100 24010KT 5SM SCT040 BKN080
FM190800 26015KT P6SM SCT100

- KTTN - KSMQ - KDYL

KTTN 181200Z 1812/1912 17009KT 2SM BR BKN005 OVC015
FM181500 18010KT 4SM -RA SCT008 OVC020
FM190100 17010KT 5SM BKN010 OVC020
FM190800 16010KT P6SM BKN010 OVC020

- KPHL - KPNE - KWAY - KOQN

KPHL 181200Z 1812/1912 17009KT 2SM BR BKN005 OVC015
FM181500 18010KT 4SM -RA SCT008 OVC020
FM190100 17010KT 5SM BKN010 OVC020
FM190800 16010KT P6SM BKN010 OVC020

- KRDG - KPTW - KMQS

KRDG 181200Z 1812/1912 17009KT 3SM BR BKN006 OVC008
FM181500 18010KT 4SM -RA SCT008 OVC010
FM190100 17010KT 4SM BKN080 OVC010
FM190800 16010KT 5SM BKN080 OVC010

- KILG - KEVY

KILG 181200Z 1812/1912 17012KT 3SM BR BKN006 OVC008
FM181500 18010KT 4SM -RA SCT008 OVC010
FM190100 17010KT 4SM BKN080 OVC015
FM190800 16010KT 5SM BKN080 OVC015

- KMTN - KAPG

KMTN 181120Z 1812/1912 12005KT 5SM OVC015
FM181600 17015KT P6SM SCT020 OVC070
FM190100 22010KT P6SM SCT040 OVC080
FM190800 22005KT P6SM BKN100

- KBWI - KFME

KBWI 181200Z 1812/1912 22012KT 5SM BR BKN020 OVC060
FM181500 18010KT 5SM SCT020 OVC070
FM190100 21010KT 5SM SCT050 OVC090
FM190800 21010KT P6SM SCT080 BKN100

- KIAD - KGAI

KIAD 181200Z 1812/1912 22012KT 5SM BR BKN020 OVC060
FM181500 17015KT 5SM SCT020 OVC070
FM190100 22010KT P6SM SCT060 OVC090
FM190800 22005KT P6SM BKN100

- KDCA

KDCA 181200Z 1812/1912 22012KT 5SM BR BKN020 OVC060
FM181500 17015KT 5SM SCT020 OVC070
FM190100 22010KT P6SM SCT040 OVC080
FM190800 22005KT P6SM SCT080 BKN100

APPENDIX B DEMOGRAPHIC DATA QUESTIONNAIRE

Background Data

1. Age: [Click here to enter age.](#)
2. Gender (Please check one): Male ☐ Female ☐
3. (This question is being asked to make sure you will be able to fly in the simulator without problems.) When you fly, do you wear bi/tri focal glasses that have lined lenses (i.e. not progressive lenses) or those with anti-glare coating or transition lenses (automatically lighten or darken in different lighting conditions)?

Yes ☐ No ☐
 - a. If so, do you have the option of wearing glasses with lenses other than those listed above or contact lenses? Please check one.
Yes ☐ No ☐
4. What is the aircraft configuration code/serial number of your Citation Mustang? Please check one:
☐ AF – Airplanes 510-00041 and on
☐ AG – Airplanes 510-001 thru -0040
☐ AH – 510-0001 thru -0065 incorporating SB510-34-02
☐ AI – Airplanes 510-0001 thru -0065 not incorporating SB510-34-02
5. What optional equipment do you have in your Citation Mustang? Check **all** that apply.
☐ Automatic direction finder (ADF)
☐ Chart view
☐ Traffic advisory system
☐ Synthetic vision system
☐ XM Radio / Audio Input Panel
☐ Iridium Handheld Satellite Phone Antenna and Port
☐ Seat customization (describe): [Click here to enter text.](#)

General Flying history

1. Check the type(s) of flying you currently do (check **all** that apply):
☐ Professional (e.g., airline transport pilot, corporate pilot)
☐ Instructional (i.e., flight instructor, mentor pilot)
☐ Personal Business
☐ Recreational
☐ Other (Please specify): [Click here to enter text.](#)
2. Number of total flying hours: [Click here to enter total flying hours.](#)

3. Number of jet hours flown as a single pilot: [Click here to enter single pilot jet hours flown.](#)
4. List all ratings and certificates held: [Click here to enter ratings and certificates held.](#)
5. What aircraft do you currently fly on a regular basis?
[Click here to enter aircraft.](#)
6. How many hours have you flown in the last 3 months?
[Click here to enter hours.](#)
7. How many hours have you flown in the past year?
[Click here to enter hours.](#)
8. When was the last time you flew as a single pilot in a jet?
[Click here to enter date.](#)
9. What geographical areas (parts of the country) do you generally fly in?
[Click here to enter areas.](#)

Citation Mustang Flying History

1. When did you take delivery of your Citation Mustang jet?
[Click here to enter date.](#)
2. When did you complete your initial training?
[Click here to enter date.](#)
3. Have you completed any Citation Mustang recurrent training?

Yes ☐ No ☐

a. If so, when? [Click here to enter date.](#)
4. How many hours, if any, have you flown your/a Citation Mustang with a mentor pilot?
[Click here to enter hours.](#)
5. How many hours have you flown your/a Citation Mustang in the last 3 months?
[Click here to enter hours.](#)
6. How many hours have you flown your/a Citation Mustang in the past year?
[Click here to enter hours.](#)
7. How many hours have you flown your/a Citation Mustang in the past year as a single pilot (without a mentor pilot on board)?
[Click here to enter hours.](#)

Personal experience with Advanced Avionics and Automation

1. Please rate your overall **experience** using different types of advanced avionics/glass cockpits. (1=little experience to 5=very experienced) Please select only one.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

2. Please rate your **experience** using the G1000 in the Citation Mustang or any other aircraft. (1=little experience to 5=very experienced) Please select only one.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3. Please rate your **skill level** using the G1000 in the Citation Mustang or any other aircraft. (1=little experience to 5=very experienced) Please select only one.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

4. Please rate your **experience** using the G430/G530 or other similar Garmin IFR avionics systems. (1=little experience to 5=very experienced; if not applicable, please jump to question 5) Please select only one.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

Please list each type of Garmin IFR avionics system currently or previously used, in addition to the G1000: [Click here to enter type](#).

- a. Please rate your **skill level** in using these other Garmin IFR avionics (not including the G1000). (1=not very skilled to 5=very skilled) Please select only one.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

5. Please rate your **experience** using *other types* of advanced avionics (e.g. Avidyne, Chelton, etc.). (1=not very experienced to 5=very experienced; if not applicable, please jump to question 6) Please select only one.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

- a. Please list each type of other advanced avionics system currently or previously used (not including any of the Garmin products).
[Click here to enter avionics systems](#).

- b. Please rate your **skill level** in using these other advanced avionics systems (not including any of the Garmin products). (1=not very skilled to 5=very skilled)
Please select only one.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

6. Rate your **experience** with using Flight Management Systems (FMS). (1=not very experienced to 5=very experienced; If not applicable, please jump to question 7) Please select only one.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

- a. Please rate your **skill level** in using FMSs. (1=not very skilled to 5=very skilled)
Please select only one.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

7. Rate your **experience** with stand alone autopilot/auto flight systems. (1= not very experienced to 5=very experienced; If not applicable, please place in return envelope & mail back to NASA). Please select only one.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

- a. Please rate your **skill level** in using autopilot/auto flight systems (1=not very skilled to 5=very skilled) Please select only one.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

APPENDIX C
ADVANCED AVIONICS AND AUTOMATION QUESTIONNAIRE

Please answer these questions with regard to any and all types of advanced automation and displays with which you have experience – not just the automation and displays in your Citation Mustang.

1. Overall, how satisfied are you with advanced avionics (glass cockpits, i.e., PFDs and MFDs) (1=very unsatisfied to 5 = very satisfied)? Please select only one.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

2. How would you rate the design of PFDs (1=poor to 5=excellent)? Please select only one.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

3. What do you like best about PFDs?

[Click here to enter text.](#)

4. What do you like least about PFDs?

[Click here to enter text.](#)

5. If you could change anything with the design or functioning of PFDs, what would you change and how would you change it?

[Click here to enter text.](#)

6. How would you rate the design of MFD (1=poor to 5=excellent)? Please select only one.

1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

7. What do you like best about the MFD?

[Click here to enter text.](#)

8. What do you like least about the MFD?

[Click here to enter text.](#)

9. If you could change anything with the design or functioning of MFDs, what would you change and how would you change it?

[Click here to enter text.](#)

10. What resources available through MFDs do you use the most?

[Click here to enter text.](#)

11. What resources available through MFDs do you use the least?
[Click here to enter text.](#)
12. Describe a situation, if any, where advanced avionics or automation kept you out of trouble or was a significant help in dealing with the situation or a problem and how the avionics or automation helped.
[Click here to enter text.](#)
13. Describe a situation, if any, where advanced avionics or automation caused you problems or inhibited your ability to deal with the situation or a problem and how the avionics or automation caused problems.
[Click here to enter text.](#)
14. What is/are the easiest things about learning to use advanced avionics and automation?
[Click here to enter text.](#)
15. What is/are the biggest hurdle(s) in learning to use advanced avionics and automation?
[Click here to enter text.](#)
16. How challenging is it for the typical pilot to remain proficient in the use of advanced avionics and automation, and if so, why?
[Click here to enter text.](#)
17. What strategies do you use or recommend to maintain proficiency in the use of advanced avionics and automation?
[Click here to enter text.](#)

APPENDIX D **CITATION MUSTANG AND G1000 COCKPIT SET-UP PREFERENCE QUESTIONNAIRE**

TIME/DATE

TIME FORMAT:	LOCAL 12hr	LOCAL 24hr
	☐	☐

DISPLAY UNITS AND MAP DATUM

NAV ANGLE:	MAGNETIC(°)	TRUE (°T)
	☐	☐
DIS, SPD:	NAUTICAL (NM, KT)	METRIC (KM, KPH)
	☐	☐
ALT, VS:	FEET (FT, FPM)	METERS (MT, MPM)
	☐	☐
PRESSURE:	INCHES (IN)	HECTOPASCALS (HPA)
	☐	☐
TEMP:	CELSIUS (°C)	FARENHEIT (°F)
	☐	☐
FUEL:	GALLONS (GL, GL/HR)	LITERS (LT, LT/HR)
	☐	☐
POSITION:	HDDD°MM'SS.S"	HDDD°MM.MM'
	☐	☐

