NASA Ames Simulation Laboratories
Year in Review
2004

Acknowledgements

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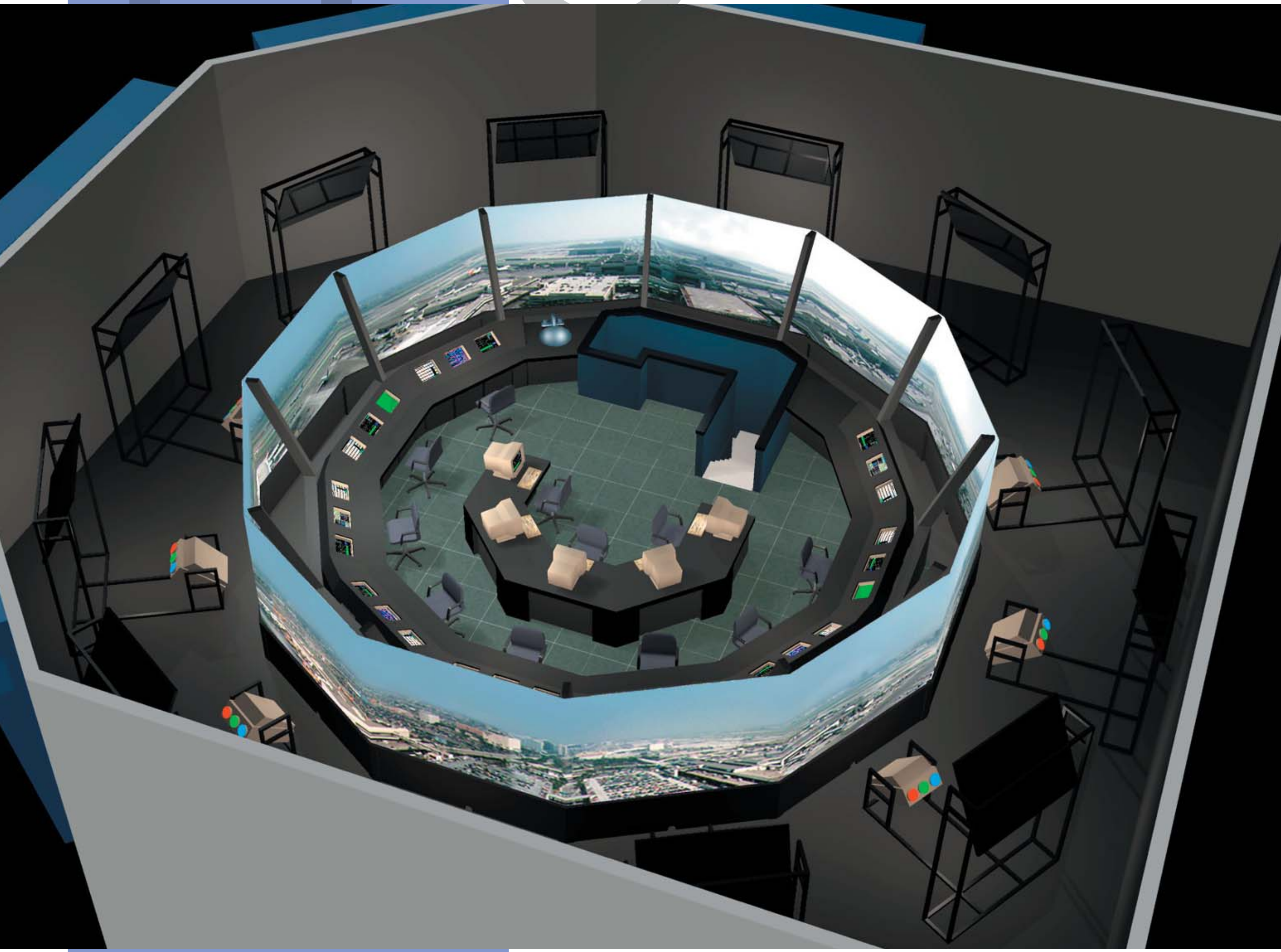
This document was produced by:
Kathleen Starmer, Northrop Grumman Information Technology.

Contents

SimLabs, located at NASA Ames Research Center in Moffett Field, California, houses some of the most sophisticated simulation facilities in the world. We support a wide range of research, with emphasis on aerospace vehicles, integrated system-level simulation, human factors, accident investigations, and studies aimed at improving aviation safety. SimLabs has partnered with numerous NASA programs over the years, as well as with other government agencies, industry, and academia, and is strategically important in meeting the Nation's present and future aerospace needs.

FFC



The FutureFlight Central tower cab provides a spectacular 360-degree field-of-view.

Executive Summary

We are proud to present our Year in Review for Fiscal Year 2004. This report documents the Simulation Research and Technology Projects accomplished in the Simulation Laboratories (SimLabs) that fulfill vital roles in NASA's Missions. During the past year—and as it has for four decades—SimLabs has made essential contributions to flight vehicle development, aviation safety, Space Shuttle landing operations, flight control and display systems, and the national airspace system. Although the utilization of SimLabs has changed significantly over the years with the evolution of NASA's research agenda and the challenge of full cost recovery, the requirement for high-fidelity, human-in-the-loop simulation has remained strong.

The Ames Simulation Laboratories consist of three separate motion platforms, four fixed-base development platforms, a virtual air traffic control tower, and air traffic control simulation laboratories. These capabilities are housed in three complexes referred to as the Vertical Motion Simulator Complex, the Crew-Vehicle Systems Research Facility, and FutureFlight Central. The Aerospace Simulation Operations Branch manages and operates the facilities, and Northrop Grumman Information Technology performs support tasks as a NASA contractor. With this premier suite of facilities and expert staff, SimLabs has the capability for high fidelity simulation of all elements of aerospace vehicle and transportation systems, including airport ground operations, air traffic management, crew station issues, crew/vehicle interfaces, vehicle design, dynamics, and handling qualities. Throughout the year, the SimLabs staff has operated all the facilities with the highest level of safety, consistently excellent quality, and dedication to customer satisfaction.

We invite the reader to peruse the articles contained within this report to discover the myriad technological issues benefiting from research conducted in the Ames Simulation Laboratories.

Tom Alderete and Barry Sullivan,
Aviation Systems Division

CVSRF

The Advanced Concepts Flight Simulator can be customized to simulate a variety of aircraft.

Simulation Facilities

Ames' Simulation Facilities are national resources, providing unique, crucial capabilities to the research community. The facilities are connected by a High Level Architecture interface, allowing for distributed simulations. A brief description of each facility follows. More detailed information can be found on our website: www.simlabs.arc.nasa.gov.

FutureFlight Central (FFC) Research Facility

FutureFlight Central is a world-class airport operation simulation facility that has the look and "feel" of an actual Air Traffic Control (ATC) tower. This unique facility offers a "fully immersive" virtual airport environment in which planners, managers, controllers, pilots, and airlines can work together in real-time to test software performance, safety, and reliability under realistic conditions. FFC is dedicated to solving present and emerging capacity problems of the nation's busiest airports and has the capability to support cost-benefit studies of planned airport expansions.

At FFC, it is possible to simulate the most complex airport operations, including real-time peak air traffic control with 12 controller positions, eight ramp tower positions, and 13 pseudo-pilot positions. The controller positions are interchangeable to accommodate any air traffic control tower configuration. FFC's full-size tower cab is equipped with functional consoles and interactive radar displays. The facility has a modular design that enables information sharing among multiple users with 360-degree views. High-fidelity simulations can be run from the tower under a variety of variable conditions (e.g., weather, time of day, visibility).

The tower cab at FFC.

The simulation facilities at FFC adhere to an open architecture which allows flexibility of operational use and custom configurations. For example, components can be configured to support a variety of subsystems that might exist in some airport facilities but not others. FFC's open architecture system allows new technologies to be incorporated during the design phase and life cycle upgrades. The environment at FFC provides a stable platform from which new requirements can be derived, offering pilots and controllers an opportunity to evaluate changes to any airport.

The sophisticated capabilities of FFC allow it to be used as more than just an ATC tower simulator, however. Indeed, FFC can be thought of as a *visualization tool*. For example, FFC possesses a Mars database and could be used as a simulated control center for directing future Mars-based robotic missions. FFC can also be used as an "eye in the sky," depicting, for instance, space craft operations in the vicinity of the International Space Station. For simulations where it is advantageous to visualize scenarios using a three-dimensional, 360-degree format, FFC is the tool of choice.

