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ARMY AVIATION SIMULATION SURVEY

Ben L. Harrison,
Major General, USA, Retired

July 1992

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A survey of aviation simulation capabilities and needs, as expressed by ten Army organizations, was conducted by IDA at the request of DARPA. MG John D. Robinson, Commander of the Army Aviation Center, co-sponsored the survey effort. A wide range of critical issues and requirements for new simulation capabilities/functionalities were identified. Most of these dealt with higher fidelity in simulating an electronic battlefield and the ability to evaluate system and subsystem contributions in combined arms and joint warfighting. The capabilities of seventeen relevant simulation facilities are included in the survey. The need for networking and interoperability within and between these facilities was expressed as a high priority.

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ABSTRACT

A survey of aviation simulation capabilities and needs, as expressed by ten Army organizations, was conducted by IDA at the request of DARPA. MG John D. Robinson, Commander of the Army Aviation Center co-sponsored the survey effort. A wide range of critical issues and requirements for new simulation capabilities/functionalities were identified. Most of these dealt with higher fidelity in simulating an electronic battlefield and the ability to evaluate system and subsystem contributions in combined arms and joint warfighting. The capabilities of seventeen relevant simulation facilities are included in the survey. The need for networking and interoperability within and between these facilities was expressed as a high priority.

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GLOSSARY

AATD	Aviation Applied Technology Directorate, AVSCOM, Ft. Eustis, VA
ACME	Air Combat Mission Enhancement, Williams AFB, AZ
ADCATT	Air Defense Combined Arms Tactical Trainer. The air defense member of the Combined Arms Tactical Trainer family.
AIRNET	The networking of distributed interactive simulators. Previously used to refer to a facility at Ft. Rucker. This facility is now called the Aviation Testbed, Battlefield Distributed Simulation-Developmental.
AMC	Army Materiel Command
ATB	Aviation Testbed, Battlefield Distributed Simulation-Developmental, Ft. Rucker
ATCCS	Army Tactical Command and Control System
ATTD	Advanced Technology Transfer Demonstration. A DoD program.
AVCATT	Aviation Combined Arms Tactical Trainer. The aviation member of the Combined Arms Tactical Trainer family.
AVSCOM	Aviation Systems Command, AMC
BDS-D	Battlefield Distributed Simulation-Developmental. A concept for the development of an electronic battlefield that has had little funding support.
Blue Canoe	Or Blue Box. The first widely used flight simulator. A short blue "box" with stubby wings, crudely resembling an airplane. Developed by Link for instrument flight training in WW II.
CATT	Combined Arms Tactical Trainer family including CCTT, AVCATT, ADCATT, and ENCATT.
CCTT	Close Combat Tactical Trainer. The armor and infantry member of the Combined Arms Tactical Trainer family.
CECOM	Communications and Electronics Command, AMC
CMT	Critical mobile targets
CSRDF	Crew Station Research and Development Facility. Operated by the Crew Station Research and Development Branch, Simulation and Aircraft Systems Division, Aeroflightdynamics Directorate, Ames Research Center, Moffett Field, CA.

DCSLOG	Deputy Chief of Staff for Logistics, Department of the Army Staff
DCSOPS	Deputy Chief of Staff for Operations and Plans, Department of the Army Staff
DTRS	Display Technology Research Simulators, NASA Langley Research Center, VA
EID	Electronic Integration Directorate, CECOM, Ft. Monmouth, NJ. Formerly the Aviation Avionics Research and Development Activity, AVSCOM.
ENCATT	Engineer Combined Arms Tactical Trainer. The engineer member of the Combined Arms Tactical Trainer family.
FLITE	Flying Lab for Integrated Test and Evaluation, Moffett Field, CA
FMS	Full Mission Simulator
HFRF	Helicopter Human Factors Research Facility, Moffett Field, CA
LABCOM	Laboratory Command, AMC
LONGBOW	Millimeter-wave radar fire control system under development for use on APACHE and COMANCHE helicopters.
MCS	Maneuver Control Station. A component of the Army Tactical Command and Control System.
MEP	Mission equipment package. Includes target acquisition and fire control systems.
MIDAS	Man-machine Integration and Analysis, Moffett Field, CA
MICOM	Missile Command, AMC, Redstone Arsenal, AL
MSS	Millimeter-wave Simulation System, MICOM, Redstone Arsenal, AL
NOE	Nap of the earth
OASA R&D	Office of the Assistant Secretary of the Army, Research and Development
PEO	Program Executive Officer
PM	Program Manager
RASCAL	Rotorcraft Aircrew Systems Concepts Airborne Laboratory, Moffett Field, CA
RPA	Rotorcraft Pilot Associate; an AVSCOM advanced research program.
SAFOR	Semiautomated forces. Entities controlled at a workstation that appear on a BDS-D image generator.
SCTB	Simulator Complexity Testbed. Now called STRATA.

STRATA	Simulator Training Research Advanced Testbed for Aviation, ARI, Ft. Rucker. Formerly known as the Simulator Complexity Testbed (SCTB).
TWBNet	Terrestrial wide band network. A DARPA developmental program for high capacity transmission of voice and data using a wide band network.
VMS/ICABS	Vertical Motion Simulator with Interchangeable Cabins, Moffett Field, CA

SUMMARY

The Defense Advanced Research Projects Agency, with co-sponsorship of MG John D. Robinson, Commander of the U.S. Army Aviation Center, asked IDA to conduct a survey and prepare a report on the priority requirements for the application of advanced technology simulations to Army aviation.

Ten organizations were asked to participate in the study. The Aviation Center and the Aviation Systems Command submitted multiple reports. Representative of the wide range of the 39 critical issues identified are:

- Determining the structure and operational concepts for future aviation organizations.
- Subsystems effectiveness relative to total system effort (e.g., weapons, communications, navigation, aircraft survivability equipment, etc.).
- Aviation C^3--development of a simulated "automated" TOC and C&C aircraft to include data exchange with ground elements and other aircraft. For example, the target hand-over processes for critical mobile targets (CMT).

Some of the 32 simulation capabilities/functionalities listed for needed development are:

- User-friendly automated tools for building models at the labs and testing centers to accurately simulate all weapon capabilities and mission equipment package subsystems to include streamlined procedures for verification, validation and accreditation.
- Low-cost reconfigurable cockpits and supporting mission equipment package subsystems.
- Air-to-air combat simulation for both rotary and fixed wing aircraft.

There is a clear need to continue the establishment of distributed interactive simulation standards and to develop interface units and intelligent gateways to facilitate networking dissimilar simulators/simulations on high bandwidth long haul systems.

The extensive simulation capabilities extant in defense industry and academia should be studied for potential applications in the Army's Battlefield Distributed

Simulation-Developmental program. A more comprehensive DoD approach under the aegis of the Defense Models and Simulation Office might be appropriate.

ARMY AVIATION SIMULATION SURVEY

1. INTRODUCTION

1.1 Simulation has been a part of development and training in aviation for decades; from the old "Blue Canoe" to the Lunar Landing Module to the F-15 air superiority fighter to the AH-64 night, adverse weather attack helicopter. Today advanced simulation technology has applications in:

- Aircraft airframe, propulsion and mission equipment package conceptual design.
- Performance specification and analytical projection.
- Engineering, developmental and operational testing.
- Acquisition strategy.
- Manufacturing process design and production.
- Training and Mission Rehearsal at the individual, crew, team, combined arms, joint and coalition levels.

1.2 Applications of new technology in surveillance, target acquisition, fire control and weapons effects are moving us from "smart" weapons to "brilliant" weapons, such as the AH-64 LONGBOW and the RAH-66 COMANCHE with still new thresholds being challenged in the Rotorcraft Pilot Associate program. There are few technical barriers except those of priority and affordability.

1.3 The most remarkable advancements are being made in the area of mission equipment packages (MEP). As the requirements writers and the material developers pick and choose from an almost limitless wonderland of sensors and weapons, it again becomes a question of priorities and affordability. But the question becomes terribly complicated by the issue of command and control, man-in-the-loop, the art of maneuver, synergy and synchronization, to achieve the end described by Clausewitz as putting the enemy "in such a condition that they can no longer carry out the fight." How much of what, needs to be applied where, by whom and when? The aircraft and mission equipment package required capabilities and how they will be controlled and applied on the future battlefield must be established in the early conceptual stages of development.

1.4 In the past we pondered these imponderables in a science called operations analysis, but most wise leaders have concluded that this science and the war games models it spawned have been inadequate to deal properly with the conduct of war by frequently unpredictable warriors and events on opposing sides. Today, great breakthroughs in the technologies of computational power, image generation and networking have converged to produce distributed interactive simulations capable of man-in-the-loop warfighting on the battlefield of the next century. But again, it is a question of priorities and affordability. There are few technical barriers, but where should the money be spent? The purpose of this survey is to aid in establishing priorities. What are the critical issues in simulation for Army aviation? What simulation facilities and capabilities now exist? What expansion and enhancements are required? What new research and development in simulation technologies should be pursued? Answers to these questions will lead to a study of affordability.

2. DATA COLLECTION

2.1 The survey was initiated by a letter from DARPA with co-sponsorship of the Aviation Center, inviting the following organizations/agencies/offices to participate:

- Office of the Deputy ASA for Research and Technology, Washington, DC
- Operational Evaluation Command, Alexandria, VA
- Army Aviation Center, Ft. Rucker, AL
  --Directorate of Training and Doctrine
  --Directorate of Combat Developments
  --Aviation Research and Development Activity, Army Research Institute
- Aviation Systems Command, AMC, St. Louis
  --Aviation Applied Technology Directorate, Ft. Eustis, VA
  --Simulation and Aircraft System Division, Moffett Field, CA
  --Crew Station Research and Development Branch, Moffett Field, CA
- PM RAH-66 COMANCHE, PEO Aviation, St. Louis
- LABCOM, AMC, Adelphi, MD
- Electronic Integration Directorate, CECOM (formerly Aviation Avionics R&D Activity, AVSCOM), Ft. Monmouth, NJ
- Aviation Division, DCSOPS, Washington

- Aviation Logistics, DCSLOG, Washington
- Aviation Division, National Guard Bureau

Annex A, Appendix 1 is a copy of the letter.

2.2 Each participant was asked to complete a survey questionnaire and add other data as deemed appropriate. Please see Annex A, Appendix 2 for a copy of the questionnaire.

2.3 All data received from participants are contained in Annexes B and C. Data were collected via telecommunications, electronic mail and overnight deliveries with the exception of visiting Ft. Rucker.

2.4 All organizations listed above responded to the survey with the exception of the Army National Guard. A personal follow-up with Colonel John Stanko, Chief of the Aviation Division, was to no avail. The Simulation and Aircraft System Division at Moffett had its Crew Station Research and Development Branch complete the survey instrument and the Division provided a draft Simulation Plan under preparation for the Aviation Systems Command.

3. AVIATION SIMULATION FACILITIES

3.1 The following facilities are relevant to Army aviation R&D simulation:

- Aviation Testbed, Battlefield Distributed Simulation-Developmental (AIRNET), Ft. Rucker
- Crew Station Research and Development Facility (CSRDF), Moffett Field, CA
- Simulator Training Research Advanced Testbed for Aviation (STRATA), ARI, Ft. Rucker
- Rotorcraft Aircrew Systems Concepts Airborne Laboratory (RASCAL), Moffett Field, CA
- Display Technology Research Simulators (DTRS), NASA Langley Research Center, VA
- Vertical Motion Simulator with Interchangeable Cabins (VMS/ICABS), Moffett Field, CA
- Helicopter Human Factors Research Facility (HFRF), Moffett Field, CA
- Flying Lab for Integrated Test and Evaluation (FLITE), Moffett Field, CA
- Man-machine Integration and Analysis (MIDAS), Moffett Field, CA
- Millimeter-wave Simulation System (MSS), MICOM, Redstone Arsenal, AL

- Air Combat Mission Enhancement (ACME), Williams AFB, AZ
- Visual Technology Research Simulator, Naval Training Center, Orlando, FL
- Institute for Simulation and Training (IST), UCF, Orlando, FL
- Georgia Institute for Technology Simulator Lab. (Flight SIM), Atlanta, GA
- Sikorsky Full Mission Simulator (FMS), Stratford, CN
- McDonnell Douglas Helicopter Company, Mesa, AZ
- Bell Helicopter Company, Ft. Worth, TX
- Boeing Helicopter Company, Philadelphia, PA.

The first three facilities listed above, Aviation Testbed, Battlefield Distributed Simulation-Developmental (AIRNET), Ft. Rucker, Crew Station Research and Development Facility (CSRDF), Moffett Field, CA, and the Simulator Training Research Advanced Testbed for Aviation (STRATA), ARI, Ft. Rucker, are the primary components for simulation in Army aviation research and development. There is a major initiative under way to network these three facilities. It is vital that this be done to facilitate closer coordination between the Army "user" community and the "development" agencies. This is crucial for such projects as the Rotorcraft Pilot Associate.

Several actions have been proposed to upgrade the Aviation Testbed visual systems, the data bases and build additional reconfigurable cockpits with significantly more sophisticated capabilities, but funding is unclear.

The last four facilities listed comprise the major helicopter manufacturing capability of the United States. There are other major defense industry firms that are critical to the future of Army aviation that have not been surveyed. This is especially true for R&D and manufacturing of components of mission equipment packages, e.g., Martin Marietta, Harris, Northrop, IBM, Hughes, General Dynamics, E-Systems, Grumman, Honeywell, ITT, Litton, Lockheed, LTV, Rockwell, etc. There are no specific plans for networking these industry simulation facilities with Army facilities, but it is a long term goal of the Battlefield Distributed Simulation-Developmental program. It would seem appropriate to conduct a more comprehensive survey of Army aviation related industrial simulation facilities.

3.2 See Annex C for a brief description of each of the above facilities.

4. SURVEY RESULTS

The names of individuals responding to the survey are provided to assist users of these data. In some cases it is apparent that the respondent is operating in an organizational climate currently in vogue that seeks "empowerment to lower echelons."

4.1 Critical Issues. Each organization surveyed was asked to identify, in order of importance, critical issues where there might be potential for the application of simulation technology.

4.1.1 Office of the Deputy Assistant Secretary of the Army for Research and Technology. Mr John Yuhas responded for this office and put the critical issues in near, mid and far term periods. (Annex B, Appendix 1)

4.1.1.1 Critical issues near term 92-94.

4.1.1.1.1 In general accordance with the Battlefield Distributed Simulation-Developmental (BDS-D) Plan, the development of an Electronic Battlefield with weather effects, dynamic terrain, electronic warfare and sufficient numbers of objects/entities for realistic joint and combined arms warfighting by a battalion task force.

4.1.1.1.2 Demonstration of long haul and local networking of dissimilar simulators such as the high fidelity CSRDF at Moffett Field and the aviation simulators (AIRNET) at Ft. Rucker.

4.1.1.1.3 Conduct of the Rotorcraft Pilot Associate (RPA) ATTD in BDS-D with a real-time, man-in-the-loop electronic combined arms battlefield that includes the AH-64 and the RAH-66 COMANCHE as baseline models.

4.1.1.1.4 Conduct RAH-66 and AH-64 simulation demonstrations in BDS-D necessary to assess and evaluate related programs including COMANCHE Dem Val and EMD acquisition phases and LONGBOW.

4.1.1.2 Critical issues mid term 95-97.

4.1.1.2.1 Expansion of the Combined Arms Tactical Trainer (CATT) family including CCTT, AVCATT, ADCATT, and ENCATT.

4.1.1.2.2 Expansion of the BDS-D electronic combined arms battlefield to the division level with select government/industry/academic networking capability.

4.1.1.3 Critical issues far term 98-00. Expansion of the BDS-D electronic battlefield to joint task force/theater level to include coalition forces.

4.1.2 Operational Evaluation Command, Alexandria, VA. Major Richard Peak of the Aviation Evaluation Directorate responded for OEC. (Annex B, Appendix 2). Major Peak stated that

> AIRNET will be programmed to perform according to specifications. If the AIRNET COMANCHE is a success, then you would be tempted to assume that if the COMANCHE aircraft is built exactly to specification, then it would also be a success. Unfortunately, the relationship between programmed capabilities in a simulator and manufactured capabilities in an aircraft is not like looking in a mirror. It is more like creating an image and then trying to make a real item. More often than not you end up changing the image (the simulator), to reflect reality (the aircraft), instead of changing reality to reflect the image. Someday when the state of the art in software development is directly equivalent to the state of the art in aircraft development we may then be able to simulate a new aircraft and be assured that the real thing would perform exactly the same way. This would be a tremendous step forward and of great benefit to all on the operational side of the house. Until then, I believe the risk of relying on simulations for operational evaluations is much too great.

An action officer from the Policy and Methodology Directorate of OPTEC commented that "USAOPTEC has not recognized a need to become an active proponent for the development of simulation technology." This issue will be discussed below in paragraph 5, Simulation in Material Development, Acquisition and Operational Testing.

4.1.3 Army Aviation Center, Ft. Rucker, AL. The Aviation Center is in the process of establishing a Simulations Directorate and will be developing a Simulation Master Plan. A Center position was not available for this survey and each of the following organizations completed a questionnaire: (Annex B, Appendix 3)

- Directorate of Training and Doctrine
- Directorate of Combat Developments
- Aviation Research and Development Activity, Army Research Institute

4.1.3.1 Directorate of Training and Doctrine critical issues were provided by its Director, Colonel Jim Beauchamp. (Annex B, Appendix 3.1)

4.1.3.1.1 Collective training simulators linked w/interactive threat and operating in a combined arms arena.

4.1.3.1.2 Aircraft survivability equipment training devices used during flight.

4.1.3.1.3 Keeping training devices current with aircraft configuration rapid reprogramming capability.

4.1.3.1.4 Improve ground training prior to flight; both cognitive and hands on.

The most important benefits expected from the use of simulations in addressing these critical issues were Improve Effectiveness and Save Resources.

4.1.3.2 Directorate of Combat Developments critical issues were provided by its Director, Colonel Ted Sendak. (Annex B, Appendix 3.2)

4.1.3.2.1 Future Aviation Organizations

4.1.3.2.2 Aviation C^3 Interface within and externally

4.1.3.2.3 Aviation Operational Concepts to Develop Doctrine

4.1.3.2.4 Concept evaluation for many hardware improvements to Aviation System

Colonel Sendak pointed out that the use of simulations may be the only way to achieve large scale operational verification of Aviation Operational Concepts to Develop Doctrine. The most important benefits expected from the use of simulations in addressing all these critical issues were Improve Effectiveness and Save Resources.

4.1.3.3 Aviation Research and Development Activity, Army Research Institute, critical issues were identified by the Chief of the Activity, Mr. Chuck Gainer. (Annex B, Appendix 3.3)

4.1.3.3.1 Use in Primary Flight Training

4.1.3.3.2 Modular/Portable Devices

4.1.3.3.3 Tactical Training Requirements Sustainment of Skill

4.1.3.3.4 Fidelity Issues in Training Systems

Again, the most important benefits expected from the use of simulations in addressing these critical issues were Improve Effectiveness and Save Resources.

4.1.4 Aviation Systems Command, St. Louis. The Aviation Systems Command (AVSCOM) is making a pioneering effort in the Army aviation community with the development of a master simulation plan for the AVSCOM Research, Development, and Engineering Center (RDEC). The initial draft of the plan was prepared by Terry Gossett, Wendell Stephens, and Nancy Bucher of the Simulation and Aircraft Systems Division of the Aeroflightdynamics Directorate. A copy of the draft plan is provided at Annex B, Appendix 3.2. Figure 4.1.4 below taken from the RDEC draft plan illustrates AVSCOM's concurrent simulation missions.

RDEC Concurrent Simulation Missions

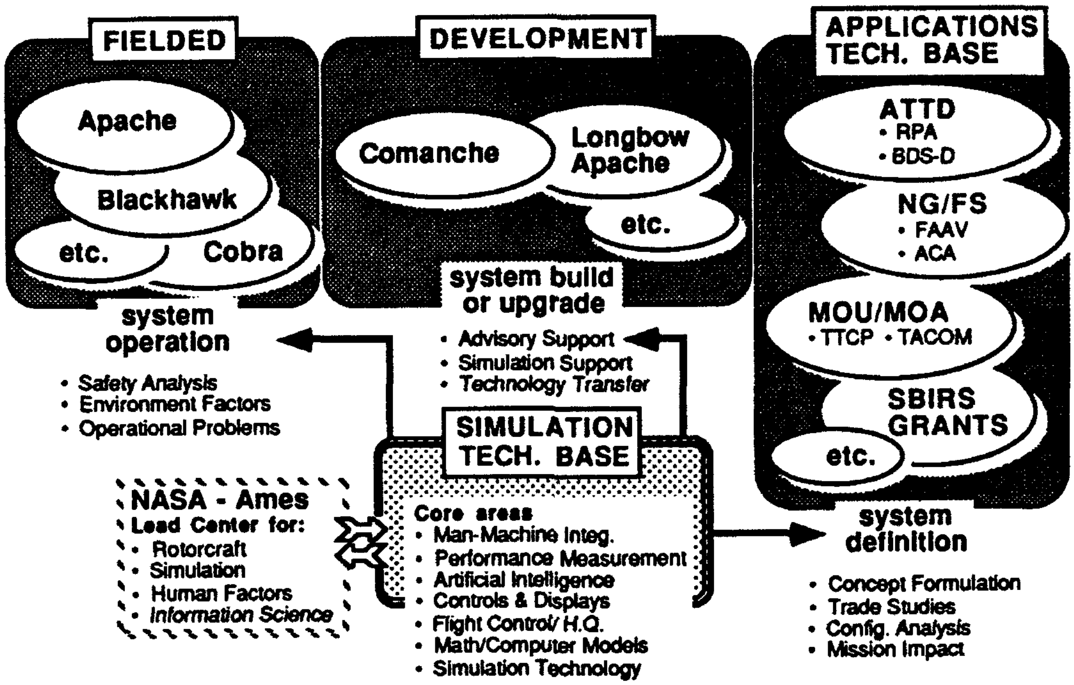

Figure 4.1.4. AVSCOM Concurrent Simulation Missions

AVSCOM elected to not respond as a Command to the survey questionnaire, but responses were made by the Aviation Applied Technology Directorate and the Crew Station Research and Development Branch, Aeroflightdynamics Directorate.

4.1.4.1 Aviation Applied Technology Directorate, Ft. Eustis, VA. Mr. John Macrino served as the point of contact for AATD. (Annex B, Appendix 4.1) Critical issues are:

4.1.4.1.1 Subsystems effectiveness relative to total systems effort (i.e., weapons, comm, NAV, ASE, etc.).

4.1.4.1.2 Man/machine system effectiveness.

4.1.4.1.3 Definition of critical operational test parameters.

4.1.4.1.4 Man/machine training (team trng).

AATD indicated that the greatest benefit to be gained in using simulation with the first two critical issues is the improvement in effectiveness. The saving of time is seen as the major benefit with the "Definition of critical operational test parameters." In "Man/machine training (team training)," the most positive benefit is saving resources.

4.1.4.2 Simulation and Aircraft System Division, Moffett Field, CA. The draft Team RDEC Simulation Plan was provided as input to the survey. As indicated in 4.1.4 above, this is a milestone event in the planned use of simulation technology. We are pleased to be permitted to publish the draft plan for the benefit of the aviation community. (Annex B, Appendix 4.2)

4.1.4.3 Crew Station Research and Development Branch, Moffett Field, CA, survey point of contact is Dr. Nancy Bucher. (Annex B, Appendix 4.3) Critical issues are:

4.1.4.3.1 Engineering requirements specification and evaluation for advanced MEP and platform concepts.

4.1.4.3.2 Mission effectiveness evaluations of advanced MEP and platform concepts (requires combined arms/joint service operations).

4.1.4.3.3 Pilot-vehicle interface information integration and optimization for current and projected advanced MEP and platform concepts.

4.1.4.3.4 Training, tactics, doctrine developments resulting from advanced MEP and platform concepts (requires combined arms/joint services operations).

It is noteworthy that two of the critical issues identified by this key research and development facility require combined arms and joint service operations. (These operations can only be realized through simulation.) It is reported that simulation applied to all of these issues will significantly save time and resources, improve effectiveness and enhance safety.

4.1.5 PM RAH-66 COMANCHE, PEO Aviation, St. Louis. Bob Tomaine provided survey data from the COMANCHE PMO. (Annex B, Appendix 5) Critical issues are:

4.1.5.1 Crew procedures. Crew station layout MANPRINT assessment

4.1.5.2 Handling qualities assessment

4.1.5.3 Flight Controls Development

4.1.5.4 Combat Effectiveness Air-To-Air Engagements

An additional benefit for simulation use was added for all four critical issues and that is, "Reduce Technical Risk."

4.1.6 LABCOM, AMC, Adelphi, MD. Mr. Joe Lacetera provided survey data for LABCOM. (Annex B, Appendix 6) Critical issues are:

4.1.6.1 Emerging Technology Assessment

4.1.6.2 Battlefield Utility of Future Systems

4.1.6.3 Man-in-the-Loop Technology Base Wargaming

The most positive benefit for Emerging Technology Assessment is "Save Time"; for Battlefield Utility of Future Systems it is "Save Resources"; and for Man-in-the-Loop Technology Base Wargaming it is "Improve Effectiveness."

4.1.7 Electronic Integration Directorate (EID), CECOM (formerly Aviation Avionics R&D Activity, AVSCOM), Ft. Monmouth, NJ. The point of contact for EID is John Respass. The survey questionnaire was completed by Captain D. Valentine from DCD, Ft. Rucker, and Major P. Bartosch (Ret.). (Annex B, Appendix 7) Critical issues are:

4.1.7.1 Flight following (automated) hardware and software development.

4.1.7.2 Tactical Operations Center development

4.1.7.3 Mission Planning System development

4.1.7.4 Target hand-over processes (internal Aviation and to combined arms units)

Saving time is the most important benefit for the Flight Following issue and Improve Effectiveness is the major benefit for the other three issues.

4.1.8 Aviation Division, DCSOPS, Washington. Major Kulungowski is the point of contact. He provided comments on networking and simulation attributes, but did not identify critical issues. (Annex B, Appendix 8)

4.1.9 Aviation Logistics, DCSLOG, Washington. Captain Craddock is the point of contact, who reported that it is believed that the type of simulation addressed in the survey has little application for the Aviation Logistics Office and that their needs are more in the area of logistics modeling, which is being performed for them by the TRADOC Analysis Command and the DCSLOG Resource Management Directorate. (Annex B, Appendix 9)

4.1.10 Aviation Division, Army National Guard Bureau chose not to respond to the invitation to participate in the survey.

4.2 New Simulation Capabilities/Functionalities. Each respondent was asked to identify, in order of importance, specific new simulation technology that would assist in addressing critical issues in their organization.

4.2.1 Office of the Deputy Assistant Secretary of the Army for Research and Technology. Mr. Yuhas identified the following pacing technologies as for achieving advanced simulation capabilities: 'Annex B, Appendix 1)

4.2.1.1 High speed and parallel processing computational capabilities in small, relatively low cost packages.

4.2.1.2 A range of low-cost, low to high fidelity graphic and animation imagery.

4.2.1.3 Low cost reconfigurable simulators.

4.2.1.4 User friendly automated tools for building models at the labs and testing centers to include streamlined procedures for Verification, Validation, and Accreditation.

4.2.1.5 User friendly automated tools for rapidly building and modifying terrain data bases.

4.2.2 Operational Evaluation Command, Alexandria, VA. "It would be of tremendous benefit to have the state of the art in software development directly equivalent to the state of the art in aircraft development to enable us to simulate a new aircraft and be assured that the real thing would perform exactly the same way." (Annex B, Appendix 2)

4.2.3 Army Aviation Center, Ft. Rucker, AL. A Center position was not reached for the purpose of this survey. Each of the following organizations completed a questionnaire: (Annex B, Appendix 3)

- Directorate of Training and Doctrine

- Directorate of Combat Developments
- Aviation Research and Development Activity, Army Research Institute

4.2.3.1 Directorate of Training and Doctrine. The following new simulation capabilities/functionalities were identified: (Annex B, Appendix 3.1)

4.2.3.2 Mission rehearsal capability on exact terrain using current threat data and at the projected time of day, weather, etc.

4.2.3.3 Train on new aircraft even before they are built.

4.2.3.4 Training against new weapon systems, such as lasers, etc.

4.2.3.5 Identify degree of fidelity that is needed to train.

4.2.3.6 How much simulation is effective in training both cognitive and manual skills?

4.2.3.2 Directorate of Combat Developments. The following requirements for new simulation capabilities/functionalities were identified: (Annex B, Appendix 3.2)

4.2.3.2.1 Accurate simulation of all weapon capabilities/ easily modified

4.2.3.2.2 Accurate simulation of all environmental conditions to include night, weather, dust, winds thermal cross over, etc.

4.2.3.2.3 Ability to interface high and low resolution simulators.

4.2.3.2.4 Ability to change all system parameters easily at a keyboard, i.e., built into the hardware and software to be user friendly.

The most important consideration for the first three capabilities is High Fidelity and for the last capability it is Speed in Development.

4.2.3.3 Aviation Research and Development Activity, Army Research Institute. The following requirements for new simulation capabilities/ functionalities were identified: (Annex B, Appendix 3.3)

4.2.3.3.1 Modularity/Portability

4.2.3.3.1 Air-To-Air Training

4.2.4 Aviation Systems Command, St. Louis. Again, AVSCOM elected not to respond as a Command to the survey questionnaire, but responses were made by the Aviation Applied Technology Directorate and the Crew Station Research and Development Branch, Aeroflightdynamics Directorate

4.2.4.1 Aviation Applied Technology Directorate, Ft. Eustis, VA. The following requirements for new simulation capabilities/functionalities were identified: (Annex B, Appendix 4.1)

4.2.4.1.1 Advanced technology subsystem models

4.2.4.1.2 Long haul network to AIRNET.

Low unit costs and low total costs are the major considerations.

4.2.4.2 Crew Station Research and Development Branch, Moffett Field, CA. The following requirements for new simulation capabilities/functionalities were identified: (Annex B, Appendix 4.3)

4.2.4.2.1 High bandwidth, high fidelity full mission simulator long haul network.

4.2.4.2.1 Reasonably priced, easily modifiable, high fidelity computer generated image systems with interchangeable databases with intersystem compatibility.

4.2.4.2.1 Interactive electronic battlefield/threat environment database w/high fidelity, validated models, usable by simulation facilities of all levels of capability (combined arms/joint services operations).

4.2.4.2.1 Reasonably priced high fidelity head tracked image display systems.

4.2.4.2.1 Rapidly reconfigurable cockpits and supporting MEPs.

Speed in Development and High Fidelity are the most important considerations for the first listed capability, High bandwidth, high fidelity full mission simulator long haul network. For the other four capabilities, Low Unit Cost and High Fidelity are listed as most important.

4.2.5 PM RAH-66 COMANCHE, PEO Aviation, St. Louis. The following requirements for new simulation capabilities/functionalities were identified: (Annex B, Appendix 5)

4.2.5.1 Increased terrain fidelity (texture) in nap of the earth environment.

4.2.5.1 Air-to-air simulation.

4.2.6 LABCOM, AMC, Adelphi, MD. The following requirements for new simulation capabilities/functionalities were identified: (Annex B, Appendix 6)

4.2.6.1 Army Research Lab Node

4.2.6.2 Realistic AI Representation of Crew Behavior

4.2.6.3 Virtual Reality

4.2.6.4 SAFOR Entities on Individual Chips

4.2.6.5 Massive Parallel Processing

4.2.7 Electronic Integration Directorate (EID), CECOM (formerly Aviation Avionics R&D Activity, AVSCOM), Ft. Monmouth, NJ. The following requirements for new simulation capabilities/functionalities were identified: (Annex B, Appendix 7)

4.2.7.1 Digital map vector graphics

4.2.7.2 Airborne command and control capability

Speed in development is the most important consideration for both new capabilities.

4.3 Networking. Survey respondents were requested to:

Describe the local area network(s) (LAN) and long haul network(s) (LHN), if applicable. If no LAN or LHN exists, is there a requirement for one or more? Describe the requirement to include gateways and interface units. Include any plans, programs and the status of funding. Bandwidth requirements--56Kbps? T1 1.544 Mbps? DARPA's TWBNet?