AIRSPACE ALERTS

ALTITUDE BUFFER:	Factory Default (200ft)	Preferred buffer: Click here to enter buffer.
	☐	

CLASS B/TMA:	Factory Default	ON	OFF
	☐	☐	☐
CLASS C/TCA:	Factory Default	ON	OFF
	☐	☐	☐
CLASS D:	Factory Default	ON	OFF
	☐	☐	☐
RESTRICTED:	Factory Default	ON	OFF
	☐	☐	☐
MOA (MILITARY):	Factory Default	ON	OFF
	☐	☐	☐
OTHER AIRSPACE:	Factory Default	ON	OFF

☐☐☐

ARRIVAL AND AUDIO ALERTS

ARRIVAL
ALERT:

Factory Default

ON

OFF

☐☐☐

ARRIVAL ALERT
DISTANCE:

Factory Default
(at destination)

Preferred Distance: [Click here to preferred distance.](#)

☐

VOICE:

MALE

FEMALE

☐☐

NAVIGATION STATUS BAR (MFD)

FIELD 1: DTK ESA ETA ETE GS MSA TKE TRK VSR XTK

☐☐☐☐☐☐☐☐☐☐

FIELD 2: DTK ESA ETA ETE GS MSA TKE TRK VSR XTK

☐☐☐☐☐☐☐☐☐☐

FIELD 3: DTK ESA ETA ETE GS MSA TKE TRK VSR XTK

☐☐☐☐☐☐☐☐☐☐

FIELD 4: DTK ESA ETA ETE GS MSA TKE TRK VSR XTK

☐☐☐☐☐☐☐☐☐☐

CDI, COM CONFIGURATION

GPS CDI:

AUTO

MANUAL

☐☐

SYSTEM CDI
(if MANUAL):

1.0nm

3.0nm

5.0nm

☐☐☐

ILS CDI
CAPTURE:

AUTO

MANUAL

☐☐

NEAREST AIRPORT

RNWX SURFACE:

ANY

HARD ONLY

HARD/SOFT

☐☐☐

RNWX MIN
LENGTH:

Factory Default
(0 ft)

Preferred Length (0 ft to 25,000 ft): [Click here to enter preferred length.](#)

☐

FLIGHT INSTRUMENTS

PFD 1 WIND INDICATOR:	Factory Default ☐	HEAD/X-WIND ☐	ARROW/SPEED ☐	ARROW/SPD/D IR ☐	OFF ☐
PFD 2 WIND INDICATOR:	Factory Default ☐	HEAD/X-WIND ☐	ARROW/SPEED ☐	ARROW/SPD/D IR ☐	OFF ☐
BEARING 1 POINTER:	Factory Default ☐	NAV 1 ☐	GPS ☐	ADF ☐	OFF ☐
BEARING 2 POINTER:	Factory Default ☐	NAV 1 ☐	GPS ☐	ADF ☐	OFF ☐

MAP SETUP

PFD INSET:	Factory Default ☐	ON ☐	OFF ☐		
ORIENTATION:	Factory Default ☐	NORTH up ☐	Track up ☐	DTK up ☐	HDG up ☐
AUTO ZOOM:	Factory Default ☐	OFF ☐	MFD Only ☐	PFD Only ☐	All On ☐

Please fill out MFD ORIENTATION if you selected “PFD only” for previous AUTO Zoom setting.

MFD ORIENTATION:	Factory Default ☐	NORTH up ☐	Track up ☐	DTK up ☐	HDG up ☐
MAX LOOK FWD:	Factory Default ☐	Preferred Number (0 to 99 minutes): Click here to enter preferred number.			
MIN LOOK FWD:	Factory Default ☐	Preferred Number (0 to 99 minutes): Click here to enter preferred number.			
TIME OUT:	Factory Default ☐	Preferred Time: Click here to enter preferred time.			
LAND DATA:	Factory Default ☐	ON ☐	OFF ☐		
TRACK VECTOR:	Factory Default (60sec) ☐	30 sec ☐	2 min ☐	5 min ☐	10 min ☐
WIND VECTOR:	Factory Default ☐	ON ☐	OFF ☐		

NAV RANGE RING:	Factory Default	ON	OFF
	☐	☐	☐
TOPO DATA:	Factory Default	ON	OFF
	☐	☐	☐
If you selected "ON" for "TOPO DATA" please indicate your preferred MAX TOPO DATA RANGE (500ft -2000nm): Click here to enter range.			
TOPO SCALE:	Factory Default	ON	OFF
	☐	☐	☐
TERRAIN DATA:	Factory Default	ON	OFF
	☐	☐	☐
If you selected "ON" for "TERRAIN DATA" please indicate your preferred TERRAIN DATA MAX RANGE: Click here to enter range.			
OBSTACLE DATA:	Factory Default	ON	OFF
	☐	☐	☐
If you selected "ON" for "OBSTACLE DATA" please indicated your preferred OBSTACLE DATA MAX range: Click here to enter range.			
FUEL RING (RSV):	Factory Default (00:45 minutes)	ON	OFF
	☐	☐	☐
If you selected "ON" for "FUEL RING (RSV)" please indicate your preferred FUEL RING RANGE: Click here to enter range.			
FIELD OF VIEW	Factory Default	ON	OFF
	☐	☐	☐
PFD INSET:	Factory Default	ON	OFF
	☐	☐	☐
PFD INSET DCLTR:	Factory Default	NO DCLTR	DCTLR (-1) DCTLR (-2) DCLTR (-3)
	☐	☐	☐ ☐ ☐
PFD INSET FUNCTIONS:	Factory Default	TRAFFIC	TOPO TERRAIN STRMSC P NEXRAD XM LTNG
	☐	☐	☐ ☐ ☐ ☐ ☐

MAP SETUP (OTHER)

MFD FLIGHT PLAN VIEW:	Factory Default	Narrow	Wide	CUM	Leg-Leg
	☐	☐	☐	☐	☐
TRAFFIC SYSTEM:	Factory Default	TIS			
	☐	☐			

CHART FULL SCREEN:	Factory Default ☐	Large ☐	Small ☐
-----------------------	---	-----------------------------------	-----------------------------------

SYMBOL SETUP (LAND)

LAT/LON TEXT:	Factory Default ☐	None ☐	Small ☐	Medium ☐	Large ☐
---------------	---	----------------------------------	-----------------------------------	------------------------------------	-----------------------------------

LAT/LONG RANGE:	Factory Default (OFF) ☐	Max Display Range (up to 2000nm): Click here to enter max display range.
--------------------	--	--

FREEWAY RANGE:	Factory Default (300nm) ☐	Max Display Range (up to 800nm): Click here to enter max display range.
-------------------	--	---

NATIONAL HWY RANGE:	Factory Default (30nm) ☐	Max Display Range (up to 80nm): Click here to enter max display range.
------------------------	---	--

LOCAL HWY RANGE:	Factory Default (15nm) ☐	Max Display Range (up to 30nm): Click here to enter max display range.
---------------------	---	--

LOCAL ROAD RANGE:	Factory Default (8nm) ☐	Max Display Range (up to 15nm): Click here to enter max display range.
----------------------	--	--

RAILROAD RANGE:	Factory Default (15nm) ☐	Max Display Range (up to 30nm): Click here to enter max display range.
--------------------	---	--

LARGE CITY TEXT:	Factory Default ☐	None ☐	Small ☐	Medium ☐	Large ☐
---------------------	---	----------------------------------	-----------------------------------	------------------------------------	-----------------------------------

LARGE CITY RANGE:	Factory Default (800nm) ☐	Max Display Range (up to 1500nm): Click here to enter max display range.
----------------------	--	--

MEDIUM CITY TEXT:	Factory Default ☐	None ☐	Small ☐	Medium ☐	Large ☐
----------------------	---	----------------------------------	-----------------------------------	------------------------------------	-----------------------------------

MEDIUM CITY RANGE:	Factory Default (100nm) ☐	Max Display Range (up to 200nm): Click here to enter max display range.
-----------------------	--	---

SMALL CITY TEXT:	Factory Default ☐	None ☐	Small ☐	Medium ☐	Large ☐
---------------------	---	----------------------------------	-----------------------------------	------------------------------------	-----------------------------------

SMALL CITY RANGE:	Factory Default (20nm) ☐	Max Display Range (up to 50nm): Click here to enter max display range.			
STATE/PROVINCE TEXT:	Factory Default ☐	None ☐	Small ☐	Medium ☐	Large ☐
STATE/PROVINCE RANGE:	Factory Default (800nm) ☐	Max Display Range (up to 1500nm): Click here to enter max display range.			
RIVER/LAKE TEXT:	Factory Default ☐	None ☐	Small ☐	Medium ☐	Large ☐
RIVER/LAKE RANGE:	Factory Default (200nm) ☐	Max Display Range (up to 500nm): Click here to enter max display range.			
USER WAYPOINT TEXT:	Factory Default ☐	None ☐	Small ☐	Medium ☐	Large ☐
USER WAYPOINT RANGE:	Factory Default (150nm) ☐	Max Display Range (up to 300nm): Click here to enter max display range.			