Crew-Vehicle Systems Research Facility (CVSRF)

The Crew-Vehicle Systems Research Facility was designed for the study of human factors in aviation. The facility is used by researchers to analyze performance characteristics of flight crews, formulate principles and design criteria for future aviation environments, evaluate new and existing air traffic control procedures, and develop new training and simulation techniques required by the continued technical evolution of flight systems. The CVSRF facility supports NASA, the Federal Aviation Administration (FAA), and industry research programs.

Studies have shown that human error plays a part in 60 to 80 percent of all aviation accidents; therefore, continued research to improve safety technologies and procedures is imperative. CVSRF allows scientists to study how errors occur and assess the effects of automation, advanced instrumentation, and factors such as fatigue, on human performance.

The facility includes two full-motion, full-mission-capable flight simulators—a Boeing 747-400 Level D-certified simulator and an Advanced Concepts Flight Simulator (ACFS)—and a simulated Air Traffic Control environment that operates with the Ames-developed Pseudo-Aircraft Systems (PAS) software. Both flight simulators are capable of full-mission simulation and have advanced visual systems that provide out-the-window cues in the cockpit.

Each simulator has a dedicated experimenter's station for monitoring and controlling the simulator. The experimenter's station contains a suite of computer graphic displays, keyboards, and terminals for interacting with the simulation computers, status lights and emergency controls, communication and audio systems, and other useful equipment. In addition to the main experimenter consoles, each of the simulators has an observer station on board from which experimenters can communicate with the simulator crew or observers.

Pilots flying a test run in the Boeing 747 simulator.

Boeing 747-400 Simulator

The Boeing 747-400 Level D simulator represents the cockpit of one of today's most sophisticated airplanes. It is equipped with programmable flight displays that can be easily modified to enhance the flight crew's situational awareness and thus improve systems safety. In addition, the simulator offers a digital control loading system, a six-degree-of-freedom motion system, a digital sound and aural cues system, and a fully integrated autoflight system that provides aircraft guidance and control. It is also equipped with a weather radar system.

The 747-400 simulator provides all modes of airplane operation, from cockpit preflight to parking and shutdown at the destination. The simulator's crew compartment is a fully detailed replica of a current airline cockpit, and all instruments, controls, and switches operate in the same way as they do in an actual aircraft. To ensure simulator fidelity, the 747-400 is maintained to the highest possible level of certification established by the FAA for airplane simulators, which ensures credibility of results for research conducted in the simulator.

Advanced Concepts Flight Simulator (ACFS)

This unique research tool simulates a generic commercial transport aircraft and employs many advanced flight systems representative of the newest aircraft being built today. The ACFS generic aircraft was conceived and sized on the basis of projected usage needs in the 21st Century. Among its many advanced systems, the ACFS includes touch-sensitive electronic checklists, state-of-the-art graphical flight displays, aircraft systems schematics, and a flight management system. The ACFS is mounted atop a six-degree-of-freedom motion system and uses side-stick controllers for aircraft control.

The ACFS' visual generation and presentation systems closely match those of the 747-400 simulator, and the visual scenes can depict specific airports and their surroundings as viewed from the cockpit at day, twilight, or night. Currently, the ACFS is used to simulate a generic 757-size aircraft and a C-17 transport vehicle. However, the system's built-in flexibility allows it to be configured to simulate a wide range of other flight vehicles in the future, including new aerospace prototypes.

Air Traffic Control (ATC) Simulator

The Air Traffic Control environment is a significant contributor to pilot workload and, therefore, to the performance of crews in flight. Full-mission simulation is greatly affected by the realism with which the ATC environment is modeled. From the crew's standpoint, this environment consists of dynamically changing verbal or data-link messages, some addressed to or generated by other aircraft flying in the immediate vicinity.

CVSRF's ATC simulator is capable of operating in three modes: stand-alone, without participation by the rest of the facility; single-cab mode, with either the ACFS or the 747-400 participating in the study; and dual-cab mode, with both cabs participating.

CVSRF's ATC simulator can operate independently or linked with the flight simulators.

Vertical Motion Simulator (VMS) Complex

The VMS complex is an important national resource that supports many of the country's most sophisticated aerospace Research and Development programs. Its motion base is the largest vertical displacement simulator in the world, allowing the VMS to provide the highest level of motion fidelity available in the simulation community.

Simulation engineers at the VMS ensure that researchers' projects run smoothly.

The VMS supports research with three dynamic, flexible laboratories: the motion lab and two fixed-base labs. These laboratories readily lend themselves to simulation studies involving controls, guidance, displays, automation, handling qualities, flight deck systems, accident investigations, and training. Other areas of research include the development of new techniques, technologies, and methodologies for simulation and the definition of requirements for other training and research simulators.

Housed in a ten-story tower, the large amplitude motion system allows the simulator to travel up to 60 feet vertically and 40 feet laterally. The simulator operates with three translational degrees of freedom (vertical, lateral, and longitudinal) and three rotational degrees of freedom (pitch, roll, and yaw), and it can perform at maximum capability in all axes simultaneously.

The operational efficiency of the laboratory is enhanced by the Interchangeable Cab (ICAB) system, which consists of five different interchangeable and completely customizable cabs. The flexibility of the ICAB system allows the VMS to simulate any type of vehicle, whether it is already in existence or merely in the conceptual phase. Each ICAB is customized, configured, and tested at a fixed-base development station, after which it is either used in-place for a simulation at one of the VMS's fixed-base labs or moved onto the motion platform.

Digital image generators in the laboratory provide full-color scenes on six channels, multiple eye points, and include a chase plane point-of-view. The VMS labs maintain a large inventory of customizable visual scenes with a unique in-house capability to design, develop, and modify the inventory of its databases. Real-time aircraft status information can be displayed to both pilot and researcher through a wide variety of analog instruments and head-up, head-down, or helmet-mounted displays.

Virtual Laboratory (VLAB) is a software tool within the VMS complex that provides a unique approach to aerospace research and development. The software is flexible, portable, and capable of operating on a variety of platforms including PC, Macintosh, and SGI. VLAB presents a virtual replica of the VMS lab environment in which a remote user can interactively define specific data and display configurations that will afford the most productivity. By housing VLAB on the remote researcher's computer and only shuttling *data* between facilities, VLAB allows researchers at distant locales to participate in VMS simulations in real-time. Currently, VLAB is used for all VMS Space Shuttle simulations, permitting researchers at Johnson Space Center to participate without leaving their home base. The VLAB concept, however, has a much broader potential, offering researchers the ability to monitor and actively participate in simulations using wind tunnels, flight test facilities, and interoperable labs from any location within the U.S. by remote access.

VLAB allows remote researchers to participate in VMS simulations in real-time. This shows a typical VLAB display.

VMS

The Vertical Motion Simulator's completely customizable interchangeable cabs allow virtually any vehicle to be simulated.

Research at SimLabs

Space Shuttle Vehicle: 2003-2004

Principal Investigators: Doug Hurley, Astronaut Office; Jim Harder, Boeing

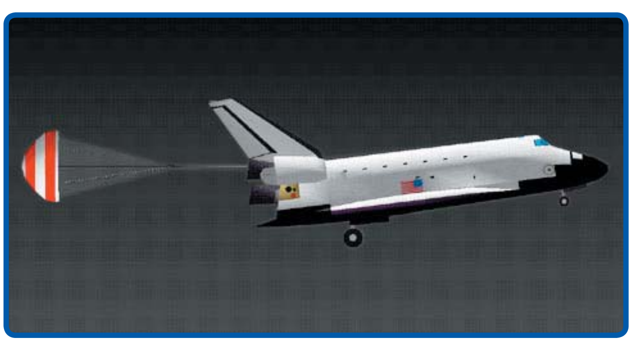
Summary

Simulations of the Space Shuttle Vehicle (SSV) were conducted at the Vertical Motion Simulator (VMS) complex to provide landing and rollout training for the NASA astronaut corps. Additionally, SimLabs provided support to the Shuttle Program's engineering and Return to Flight (RTF) efforts. These included: re-evaluation of the tire "Load Persistence" model, code audits and modifications of the simulation math model, software and hardware upgrades, and the development of a new visual database.