4.3.1 Networking of CSRDF-STRATA-AIRNET. There was near universal agreement for top priority to link the the high fidelity simulator nodes of the Crew Station Research and Development Facility (CSRDF), Moffett Field, and the Simulator Training Research Advanced Testbed for Aviation (STRATA) with the lower fidelity simulators of the Aviation Testbed of the Battlefield Distributed Simulation-Developmental (AIRNET) site at Ft. Rucker. MG Jerry Harrison, Commander of LABCOM, stated in a separate letter that, "The purpose of the linkage is to allow the Rotorcraft Pilot's Associate program to be tested in a viable combined-arms environment." Mr. John Yuhas, OASA

(RDA), listed this networking as a near term critical issue. This networking was also urged by PMO COMANCHE, ARI, AVSCOM, and the Aviation Center.

4.3.2 Networking of Aviation Simulation Nodes with the Army Tactical Command and Control System (ATCCS). The Electronic Integration Directorate and the Aviation Center indicated the need to network aviation simulation nodes with ATCCS, especially the Maneuver Control System (MCS).

4.3.3 Networking by the Combined Arms Center. With the technical support of the U.S. Army Communications-Electronics Command Center for C^3 Systems, the Combined Arms Center at Fort Leavenworth has gained extensive experience in networking over the past five years. Installations initiating or expanding their networking capabilities can get valuable information from the Audit Report by the CECOM contractor, SRI International, entitled "Combined Arms Command Network Logical Interconnection" dated October 1991. Figure 4.3.3, CACNET Fiber-Optic Network, illustrates the current status at Fort Leavenworth.

4.3.4 Networking of Aviation Simulation Nodes with Aircraft. EID and DCD, Aviation Center, stated that provisions should be made to network with the MIL STD 1553 Data Bus. This would allow operational equipment such as the APACHE and KIOWA WARRIOR and developmental equipment such as COMANCHE, LONGBOW and RPA to exercise in a combined arms simulation.

4.3.5 Network Bandwidth LABCOM has suggested that the CSRDF-STRATA-AIRNET link use the DARPA TWBNet while CSRDF has envisioned a T1 line.

4.3.6 Networking of Aviation Simulation Nodes with Industry and Academia. AATD suggested linking AIRNET BDS-D with industry and academia. OASA (RDA) listed networking with industry and academia as a critical issue for the mid term 95-97. Both industry and academia have extensive simulation capabilities relevant to Army aviation. An industry sample is included at Annex C, Appendices 15 thru 18, for the four helicopter "majors." There is a great deal more aviation related capability in companies like Martin-Marietta, Westinghouse, IBM, General Dynamics. A small sample of academia is at Annex C, Appendices 13 and 14, for Georgia Tech and Central Florida's IST.

4.4 Simulation Attributes. Respondents were asked to rank the relative importance of 49 simulation attributes to their organization using the AASS questionnaire. The only clear consensus was that "Interoperability with other simulators/simulations" and "Need for man-in-the-loop" were given the highest ratings of importance. Ratings for each attribute by organization are provided in Annex B.

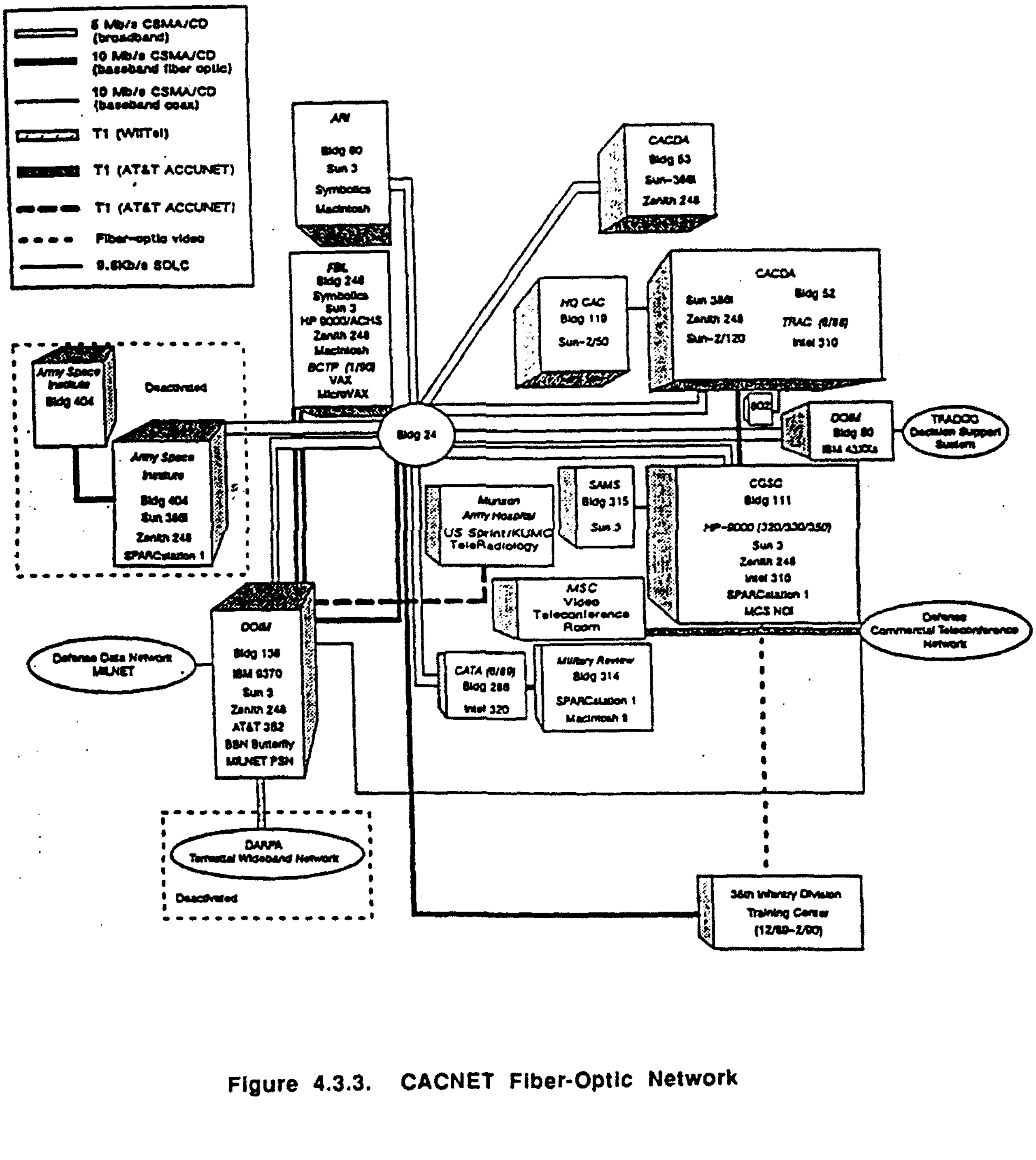

Figure 4.3.3. CACNET Fiber-Optic Network

5. DISCUSSION

5.1 Simulation in Aviation Material Development, Acquisition and Operational Testing

Acceptance of Simulation by the Developer and Tester. There is a basic skepticism about simulation in both the developer and tester communities, as voiced in this survey.

5.1.1 The PM COMANCHE Office stated: "Since the results of operational analyses are heavily dependent on the specific scenarios that are formulated I believe that statistical analyses for operational effectiveness is more valid than individual pilot-in-the-loop or analytical simulations. Thus I believe that pilot-in-the-loop simulations should not be utilized or advertised as a tool to provide significant improvements in the predictions system or system modification effectiveness. Thus extensive expenditures to obtain large pilot-in-the-loop battlefield simulations are not justified."

5.1.2 USAOPTEC Policy and Methodology Directorate stated: "USAOPTEC has not recognized a need to become an active proponent for the development of simulation technology." This statement of course will be big news for the Commander of USAOPTEC who is a signatory to the plan for the development of BDS-D simulation technology.

5.1.3 SIMNET/AIRNET Developmental and Operational Testing. The above sample attitudes are not shared by the developers and testers that used SIMNET/AIRNET for Forward Area Air Defense Line of Sight-Heavy (FAADS LOS-H) and the Non-Line of Sight (NLOS) systems.

5.1.3.1 FAADS LOS-H. Three exercises/tests were conducted with a platoon of four FAADS LOS-H firing units at the Ft. Knox and Ft. Rucker SIMNET/AIRNET long-haul networked sites. There was universal praise from the user, the Air Defense Center; the developer, PM FAADS and the contractor, Martin-Marietta. The exercises resulted in major changes to the FAADS doctrine and training strategy as well as changes to the firing unit hardware.

5.1.3.2 NLOS. The NLOS/SIMNET simulator system was tested as a potential "user testing tool" at the AIRNET site at Ft. Rucker in the spring of 1991. The following quotes are from the USAOPTEC Independent Operational Assessment Report OA-1394 dated October 1991:

> The NLOS/SIMNET system during the standard trials (NS1) and during the excursion trials (NSX) closely replicated the performance of the systems

used during the IOE captive flight tests (CFT) and missile firing tests (MFT) in several areas. *** The NLOS/SIMNET system did not replicate the performance of the IOE systems in several important areas, but most of the observed differences could have been controlled through software modification.

Personnel, test time, and total dollar cost were significantly reduced. The NLOS/SIMNET system had a mean time between failure of 72 hours, an operational availability of .99, and a mean time to repair of 18 minutes, and important system functions and characteristics were generally rated as being realistic by system operators and subject matter experts. For example, the gunner's console, field of view management, and missile flight, speed, and climb profiles were rated as realistic and important. Target recognition, on the other hand, was rated as important but not realistic. Data base management software indigenous to the system was effective.

Results generally support the future use of weapon system simulators requiring optics, CRTs, and out of the window views in a simulated battlefield environment early in the acquisition process. The simulator/SIMNET system concept should be considered for incorporating into the testing strategy during the early developmental stages of Army weapon systems. A simulator/SIMNET system should assist the materiel developer in defining system characteristics and capabilities and in identifying problems and should assist the combat developer in defining operating procedures and tactics.

Not specifically stated in the report, but from field testing experience, a very big payoff using this type simulation should be field test and data collection design so that valuable resources are not wasted in poorly designed field tests that prove nothing or the "wrong" thing.

It should be especially noted that the two NLOS simulators were built and integrated into SIMNET by a contractor not previously associated with the development of SIMNET.

Figure 5.1.3.2, Comparative Costs for NLOS Tests, is a copy of Table 2-11 from the referenced test report.

5.2 DoD Guidance and Initiatives. The traditional view of developers and testers seems to have been to look down their analytical scientific noses at the trainers who apparently have little or no regard for standards. Indeed, they might expect to see the Army Chief of Staff's call for the "1941 Louisiana Maneuvers in 1994 with Simulation" to again be conducted with broomsticks for rifles. This attitude toward simulation and trainers is inexorably changing.

	Captive Flight	Missile Firing	NLOS/SIMNET
Costs:			
Weapon Sys/Sim	$300,000	$5,100,000	$1,372,128
Test Facilities	3,900,000	1,400,000	150,000
Test Team Personnel	2,445,939	2,292,315	472,006
Total Cost	$6,645,939	$8,792,315	$1,994,134
# Test Trials* Completed	637	19	936
Cost/Trial*	$10,433	$462,753	$2,130
Length of Test	160 days	63 days	30 days
Trials*/Day	3.98	0.30	31.20
# Test Team Personnel	205	205	10 Test Supt 11 Gunners
Personnel Requirements/Trial*	0.32	10.79	0.02

* CFT Trials were aircraft flights; MFT and NLOS/SIMNET trials were missile shots.

Figure 5.1.3.2. Comparative Costs for NLOS Tests

5.2.1 Defense Models and Simulation Office (DMSO). Created in June 1991, the DMSO developed a master plan that sought to unify the OSD staff, the Joint Staff, the Military Service staffs and the Federally Funded Research and Development Centers to issue guidance and coordinate R&D funding towards standards and enabling software and hardware for interoperability of simulators and simulations.

5.2.2 DDR&E Science and Technology Strategy. In January 1992 Dr. Vic Reis, the DDR&E, announced his Science and Technology Strategy. The strategy provides for seven principal thrusts. S&T Thrust #6 is Simulation. The scope and milestones for S&T Panel #6 Technology Demonstrations is at Annex D. The proposed technical development and demonstrations support the concept of networking simulators, wargames(BCTP), and instrumented combat ranges for a synthetic environment or "Electronic Battlefield."

This specific DDR&E Science and Technology Thrust is extremely important to future Army aviation simulation development and application. Many of the technologies relate directly to work planned or under way at CSRDF and the Aviation Testbed (AIRNET). Some of the candidate technologies are shown in Figure 5.2.2, Technologies for Demonstration.

5.3 Simulation in Aviation Training. The use of simulation in aviation training is and has been a much discussed issue and well it should continue to be.

5.3.1 Simulation of the RAH-66 COMANCHE. The CSRDF (Annex C, Appendix 2) has been used to train both support and assessment pilots for the LH DEM/VAL phase indicating some degree of COMANCHE expertise and capability. ARI's STRATA (Annex C, Appendix 3) will have a COMANCHE cockpit, flight dynamics and MEP. The Aviation Testbed, BDS-D, initiated an effort in the summer of 1991 with the ADST contractor, Loral, to build eight COMANCHE cockpits primarily to conduct the series of FDT&Es. PM COMANCHE contracted with CAE-Link in September 1991 for $21.5 million to study and design the training system for the COMANCHE. And, of course, Sikorsky has a full mission COMANCHE simulator (Annex C, Appendix 15). By inspection, one would think that there should be an opportunity for savings in these possibly duplicative efforts.

Technologies for Demonstration

For <u>subsistent TES</u>:

- Use and fusion of existing intell. sensors
- Comprehensive geo-ref.
- Passive, continuous positioning
  --cooperative *[e.g., Iridium]*
  --noncooperative *[e.g., JSTARS]*
- Vector detection
- Engagement sensing
  --Outbound
  --Inbound
  --Evasive actions
- *In situ* processing
- Packet communications

For both <u>subsistent</u> and <u>virtual</u> <u>TES</u>:

- SAFOR
- Intelligent Gateways
- Scalable processors
- High-n object processing
- Dense behavioral data analyses
- Exoskeletal monitoring suites
- Audio-visual-tactile interfaces

<u>Advanced Technology Demos</u>

- *ODIN for sensor fusion, C3I*
- *hyper-small LORAN or GPS*
- *highly compact parallel processors*
- *modulated Directed Energy beam*
- *Micro-Electric Mechanical Systems*
  --accelerometers
  --gyroscopes
  --angular-displacement meters
  --switches and actuators
- *Light, CINC-particular satellite(s)*
- *Myoelectric detectors*
- *Unobtrusive vital-signs sensors*
- *Tele-operations/presence*

Figure 5.2.2. Technologies for Demonstration

5.3.2 Aviation Team Training Simulator Mobility. Recognizing the inevitable re-stationing of aviation units and the new Army imperative for Force Projection, the question of brick and mortar versus portability for new simulators requires thorough analysis.

5.3.3 Aviation as a Threat. Each branch member of the combined arms team and, indeed, each service member of the joint force can happily burn up each of their entire training budgets conducting interesting and rewarding training without the slightest interface with another team member. Our wise leaders of the past tried to force the issue with ATT's and then ARTEPs. Today it is CTCs and BCTP. Notwithstanding these powerful motivators, there is much discretion in spending the training dollar left to the branch and service(as it should be).

The most powerful motivator for gaining expertise and polished unit competence in combined and joint operations is to pay the price in humiliation and defeat on the battlefield. Infantry and armor guys rediscovered the engineers at the NTC! Most of them have learned the value of reconnaissance and counter-reconnaissance and some of the brighter ones even understand the value of aviation in this undertaking. But generally speaking, the full potential of aviation is rarely recognized and appreciated. The obvious answer is more and better training with aviation as part of the team.

It is believed that one of the best ways to learn what aviation can do for you is to learn what it can do to you. Threat aviation in support of the NTC OPFOR is barely given token play. There should be a much more formidable aviation support package available to the OPFOR at our CTCs. It would be interesting to get the views on threat aviation from the NTC OPFOR commander now that he has seen a few APACHEs and KIOWA WARRIORs!

5.4 A Unified Effort for Doctrine and Training Development, Material Development and Acquisition, Testing, and Training Readiness and Operations Rehearsal

5.4.1 Simulation writ LARGE. All training and rehearsals--field exercises, range firing, NTC is simulation. All analyses--models, wargames is simulation. All acquisition planning--critical design reviews, performance projections is simulation. And certainly all testing is simulation.

5.4.2 An electronically simulated battlefield. The simulation by live forces on instrumented firing ranges, the virtual simulation of BDS-D and the constructive war games using models such as JANUS and JESS can all be connected to interact electronically as envisioned in the DDR&E Simulation Thrust. This will be an expensive undertaking, but the potential applications are unbounded. Once the technologies are developed expansion of multiple capabilities should be readily affordable. Funding of the initial development is expected to be shared by developers, testers and users of all DoD. Figure 5.4.2, The Synthetic Environment, illustrates this concept.

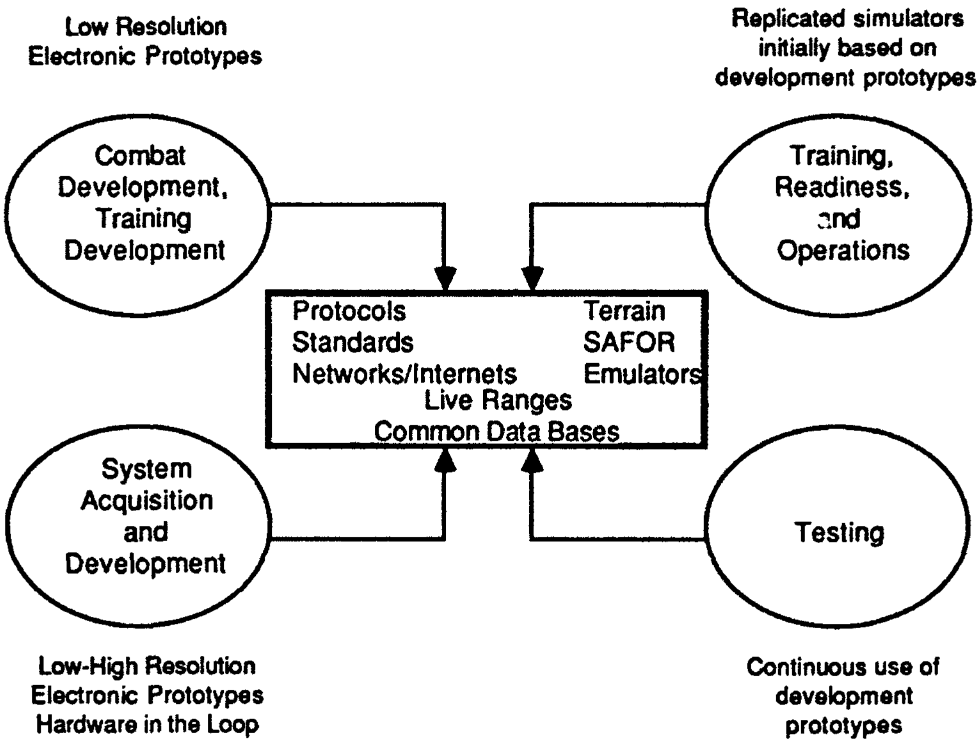

Figure 5.4.2. The Synthetic Environment

6. RECOMMENDATIONS

6.1 Critical Issues. Of the 39 critical issues identified by survey respondents, the 19 are considered the most important for Army aviation and priority should be given to the development of simulation capabilities to address these issues. The author made the selections based on his judgment as to contribution to aviation's effectiveness as a member of the combined arms team and his knowledge of the state of the simulation art. [The identifying source(s) for the issue is shown in parenthesis.]

- The development of an Electronic Battlefield with weather effects, dynamic terrain, electronic warfare and sufficient numbers of objects/entities for realistic joint and combined arms warfighting by a battalion task force. (OASA RDA)

- Demonstration of long haul and local networking of dissimilar simulators such as the high fidelity CSRDF at Moffett Field and the aviation simulators (AIRNET) at Ft. Rucker. (OASA RDA)
- Conduct of the Rotorcraft Pilot Associate (RPA) ATTD in BDS-D with a real-time, man-in-the-loop electronic combined arms battlefield that includes the AH-64 and the RAH-66 COMANCHE as baseline models. (OASA RDA)
- Conduct RAH-66 and AH-64 simulation demonstrations in BDS-D necessary to assess and evaluate related programs including COMANCHE Dem Val and EMD acquisition phases and LONGBOW. (OASA RDA)
- Expansion of the Combined Arms Tactical Trainer (CATT) family including CCTT, AVCATT, ADCATT, and ENCATT. (OASA RDA)
- Expansion of the BDS-D electronic combined arms battlefield to the division level with select government/industry/academic networking capability. (OASA RDA)
- Simulation of aircraft survivability equipment that can be used during flight. (DOTD, Avn Cen)
- Determining the structure and operational concepts for future aviation organizations. (DCD, Avn Cen)
- Training, tactics, doctrine developments resulting from advanced MEP and platform concepts for the combined arms/joint battlefield. (CSRDF)
- Aviation C^3--development of a simulated "automated" TOC and C&C aircraft to include data exchange with ground elements and other aircraft. For example, the target hand-over processes for critical mobile targets (CMT). (DCD, Avn Cen and EID, CECOM)
- The development and proliferation of modular/portable training devices. (Avn R&D Activity, ARI)
- The appropriate/adequate/selective fidelity issues in training systems. (Avn R&D Activity, ARI)
- Subsystems effectiveness relative to total system effort (i.e., weapons, comm, NAV, ASE, etc.). (AATD, Ft. Eustis, and DCD, Avn Cen)
- Mission effectiveness evaluations of advanced MEP and platform concepts for the combined arms/joint battlefield. (CSRDF)
- Pilot-vehicle interface information integration and optimization for current and projected advanced MEP and platform concepts. (CSRDF and AATD)
- Combat effectiveness in air-to-air engagements. (PMO COMANCHE)

- Assessment of emerging technology for battlefield utility of future systems. (LABCOM)

6.2 New Simulation Capabilities/Functionalities. Of the 32 new simulation capabilities/functionalities identified by survey respondents, the following 14 are considered the most important for Army aviation and priority should be given to their development. The author made the selections based on his judgement as to contribution to aviation's effectiveness as a member of the combined arms team and his knowledge of the state of the simulation art. [The identifying source(s) is shown in parenthesis.]

- High speed and parallel processing computational capabilities in small, relatively low cost packages. (OASA RDA and LABCOM)
- Reasonably priced, easily modifiable, high fidelity computer generated image systems with interchangeable databases with intersystem compatibility. (CSRDF and OASA RDA)
- Low cost reconfigurable cockpits and supporting MEPs. (CSRDF and OASA RDA)
- User friendly automated tools for building models at the labs and testing centers to accurately simulate of all weapon capabilities and MEP subsystems to include streamlined procedures for VV and A. (OASA RDA, AATD and DCD, Avn Cen)
- User friendly automated tools for rapidly building and modifying terrain data bases for interactive electronic battlefield/threat environment w/high fidelity, validated models, usable by simulation facilities of all levels of capability (combined arms/joint services operations). (OASA RDA and CSRDF)
- Mission rehearsal capability with increased terrain fidelity (texture) in NOE environment using current threat data and at the projected time of day, weather, etc. (DOTD, Avn Cen and PMO COMANCHE)
- Accurate simulation of all environmental conditions to include diurnal cycle, weather, dust, winds, acoustics, thermal cross over, etc. (DCD, Avn Cen)
- Ability to interface high and low resolution simulators. (DCD, Avn Cen)
- More affordable modular and portable devices. (Avn R&D Activity, ARI)
- Air to air combat simulation for both rotary and fixed wing aircraft. (PMO COMANCHE and Avn R&D Activity, ARI)
- High bandwidth, high fidelity full mission simulator long haul network. CSRDF and AATD)
- Realistic AI representation of crew behavior. (LABCOM)

- Digital map vector graphics. (EID, CECOM)
- Airborne command & control capability to interface with ATCCS, especially MCS. (EID, CECOM)

6.3 Networking

- Interface units and intelligent gateways accommodating distributed interactive simulation (DIS) standards are required to network CSRDF-STRATA-AIRNET using DARPA's TWBNet.
- Organizations participating in BDS-D should build on the networking experience of the Combined Arms Center at Fort Leavenworth.
- Interface units should be developed for networking with ATCCS, the MIL STD 1553 data bus and operational equipment such as HAWK and PATRIOT.
- DARPA and CECOM should support the development of an airborne command and control simulation capability at Ft. Rucker's Aviation Testbed site to interface with ATCCS networked with the U.S. Army Communications-Electronics Command Center for C^3 Systems and the Future Battle Lab of the Combined Arms Center.
- DARPA should continue its effort to facilitate the networking of BDS-D sites with industry and academia.

6.4 Aviation Simulation Facilities

The principal aviation R&D simulation facilities are:

- Aviation Testbed, Battlefield Distributed Simulation-Developmental (AIRNET), Ft. Rucker
- Crew Station Research and Development Facility (CSRDF), Moffett Field, CA
- Simulator Training Research Advanced Testbed for Aviation (STRATA), ARI, Ft. Rucker

The need for enhancements, new functionalities and extended networking for these facilities have been addressed in paragraphs 6.1, 6.2, and 6.3 above.

The simulation facilities for the four major helicopter manufacturing companies of the United States were presented in Annex C. There are other major defense industry firms that are critical to the future of Army aviation that have not been surveyed. This is especially true for R&D and manufacturing of components of mission equipment packages (MEP), e.g., Martin Marietta, Harris, Northrop, IBM, Hughes, General Dynamics, E-Systems, Grumman, Honeywell, ITT, Litton, Lockheed, LTV, Rockwell, etc. There are no specific plans for networking any of the major helicopter manufacturers on any of the MEP industry simulation facilities with Army facilities, but it is a long term goal of the Battlefield Distributed Simulation-Developmental program. A more comprehensive survey of Army aviation related industrial simulation facilities and the need for networking should be undertaken. This could be sponsored by the Defense Models and Simulation Office.

6.5 Simulation in Aviation Training

- The Commanders of the Aviation Center and AVSCOM and the PEO COMANCHE should jointly examine the possibly duplicative efforts in the development of simulators for the COMANCHE.
- The inevitable re-stationing of aviation units and the new Army imperative for Force Projection dictates thorough analysis the question of brick and mortar vs portability for new and possibly existing simulators.
- Emphasis should be placed on ensuring the presence of a robust threat aviation force in all training, especially at the CTCs and in the BCTP.

6.6 A Unified Effort for Doctrine and Training Development, Material Development and Acquisition, Testing, and Training Readiness and Operations Rehearsal

- The researchers (DARPA, AVSCOM, CECOM, LABCOM), the developers (PEO Aviation), and the testers (OPTEC) will all greatly benefit in joining with the trainers (AVNCEN and CAC) in funding for the development of the aviation portion of the Electronic Battlefield.

ANNEXES

ANNEX A

SURVEY DOCUMENTS

ANNEX A
AASS SURVEY DOCUMENTS

The Army Aviation Simulation Survey (AASS) was initiated by the Director of DARPA and the Commanding General of the Army Aviation Center in November 1991. The Institute for Defense Analyses was tasked to conduct the survey. A letter (see Appendix 1) from DARPA invited the following offices/agencies/organizations to participate in the survey:

- Office of the Deputy ASA for Research and Technology, Washington, DC
- Operational Evaluation Command, Alexandria, VA
- Army Aviation Center, Ft. Rucker, AL

  --Directorate of Training and Doctrine

  --Directorate of Combat Developments

  --Aviation Research and Development Activity, ARI
- Aviation Systems Command, AMC, St. Louis

  --Aviation Applied Technology Directorate, Ft. Eustis, VA

  --Simulation and Aircraft System Division, Moffett Field, CA

  --Crew Station Research and Development Branch, Moffett Field, CA
- PM RAH-66 COMANCHE, PEO Aviation, St. Louis
- LABCOM, AMC, Adelphi, MD
- Electronic Integration Directorate, CECOM (formerly Aviation Avionics R&D Activity, AVSCOM), Ft. Monmouth, NJ
- Aviation Division, DCSOPS, Washington
- Aviation Logistics, DCSLOG, Washington
- Aviation Division, National Guard Bureau

Participants were asked to complete the survey questionnaire (Appendix 2) and provide any additional information they thought appropriate.

ANNEX A, APPENDIX 1, SURVEY INITIATING LETTER

DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

3701 N. Fairfax Drive

Arlington, VA 22203-1714

Dear :

DARPA would like to continue its partnership with the Army in applying advanced computer technology in further development of distributed and networked simulation; especially in aviation applications. There are currently three aviation facilities with advanced simulation capabilities:

1. The Crew Station Research and Development Facility (CSRDF) at Moffett Field, CA.
2. ARI's Simulator Complexity Testbed to be completed by CAE in Toronto in January 92 and moved to Ft. Rucker when a building is ready for it.
3. The Aviation Testbed of the Battlefield Distributed Simulation-Developmental (BDS-D) program (better known as AIRNET) at Ft. Rucker, AL.

The capabilities of the first two of these are fairly well defined except it is not clear what some type of networking might yield in the way of enhancements. The third facility, AIRNET, is in the initial phase of obtaining significant enhancements through the BDS-D support contract, Advanced Distributed Simulation Technology (ADST). Loral is the contractor and PM TRADE the contracting office.

For an approach that will make the most of these facilities and any new investments, it would be helpful to know the greatest technical challenges which DARPA might be able to assist. What does aviation need to do in simulation that it cannot do now? What are the current, mid-term and long range critical aviation issues in:

- Doctrine, tactics, techniques and procedures?
- Command and control?
- Material requirements?
- Material acquisition process?
- Developmental experimentation and testing?
- Operational testing?
- Training?
- Operations/Mission planning and rehearsal?
- Unmanned aerial vehicles-development, acquisition, O & O, C & C?

What tests or experiments are now planned for using simulation capabilities to address these critical issues?

Under DARPA sponsorship, the Institute for Defense Analyses (IDA) has asked Major General Ben Harrison, U.S. Army (Retired) to conduct a survey and prepare a report on the priority requirements for advanced technology simulations to Army aviation, and the current and funded capabilities extant to meet these needs. Major General Dave Robinson, CG of the Aviation Center, has agreed to co-sponsor this effort.

General Harrison will be working with Colonels Sendak and Beauchamp at Ft. Rucker, but input from your organization is essential for a comprehensive treatment of this topic. Could you identify a point of contact who can speak for you in addressing these issues with the IDA study? It would be very helpful if IDA could receive the name and phone number of your representative by 1 November. Colonel Neale Cosby (U.S. Army, Retired) at IDA is collecting these names. (703) 845 6800.

Thank you for your support of this effort.

Jack A. Thorpe, Col, USAF

Special Assistant for Simulation

ANNEX A, APPENDIX 2, SURVEY QUESTIONNAIRE

ARMY AVIATION SIMULATION SURVEY

Conducted by the Institute for Defense Analyses

Organization______________________________ **Date**__________________

____

Point of Contact_________________________ **Phone**__________________

Current Simulation Plan:

Attach a description of the organization's plan for the use of simulations to address key issues. Indicate current capabilities and planned new functionalities/enhancements and the funding profile for improvements.

Critical Issues:

List below the critical issues facing your organization where there might be potential for the application of simulation if new technology were available. List the issues in order of importance. Please highlight requirements for simulation of joint and combined arms operations.

To the right of the issue are listed potential benefits from the use of simulation. Estimate the value of the simulation for each benefit using a scale of 1 to 5 with 5 being the best, most positive rating. (Please change "Benefit"headings and/or specify "Other" as appropriate for your organization/mission.)

CRITICAL ISSUES:	SIMULATION BENEFITS				
	Save Resources	Save Time	Improve Effectiveness	Safety	Other
A. ________________________					
__________________________	___	___	___	___	___
B. ________________________					
__________________________	___	___	___	___	___
C. ________________________					
__________________________	___	___	___	___	___
D. ________________________					
__________________________	___	___	___	___	___

New Simulation Technology:

Please identify, in order of importance, specific new simulation technology that would assist in addressing critical issues in your organization. (New simulation technology is defined as that which requires some level of research and development effort.) Please highlight requirements for simulation of joint and combined arms operations. To the right of the new capability/functionality are listed R & D cost considerations. Indicate the relative importance of the considerations on a scale of 1 to 5 with 5 being the most important.