SYMBOL SETUP (AVIATION)

ACTIVE FPL RANGE:	Factory Default (2000nm) ☐	Max Display Range (up to 2000nm): Click here to enter max display range.			
ACTIVE FPL WPT TEXT:	Factory Default ☐	None ☐	Small ☐	Medium ☐	Large ☐
ACTIVE FPL WPT RANGE:	Factory Default (2000nm) ☐	Max Display Range (up to 2000nm): Click here to enter max display range.			
LARGE APT TEXT:	Factory Default ☐	None ☐	Small ☐	Medium ☐	Large ☐
LARGE APT RANGE:	Factory Default (250nm) ☐	Max Display Range (up to 500nm): Click here to enter max display range.			
MEDIUM APT TEXT:	Factory Default ☐	None ☐	Small ☐	Medium ☐	Large ☐

MEDIUM APT RANGE:	Factory Default (150nm) ☐	Max Display Range (up to 300nm): Click here to enter max display range.			
SMALL APT TEXT:	Factory Default ☐	None ☐	Small ☐	Medium ☐	Large ☐
SMALL APT RANGE:	Factory Default (50nm) ☐	Max Display Range (up to 100nm): Click here to enter max display range.			
SAFE TAXI RANGE:	Factory Default (3nm) ☐	Max Display Range (up to 20nm): Click here to enter max display range.			
INTERSECTION WPT TEXT:	Factory Default ☐	None ☐	Small ☐	Medium ☐	Large ☐
INTERSECTION WPT RANGE:	Factory Default (15nm) ☐	Max Display Range (up to 30nm): Click here to enter max display range.			
NDB WAYPOINT TEXT:	Factory Default ☐	None ☐	Small ☐	Medium ☐	Large ☐
NDB WAYPOINT RANGE:	Factory Default (15nm) ☐	Max Display Range (up to 30nm): Click here to enter max display range.			
VOR WAYPOINT TEXT:	Factory Default ☐	None ☐	Small ☐	Medium ☐	Large ☐
VOR WAYPOINT RANGE:	Factory Default (150nm) ☐	Max Display Range (up to 300nm): Click here to enter max display range.			
CLASS B/TMA RANGE:	Factory Default (200nm) ☐	Max Display Range (up to 500nm): Click here to enter max display range.			
CLASS C/TMA RANGE:	Factory Default (200nm) ☐	Max Display Range (up to 500nm): Click here to enter max display range.			
CLASS D RANGE:	Factory Default (150nm) ☐	Max Display Range (up to 300nm): Click here to enter max display range.			
RESTRICTED AIRSPACE RANGE:	Factory Default (200nm) ☐	Max Display Range (up to 500nm): Click here to enter max display range.			

MOA (MILITARY) RANGE:	Factory Default (200nm) ☐	Max Display Range (up to 500nm): Click here to enter max display range.
OTHER/ADIZ RANGE:	Factory Default (200nm) ☐	Max Display Range (up to 500nm): Click here to enter max display range.
TFR RANGE:	Factory Default (500nm) ☐	Max Display Range (up to 2000nm): Click here to enter max display range.

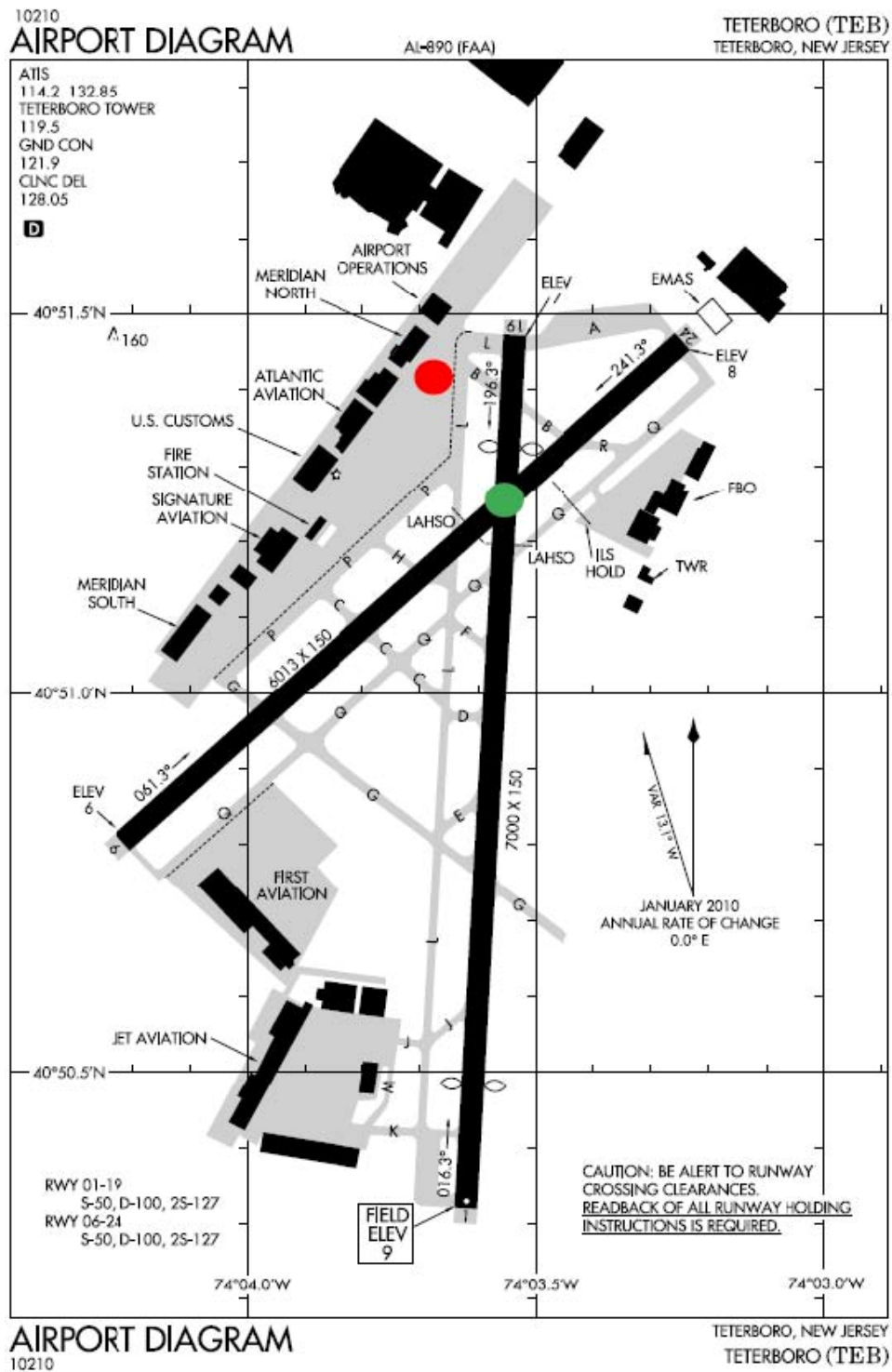
APPENDIX E
PILOT BRIEFING PACKAGE

Flight Package for Leg 1 KTEB-KMTN

Introduction to flight

- Flight: This is a two leg flight taken for personal business from Teterboro, NJ (KTEB) to Martin State Airport (KMTN) in Baltimore, MD to pick up a package and then on to Hot Springs/Ingalls Field, VA (KHSP) for leg two. You are the only person on board, there are no passengers.
- Today's Date is: Tuesday, September 18, 2010
- Propose Time of Departure from KTEB: 9:00 a.m. (local) (1300Z)
- Aircraft location at KTEB: Parked on ramp close to runway for the sake of communications (red spot). However, position of the simulator will be on runway 24 at the intersection of runway 19 (green spot). See the airport diagram on the next page depicting your location starting point.
- Planned aircraft parking at KMTN: Transient parking

Location on the Ramp at KTEB



U.S. DEPARTMENT OF TRANSPORTATION FEDERAL AVIATION ADMINISTRATION		(FAA USE ONLY) ☐ PILOT BRIEFING ☐ VNR			TIME STARTED		SPECIALIST INITIALS	
FLIGHT PLAN		☐ STOPOVER						
1. TYPE	2. AIRCRAFT IDENTIFICATION	3. AIRCRAFT TYPE / SPECIAL EQUIPMENT	4. TRUE AIRSPEED	5. DEPARTURE POINT	6. DEPARTURE TIME		7. CRUISING ALTITUDE	
☒ VFR ☐ IFR ☐ DVFR	N510C	C510/L	240 KTS	KTEB	PROPOSED (Z) 1300	ACTUAL (Z)	FL200	
8. ROUTE OF FLIGHT								
TEB6.TEB BIGGY J75 MURPH								
9. DESTINATION (Name of airport and city)			10. EST. TIME ENROUTE		11. REMARKS			
Baltimore Martin State KMTN			HOURS 0	MINUTES 41				
12. FUEL ON BOARD		13. ALTERNATE AIRPORT(S)		14. PILOT'S NAME, ADDRESS & TELEPHONE NUMBER & AIRCRAFT HOME BASE			15. NUMBER ABOARD	
HOURS 3	MINUTES 30			Mustang Pilot (On file)			1	
				17. DESTINATION CONTACT/TELEPHONE (OPTIONAL)				
16. COLOR OF AIRCRAFT		CIVIL AIRCRAFT PILOTS, FAR Part 91 requires you file an IFR flight plan to operate under instrument flight rules in controlled airspace. Failure to file could result in a civil penalty not to exceed \$1,000 for each violation (Section 901 of the Federal Aviation Act of 1958, as amended). Filing of a VFR flight plan is recommended as a good operating practice. See also Part 99 for requirements concerning DVFR flight plans.						
White with blue strip								

FAA Form 7233-1 (8-82)
Electronic Version (Adobe)

CLOSE VFR FLIGHT PLAN WITH _____ FSS ON ARRIVAL

Navigation Log

KTEB to KMTN: TC=230° : MC= 242° : ST. LINE= 142nm : AIRWAY=145nm : Extra=2%

Winds Aloft	FL220 ISA(-29) Comp	FL200 ISA(-25) Comp	FL180 ISA(-21) Comp	FL160 ISA(-17) Comp
BIGGY	240/045 +06 -044	230/044 +09 -042	230/046 +09 -044	230/044 +18 -042
MXE	230/045 +07 -044	225/047 +10 -046	220/047 +10 -045	220/048 +08 -046
Avg. Trip Winds=>	- 44 Headwind	- 44 Headwind	- 44 Headwind	- 44 Headwind
FLT TIME==>	0:30 @ 337TAS	0:31 @ 330TAS	0:32 @ 320TAS	0:33 @ 310TAS
Fuel Burn==>	600 Lbs	616 Lbs	633 Lbs	650 Lbs