Introduction

NASA's Space Shuttle program features the United States' first reusable space vehicle fleet. As originally conceived, the Space Shuttle program was intended to provide routine, economical access to space and deliver a variety of government and commercial satellites to low-Earth orbit. The goals of the Space Shuttle program have evolved over time and now include servicing the International Space Station (ISS), ferrying both cargo and astronauts to and from the ISS, and developing next-generation reusable space transportation systems.

Since 1980, the Vertical Motion Simulator at NASA Ames Research Center has supported the Space Shuttle program, providing high fidelity, piloted simulations of Space Shuttle landings and rollouts and serving as a critical training facility for the astronaut corps. The corps has extremely high confidence in the technical fidelity of the VMS simulations and requires all astronaut pilots to train here. Astronauts experience both typical and off-nominal conditions during simulation, including poor visibility, inclement weather, Auxiliary Power Unit failures, Head-Up Display (HUD) misalignment, nose-wheel steering failure, tire failures, and brake failures. It is far safer for astronauts to train for off-nominal conditions in a ground-based, high-fidelity simulator than to encounter such conditions for the first time during a real flight scenario.



Simulated Space Shuttle with parachute deployed.

In addition to astronaut training, the VMS offers a cost-effective research platform for testing enhancements to the Orbiter vehicle. Past research has included modifications to the flight-control system, landing system, and flight rules. For example, flight handling qualities can be tested and evaluated in the VMS before the improvements are actually implemented on the Shuttle. This allows any anomalies to be detected and addressed before they become an expensive, real-life problem. Engineering studies are also conducted in the VMS and have contributed greatly to program safety.

Space Shuttle Endeavour landing at Edwards Air Force Base.

These projects and studies are enhanced by the use of SimLabs' Virtual Laboratory (VLAB) tool. VLAB's collaborative engineering environment enables researchers at Johnson Space Center and Marshall Space Flight Center to interact with VMS experiments in real-time by linking the facilities through a high-speed communications network and specialized software. During Orbiter simulations, remote researchers use VLAB to view live data from the VMS, communicate with the pilot and on-site researchers and engineers, and interact with simulations as they occur. This remote participation capability saves the Shuttle program two very valuable resources: time and money.

The VMS is playing a critical role in the fleet's 2005 Return to Flight by providing enhanced training for the corps, not only in the realm of landing and rollout, but also with "abort on ascent" scenarios. In addition to the standard end-of-mission landing sites (including Kennedy Space Center, Dryden Air Force Base, and White Sands Missile Range), the VMS currently has 17 Shuttle abort landing sites in its database, covering most abort options for standard Shuttle missions.

The primary focus of this year's Shuttle simulations was astronaut training. Additional work included re-evaluation of the tire "Load Persistence" model, code audits and modifications of the math model, software and hardware upgrades, and the development of a new visual database.

Simulation

For this fiscal year, training was provided for upcoming mission crews during three sessions of flight simulations. Various runways, visibility conditions, and wind conditions were simulated, while system failures such as tire failures and HUD misalignment were periodically introduced.

The math model was enhanced in several ways. Lake bed landings—such as might be encountered at the Edwards or White Sands landing sites—were made more realistic. The tire model was also altered with regard to cord wear and load, allowing for more realistic simulations of tire wear. The flight display software for the Multifunctional Electronic Display Subsystem (MEDS) was upgraded to OI-30, which is the version currently in use in the Shuttle fleet. Additionally, the HUD for the Orbiter's Backup Flight System (BFS) was successfully emulated. The BFS utilizes independent ascent and entry software should the primary software in the Orbiter experience a failure.

In addition to modifications, the math model also underwent a code audit to ensure agreement between the models at Ames and Johnson Space Center with regard to nose gear tire performance. This work ultimately supported a Return to Flight task certifying the nose gear tire code for use with nose wheel steering.

An additional modification involved the expansion of the SSV visual database. In standard visual database development, digital feature analysis data (DFAD) is used to create realistic terrain models in a streamlined, relatively rapid process. For the new Le Tube, France, database—which debuted this year—DFAD data was unavailable, so SimLabs personnel created the digital visual scene from maps and aerial photographs of the Le Tube runways and surrounding areas to create the most accurate database possible. Digital images of roads, farmland, industrial, and suburban areas were then created by SimLabs 3-D graphics experts and added to the visual scene to enhance its realism.

In addition to the model modifications, the simulator cockpit was upgraded. A MEDS set-up was added to the left seat in S-Cab, converting the Cab into a true "glass cockpit." This format features flat LCD screens and offers easy-to-read graphical views of key flight indicators such as attitude display and the horizontal situation indicator. It also permits a dramatic increase in display options and enhances pilots' situational awareness.

As an engineering study, the Load Persistence Model (which was incorporated last year to more accurately predict tire failures) was reevaluated to ensure its proper implementation in the VMS. With the new model, researchers hope to expand the Orbiter's flight envelope by testing the structural limits of the tires and the pilots' ability to control the vehicle under adverse conditions.

Results

During the four-week simulation in 2003, 33 pilots flew 596 training runs, and four mission specialists also participated. Thirty-three pilots flew 533 training runs during the three-week Spring 2004 simulation session, and 16 mission specialists received training, as well. 26 pilots flew 496 runs in Fall 2004, and eight mission specialists also underwent training. The crew familiarization phase underscored the important role the VMS plays in preparing upcoming crews for Shuttle landings and rollouts and the management of potential off-nominal conditions.

The Return to Flight task involving certification of the nose gear tire code generated data (via 731 runs) which was refined to create load profiles that will ultimately be used to test Orbiter flight hardware at Wright Patterson Air Force Base. The Load Persistence Engineering Study was completed with four pilots flying 124 data runs. Preliminary results indicate that the new model does not significantly alter the frequency or timing of Orbiter tire failures.

Investigative Team

NASA Johnson Space Center
NASA Ames Research Center
Boeing North American
Lockheed Martin Engineering and Services Corporation
United Space Alliance
Northrop Grumman Information Technology

Astronauts in training at the VMS.

Cockpit Display of Traffic Information

Principal Investigator: Gordon Hardy, Northrop Grumman Information Technology

Summary

The Cockpit Display of Traffic Information (CDTI) simulation examined ways of improving safety and efficiency for closely spaced parallel approaches (CSPA) during Instrument Flight Rule (IFR) conditions. Effectiveness of updated cockpit displays and operational procedures, with specific emphasis on traffic and wake information, were studied.

Introduction

Spacing requirements during CSPA at airports are set so that landing aircraft can avoid turbulence wakes generated by other aircraft during a parallel approach. Landing operations during Visual Meteorological Conditions (VMC) require a minimum lateral spacing between parallel runways of 750 feet (ft). However, during low-visibility (i.e., IFR) conditions, the spacing requirement increases to at least 3000 ft. Consequently, at an airport like San Francisco International (SFO) where the parallel runways are spaced 750 ft apart, incoming traffic acceptance rate is effectively cut in half during IFR conditions.

Since the original CSPA spacing requirements were determined, new technologies such as the Global Positioning System have been developed. Such technologies offer the possibility of narrowing separation distances for simultaneous approaches during IFR conditions to those used during high-visibility conditions. Additionally, new algorithms for predicting wake vortex movement may allow instrument operations to be conducted with greater safety than exists for present visual operations.

CDTI research supports NASA's Advanced Air Transportation Technologies (AATT) Program, which explores promising technologies for modernization of the National Airspace System. This study was the first of a series that will investigate how best to utilize new navigational technologies, synthesize information, and present it to pilots in a useful manner for application during CSPAs.

Simulation

The study scenario involved flying a conventional and a runway-independent aircraft (RIA) on parallel approaches. A 747 (referred to hereafter as the CTOL) was chosen as the conventional aircraft, and a Civil Tilt Rotor (CTR) was selected as the RIA vehicle because of its short takeoff and landing capabilities.

A new CDTI was created for the CTR by modifying the Primary Flight Display (PFD) and Navigation (NAV) display from prior CTR experiments. A wake prediction algorithm, developed at NASA Ames Research Center, was implemented to depict predicted hazardous wake areas (HWA) for the CTR and CTOL on the NAV display. An algorithm was also developed to display predicted positions of both airplanes on the NAV. Speed control profiles enhanced the guidance logic, which was used to drive the PFD symbology.