NEW CAPABILITY/FUNCTIONALITY	R & D COST CONSIDERATIONS			
	Speed in Developm't	**Low Unit Cost**	**Low Total Cost**	**High Fidelity**
E. ____________________				
____________________	___	___	___	___
F. ____________________				
____________________	___	___	___	___
G. ____________________				
____________________	___	___	___	___
H. ____________________				
____________________	___	___	___	___
I. ____________________				
____________________	___	___	___	___

Networking:

Describe the local area network(s) (LAN), if applicable. If no LAN exists, is there a requirement for one? Describe the requirement.

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Describe the long haul network(s) (LHN), if applicable. If no LHN exists, is there a requirement for one or more? Describe the requirement to include gateways and interface units. Include any plans, programs and the status of funding. Bandwidth requirements--56Kbps? T1 1.544 Mbps? DARPA's TWBNet?

____

____

____

____

Rate items 1 through 24 on a scale of 1 to 5 with 5 being the highest rating.

How important is it to your organization to network with the following nodes, LANs, facilities:

(Please comment using extra paper keying comments to the appropriate numbers below.)

Node/Facility	Rating
1. Aviation Testbed, BDS-D (AIRNET), at Ft. Rucker, AL	_____
2. Crewstation Research and Development Facility (CSRDF), Moffett Field, CA	_____
3. Air Combat Mission Enhancement (ACME), Williams AFB, AZ	_____
4. Visual Technology Research Simulator, Naval Training Center, Orlando, FL	_____
5. Institute for Simulation and Training, Orlando, FL	_____
6. Other______________________________	_____
7. Other______________________________	_____

How important to your organization are the following simulation attributes? Answer for "a just barely good enough--60% solution," recognizing that funding is extremely tight. (Please comment as desired, using extra paper keying comments to the appropriate numbers below.)

8. Need for interoperability with other simulators/simulations?	_____
9. Need for man-in-the-loop?	_____
10. Fidelity in:	
10.1 Visuals?	_____
10.1.1 Diurnal cycle?	_____
10.1.2 Shadows?	_____
10.1.3 Weather?	_____
10.1.3.1 Clouds?	_____
10.1.3.2 Rain?	_____
10.1.3.3 Snow?	_____
10.1.3.4 Fog?	_____
10.1.4 Smoke	_____
11. Field of view?	_____
12. Terrain data base?	_____
13. Dynamic terrain?	_____

14. Weapons effects? ____
    14.1 Ph, Pk? ____
    14.2 Trajectory? ____
    14.3 Signature? ____
        14.3.1 Visual? ____
        14.3.2 IR? ____
        14.3.3 Radar? ____
        14.3.4 Acoustical? ____
        14.3.5 Directed energy weapons? ____
15. Vehicle signature? ____
    15.1 Visual? ____
    15.2 IR? ____
    15.3 Radar? ____
    15.4 Acoustical? ____
16. Need for semi-automated forces (SAF)? ____
17. Operations with combined arms team? ____
18. Operations with other Services? ____
19. Operations with other nations? ____
20. Number of objects? ____
    20.1 Include 10 objects? ____
    20.2 Include 50 objects? ____
    20.3 Include 100 objects? ____
    20.3 Include 500 objects? ____
    20.5 Include 1000 objects? ____
    20.6 Include 5000 objects? ____
    20.7 Include 10000 objects? ____
21. Combat service suppor: - RAM - impact? ____
22. Electronic warfare? ____
    22.1 ECM? ____
    22.2 ECCM? ____
    22.3 EMP? ____
23. Mobility of the simulator/simulation? ____
    23.1 Vehicle mounted? ____
    23.2 Portable by vehicle? ____
24. V & V, Accreditation of models? ____

<u>**Funding:**</u> If you had the authority to reprogram your funding, would you do so to achieve the simulation capabilities you have indicated are needed? Yes___. No___.

ANNEX B

DATA COLLECTION

ANNEX B
DATA COLLECTION

This annex contains the raw data submitted by participants in the Army Aviation Simulation Survey.

The Aviation Division of the National Guard Bureau was invited to participate in the survey, but chose not to respond.

ANNEX B, APPENDIX 1, OFFICE OF THE DEPUTY ASA FOR RESEARCH & TECHNOLOGY, WASHINGTON, DC

These data were obtained through a series of telephone discussions between Harrison and Yuhas and documented in the memorandum provided below:

Memorandum for:	Ben Harrison IDA Simulation Center	6 Jan 92
Subject:	Army Aviation Simulation Survey	
From:	John S. Yuhas Technology Directorate, OASA (RDA)	

1. This response is in lieu of the survey questionnaire which may be more appropriate for agencies/organizations actually operating simulation systems. I will focus on critical issues and pacing technology as requested by the survey questionnaire. For the critical issues, I would rate all the Simulation Benefits the highest rating of 5.

2. Critical issues near term 92-94.

a. In general accordance with the BDS-D Plan, the development of an Electronic Battlefield with weather effects, dynamic terrain, electronic warfare and sufficient numbers of objects/entities for realistic joint and combined arms warfighting by a battalion task force.

b. Demonstration of long haul and local networking of dissimilar simulators such as the high fidelity CSRDF at Moffett Field and the aviation simulators (AIRNET) at Ft. Rucker.

c. Conduct of the Rotorcraft Pilot Associate (RPA) ATTD in BDS-D with a real-time, man-in-the-loop electronic combined arms battlefield that includes the AH-64 and the RAH-66 COMANCHE as baseline models.

d. Conduct RAH-66 and AH-64 simulation demonstrations in BDS-D necessary to assess and evaluate related programs including COMANCHE Dem Val and EMD acquisition phases and LONGBOW.

3. Critical issues mid term 95-97.

a. Expansion of the Combined Arms Tactical Trainer (CATT) family including CCTT, AVCATT, ADCATT, and ENCATT.

b. Expansion of the BDS-D electronic combined arms battlefield to the division level with select government/industry/academic networking capability.

4. Critical issues far term 98-00. Expansion of the BDS-D electronic battlefield to joint task force/theater level to include coalition forces.

5. Pacing technology.

a. High speed and parallel processing computational capabilities in small, relatively low cost packages.

b. A range of low cost, low to high fidelity graphic and animation imagery.

c. Low cost reconfigurable simulators.

d. User friendly automated tools for building models at the labs and testing centers to include streamlined procedures for VV and A.

e. User friendly automated tools for rapidly building and modifying terrain data bases.

ANNEX B, APPENDIX 2, OPERATIONAL EVALUATION COMMAND, ALEXANDRIA, VA

a. CRITICAL ISSUES:

UTILITY TO AN INDEPENDENT OPERATIONAL EVALUATOR WHEN THE SYSTEM BEING SIMULATED DOES NOT EXIST: Using AIRNET for an example, it becomes very questionable whether the data gathered is indicative of system performance when you do not have the real thing to compare it to and past experience (APACHE) proves that the simulation and the aircraft are different. AIRNET will be programmed to perform according to system specifications. If the AIRNET Comanche is a success, then you would be tempted to assume that if the Comanche aircraft is built exactly to specification, then it would also be a success. Unfortunately, the relationship between programmed capabilities in a simulator and manufactured capabilities in an aircraft is not like looking in a mirror. It is more like creating an image and then trying to make a real item. More often than not you end up changing the image (the simulator), to reflect reality (the aircraft), instead of changing reality to reflect the image. Someday when the state of the art in software development is directly equivalent to the state of the art in aircraft development we may then be able to simulate a new aircraft and be assured that the real thing would perform exactly the same way. This would be a tremendous step forward and of great benefit to all on the operational side of the house. Until then, I believe the risk of relying on simulations for operational evaluations is much too great. If the technology relationship was equivalent then the ratings would be 5 for Effectiveness, 4 for Resources, 3 for Time and 2 for Safety.

b. UTILITY TO AN INDEPENDENT OPERATIONAL EVALUATOR WHEN THE SYSTEM BEING SIMULATED DOES EXIST: The credibility problem must have already been minimized by modifying the simulator to replicate the performance of the aircraft. When the point is reached that we have a high degree of confidence that the simulator is a true replica of the aircraft, we can then benefit from its use. The obvious benefit (rated as a 5), here is resource savings when the simulator would be used to perform real missions. Effectiveness would be rated a 4 and safety a 3.

c. NEW SIMULATION TECHNOLOGY:

It would be a tremendous benefit to have the state of the art in software development directly equivalent to the state of the art in aircraft development to enable us to simulate a new aircraft and be assured that the real thing would perform exactly the same way. R&D Cost considerations are rated as 5 for High Fidelity, 4 for Low total cost and 3 for Low unit cost.

d. NETWORKING:

The only LAN that we have is for administrative purposes within OPTEC and externally via PROFS. There is no other LAN or LHN within OPTEC. Since OEC evaluates the effectiveness and suitability of systems based on an operational test which is after the fact and not real time, no LAN/LHN or networking with the listed nodes/facilities is needed.

e. SIMULATION ATTRIBUTES:

Based on my comments in paragraph 7.a. above, I would have to rate the majority of them as very important as we are evaluating whether or not the system performs in a real operational sense. The only ones I would consider not important would be numbers 19, 20.5, 20.6, 20.7 and 23.

f. FUNDING:

No. This capability will evolve naturally at a smaller cost and with more reliability. The quantity of funding it would take to produce the capability now (if even the state of the art could produce it), would be financially devastating to all other efforts for years.

Richard A. Peak
RICHARD A. PEAK
MAJ AV
Aviation Evaluator

From: PEAK 12/2/91 3:49PM (3595 bytes: 55 ln)
PEAK
ect: COMMENTS ON MAJ PEAK'S RESPONSES TO IDA AVIATION SIM SURVEY
-------------------------- Message Contents --------------------------
MG Harrison, the paras below are comments from one of the action officers in our Policy and Methodology directorate. I printed this off of E-Mail. If you need it in memo form, I can do that for you. I Hope we have been of some help. I faxed you my comments this morning. (Maj. Rich Peak 703-756-2468/86)

1. "In the paragraph titled 'Current Simulation Plan,' the contractor (IDA) directs the respondent (the Aviation Evaluation Directorate, OEC) to 'Attach a description of the organization's plan for the use of simulators to address key issues.' Our higher headquarters, USAOPTEC may permit properly verified and validated simulation technology to supplement selected, specific areas of its continuous evaluation program for aviation. However, key issues will not be addressed exclusively through simulation. Also, the survey asks for 'current capabilities and planned new functionalities / enhancements and the funding profile for improvements.' Our directorate does not respond to questions on such programatic decisions. USAOPTEC has not recognized a need to become an active proponent for the development of simulation technology. Rather, USAOPTEC may assist in the development of simulation requirements when pertinent to its evalaution mission, or it may use simulation technology when available and accredited for accomplishing that mission. Additionally, USAOPTEC will only provide funding for simulation technology when it can directly contribute toward accomplishment of its mission."

2. The "Critical Issues" paragraph directs the respondent to "estimate the value of the simulation for each benefit." Only benefits are presented, but there is the possibility for extra costs also. If a simulation already exists, or can be quickly and easily modified, to satisfy an evaluation need, that is fine. On the other hand, concerns about resources, time, and effectiveness would have to be address in a case by case basis when such is not the case. Furthermore, the category "Save Resources" is insufficiently precise. It should be broken down to more specific subcategories such as personnel, funding, equipment, and instrumentation.

3. The "New Simulation Technology" paragraph again only addresses the positive. The "R & D Cost Considerations" should also consider mission accomplishment in a timely manner.

4. The "Networking" paragraph directs the respondent to rate many factors for the importance of networking in a simulation environment. Once more, the lack of specificity and implying only positive benefits makes it very difficult to address these factors. For example, the human factor, or "Need for man-in-the-loop" can never be separated from other functional factors within an objective evaluation. However, human factors include engineering and interfacing considerations; individual, crew, and team performance; and command and control. For another example, what is the definition of objects in order to rate the relative importance of "Number of objects." A final example is found in paragraphs 17 to 19, "Operations" include many distinct varieties, which can hardly be addressed as a single category.

ANNEX B, APPENDIX 3, ARMY AVIATION CENTER, FT. RUCKER, AL

ANNEX B, APPENDIX 3.1, DIRECTORATE OF TRAINING AND DOCTRINE, ARMY AVIATION CENTER, FT. RUCKER, AL

ARMY AVIATION SIMULATION SURVEY

Conducted by the Institute for Defense Analyses

Organization	**DOTD**	**Date 26 Dec 91**
Point of Contact	**COL Beauchamp**	**Phone 255-3320**

Current Simulation Plan:

Attach a description of the organization's plan for the use of simulations to address key issues. Indicate current capabilities and planned new functionalities/enhancements and the funding profile for improvements.

Critical Issues:

List below the critical issues facing your organization where there might be potential for the application of simulation if new technology were available. List the issues in order of importance. Please highlight requirements for simulation of joint and combined arms operations.

To the right of the issue are listed potential benefits from the use of simulation. Estimate the value of the simulation for each benefit using a scale of 1 to 5 with 5 being the best, most positive rating. (Please change "Benefit"headings and/or specify "Other" as appropriate for your organization/ mission.)

CRITICAL ISSUES:	SIMULATION BENEFITS				
	Save Resources	Save Time	Improve Effectiveness	Safety	Other
A. Collective training simulators linkedw/ interactive threat and operating in a combined arms arena.	5	5	5	4	
B. Aircraft survivability equipment training devices used during flight	3	3	5	2	
C. Keeping training devices current w/ aircraft configuration rapid reprogramming capability.	5	3	5	4	
D. Improve ground training prior to flight; both cognitive and hands on.	3	4	5	3	

New Simulation Technology:

Please identify, in order of importance, specific new simulation technology that would assist in addressing critical issues in your organization. (New simulation technology is defined as that which requires some level of research and development effort.) Please highlight requirements for simulation of joint and combined arms operations. To the right of the new capability/ functionality are listed R & D cost considerations. Indicate the relative importance of the considerations on a scale of 1 to 5 with 5 being the most important.

NEW CAPABILITY/FUNCTIONALITY	R & D COST CONSIDERATIONS			
	Speed in Developm't	Low Unit Cost	Low Total Cost	High Fidelity
E. Mission rehearsal capability on exact terrain using current threat data and at the projected time of day, wx, etc.	3	4	4	5
F. Train on new aircraft even before they are built.	4	4	4	3
G. Training against new weapon systems such as lasers, etc.	4	4	3	4
H. Identify degree of fidelity that is needed to train.	4	3	3	3
I. How much simulation is effective in training both cognitive and manual skills?	3	2	3	5

Networking:

Describe the local area network(s) (LAN), if applicable. If no LAN exists, is there a requirement for one? Describe the requirement.

- LAN should be capable of linking all visual simulators, the AIRNET site, and the simulator complexity test bed. The ability to use all or part of them at once is important.

Describe the long haul network(s) (LHN), if applicable. If no LHN exists, is there a requirement for one or more? Describe the requirement to include gateways and interface units. Include any plans, programs and the status of funding. Bandwidth requirements--56Kbps? T1 1.544 Mbps? DARPA's TWBNet?

Rate items 1 through 24 on a scale of 1 to 5 with 5 being the highest rating.

How important is it to your organization to network with the following nodes, LANs, facilities:

(Please comment using extra paper keying comments to the appropriate numbers below.)

Node/Facility	Rating
1. Aviation Testbed, BDS-D (AIRNET), at Ft. Rucker, AL	5
2. Crewstation Research and Development Facility (CSRDF), Moffett Field, CA	4
3. Air Combat Mission Enhancement (ACME), Williams AFB, AZ	2
4. Visual Technology Research Simulator, Naval Training Center, Orlando, FL	2
5. Institute for Simulation and Training, Orlando, FL	2

How important to your organization are the following simulation attributes? Answer for "a just barely good enough--60% solution," recognizing that funding is extremely tight. (Please comment as desired, using extra paper keying comments to the appropriate numbers below.)

8. Need for interoperability with other simulators/simulations?	5
9. Need for man-in-the-loop?	5
10. Fidelity in:	
10.1 Visuals?	4
10.1.1 Diurnal cycle?	4
10.1.2 Shadows?	4
10.1.3 Weather?	4
10.1.3.1 Clouds?	2
10.1.3.2 Rain?	4
10.1.3.3 Snow?	4
10.1.3.4 Fog	4
10.1.4 Smoke?	5
11. Field of view?	3
12. Terrain data base?	4
13. Dynamic terrain?	4
14. Weapons effects?	5
14.1 Ph, Pk?	5
14.2 Trajectory?	3
14.3 Signature?	5
14.3.1 Visual?	4
14.3.2 IR?	4
14.3.3 Radar?	4
14.3.4 Acoustical?	3
14.3.5 Directed energy weapons?	3
15. Vehicle signature?	4
15.1 Visual?	5
15.2 IR?	4
15.3 Radar?	2
15.4 Acoustical?	2
16. Need for semi-automated forces (SAF)?	5
17. Operations with combined arms team?	5
18. Operations with other Services?	4
19. Operations with other nations?	3
20. Number of objects?	4
20.1 Include 10 objects?	5
20.2 Include 50 objects?	5
20.3 Include 100 objects?	3
20.3 Include 500 objects?	3

	20.5 Include 1000 objects?	3
	20.6 Include 5000 objects?	2
	20.7 Include 10000 objects?	2
21.	Combat service support - RAM - impact?	4
22.	Electronic warfare?	4
	22.1 ECM?	5
	22.2 ECCM?	5
	22.3 EMP?	2
23.	Mobility of the simulator/simulation?	4
	23.1 Vehicle mounted?	3
	23.2 Portable by vehicle?	5
24.	V & V, Accreditation of models?	5

Funding: If you had the authority to reprogram your funding, would you do so to achieve the simulation capabilities you have indicated are needed? Yes_X__. No___.

ANNEX B, APPENDIX 3.2, DIRECTORATE OF COMBAT DEVELOPMENTS, ARMY AVIATION CENTER, FT. RUCKER, AL

ARMY AVIATION SIMULATION SURVEY

Conducted by the Institute for Defense Analyses

Organization DCD Ft. Rucker, AL **Date** 9 Jan 92

Point of Contact COL Ted Sendak **Phone** AV 558-3203

Current Simulation Plan:

Attach a description of the organization's plan for the use of simulations to address key issues. Indicate current capabilities and planned new functionalities/enhancements and the funding profile for improvements.

Critical Issues:

List below the critical issues facing your organization where there might be potential for the application of simulation if new technology were available. List the issues in order of importance. Please highlight requirements for simulation of joint and combined arms operations.

To the right of the issue are listed potential benefits from the use of simulation. Estimate the value of the simulation for each benefit using a scale of 1 to 5 with 5 being the best, most positive rating. (Please change "Benefit"headings and/or specify "Other" as appropriate for your organization/ mission.)

CRITICAL ISSUES:	SIMULATION BENEFITS				
	Save Resources	Save Time	Improve Effectiveness	Safety	Other
A. Future Aviation Organizations	4	3	5	2	1
B. Aviation C3 Interface w/i and externally	5	3	4	2	1
C. Aviation Operational Concepts to Develop Doctrine	4	1	5	3	2
D. Concept evaluation for many hardware improvements to Aviation System	5	2	4	3	1

New Simulation Technology:

Please identify, in order of importance, specific new simulation technology that would assist in addressing critical issues in your organization. (New simulation technology is defined as that which requires some level of research and development effort.) Please highlight requirements for simulation of joint and combined arms operations. To the right of the new capability/

functionality are listed R & D cost considerations. Indicate the relative importance of the considerations on a scale of 1 to 5 with 5 being the most important.

NEW CAPABILITY/FUNCTIONALITY	R & D COST CONSIDERATIONS			
	Speed in Developm't	Low Unit Cost	Low Total Cost	High Fidelity
E. Accurate simulation of all weapon capabilities/easily modified	4	3	3	5
F. Accurate simulation of all environmental conditions to include night, weather, dust, winds thermal cross over, etc.	4	3	3	5
G. Ability to interface high and low resolution simulators	2	4	4	5
H. Ability to change all system parameters easily at a keyboard, i.e., built into the hardware and software to be user friendly	5	4	4	3

Networking:

Describe the local area network(s) (LAN), if applicable. If no LAN exists, is there a requirement for one? Describe the requirement.

- LAN for Ft. Rucker would join all of our resolution training simulation w/the BDS-D/AVCAT simulators.
- Within the simulation systems, the LAN would tie into the Army tactical command and control system and other joint & combined C&C systems as appropriate.

Describe the long haul network(s) (LHN), if applicable. If no LHN exists, is there a requirement for one or more? Describe the requirement to include gateways and interface units. Include any plans, programs and the status of funding. Bandwidth requirements--56Kbps? T1 1.544 Mbps? DARPA's TWBNet?

- Long haul is key for both training and developmental efforts to get the combined area properly exercised. Joint & combined efforts also have great potential. The LHN will have to handle gigabits of info through satellite links to pull all of this together.

Rate items 1 through 24 on a scale of 1 to 5 with 5 being the highest rating.

How important is it to your organization to network with the following nodes, LANs, facilities:

(Please comment using extra paper keying comments to the appropriate numbers below.)

Node/Facility	Rating
1. Aviation Testbed, BDS-D (AIRNET), at Ft. Rucker, AL	That's us
2. Crewstation Research and Development Facility (CSRDF), Moffett Field, CA	5
3. Air Combat Mission Enhancement (ACME), Williams AFB, AZ	2

4.	Visual Technology Research Simulator, Naval Training Center, Orlando, FL	4
5.	Institute for Simulation and Training, Orlando, FL	2
6.	Other: Industries simulators as required for RDT&E programs	3
7.	Other: Aviation units worldwide (AIRNET)	3

How important to your organization are the following simulation attributes? Answer for "a just barely good enough--60% solution," recognizing that funding is extremely tight. (Please comment as desired, using extra paper keying comments to the appropriate numbers below.)

8. Need for interoperability with other simulators/simulations?	4
9. Need for man-in-the-loop?	5
10. Fidelity in:	
10.1 Visuals?	4
10.1.1 Diurnal cycle?	4
10.1.2 Shadows?	4
10.1.3 Weather?	4
10.1.3.1 Clouds?	3
10.1.3.2 Rain?	4
10.1.3.3 Snow?	4
10.1.3.4 Fog	4
10.1.4 Smoke?	4
11. Field of view?	3
12. Terrain data base?	3
13. Dynamic terrain?	3
14. Weapons effects?	5
14.1 Ph, Pk?	5
14.2 Trajectory?	5
14.3 Signature?	5
14.3.1 Visual?	4
14.3.2 IR?	4
14.3.3 Radar?	3
14.3.4 Acoustical?	1
14.3.5 Directed energy weapons?	4
15. Vehicle signature?	4
15.1 Visual?	4
15.2 IR?	4
15.3 Radar?	4
15.4 Acoustical?	1
16. Need for semi-automated forces (SAF)?	5
17. Operations with combined arms team?	5
18. Operations with other Services?	3
19. Operations with other nations?	2

20.	Number of objects?	4
	20.1 Include 10 objects?	___
	20.2 Include 50 objects?	___
	20.3 Include 100 objects?	Minimum
	20.3 Include 500 objects?	___
	20.5 Include 1000 objects?	___
	20.6 Include 5000 objects?	___
	20.7 Include 10000 objects?	___
21.	Combat service support - RAM - impact?	3
22.	Electronic warfare?	4
	22.1 ECM?	4
	22.2 ECCM?	4
	22.3 EMP?	1
23.	Mobility of the simulator/simulation?	1
	23.1 Vehicle mounted?	1
	23.2 Portable by vehicle?	1
24.	V & V, Accreditation of models?	5

Funding: If you had the authority to reprogram your funding, would you do so to achieve the simulation capabilities you have indicated are needed? Yes_X__. No___.

- Under our old funding levels, yes. Today, I barely have enough to pay my civilians, no.

ANNEX B, APPENDIX 3.3, ARI AVIATION R&D ACTIVITY,
FT. RUCKER, AL

ARMY AVIATION SIMULATION SURVEY

Conducted by the Institute for Defense Analyses

Organization **Army Research Institute Aviation R&D Activity** **Date 29 Jan 92**

Point of Contact **Charles A. Gainer** **Phone (205) 255-4404**

Current Simulation Plan:

Attach a description of the organization's plan for the use of simulations to address key issues. Indicate current capabilities and planned new functionalities/enhancements and the funding profile for improvements.

Critical Issues:

List below the critical issues facing your organization where there might be potential for the application of simulation if new technology were available. List the issues in order of importance. Please highlight requirements for simulation of joint and combined arms operations.

To the right of the issue are listed potential benefits from the use of simulation. Estimate the value of the simulation for each benefit using a scale of 1 to 5 with 5 being the best, most positive rating. (Please change "Benefit"headings and/or specify "Other" as appropriate for your organization/ mission.)

CRITICAL ISSUES:	SIMULATION BENEFITS				
	Save Resources	Save Time	Improve Effectiveness	Safety	Other
A. Use in Primary Flight Training	x		x		
B. Modular/Portable Devices	x	x	x		
C. Tactical Training Requirements Sustainment of Skills	x		x	x	
D. Fidelity Issues in Training Systems	x		x		

New Simulation Technology:

Please identify, in order of importance, specific new simulation technology that would assist in addressing critical issues in your organization. (New simulation technology is defined as that which requires some level of research and development effort.) Please highlight requirements for simulation of joint and combined arms operations. To the right of the new capability/functionality are listed R & D cost considerations. Indicate the relative importance of the considerations on a scale of 1 to 5 with 5 being the most important.

• Current Simulation Plan: STRATA - Simulation Training Research Advanced Testbed for Aviation

Descriptions: The flight simulator will include software modules based on distributed processing for mission support, experimenter/operator station actions, threats, visual environment, control loading, sensors, navigation and communications, aural cues, and flight aerodynamics. The FOHMD with eye tracking will be used for the pilot stations while the second crew station will use a backlit CRT screen(s). A relational database will be used to create tactical scenarios and control sites, intelligent companions and adversaries, weapons, site interaction with terrain, gaming area weather, and the visual interface. The database is referred to as ITEMS (Interactive Tactical Environment Management System).

The STRATA will be unique, versatile, flexible, and reconfigurable. It will encompass the RAH-66 crew station design and flight dynamics.

NEW CAPABILITY/FUNCTIONALITY	R & D COST CONSIDERATIONS			
	Speed in Developm't	Low Unit Cost	Low Total Cost	High Fidelity
E. Modularity/Portability	x	x	x	
F. Air-to-air Training			x	x

Networking:

Describe the local area network(s) (LAN), if applicable. If no LAN exists, is there a requirement for one? Describe the requirement.

• None available. There is a requirement for placing dissimilar high fidelity simulators in the same environment and to interface with local low fidelity devices to increase active players.

Describe the long haul network(s) (LHN), if applicable. If no LHN exists, is there a requirement for one or more? Describe the requirement to include gateways and interface units. Include any plans, programs and the status of funding. Bandwidth requirements--56Kbps? T1 1.544 Mbps? DARPA's TWBNet?

• No; long haul plans do exist for tieing CSRDF and STRATA together.

Rate items 1 through 24 on a scale of 1 to 5 with 5 being the highest rating.

How important is it to your organization to network with the following nodes, LANs, facilities:

(Please comment using extra paper keying comments to the appropriate numbers below.)

Node/Facility	Rating
1. Aviation Testbed, BDS-D (AIRNET), at Ft. Rucker, AL	5
2. Crewstation Research and Development Facility (CSRDF), Moffett Field, CA	5
3. Air Combat Mission Enhancement (ACME), Williams AFB, AZ	4
4. Visual Technology Research Simulator, Naval Training Center, Orlando, FL	2

5.	Institute for Simulation and Training, Orlando, FL	2
6.	Other: Simulator Training Research Advanced Testbed for Aviation (STRATA)	5
7.	Other: AH-64/AH-1, Ft. Rucker	4

How important to your organization are the following simulation attributes? Answer for "a just barely good enough--60% solution," recognizing that funding is extremely tight. (Please comment as desired, using extra paper keying comments to the appropriate numbers below.)

8. Need for interoperability with other simulators/simulations?	4
9. Need for man-in-the-loop?	5
10. Fidelity in:	
10.1 Visuals?	5
10.1.1 Diurnal cycle?	5
10.1.2 Shadows?	4
10.1.3 Weather?	5
10.1.3.1 Clouds?	5
10.1.3.2 Rain?	5
10.1.3.3 Snow?	5
10.1.3.4 Fog	5
10.1.4 Smoke?	5
11. Field of view?	5
12. Terrain data base?	5
13. Dynamic terrain?	
14. Weapons effects?	
14.1 Ph, Pk?	
14.2 Trajectory?	
14.3 Signature?	
14.3.1 Visual?	4
14.3.2 IR?	4
14.3.3 Radar?	4
14.3.4 Acoustical?	3
14.3.5 Directed energy weapons?	3
15. Vehicle signature?	4
15.1 Visual?	5
15.2 IR?	4
15.3 Radar?	2
15.4 Acoustical?	2
16. Need for semi-automated forces (SAF)?	5
17. Operations with combined arms team?	5
18. Operations with other Services?	4
19. Operations with other nations?	3
20. Number of objects?	4
20.1 Include 10 objects?	5

20.2 Include 50 objects?	5
20.3 Include 100 objects?	3
20.3 Include 500 objects?	3
20.5 Include 1000 objects?	3
20.6 Include 5000 objects?	2
20.7 Include 10000 objects?	2
21. Combat service support - RAM - impact?	4
22. Electronic warfare?	4
22.1 ECM?	5
22.2 ECCM?	5
22.3 EMP?	2
23. Mobility of the simulator/simulation?	4
23.1 Vehicle mounted?	3
23.2 Portable by vehicle?	5
24. V & V, Accreditation of models?	5

Funding: If you had the authority to reprogram your funding, would you do so to achieve the simulation capabilities you have indicated are needed? Yes_X__. No___.

ANNEX B, APPENDIX 4, AVIATION SYSTEMS COMMAND, ST. LOUIS

ANNEX B, APPENDIX 4.1, AVIATION APPLIED TECHNOLOGY DIRECTORATE, AVSCOM, FT. EUSTIS, VA

ARMY AVIATION SIMULATION SURVEY

Conducted by the Institute for Defense Analyses

Organization Aviation Applied Tech. Dir., AVSCOM-Ft. Eustis **Date** 3 Dec 91

Point of Contact John A. Macrino **Phone** (804) 878-2122

Current Simulation Plan:

Attach a description of the organization's plan for the use of simulations to address key issues. Indicate current capabilities and planned new functionalities/enhancements and the funding profile for improvements.

Critical Issues:

List below the critical issues facing your organization where there might be potential for the application of simulation if new technology were available. List the issues in order of importance. Please highlight requirements for simulation of joint and combined arms operations.

To the right of the issue are listed potential benefits from the use of simulation. Estimate the value of the simulation for each benefit using a scale of 1 to 5 with 5 being the best, most positive rating. (Please change "Benefit"headings and/or specify "Other" as appropriate for your organization/ mission.)

CRITICAL ISSUES:	SIMULATION BENEFITS				
	Save Resources	Save Time	Improve Effectiveness	Safety	Other
A. Subsystems effectiveness relative to total sys effort (i.e., weapons, comm, NAV, ASE, etc.)	3	4	5		
B. Man/machine system effectiveness	4	3	5		
C. Definition of critical operation test parameters	4	5	3		
D. Man/machine training (team trng)	5	2	4	3	

New Simulation Technology:

Please identify, in order of importance, specific new simulation technology that would assist in addressing critical issues in your organization. (New simulation technology is defined as that which requires some level of research and development effort.) Please highlight requirements for simulation of joint and combined arms operations. To the right of the new capability/

functionality are listed R & D cost considerations. Indicate the relative importance of the considerations on a scale of 1 to 5 with 5 being the most important.

NEW CAPABILITY/FUNCTIONALITY	R & D COST CONSIDERATIONS			
	Speed in Developm't	Low Unit Cost	Low Total Cost	High Fidelity
E. Adv. technology subsystem models	4	5	5	2
F. LHN to AIRNET	4	5	5	2

Networking:

Describe the local area network(s) (LAN), if applicable. If no LAN exists, is there a requirement for one? Describe the requirement.

- Ethernet

Describe the long haul network(s) (LHN), if applicable. If no LHN exists, is there a requirement for one or more? Describe the requirement to include gateways and interface units. Include any plans, programs and the status of funding. Bandwidth requirements--56Kbps? T1 1.544 Mbps? DARPA's TWBNet?