FIX	ST	LAT/LON	InB/Out	Leg	Rem	Fuel Leg	Burn Tot.	Leg	Rem	ETE	WX
KTEB 108.4 TETERBORO	NJ	N4051.0W07403.7	---/250	0	145	100	100	0:00	0:31	0:00	
BIGGY	NJ	N4025.2W07458.4	248/237	49	96	166	266	0:10	0:21	0:10	134.72
MXE 113.2 MODENA	PA	N3955.1W07540.2	236/240	44	52	150	416	0:09	0:12	0:19	134.72
MURPH 113.2/240/43		N3927.9W07623.1	240/197	43	9	150	566	0:09	0:03	0:28	134.72
KMTN BALTIMORE	MD	N3919.5W07624.8	200/---	9	0	50	616	0:03	0:00	0:31	

Fuel hourly method: 616

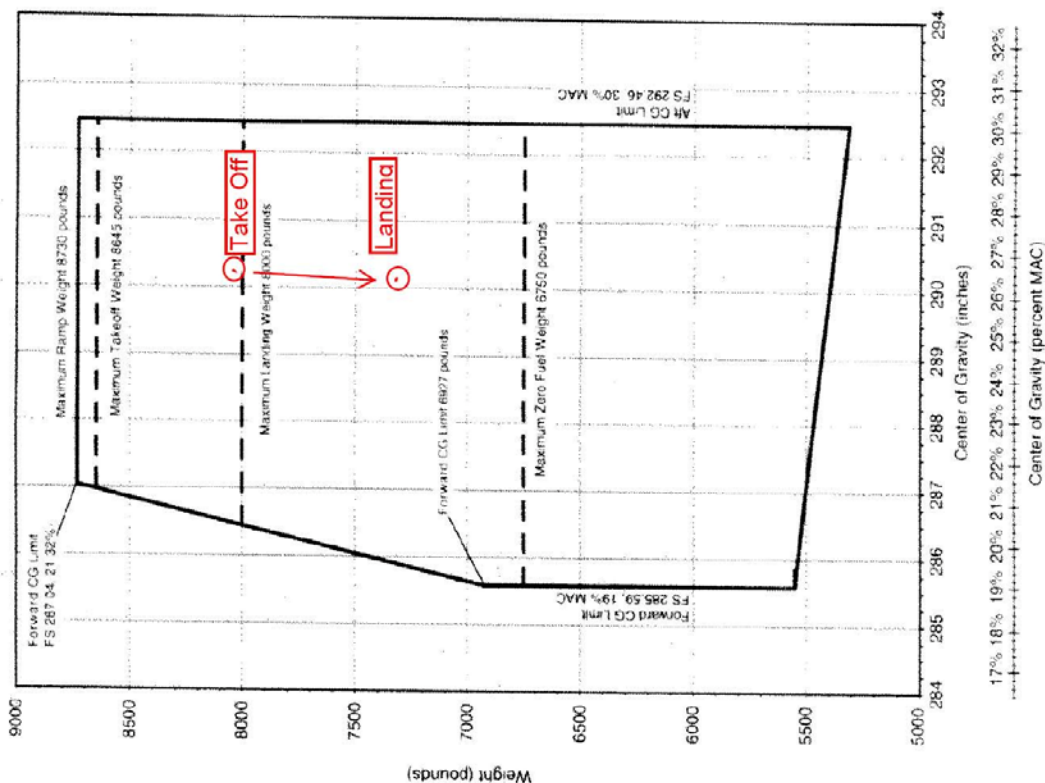
09/18	Sunrise	Sunset
KTEB	7:11	18:12
KMTN	7:28	18:11

Weight and Balance

Weight Limitations for Cessna Mustang C510				
Maximum Design Ramp Weight		8730 lbs	Maximum Design Landing Weight	
Maximum Design Takeoff Weight		8645 lbs	Maximum Design Zero Fuel Weight	
Item	Weight (lbs)	Arm (inches)	Moment/100 (in-lbs)	Maximum Limit Weights
BOW of A/C	5,344.00	296.13	15,825.19	
Pilot	170.00	182.80	310.76	
Nose Baggage	80.00	96.00	76.80	
Fuel	2,500.00	291.72	7,293.00	
Taxi Fuel	-85.00	296.47	-252.00	
Zero Fuel weight	5,594.00			6750 = OK 8645 = OK 8000 = OK
Take Off Weight	8,009.00		23,253.75	
Enroute Fuel Burn	-616.00	291.72	-1,797.00	
Landing Weight	7,393.00		21,456.75	

Take Off Weight	8,009.00	CG =	290.35	OK
Landing Weight	7,393.00	CG =	290.23	OK

CENTER-OF-GRAVITY LIMITS



Boston Area Forecast (FA)

Forecast updated: 1200 UTC

BOSC FA 181200
SYNOPSIS AND VFR CLDS/WX
SYNOPSIS VALID UNTIL 191200
CLDS/WX VALID UNTIL 191200..OTLK VALID 181200-191200
ME NH VT MA RI CT NY LO NJ PA OH LE WV MD DC
DE VA AND CSTL WTRS

SEE AIRMET SIERRA FOR IFR CONDS AND MTN
OBSCN.
TS IMPLY SEV OR GTR TURB SEV ICE LLWS AND IFR
CONDS.
NON MSL HGTS DENOTED BY AGL OR CIG.

SYNOPSIS..BROAD UPR TROF CONTS FM THE
MID/LWR MS VLY INTO THE
GLFMEX. TROF WL SHFT SLOLY EWD. STNR FNT
CONTS FM THE MD/VA CSTL
WTRS-VA/NC BORDER-ERN TN-SRN MS. BY 12Z WK
LOW WL BR OVR SWRN NC
WITH STNR FNT ENEWD TO MD/VA CSTL WTRS. WK
CDFNT WL EXTD FM THE
LOW SWWD TO SRN AL. DEEP MOIST AIRMASS
EXTDS FM THE MID ATLC RGN
TO THE SERN US. MSTR WL SPRD SLOLY NWD INTO
PA/NJ-EXTRM SE NY AFT 06Z.

ME NH VT
SCT060 SCT CI. 00Z SCT CI. OTLK..VFR.
MA RI CT
SERN MA..BKN010-020. TOPS 040. BKN CI.
OTLK..MVFR CIG.
CT/RI..SCT050 BKN CI. 05Z SCT050 BKN120. TOPS
FL180. OYLK..VFR.
RMNDR MA..SCT CI. 04Z BKN CI. OTLK..VFR.

NY LO
NERN NY..SCT050 SCT CI. 00Z SCT CI. OTLK..VFR.
LONG ISLAND/EXTRM SERN NY..SCT010 BKN020.
TOPS FL200. 05Z SCT030
BKN120. OTLK..VFR.
RMNDR SERN NY..BKN CI. OTLK..VFR.
WRN NY/LO..SCT CI. OTLK..VFR.

PA NJ
SERN PA/SRN NJ..SCT010-020 OVC030. TOPS FL200.
WDLY SCT -SHRA.
BECMG 1218 BKN010-020 OVC030. OCNL VIS 3-5SM
-RA BR. OTLK..IFR
CIG RA BR.
NERN PA/NRN NJ..SCT010 BKN CI. BECMG 0306
BKN010. TOPS FL200.
OTLK..VFR BECMG MVFR CIG SHRA AFT 11Z.
SWRN PA..BKN040-050. TOPS 080. BKN CI. BECMG
0306 BKN030 OVC100.
TOPS FL220. OCNL VIS 3-5SM -SHRA BR. OTLK..IFR
CIG SHRA BR.
NWRN PA..SCT050-060 BKN CI. 05Z SCT-BKN040-
050. TOPS 080. BKN
CI. OTLK..MVFR CIG.

OH LE
SERN OH..BKN020-030 OVC100. TOPS FL200. OCNL
VIS 3-5SM -SHRA BR.
OTLK..MVFR CIG SHRA BR.
SWRN OH..SCT120 OVC CI. OTLK..VFR.
NRN OH/LE..BKN CI. OTLK..VFR.

WV
BKN-OVC030-040 LYRD TO FL220. OCNL VIS 3-5SM -
RA BR. TIL 02Z ISOL
-TSRA EXTRM S. CB TOPS FL400. OTLK..IFR CIG SHRA
BR.

MD DC DE VA
WRN MD/NWRN VA..OVC020-030 LYRD TO FL250.
OCNL VIS 3-5SM -RA BR.
OTLK..IFR CIG RA BR.
SWRN VA..BKN010-020 OVC030. TOPS 250. SCT -
SHRA/-TSRA. CB TOPS
FL420. BECMG 0003 OVC030-040 LYRD TO FL250.
OCNL VIS 3-5SM -SHRA
BR. OTLK..IFR CIG SHRA BR.
FAR S CNTRL/SERN VA..BKN020 BKN100. TOPS 150.
SCT -SHRA/-TSRA.
CB TOPS FL420. BECMG 1218 BKN010-020 OVC100.
TOPS FL240. OCNL VIS
3-5SM -SHRA BR. OTLK..IFR CIG SHRA BR.
RMNDR ERN VA/ERN MD/DC/DE..BKN-OVC010-020
LYRD TO FL250. OCNL
VIS 3-5SM -RA BR. OTLK..IFR CIG RA BR.

CSTL WTRS
S OF CYN..BKN010-020 BKN-OVC100
SCT -SHRA.
OTLK..IFR CIG SHRA BR.
BTN CYN AND ACK..BKN015-025 OVC
FL200. WDLY SCT -SHRA.
OTLK..MVFR CIG SHRA BR.
N OF ACK..SCT-BKN010-020. TOPS 04
OFSHR.VFR
NEARSHR.