A screenshot of the NAV display during a CSPA. The RIA is shown on the left, and the CTOL is shown on the right.

The CTOL operated along predetermined flight paths, and test pilots flew the simulated CTR during CSPAs with the CTOL onto SFO Runways 28L and 28R. Researchers studied how CTR pilots utilized the enhanced cockpit displays to avoid wake encounters under varying conditions (left crosswind, right crosswind, unpredicted headwind error, initial position error, and CTOL flying faster than cleared speed; all scenarios included turbulence).

Results

Four Ames' test pilots flew 97 data runs over a three-week period. Cooper-Harper handling-quality ratings and pilot comments were collected for each run. The wake and predictor displays received favorable pilot ratings, with the consensus that the additional cockpit information was useful—especially for a two-person crew—and helped pilots maintain traffic separation while avoiding wake turbulence. Furthermore, the improved guidance produced minimal performance errors, even during demanding tasks. Overall, results indicate that the new CDTI concept is feasible and merits further investigation.

Investigative Team

NASA Ames Research Center
Northrop Grumman Information Technology

Distributed Air/Ground Traffic Management Demonstrations 2004

Principal Investigator: Vernol Battiste, Walter Johnson, Everett Palmer, and Nancy Smith, NASA Ames Research Center; Thomas Prevot, San Jose State University

Summary

Distributed Air/Ground Traffic Management (DAG-TM) research examines airspace operations technologies and procedures with the goal of increasing system capacity. This year's studies investigated the feasibility and benefits of two DAG-TM elements which address en route, arrival, and approach phases of flight.

Introduction

As part of NASA's Advanced Air Transportation Technologies Program, NASA Researchers have been exploring a "free-flight" concept, which would allow pilots of autonomous aircraft to choose their flight paths and maintain en route separation from other vehicles. It is hoped that free-flight will ultimately triple airspace capacity.

To be considered an autonomous aircraft, the vehicle must be equipped with Cockpit Display of Traffic Information (CDTI) software, which aids pilots in maintaining safe separation distances. The pilots of autonomous aircraft must meet traffic flow management constraints assigned by Air Traffic Control (ATC) personnel; however, the pilots have the flexibility to choose their own routes and are relieved from certain flow control restrictions.

A CDTI display during spacing operations.

To test the feasibility of the free-flight concept, the DAG-TM program was implemented. Specifically, DAG-TM examines airspace operations technologies and procedures with the goal of increasing system capacity. Several Concept Elements (CE) comprise DAG-TM, including CE5 (En Route Free Maneuvering) and CE11 (Self-Spacing for Merging and In-Trail Separation). CE5 aims to improve airspace capacity by allocating aircraft separation responsibilities to appropriately equipped autonomous aircraft while en route, while CE11 focuses on allowing aircraft to self-merge and maintain spacing during the arrival and approach phases of flight. In this year's DAG-TM experiments, NASA researchers from both Ames and Langley investigated the feasibility and benefits of CE5 and CE11 using distributed, high-fidelity, human-in-the-loop flight simulations.

Simulation

The DAG-TM simulation environment was distributed across several facilities and two NASA Centers. Participating facilities included Ames' Airspace Operations Laboratory (AOL), Ames' Flight Deck Display Research Laboratory (FDDRL), Ames' Crew-Vehicle Systems Research Facility [CVSRF, which houses the Advanced Concepts Flight Simulator (ACFS)], and Langley's Air Traffic Operations Laboratory (ATOL).

The CDTI software was the key airborne decision support tool used by the ACFS pilots, and the version integrated for the DAG-TM study included several features that supported free maneuvering and spacing logic. The Flight Management System continued to be used as the main airborne automation system interfacing with the CDTI. The FMS was updated to support the specific scenarios and functions required for the CE5 and CE11 investigations.

The simulation took place in a modified portion of the airspace in and around the ZFW ATC Center and the Dallas/Fort Worth Terminal Radar Approach Control (TRACON) perimeter. Five controllers and 22 commercial pilots participated in the study. Twelve subject pilots were located at ATOL piloted workstations, and eight subject pilots were located at the FDDRL single-pilot workstations. The ACFS was the only full-flight simulator in the network, and two pilots were assigned to fly the scenarios. The Center and TRACON ATC controller stations were all located at the AOL.

CE5 studies were conducted in June 2004 at both NASA Centers. The project continued in August 2004, with investigation of CE11 elements at Ames. A total of 20 data runs for the CE5 and 40 runs for CE11 were successfully completed in the ACFS.

Results

Extensive data was collected at the various facilities, and analysis is currently underway. The DAG series of experiments has provided the CVSRF staff with valuable insight into how the FMS functionality can be advanced for future air-ground operations.

Investigative Team

NASA Ames Research Center
NASA Langley Research Center
San Jose State University
Northrop Grumman Information Technology

Aircraft Landing Lights to Enhance Runway Traffic Safety

Principal Investigators: Karen Buondonno, FAA WJH Technical Center; Will Swank, FAA RSO

Summary

This simulation investigated the use of new aircraft lighting Standardized Operating Procedures (SOP) during departure and arrival operations to improve safety at airports, with the goal of determining the SOP's potential to prevent runway incursion incidents and accidents.

Introduction

The Commercial Aviation Safety Team and the General Aviation Joint Steering Committee [both part of the Federal Aviation Administration's (FAA) "Safer Skies" initiative] has chartered the Runway Incursion Joint Safety Implementation Team to reduce the occurrence of accidents caused by general aviation runway incursions. One plan developed to address this issue proposes the use of SOP for aircraft that have been cleared to depart or cross a runway. The hypothesis is that if all pilots clearly understand the intent of other aircraft in the area, there will be reduced errors in the system and therefore a decrease in runway incursion incidents and accidents. This simulation investigated whether safety was significantly improved using the new aircraft lighting SOP and examined the resultant effect of the SOP on flight crew workload.

An aircraft with illuminated landing lights.

Simulation

The simulation utilized the Level D-certified Boeing 747-400 simulator at the Crew-Vehicle Systems Research Facility (CVSRF). Departure and arrival operations at two airports, San Francisco International Airport (SFO) and Chicago O'Hare International Airport (ORD), were simulated.

Experiment scenarios were developed by researchers and flown by the subject crews, beginning with a departure from the gate, taxiing for departure, or on a final approach. An Experimenter/Operator Station scenario page was developed to control the movement of simulated traffic and their landing, strobe, and collision lights. A trained pseudo-pilot and air traffic controller emulated all other air traffic communications at the simulated airport.

Of the 16 subject flight crews, half were assigned to use the new SOP, and the other half used current company operating procedures for aircraft lighting during ground operations. All of the subjects were current airline pilots. Each crew was briefed with minimal information concerning the study but was allowed several training simulations for familiarization purposes. Each crew was assigned 16 randomly selected scenarios where a simulated traffic aircraft would—or would not—make an error that could cause a runway incursion.

In support of the simulation, the CVSRF's SFO visual database was updated to include a new taxiway. Several aircraft visual models were also enhanced to add different light configurations to meet the simulation requirements. Experimental data was recorded by a researcher in the cockpit of the 747-400 simulator; video, audio, and aircraft state recordings were also collected. Flight crew post-simulation surveys were conducted to document crew situational awareness.

Results

The simulation was conducted from November 6, 2003 to February 4, 2004. All study objectives were successfully met. Preliminary results indicate that the majority of the 16 subject crews felt that the simulation was realistic, and training was adequate to navigate the scenarios. No crews had reservations about relying on lighting procedures as a messaging system, nor did they feel a noticeable increase in workload using the new lighting SOP. All crews agreed that the clear and overt signals provided by the new SOP would produce a great benefit in the real world, assuming the procedures were used both correctly and consistently. Preliminary results also show that using the new lighting SOP increased pilot situational awareness to some degree and significantly reduced crew reaction time to an imminent runway incursion. Final results of this study will be reported at:
www.tc.faa.gov/ACB300/330_documents.asp.