- Currently none. LHN req to AIRNET/BDS-D and industry.

Rate items 1 through 24 on a scale of 1 to 5 with 5 being the highest rating.

How important is it to your organization to network with the following nodes, LANs, facilities:

(Please comment using extra paper keying comments to the appropriate numbers below.)

Node/Facility	Rating
1. Aviation Testbed, BDS-D (AIRNET), at Ft. Rucker, AL	5
2. Crewstation Research and Development Facility (CSRDF), Moffett Field, CA	2
3. Air Combat Mission Enhancement (ACME), Williams AFB, AZ	2
4. Visual Technology Research Simulator, Naval Training Center, Orlando, FL	3
5. Institute for Simulation and Training, Orlando, FL	2
6. Rotorcraft Industry	5

How important to your organization are the following simulation attributes? Answer for "a just barely good enough--60% solution," recognizing that funding is extremely tight. (Please comment as desired, using extra paper keying comments to the appropriate numbers below.)

8. Need for interoperability with other simulators/simulations?	3
9. Need for man-in-the-loop?	5

10. Fidelity in:	
10.1 Visuals?	4
10.1.1 Diurnal cycle?	4
10.1.2 Shadows?	3
10.1.3 Weather?	4
10.1.3.1 Clouds?	4
10.1.3.2 Rain?	4
10.1.3.3 Snow?	4
10.1.3.4 Fog	4
10.1.4 Smoke?	3
11. Field of view?	4
12. Terrain data base?	5
13. Dynamic terrain?	4
14. Weapons effects?	5
14.1 Ph, Pk?	5
14.2 Trajectory?	4
14.3 Signature?	4
14.3.1 Visual?	4
14.3.2 IR?	4
14.3.3 Radar?	4
14.3.4 Acoustical?	3
14.3.5 Directed energy weapons?	3
15. Vehicle signature?	5
15.1 Visual?	5
15.2 IR?	4
15.3 Radar?	5
15.4 Acoustical?	4
16. Need for semi-automated forces (SAF)?	4
17. Operations with combined arms team?	5
18. Operations with other Services?	4
19. Operations with other nations?	3
20. Number of objects?	
20.1 Include 10 objects?	1
20.2 Include 50 objects?	1
20.3 Include 100 objects?	3
20.3 Include 500 objects?	5
20.5 Include 1000 objects?	4
20.6 Include 5000 objects?	4
20.7 Include 10000 objects?	3
21. Combat service support - RAM - impact?	4

22. Electronic warfare?	5
22.1 ECM?	5
22.2 ECCM?	5
22.3 EMP?	4
23. Mobility of the simulator/simulation?	3
23.1 Vehicle mounted?	3
23.2 Portable by vehicle?	3
24. V & V, Accreditation of models?	4

Funding: If you had the authority to reprogram your funding, would you do so to achieve the simulation capabilities you have indicated are needed? Yes_X__. No__ .

ANNEX B, APPENDIX 4.2

SIMULATION AND AIRCRAFT SYSTEMS DIVISION, AVSCOM

RDEC SIMULATION PLAN

TEAM RDEC

SIMULATION PLAN

Prepared by:
Simulation and Aircraft Systems Division
Aeroflightdynamics Directorate
Ames Research Center
Moffett Field, CA 94035

December 5, 1991

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FIGURES

TABLES

SIMULATION PLAN

1. BACKGROUND

1.1 Topic Overview

Aeronautical flight simulation is an accepted part of air vehicle research and development in both the fixed wing and rotary wing domains. As the number of complex, interacting capabilities incorporated into the aircraft increases, both analytical and man-in-the-loop flight simulators are increasingly relied upon to support the integration of avionics, flight/propulsion controls, handling qualities and crew systems. Simulators are used throughout the life cycle of the air vehicle, from the conceptual stage, through product development, operational evaluation, pilot training, and product improvement. Based on past history, flight simulators used at the design stage also continue to play a critical role in analyzing the root causes of accidents and operational problems after new aircraft are put to service. This is because the R&D simulator's models support the extrapolation of unusual operational or environmental effects, which is generally not possible with training devices.

LIFE CYCLE USES OF SIMULATORS

- Air-Vehicle Concept Evaluation
- Performance Specification
- Product Engineering and Development
- Air-Vehicle Testing and Certification
- Aircrew Training
- Post-Accident Analysis
- Product Improvement

Figure 1-1. R&D Uses of Simulators During the Air-Vehicle Life Cycle

1.2 R&D Simulation Domains

The early, real-time flight simulators developed in the 1960s and 1970s by the Navy, Air Force and NASA focused primarily on flight control and handling qualities.

Several national facilities were built that incorporated large excursion, high fidelity motion systems, and these were used to study take off, approach to landing, and various air combat maneuvering segments of flight. As graphics display technology improved, and greater concern developed for the hazardous consequences of human error, a different class of R&D simulator emerged in the early 1980s to address human factors and man-machine integration problems. These focused on crew station design, pilot workload, crew coordination, cockpit resource management and stress effects on the pilot. By the end of the decade, this evolving technology led into the emergence of flight simulators to deal with combat team performance and related measures of mission performance effectiveness. At the same time, the evolution of modern computer workstations bolstered by the growth of information science, led to the development of product design tools based on simulation methods and models. In the 1990s, further evolution of these capabilities using national and worldwide networking will provide a means for evaluating notional weapon systems operating in hypothetical, multi-mission battlefield environments. Based on these developments, it is clear that flight simulations will will contribute most when used on a concurrent basis with other engineering efforts to reduce development risk and improve system effectiveness during the entire life cycle of the equipment. This will also provide a foundation for performance assessment at a variety of levels prior to full scale development, while making maximum use of "lessons learned" from feedback provided through safety diagnosis.

R&D ISSUES ADDRESSED IN SIMULATORS

- Flight Control and Handing Qualities
- Man-Machine Integration
- Controls and Displays
- Cockpit Automation
- Crew Station Design
- Aircraft, Crew, and Mission Performance
- Safety Analysis

Figure 1-2. Primary Domains for R&D Flight Simulation

1.3 AVSCOM Simulation Capabilities

Although detailed facility summaries are presented elsewhere in this report (see Appendix), it should be noted that AVSCOM has consistently supported the development of a wide range of flight simulators that are presently being used to address important, current R&D problems. The large excursion Vertical Motion Simulator (VMS) was developed at NASA-Ames to allow systematic examination of handling qualities and flight controls. This facility has also been used to conduct post-accident investigations, and to determine engineering design limitations of various aircraft. AVSCOM recently completed the Crew Station R&D Facility, also located at NASA Ames, to address generic issues of crew complement, cockpit information integration, and full-mission combat performance.

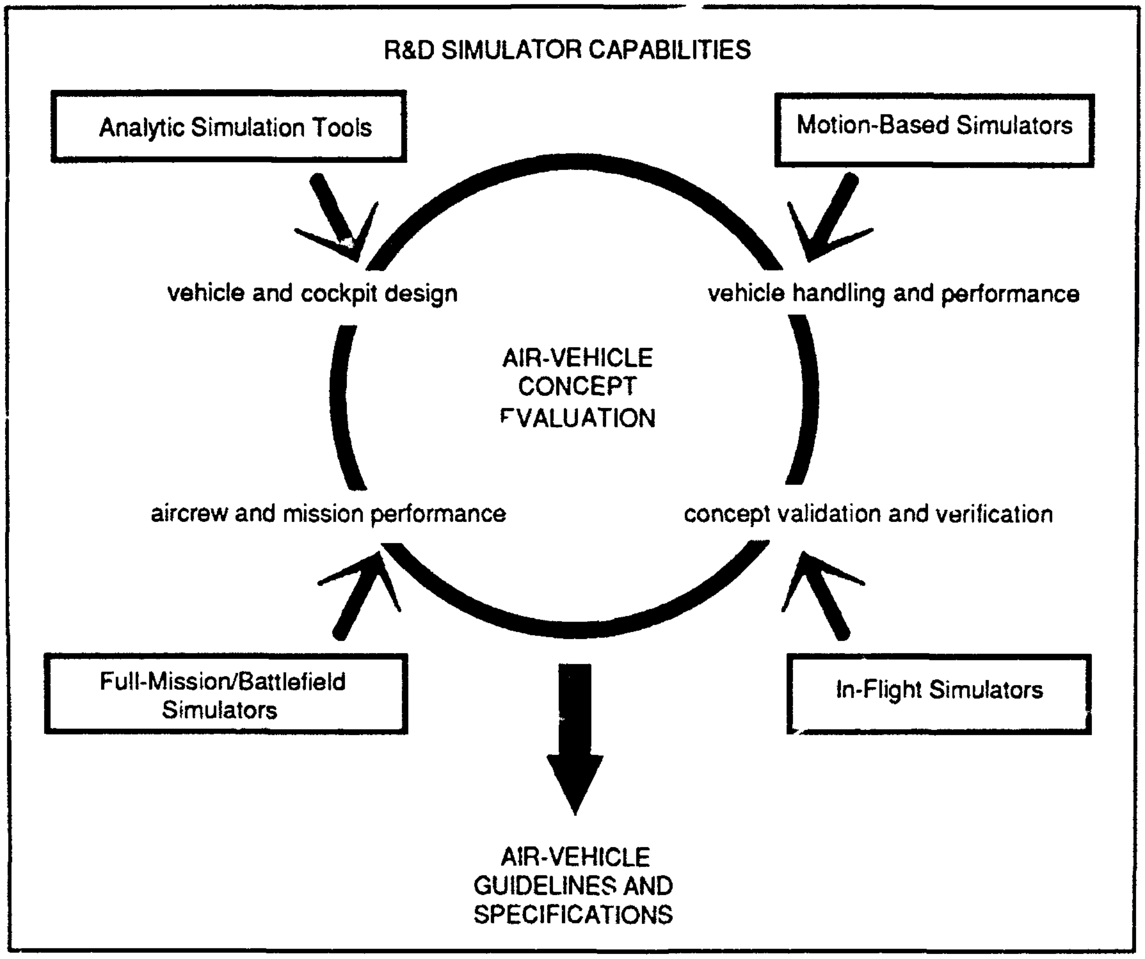


Figure 1-3. Types and Purposes of R&D Simulators

The facility has already played a key roll in familiarization of LH pilot evaluation teams, so that they could effectively critique high-technology contractor proposals. Non-real-time analytic tools for cockpit analysis/synthesis have been developed in the Army-NASA Aircrew/Aircraft Integration (A^3I) program, and are now being used. For example, Boeing design engineers on Comanche have stated an intention to use A^3I software products during the design process. At the other end of the spectrum the development of in-flight simulation capabilities have been supported by AVSCOM for the domains of handling qualities, human factors, and avionics integration. These capabilities allow systematic verification and validation of ground based development efforts. Finally, AVSCOM has supported the concept of networking these and other Department of Defense simulation capabilities to allow evaluations of integrated battlefield performance.

1.4 Classes and Use of Simulators

Although sharing a great deal of underlying technology, a fundamental distinction exists between simulators used for training versus R&D. In general, training simulators, which are not considered to be a part of the RDEC mission, are designed to familiarize students with fielded aircraft. Hence, they are built to mimic the exact form and function of a specific vehicle, based on the concept that the higher the level of perceived realism to the trainee the greater the positive transfer of training that will result. Offsetting the cost of making training simulators "face valid" in this way, they often use rather minimal end-effect models that do not reflect the true complexity of vehicle dynamics, propulsion, controls, or avionic subsystems that are so necessary in the R&D environment.

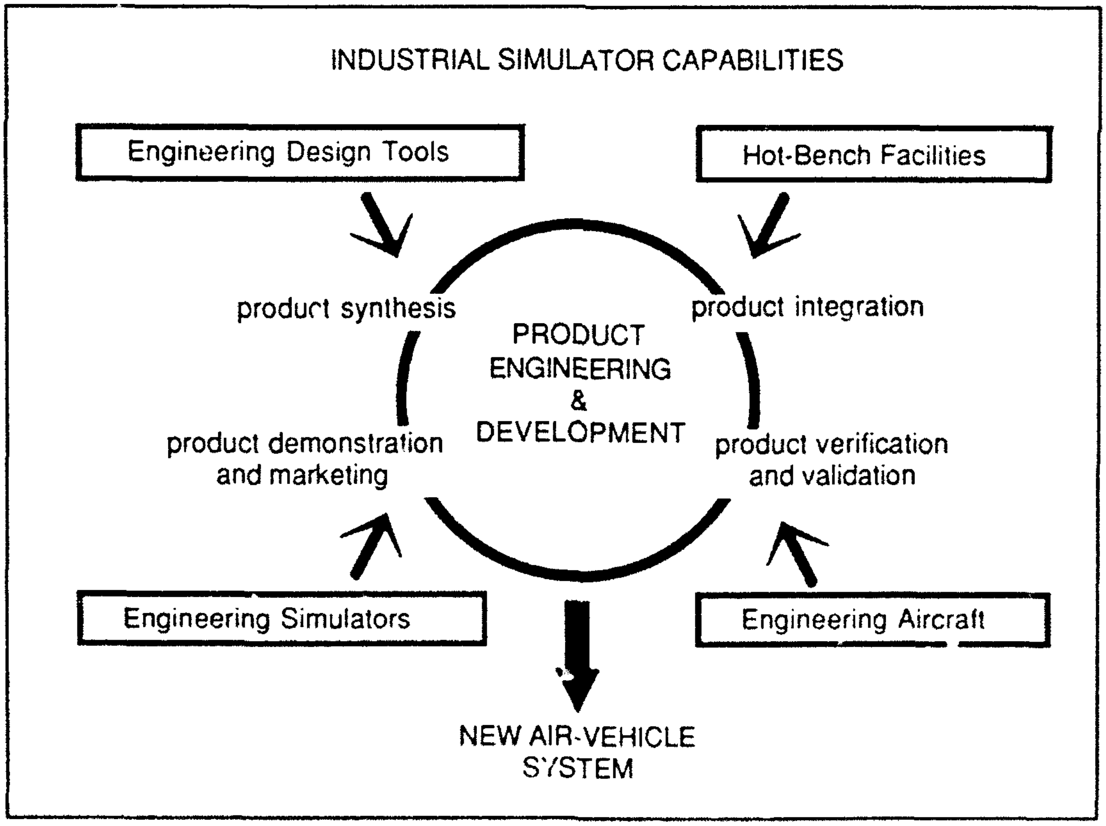


Figure 1-4. Types and Purposes of Engineering Simulators

R&D simulators, in contrast, are optimized in the opposite manner. In order to facilitate the exploration of advanced vehicle concepts it is usually adequate to employ a "generic" vehicle structure. This is supported, however, by dynamic computer models of sufficient complexity to reflect the intricacies of blade dynamics, propulsion/control response, avionic subsystem performance, and pilot decision aiding systems. A key provision in all R&D simulators is to retain the flexibility needed to meet a chronic demand for emulating new design concepts, unusual environmental conditions, or complex combat situations.

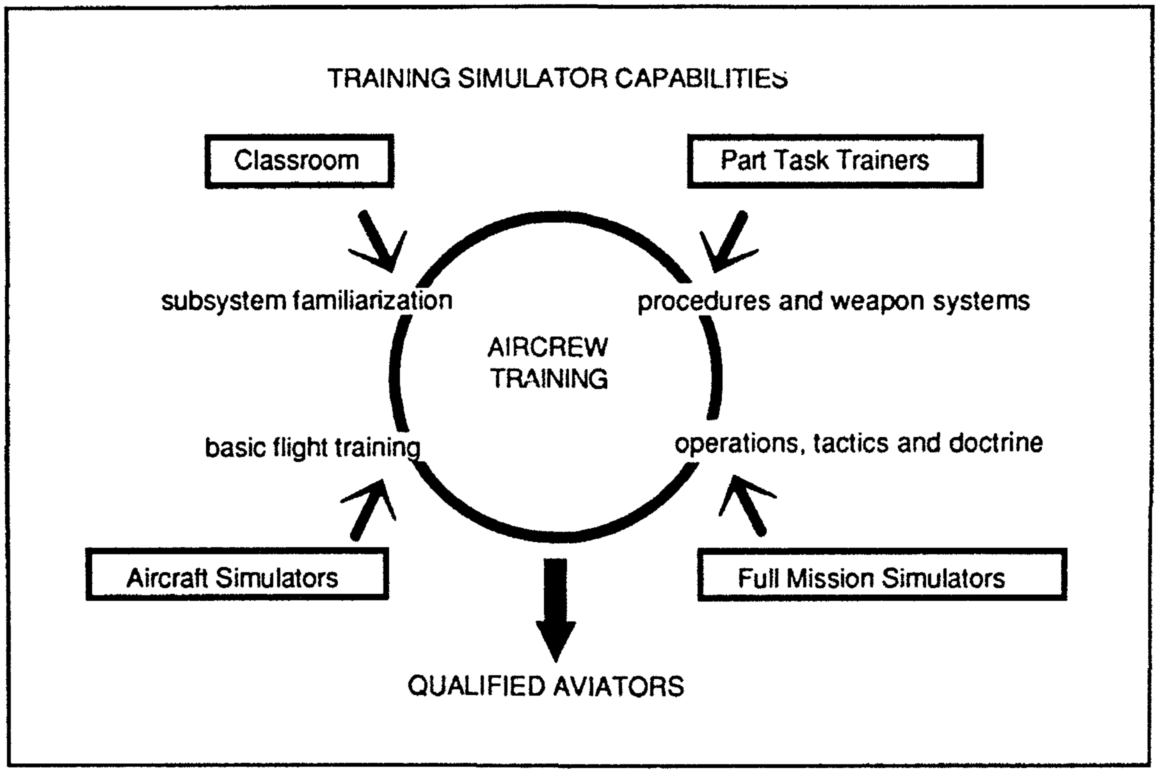


Figure 1-5. Types and Purposes of Training Simulators

Depending on the issues being considered, R&D simulators are used in a variety of modes to satisfy the statistical rigor demanded by the research design. These include part-task, part-mission, full mission and, in some cases, multi-mission or "warfighting" configurations. It should be noted, therefore, that the particular mode of simulation that is chosen is not only dictated by the boundary capabilities of the simulator, but also by the particular problems under consideration. Again, this fundamental flexibility of R&D simulators brings to the acquisition process the ability to support vehicle design, development, and product improvement programs. It also provides a supporting technology base for investigating new aspects of flight management and man-machine integration that could not be modeled in any other manner.

1.5 Concurrent Engineering and R&D Simulation

The philosophy of concurrent engineering, which has recently been adopted by AMC (reference 13), places strong emphasis on the "total integrated life cycle approach." This concept is fully consistent with an expanded reliance on simulation, which can be expected to provide a foundation for many parallel engineering activities, functional evaluations, performance assessments, training and doctrine exercises, and safety analyses.

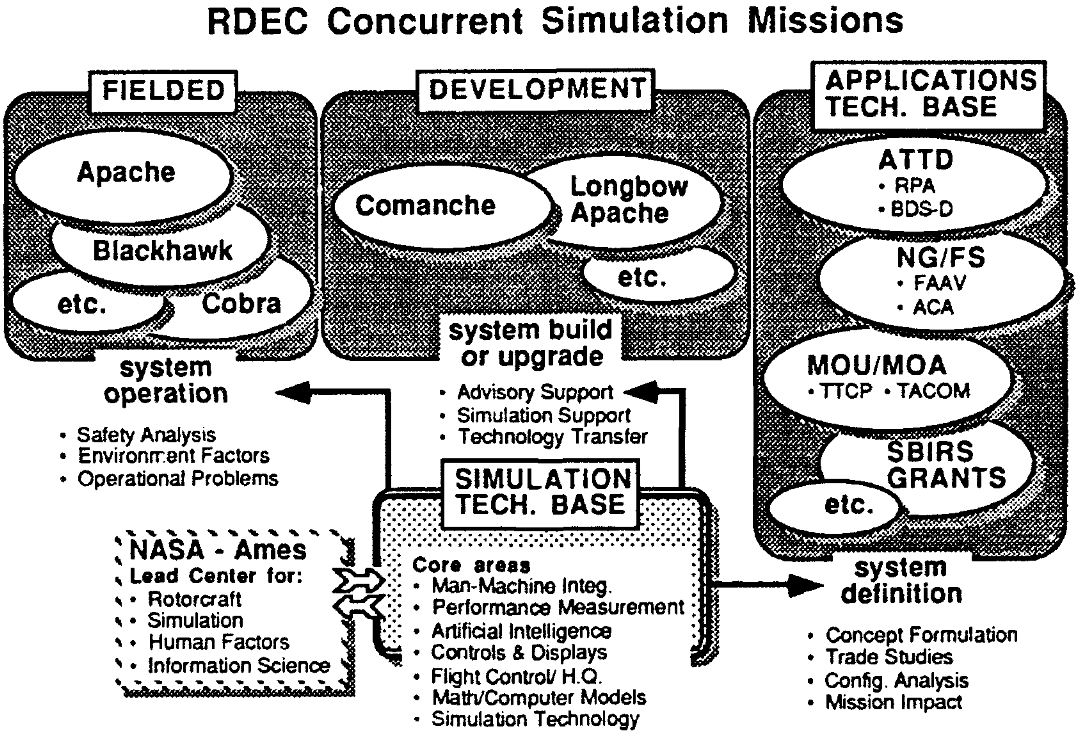


Figure 1-6. The RDEC Foundation for Concurrent Simulation

1.6. R&D Simulation Infrastructure and Missions

Referring to Figure 1-6, the RDEC's Simulation activity gives highest priority to supporting Fielded Systems and Systems under Development. Here, operational and contract demands often dictate that attention be focused on critical issues which the simulation staff can support on an advisory or consulting basis. Where it appears to be valuable, the staff also become involved with safety analyses, in-house simulation studies, and the transfer of simulation models and design tools to contractors. Absent time critical demands, there is an ongoing requirement to nurture emerging system concepts. These are shown as part of the Applications Tech. Base, and involve a wide range of interrelated activities including: (a) innovative research through university grants and SBIR contracts, (b) technical coordination with colleagues worldwide based on MOUs/MOAs, (d) team participation in NG/FS studies and (d) teaming with other organizations to support specific ATTDs.

It should be noted that the knowledge and experience gained from dealing with Fielded Systems and Development Systems issues provides a rich context for innovative concepts that may be applied to Next Generation/Future Systems. This involvement with "real problems," however, is not fully sufficient to maintain a support capability, because the staff must also have technical currency in a number of core discipline areas. In short, in order to be able to meet application challenges effectively, it is essential that expertise be maintained in the following generic areas which together constitute the *Simulation Tech. Base*:

- Man-Machine Integration - research into basic principles of operator-vehicle interaction.
- Performance Measurement - methods for the study of pilot, crew, aircraft system, or combat team behavior.
- Artificial Intelligence - methods to support "intelligent simulation," and the emulation of intelligent cockpit technology.
- Controls & Displays - devices used specifically for the exchange of information between man and machine.
- Flight Control & Handling Qualities - application of control theory to understand vehicle maneuverability or agility.
- Mathematical/Computer Modeling - application of static and dynamic modeling to mimic machine systems, force representation, human performance, or human cognition.
- Simulation Technology - use of computer science, graphics and psychophysical knowledge to create perceptual realism.

Given this technical capability, and staff to perform needed liaison functions (e.g., with PMs, ATTD leaders, and AVSCOM H.Q.), a highly effective program will exist to support systems technology throughout the equipment life cycle. A separate sections (see Appendix) summarize current Simulation Tech. Base resources.

2. APPLICABLE DOCUMENTS

1. Letter from Kirkwood, James S., dated 9 October 1991, Subject: U.S. Army Aviation Systems Command Aviation Research, Development, and Engineering Center (RDEC) Business Planning Process.

2. Letter from Borowski, Richard A., dated 7 October 1991 to "To All JDL Air Vehicle Panel Members", subject "Development of JDL Air Vehicle Technology Panel Joint Plan"

3. Mission and Function Statements, Aeroflightdynamics Directorate

4. AMC Vision, Strategy and Environment, dated 30 August 1991, prepared for the AMC Deputy Chief of Staff for Management and AMC Business Plans Working Group

5. AMC RDEC Priorities List, untitled or dated

6. AVSCOM Flight Simulation and Man-Machine Integration Program, dated 13 February 1991, Aviation RDE Center Program Review briefing charts

7. Memorandum titled "Army Aviation Modernization Plan (AAMP) 1991 Update", received from Basket, Barry J., AMSAV-NBM (5-5c) on July 5, 1991 with enclosure "Army Aviation Modernization Plan 1991" prepared by U.S. Army Aviation Systems Command and U.S. Army Aviation Center.

8. Memorandum titled "Army Aviation Program Plan (AAPP) 1991 Update", received from Basket, Barry J., AMSAV-NBM (5-5c) on October 11, 1991 with enclosure "Army Aviation Program Plan, Annex A" to the AAMP 1991 prepared by U.S. Army Aviation Systems Command PEO for Aviation and U.S. Army Aviation Center.

9. Army Technology Base Master Plan, Volumes I and II, November 1990.

10. Light Helicopter Program (LH), Development Program, System Specification 2000-315-512-1, dated 22 February 1991.

11. Light Helicopter Program (LH), Development Program, Technical/Airworthiness Qualification SOW 2000-315-512-2, dated 22 February 1991.

12. AVSCOM Annual Aviation RDE Center Report, FY 90.

13. Letter from Billy M. Thomas, Lt Gen., U.S. Army, AMC, to Dr. Richard G. Rhoades, MICOM, dated August 26, 1991.

14. AVSCOM Regulation, AVSCOMR10-1, Organization, Mission and Functions; Headquarters, U.S. Army Aviation Systems Command, 1 March 1989.

15. ARTA Regulation 10-1, Organization and Functions; Mission and Major Functions of the U.S. Army Aviation Research and Technology Activity; Headquarters, U.S. Army Aviation Research and Technology Activity, 1 October 1989.

16. Ames Research Center Aeronautics Strategic Plan 1991.

17. Artificial Intelligence Technology Master Plan, Army Material Command, August 1991.

18. Army Science Board 1991 Summer Study on Army Simulation Strategy, 1 August 1991.

19. Aerospace Human Factors Research Division, Code FL, Dr. Robert K. Dismukes, Chief, NASA, August 1991.

3. COMMITMENT, VISION, OBJECTIVES, AND MISSION

3.1 RDEC Commitment Statement

The RDEC commitment statement from reference 1 is to:

Function as an integrated, unified team to execute the RDEC mission through technology base, development, and field support in an environment of declining resources.

3.2 Vision Statement

The Vision statement for AMC is taken from reference 4. The RDEC Vision statement for the Simulation Core Discipline is drafted to be consistent with both the AMC Vision statement and the RDEC commitment statement.

3.2.1 AMC Vision Statement

The AMC Vision statement from Reference 4 is:

AMC has a continuing mission to support the soldier, the Army, and other customers. AMC can compete on the open market in both the quality and cost of its products and services. Customer expectations about the performance, cost, quality, and timeliness of products, services and operations are met. Army systems possess the technology that gives U.S. Forces an overwhelming advantage on the battlefield. Testing technology instrumentation and test facilities are synchronized with advanced technology and the complexities of weapons systems. AMC employees work as a team, continuously seeking opportunities to improve processes and to help their customers. High performance people aspire to be a part of AMC.

AMC's priorities are to support the Army's evolving force structure and new military strategy, which entails rapid projection from CONUS; managing the build down of AMC, minimizing the impact on people and retaining the expertise and organizational structure to perform assigned missions; achieving an acceptable level of AMC's infrastructure cost; environmental stewardship; modernization, including research, development, and testing (RDT&E) programs, equipment, infrastructure, and the production base; security assistance programs; and implementation of DOD concepts of operation, particularly in areas of consolidation and inter-servicing.

AMC has the lead Army role for R&D and for testing. This includes stewardship, the responsibility to select investments to ensure Army's technological superiority and realistic testing. AMC's flagship laboratory, research, development and engineering centers (RDECs), and test activities will "centers of excellence" for research and developmental technology and testing in areas assigned to the Army. The Army's proposed continuous modernization strategy depends on active R&D for major modification and new production for each major class of equipment. Adopting strategies to shorten the time from concept to fielding and to reduce design and testing costs are major objectives."

3.2.2 RDEC Simulation Vision Statement

AVSCOM Team RDEC has a commitment to maintain the cutting edge in flight simulation for (1) flight management simulation, (2) MMI/behavioral studies, and (3) full combat mission simulation. The RDEC leadership in flight simulation will be based on a superior, well-trained staff, state-of-the-art simulation facilities in both hardware and software, and a well-focused, forward looking tech base program. Team RDEC will invest its resources--personnel, funds, and facilities--in such a manner that it will maintain this leadership role for Army aviation in simulation. As a result of this leadership role, Team RDEC will meet customer expectations about performance, cost, quality, and timeliness of products, services, and operations. The Team RDEC flight simulation capabilities shall be used to support not only tech base programs but also to fulfill the AVSCOM roles in system development and fleet support. The resources in the Simulation core discipline area will function as part of integrated, unified team to meet RDEC responsibilities.

3.3 Objectives

1. Give highest priority to development and fielded systems with high fidelity simulations of aircraft, the aircraft subsystems, the crewstation, and man-machine interfaces to assist PM/PEO technical activities or PM/PEO resolve issues, as required;
2. Establish an integrated technology base program to address near-term and long term RDEC simulation technology goals;
3. Establish an integrated, unified simulation team that represents a balanced use of available RDEC skill, funds, and facilities;
4. Promote direct communications among the simulation RDEC resources to permit better control and distribution of tasks;

5. Focus on an integrated team effort to execute the RDEC simulation tasks.

3.4 Mission

The current mission statement from the reference 3 for the Simulation and Aircraft Systems Division (SASD) of the AFDD is as follows:

> To plan, manage, and execute a joint Army/NASA program for the design, development, integration, and test of advanced cockpit simulations, and to conduct part-task and full combat simulations for man-machine integration with specific emphasis on crew complement efficiencies of mission management for advanced Army aircraft. To develop, maintain, and continually extend the technical data base required for simulation, flight controls, man-machine integration, and flight test equipment and systems, and to supplement the NASA Ames Research Center's personnel strength as necessary to increase the NASA capability to pursue investigations of interest to the Army.
>
> The missions of the SASD Branches and Office are:
>
> The mission of the Flight Controls Branch is "to develop, maintain, & continually extend the technical data base & simulation capabilities required for the production of the state-of-the-art Army aviation equipment & systems in the area of flight controls & handling qualities for rotorcraft & supplement the NASA Ames Research Center's research personnel strength as necessary to increase the NASA capability to pursue investigations of interest to the Army."
>
> The mission of Army/NASA Aircrew-Aircraft Integration/Man-Machine Integration (A^3I/MMI) Branch is "to develop, maintain, & continually extend the technical data base required for Army aviation equipment & systems in the areas of computer aided design (CAD) of human factors engineering, artificial intelligence, expert systems, and MMI."
>
> The mission of the Crew Station Research and Development Branch is "to develop, maintain, & continually extend the technical data base for state-of-the-art simulation of crewstation operations, with emphasis on mission effectiveness & human factors issues."

4. CURRENT RDEC SIMULATION ORGANIZATION

4.1 Organizational Structure

The organizational structure for the Simulation core discipline is shown in Figure 4-1. The organizational entities are identified that have the responsibility within RDEC for maintaining and running the simulation facilities. The simulation facilities are described in detail in the appendix. The RDEC simulation facilities are all located at the Directorate Laboratories. The primary location of all RDEC simulation facilities and expertise is at AFDD within the SASD. The CSRDF and the FLITE simulation facilities are maintained and operated by the Crew Station Research & Development Branch; the VMS/ICABs are maintained jointly by NASA and the Army with the Flight Controls Branch serving as the Army interface; RASCAL which is a jointly funded NASA/Army program with NASA leadership, has the Flight Controls Branch as the Army point of contact; and HFRF and A^3I-MIDAS are maintained and operated by the Computational Human Engineering Research Office (CHERO). These simulation facilities are located at AFDD. The DTRS facility is located at Langley and is a NASA simulator. ASTD can schedule the use of DTRS when needed.