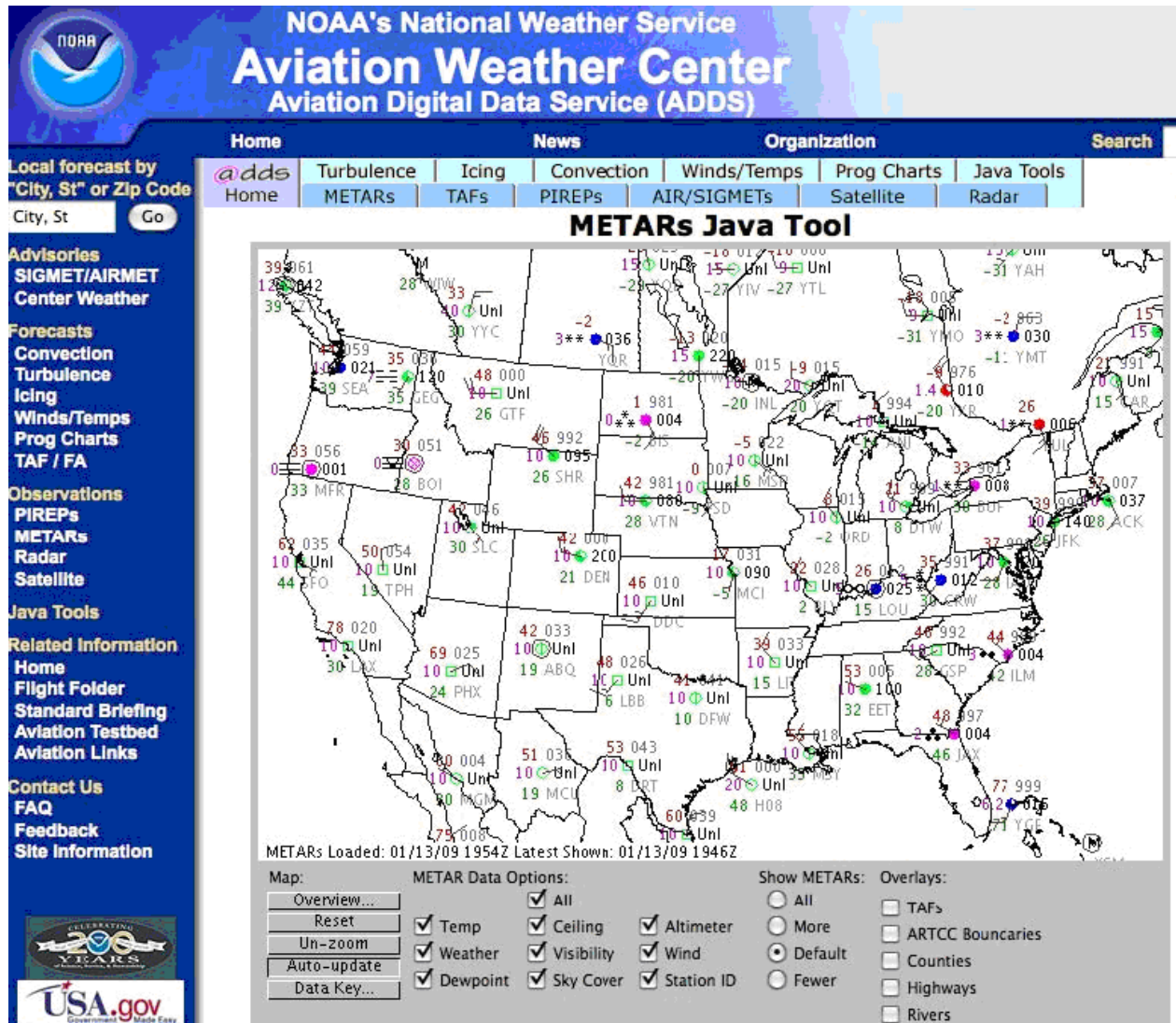
AIRMET MTN OBSCN..PA WV MD VA
FROM HAR TO 40SSE PSK TO HNV T
40SE AIR TO HAR
MTNS OBSC BY CLDS/PCPN/BR. CON
21Z.

AIRMET TURB..VT NY LO PA OH LE W
FROM YSC TO 20SSW ALB TO 30SSW
CVG TO FWA TO DXO
TO MSS TO YSC
MOD TURB BLW FL180. CONDS CON
THRU 03Z.

FRZLVL..RANGING FROM 120-140 AC
120 ALG 40S FWA-20ENE ERI-MSS-
140 ALG 30S HNN-30W SAX-20SSE

[illegible]

Current Conditions: METAR



KTEB Terminal Weather

METAR KTEB 181253Z 22009G15KT 2SM -RA BKN005 OVC008 20/17 A29.85

Teterboro 1253 Zulu automated weather, wind is 220° at 9 gusting to 15, visibility 2 miles in light rain, 500 broken, 800 overcast, temperature 20, dew point 17, altimeter 29.85.

KTEB 181200Z 1812/1912 23009KT 2SM -RA BKN005 OVC008
FM181500 23012KT 5SM -RA SCT010 OVC020
FM190100 24010KT 5SM BKN010 OVC020
FM190800 26015KT P6SM BKN010 OVC020

Teterboro NJ [KTEB] terminal forecast issued at 8:00am EDT (1200Z), valid for 24 hours

8:00am EDT (12Z) wind 230 at 9 knots, visibility 2 miles, light rain, 500 feet broken, 800 feet overcast

11:00am EDT (1500Z) wind 230 at 12 knots, visibility 5 miles, light rain, 1000 feet scattered, 2000 feet overcast

9:00pm EDT (0100Z) wind 240 at 10 knots, visibility 5 miles, 1000 feet broken, 2000 feet overcast

4:00am EDT (0800Z) wind 260 at 15 knots, visibility 6 miles, 1000 feet broken, 2000 feet overcast

KTEB NOTAMS

TEB 11/031 **TEB** AD ALL IN PAVEMENT LGTS AND ELEVATED GUARD LGTS OTS

TEB 04/069 **TEB** RWY 1 REIL CMSND

TEB 07/065 **TEB** RWY 1 PAEW 1300 S AER 1030-2100 MON-FRI WEF 1007191030

TEB 02/065 **TEB** OBST BRIDGE UNKN (624 AGL) 5 E (4051N7357W) LGT OTS WEF 0902231208

TEB 11/006 **TEB** OBST CRANE 237 (230 AGL) 1 S AER 6 FLAGGED/LGTD

TEB 11/032 **TEB** OBST CRANE 65 (60 AGL) .6 SSW AER 1 LGTD/FLAGGED 1200-2100 DLY TIL 1011122100

TEB 11/030 **TEB** NAV RWY 19 ILS LLZ OTS WEF 1011101139

UAR 04/009 **TEB** AIRSPACE JAIKE TWO ARRIVAL.. EXPECT TO CROSS JAIKE WAYPOINT AT 13,000 FEET.

USD 07/209 **TEB** AIRSPACE TETERBORO SIX DEPARTURE CHANGE RWY 24 DEPARTURE ROUTE DESCRIPTION TO READ: TAKE-OFF RWY 24: CLIMB HEADING 240 TO 1500, THEN RIGHT TURN VIA HEADING 280, CROSS TEB 4.5 DME AT 1500 (NON-DME AIRCRAFT CROSS COL R-011 AT 1500), CLIMB AND MAINTAIN 2000, THENCE..

TEB 05/146 **TEB** TWY K NONMOVEMENT AREA BOUNDARY NONSTD MARKING

TEB 11/020 **TEB** TWY B EDGE LINES W RWY 1/19 NONSTD

TEB 08/037 **TEB** RAMP ATLANTIC AVIATION RAMP FENCING 56 FT LONG BY 160 FT WIDE ADJ HANGER 3 LGTED

Weather En route METARs

KCDW 181253Z 23010G14 3SM -RA BKN006 OVC009 20/16 A2984

KSMQ 181253Z 22010KT 4SM SCT020 BKN030 21/16 A2985 RMK AO2

KDYL 181253Z 210KT 4SM RA SCT010 BKN030 OVC040 20/15 A2985 RMK AO2

KTTN 181253Z 20009KT 2SM BR BKN007 OVC015 18/16 A2988

KPTW 181253Z 00000KT 1SM OVC008 15/14 A2984 RMK AO2

KPHL 181253Z 17010KT 4SM BR BKN009 OVC020 20/15 A2990

KMQS 181253Z 16015KT 5SM FEW035 OVC040 15/09 A2990 RMK AO2

KILG 181253Z 14009KT 2SM BR BKN005 OVC015 18/16 A2985

KAPG 181253Z 14009KT 2SM BR BKN005 OVC015 18/16 A2985

KBWI 181253Z 13013KT 3SM BR SCT008 OVC010 18/16 A2989

KDCA 181253Z 14008KT 4SM BR SCT009 OVC011 17/13 A2989

Weather En route TAFs

KTTN 181200Z 1812/1912 17009KT 2SM BR BKN005
FM181500 18010KT 4SM -RA SCT008 OVC020
FM190100 17010KT 5SM BKN010 OVC020
FM190800 16010KT P6SM BKN010 OVC020

KRDG 181200Z 1812/1912 17009KT 3SM BR BKN006
FM181500 18010KT 4SM -RA SCT008 OVC010
FM190100 16010KT 4SM BKN080 OVC010
FM190800 16010KT 5SM BKN080 OVC010

KILG 181200Z 1812/1912 17012KT 3SM BR BKN006
FM181500 18010KT 4SM -RA SCT008 OVC010
FM190100 17010KT 4SM BKN080 OVC015
FM190800 16010KT 5SM BKN080 OVC015

KBWI 181200Z 1812/1912 22012KT 5SM BR BKN020
FM181500 18010KT 5SM SCT020 OVC070
FM190100 21010KT 5SM SCT050 OVC090
FM190800 21010KT P6SM SCT080 BKN100

KDCA 181200Z 1812/1912 22012KT 5SM BR BKN020
FM181500 17015KT 5SM SCT020 OVC070
FM190100 22010KT P6SM SCT040 OVC080
FM190800 22005KT P6SM SCT080 BKN100

Notices to Airmen: FAA Plotweb Airway

NEW YORK ARTCC

FDC 8/5594 ZNY FI/T AIRWAY ZNY ZOB. J190 SLATE RUN (SLT) VORTAC, PA TO BINGHAMTON (CFB) VORTAC, NY MAA FL380 EXCEPT FOR AIRCRAFT EQUIPPED WITH SUITABLE RNAV SYSTEM WITH GPS.