Investigative Team

NASA Ames Research Center
FAA Runway Safety Office (RSO)
FAA WJH Technical Center
FAA Liaison Office
Northrop Grumman Information Technology

Joint Strike Fighter 2004

Principal Investigators: Sibille Tallant, John Bessolo, Andrew Robbins, Eric Somers, and Paul Dobberstein, Lockheed Martin Aeronautics

Summary

This simulation was the first in a series of experiments designed to evaluate the flight control system design and pilot-vehicle interface of the three different variants of the Joint Strike Fighter (JSF) aircraft: Conventional Take-Off & Landing (CTOL), Short Take-Off & Vertical Landing (STOVL), and Carrier Variant (CV).

Introduction

The F-35 JSF will provide the US Air Force, Navy, and Marines with an affordable combat aircraft for the 21st century. Lockheed Martin was awarded the F-35 JSF contract in 2001 and is in the process of building the prototype of three JSF variant airframes. During the contract competition, Lockheed Martin performed a series of simulations at NASA Ames Research Center and realized the importance of the unique motion capabilities of the Vertical Motion Simulator (VMS). In order to evaluate and enhance their flight control design and pilot-vehicle interface for the F-35, Lockheed Martin and the Joint Program Office (US Air Force, US Navy, and US Marine Corps) conducted a series of experiments using the large VMS motion platform. Three variants of the JSF (CTOL, STOVL, and CV) were examined during this simulation.

Simulation

To accommodate the complex JSF experiment requirements, which included the integration of a large engine model supplied by the researchers, the VMS simulation host computer was upgraded to a faster processor, and an additional computer was added as an attached processor to run the engine model. The hardware interface was also upgraded to interface with the researcher-supplied control inceptors. Additionally, the real-time host computer system software was extensively modified to support the additional processor and the researcher-supplied software. New simulation software operational procedures were then devised to make it easier to accommodate the data supplied by the researchers.

The cockpit was built based on the layout specification given by Lockheed Martin. All three variants tested in the study shared a common cockpit.

Three groups of researchers—one for each JSF variant—participated in the simulation, and each group had different requirements and objectives. Therefore, the study was divided into three separate, but related, software configurations.

The experiment was performed over a three-week period in February and March of 2004, with each of the JSF variants having a one-week time slot. The CTOL researchers investigated conventional take-offs, landings, ground-handling, formation flying, and aerial refueling tasks. The CV researchers investigated both conventional and carrier-based landings and take-offs, and ground-handling tasks. Visual flight rules patterns and failure modes were tested for both the CTOL and CV configurations. The STOVL researchers investigated ship and shore vertical take-offs, recovery and landings, hover, and formation flying tasks. Many of the tasks were developed "on-the-fly," based on pilot comments and post-test analysis. Over forty representatives from various JSF contractor and Program Office organizations participated in the motion runs in the VMS.

The F-35 JSF as depicted in the VMS.

Results

During the three-week study, eight pilots flew 1,362 data runs (CTOL:502 runs; CV:368 runs; STOVL:492 runs). Operations went smoothly and there was minimal down time. Post-simulation interviews revealed that both researchers and evaluation pilots were very pleased with the results. Commendations were given to SimLabs by all customer groups, both during and after the experiment.

Investigative Team

BAE Systems
Corsair Training Systems
Joint Program Office
Lockheed Martin Aeronautics
United Kingdom Ministry of Defense
QinetiQ
NASA Ames Research Center
Northrop Grumman Information Technology

FAA Obstacle Clearance Panel Simulation

Principal Investigators: Gerry McCartor, FAA Flight Operations Simulation & Analysis Branch; Mike Monroney, FAA Aeronautical Center; Bill Larsen, FAA NASA Ames; Jerry Robinson, John Towler, and Gerald Whites, Boeing Commercial Airplane Group

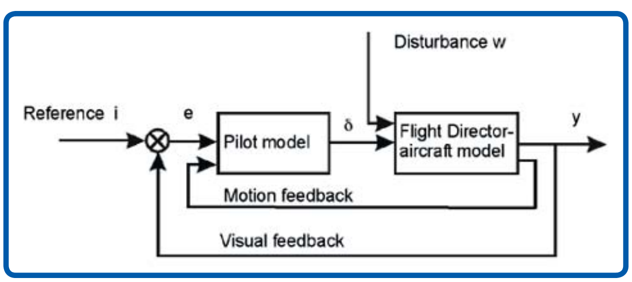
Summary

This was the latest in a series of studies utilizing the Crew-Vehicle Systems Research Facility's (CVSRF) B747-400 simulator to examine large aircraft flight tracks and height loss arrest points as a result of balked landings. Collected data will be applied toward the development of a mathematical pilot model that will ultimately be used to determine required Obstacle Free Zones (OFZ) for new large aircraft.

Introduction

The Federal Aviation Administration's (FAA) "Airport Design Standards" Advisory Circular (No. 150/5300-13) prescribes runway design dimensions for various elements affecting runway utilization, including runway length, minimum safety areas, and adjacent taxiways for large aircraft. This Circular also mandates OFZ dimensions for airplanes with wingspans up to 262 feet; OFZs are necessary to provide safe conditions below landing decision height. This simulation supported an effort by the International Civil Aviation Organization (ICAO) to develop pilot models for use in determining OFZs for *future* large aircraft. Specifically, the ICAO is collecting data on pilot reaction during balked landing scenarios with the goal of developing a mathematical model of pilot behavior.

In support of the ICAO's efforts, the FAA and Boeing utilized CVSRF's B747-400 simulator in 1999 to examine pilot behavior during balked landings. The current study used the same simulator and gathered additional balked landing data under various environmental conditions for the construction and calibration of pilot models. To create the most accurate data set, both intra-pilot variation (varying performance from occasion to occasion) and inter-pilot variation (difference between pilots) were investigated.



Data from this study will be used to develop a pilot model for new large aircraft, which will control the Flight Director model and aid in the determination of appropriate Obstacle Free Zones.

Simulation

Arrivals were conducted into John F. Kennedy International Airport runway 04R. A simulated local controller provided various calls to affect balked landings for the crews. Wave-off calls occurred at heights of 10, 20, 35, and 50 feet. Calls were assigned in a random manner according to a Latin Square design.

An Experimenter/Operator Station scenario page was created to provide researchers with a choice of simulated environmental variations during approach. Twelve distinct experimental conditions were available, made up of a combination of low and high steady wind; light and heavy aircraft weight; and low, medium, and high turbulence.

Thirteen pilots participated, each flying a series of 12 approaches with varying environmental conditions and two full-stop landings. To support the assessment of intra-pilot variability, each series was repeated four times for a total of 56 approaches. For each run, data collection began at 1,500 feet above ground level (AGL) and continued through 500 feet AGL for balked landings, or through 2000 feet after touchdown for completed landings. New software written by SimLabs personnel automated the data collection process. Aircraft position during balked landings—relative to the intended flight track—was recorded; audio and video data were also collected. Additionally, pilots completed pre-and post-flight questionnaires.

Results

Seven hundred twenty-eight data runs were conducted between July 12 and August 6, 2004. Results are pending, but post-flight analysis of this data will evaluate the B747-400's lateral and vertical dispersions during balked landings, relative to the intended flight path. Results from this study will assist the FAA and Boeing in the development of a mathematical pilot behavior model for the B747-400, which will ultimately aid the ICAO in efforts to develop pilot models for new large aircraft and determine appropriate OFZs.

Investigative Team

FAA Flight Standards Aviation Laboratory Branch
FAA NASA Ames
Boeing Commercial Airplane Group
NASA Ames Research Center
Northrop Grumman Information Technology

CH-47 Digital Advanced Flight Control System

Principal Investigator: Chris Blanken, US Army

Summary

This simulation compared a new digital advanced flight control system versus the standard analog flight control system during both daytime and nighttime operations of a CH-47 helicopter. Pilot performance and workload were evaluated.

Introduction

The CH-47 Chinook helicopter is the US Army's cargo-class helicopter. It was designed in the 1960s when the Army's helicopters primarily operated in the day; now they operate mainly at night. The CH-47D uses the original analog flight control system (FCS), which has a rate-command response. Operating a rate-command response FCS at night results in degraded handling qualities which contributes to increased accidents.

To improve its handling qualities for nighttime operations, the helicopter is being upgraded to the CH-47F, which will host two new digital computers as well as new electronic sensors, enabling the inclusion of a new digital advanced flight control system (DAFCS) designed by Boeing. The simulation at the Vertical Motion Simulator (VMS) compared pilot performance and workload using the DAFCS with that using the standard analog FCS.