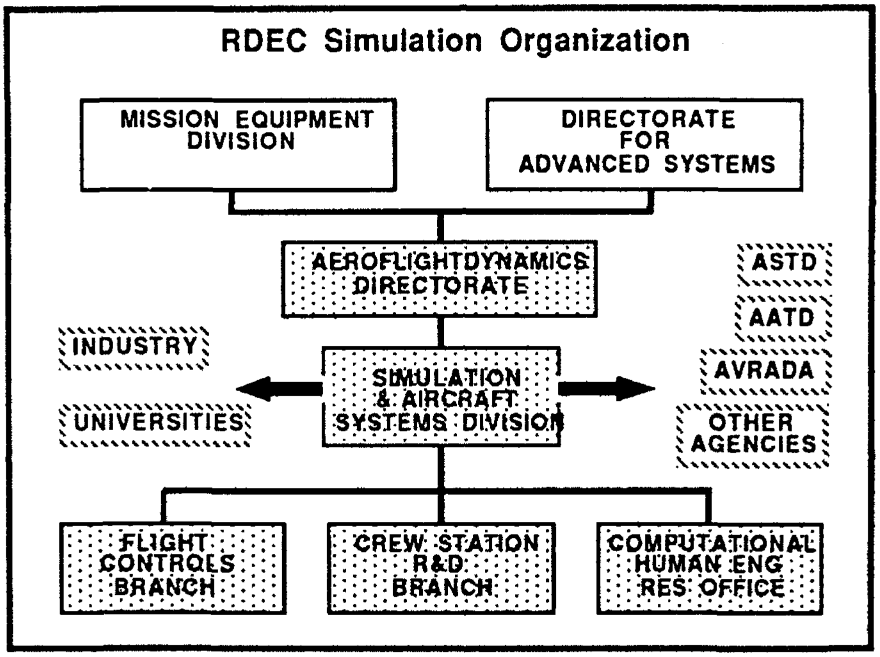


Figure 4-1. RDEC Simulation Facilities and Their Organizational Control

AATD and DE/DAS have no simulation facilities. The simulation needs of these organizational components are fulfilled either by contract or by requests for support from AFDD and ASTD. Such requests are made through the usual organizational chain of command. Similarly, these organizational components fulfill advisory roles to AFDD and ASTD simulation efforts. Again requests for the the consulting or advisory support by AFDD/ASTD are made through the usual chain of command.

There are also other agencies such as AVRADA which provide advise or consultant support to simulations involving their particular area of expertise. These roles are usually formalized through interagency memoranda of agreements (MOAs).

Typically, organizations which provide advisory services neither plan or perform the simulation or conduct and report the simulation research program. These functions are performed by the personnel in SASD.

The industry and academic simulation facilities are not under RDEC control and may be used only through proper contractual or grant arrangements.

The point of contact at RDEC for simulation-related tasks is the Mission Equipment Division office (AMSAV-ES). The lead center for the Simulation Functional Area within RDEC is AFDD.

4.2 Functions Performed

The functional responsibilities are listed for DE, DAS, and SASD in the area of Simulation support. Other groups such as AVRADA, ASTD, and AATD provide only an advisory role in reviewing simulation plans relative to their area of expertise. Basically, the DE interface is used for system development and fielded system tasks and the DAS interface is used for Tech Base programs, grants, IR&D, etc.

4.2.1 Functions Performed by DE

The functions performed by the Aircrew Integration Branch in the Mission Equipment Division (AMSAV-ES) with respect to simulation are listed below. This Branch of AMSAV-ES:

1. Provides technical specialists in support of all training and simulation (T&S), serving as command functional lead. Represents the Command on all appropriate technical committees, etc.
2. Prepares statements of work (SOWs), contract data requirements lists (CDRLs), and all other related documentation necessary to support the T&S arena.
3. Serves as the Command functional interface/technical problem solvers and the central point of contact (POC) for all Directorate of Engineering (DE) disciplines as applied to relevant Research and Development (R&D) and/or T&S programs. Through application of past 'lessons learned', acts as the 'honest broker" for Program Executive office (PEO)/Program Management (PM) organizations.
4. Supports and participates in all T&S Source Selections Evaluation Boards (SSEBs) relating to Requests for Proposal (RFP), preparation, Proposal; evaluations, contractual negotiations, etc.

5. Reviews all T&S Engineering Change Proposals (ECPs), Specification Cnange Notices (SCNs), Deviation & Waivers (DWs). and other product modification/improvement documentation to ensure technical integrity from an engineering point of view.
6. Reviews and approves all T&S related system design documentation, test plans, reports, specified drawings, and material process specifications in substantiation of qualifications requirements.
7. Evaluates and substantiates adequacy of training subsystems (including the hardware/software aspects of embedded training) for airworthiness, system effectiveness, and economy.

4.2.2 Functions Performed by DAS

The simulation functions performed by DAS are contained in reference 14. Although there are no functions that specifically state simulation responsibilities, the DAS oversees all Tech Base and Tech Base-related programs.

4.2.3 Functions Performed by SASD of AFDD

The functions performed by the SASD and its Branches (shown in Figure 4-1) were listed in Reference 3. Those functions have been modified, integrated, and updated to reflect the Simulation Team RDEC approach.

1. Conduct the Army Tech Base program in simulation technology, full combat mission simulation technology, handling qualities, flight management, and computational human engineering research in such a manner that simulation resources can utilized to support Army aviation requirements in system development or fielded system support when required.
2. Conduct theoretical and experimental investigations in the simulation of rotorcraft systems or on aircraft systems as agreed upon by the AFDD Director, SASD Chief, and the NASA Ames Research Center:
   a. to include all aspects of mission equipment and flight management issues of either a basic or an applied nature designed to improve Army aviation technology.
   b. to further knowledge in flight control, human factors, mission equipment, and information management
3. Conduct research and development as agreed upon with the SASD Chief.
   a. in flight controls and simulation of rotorcraft

b. in human factors engineering and the design of cockpit systems for research or training applications.

c. into issues of crew size, cockpit displays, allocation of functions, level of automation, effects of malfunctions and training, and other mission effectiveness, human factors, and pilot performance issues.

4. Represent the AFDD and RDEC in the control of contracts let to industry or to academic institutions in the areas of

   a. flight simulation, artificial intelligence, and aircraft systems.

   b. human factors engineering, man-machine integration, artificial intelligence, and aircrew-aircraft integration.

   c. crew station research and development simulation issues.

5. Conduct theoretical and experimental investigations designed to improve Army aviation technology in:

   a. flight controls and simulation of rotorcraft of either basic or an applied nature

   b. the integration of man-machine systems and aircrew-aircraft systems.

   c. full and partial mission simulations of Army aircraft team operation in combat scenarios.

6. Function as a focal point point at Ames Research Center for requests for simulation of flight controls or handling qualities.

7. Negotiate specific work packages and responsibilities with other organizations as required to provide necessary support of crew station research and development.

8. Augment the NASA Ames Research Center technical and administrative staff to compensate for workload created by the tenant Army activities as negotiated by the AFDD Director and the NASA Ames Research Center.

Further detail in the area of the handling qualities program functions of the Flight Control Branch are:

1. Identify handling qualities needed to perform near, mid, and far-term mission tasks in operational environments.

2. Develop design criteria and test assessment techniques required to achieve the desired handling with advanced platforms.

3. Integrate handling qualities criteria into a comprehensive aeronautical design standard. Review and update to cover advanced missions and platforms.

4. Develop techniques to provide designers with systematic multi-input multi-output digital flight control design methods.
5. Develop, maintain, and exploit ground-based and in-flight piloted simulation capabilities.

All organizational entities of the SASD are responsible for function which:

1. Transfer technology to industry, Army, and other Government agency users by timely workshops, reports, and conference papers.
2. Act as a knowledge base to support Army aviation system development, evaluation, sustainment, and use.
3. Maximize leverage on resources by exploiting capabilities of industry, Army, USAF, Navy, and other domestic and foreign capabilities, especially NASA through the Army-NASA joint agreement.
4. Participate in IR&D reviews to influence efforts for maximum benefit to the military.

4.3 Simulation Customer Base

The customers for the RDEC simulation activity are

1. RDEC fleet support and system development support through

a. Tech support on assigned problems

b. Advisory support to TIWG, TEMP, CSWG, etc.

2. PM/PEOs on vehicle development system studies for Comanche and Longbow Apache.
3. Technology base users in the helicopter community - primarily rotorcraft manufacturers and Universities - by documenting significant Technology Base contributions in appropriate reports, conference proceedings, and/or literature.
4. Accident investigations teams
5. SSEB teams
6. NASA civil helicopter research and development
7. Other agencies such PM-trade, Comanche-TSM, etc., for pilot training on new concepts or evaluation of new crew station concepts.
8. Other agencies through memorandum of agreements (MOAs) or foreign governments through memoranda of understanding (MOUs).
9. Professional society support as chairpersons, editors, officers, and/or speakers.

10. Contract Officers in managing, monitoring, defining, reviewing, and certifying technical work.

4.4 Identify RDEC Simulation Products

The RDEC's simulation products are best visualized by reference to Figure 1-6, where it can be seen that in addition to maintaining a Simulation Tech Base, vital support is provided on a rapid turnaround basis for currently fielded systems, systems under development, and sundry Applications Tech Base programs. In each case the specific "products" vary, but in rough order may be summarized as follows:

- For currently Fielded systems, products include active participation in the evaluation of problems of an operational or safety nature. Where necessary, analytical simulation studies are produced which lead to a deep engineering understanding of causes and potential solutions.
- For systems under Development, direct products include providing technical advisors, and, where needed, in-house simulation studies leading to "user" group involvement. Often, these products become incorporated into contract specifications. With regard to the art and science of simulation itself, products include the transfer of technology (e.g., software), or knowledge concerning study methodology, into the hands of contractors.
- The products resulting from the broad Applications Tech Base activities are quite varied. At one extreme, such as ATTDs, the products are very similar to those for Development systems, and include advisory and simulation study support. At the other extreme, such as SBIRs and University Grants, the products generally turn out to be innovative concepts and trade studies which contribute to a practical knowledge-base that may be factored into Next Generation/ Future Systems (NG/FS). Most often, this knowledge is embodied in contractor reports, presented at technical meetings, or published in journals.
- It should not be forgotten that the Simulation Tech Base, itself, with its array of experts in the Core areas, produce a wide variety of products including technical publications, computer models, design tools, improved methodology, and "proof of concept" knowledge. Again, these products are most often found in contractor reports, presentations, or journal articles. Appendix C identifies the Tech Base reports during FY91 that were generated by AFDD personnel. These reports document only a small fraction of the various functions actually performed in the Simulation area, and the list does not include the contributions of personnel outside of AFDD, i.e., ASTD, AVRADA, AATD, and Headquarters.

4.5 Adjuncts to RDEC Simulation

The RDEC Simulation capabilities have no direct competitors since the industrial and academic organizations overlap with our capabilities only in a peripheral sense. In the R&D community, there are no other facilities and associated expertise available that can conduct research in the areas of full combat mission simulation for handling qualities, crew station integration, and human factors engineering to the extent that RDEC is capable of. This capability includes interchangeability of cockpits, models, and symbology. The RDEC simulation staff and tech base programs have been directed toward improving the simulation fidelity as shown in the figure. The figure shows that measurable, consistent improvements in simulation fidelity have been made in the past decade. This improvement is largely a result of government investment and expertise.

The relevant industry and University rotorcraft simulators are described in Appendix A. Typically, for tech base work, specialized research is either performed in-house, contracted out to Universities, or, on a limited basis, to manufacturers. Industry simulators are usually specific to the manufacturers product line and the inherent limitations in such an approach do not make manufacturers an ideal candidate for generic state-of-the-art simulation work in the areas of handling qualities, crew station interfaces, and human factors engineering. Industry simulation is aimed at achieving proof of their design concept. Universities, on the other hand, tend to specialize in specific areas and tend to gravitate by necessity to part-task simulators instead of to full mission simulators. It is extremely difficult for Universities to obtain resources to assemble and maintain a full mission simulator. Thus, the RDEC simulation capabilities which include outstanding facilities are tailored to look at full combat mission simulations. Alternatively, the RDEC facilities can easily be adapted to look at part-task or part-mission issues. The RDEC facilities are also designed to be rapidly reconfigurable in order to represent the full range of Army fielded or development systems in terms or both crew station layout and math models for vehicle flight.

The RDEC simulation fidelity is often improved by the basic model research conducted by the academic community. The specific model improvements made by the university community can usually be transported to the RDEC simulation effort. These efforts on the part of the Universities are generally funded by the RDEC tech base program. Thus, while there is some overlap between university and government tech base efforts the overall mission of the RDEC simulation effort is benefited directly by this competition. The manufacturers, typically, use their simulators to prove a concept under design or development and are not as well situated as the government is to pursue tech base, requirements definition, or accident investigation efforts.

Other government agencies such those at ARI Aviation Research and Development Activity or PM-Trade tend to use simulators primarily for training and warfighting doctrine studies.

The interaction of these adjuncts to RDEC simulation is depicted in the following figure.

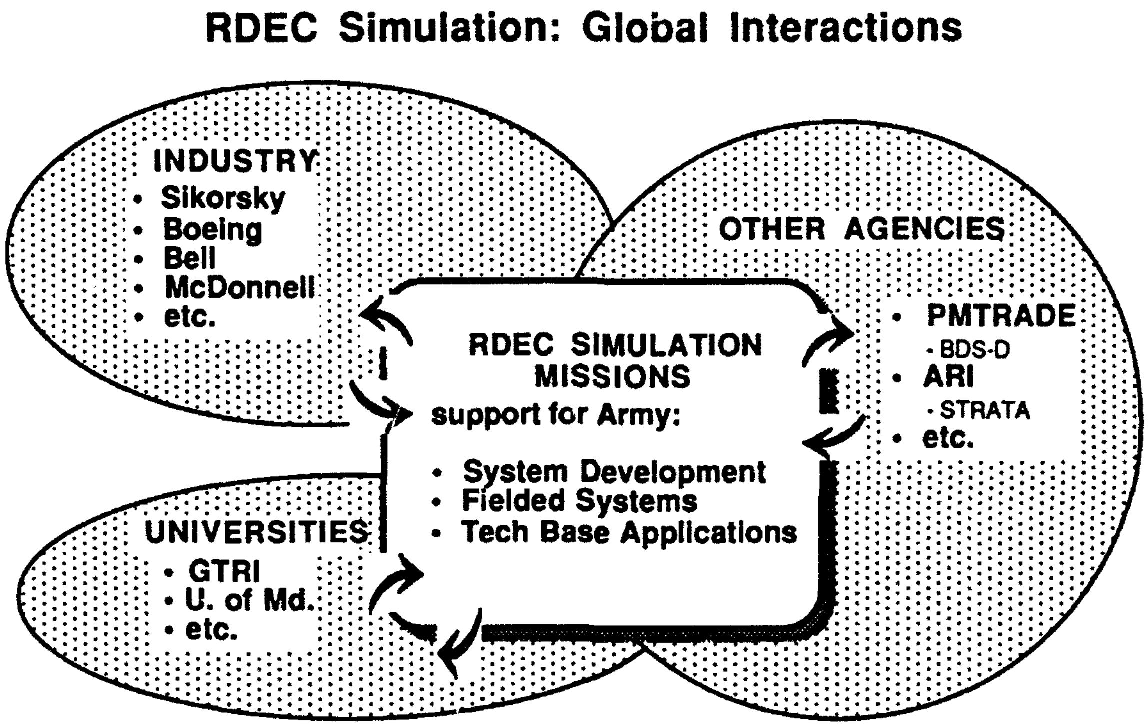


Figure 4-2. Relationship of RDEC Simulation to Other Agencies, Universities, and Industry.

4.6 Constraints/Opportunities

The RDEC Simulation activity is constrained by current funding levels. The funding level for Tech Base development is expect to decrease slightly over the next 5 years at roughly a 1.5% rate per year. Similarly, personnel levels are forecast to decrease at the same rate. The simulation facilities and activities are currently understaffed. The shortfall is made up in part by contract support activities. The funds needed to keep the facilities functioning reduce the resources which can be applied to program support. Thus funding and hiring constraints and/or RIF procedures place constraints on the simulation programs.

Other constraints are identified in the resources section of this report. The average age of the professional staff is unusually high. This indicates that sufficient younger personnel are not being brought into the agency to maintain a consistent program over an extend period of time - perhaps before Comanche and Apache Longbow come on line. Conversely, the high average age and grade level implies that staff is well postured to meet current technical challenges.

The location of the RDEC simulation facilities represents an opportunity for the RDEC. The San Francisco bay area is easy to reach and the NASA staff complements and leverages both the staff and facility development and maintenance.

5. RDEC SIMULATION RESOURCES

5.1 Government Personnel

AVSCOM RDEC Simulation is described in the tables below. Both contractor and government personnel strengths and profiles are described.

There are 23 scientists and engineers (S&Es) professionals located at AFDD in the Simulation and Aircraft Systems Division (SASD, SAVRT-AF-B) whose major tasks are related to the Simulation core discipline. Their names, organization code, grade level, and discipline area of expertise are given in Appendix B. The table below summarizes the AFDD personnel assigned to the various aspects of flight simulation.

Table 5-1. AFDD Simulation Personnel Profile

GS/GM Level	Number of Employees
GM/GS-15	4
GS-14	5
GS-13	9
GS-12	3
GS-11	1
LTC	1

The SASD personnel are assigned to the following Branches and Offices within SASD.

Table 5-2. AFDD Employees in the Simulation Functional Area by Organizational Unit

SASD (SAVRT-AF-B)	No. of Government S&E Employees
Division Office	3
Flight Controls Branch	14
Crewstation Research and Development Branch	4
Computational Human Engineering Research Office	2

As shown in the next section, these professionals are augmented by on-site contractors supporting the various simulation tasks. The contractor personnel are, in general, highly skilled and specialized. By contractual agreement, contractors perform specific technical tasks for which advanced degrees are generally required.

In the RDEC DE office (AMSAV-ES) there are six Federal employees with Simulation functional area responsibilities. In the RDEC DAS office (AMSAV-N) there is one Federal employee with Simulation functional area responsibility. The government employees are identified by name in Appendix B.

Table 5-3. RDEC DE/DAS Simulation Personnel Profile

GS/GM Level	Number of Employees
GM/GS-15	3
GS-14	1
GS-13	1
GS-12	1
GS-11	1

5.2 Contractor Personnel

The Flight Controls Branch (SAVRT-AF-BC) of 14 professionals is augmented by an on-site contractor staff of five people. The contractor personnel in this and the other branches are used to perform specific technical tasks usually involving a high degree of specialization in a very specific discipline. By necessity the contractors generally have advanced degrees or the equivalent in experience in their speciality area.

Table 5-4. Contractor Support Personnel for SAVRT-AF-BC

Contractor	No of Employees	Responsibility	Skill Level
SFS	2	Math models	Engr/Computer scientists
STI	3	Handling qualities, simulation	Scientists, Computer scientists
Total	5		

The Crewstation Research and Development Branch has the responsibility to manage not only the CSRDF operationally but also to manage the tech base program associated with the facility. Since the Branch has only four people, the operational tasks are performed under contract by CAE. CAE assists in maintaining the facility for two shifts per day as well as advising, planning, and implementing improvements in simulation technology. The remaining contractors are used to design, code, and test software for the various full combat mission math models used in the CSRDF. The CSRDB is augmented by an on-site staff of 26 contract employees.

Table 5-5. Contractor Support Personnel for SAVRT-AF-BH

Contractor	No of Employees	Responsibility	Skill Level
SFS	7	Mission planning and CDA models	Engr/Computer scientists
MTI	7	Full combat mission sim. performance models	Scientists, Computer scientists
PLRA	4	Control and displays human factors models	Scientists
CAE	8	CSRDF Facility development and operational support	Engineers, computer scientists, and technicians
Total	26		

The CHERO has only two government employees. The major portion of the human engineering program is supported by a 19-member on-site contractor team. The sophisticated A^{3}I-MIDAS program requires the use of two software teams from SFS to design, code, and test the graphics and symbology modules. The remaining 4 contractors provide highly specialized skills to augment the overall A^{3}I development.

Table 5-6. Contractor Support Personnel for SAVRT-AF-BI

Contractor	No of Employees	Responsibility	Skill Level
SFS	15	Symbolics, graphics, sim technology	Scientists/ Computer scientists
Tica Assoc.	1	MIDAS design,coding	Software system design
Select Sys.	1	Statistical analysis	Scientist
Navajo Co	1	Technical consultant	Engineer, computer scientist
BTH Corp	1	Software development	Computer scientist
Total	19		

The following table summarizes the S&E professional staff for the Simulation functional area in Team RDEC.

Table 5-7. Simulation Functional Area S&E Personnel

Organization	Government S&E Employees	Contractor S&E Employees	Total
DE-MEP	7		7
DAS	1		1
SASD	3		3
Flight Controls Branch	14	5	19
CSRD Branch	4	26	30
CHER Office	2	19	21

In addition to the Army employees and contractors the Army-NASA agreement and the NASA Ames designation as lead center within NASA for rotorcraft research and technology advancement leverages the Army investment in shared programs. The following table shows the NASA civilian S&E staff supporting rotorcraft simulation efforts. This support is primarily in the area of VMS studies, RASCAL, and human factors research.

Table 5-8. NASA ARC S&E Staff Supporting Rotorcraft Simulation

Grade	Flight Systems and Simulation Research Division	Aerospace Human Factors Branch
SES	1	
GS/GM-15	9	1
GS-14	9	2
GS-13	2	2
GS-12		1

AVRADA, ASTD, and AATD personnel are not included in the S&Es assigned to simulation since these organizations act only in an advisory capacity to simulation studies.

5.3 Facilities

The facilities are shown and described in Appendix A. The RDEC facilities are CSRDF, VMS/ICABS, RASCAL, FLITE, HFRF, and A^3I-MIDAS. Only the CSRDF is completely operated by the Army. The other facilities are jointly operated with NASA. The DTRS facility is operated by the Army and NASA at LaRC. AATD will on occasion use simulators at MICOM. The simulator they most frequently use is the Hardware-in-the-loop (HWIL) simulator at Redstone Arsenal. The HWIL is described in Appendix A. The figure below locates the major RDEC facilities. The industry and University simulator facilities are included for completeness. These facilities could be made available to RDEC through contractual agreements if the need arose. The industry and University simulation facilities list is not intended to be inclusive but rather to include only those facilities which the Army has used in the recent past for Tech base or fielded vehicle support.

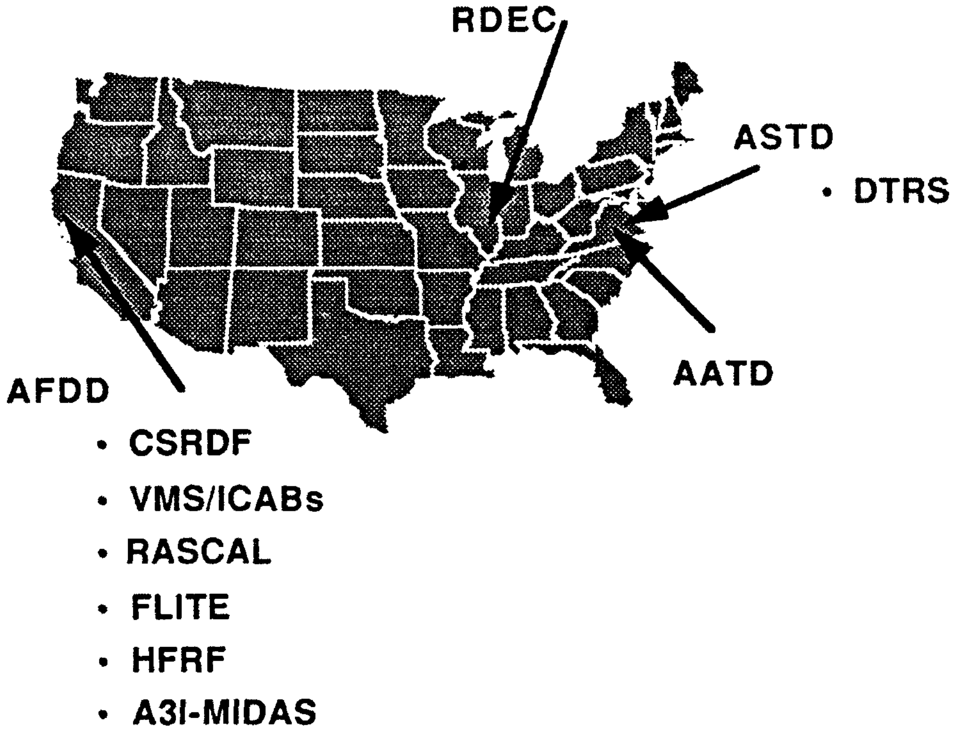


Figure 5-1. Location of Simulation Facilities Used by RDEC

Simulation facilities, like wind tunnels or experimental aircraft, represent large investments and are considered major assets of research or development organizations. For example, Sikorsky Aircraft Corporation estimates it has invested $50 million in the FMS simulation and approximately 350 man-years in the GENHEL series of math models. Table 5-9 lists the RDEC facilities and the estimated funds invested into the asset.

Table 5-9. Simulation Facilities Investment Cost

Facility	Investment cost $, Millions
CSRDF	25.0[a]
VMS/ICABs	35.0[a]
RASCAL	30.6[b]
FLITE	3.5
HFRF	<1.0
A^3I-MIDAS	12.0

[a] These figures reflect only the Army investment and not the additional funds invested by NASA.

[b] Approximately $9M to date; $30.6M is planned by end of FY 94.

5.4 Funds

The cumulative AFDD funds requested for the next three fiscal years are shown in Figure 5-2. The funding shows that there is no increase for FY 93. The expected increase in resources for FY 94 is due to expected activities related to RPA ATTD. The tables in the next subsection show that increase is in CSRDF-related work package. The figure and the tables show an overall decrease in spending except for the RPA activity area. The tables indicate the organizational breakout of the funding.

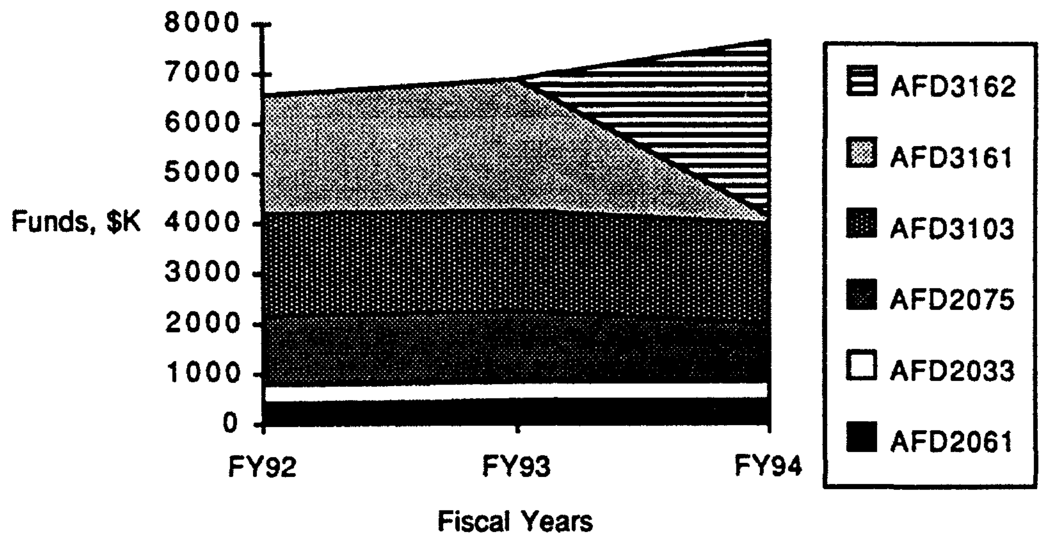


Figure 5-2. Funds for Simulation Functional Area

The FY 92 funds expenditures are managed by the organizational subunits of SASD (SAVRT-AF-B). The Branches and Office are shown in Figure 4-1. The Flight Control Branch (FCB) is SAVRT-AF-BC, the Crew Station Research and Development Branch (CSRDB) is SAVRT-AF-BH, and Computational Human Engineering Research Office (CHERO) is SAVRT-AF-BI.

The funds in WP AFD2061 are used to improve simulation fidelity in the design process, develop an in-flight simulation and handling qualities research tool, and provide access to a high fidelity simulator for Army research. The contract with STI provides manpower and critical mass to the VMS rotorcraft studies jointly supported by NASA and the Army for studies on ADS-33 specifications, Apache, HIMARCs, air-to-air-combat, carefree maneuvering, LHX (Comanche), and advanced configurations. The contracts with U.C. Davis, University of Maryland, Georgia Tech, and STI are used to develop tools and models aimed at improving ground-based simulation fidelity and include tasks in validation, parameter identification, fidelity assessment techniques, improved turbulence math models, and the RASCAL project.

The WP AFD2033 is directed toward development of human factors principles, display prototypes, and training systems to support design and operation of advanced helicopters. Specifically, the research effort is directed toward guidelines for helmet and panel displays of sensors and map imagery. One contract is with Sterling Federal Systems (SFS) to develop experimental tasks for government and University research in areas of human behavior in both the lab and field, and to develop part-task simulation facilities in support of helmet and panel displays for advanced cockpits. The tasks include night-vision goggles, electronic map displays system, terrain navigation trainer, and thermal imagery trainer. A contract with the University of Illinois is for modeling cognitive performance in aviation environments such as navigation and strategic control.

The work package (WP) AFD2075 funds A^{3}I-MIDAS project and the coordinated efforts of out-of-house contractors and grantees as well on-site contractors. The primary objective is the design and development of the man-machine integration design analysis system (MIDAS). The funds include support for a contract with Navajo Company for technical and administrative support, a grant to the University of Pennsylvania for the development of a computer-based dynamic anthropometric mannequin model for helicopter cockpit environment, a grant to the lighthouse for a 3D binocular field of view model for human operator visual performance to used in conceptual designs of cockpits, a contract with David Sarnoff Research Center to improve visibility models with respect to various stimuli in the cockpit environment, and a grant to the University of Illinois to investigate theories about effects of display attributes in a complex environment.

The WP AFD3103 is directed toward the CSRDF operational support and the improvements in simulation technology. The primary contract is with CAE to provide these services. CAE will insure that the CSRDF is operational, maintained, and upgraded in such a manner that the facility is available for two shifts per day on a five-day work schedule, and that the facility has a minimum of down time to accommodate these enhancements and maintenance requirements. In addition, the contractor will support and implement advanced simulation technology into the CSRDF required to support the RPA ATTD.

WPs ADF3161 (and ADF3162) are for RPA research and simulation support in the areas of PVI, MANPRINT, and functional compatibility of all prototype software and subsystem models. The CSRDF is required for the full mission functional validation of the RPA integrated system.

Table 5-10. AFDD Funds for FY 92

Organization	Project and Tech Area	Work Package	Funds
SAVRT-AF-BC	A47A K	AFD2061	$419
SAVRT-AF-BI	A47A M	AFD2033	$335
SAVRT-AF-BI	A47A M	AFD2075	$1418
SAVRT-AF-BH	D436 03	AFD3103	$2000
SAVRT-AF-BH	D436 03	AFD3161	$2373
FY92 Total			$6545

It should be noted that AFD3161 is currently underfunded for FY 92 by $227K. This underfunding puts at risk the RPA task related to BDS-D networking.

Another underfunded WP is AFD2033. The FY 92 guidance has been reduced by $200K. This reduction follows a guidance figure that was already $600K below that which was requested. Grants with Georgia Tech and the University of Illinois and a subcontract with Sequitur systems will be severely curtailed or eliminated to meet budget constraints. Some aspects of the MIDAS project will be delayed as a result of the underfunding of the project in FY 92.

Table 5-11. AFDD Funds for FY 93

Organization	Project and Tech Area	Work Package	Funds
SAVRT-AF-BC	A47A K	AFD2061	$471
SAVRT-AF-BI	A47A M	AFD2033	$339
SAVRT-AF-BI	A47A M	AFD2075	$1434
SAVRT-AF-BH	D436 03	AFD3103	$2000
SAVRT-AF-BH	D436 03	AFD3161	$2629
FY93 Total			$6873

Table 5-12. AFDD Funds for FY 94

Organization	Project and Tech Area	Work Package	Funds
SAVRT-AF-BC	A47A K	AFD2061	$ 471.
SAVRT-AF-BI	A47A M	AFD2033	$ 339
SAVRT-AF-BI	A47A M	AFD2075	$1181.
SAVRT-AF-BH	D436 03	AFD3103	$2000.
SAVRT-AF-BH	D436 03	AFD3161	$ 146.
SAVRT-AF-BH	D436 03	AFD3162	$3454.
FY94 Total			$7591

5.5 Identify Excess/Shortfall

Three shortfalls have been identified. The first shortfall affects AFDD as whole. Under the terms of the NASA-Army agreement, the Army has promised to provide a certain number of employees to NASA to assist on joint NASA-Army projects or to assist in NASA administrative tasks. Currently, AFDD owes NASA a number of employees which would work within the NASA organizational structure.