FDC 8/4929 ZNY FI/T AIRWAY ZBW ZNY. V408 LAKE HENRY (LHY) VORTAC, PA TO SAGES INT, NY MAA 15000 EXCEPT FOR AIRCRAFT EQUIPPED WITH SUITABLE RNAV SYSTEM WITH GPS.

FDC 8/2384 ZNY NY. FI/T AIRWAY ZNY. J95 GAYEL INT, NY TO BUFFY INT, PA NA.

FDC 8/1389 ZNY FI/T AIRWAY ZDC ZNY. J42- 191 DAVYS INT, NJ TO ROBBINSVILLE (RBV) VORTAC, NY MAA 29000 EXCEPT FOR AIRCRAFT EQUIPPED WITH SUITABLE RNAV SYSTEM WITH GPS.

FDC 6/8776 ZNY CT. FI/T AIRWAY ZBW ZNY. J42 DME REQUIRED AT SANTT INT.

FDC 6/1470 ZNY NY. FI/T AIRWAY ZNY. V433 TICKL INT, NY TO LA GUARDIA (LGA) VOR/DME, NY LGA R-225 UNUSEABLE. LA GUARDIA (LGA) VOR/DME, NY TO DUNBO INT, NY LGA R-06 UNUSEABLE.

FDC 6/1269 ZNY FI/T AIRWAY ZNY. V36 HAWLY INT, PA TO NEION INT, NJ LGA R-322 UNUSEABLE.

FDC 6/1267 ZNY FI/T AIRWAY ZNY. J106 STILLWATER (STW) VOR/DME, NJ TO LA GUARDIA (LGA) VOR/DME, NY LGA R-298 UNUSEABLE.

FDC 6/1266 ZNY FI/T AIRWAY ZNY. J70 STILLWATER (STW) VOR/DME, NJ TO LA GUARDIA (LGA) VOR/DME, NY LGA R-298 UNUSEABLE. LA GUARDIA (LGA) VOR/DME, NY TO KENNEDY (JFK) VOR/DME, NY LGA R-166 UNUSEABLE.

FDC 6/1247 ZNY NY. FI/T AIRWAY ZNY. V451 LA GUARDIA (LGA) VOR/DME, NY TO NESSI INT, NY LGA R-075 UNUSEABLE.

FDC 6/1245 ZNY NY. FI/T AIRWAY ZBW ZNY. V6- 445 Nanci INT, NY TO LA GUARDIA (LGA) VOR/DME, NY LGA R225 UNUSEABLE.

FDC 6/1243 ZNY NY. FI/T AIRWAY ZNY. V475- 487 LA GUARDIA (LGA) VOR/DME, NY TO DUNBO INT, NY LGA R-068 UNUSEABLE.

FDC 6/1238 ZNY NY. FI/T AIRWAY ZNY. V123 RENUE INT, NY TO LA GUARDIA (LGA) VOR/DME, NY LGA R-225 UNUSEABLE. LA GUARDIA (LGA) VOR/DME, NY TO RYMES INT, NY LGA R-044 UNUSEABLE.

FDC 6/1237 ZNY NY. FI/T AIRWAY ZNY. V157 RENUE INT, NY TO LA GUARDIA (LGA) VOR/DME, NY LGA R-225 UNUSEABLE. LA GUARDIA (LGA) VOR/DME, NY TO HAARP INT, NY LGA R-044 UNUSEABLE.

FDC 4/9357 ZNY NY. FI/T AIRWAY ZNY ZBW. V139-268-308 DUNEE INT, NY TO SARDI INT, NY DEER PARK (DPK) VOR/DME MRA 5000 AT KOPPY INT, NY.

FDC 4/9343 ZNY NY. FI/T AIRWAY ZNY V374 VOLLU INT, NY TO GAYEL INT, NY MEA 5000.

FDC 4/9182 ZNY NJ FI/T AIRWAY ZNY V312 LEGGS INT, NJ TO PREPI INT, OA FOR NON-DME EQUIPPED AIRCRAFT MEA 3000.

FDC 4/6630 ZNY PA. FI/T AIRWAY ZNY. V36 DOMVY INT, PA TO HAWLY INT, PA NA.

FDC 4/3616 ZNY FI/T AIRWAY ZNY ZDC V210 PROPP INT, PA TO YARDLEY (ARD) VOR/DME, PA MOCA 1700.

APPENDIX F
POST-STUDY INTERVIEW QUESTIONS

**Advanced Automation and Single-Pilot Operations
in Very Light/Entry Level Jets
Post-Study Interview and Debriefing**

Overall Feedback:

1. How does the amount and kind of planning/preparation you did for the familiarization flight compare with the amount and kind of planning/preparation you did for the study flights?
(more/less/the same – if more or less, ask why)
2. How does the amount and kind of planning/preparation you did for the two study flights compare with what you normally do when you are going to make an IFR flight? *(if different from what they normally do, ask how different and why)*
3. Have you ever flown in the Oklahoma area and/or landed at Clinton-Sherman or OKC before?
 - a. If so, how did this scenario flight compare with the flight(s) you took? *(weather, traffic, operational environment and tasks, etc?)*
4. Have you ever flown in the New York or Washington, DC areas and/or landed at TEB or MTN before?
 - a. If so, which airports/airspace and how did this scenario compare with the flight(s) you took? *(weather, traffic, operational environment and tasks, etc?)*
5. Do you have much experience flying in mountainous terrain/landing at mountain airports? Have you ever landed at Hot Springs/Ingalls Airport (HSP) before?
 - a. If yes *(to either question)*, how did that portion of the study scenario compare with your previous experiences? *(weather, traffic, operational environment and tasks, etc?)*

6. Overall, how do you feel about your flights today, both the Oklahoma flight and the study flights on the east coast? *(looking for an assessment of their own performance)*
 - a. Oklahoma (familiarization) flight:
 - b. East coast (study) flights (both legs):
7. In the study scenario, you flew two legs, the first from TEB to MTN and the second from MTN to HSP. How would you compare the two legs in terms of workload?
 - a. How about in terms of difficulty of flight or operational tasks?
8. In the first leg from TEB to MTN, were there any tasks that you found to be particularly challenging, and if so, why?
 - a. How about in the second leg from MTN to HSP?
9. In the first leg (TEB to MTN), were there any tasks that you found to be particularly easy, and if so, why?
 - a. How about the second leg (MTN to HSP)?

Workload:

10. In this study we were particularly interested in how single pilots manage workload in jets during flights. Overall, how do you think that went?
11. How would you describe your approaches to workload management during the two flights *(get information about each flight and study scenario leg separately, and/or compare or contrast the approaches within the flights and legs, were any differences intentional/ planned, etc.)*?
 - a. How does this compare with the way that you typically approach workload management when flying IFR? *(make sure you get information about how they typically approach workload management during regular IFR flights)*

12. Was there anything about the tasks you had to complete in the familiarization scenario that changed your approach to workload management in the study scenario? *(If yes, what were the tasks and how did they influence your workload management strategy?)*

- a. Was there anything about the tasks you had to complete in the first leg (TEB to MTN) that changed your approach to workload management in the second leg (MTN to HSP)? *(If yes, what were the tasks and how did they influence your workload management strategy?)*

13. *(with regard to responses to Question 12)* What techniques or strategies worked best?

14. *(with regard to responses to Question 12)* What techniques or strategies didn't work out as well as hoped?

15. Were there times you felt behind or task saturated?

- a. If so, when,
- b. why do think that was, and
- c. what did you do to deal with it?

Automation:

16. As you know, we are also very interested in how automation and advanced technology is a help or hindrance. To what degree (and how) would you say that automation and advanced technology helped you with the tasks you faced while flying the two legs of the study scenario?

17. Were there specific features or resources within the G1000 or the Mustang that were particularly helpful? If so, what were they and how were they helpful?

18. To what degree (and how) did automation and advanced technology cause you problems or hinder you with the tasks you faced while flying the study scenario legs?

19. Were there specific features or resources within the G1000 or the Mustang that were particularly problematic? If so, what were they and how were they problematic?
20. To what degree would you say you are familiar with the full range of resources available through the G1000 and the multiple ways to use the G1000 to accomplish the same tasks?
21. To what degree would you say you use the full range of resources available through the G1000?
- a. Which features do you use the most?
 - b. Which features do you use the least?
 - c. Are there any particular features of the G1000 that you find particularly easy to use? If so, what are they and why do you feel they are easy?
 - d. Are there any particular features of the G1000 that you find particularly difficult to use? If so, what are they and why do you feel they are difficult?
 - e. If you were going to re-design the G1000 what would you change, add, or delete from it and why?

Closing:

22. If you were to fly these flights again, would you do anything differently? If so, what would you do differently and why?
23. Before coming here to participate in this study, did you do any sort of special preparation, study, or review that you wouldn't normally have been doing already? If so, what did you do?
24. Do you have any other comments, thoughts, or suggestions you would like to make regarding single-pilot workload management, automation use, or this study in general?

Thank you very much for participating in this study and providing us this very important information. Your involvement and feedback will benefit the industry greatly. Thanks!