Simulation

The principal objectives of the simulation were to: assess the DAFCS to address control mode questions and design trade-offs prior to flight tests (i.e., to solidify the design of the control laws in an effort to reduce the number of flight test hours), compare pilot performance and workload using the DAFCS with that using the standard analog FCS, and quantify the reduced visibility scene during night operations by determining its usable cue environment rating. To conduct the evaluation, each pilot flew two different simulated helicopters to perform each of several flight tasks during both day and night conditions. For night operations, the pilots used night vision goggles. To meet the first two objectives, pilots flew a simulated CH-47, and to meet the third objective, they flew a simulated generic helicopter that used an enhanced stability derivative (ESD) model.

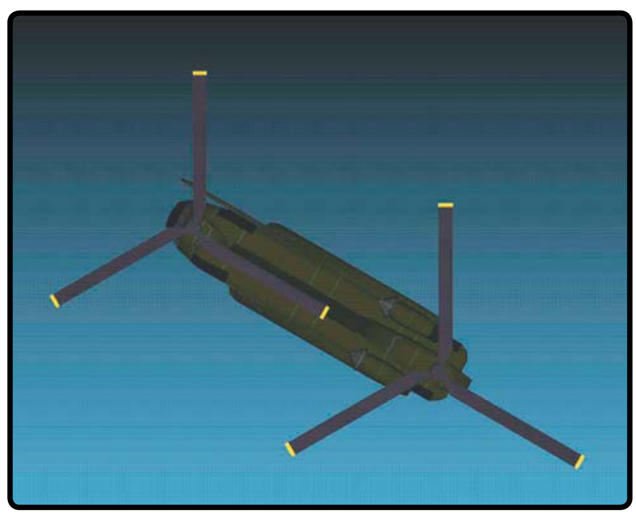
To prepare for the simulation experiments, SimLabs' personnel modified, integrated, and checked out simulation software provided by Boeing for the CH-47 helicopter and restored existing simulation software developed at SimLabs for the ESD-model helicopter. They also developed software for performing the various flight tasks, data collection, and statistical calculations, and for creating data displays in the lab. In addition, SimLabs developed software for the drive laws and real-time graphics for the symbology on the heads-down displays and the lab data displays.

Results

The first phase of piloted evaluations of the CH-47F DAFCS is complete. Three US Army experimental test pilots performed 417 formal evaluation runs on the VMS to assess the new DAFCS for both day and night operations. Comparisons were made between two different mechanizations of the DAFCS and the legacy CH-47D analog FCS. Following consensus with the evaluation pilots, the results will be presented to the Army Program Office and Boeing. Final VMS data collection will resume during October 2004, and flight tests will begin in March 2005.

Investigative Team

US Army
NASA Ames Research Center
Northrop Grumman Information Technology



A top-down view of the CH-47, as shown in the VMS.

Sim

airspace operations

flight characteristics

mission risk reduction

system design

human performance

human interface

There are many research areas that benefit from aerospace simulation.

Research-Directed Projects at SimLabs

Virtual Airspace Simulation Technology-Real-Time

Principal Investigators: Debbi Ballinger, NASA Ames Research Center;
Ronald Lehmer, Northrop Grumman Information Technology

Summary

The Virtual Airspace Simulation Technology-Real-Time (VAST-RT) Project was established at NASA Ames Research Center as part of the Virtual Airspace Modeling and Simulation (VAMS) Project. The objective of VAST-RT is to provide new tools to simulate future air traffic management technologies and techniques, with the ultimate goal of increasing National Airspace System (NAS) capacity, efficiency, and safety. Through six interim test phases, culminating in a Verification and Validation (V&V) simulation, VAST-RT has developed an environment that integrates multiple existing simulation facilities with ATC simulation components developed by VAST-RT. The distributed environment can provide a human-in-the-loop simulation using combinations of all ATC domains in the NAS. VAST-RT provides revolutionary capabilities to evaluate the human factors aspects of air traffic management and control concepts, both system-wide and in localized segments of the NAS.

Introduction

Air transportation continues to grow at an unprecedented rate due to increasing demand for air travel and shipping. Without further advancements in air traffic management (ATM) and air traffic control (ATC), the NAS will not be able to safely meet rising air transportation requirements. In 2000, NASA—in partnership with the Federal Aviation Administration (FAA), academia, and industry—created the VAMS project to address this problem. The Virtual Airspace Simulation Technologies (VAST) part of the project is responsible for providing a simulation and modeling environment for testing and evaluating the new ATM/ATC concepts developed within VAMS.

The VAST Project encompasses both real-time and non-real-time simulation. The Airspace Concept Evaluation System (ACES) is the non-real-time simulation tool and focuses on modeling broad, system-level operational concepts. VAST-RT simulates gate-to-gate, real-time, human-in-the-loop scenarios and provides a customizable framework for connecting low- and medium-fidelity real-time components with high-fidelity human-in-the-loop facilities in a distributed simulation environment.

The VAST-RT architecture is the "backbone" that links the simulation together. It relies on High Level Architecture (HLA), a Department of Defense software suite that is used to connect applications and facilities in a real-time simulation. Typically, HLA works by combining disparate simulation systems ("federates") into a larger, common "federation," where information is exchanged in real-time between federates using Run-Time Infrastructure (RTI) software. In the VAST-RT architecture, the HLA communications infrastructure is integrated with existing simulators using existing external interfaces where possible to minimize the cost and impact of connecting the simulators to the HLA federation.

The innovative interface design of VAST-RT allows for rapid and cost-effective integration of new and existing facilities, software models, and new ATC technology. The architecture and VAST-RT simulation components provide communications, control, and simulation support functions for widely distributed ATC simulations.

VAST-RT has completed a series of six Interim Tests (IT) and a V&V simulation. The simulations were conducted in multiple NASA Ames facilities, including FutureFlight Central (FFC), the Crew-Vehicle Systems Research Facility (CVSRF), and the Vertical Motion Simulator (VMS). ITs #1-4 were conducted during 2003, while the remaining tests and demonstrations occurred in 2004.

View from the FFC control tower. Because of HLA bridging technology, multiple simulators can participate in the same scenario in real-time.

Ames' Airspace Operations Lab was incorporated into the VAST-RT architecture during IT #6.

After the completion of the V&V simulation, VAST-RT Capability One was released. Capability One is operational software and is available to the VAMS Project and other customers for their use. Several components of Capability One are also available as source code from the VAMS Project.

Simulation

The performance of the VAST-RT environment was measured quantitatively and qualitatively during the tests described below. Quantitative assessments were made of system and network loading, operational stability, and data integrity. Qualitative measurements of displays and usability were also made.

IT #5: The fifth test validated three subsystems of VAST-RT, including initial delivery of the VAST-RT portal to the system interface and Airspace Operations Laboratory (AOL), FFC bridge enhancements for transfer of target control, and the VAST-RT User Interface Toolbox. The IT #5 simulation consisted of a Distributed Air/Ground scenario of south-flow traffic on the east side of Dallas/Fort Worth (DFW) and included arriving and departing flights at DFW, as simulated by the FFC federate. This simulation successfully demonstrated ownership transfer between the VAST-RT federation and the FFC federate.

IT #6: The final IT involved tests on network bandwidth, data compatibility, visual alignment, data collection capability, and reliability. This test incorporated a high-fidelity, en route airspace simulator in the simulation and demonstrated a gate-to-gate simulation between DFW and Chicago O'Hare International Airport (ORD).

Verification and Validation: Verification of the VAST-RT environment was accomplished using a simulation integrating CVSRF, FFC, AOL, the Airspace Target Generator, and other VAST-RT simulation control and support components located at the VMS complex. The simulation included flights arriving and departing from DFW and ORD, and all the airspace in between. The V&V demonstrated the successful implementation of a distributed simulation that included medium- and low-fidelity simulation components with existing high-fidelity human-in-the-loop simulation facilities. VAST-RT performance and data were analyzed by a human factors researcher and validated for use in experimental research.