The second shortfall is in staff for SASD. The CSRDB has identified a need for 2 additional S&Es and the CHERO has identified a need for 3 additional S&E employees. The 2 additional staff for CSRDB have been identified as a research psychologists and a computer scientist. The 3 additional staff for CHERO have been identified as a Deputy Project Manager with an electronics speciality, a research psychologist, and a research psychologist to work in human factors within the NASA-Army MOA.

The Deputy Project Manager for CHERO and the computer scientist for CSRDB have been identified and AFDD is awaiting a decision from DE on whether the individuals can be extended a firm offer.

The third shortfall is identified in the previous subsection. That is, work package AFD3161 for FY 92 is underfunded by $227K. This work is managed by the Flight Controls Branch. The work package AFD2033 guidance has been reduced by $200K for FY 92. In both cases a reclama to DE for funds has been made by SASD and AFDD.

6. "BETTER WAYS" TO CONDUCT RDEC BUSINESS

A better way for providing simulation support throughout the RDEC will be described in this chapter. The "better way" will address the challenge laid down to the RDEC division chiefs in Cedar Creek II, and, in simulation, will address infrastructure and simulation specific issues that must be developed to satisfy the commitment, vision, and needs presented by TEAM RDEC. The simulation baseline within the AVSCOM RDEC to which the "better way" will be compared is as described in Chapter 5, the current customers and their needs are as described in Chapter 7, and the assumed RDEC organization is as described by Mr. House in briefings to Cedar Creek II (see Figure 6-1).

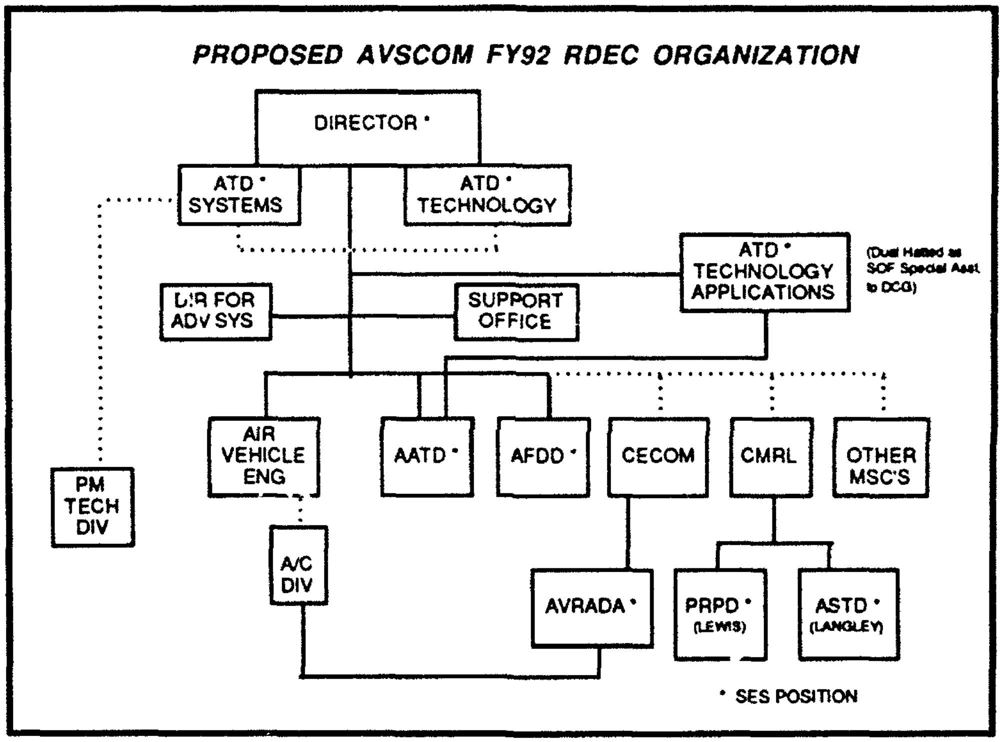


Figure 6-1. RDEC Organizational Structure

As outlined in Section 2.1, the most effective way of doing business in the Simulation area is entirely consistent with the "concurrent engineering" management principles that have been directed by AMC (Thomas, 1991, Ref. 13). This philosophy has not yet been fully incorporated into the RDEC infrastructure, however, and it is to this and related matters that the following analysis and recommendations are addressed.

As a starting premise, the RDEC has three interrelated and mutually dependent goals:

- Support fielded systems (FS)
- Support new system under development (SD)
- Maintain an effective tech base program (TB).

As discussed in prior sections, the ability to support FS and SD is based upon having a strong Tech Base, but it is equally true that the RDEC's involvement with today's development systems is a prerequisite for dealing with tomorrow's fielded systems. Hence, the issue is primarily a matter of how to maintain an effective balance of resources across the three enterprises.

The St. Louis-based Directorate of Engineering (DE) has primary responsibility for responding to goals of FS and SD programs, based upon their knowledge of the various PMs' needs. Other agencies (e.g., AFDD, AATD, AVRADA) have responsibility for being smart buyers and maintaining the TB objectives, but they also have a clear requirement for supporting the FS and SD objectives on a prioritized basis. Future resource constraints are a major issue that may well require many changes within the RDEC, the basic question becomes how to respond to these changes while satisfying our requirements more *efficiently*. The following recommendations are put forward, therefore, to eliminate major inefficiencies that encumber our present way of doing business.

1. Initiate an immediate review and revision of the current *Organization, Mission and Functions* documents (AMSAVR10-1, ARTA 10-1, Ref. 14) to reflect the new AVSCOM organization and chain of command. In the new regulations, focal points for each of the nine technical areas should be established (see Figure 6-2), and the process for recognizing or supporting key programs (e.g., Comanche, RPA, APT, etc.) should be described. It is understood that the organization chart may require variations tuned to each of the nine areas, but this document should attempt to capture the basic management principles involved, overlaid by these particulars in each case.
2. Establish a concurrent engineering management organization structure, analogous to what is being instituted at AMC, by establishing an office within the RDEC that is responsible for development and operation of an electronic communication system to coordinate its business. This infrastructure is vital for efficient utilization of resources, particularly for formulating well organized responses or proposals to customers that require coordination of many disciplines. It would also help to tap the rich capabilities throughout the farflung RDEC and in particular, within the Tech Base much more effectively.

RDEC Core Functional Areas

Source	STR	PROP	AERO	MEP	SIM	SURV	LCSE	TEST	SUBS
DE	●	●	●	●	○	○	●	●	●
AATD	○	○			○	●			○
AFDD			◉	◉	●	○			
CMRL	○	○	○	○		○			
CECOM(A)				◉	○		○		○
CECOM(B)				◉			◉		○
MICOM				◉		○	○		
AMCCOM							○		
Contract				○	○	○	◉	◉	

● Leader ◉ Some capability ○ Limited capability

Figure 6-2. RDEC Functional Core Areas Versus Organizational Responsibility

3. Establish a Tech Area Annual Review (TAAR) within AVSCOM where the needs in each technical area can be put forward and prioritized to support fielded systems, development systems and applications tech base customers. The results of this objective review should be organized and published each year to serve as a common basis for delineating the matrixing of the Command's concurrent engineering activities across the nine technical areas.

The resulting document will serve as the foundation for the AVSCOM RDEC business plan.

4. Use this RDEC restructuring exercise to rectify serious manpower imbalances in the human resources available to each of the core disciplines within the RDEC. In the simulation area five critical positions need to be filled in the computational human engineering and crew station R&D programs. (See Chapter 5.5 for specific manpower and budget deficiencies.)

5. As a corollary to establishing concurrent engineering practices, it is recommended that strong consideration be given to identifying a cadre of staff for liaison purposes and tech area-interfacing. This would foster greater cost effectiveness in each technical area, while assuring proper information flow with customers. In the simulation area, this would be implemented through an organization as depicted in Figure 4-1. Simulation support for fielded systems and system development would be accessed through, and coordinated with, AMSAV-ES, and tech base applications would be coordinated through DAS.

6. A formal business approach to all significant assignments and RDEC products should be used that incorporates configuration management practices. Currently, assignments often do not result in traceable products or documents which indicate that the assignment has been successfully completed. All technical reports, action items of RDEC importance assigned various teams or organizations should be subject to a level of configuration management. That is, action items (such as this Simulation Plan), ECRs, SCNs, CDRLs, DWs, contracts, planned technical reports, etc., should be tracked and traceable. Such approaches are commonly used in Army Project Offices. Generally, the traceability is recorded in a logging program on a central computer. This central electronic communication capability was referred to in item 2 above. Summary reports of all assignments can be generated and made available to managers to assist in tracking closure on assignments. Under the current ad hoc approach assignments are often "lost" or are assumed completed at a view graph level. In such cases no product is produced that documents the essential actions or decisions. In addition, assignments are often verbal instead of being written and therefore held accountable to all parties.

7. SIMULATION PRIORITIES

RDEC centers of excellence in a functional area such as Simulation have two primary responsibilities: (1) to develop a viable, well-focused, high-quality tech base program, and (2) to support the system development and fielded systems as required. This is generally interpreted as considering the tech base programs as the primary task until an issue arises with respect to either a fielded Army aviation system or an Army system development project. When an assignment arises in these latter areas then the resolution of that assignment becomes the top priority task within the functional area.

7.1 Simulation Fielded System Priorities

1. Safety Analysis and Modeling, e.g., Blackhawk accident and subsequent simulation to identify probable cause

2. Operational Problems, e.g., modification and documentation of a communication switch operational problem on the Cobra aircraft.

3. Environmental Factors, e.g., development, in collaboration with CCNVEO, of alternative symbologies for using cuing lights for night pilotage

7.2 Simulation System Development Priorities

1. Advisory Support, e.g., Comanche Crew Station Working Group or the Longbow Apache Crew Station Design Validation

2. Simulation Support, e.g., ADS-33C for the Comanche or full combat mission simulation support for Comanche Dem/Val

3. Tech Transfer, e.g., use of the ADOCS control laws in the LHX or use of the mannequin model developed on A^3I to replace the one used within McDonnell Douglas Helicopter Co.

7.3 Simulation Tech Base Priorities

1. Mission Impact or Improvement, e.g., RPA sim support or development of VECTR/APT models and simulation

2. Configuration Design and Analysis, e.g., development of handling quality specs, development of MMI design and analysis tools, refinement of pilot-vehicle interfaces

3. Trade Studies, e.g., improve real-time models and simulation, apply artificial intelligence modules to Army Aviation in "intelligent simulation," apply simulation technology to solve aviation problems

4. Concept Formulation, e.g., support or initiate MOA, MOU, SBIR, IRAD, academia, to maximize the development of innovative concepts to support Army Aviation systems.

8. HORIZONTAL INTERDISCIPLINARY INTERFACES

Simulation within the AVSCOM RDEC involves continuing support to a wide variety of customers as well as support to, and coordination with, industry, other agencies, and other countries. When the interaction with these groups is for a limited time or specific endeavor, it is beneficial to both parties to capture the expectations and mutual responsibilities in a written agreement. These agreements achieve early coordination and agreement on technology issues, benefit the Army through economies of scale, and allow simulation models and issues to be more broadly applicable throughout the RDEC/ DA/U.S./or world. This section summarizes some of the current agreements that exist between the AVSCOM RDEC and other entities interested in models and simulation. The leveraging agreements add breadth and depth to the tech base studies and produce tools or products that yield attributes such as higher simulation fidelity, efficiency, quality, generality, interchangeability of models, improved communications interfaces, and/or application databases. Thus, new simulation technology developed by a larger community than the RDEC resources is available for application to Army Aviation development systems and fielded systems.

8.1 Within RDEC

First, agreements between AFDD and other groups within the RDEC include the following: a Joint Research Plan for ATR Man-Machine Interface Evaluation (AMMIE) between AFDD and AATD, a Joint Research Plan for Air-to-Air Tracking Systems (ATATS) between AFDD and AATD. Both of these agreements provide use of existing facilities within the RDEC to joint research teams so that an RDEC team could better leverage resources to solve technical problems.

8.2 Within DA

Second, agreements between the AVSCOM RDEC and other DA organizations; these include the MOU between AVSCOM and TACOM for the purpose of better interfacing for electronic architectures, data distribution, power distribution and control, processors, MANPRINT, test beds, communications, navigation and identification, environmental standards, crew station design simulators, computer modeling, and man-machine interface. An MOU was established with Army Research Institute for the purpose of defining and coordinating the relationship between two Defense Development Share Programs with the Canadian government on simulation technology. Neither of these two MOU involved funding other than access to contracts and technical personnel to effect better coordination between the TACOM and ARI communities with AVSCOM. Agreements with our customers should also be included in this section, such as the LHX PM for DEM/VAL simulation support, and for Longbow Apache Crew Station Design Validation support. In the support to the LHX PM an agreement was drafted spanning 18 months of consultation, travel, simulation, and orientation of assessment teams and support pilots. The funding for that total effort was $900K and the effort was concluded with reports and a brief out to MG Andreson. The leverage involved use of NASA supported simulators, the flight line at AFDD, access to NASA personnel, and the NASA infrastructure.

8.3 With U.S. Agencies

Third, agreements between the RDEC/DA and other U.S. Government agencies; examples include the Master Agreement between DA and the NASA for purposes of "fostering research and development of aircraft..., for joint use and support of certain facilities at NASA Research Facilities..., to lead to the development of advanced aircraft operating within the atmosphere...." The leverage through this mechanism has been well documented over the last 26 years and until the establishment of CMRL included the Structures Directorate and the Propulsion Directorate. Now the AFDD is the only surviving beneficiary of this leveraging with NASA.

8.4 With Industry and Academia

Fourth, agreements between the RDEC and industry or academia; these include agreements between Boeing Helicopters and the Boeing Advanced Technology Center with NASA Ames as the executive agent for the purpose of enhancement and application of computational human engineering design tools. Another example is the agreement with McDonnell Douglas on the Longbow Apache. In both these cases the industry leverages the tools developed by the AFDD to aid in the design and development of their systems.

8.5 With Other Nations

Fifth, agreements between the RDEC/DA and other countries; these include the Defense Development Share Program with Canada for the purpose of Simulation Program for Improved Rotorcraft Integrated Technology (SPIRIT). Products from the SPIRIT program include: side arm controllers, helmet-mounted displays, reconfigurable cockpits, and simulation network technology. The U.S. Army provides 50 percent funding, as does the Canadian government for this joint development.

9. SUMMARY

9.1 Elements of the Overall Plan

This simulation plan and report is very simple, and it relies on the principle of concurrent engineering throughout the three phases of the acquisition cycle (fielded systems, system development, and tech base). Programs, projects, and tech demos within the RDEC should retain autonomy and independence in funding, in prioritization, and in execution within each phase. However, to be able to use resources effectively a process is needed that will allow resources to be rapidly accessed and matrixed to support the customers. To permit clear and rapid exchange of technical information in this matrix process, nine core disciplines have been identified [propulsion, structures, aeromechanics, subsystems, mission equipment, test and evaluation, life cycle software engineering, survivability and vulnerability, and simulation (see Figure 6-2)].

9.2 Process for the Implementation

THROUGHOUT RDEC - In the proposed process for meeting the challenge "to function as an integrated, unified team to execute the RDEC mission through technology base, development, and field support in an environment of declining resources," the simulation group feels that throughout the RDEC community we first need to initiate an immediate review and revision of the current ORGANIZATION, MISSION, AND FUNCTIONS (AMSAVR10-1 and ARTA 10-1) to reflect the outcome of these TEAM RDEC recommendations; secondly, we need to establish an electronic communication system that will let us work within RDEC with other core disciplines in responding to our customers as well as for communicating with our industry. This electronic communication should be used to establish a configuration management scheme for identifying and tracking significant assignment emanating from RDEC as well as significant actions at the Directorate level which should have RDEC oversight. Thirdly, we need to implement an annual RDEC Tech Area Annual Review wherein needs, priorities, and mandates and directives from higher authorities can be resolved at the appropriate Associate Tech Director level before securing the Tech Director's approval. The results of this review should be organized and published each year to serve as a common basis for understanding and matrixing of the RDEC's resources across the nine core disciplines.

WITHIN THE SIMULATION AREA - Within the RDEC some manpower imbalances exist. The simulation area has identified five critical personnel positions in crew station and computational human engineering that need to be filled so that support can be readily provided to the RDEC, especially to the development systems. Simulation personnel would be accessed through, and would coordinate with, the mission equipment division for support to fielded or development systems, and would be accessed through, and coordinate with, DAS for normal tech base programs or other support such as international programs, SBIR, IRAD, etc.

APPENDIX A--RDEC AND RELATED ORGANIZATIONS SIMULATOR FACILITY DESCRIPTIONS

The Simulators included in this facilities Appendix are either RDEC simulators or simulators operated by our customer base. Our need to understand the mission of these facilities is consistent with the RDEC vision statement for the Simulation Plan. The Simulators described in this Appendix are listed below.

Under AFDD operational control:
- CSRDF

Under joint AFDD/NASA-ARC operational control
- VMS/ICABs
- RASCAL
- FLITE
- HFRF
- A^3I-MIDAS

Under LaRC/ASTD control
- DTRS

MICOM simulator used by AATD
- HWIL (MICOM)

ARI
- STRATA

AVNC
- RWA SS
- AIRNET

Universities
- IST
- GT

Industry
- Sikorsky - SHADOW
- Sikorsky - Full Mission Simulator
- McDonnell Douglas Helicopter Company
- Bell Helicopter Textron
- Boeing Helicopter Company

The definition of simulators for this report is restricted to flight simulators. These include moving base and fixed simulators as well as in-flight simulators such as RASCAL and FLITE. The AVRADA flight test vehicle, STAR, is not included in this list since the AVRADA organization classifies the facility as hot-bench test bed.

CSRDF - CREW STATION RESEARCH AND DEVELOPMENT FACILITY

Location: AFDD at NASA Ames Research Center

Sponsor: AFDD

Purpose: CSRDF has been used to research, develop, and define crew station configurations, pilot HMD symbology, and speech I/O command and recognition systems. The CSRDF has been used train both support and assessment pilots for the LH DEM/VAL program phase. The CSRDF was originally created to answer the crew question for the LHX and since has evolved into a testbed for the the RPA ATTD functional pilot vehicle interface and nap-of-the-earth assessment methodology.

Major components: The major components of the CSRDF include:

1. 3 blue or red team stations,
2. a fiber optic HMD (helmet mounted display),
3. a communications workstation,
4. an experimenter/operator console, and
5. a one or two seat cockpit.

Auxiliary to these facility components are mission planning computers to upload plans, low cost training stations to orient pilots to cockpit layout and symbology, a visual laboratory, a coordinated pilot training development station, and an audio laboratory.

Description: The simulator consists of a two-seat cab on a fixed platform. The pilot's visual imagery is produced by a fiber optic display mounted on his helmet. Wide-angle eyepieces fit closely over the pilot's eyes, producing a large, high-resolution image. The pilot has an instantaneous field of view measuring 67° vertical and 107° horizontal. The motion of the pilot's head is tracked by an infrared device in the helmet to display the correct image wherever he looks. The resulting field of regard is unlimited. The scene the pilot sees is generated by a GE Compuscene IV image generation system, driven by a Gould Multi-SEL computer.

The flight control mechanism is a four-axis hand controller. Two hand controllers are available to the pilot if necessary. A DEC VAX 8650 computer coordinates the simulation. Helicopter rotor blades and engine are modeled so that flight characteristics of the aircraft can be rapidly changed. The simulated missions are supported by a tactical center that provides up to 11 other aircraft, 99 threats, 20 moving targets, and communications, command and control. Up to three other operators may control the additional aircraft which may be friends or foes. The experimenter-operator center (EOC) serves as a central data collection point and control center for the simulation. Flexibility is achieved with system editors located in the EOC which allow the pilot's switches, symbology, or threat parameters to be modified while the simulation is in progress.

Research Applications: The CSRDF has been used in a number of studies. The recent studies include:

Initial study on AAMWD for RPA completed

D/NAPS for RPA ATTD hardware ordered and software team assembled. Initial simulations and lab studies in support of D/NAPS and AAMWD completed.

Planned Research and/or Improvements:

CATC2D models to be integrated into CSRDF

APSD sensor models to be modeled with Compuscene IV

D/NAPS and AAMWD models to be integrated into CSRDF

Conduct simulations in support of RPA PVI

Develop, test and evaluate performance measures for assessing contribution of RPA system to aircrew performance.

VMS/ICABS - VERTICAL MOTION SIMULATOR WITH INTERCHANGEABLE CABINS

Location: Ames Research Center, Moffett Field, CA

Sponsor: NASA

Purpose: The VMS is used to investigate handling qualities of advanced rotorcraft performing Army mission tasks. In addition, it is used to investigate landing, takeoff, and general handling qualities of STOL and VTOL aircraft and other advanced aircraft of interest to NASA such as Space Shuttle landing and High Speed Transport aircraft studies.

Major components: The primary VMS components are:

1. Interchangeable cabins with virtual image TV display
2. Panel, center, and overhead instruments
3. A hydraulic control loader system
4. Autothrottles
5. An aircraft sound generation system.

Description: The VMS may be used with any one of the interchangeable cabins as a moving base simulator. Conversely, an individual ICAB can be used on part-task studies as a fixed based simulator. The VMS can accommodate both a pilot and copilot. There are 4 cabins which may be uniquely configured to model different aircraft and cockpit layouts. Once a cabin is installed on the VMS it is capable of undergoing large vertical and lateral motions. The VMS generates a cabin roll of ±22°, pitch from +26° to -24°, a yaw of ±29°, a vertical movement of ±30 ft, a longitudinal motion of ±2.5 ft, and lateral motion of ±20 ft. Similarly, acceleration and velocities in the six degrees of freedom are allowed. The vertical motion is powered by 8 servo motors. The VMS is supported by two equilibrator columns which are internally pressurized to provide a smooth ride and rapid accelerations. The lateral motion is powered by 4 servo motors which drive the carriage on the vertical platform through pinion gears. A CAE hexapod motion system mounted on top of the lateral carriage provides motion in the pitch, roll, yaw, and longitudinal axes.

Research Applications:

1. UH-60 ground/flight
2. Apache initial checkout
3. LH/ADS-33 yaw attitude quickness simulation-HQ
4. Simval visual and motion lags
5. ANOE v & V & demo
6. ANOE/STAR guidance, control, display laws
7. Evaluation of STOVAL fighter
8. UH-60 validation
9. UH-60 accident investigation simulations
9. Helicopter maneuvering/agility envelop simulations (HELMEE)
9. First Apache simulations
10. RASCAL failure monitoring requirements
11. R/C specification development
12. Helicopter stability for NOE
13. Tiltrotor certification
14. Terrain following/terrain avoidance
15. Wide angle sensor projection (WASP)
16. Visual/motion synchron

17. Time delay effects Simulation
18. Higher order math model of UH-60 for FCS analyses

Planned Research and/or Improvements

1. Refine/validate Apache simulations
2. Apply automated adversary for air-to-air combat simulation
3. HIMARCS agility/maneuverability simulations
4. Carefree maneuvering simulation
5. Comanche support
6. Support Army R&D simulations for LH, APT, NG/NS, fielded systems.

RASCAL - ROTORCRAFT AIRCREW SYSTEMS CONCEPTS AIRBORNE LABORATORY

Location: Ames Research Center

Sponsor: AFDD/NASA

Purpose: RASCAL is a long-term research facility capable of flight investigation and validation of advanced control, display, and guidance concepts.

Major components: The RASCAL aircraft is a JUH-60 Black Hawk helicopter. The UH-60 replaced the CH-47B in 1989. The Black Hawk is being modified to include:

1. Programmable panel- and helmet-mounted displays
2. Digital, programmable flight control system
3. Instrumentation and inertial navigation sensors
4. Passive and active ranging sensors
5. System operator/researcher station
6. Extensive computing and modern architecture
7. Safety pilot & evaluation pilot cockpits.

Description: The UH-60 is being upgraded using a phased improvement program which will allow the vehicle to concurrently support ongoing research programs such as SCAMP, RAPID, Auto NOE, LH, HIMARCS, APT, etc. The phase 0 includes instrumentation and display upgrade is to be completed by end of year in 1991, phase 1, which is to add high bandwidth flight control system and low altitude guidance, will be complete in 1995, phase 2 will add rotor state feedback and NOE guidance capability, phase 3 will add programmable RPM control, and phase 4 will add higher higher harmonic and individual blade control.

The RASCAL will provide flexible and powerful research systems which will allow integration and examination of developing technologies. The RASCAL will provide the Army, NASA, and industry a flight verification of ground-based simulation results. The RASCAL will be the only U.S. Government-owned rotorcraft in-flight simulator.

The RASCAL on-board will include a full authority fly-by-wire flight control system with a mechanical backup, state-of-the-art computers and sensors including rotor state measurements, and integrated helmet-mounted and panel mounted displays. In a later phase integrated flight/propulsion control will also be included.

Research Applications: When fully instrumented the RASCAL will be uniquely equipped to perform flight validation of wide ranging control and display concepts for the enhancement of handling qualities and mission effectiveness. Research programs planned for flight on RASCAL include the development of methodologies for highly integrated, high -performance control design to improve rotorcraft maneuverability and agility beyond what is being implemented for LH. It is planned to demonstrate integrated flight/fire control and improved pilotage through advance display symbology and to continue development of handling qualities criteria through in-flight simulation.

The CH-47B in-flight simulator from 1982 to 1989 flew 450 flight hours and produced 25 technical papers.

Planned Research and/or Improvements: The RASCAL will be used primarily to support the following research programs:

1. SCAMP (superaugmented Controls for agile maneuvering performance). This program will promote advancement and flight verification of state of the art control integration methods and solve the Army need for highly agile and maneuverable rotorcraft for NOE and air combat flight.
2. Auto NOE (automated nap-of-the-earth). This program will promote development and flight verification of optimal guidance algorithms, pilot displays, and real-time vision-based sensor processing as well as provide significant advances in adverse weather NOE flight capability.
3. Rapid (Army rotorcraft agility and pilotage improvement demonstration program). The purpose of this program is to flight validate improvements in platform technology, including flight envelope, pilot-vehicle interface, and mission effectiveness. This program is directed toward the Army-identified barriers such as high agility and maneuverability, carefree maneuvering, slung load operations, and integrated flight/fire control operations.
4. CONDOR (covert night-day operations for rotorcraft). This program will use Nunn-Quayle amendment funds in a joint program with the UK. The basic ingredient is an advanced helmet oriented display which is used in a program to investigate the interaction between night vision displays, symbology, and flight control system response.

FLITE - FLYING LABORATORY FOR INTEGRATED TEST AND EVALUATION

Location: Ames Research Center

Sponsor: AFDD/NASA

Purpose: The primary mission of FLITE is to provide a flight research facility capable of supporting research and validation of man-machine interfaces, audio and visual, in a single and tandem cockpit.

Major components: The FLITE aircraft is a modified AH-1S attack helicopter designated NAH-1S. It contains the following equipment packages:

1. Apache pilot night vision system
2. Reconfigurable voice I/O system
3. Physiological instrumentation
4. Programmable symbol generator (in development), and
5. Data acquisition system with 1533 data bus.

Description: The NAH-1S helicopter is a production AH-1S helicopter that was highly modified to accept the AH-64A PNVS system. An instrumentation package has been integrated with the helicopter that includes three IBM 386/486 computers.

Research Applications: The highly modified FLITE vehicle is equipped to act as a research and in-flight simulation facility for both the crew station and man-machine and engineering investigations. The FLITE research facility can/will provide the capability for head down and helmet mounted display systems, voice systems, flight symbology, visual sensor systems, visually coupled systems, head/eye tracking systems, systems integration and algorithm exploration in the flight environment. Instrumentation installed on the aircraft and flight range instrumentation will allow measurement, recording, and data reduction of most flight and cockpit parameters for research personnel.

Planned Research and/or Improvements: The FLITE aircraft will be used to support programs using the following systems:

1. The use of voice input/output systems in the cockpit will be continued.
2. Active Noise Reduction (ANR) systems from RAE, Farnborough, and BOSE, Inc., will be evaluated and combined with the voice input/output research.
3. An electronic chart/moving map display being developed by NASA will be installed and pilot navigation and crew coordination will be investigated by NASA and Army personnel.
4. The pilot night vision system (PNVS) will be coupled with a programmable symbol generator to allow researchers to combine various symbology sets and compare them with MIL STD 1295.
5. A high sensitivity daylight TV will be coaxially mounted with the PNVS FLIR system to allow comparison of scene content and interpretation of the FLIR with day TV. This a joint Army/NASA project.
6. The helmet mounted field of view (FOV) limiter is being fabricated and will allow the FOV to be controlled in the high work load environments of nap of the earth flight and air to air combat. The PNVS head tracker will determine effect of limited FOV with head movement.

7. A wider field of view helmet display is being developed for the FLITE vehicle, but it will be several years in development.

HFRF - HELICOPTER HUMAN FACTORS RESEARCH FACILITY

Location: Ames Research Center

Sponsor: Army/NASA

Purpose: The HFRF is a laboratory which contains several part task simulators aimed at improving or understanding how pilots orient themselves to the immediate environment and extract dynamic information from direct visual cues, light-intensification systems, thermal imagery combined with computer-generated flight symbology, or cockpit displays.

Major components: The laboratory contains four part task simulators which are to investigate:

1. Geographical orientation
2. Visual cues simulator
3. Voice-activated controls
4. Pilot decision-making.

Description:

Research Applications: The goal of the geographic orientation study is to develop conceptual designs for electronic maps that depict terrain, planned flight path, significant natural or man-made objects, and current position in a manner that is both perceptually and cognitively compatible with the pilot's internal representations.

Thermal imaging systems allow pilots to fly at very low levels and avoid obstacles in reduced visibility. Despite the use of these sensors little is known about the human capabilities and limitations of these systems. This research is directed improved system specifications and design modifications by identifying the most significant human factors problems.

Research has been conducted to identify tasks for which voice controls offer a workload or performance benefit.

Recent simulation research evaluated the effects of crew planning on subsequent decisions and flight safety.

Identified performance limits with current night vision devices and maps.

Planned Research and/or Improvements:

A^{3}I-MIDAS - ARMY-NASA AIRCREW/AIRCRAFT INTEGRATION PROGRAM - MAN-MACHINE INTEGRATION DESIGN AND ANALYSIS SYSTEM

Location: Ames Research Center

Sponsor: Army/NASA, Computational Human Engineering Research Office.

Purpose: Develop model and principle based humans factors methodology to aid in conceptual design of rotorcraft crewstations. Produce prototype design/analysis workstation (MIDAS) which moves MMI from hardware to software. Develop the ability to predict quantitative human performance impacts of increasingly complex missions and equipment. Improve cockpit designs and reduce costs through human factors oriented computer-aided engineering practices.

A^{3}I is an exploratory program to advance computational representations of human performance and behavior in the design, synthesis, and analysis of manned systems. The major product is MIDAS which provides analysts/engineers with interactive symbolic, analytic, and graphical components which permit early integration and visualization of human engineering principles.

Major components: The major components of MIDAS are an integrated set of computer workstations supporting multiple perspectives containing information about mission, operator and environment in varying levels of detail.

Description: The core of MIDAS is a set of integrated human behavior and performance models which address perception, workload, cognition, task analysis, mission results, anthropometry, training assessment methods, vehicle and equipment representations, mission/task descriptions, cockpit design tools, and world models. The workstation graphics are used to display interactions between cockpit designs, mission, operator performance and behavior, and the dynamics of complex interactions.

Research Applications: Successfully completed phase IV of a fully integrated pilot and equipment model, aero-guidance, and visualization. Conducted a proof-of-concept test on Apache Longbow crewstation evaluation.

Planned Research and/or Improvements: Demonstrate phase V implementation of new cognitive model architecture, integrate perceptual cognitive models and improve the user interface.

DTRS - DISPLAY TECHNOLOGY RESEARCH SIMULATORS

Location: NASA/Army

Sponsor: Langley Research Center

Purpose: The DTRS programs are aimed at improving display technologies; current programs include (1) research on thin film electroluminescence (TFEL) display media, (2) advanced graphics engines for display generation techniques, and (3) integrated control panels, multifunction keyboards, and cockpit-integration media.