APPENDIX G

SIMULATOR LESSON PLANNER SCRIPTS

TEB Lesson Planner Script

```
SET          Total Freeze = 1
SETUP        TEB.sst
SETUP        TEB.sar
SETUP        TEB.srd
SETUP        TEB.SSM
SETUP        TEB.sst
SETUP        TEB.svz
SETUP        startup.smp
SET          Fuel Weight Pounds = 192.5
SET          Ground Level Wind Direction = 40
SET          Ground Level Wind Gust = 9
SET          Ground Level Wind Speed = 9
SET          Outside Air Temperature = 20
SET          Cloud Layer 1 Base AGL = 800
SET          Cloud Layer 1 Top AGL = 5000
SET          Cloud Layer 1 Type = 4
SET          Cloud Layer 2 Base AGL = 10000
SET          Cloud Layer 2 Top AGL = 25000
SET          Cloud Layer 2 Type = 4
SET          Visibility Enable = 1
SET          Visibility Ft = 15000
SET          Ground Fog Enable = 0
SETUP        TEB16.traffic
WAITIL       AGL GREATER THAN OR EQUAL TO 10
SETUP        TEB1.traffic
SETUP        TEB3.traffic
SETUP        TEB4.traffic
SETUP        TEB8.traffic
SETUP        TEB9.traffic
SETUP        TEB12.traffic
SETUP        TEB6.traffic
SETUP        TEB27.traffic
SETUP        TEB13.traffic
SETUP        TEB15.traffic
SETUP        TEB19.traffic
WAITIL       AGL GREATER THAN OR EQUAL TO 850
SET          Ground Fog Enable = 1
SET          Ground Fog Ceiling MSL Ft = 5000
SET          Ground Fog Range Ft = 15000
WAITIL       Latitude LESS THAN OR EQUAL TO 40.584167
SET          Outside Air Temperature = 9
WAITIL       Latitude LESS THAN OR EQUAL TO 40.422778
SET          Cloud Layer 1 Base AGL = 4000
SET          Cloud Layer 1 Top AGL = 4500
SET          Cloud Layer 1 Type = 4
SET          Outside Air Temperature = -13
WAITIL       Latitude LESS THAN OR EQUAL TO 39.916944
SET          Outside Air Temperature = -11
SET          Cloud Layer 1 Base AGL = 1500
SET          Cloud Layer 1 Top AGL = 4000
```

```

SET          Cloud Layer 1 Type = 4
WAITIL      Latitude LESS THAN OR EQUAL TO 39.679444
SET          Cloud Layer 1 Type = 4
SET          Cloud Layer 1 Base AGL = 1000
SET          Cloud Layer 1 Top AGL = 3500
WAITIL      Latitude LESS THAN OR EQUAL TO 39.491944
SETUP       TEB2.traffic
WAITIL      Altitude LESS THAN OR EQUAL TO 3900
SET          Outside Air Temperature = 10
SET          Ground Fog Enable = 0
SET          Ground Level Wind Direction = 300
SET          Ground Level Wind Gust = 13
SET          Ground Level Wind Speed = 13
SET          Cloud Layer 1 Base AGL = 1100
SET          Cloud Layer 1 Top AGL = 25000
SET          Cloud Layer 1 Type = 5
WAITIL      AGL LESS THAN OR EQUAL TO 3000
SET          Outside Air Temperature = 19

```

MTN Lesson Planner Script

```

SET          Total Freeze = 1
SETUP       MTN.sst
SETUP       MTN.svz
SETUP       MTN.srd
SETUP       MTN.sar
SETUP       MTN.ssm
SETUP       MTNstartup.smp
SET          Visibility Enable = 1
SET          Visibility Ft = 16000
SET          Ground Fog Enable = 0
SET          Ground Level Wind Direction = 300
SET          Ground Level Wind Gust = 13
SET          Ground Level Wind Speed = 13
SET          Outside Air Temperature = 19
SET          Cloud Layer 1 Base AGL = 1100
SET          Cloud Layer 1 Top AGL = 3000
SET          Cloud Layer 1 Type = 4
SET          Cloud Layer 2 Base AGL = 10000
SET          Cloud Layer 2 Top AGL = 25000
SET          Cloud Layer 2 Type = 4
WAITIL      AGL GREATER THAN OR EQUAL TO 5
WAITIL      AGL GREATER THAN OR EQUAL TO 1500
SET          Ground Fog Enable = 1
SET          Ground Fog Range Ft = 10000
SET          Ground Fog Ceiling MSL Ft = 3000
SET          2nd Level Wind Direction = 360
SET          2nd Level Wind Altitude = 2300
SET          2nd Level Wind Gust = 29
SET          2nd Level Wind Speed = 29
SET          3rd Level Wind Altitude = 12000
SET          3rd Level Wind Direction = 360
SET          3rd Level Wind Speed = 48
SET          3rd Level Wind Gust = 48
SET          Outside Air Temperature = 12
WAITIL      Latitude LESS THAN OR EQUAL TO 39.04

```

```

SETUP      MTNA320.traffic
WAITIL     Longitude GREATER THAN OR EQUAL TO 76.747222
SET        2nd Level Wind Altitude = 12000
SET        2nd Level Wind Direction = 360
SET        2nd Level Wind Gust = 48
SET        2nd Level Wind Speed = 48
SET        3rd Level Wind Altitude = 18000
SET        3rd Level Wind Direction = 360
SET        3rd Level Wind Gust = 52
SET        3rd Level Wind Speed = 52
SET        Outside Air Temperature = 2
WAITIL     Longitude GREATER THAN OR EQUAL TO 77.862778
SET        CB SKID CONTROL = 1
SET        Anti-Skid Control CAS Message = 1
SET        Cloud Layer 1 Base AGL = 1100
SET        Cloud Layer 1 Top AGL = 7000
SET        Cloud Layer 1 Type = 4
WAITIL     AGL LESS THAN OR EQUAL TO 16000
SET        Ground Level Wind Direction = 50
SET        Ground Level Wind Gust = 24
SET        Ground Level Wind Speed = 24
SET        2nd Level Wind Altitude = 9000
SET        2nd Level Wind Direction = 50
SET        2nd Level Wind Gust = 35
SET        2nd Level Wind Speed = 35
SET        3rd Level Wind Altitude = 12000
SET        3rd Level Wind Direction = 60
SET        3rd Level Wind Gust = 45
SET        3rd Level Wind Speed = 55
WAITIL     Longitude GREATER THAN OR EQUAL TO 79.107778
SET        Ground Level Wind Direction = 40
SET        Ground Level Wind Gust = 10
SET        Ground Level Wind Speed = 10
SET        Outside Air Temperature = 11
SET        Visibility Ft = 37000
WAITIL     Longitude GREATER THAN OR EQUAL TO 79.67
SETUP      MTN1.traffic
SET        Ground Fog Enable = 0

```


APPENDIX H

VISUAL BASIC FOR APPLICATIONS CODE TO FORMAT GOOGLE EARTH DATA

```
Sub CreateCols()  
,  
' Macro1 Macro  
' Macro recorded 11/17/2011 by DOT/FAA  
' Code added by Kevin W. Williams  
,  
  
    Dim OldGear As Boolean  
    Dim gear As Boolean  
    Dim OldAp As Integer  
    Dim ap As Integer  
    Dim OldSpdbrk As Boolean  
    Dim spdbrk As Boolean  
    Dim OldFlaps As Single  
    Dim flaps As Single  
    Dim transitioning As Boolean  
  
    OldGear = True  
    OldAp = 0  
    OldSpdbrk = False  
    OldFlaps = 15  
    transitioning = False  
    Dim FirstSheet As String  
  
    Set NewSheet = Worksheets.Add(, Sheets(1), 1)  
    NewSheet.Name = "KMLData"  
    Worksheets("KMLData").Cells(1, 1).Value = "Frame"  
    Worksheets("KMLData").Cells(1, 2).Value = "Longitude"  
    Worksheets("KMLData").Cells(1, 3).Value = "Latitude"  
    Worksheets("KMLData").Cells(1, 4).Value = "AltMSL"  
    Worksheets("KMLData").Cells(1, 5).Value = "AltAGL"  
    Worksheets("KMLData").Cells(1, 6).Value = "AltUse"  
    Worksheets("KMLData").Cells(1, 7).Value = "Event"  
    Worksheets("KMLData").Cells(1, 8).Value = "IconNum"  
    Worksheets("KMLData").Cells(1, 9).Value = "Airspeed"  
    Worksheets("KMLData").Cells(1, 10).Value = "N1%"  
    Worksheets("KMLData").Cells(1, 11).Value = "Bank"  
    Worksheets("KMLData").Cells(1, 12).Value = "VSpeed"  
    Worksheets("KMLData").Range("A1:L1").Font.Bold = True  
  
    Worksheets(1).Activate  
  
    Dim i As Integer  
    i = 2  
  
    For Each cell In [A10.A25000]  
        Frame = cell.Offset(0, 0)  
        lat = cell.Offset(0, 2)  
        lon = cell.Offset(0, 3)  
        airspeed = cell.Offset(0, 4)  
        altMSL = cell.Offset(0, 5)  
        altAGL = cell.Offset(0, 6)
```

```

vSpeed = cell.Offset(0, 8)
N1 = cell.Offset(0, 9)
flaps = cell.Offset(0, 11)
spdbrk = cell.Offset(0, 12)
ap = cell.Offset(0, 14)
gear = cell.Offset(0, 15)
bank = cell.Offset(0, 16)

```

```

If Frame = 0 Then
    Exit For
End If

```

'write out the data to the KLM worksheet

'i = the row number

```

Worksheets("KMLData").Cells(i, 1).Value = Frame
Worksheets("KMLData").Cells(i, 2).Value = 0 - Application.WorksheetFunction.Degrees(lon)
Worksheets("KMLData").Cells(i, 3).Value = Application.WorksheetFunction.Degrees(lat)
Worksheets("KMLData").Cells(i, 4).Value = Format(altMSL, "0.00")
Worksheets("KMLData").Cells(i, 5).Value = Format(altAGL, "0.00")
Worksheets("KMLData").Cells(i, 6).Value = "MSL" 'for MTN files we plot MSL

```

'skip event here since we handle below

```

Worksheets("KMLData").Cells(i, 8).Value = 1 'icon number
Worksheets("KMLData").Cells(i, 9).Value = Format(airspeed, "0.00")
Worksheets("KMLData").Cells(i, 10).Value = Format(N1, "0.00")
Worksheets("KMLData").Cells(i, 11).Value = Format(bank, "0.00")
Worksheets("KMLData").Cells(i, 12).Value = Format(vSpeed, "0.00")

```

'Check for gear change

```

If gear <> OldGear Then
    If gear = False Then 'gear is up
        Worksheets("KMLData").Cells(i, 7).Value = "Gear Up"
    Else 'gear is down
        Worksheets("KMLData").Cells(i, 7).Value = "Gear Down"
    End If
Worksheets("KMLData").Cells(i, 8).Value = 2
OldGear = gear
End If