Results

The capability of the VAST-RT system to simulate large segments of the NAS in real-time and utilize multiple simulation facilities was successfully demonstrated. The conclusion of this portion of VAST-RT marked the achievement of a VAMS milestone with the delivery of Capability One. Preparations for Capability Two and testing of VAMS concepts are already underway.

Investigative Team

NASA Ames Research Center
Northrop Grumman Information Technology

The VAST-RT team won a NASA Honor Award in 2004 for their accomplishments on the project.

Lunar Lander Module Demonstration at the Vertical Motion Simulator

Project Lead: Kathleen Starmer, Northrop Grumman Information Technology

Summary

The Lunar Lander Module (LLM) project was a proof-of-concept simulation, demonstrating that the Vertical Motion Simulator (VMS) can be used to simulate vehicles beyond those found in traditional aeronautics. SimLabs' simulation expertise and efficiency allowed the project to be developed in just four weeks.

Introduction

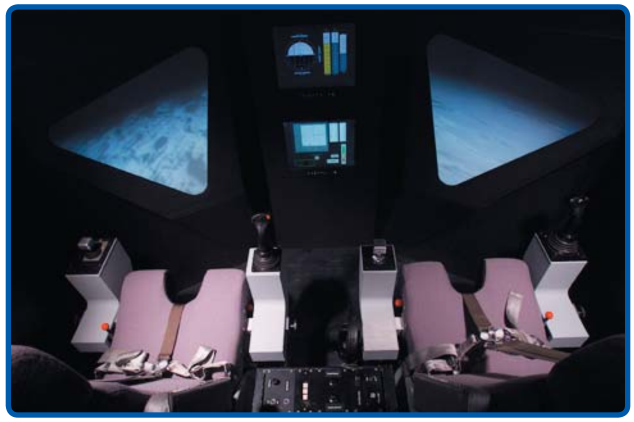
In January 2004, the President announced his Space Initiative, and a new era of space exploration was born. The Initiative calls for the development of a Crew Exploration Vehicle (CEV), and with its full-motion system and customizable infrastructure, the VMS is perfectly suited to participate in the design process. However, since the VMS has historically been used for development of vehicles flying in Earth's atmosphere, VMS personnel decided to create a proof-of-concept demonstration, showcasing the facility's ability to simulate vehicles beyond those found in traditional aeronautics. Because the actual design for the CEV is undetermined, VMS personnel simulated a previously constructed space vehicle so as not to advocate a particular CEV model. The chosen vehicle was the Apollo LLM.

Project Description

The Space Initiative timeline is short, with the first CEV flight test scheduled for 2008. With this in mind, VMS personnel determined that the LLM simulation should be shown to NASA Space Exploration personnel as early as possible. Thus, an important criterion was an extremely rapid development time. Additionally, since this was an unsponsored project, it was decided that material expenditures be kept to a minimum.

Developers obtained actual Apollo LLM flight manuals and created a math model to closely approximate LLM behavior. An autopilot function was added so that visitors could experience an "autopilot failure" scenario in which they would have to take over the vehicle's controls to effect a safe landing on the lunar surface. Modeling allowed for a vehicle that would respond as if it were operating in the lunar environment (one-sixth of Earth's gravity and no atmosphere).

Due to the rapid development time, it was determined that pilots would operate the LLM in a seated position rather than the standing position actually used in the Apollo program; this alleviated the need to crew-rate a novel configuration. Windows were constructed to the exact dimensions of the Apollo LLM and placed over the cab's out-the-window (OTW) screens to create a similar field of view to that experienced by Apollo astronauts. Sidestick controllers for thrust and attitude/translational control—comparable to those found in the actual LLM—were placed on both sides of each pilot seat.



Interior of a VMS cab, configured for the Lunar Lander Module simulation. The lunar surface is visible through the Apollo-style triangular windows.

A visual database of the lunar surface was developed using scanned photographs, and crater models were added to create additional topography. A visual model of the LLM itself was constructed to provide an observer's view of simulations in progress to outside viewers. Head-down displays were created to mimic critical instrumentation present in the Apollo LLM. Additional displays, including a moving-map guidance system, were created to make the landing task easier for pilots and to showcase the VMS' in-house software capabilities.

Results

All components of the simulation were successfully integrated, VMS motion was tuned, and the simulation was ready to fly four weeks after the project began. Ames test pilots and an astronaut provided valuable improvements and feedback during the checkout period. Numerous visitors have flown the LLM simulation, including astronauts and Space Exploration personnel from NASA Headquarters, and the feedback has been very positive. By implementing the LLM simulation, VMS personnel proved that the VMS is a valuable, capable asset, with the flexibility to rise to new challenges in NASA's revitalized Space Exploration program.

Investigative Team

NASA Ames Research Center
Northrop Grumman Information Technology

Mars Database Development at FutureFlight Central

Project Lead: Boris Rabin, NASA Ames Research Center

Summary

Visualization of the Mars Exploration Rover (MER) image data in FutureFlight Central (FFC) using 2D, 3D and stereo formats was developed as a proof-of-concept demonstration intended to illustrate the potential of utilizing FFC for planetary surface mission operations. This capability could broaden the scope of research within the Aerospace Simulation Operations Branch to include planetary surface science and remote robotic operations.

Introduction

Recent robotic Mars missions represent an emerging vision within NASA of intensive planetary exploration within our solar system. One of the enabling technologies is the use of remotely operated intelligent mechanisms.

A primary challenge for remote mission scientists however, will be the immediate and continuous situational understanding of a rover in a distant environment. Because the number of command cycles during missions such as Mars Exploration Rover (MER) 2004 is limited due to transmission delays, it is important to maximize the science return potential of each commanded operation. One way to gain this efficiency is to analyze and refine robot operations offline before sending a command sequence to the rover. The objective of this project, therefore, was to develop a high-fidelity simulation environment for science operations planning, as well as tools and visualization techniques for science analysis and terrain exploration. This was accomplished by leveraging FFC's advanced 360º display system and powerful Image Generator in conjunction with surface reconstruction software developed at Ames by the Autonomy and Robotics Area (ARA) in Code IC.

Project Description

In order to evaluate robot operations offline, a set of tools and visualization techniques were needed for the rapid development and optimization of a 3D Mars terrain model. Viz software, developed by ARA, was heavily utilized by scientists during the MER 2004 missions. A number of 3D models from the Spirit and Opportunity sites were generated from 2D stereo pairs. These models proved to be invaluable tools for scientists to explore in more detail the spatial characteristics and geological features of the terrain. For smooth navigation through the virtual Mars environment, however, a real-time, 30 Hz frame rate is required, which is impossible without optimization of the model.

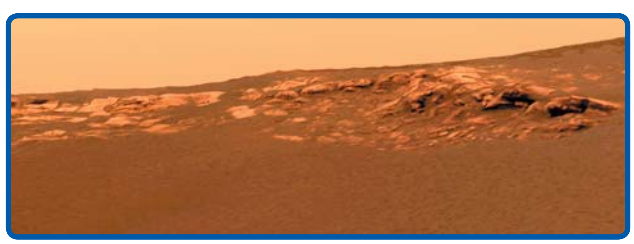
One of the main difficulties in optimizing the model was the large number of segments produced by the Viz software. On average, a 360-degree panorama is comprised of more than 120 tiles with a texture map associated with each tile. In order to reduce the number of polygons, each segment required manual processing and entailed over 50 labor-hours of tedious effort. The turn-around time to produce a usable panorama was less than acceptable. Thus, this project focused on finding the set of parameters that would allow reduction of the polygon count, without compromising the fidelity of the database, thereby enabling smooth 30 Hz navigation through the scene.

To accomplish this, FFC engineers developed a conversion process to perform polygon reduction and phototexture color enhancement in a batch mode. This reduced processing time to about 15-20 minutes per panorama, which is a far more useable timeframe.

Results

Viewing the Eagle crater in 360 degrees and navigating through it in 3D provides scientists with a new level of situational awareness. It opens the possibility for integrating rover autonomy software in FutureFlight Central with human workflow simulation. It also creates a potential for distributed simulation with existing Jet Propulsion Laboratory rover simulation facilities. The integrated simulations could be exercised on single-rover, multi-rover, and human-plus-rover scenarios.

During this project it was demonstrated that a combination of 3D modeling, image processing expertise, and FutureFlight Central's unique visualization capability could support NASA's long-term robotic surface exploration missions. Immersive visualization and environment simulation will be particularly relevant where significant communications delays will be encountered.