Major components: The DTRS facility is a combination of the Ambient Lighting Simulator (ALS) and several part task simulators. ALS is a domed simulator into which several different cockpits can be inserted. Adverse lighting effects on the displays can be studied.

Description:

Research Applications:

Planned Research and/or Improvements:

MICOM MILLIMETER-WAVE SIMULATION SYSTEM (MSS) HARDWARE-IN-THE-LOOP (HWIL) FACILITY

Location: U.S. Army Missile Command, Redstone Arsenal, AL

Sponsor: MICOM

Purpose: The MSS HWIL Facility is used to test tactical missile seeker hardware and software in a real time closed-loop situation over the full missile flight scenario.

Major Components: The primary MSS HWIL components are:

1. Test Article 5-DOF support system
2. Target and clutter signature generators.
3. ECM environment generators.

Description: The MSS HWIL Facility was modified for operation at Ka-band to support LONGBOW seeker development and flight readiness testing. This facility transmits a modulated and delayed sample of the seeker-transmitted signal to produce an RF signal at the seeker antenna which represents the radar return from the selected environment. Tactical seeker hardware and software are tested in a real time closed-loop situation over the full flight scenario. The seeker IMU hardware is bypassed, and simulated accelerometer and gyro signals are provided by a real time 6-DOF missile simulation. Seeker computer guidance commands are fed back to this simulation to provide closed-loop operation. Target and clutter environments are simulated by appropriately modulating the sampled seeker waveform. Various ECM environments can also be represented simultaneously with target and clutter signals.

Research Applications:

1. Verification of test readiness for all seeker flight hardware and software.
2. Evaluation of seeker performance envelope.
3. Parametric performance analyses and algorithm optimization.
4. Independent seeker evaluation by Government agencies.
5. Verification of contractor simulations of seeker hardware and software.

Planned Research and/or Improvements: Support of LONGBOW Full Scale Development program.

STRATA - SIMULATOR TRAINING RESEARCH ADVANCED TESTBED FOR AVIATION - FORMERLY THE SCTB (SIMULATOR COMPLEXITY TESTBED)

Location: ARI, Ft. Rucker, AL

Sponsor: Army Research Institute. ARI list the following research sponsors: PM Trade, USAAVNC, TRADOC Systems Manager, AMSAA, HEL, AVSCOM, PEO-Longbow, NTSC, A.F. Armstrong Lab, A.F. Simulation Systems Project Office, Canadian Government, FAA, Commercial - CAE Electronics, CAE Link (Comanche), Charles River Analytics, Sikorsky Aircraft

Purpose: The STRATA, which will be operational in March 1992, is a simulator designed to (a) enable estimation of minimum simulator fidelity requirements to train specified tasks, (b) development of simulator-based training systems and strategies, (c) support war-fighting doctrine development based on man-in-the-loop, and (d) provide device design requirements of advanced training systems.

Major components: The major hardware components include:

1. A pilot station (AH-64 initially) with FOHMD
2. Copilot/gunner station with a rear screen projection
3. A blue/red station to control aircraft, vehicles or threats
4. An experimenter/operator station
5. A relational database management system workstation
6. An Evans & Sutherland ESIG-1000
7. A visual database workstation.

Description: The flight simulator will include software modules based on distributed processing for mission support, experimenter/operator station actions, threats, visual environment, control loading, sensors, navigation and communications, aural cues, and flight aerodynamics. The FOHMD with eye tracking will be used for the pilot stations while the second crew station will use a backlit CRT screen(s). A relational database will be used to create tactical scenarios and control sites, intelligent companions and adversaries, weapons, site interaction with terrain, gaming area weather, and the visual interface. The database is referred to as ITEMS (interactive tactical environment management system).

The STRATA will be unique, versatile, flexible, and reconfigurable. It will encompass the RAH-66 crew station design and flight dynamics.

Research Applications: The research objectives are to (1) determine the least expensive fidelity requirements for future aviation simulation (for training), (2) demonstrate models that trade off realism vs cost for simulation and training devices, and (3) determine training requirements for force-on-force exercises using networked simulators using ALO doctrinal requirements.

Planned Research and/or Improvements: Simulator will be operational in 1992.

RWA SS.- ROTARY WING AIRCRAFT SIMULATOR SYSTEM

Location: Ft. Rucker, AL

Sponsor: AVNC-TSM Comanche

Purpose: The basic purpose of the RWA SS is to define, refine, and mature warfighting tactics, techniques, procedures for current and future Army helicopters such the Comanche, Apache, and AHIP.

Major components: The RWA SS will be a suite of 8 intervisible, integrated fixed-base simulators having a domed projection with 360° field of regard. The crew cabin will be reconfigurable with either 1 or 2 crew cabins. The simulation will support 200 visible ground vehicles (400 coordinate systems), 75 visible weapons/weapons effects, 16 visible aircraft. The crew station and flight dynamics models will be able to accommodate RAH-66, Apache B and D, and OH-58D models.

Description: See above discussion.

Research Applications: See purpose statement above.

Planned Research and/or Improvements: An early operational capability is scheduled for 2nd quarter FY 93 and the final system will be completed in FY 98.

AIRNET

Location: Ft. Rucker, AL

Sponsor: Army Aviation Center

Purpose: Train pilot in combat missions and tactics

Major components: The training facility includes

1. 8 rotary wing aircraft (RWA) simulators
2. 2 M1 tank simulators
3. 2 M2/3 Bradley simulators
4. 2 fixed wing aircraft (FWA) simulators
5. 1 stealth aircraft simulator
6. 4 semiautomated forces (SAFOR) stations
7. 4 air defense artillery anti-tank systems (ADATS) simulators
8. 2 non-line of sight (NLOS) simulators.

Description: The simulators are fixed based with CRT images for visual terrain. The simulator all interact and have own ship controls.

Research Applications: The simulators are for training purposes.

Planned Research and/or Improvements:

FLIGHT SIM - GEORGIA INSTITUTE OF TECHNOLOGY SIMULATOR LABORATORY'

Location: Georgia Institute of Technology, Atlanta, Georgia

Sponsor: PM-Trade, ARI, and IST (UCF)

Purpose: Flight SIM is a laboratory and organization developed to interact with UCF's IST. It was established to provide a university-based unique man-in-the-loop real time rotorcraft flight simulator for training, evaluation, and integrated mathematical model development.

Major components: The major simulation components of Flight SIM are

1. Analytic model of elastic rotor and complex flight control system. The blade element is based on GENHEL element.
2. Rapid evaluation of proposed design criteria and quick feedback to the design process.
3. Cockpit integration of man-machine interface, multi-function displays, virtual cockpit, HUD configurations and symbology, RPA
4. Multiple pilot workstations
5. Utilize DMA data for training simulation
6. Digital control loading
7. Interface with SIMNET and CSRDF

Description:

Research Applications:

Planned Research and/or Improvements: The 4 phase, 5 year development of Flight SIM began in 1990. It is closely coupled with IST program.

IST - INSTITUTE FOR SIMULATION AND TRAINING

Location: University of Central Florida, Orlando, FL

Sponsor: UCF, DARPA, PM Trade, ARI, NTSC, DOT

Purpose:

Major components: The IST elements include:

1. Networking laboratory
2. Simulated forces laboratory
3. Visual systems laboratory
4. Aviation systems laboratory.

Description:

Research Applications:

1. Incremental improvements in current simulation networking technologies such ethernet variations, token ring, or token bus
2. Incorporation of next generation network technologies into networked simulations such as fiber optics based or open system interconnection protocols
3. Development of approaches for compression of digitized voice data over communications networks
4. Development of software programs to model simulator networks
5. Automated forces simulation research for
   a. Rapid prototype capability for different AF components, terrain reasoning algorithms, mission spec languages, and protocols
   b. Evaluation of wide area mine algorithms and dismounted infantry approaches.

Planned Research and/or Improvements:

SHADOW - SIKORSKY IN-FLIGHT SIMULATOR

Location: Stratford, Conn

Sponsor: Sikorsky Aircraft Corporation

Purpose: In flight simulator or hot-bench vehicle to flight test avionics equipment.

Major components: A modified S-76 helicopter adapted to record flight data and control data.

Description:

Research Applications:

Planned Research and/or Improvements:

FMS - SIKORSKY FULL MISSION SIMULATOR (SEE REF 10, SECTION F.6.3.4.3)

Location: Stratford, Conn.

Sponsor: Sikorsky Aircraft Corporation

Purpose: The FMS represents the air vehicle, crewstation, and MEP designs for the purpose of evaluating the LH system during development. The FMS addresses total mission environment, future threat environment, system effectiveness, subsystem performance, levels of automation, and pilot workload and performance.

Major components: The full mission simulator includes a domed moving base simulator coupled to a domed fixed base simulator. The dome is 20 feet in diameter. The image generator is base on a Compuscene IV or IV-plus. The motion based dome undergoes ±30° angular motion and ±4 feet of translational motion. The FMS has the capability to integrate flight controls, handling qualities, crewstation, and MEP/armament systems.

Description: The major components include

1. 20-ft moving base dome
2. Domed fixed base simulator
3. Compuscene IV-plus image generators
4. Test director station
5. Red/blue team station
6. Tactical gaming station
7. GENHEL math models with a library of models and databases including GENWORLD, GENDATA, GENMEP.

Research Applications: Comanche development program

Planned Research and/or Improvements: Integrated with a fixed based simulator.

MCDONNELL DOUGLAS HELICOPTER COMPANY

Location: Mesa, AZ

Sponsor: McDonnell Douglas Helicopter company

Purpose: TBD

Major components:

Description:

Research Applications:

Planned Research and/or Improvements:

BELL HELICOPTER TEXTRON

Location: TBD

Sponsor:

Purpose:

Major components:

Description:

Research Applications:

Planned Research and/or Improvements:

BOEING HELICOPTER COMPANY

Location:

Sponsor:

Purpose:

Major components:

Description:

Research Applications:

Planned Research and/or Improvements:

APPENDIX B--SIMULATION EMPLOYEES - FEDERAL AND ON-SITE CONTRACTORS

AFDD SIMULATION PERSONNEL - FEDERAL GOVERNMENT

NAME	ORGANIZATION	GRADE	DISCIPLINES
Gossett, Terry	SAVRT-AF-B	GM-15	Manager, Simulation & A/C Systems
Stephens, Wendell	-B	GM-15	Staff Scientist, Aero Modelling Simulation Technology
Kaster, Fran	-B	GS-13	Computer Specialist Facility Support
Hartzell, Jim	-BI	GM-15	Manager, Computational Human Engineering
Shively, Jay	-BI	GS-13	Human Factors
Bucher, Nancy	-BH	GM-14	Manager,Crew Station R&D
Haworth, Loran	-BH	GS-14	In-Flight Simulation Flight Symbology
Perlaki, Kinga	-BH	GS-12	Simulation Lab Mgr Simulation Training
Rogers,Steve	-BH	GS-12	Data Reduction and Analysis
Key, David	-BC	GM-15	Manager, Flt Control, Sim Fidelity, Param. ID, Math Models
Danek, George	-BC	GS-13	Simulation Technology
Atencio, Adolph	-BC	GS-13	Sim Validation Turbulence Models
Eshow, Michelle	-BC	GS-13	In-Flt Sim, Display Dynamics, Flt Valid
Tischler, Mark	-BC	GS-14	System ID, Math Models, Models

NAME	ORGANIZATION	GRADE	DISCIPLINES
Whalley, Matt	-BC	GS-13	Rotorcraft Air to Air Combat/Automan
Mansur, Mohammadreza	-BC	GS-13	Apache/701C models
Hart, Dan	-BC	GS-11	Visual/Motion Fidelity.
Fletcher, Jay	-BC	GS-12	UH-60 Param. ID
Blanken, Chris	-BC	GS-14	LH Sim Eval of Flt Control/HQ
Takahashi, Mark	-BC	GS-13	FCS design, math models
Churchill, Gary	-BC	GS-14	HQ, flight control, simulation
Reynolds, Thomas	-BC	LTC	Test pilot
Bivens, Court	-BC	GS-13	Simulation, flight test, math models

DIRECTOR OF ENGINEERING SIMULATION PERSONNEL

Lindberg, Wayne	AMSAV-ES	GM-15	MEP/Weapons
Metzler, Tom	-ES	GM-15	Crewstations, Controls and Displays
Boen, Gil	-ES	GM-14	Mission support, crew system, and training
Nash, Joe	-ES	GS-12	Mission support, crew systems, and training
Bouschillon, John	-ES	GS-13	Weapons and stores
Than, Pham	-ES	GS-11	Weapons and stores
Bick, Frank	-ES	GM-14	Human factors

DIRECTORATE OF ADVANCED SYSTEMS

Sundmacher, Doug	AMSAV-N	GS- 12	Simulation POC

APPENDIX C--TECHNICAL PRESENTATIONS AND REPORTS IN THE SIMULATION FUNCTIONAL AREA AT AFDD

1. Tischler, Mark B., *Frequency-Response Method for Rotorcraft System Identification with Applications to the BO-105 Helicopter*, Stanford University Seminar on Guidance and Control, 28 November 1990.

2. Kirlik, A.; Markert, W.J.; and Shively, R.J., "Perceptual and Contextual Influences on Dynamic Decision-Making Performance", *Proceedings of the IEEE Conference on Systems, Man and Cybernetics*, Anaheim, CA, November 1990.

3. Anon., *2GCHAS User's Manual*, Vols. I & II," U.S. Army AVSCOM Aeroflight-dynamics Directorate, Moffett Field, CA, December 1990, Michael J. Rutkowski, Editor.

4. Anon., *2GCHAS Theory Manual*, Vols. I and II, U.S. Army AVSCOM Aeroflight-dynamics Directorate, Moffett Field, CA, December 1990, Michael J. Rutkowski, Editor.

5. Anon., *2GCHAS Programmer's Manual*, U.S. Army AVSCOM Aeroflight-dynamics Directorate, Moffett Field, CA, December 1990, Michael J. Rutkowski, Editor.

6. Anon., *2GCHAS Applications Manual*, U.S. Army AVSCOM Aeroflightdynamics Directorate, Moffett Field, CA, December 1990, Michael J. Rutkowski, Editor.

7. Haworth, Loran A., *Flight Symbology for Helmet Mounted Display*, Revision 3B, Flight Symbology Working Paper on distribution to NASA, U.S. Army (AVSCOM), and the Royal Aerospace Establishment, England, January 1991.

8. Fan, __; Tits, __; Barlow, __; Tsing, __; and Tischler, M., *On the Design of Decoupling Controllers for Advanced Rotorcraft in the Hover Case*, 29th Aerospace Sciences Meeting, Reno, Nevada, 7-10 January 1991.

9. Prevost, Michael, and Banda, Carolyn, *A Visualization Tool for Human-Machine Interface Designers*, SPIE/SPSE Symposium, San Jose, CA, 24 February-1 March 1991.

10. Nsi-Mba, M.; Ramachandran, K.; and Caradonna, F.X., *Experimental and Computational Studies of Hovering Rotor Flows*, International Basic Research Conference, Georgia Tech, Atlanta, GA, 25-27 March 1991.

11. Rutkowski, Michael; Ruzicka, Gene; Tan, Carina; Ormiston, Robert; and Stephens, Wendell, *First Level Release of 2GCHAS for Comprehensive Helicopter Analysis--A Status Report*, AHS Specialists Meeting, Atlanta, GA, 25-27 March 1991.

12. Yu, Yung H., *Rotorcraft Aeroacoustics Technology--U.S. Army's Perspective*, AHS Specialists Meeting, Atlanta, GA, 25-27 March 1991.

13. Key, David L., *Bandwidth and SIMDUCE as Simulation Fidelity Criteria*, NASA/FAA Helicopter Simulator Workshop, Santa Clara, CA, April 1991.

14. Tischler, Mark B., *Frequency-Response Techniques for Documentation and Improvement or Rotorcraft Simulators*, FAA Conference on Rotorcraft Simulation, Santa Clara, CA, 24 April 1991.

15. Newman, R., and Haworth, L.A., *An Approach for Display Evaluation*, presented at the 1991 European Society of Experimental Test Pilots Symposium, Bath, England, May 1991.

16. Mitchell, D.; Hoh, R.; Atencio, Adolph; and Key, David, *The Use of Ground-Based Simulation for Handling Qualities Research: A New Assessment*, 1991 AHS Annual Forum, Phoenix, AZ, 6-8 May 1991.

17. Blanken, Christopher L.; Hart, Daniel C.; and Hoh, R.H., *Helicopter Control Response Types for Hover and Low-Speed Near-Earth Tasks in Degraded Visual Conditions*, 1991 AHS Annual Forum, Phoenix, AZ, 6-8 May 1991.

18. Austin, Fred; George, Dino; and Bivens, Courtland, *Real-Time Simulation of Helicopter Air-to-Air Combat*, 1991 AHS Annual Forum, Phoenix, AZ, 6-8 May 1991.

19. Kim, Frederick; Celi, Roberto; and Tischler, Mark, *Forward Flight Trim Calculations and Frequency-Response Validation of a High-Order Helicopter Simulation Model*, 1991 AHS Annual Forum, Phoenix, AZ, 6-8 May 1991.

20. Velkoff, Henry, and Tung, Chee, *Aerodynamic Design of a Coanda Induced Force and Thruster Anti-Torque System*, 1991 AHS Annual Forum, Phoenix, AZ, 6-8 May 1991.

21. Riaz, J.; Prasad, J.; Schrage, D.; and Gaonkar, G., *A New Method for Simulating Atmospheric Turbulence for Rotorcraft Applications*, AGARD Symposium, Seville, Spain, 20-23 May 1991.

22. Tischler, Mark B., *System Identification Requirements for High-Bandwidth Rotorcraft Flight Control System Design*, presented at the 1991 Meeting of the American Control.

23. Conference, Boston, Mass., 26-28 June 1991.

24. Key, David; and Hoh, Roger, *The Role of In-Flight Simulation for Developing and Validating ADS-33 Requirements*, International Symposium, Braunschweig, FRG, 1-3 July 1991.

25. Aiken, Edwin; Hindson, William; Lebacqz, J. Victor; Denery, Dallas; and Eshow, Michelle, *Rotorcraft In-Flight Simulation at NASA Ames: A Review of the 80s and Plans for the 90s*, International Symposium on In-Flight Simulation for the 1990s, Braunschweig, Federal Republic of Germany, 1-3 July 1991.

26. Takahashi, Marc, *Helicopter Flight-Control Design Using an H2 Method*, Paper No. AIAA-91-2753, AIAA Guidance, Navigation and Control Conference, New Orleans, LA, 12-14 August 1991.

27. Mitchell, David; Hoh, Roger; Atencio, Adolph; and Key, David, *Simulation Evaluation of the Effects of Time Delay and Motion on Rotorcraft Handling Qualities*, AIAA Atmospheric Flight Mechanics Conference, New Orleans, LA, 12 August 1991.

28. Schroeder, J.; Tischler, Mark; Watson, D.; and Eshow, Michelle, *Identification and Simulation Evaluation of an AH-64 Helicopter Hover Math Model*, AIAA Atmospheric Flight Mechanics Conference, New Orleans, LA, 12-14 August 1991, AIAA Paper No. 91-2877.

29. Tischler, Mark B., *Rotorcraft System Identification* (contributing author), AGARD Advisory Report No. 280, 1991.

30. Eshow, Michelle; Aiken, Edwin; Hindson, William; Lebacqz, J. Victor; and Denery, Dallas, *A Review of Recent Programs and Future Plans for Rotorcraft In-Flight Simulation at Ames Research Center*, SAE Aerospace Technology Conference, Long Beach, CA, 23-26 September 1991.

31. Ruzicka, Gene C.; and Ormiston, Robert A., *Finite Element Analysis and Multibody Dynamics Issues in Rotorcraft Dynamic Analysis*, Paper No. 91-10, 17th European Rotorcraft Forum, Berlin, Germany, 24-27 September 1991.

32. Ormiston, Robert; Ruzicka, Gene; Tan, Carina; and Rutkowski, Michael, *First Level Release of 2GCHAS for Comprehensive Helicopter Analysis*, 17th European Rotorcraft Forum, Berlin, Germany, 24-27 September 1991.

33. Mitchell, David; Hoh, Roger; Atencio, Adolph; and Key, David, *Use of Ground Based Simulation for Handling Qualities Research: A New Assessment*, AGARD FMP Symposium, Brussels, Belgium, October 1991.

34. Ormiston, Robert A., "Rotor-Fuselage Dynamics of Helicopter Air and Ground Resonance," *Journal of the American Helicopter Society*, April 1991.

35. Hodges, Dewey H.; Hopkins, A. Stewart; Kunz, Donald L.; and Hinnant, Howard E., *General Rotorcraft Aeromechanical Stability Program (GRASP) Theory Manual*, NASA TM 102255, USAAVSCOM TM 89-A-003, October 1990.

36. Atchley, Paul, *Perceptual Style and Air-to-Air Tracking Performance*, AVSCOM Report #TR-90-A-004.

37. Lifshitz, S.; Merhav, S.; Grunwald, A.; Tucker, G.; and Tischler, Mark, *Suppression of Biodynamic Interference in Head-Tracked Teleoperation*, AVSCOM Report #TR-90-A-005.

38. Whalley, Matthew S., *Development and Evaluation of an Inverse Solution Technique for Studying Helicopter Maneuverability and Agility*, AVSCOM Report #TR-90-A-008, NASA TM 102889, July 1991.

39. Becker, Curtis A.; Hayes, Brian C.; and Gorman, Patrick C., *User Acceptance of Intelligent Avionics: A Study of Automatic-Aided Target Recognition*, AVSCOM Report #TR-90-A-009

40. Kumar, S.; Harding, J.; and Bass, S., *AH-64 Apache Engineering Simulation Non-Real Time Validation Manual*, AVSCOM Report #TR-90-A-010, October 1990.

41. Kumar, S.; Harding J.; and Bass, S., *AH-64 Apache FLYRT Engineering Manual*, AVSCOM Report #TR-90-A-011, October 1990.

42. Kumar, S.; Harding, J.; Bass, S.; Metz, B.; and Mouritsen, S., *AH-64 Apache Engineering Simulation Program Documentation*, AVSCOM Report #TR-90-A-012, October 1990.

43. Kumar, Shantha, *Documentation of the DASE/BUCS Module Digital Computer Code to Model the AH-64 Helicopter (FLYRT)*, AVSCOM Report #TR-91-A-002.

44. Fabunmi, James A., *Control of Helicopter Rotor Blade Aerodynamics*, NASA CR-4350, Contract NAS2-13095, July 1991.

45. Bivens, Courtland C., and Mansur, Hossein, *AH-64 Apache Piloted Simulated Development and Assessment*, AVSCOM Report #TR-91-A-004, (date) .

46. Mansur, Hossein, and Chaimoavich, Menahem, *Modeling Methods for High-Fidelity Rotorcraft Flight Mechanics Simulation*, AVSCOM Report #TR-91-A-005, (date) .

47. Takahashi, Marc D., *Design of Flight-Control Laws for a UH-60 Helicopter in Hover Using an H-2 Loop-Shaping Design Method*, AVSCOM Report #TR-91-A-006, (date) .

48. McCauley, M.E.; Cook, A.M.; and Voorhees, J.W., *Recent Proceedings of the NASA Steering Committee on Simulator Induced Sickness*, AIAA Meeting, Washington, DC, Paper No. AIAA-91-2973-CP.

49. Kumar, S.; Harding, J.; and Bass, S., *AH-64 Apache Engineering Simulation Real-Time Program Verification Checkout Data (Volumes I and II)*, AVSCOM Report #TR-91-A-007, October 1990.

AFDD SIMULATION FUNCTIONAL AREA CONTRACTOR PRESENTATIONS

1. Simpson, Carol A., "Voice Systems," briefing for Integrated Crew Station Design Workshop for Future Armored Fighting Vehicles, February 1991.

2. Simpson, Carol A., "Combat Helicopter Voice Interactive Systems," invited presentation for Study 3147 AI, NATO 22nd Meeting of the Aircraft Displays and Aircrew Station Working Party (WP), NATO HQ, Brussels, Belgium, September 1991.

3. McCauley, M.E.; and Sharkey, T.J., "Spatial Orientation and Dynamics in Virtual Reality Systems: Lessons Learned from Flight Simulation," *Proceedings of the Human Factors Society 35th Annual Meeting*, pp. 1348-1352, 1991.

4. Sharkey, T.J.; and McCauley, M.E., *The Effect of Global Visual Flow on Simulator Sickness*, AIAA Meeting, Washington, DC, 1991.

5. Sharkey, T.J., *Army CSRDB/NASA Ames: Research Update*, paper presented at the NASA Simulator Sickness Steering Committee Meeting, Naval Training Systems Center, Orlando, FL, March 1991.

6. McCauley, M.E.; and Sharkey, T.J., "Spatial Orientation and Dynamics in Virtual Reality Systems: Lessons Learned from Flight Simulation," *Proceedings of the Human Factors Society 35th Annual Meeting*, pp. 1348-1352, 1991.

7. Sharkey, T.J.; and McCauley, M.E., *The Effect of Global Visual Flow on Simulator Sickness*, AIAA Meeting, Washington, DC, Paper AIAA-91-2975.

8. Staveland, Lowell, *MIDAS TLM: Man-Machine Integrated Design and Analysis System Task Loading Model*, work performed under NASA Contract NA2-13210, July 1991.

9. Larimer, James; Prevost, Michael; Arditi, Aries; Azueta, Steven; Bergen, James; and Lubin, Jeffrey, "Human Visual Performance Model for Crewstation Design," *Proceedings of the International Society for Optical Engineering*, San Jose, CA, 26-28 February 1991.

ANNEX B, APPENDIX 4.3, CREW STATION R&D BRANCH, AEROFLIGHTDYNAMICS DIRECTORATE, MOFFETT FIELD, CA

ARMY AVIATION SIMULATION SURVEY

Conducted by the Institute for Defense Analyses

Organization USA Aeroflightdynamics Dir - CSRDF, Moffett **Date** 27 Nov 92

Point of Contact Dr. Nancy M. Bucher **Phone** 415 604 5161

Current Simulation Plan:

Attach a description of the organization's plan for the use of simulations to address key issues. Indicate current capabilities and planned new functionalities/enhancements and the funding profile for improvements.

Critical Issues:

List below the critical issues facing your organization where there might be potential for the application of simulation if new technology were available. List the issues in order of importance. Please highlight requirements for simulation of joint and combined arms operations.

To the right of the issue are listed potential benefits from the use of simulation. Estimate the value of the simulation for each benefit using a scale of 1 to 5 with 5 being the best, most positive rating. (Please change "Benefit"headings and/or specify "Other" as appropriate for your organization/ mission.)

CRITICAL ISSUES:	SIMULATION BENEFITS				
	Save Resources	Save Time	Improve Effectiveness	Safety	Other
A. Engineering requirements spec and eval for advanced MEP and platform concepts	5	5	5	5	5
B. Mission effectiveness evaluations of advanced MEP and platform concepts (requires combined arms/joint service ops)	5	5	5	5	5
C. Pilot-vehicle interface information integration and optimization for current and projected advanced MEP and platform concepts.	5	5	5	5	5
D. Training, tactics, doctrine developments resulting from advanced MEP and platform concepts (requires combined arms/joint services ops)	5	5	5	5	5

New Simulation Technology:

Please identify, in order of importance, specific new simulation technology that would assist in addressing critical issues in your organization. (New simulation technology is defined as that which requires some level of research and development effort.) Please highlight requirements for simulation of joint and combined arms operations. To the right of the new capability/functionality are listed R & D cost considerations. Indicate the relative importance of the considerations on a scale of 1 to 5 with 5 being the most important.

NEW CAPABILITY/FUNCTIONALITY	R & D COST CONSIDERATIONS			
	Speed in Developm't	Low Unit Cost	Low Total Cost	High Fidelity
E. High bandwidth, high fidelity full mission simulator long haul network.	5	3	3	5
F. Reasonably priced, easily modifiable, high fidelity computer generated image systems w/interchangeable databases w/intersystem compatibility.	5	5	4	5
G. Interactive electronic battlefield/threat environment database w/high fidelity, validated models, usable by simulation facilities of all levels of capability (combined arms/joint services ops)	4	5	4	5
H. Reasonably priced high fidelity head tracked image display systems.	3	5	4	5
I. Rapidly reconfigurable cockpits and supporting MEPs.	3	5	4	5

Networking:

Describe the local area network(s)(LAN), if applicable. If no LAN exists, is there a requirement for one? Describe the requirement.

1. Ethernet for networking local simulation players.
2. SCRAMNET for networking simulation software processors (to be installed in FY92).

Describe the long haul network(s) (LHN), if applicable. If no LHN exists, is there a requirement for one or more? Describe the requirement to include gateways and interface units. Include any plans, programs and the status of funding. Bandwidth requirements--56Kbps? T1 1.544 Mbps? DARPA's TWBNet?

1. T1 line shared for base communications.
2. TWBNet dedicated to DARPA/NAS project.
3. T1 line dedicated to CSRDF for CSRDF/BDS-D link (to be installed in FY92).

Rate items 1 through 24 on a scale of 1 to 5 with 5 being the highest rating.

How important is it to your organization to network with the following nodes, LANs, facilities:

(Please comment using extra paper keying comments to the appropriate numbers below.

Node/Facility	Rating
1. Aviation Testbed, BDS-D (AIRNET), at Ft Rucker, AL	5
2 Crewstation Research and Development Facility (CSRDF), Moffett Field, CA	N/A
3. Air Combat Mission Enhancement (ACME), Williams AFB, AZ	3
4. Visual Technology Research Simulator, Naval Training Center, Orlando, FL	3
5. Institute for Simulation and Training, Orlando, FL	4
6. SCTB, ARI, Ft. Rucker, AL	5
7. Other: Aviation units worldwide (AIRNET)	N/A

How important to your organization are the following simulation attributes? Answer for "a just barely good enough--60% solution," recognizing that funding is extremely tight. (Please comment as desired; using extra paper keying comments to the appropriate numbers below.)

8. Need for interoperability with other simulators/simulations?	5
9. Need for man-in-the-loop?	5
10. Fidelity in:	
10.1 Visuals?	5
10.1.1 Diurnal cycle?	3
10.1.2 Shadows?	4
10.1.3 Weather?	4
10.1.3.1 Clouds?	4
10.1.3.2 Rain?	3
10.1.3.3 Snow?	3
10.1.3.4 Fog	4
10.1.4 Smoke?	4
11. Field of view?	5
12. Terrain data base?	5
13. Dynamic terrain?	5
14. Weapons effects?	5
14.1 Ph, Pk?	5
14.2 Trajectory?	5
14.3 Signature?	5
14.3.1Visual?	5
14.3.2 IR?	5
14.3.3 Radar?	5
14.3.4 Acoustical?	TBD
14.3.5 Directed energy weapons?	TBD

15.	Vehicle signature?	5
	15.1 Visual?	5
	15.2 IR?	5
	15.3 Radar?	5
	15.4 Acoustical?	TBD
16.	Need for semi-automated forces (SAF)?	5
17.	Operations with combined arms team?	4
18.	Operations with other Services?	4
19.	Operations with other nations?	3
20.	Number of objects?	5
	20.1 Include 10 objects?	5
	20.2 Include 50 objects?	5
	20.3 Include 100 objects (targets & friendly)?	5
	20.3 Include 500 objects?	4
	20.5 Include 1000 objects?	3
	20.6 Include 5000 objects?	3
	20.7 Include 10000 objects?	5
21.	Combat service support - RAM - impact?	5
22.	Electronic warfare?	5
	22.1 ECM?	5
	22.2 ECCM?	TBD
	22.3 EMP?	TBD
23.	Mobility of the simulator/simulation? (all cases)	2
24.	V & V, Accreditation of models?	5

Funding: If you had the authority to reprogram your funding, would you do so to achieve the simulation capabilities you have indicated are needed? Yes___. No___.

ANNEX B, APPENDIX 5, PM RAH-66 COMANCHE, PEO, AVIATION, ST. LOUIS

ARMY AVIATION SIMULATION SURVEY

Conducted by the Institute for Defense Analyses

Organization COMANCHE PMO **Date** 18 Dec 91

Point of Contact Bob Tomaine **Phone** 314 263 1349

Current Simulation Plan:

Attach a description of the organization's plan for the use of simulations to address key issues. Indicate current capabilities and planned new functionalities/enhancements and the funding profile for improvements.