```

'Check for Speed Brake change

```

If spdbrk <> OldSpdbrk Then
    If spdbrk = False Then 'speed brake is retracted
        Worksheets("KMLData").Cells(i, 7).Value = "Speed Brake Retracted"
    Else 'speed brake is extended
        Worksheets("KMLData").Cells(i, 7).Value = "Speed Brake Extended"
    End If
Worksheets("KMLData").Cells(i, 8).Value = 2
OldSpdbrk = spdbrk
End If

```

'Check for autopilot change

```

If ap < 2 Then 'ignore everything greater than 1 for now
    If ap <> OldAp Then
        If ap = 1 Then 'autopilot is on
            Worksheets("KMLData").Cells(i, 7).Value = "Autopilot On"
        Else 'autopilot is off

```

```

        Worksheets("KMLData").Cells(i, 7).Value = "Autopilot Off"
    End If
    Worksheets("KMLData").Cells(i, 8).Value = 2
    OldAp = ap
    End If
End If

'Check for flaps change
If flaps <> OldFlaps And (Not transitioning) Then 'find out what new flap setting is
    transitioning = True
    OldFlaps = cell.Offset(28, 11) 'approximately 5 seconds to transition plus a cushion
    If OldFlaps = 0 Then
        Worksheets("KMLData").Cells(i, 7).Value = "Flaps 0"
    ElseIf OldFlaps = 15 Then
        Worksheets("KMLData").Cells(i, 7).Value = "Flaps 15"
    ElseIf OldFlaps = 30 Then
        Worksheets("KMLData").Cells(i, 7).Value = "Flaps 30"
    End If
    Worksheets("KMLData").Cells(i, 8).Value = 2
End If
If transitioning Then
    If flaps = 0 Or flaps = 15 Or flaps = 30 Then
        transitioning = False
    End If
End If
i = i + 1 'increment to the next row
Next

End Sub

```


APPENDIX I

VISUAL BASIC FOR APPLICATIONS CODE FOR CREATING KML FILE

```

Sub generateKML()
,
' GenerateKML Macro
' Created by Kevin Williams, 11/19/2011
,
    Dim outputText As String

    ' Set file details
    filepath = Application.GetSaveAsFilename( "KML Files (*.kml)*.kml", , "Get KML File Name")
    If filepath = False Then Exit Sub

    ' Set document name
    docName = InputBox("Enter Document Name", "Google Earth Display Name")
    If docName = "" Then docName = "My KML File"

    Open filepath For Output As #1

    'Write header to file
    Dim header As String
    header = "<?xml version=""1.0"" encoding=""UTF-8""?>" & vbCrLf & _
    "<kml xmlns=""http://earth.google.com/kml/2.2"">" & vbCrLf & _
    "    <Document>" & vbCrLf & vbTab & "    <name>" & docName & "</name>"
    Print #1, header

    'Write the styles you need
    outputText = "<Style id=""RedIcon"" > <IconStyle>" & vbCrLf
    outputText = outputText & "    <scale>1.0</scale> <Icon>"
    outputText = outputText & "    <href>http://maps.google.com/mapfiles/kml/pal4/icon49.png</href> </Icon>"
    outputText = outputText & vbCrLf & "</IconStyle> </Style>"
    Print #1, outputText

    outputText = "<Style id=""BlackIcon"" > <IconStyle>" & vbCrLf
    outputText = outputText & "    <scale>0.6</scale> <Icon>"
    outputText = outputText & "    <href>http://maps.google.com/mapfiles/kml/pal4/icon57.png</href> </Icon>"
    outputText = outputText & vbCrLf & "</IconStyle> </Style>"
    Print #1, outputText

    'loop through the flight waypoints
    For Each cell In [A2.A50001]

        Frame = cell.Offset(0, 0)
        longitudeValue = cell.Offset(0, 1)
        latitudeValue = cell.Offset(0, 2)
        altitudeMSL = cell.Offset(0, 3)
        altitudeAGL = cell.Offset(0, 4)
        AltUse = cell.Offset(0, 5)
        eventName = cell.Offset(0, 6)
        IconNum = cell.Offset(0, 7)
        airspeed = cell.Offset(0, 8)
        N1 = cell.Offset(0, 9)
        Bank = cell.Offset(0, 10)
    
```

```

VSpeed = cell.Offset(0, 11)

If Frame = 0 Then
    Exit For
End If

'Create a point
'first the header then the icon style
outputText = "<Placemark> <styleUrl>#"
If IconNum = 1 Then
    outputText = outputText & "BlackIcon</styleUrl>"
Else
    outputText = outputText & "RedIcon</styleUrl>"
End If
Print #1, outputText

'See if there is a name for the point
If eventName <> "" Then
    outputText = "<name>" & eventName & "</name>"
    Print #1, outputText
End If

'Now put in the description
outputText = "<description>Frame: " & Frame & " Airspd: " & airspeed & vbCrLf
outputText = outputText & "AltMSL: " & altitudeMSL & " AltAGL: " & altitudeAGL & vbCrLf
outputText = outputText & "N1: " & N1 & " Bank: " & Bank & " VSpd: " & VSpeed & "</description>"
Print #1, outputText

'lat, lon, and alt for point
Dim thisAlt As Single
Dim altMessage As String
If AltUse = "AGL" Then
    altMessage = "relativeToGround"
    thisAlt = altitudeAGL / 3.2808399
Else
    altMessage = "absolute"
    thisAlt = altitudeMSL / 3.2808399
End If
outputText = "<Point> <extrude>1</extrude> <altitudeMode>" & altMessage & "</altitudeMode>"
<coordinates>" & longitudeValue & "," & latitudeValue & ","
outputText = outputText & thisAlt
outputText = outputText & "</coordinates></Point></Placemark>"
Print #1, outputText

Next

'Write footer to file
outputText = "</Document></kml>"
Print #1, outputText

Close #1
i = MsgBox("File " & filepath & " created", vbOKOnly, "Finished")
,
End Sub

```

APPENDIX J

VISUAL BASIC FOR APPLICATIONS CODE FOR CREATING A FIXED CYLINDER

```

Sub GenerateCylinder()
'
' GenerateCylinder Macro
' Created by Kevin Williams, 11/28/2011
'

    Dim outputText As String

    ' Set file details
    filepath = Application.GetSaveAsFilename( "KML Files (*.kml)*.kml" , "Get KML File Name")
    If filepath = False Then Exit Sub

    ' Set document name
    docName = InputBox("Enter Cylinder Name", "Google Earth Display Name")
    If docName = "" Then docName = "My Cylinder"

    Open filepath For Output As #1

    'Write header to file
    Dim header As String
    header = "<?xml version=""1.0"" encoding=""UTF-8""?>" & vbCrLf & _
    "<kml xmlns=""http://earth.google.com/kml/2.2"">" & vbCrLf & _
    "    <Document>" & vbCrLf & vbTab & "<name>" & docName & "</name>"
    Print #1, header

    'Write the style you need
    outputText = "<Style id=""Style1""> <PolyStyle>" & vbCrLf
    outputText = outputText & "<color>000000cc</color>"
    outputText = outputText & vbCrLf & "</PolyStyle> </Style>"
    Print #1, outputText

    'Get your variables
    Lon = Cells(2, 1).Value
    Lat = Cells(2, 2).Value
    LonRad = Application.WorksheetFunction.Radians(Lon)
    latRad = Application.WorksheetFunction.Radians(Lat)
    Alt = Cells(2, 3).Value
    AltUse = Cells(2, 4).Value
    Distance = Cells(2, 5).Value 'This is the radius of the cylinder
    DUnits = Cells(2, 6).Value 'This is the units that the distance is expressed (ft, m, km, miles, nm)

    'first the header then the icon style
    outputText = "<Placemark> <styleUrl>#Style1</styleUrl>" & vbCrLf
    outputText = outputText & "<Polygon>" & vbCrLf & "<extrude>1</extrude>" & vbCrLf

    'alt mode for cylinder
    Dim thisAlt As Single
    Dim altMessage As String
    If AltUse = "AGL" Then
        altMessage = "relativeToGround"
    Else
        altMessage = "absolute"
    
```

```

End If
thisAlt = Alt / 3.2808399 'convert from feet to meters
outputText = outputText & "<altitudeMode>" & altMessage & "</altitudeMode>" & vbCrLf

outputText = outputText & "<outerBoundaryIs> <LinearRing> <coordinates>"
Print #1, outputText

Dim brng As Single 'this is the angle in radians
Dim distKM As Single 'this is the distance in kilometers
Dim lon2 As Double 'this is the new longitude point
Dim lat2 As Double 'this is the new latitude point

Select Case DUnits 'convert the distance units to kilometers for the equation
    Case "ft", "feet"
        distKM = Distance / 3280.8399
    Case "m", "meters"
        distKM = Distance / 1000
    Case "km"
        distKM = Distance
    Case "miles"
        distKM = Distance * 1.609344
    Case "nm", "NM"
        distKM = Distance * 1.852
End Select

'now write out all of the lon,lat,alt tuples
For i = 1 To 360
    brng = Application.WorksheetFunction.Radians(i)
    lat2 = Application.WorksheetFunction.Asin(Sin(latRad) * Cos(distKM / 6371) + Cos(latRad) * Sin(distKM /
6371) * Cos(brng))
    lon2 = Application.WorksheetFunction.Atan2(Cos(distKM / 6371) - Sin(latRad) * Sin(lat2), Sin(brng) *
Sin(distKM / 6371) * Cos(latRad))
    lat2 = Application.WorksheetFunction.Degrees(lat2)
    lon2 = Lon + Application.WorksheetFunction.Degrees(lon2)
    outputText = lon2 & "," & lat2 & "," & thisAlt
    Print #1, outputText
Next i

'Write footer to file
outputText = "</coordinates></LinearRing></outerBoundaryIs></Polygon></Placemark></Document></kml>"
Print #1, outputText

Close #1
i = MsgBox("File " & filepath & " created", vbOKOnly, "Finished")

End Sub

```