The Mars 3D database, textured.

Investigative Team

NASA Ames Research Center
Northrop Grumman Information Technology

Voice Communication System Upgrade

Project Lead: Dan Wilkins, Northrop Grumman Information Technology

Summary

The purpose of the Voice Communication System (VCS) upgrade project is to enhance the network-based voice communication capabilities for SimLabs at NASA Ames Research Center in support of VAST-RT concept development (see page 22 of this report).

Introduction

Each of the SimLabs laboratories–FutureFlight Central (FFC), the Vertical Motion Simulator (VMS), and the Crew-Vehicle Systems Research Facility (CVSRF)–incorporate localized voice communication capabilities to meet site-specific needs. The VAST-RT development effort called for a common set of network-based voice communication capabilities across all SimLabs sites to meet integrated operational demonstration objectives. This, in turn, required HLA (High Level Architecture)-based aircraft radio communication, administrative intercom, and dial-up emulation over local (LAN) and wide area (WAN) digital networks. A method of capturing digital voice communications for event-based record/playback and archiving was also required.

Project Description

A project team was formed to evaluate existing VCS capabilities across all SimLabs sites and develop a strategic approach for upgrading or replacing localized voice communication systems while maintaining current operational capabilities in support of existing simulations.

Initial assessment of the facilities revealed that both the VMS and CVSRF sites supported DIS (Distributed Interactive Simulation) standard network VCS for radio communication only; intercom communications were accomplished using site-specific analog systems, and dial-up emulation did not exist at either site. Record/playback was analog only and did not provide event logging. Conversely, the FFC site incorporated a proprietary, closed-network VCS that supported only local radio communications, intercom, and dial-up emulation along with limited analog record/playback functionality.

The team then conducted an industry survey of voice communication technologies. Based on the findings, a multi-phased approach was proposed. The first phase connected the proprietary FFC VCS network to DIS standard protocol. This was accomplished by creating an analog-to-digital bridge with existing hardware and software. The second phase consisted of acquiring and integrating a commercial off-the-shelf DIS/HLA bridge solution to upgrade the DIS-networked VCS to an HLA radio voice communication standard. This system was successfully implemented to support the VAST-RT interim tests.

The third phase incorporated a full and open competitive procurement effort to replace the FFC VCS. The replacement VCS meets the needs of the VAST-RT project as well as enhancing several site-specific capabilities at FFC. The new VCS provides all-digital voice communications for radio, intercom, dial-up emulation, direct connect, station-to-station, and record/playback. This VCS also supports both DIS and HLA standard network-based voice communication protocols along with multiple simultaneous simulation operations. Record/playback capacity has been increased from 10 analog to 32 digital streams with event capture and upward growth capability. A user-definable Graphical User Interface has been implemented to provide enhanced flexibility of the VCS setup at each user station.

The Symphonics set-up panel.

In parallel with the FFC upgrade, a number of significant improvements were made to the existing CVSRF VCS. First, several new radio models were created and standardized using best Original Equipment Manufacturer practices. Additionally, HLA and IP-multicast network protocols were implemented to compliment the existing DIS VCS. Lastly, a Voice over Internet Protocol bridge was created to integrate external facilities' VCS with the CVSRF system.

Results

The FFC VCS is undergoing final testing and has been used to support VAST-RT efforts as well as site-specific operations and demonstrations. The remaining phases of this task include upgrading and replacing the CVSRF and VMS VCS systems, and work is in progress. The results of the team's efforts have enhanced SimLabs' voice communications capabilities and benefited the VAST-RT Project.

Investigative Team

Symphonics
NASA Ames Research Center
Northrop Grumman Information Technology

High Level Architecture Enhancements at FutureFlight Central

Project Lead: Joe Mastroieni, Northrop Grumman Information Technology

Summary

This project enhanced the FutureFlight Central (FFC) operational software, enabling it to participate in the VAST-RT Project development and future projects using the VAST-RT infrastructure. The upgrade was accomplished in time to support VAST-RT Interim Tests #5 and #6, as well as the Verification and Validation simulation.

Introduction

The goal of the VAST-RT project is to develop a gate-to-gate, real-time, human-in-the-loop distributed simulation environment to evaluate concepts for improving the safety and effectiveness of the National Airspace System (refer to page 22 for more details). The VAST-RT architecture is based on a High Level Architecture (HLA), a common framework allowing for data transfer and control between simulation components during real-time operations of distributed simulations.

FFC is a critical resource in the VAST-RT project, serving as the air traffic control tower simulator federate required in most simulations. The core FFC operating software included an HLA implementation that allowed it to act as a federate and participate in distributed simulations, but it did not incorporate ownership transfer, which allows a federate to divest or acquire ownership of an object (typically an aircraft) under certain conditions. In particular, the VAST-RT project needed FFC to have the ability to transfer ownership of aircraft coming into or out of simulated FFC tower air space during VAST-RT experiments.

Project Description

The operational software used at FFC is a proprietary system from Adacel called MaxSim. As such, the upgrade project was a collaboration involving NASA, Adacel, and Northrop Grumman Information Technology (NGIT). NASA and NGIT determined the requirements and specifications for the upgrade to support the transfer of ownership function and provided the Statement of Work. NASA provided the Acceptance Test Procedures and test scenarios used to determine the software's adherence to the requirements. NGIT provided the contract vehicle for the design, installation, and testing support tasks to be accomplished by Adacel, and also provided key technical support. Adacel designed and implemented the enhancement to the operational software.

The enhancement needed to retain all functionality of the existing software and operate on both the FFC tower and development systems. Adacel implemented a mechanism to allow the Ownership Handoff Manager (OHM), a component of the VAST-RT system, to initiate transfer of arrivals to MaxSim ownership. They also implemented a mechanism to allow the OHM to initiate transfer of MaxSim-owned targets to other federates for departures.

An air traffic controller in FFC.

NASA directed the testing, and NGIT provided support. In particular, NGIT engineers responsible for the VAST-RT FFC bridge and the OHM components provided detailed troubleshooting during the comprehensive on-site testing and debugging of the MaxSim enhancements, working closely with the Adacel engineers.

The upgraded MaxSim software was initially installed in December 2003. Adacel provided an on-site engineer to assist in the installation and conduct initial testing. Further testing and debugging was conducted in January 2004 with the Adacel engineer on-site. Functionality of the enhancement was demonstrated, and the software was successfully used for VAST-RT Interim Tests 5 and 6, as well as the Verification and Validation simulation.

Results

The HLA portion of the FFC operational software was successfully enhanced to support the transfer of ownership capability. The ability of the system to handoff and transfer virtual aircraft to other domains in a distributed simulation environment was demonstrated three times during VAST-RT simulations, and the associated VAST-RT project requirements were met. The new enhancement enables FFC to fully participate as a key facility in future VAST-RT simulations. With the addition of FFC, VAST-RT provides a new airspace modeling and simulation capability to evaluate revolutionary Air Traffic Management concepts across all segments of the National Airspace System.

Investigative Team

Adacel
NASA Ames Research Center
Northrop Grumman Information Technology

About the back cover

A High Level Architecture (HLA) integrates all the SimLabs facilities and allows them to concurrently participate in distributed simulations. The image on the back cover depicts the Kennedy Space Center Shuttle Landing Facility from FutureFlight Central's database collection and shows the Space Shuttle landing during a real-time simulation occuring in tandem with the Vertical Motion Simulator. The Crew-Vehicle Systems Research Facility could tie in to this simulation, as well, as suggested by the 757 aircraft.

In addition to traditional aeronautics, SimLabs is expanding to meet the challenges posed by the Nation's Exploration Vision. FutureFlight Central has created a 3-D database using the latest Mars Rover images, and the Vertical Motion Simulator developed a conceptual Lunar Lander simulation based on metrics from the Apollo program. Both of these projects are represented by the space view presented at the top of image.

For additional information, please contact:

Tom Alderete
Assistant Division Chief
for Simulation Facilities
Aviation Systems Division
(650) 604-3271
thomas.s.alderete@nasa.gov

or

Barry Sullivan
Branch Chief
Aerospace Simulation Operations
Aviation Systems Division
(650) 604-6756
barry.t.sullivan@nasa.gov