Critical Issues:

List below the critical issues facing your organization where there might be potential for the application of simulation if new technology were available. List the issues in order of importance. Please highlight requirements for simulation of joint and combined arms operations.

To the right of the issue are listed potential benefits from the use of simulation. Estimate the value of the simulation for each benefit using a scale of 1 to 5 with 5 being the best, most positive rating. (Please change "Benefit"headings and/or specify "Other" as *appropriate* for your organization/ mission.)

CRITICAL ISSUES:	SIMULATION BENEFITS				
	Save Resources	Save Time	Improve Effectiveness	Safety	Reduce Tech Risk
A. Crew procedures. Crew station layout MANPRINT assessment		4	3	4	4
B. Handling qualities assessment	4	4			4
C. Flight Controls Development	4	4		4	3
D. Combat Effectiveness Air-To-Air Engagements			4	2	3

New Simulation Technology:

Please identify, in order of importance, specific new simulation technology that would assist in addressing critical issues in your organization. (New simulation technology is defined as that which requires some level of research and development effort.) Please highlight requirements for simulation of joint and combined arms operations. To the right of the new capability/ functionality are listed R & D cost considerations. Indicate the relative importance of the considerations on a scale of 1 to 5 with 5 being the most important.

NEW CAPABILITY/FUNCTIONALITY	Speed in Developm't	Low Unit Cost	Low Total Cost	High Fidelity
	R & D COST CONSIDERATIONS			
E. Increased terrain fidelity (texture) in NOE environment.	3			5
F. Air-to-air simulation	4		4	4

Networking:

Describe the local area network(s)(LAN), if applicable. If no LAN exists, is there a requirement for one? Describe the requirement.

- N/A

Describe the long haul network(s) (LHN), if applicable. If no LHN exists, is there a requirement for one or more? Describe the requirement to include gateways and interface units. Include any plans, programs and the status of funding. Bandwidth requirements--56Kbps? T1 1.544 Mbps? DARPA's TWBNet?

- N/A. Would be useful to have access to an Army "approved" simulation battlefield to obtain objectives operational effectivness impact and comparisons with other systems.

Rate items 1 through 24 on a scale of 1 to 5 with 5 being the highest rating.

How important is it to your organization to network with the following nodes, LANs, facilities:

(Please comment using extra paper keying comments to the appropriate numbers below.)

Node/Facility	Rating
1. Aviation Testbed, BDS-D (AIRNET), at Ft. Rucker, AL	3
2. Crewstation Research and Development Facility (CSRDF), Moffett Field, CA	4
3. Air Combat Mission Enhancement (ACME), Williams AFB, AZ	1
4. Visual Technology Research Simulator, Naval Training Center, Orlando, FL	1
5. Institute for Simulation and Training, Orlando, FL	1

How important to your organization are the following simulation attributes? Answer for "a just barely good enough--60% solution," recognizing that funding is extremely tight. (Please comment as desired; using extra paper keying comments to the appropriate numbers below.)

8. Need for interoperability with other simulators/simulations?	2
9. Need for man-in-the-loop?	5
10. Fidelity in:	
10.1 Visuals?	5
10.1.1 Diurnal cycle?	3
10.1.2 Shadows?	3
10.1.3 Weather?	3
10.1.3.1 Clouds?	1
10.1.3.2 Rain?	2

10.1.3.3 Snow?	2
10.1.3.4 Fog	2
10.1.4 Smoke?	3
11. Field of view?	5
12. Terrain data base?	5
13. Dynamic terrain?	3
14. Weapons effects?	
14.1 Ph, Pk?	2
14.2 Trajectory?	4
14.3 Signature?	2
14.3.1 Visual?	2
14.3.2 IR?	2
14.3.3 Radar?	2
14.3.4 Acoustical?	2
14.3.5 Directed energy weapons?	1
15. Vehicle signature?	1
15.1Visual?	1
15.2 IR?	1
15.3 Radar?	1
15.4 Acoustical?	1
16. Need for semi-automated forces (SAF)?	3
17. Operations with combined arms team?	2
18. Operations with other Services?	1
19. Operations with other nations?	1
20. Number of objects?	
20.1 Include 10 objects?	5
20.2 Include 50 objects?	5
20.3 Include 100 objects?	5
20.3 Include 500 objects?	3
20.5 Include 1000 objects?	1
20.6 Include 5000 objects?	1
20.7 Include 10000 objects?	1
21. Combat service support - RAM - impact?	1
22. Electronic warfare?	1
22.1 ECM?	1
22.2 ECCM?	1
22.3 EMP?	1
23. Mobility of the simulator/simulation?	1
23.1 Vehicle mounted?	1
23.2 Portable by vehicle?	1
24. V & V, Accreditation of models?	4

<u>Funding:</u> If you had the authority to reprogram your funding, would you do so to achieve the simulation capabilities you have indicated are needed? Yes___. No_X__.

ANNEX B, APPENDIX 5, PM RAH-66 COMANCHE, PEO, AVIATION, ST LOUIS

ARMY AVIATION SIMULATION SURVEY

Current Simulation Plan

For the Comanche this simulation plan is a summary description of the Contractors planned use of simulation for the Comanche development program.

A full mission moving base simulator will be used to examine and evaluate handling qualities characteristics including specification compliance, assist in crew station design, define pilot/vehicle interface specifications, examine MANPRINT issues and obtain subjective evaluations of combat effectiveness. The plan includes significant use of Army operational and experimental test pilots to obtain "user" input. The simulator will also be used to train pilots for developmental testing of Comanche prototype vehicles.

In addition to the FMS a crew station/flight procedures simulator will be used extensively to develop the flight control system. This simulator will be integrated with the flight control system development laboratory to eventually drive actual flight control system hardware. Tasks include development and verification of flight control laws, system response and lag characteristics and to examine safety-of-flight procedures.

Additional Comments

Since the results of operational analyses are heavily dependent on the specific scenarios that are formulated I believe that statistical analysis for operational effectiveness is more valid than individual pilot-in-the-loop or analytical simulations. Thus I believe that pilot-in-the-loop simulations should not be utilized or advertised as a tool to provide significant improvements in the predictions system or system modification effectiveness. Thus extensive expenditures to obtain large pilot-in-the-loop battlefield simulations are not justified.

DEPARTMENT OF THE ARMY
HEADQUARTERS, U.S. ARMY LABORATORY COMMAND
2800 POWDER MILL RD., ADELPHI, MD 20783-1145

REPLY TO
ATTENTION OF

AMSLC-TP (70)

2 December 1991

MEMORANDUM FOR Defense Advanced Research Project Agency, ATTN: COL Jack Thorpe, 3701 North Fairfax Drive, Arlington, VA 22203-1714

SUBJECT: ATR Program

1. Thank you for your recent letter. I appreciate DARPA's desire to continue its partnership with the Army in applying advanced simulation technology in further development of distributed, networked simulation in aviation applications.

2. The Crew Station Research and Development Facility (CSRDF) at Moffet Field, CA, the ARI Simulator Complexity Testbed, and the Aviation Testbed at Ft. Rucker, AL, (AIRNET) are significant components of the Battlefield Distributed Simulation - Developmental (BDS-D) program plan. Part of that plan is to connect the CSRDF with the DBS-D Aviation Test Bed. The purpose of this linkage is to allow the Rotorcraft Pilot's Associate program to be tested in a viable combined-arms environment. This linkage would be the first of its kind in linking a very high-fidelity/resolution simulator with the lower-fidelity/resolution simulators in the BDS-D environment.

3. The issues involved in linking the CSRDF into BDS-D include level-playing field (high-resolution vs. low-resolution) and interoperability of dissimilar simulators. These issues entail technical challenges which DARPA could address in a time frame suitable for Army requirements, and are appropriately high-risk for DARPA involvement. We welcome DARPA's interest in these technologically problematical, high-risk areas, and will assist you in identifying appropriate Army POCs to contribute to your survey.

4. My POC for this effort is Mr. Joseph Lacetera, 301-394-4287.

JERRY C. HARRISON
Major General, USA
Commanding

ARMY AVIATION SIMULATION SURVEY

Conducted by the Institute for Defense Analyses

Organization U.S. Army LABCOM **Date** 2 Jan 92

Point of Contact Joe Lacetera **Phone** (301) 394-4285

Current Simulation Plan:

Attach a description of the organization's plan for the use of simulations to address key issues. Indicate current capabilities and planned new functionalities/enhancements and the funding profile for improvements.

Critical Issues:

List below the critical issues facing your organization where there might be potential for the application of simulation if new technology were available. List the issues in order of importance. Please highlight requirements for simulation of joint and combined arms operations.

To the right of the issue are listed potential benefits from the use of simulation. Estimate the value of the simulation for each benefit using a scale of 1 to 5 with 5 being the best, most positive rating. (Please change "Benefit"headings and/or specify "Other" as appropriate for your organization/ mission.)

CRITICAL ISSUES:	SIMULATION BENEFITS				
	Save Resources	Save Time	Improve Effectiveness	Safety	Other
A. Emerging Technology Assessment		5	3		
B. Battlefield Utility of Future Sytems	5		3		
C. Man-in-the-Loop Tech Base Wargaming		3	5		
D. Left Blank					

New Simulation Technology:

Please identify, in order of importance, specific new simulation technology that would assist in addressing critical issues in your organization. (New simulation technology is defined as that which requires some level of research and development effort.) Please highlight requirements for simulation of joint and combined arms operations. To the right of the new capability/functionality are listed R & D cost considerations. Indicate the relative importance of the considerations on a scale of 1 to 5 with 5 being the most important.

NEW CAPABILITY/FUNCTIONALITY	R & D COST CONSIDERATIONS			
	Speed in Developm't	Low Unit Cost	Low Total Cost	High Fidelity
E. Army Research Lab Node	5	2	3	3
F. Realistic AI Representation of Crew Behavior	3	2	3	5
G. Virtual Reality	1	5	3	3
H. SAFOR Entities on Individual Chips	3	2	3	5
I. Massive Parallel Processing	3	2	3	4

Networking:

Describe the local area network(s)(LAN), if applicable. If no LAN exists, is there a requirement for one? Describe the requirement.

- BDS-D aviation test bed LAN at Ft. Rucker is in development.
- Air defense LAN at Ft. Bliss is required as part of evolution toward combined arms environment.

Describe the long haul network(s) (LHN), if applicable. If no LHN exists, is there a requirement for one or more? Describe the requirement to include gateways and interface units. Include any plans, programs and the status of funding. Bandwidth requirements--56Kbps? T1 1.544 Mbps? DARPA's TWBNet?

- There is a need to link existing Army and Air Force Laboratory Networks to DARPA terrestrial wide-band network bandwidth requirement will be T3.

Rate items 1 through 24 on a scale of 1 to 5 with 5 being the highest rating.

How important is it to your organization to network with the following nodes, LANs, facilities:

(Please comment using extra paper keying comments to the appropriate numbers below.)

Node/Facility	Rating
1. Aviation Testbed, BDS-D (AIRNET), at Ft. Rucker, AL	5
2. Crewstation Research and Development Facility (CSRDF), Moffett Field, CA	3
3. Air Combat Mission Enhancement (ACME), Williams AFB, AZ	4
4. Visual Technology Research Simulator, Naval Training Center, Orlando, FL	1
5. Institute for Simulation and Training, Orlando, FL	2
6. Other: Laboratory Networks	3
7. Other: Supercomputer Networks	1

How important to your organization are the following simulation attributes? Answer for "a just barely good enough--60% solution," recognizing that funding is extremely tight. (Please comment as desired; using extra paper keying comments to the appropriate numbers below.)

8. Need for interoperability with other simulators/simulations?	5
9. Need for man-in-the-loop?	5
10. Fidelity in:	
10.1 Visuals?	1
10.1.1 Diurnal cycle?	1
10.1.2 Shadows?	1
10.1.3 Weather?	
10.1.3.1 Clouds?	1
10.1.3.2 Rain?	2
10.1.3.3 Snow?	2
10.1.3.4 Fog	3
10.1.4 Smoke?	4
11. Field of view?	3
12. Terrain data base?	5
13. Dynamic terrain?	2
14. Weapons effects?	5
14.1 Ph, Pk?	5
14.2 Trajectory?	5
14.3 Signature?	5
14.3.1 Visual?	5
14.3.2 IR?	5
14.3.3 Radar?	5
14.3.4 Acoustical?	5
14.3.5 Directed energy weapons?	5
15. Vehicle signature?	5
15.1Visual?	5
15.2 IR?	5
15.3 Radar?	5
15.4 Acoustical?	3
16. Need for semi-automated forces (SAF)?	5
17. Operations with combined arms team?	3
18. Operations with other Services?	3
19. Operations with other nations?	1
20. Number of objects?	
20.1 Include 10 objects?	3
20.2 Include 50 objects?	5
20.3 Include 100 objects?	3
20.3 Include 500 objects?	1
20.5 Include 1000 objects?	1
20.6 Include 5000 objects?	1
20.7 Include 10000 objects?	1
21. Combat service support - RAM - impact?	1

22. Electronic warfare?	5
22.1 ECM?	5
22.2 ECCM?	5
22.3 EMP?	5
23. Mobility of the simulator/simulation?	2
23.1 Vehicle mounted?	2
23.2 Portable by vehicle?	2
24. V & V, Accreditation of models?	5

Funding: If you had the authority to reprogram your funding, would you do so to achieve the simulation capabilities you have indicated are needed? Yes_X__. No___.

ANNEX B, APPENDIX 7, ELECTRONIC INTEGRATION DIRECTORATE, CECOM (FORMERLY AVIATION AVIONICS R&D ACTIVITY, AVSCOM), FT. MONMOUTH

ARMY AVIATION SIMULATION SURVEY

Conducted by the Institute for Defense Analyses

Organization **AVRADA** **Date 21 Nov 92**

Point of Contact **CPT Valentine/Pete Bartosch** **Phone DSN 558-3973**

Current Simulation Plan:

Attach a description of the organization's plan for the use of simulations to address key issues. Indicate current capabilities and planned new functionalities/enhancements and the funding profile for improvements.

Critical Issues:

List below the critical issues facing your organization where there might be potential for the application of simulation if new technology were available. List the issues in order of importance. Please highlight requirements for simulation of joint and combined arms operations.

To the right of the issue are listed potential benefits from the use of simulation. Estimate the value of the simulation for each benefit using a scale of 1 to 5 with 5 being the best, most positive rating. (Please change "Benefit"headings and/or specify "Other" as appropriate for your organization/ mission.)

CRITICAL ISSUES:	SIMULATION BENEFITS				
	Save Resources	Save Time	Improve Effectiveness	Safety	Other
A. Flight following (automated) hardware & software development.	2	5	4	3	1
B. Tactical Operations Center development	4	3	5	2	1
C. Mission Planning System development	3	4	5	2	1
D. Target hand-over processes (internal AVN & to combined arms units)	4	3	5	2	1

New Simulation Technology:

Please identify, in order of importance, specific new simulation technology that would assist in addressing critical issues in your organization. (New simulation technology is defined as that which requires some level of research and development effort.) Please highlight requirements for simulation of joint and combined arms operations. To the right of the new capability/ functionality are listed R & D cost considerations. Indicate the relative importance of the considerations on a scale of 1 to 5 with 5 being the most important.

NEW CAPABILITY/FUNCTIONALITY	R & D COST CONSIDERATIONS			
	Speed in Developm't	Low Unit Cost	Low Total Cost	High Fidelity
E. Digital map vector graphics	5	3	2	4
F. Airborne command & control capability	5	3	4	2

Networking:

Describe the local area network(s)(LAN), if applicable. If no LAN exists, is there a requirement for one? Describe the requirement.

1. Must interoperate with MSC (maneuver control system) LAN and/or WAN.
2. Aviation will use 1553 database on aircraft. This must be submitted in systems development for Army Aviation.

Describe the long haul network(s) (LHN), if applicable. If no LHN exists, is there a requirement for one or more? Describe the requirement to include gateways and interface units. Include any plans, programs and the status of funding. Bandwidth requirements--56Kbps? T1 1.544 Mbps? DARPA's TWBNet?

- Not a requirement from our perspective. Target handover with Armor Center would be an exploration tool we should use. Connecting AIRNET & SIMNET between the two schools may be useful in issuing out protocols between IVIS & AMPS or IVIS & longbow.

Rate items 1 through 24 on a scale of 1 to 5 with 5 being the highest rating.

How important is it to your organization to network with the following nodes, LANs, facilities:

(Please comment using extra paper keying comments to the appropriate numbers below.)

Node/Facility	Rating
1. Aviation Testbed, BDS-D (AIRNET), at Ft. Rucker, AL	4
2. Crewstation Research and Development Facility (CSRDF), Moffett Field, CA	2
3. Air Combat Mission Enhancement (ACME), Williams AFB, AZ	2
4. Visual Technology Research Simulator, Naval Training Center, Orlando, FL	2
5. Institute for Simulation and Training, Orlando, FL	2
6. SIMNET (Armor Center)	3
7. Combat Unit such as the 101st.	3

How important to your organization are the following simulation attributes? Answer for "a just barely good enough--60% solution," recognizing that funding is extremely tight. (Please comment as desired; using extra paper keying comments to the appropriate numbers below.)

8. Need for interoperability with other simulators/simulations?	3
9. Need for man-in-the-loop?	4

10. Fidelity in:	
10.1 Visuals?	2
10.1.1 Diurnal cycle?	3
10.1.2 Shadows?	3
10.1.3 Weather?	3
10.1.3.1 Clouds?	3
10.1.3.2 Rain?	3
10.1.3.3 Snow?	2
10.1.3.4 Fog	2
10.1.4 Smoke?	3
11. Field of view?	5
12. Terrain data base?	4
13. Dynamic terrain?	5
14. Weapons effects?	4
14.1 Ph, Pk?	4
14.2 Trajectory?	3
14.3 Signature?	3
14.3.1Visual?	3
14.3.2 IR?	3
14.3.3 Radar?	3
14.3.4 Acoustical?	3
14.3.5 Directed energy weapons?	3
15. Vehicle signature?	3
15.1 Visual?	3
15.2 IR?	3
15.3 Radar?	3
15.4 Acoustical?	3
16. Need for semi-automated forces (SAF)?	2
17. Operations with combined arms team?	4
18. Operations with other Services?	4
19. Operations with other nations?	3
20. Number of objects?	4
20.1 Include 10 objects?	5
20.2 Include 50 objects?	5
20.3 Include 100 objects?	4
20.3 Include 500 objects?	4
20.5 Include 1000 objects?	3
20.6 Include 5000 objects?	2
20.7 Include 10000 objects?	1
21. Combat service support - RAM - impact?	4

22.	Electronic warfare?	3
	22.1 ECM?	3
	22.2 ECCM?	3
	22.3 EMP?	3
23.	Mobility of the simulator/simulation?	4
	23.1 Vehicle mounted?	4
	23.2 Portable by vehicle?	4
24.	V & V, Accreditation of models?	3

Funding: If you had the authority to reprogram your funding, would you do so to achieve the simulation capabilities you have indicated are needed? Yes___. No_X__.

- I would use mock-ups and existing hardware, actual aircraft and actual units to do the simulation; leaving the equipment with them for long term evaluation and use.

ANNEX B, APPENDIX 8, AVIATION DIVISION, ODCSOPS, DA, WASHINGTON

ARMY AVIATION SIMULATION SURVEY

Conducted by the Institute for Defense Analyses

Organization ODCSOPS (Aviation) **Date** 2 Dec 91

Point of Contact MAJ Kulungowski **Phone** (703) 695-7419

Current Simulation Plan:

Attach a description of the organization's plan for the use of simulations to address key issues. Indicate current capabilities and planned new functionalities/enhancements and the funding profile for improvements.

Critical Issues:

List below the critical issues facing your organization where there might be potential for the application of simulation if new technology were available. List the issues in order of importance. Please highlight requirements for simulation of joint and combined arms operations.

To the right of the issue are listed potential benefits from the use of simulation. Estimate the value of the simulation for each benefit using a scale of 1 to 5 with 5 being the best, most positive rating. (Please change "Benefit"headings and/or specify "Other" as appropriate for your organization/ mission.)

CRITICAL ISSUES:	SIMULATION BENEFITS				
	Save Resources	Save Time	Improve Effectiveness	Safety	Reduce Tech Risk

Not completed.

New Simulation Technology:

Please identify, in order of importance, specific new simulation technology that would assist in addressing critical issues in your organization. (New simulation technology is defined as that which requires some level of research and development effort.) Please highlight requirements for simulation of joint and combined arms operations. To the right of the new capability/ functionality are listed R & D cost considerations. Indicate the relative importance of the considerations on a scale of 1 to 5 with 5 being the most important.

NEW CAPABILITY/FUNCTIONALITY	R & D COST CONSIDERATIONS			
	Speed in Developm't	Low Unit Cost	Low Total Cost	High Fidelity

Not completed.

Networking:

Describe the local area network(s)(LAN), if applicable. If no LAN exists, is there a requirement for one? Describe the requirement.

- Required to provide collective combined arms training for attack and air cavalry units. Need capability for elements to interact in real time with ground and air forces to engage threat arrays. Critical to future combined arms training strategy.

Describe the long haul network(s) (LHN), if applicable. If no LHN exists, is there a requirement for one or more? Describe the requirement to include gateways and interface units. Include any plans, programs and the status of funding. Bandwidth requirements--56Kbps? T1 1.544 Mbps? DARPA's TWBNet?

- N/A.

Rate items 1 through 24 on a scale of 1 to 5 with 5 being the highest rating.

How important is it to your organization to network with the following nodes, LANs, facilities:

(Please comment using extra paper keying comments to the appropriate numbers below.)

Node/Facility	Rating
1. Aviation Testbed, BDS-D (AIRNET), at Ft. Rucker, AL	
2. Crewstation Research and Development Facility (CSRDF), Moffett Field, CA	
3. Air Combat Mission Enhancement (ACME), Williams AFB, AZ	
4. Visual Technology Research Simulator, Naval Training Center, Orlando, FL	
5. Institute for Simulation and Training, Orlando, FL	

How important to your organization are the following simulation attributes? Answer for "a just barely good enough--60% solution," recognizing that funding is extremely tight. (Please comment as desired; using extra paper keying comments to the appropriate numbers below.)

8. Need for interoperability with other simulators/simulations?	5
9. Need for man-in-the-loop?	5
10. Fidelity in:	
10.1 Visuals?	4+
10.1.1 Diurnal cycle?	4
10.1.2 Shadows?	4
10.1.3 Weather?	4
10.1.3.1 Clouds?	4
10.1.3.2 Rain?	4
10.1.3.3 Snow?	4
10.1.3.4 Fog	5
10.1.4 Smoke?	5
11. Field of view?	5
12. Terrain data base?	5

13. Dynamic terrain?	?
14. Weapons effects?	5
14.1 Ph, Pk?	5
14.2 Trajectory?	1
14.3 Signature?	5
14.3.1 Visual?	5
14.3.2 IR?	5
14.3.3 Radar?	4
14.3.4 Acoustical?	3
14.3.5 Directed energy weapons?	
15. Vehicle signature?	4
15.1Visual?	4
15.2 IR?	4
15.3 Radar?	4
15.4 Acoustical?	2
16. Need for semi-automated forces (SAF)?	?
17. Operations with combined arms team?	5
18. Operations with other Services?	3
19. Operations with other nations?	2
20. Number of objects?	
20.1 Include 10 objects?	5
20.2 Include 50 objects?	3
20.3 Include 100 objects?	2
20.3 Include 500 objects?	?
20.5 Include 1000 objects?	
20.6 Include 5000 objects?	
20.7 Include 10000 objects?	
21. Combat service support - RAM - impact?	4
22. Electronic warfare?	5
22.1 ECM?	5
22.2 ECCM?	5
22.3 EMP?	5
23. Mobility of the simulator/simulation?	5
23.1 Vehicle mounted?	5
23.2 Portable by vehicle?	4
24. V & V, Accreditation of models?	?

Funding: If you had the authority to reprogram your funding, would you do so to achieve the simulation capabilities you have indicated are needed? Yes_X_. No___.

ANNEX B, APPENDIX 9, AVIATION LOGISTICS, ODCSLOG, WASHINGTON

DEPARTMENT OF THE ARMY
OFFICE OF THE DEPUTY CHIEF OF STAFF FOR LOGISTICS
WASHINGTON, D.C. 20310

REPLY TO
ATTENTION OF

25 Nov 91

Aviation Logistics Office

General Ben L. Harrison
221 East 21st Avenue
Belton, Texas 76513

Dear ~~General~~ Ben Harrison:

We received and thoroughly reviewed your Army Aviation Simulation Survey. Simulation is of critical importance to Army Aviation, but the type of simulation addressed in your survey has little application in the Aviation Logistics Office. Our needs are more in the area of logistics modeling, which is being performed for us by the TRADOC Analysis Command, Ft. Lee and the Resource Management Directorate, here in DCSLOG.

Feel free to contact my point of contact, Captain Craddock, (703) 697-0487, if he can be of any assistance.

Sincerely,

Warmest Regards,

Joseph P. Cribbins
Chief, Aviation Logistics
Office

ANNEX C

AVIATION SIMULATION FACILITIES

ANNEX C
AVIATION SIMULATION FACILITIES

Only facilities that are relevant to Army aviation research and development are listed, i.e., crew flight training simulators are not included. The Aviation Systems Command's Research, Development, and Engineering Center (RDEC) simulation plan, prepared by the Simulation and Aircraft Systems Division of the Aeroflightdynamics Directorate, contains a description of several simulation facilities. This plan is included in this report as Annex B, Appendix 4.2. Six new facility descriptions have been added and are indicated with an *. Two of the descriptions in the RDEC plan have been updated and are indicated by ••.

Appendix 11	*	Visual Technology Research Simulator, Naval Training Center, Orlando, FL (p. C-35)
Appendix 12		Air Combat Mission Enhancement (ACME), Williams AFB, AZ (p. C-49)
Appendix 13	*	Institute for Simulation and Training (IST), UCF, Orlando, FL (p. C-51)
Appendix 14		Georgia Institute of Technology Simulator Lab (Flight SIM), Atlanta, GA (p. C-53)
Appendix 15	••	Sikorsky Full Mission Simulator (FMS), Stratford, CN (p. C-55)
Appendix 16	*	McDonnell Douglas Helicopter Company, Mesa, AZ (p. C-57)
Appendix 17	*	Bell Helicopter Company, Ft. Worth, TX (p. C-61)
Appendix 18	*	Boeing Helicopter Company, Philadelphia, PA (p. C-65)

Note 1: The COMANCHE configuration for STRATA is unfunded. The STRATA facility is scheduled to become operational in July 1992 with an APACHE cockpit.

The first three facilities listed above, Aviation Testbed, Battlefield Distributed Simulation-Developmental (AIRNET), Ft. Rucker, Crew Station Research and Development Facility (CSRDF), Moffett Field, CA, and the Simulator Training Research Advanced Testbed for Aviation (STRATA), ARI, Ft. Rucker, are the primary components for simulation in Army aviation research and development. There is a major initiative under way to network these three facilities. It is vital that this be done to facilitate closer coordination between the Army "user" community and the "development" agencies. This is crucial for such projects as the Rotorcraft Pilot Associate.

Several actions have been proposed to upgrade the Aviation Testbed visual systems, the data bases and build additional reconfigurable cockpits with significantly more sophisticated capabilities, but funding is unclear.

The last four facilities listed comprise the major helicopter manufacturing capability of the United States. There are other major defense industry firms that are critical to the future of Army aviation that have not been surveyed. This is especially true for R&D and manufacturing of components of mission equipment packages, e.g., Martin Marietta, Harris, Northrop, IBM, Hughes, General Dynamics, E-Systems, Grumman, Honeywell, ITT, Litton, Lockheed, LTV, Rockwell, etc. There are no specific plans for networking these industry simulation facilities with Army facilities, but it is a long term goal of the Battlefield Distributed Simulation-Developmental program. It would seem appropriate to

ANNEX C, APPENDIX 1, AVIATION TESTBED, BATTLEFIELD DISTRIBUTED SIMULATION-DEVELOPMENTAL (ATBDSD) ("AIRNET"), FT. RUCKER, AL

Location: Building 5101, Fort Rucker, AL 36362-5000

Telephone: (205)598 3066 Fax: (205)598-5370

Sponsor: United States Army Aviation Center

Purpose: The ATBDSD is the aviation component of Advanced Distributed Simulation Technology and provides Department of Defense agencies with an aviation-oriented, research and development facility consisting of aviation, armor, infantry, air defense artillery, and non-line-of-sight missile systems simulation devices. In a training development role, the ATBDSD serves as a joint and combined arms, collective task trainer and provides simulations which replicate battle at each tactical echelon, team through battalion task force, inclusive of combat, combat support, and combat service support functions. In the former capacity, the ATBDSD provides users with a cost effective, pre-prototype development, systems modeling and evaluation facility. In the latter capacity, the ATBDSD allows users a means to hone warfighting skills in a professional, cost-effective, and safe environment.

Major Components: The major components of the ATBDSD include:

1. 2 local area networks, 2 AppleTalk™ networks, and 1 long haul network.
2. 8 rotary wing aircraft (RWA) simulation devices.
3. 2 fixed wing air (FWA) simulators.
4. 2 M1 Abrams tank simulators.
5. 2 M2/M3 Bradley Fighting Vehicle (BFV) simulators.
6. 1 stealth vehicle with logging, playback, and VCR recording capabilities.
7. 2 plan view displays (PVD) powered by Massachusetts Computer Corp. (MASSCOMP™) 5600 computers.
8. 4 semiautomated forces (SAFOR) workstations.
9. 4 air defense artillery anti-tank system (ADATS) simulators.
10. 2 non-line-of-sight (NLOS)/fiber-optic guided missile (FOG-M) simulators.
11. 2 management command and control systems (MCC).
12. 2 simulation networking control consoles (SCC).

13. 1 close air support (CAS) Macintosh® workstation.
14. 1 fire support Macintosh workstation.
15. 1 combat engineer Macintosh workstation.
16. 1 administration and logistics Macintosh workstation.
17. 1 maintenance Macintosh workstation.
18. 2 data loggers powered by MC5600 MASSCOMP computers.
19. 8 Bolt, Baranek, and Newman (BBN) GT-111 computer image generators (CIG).
20. 4 BBN GT-101 CIGs.
21. 1 MicroVAX 3600 Computer for data analysis.

In addition to the aforementioned components, the complex offers users with limited office space; limited administrative support; a conference room; a classroom with TV/VCR, overhead and 35mm slide projection capabilities; a student break area; and two tactical operations centers complete with requisite maps, charts, and radio communications.

Description: For introductory purposes, all vehicle simulators and their supporting elements communicate via local area and long haul networks. Simulators within the complex are linked via a 10-Megabit per second Ethernet. The Ethernet is connected to a single long haul network by a gateway. The gateway is facilitated by a parallel processor, Butterfly computer.

The RWA simulator is reconfigurable as either a scout or an attack aircraft. It is configured with three seats, two of which are manned at any given time, by the pilot and either the copilot/observer (CPO) or the copilot/gunner (CPG). The simulator provides auditory, tactile, and visual stimuli to replicate the effects of shooting, flying, and communicating. Visual effects are generated through eight TV monitors by a dedicated BBN GT-111 CIG. The CIG outputs eight low-resolution channels, each channel providing a 25 × 15.6 degree view of the virtual world out to 3.5 kilometers, and one high-resolution channel for the sensor system with a visual range of 7 kilometers. The out-the-window (OTW) views are vertically slewable and update in real time as the aircraft flies. The sensor views replicate day TV and forward-looking infrared (FLIR) and have various fields of view that are selectable by the CPO or CPG. The simulator can be armed with 30mm cannon, Hellfire missiles, Air-to-Air Stinger (ATAS), and Hydra 70 rockets. In the OPFOR mode, it is armed with Soviet counterpart munitions.

The FWA is configured as a single pilot device and replicates the flight dynamics and munitions of a USAF A-10 Wart Hog aircraft. It is armed with the Maverick missile, ATAS, and the 30mm GAU-8 gun. The FWA also requires a dedicated BBN GT-111 CIG but its visual effects are slightly different than those described above. Like the RWA, the FWA uses two rows of TV monitors, three monitors on the top row and five monitors on the bottom row, for OTW views. Unlike the RWA, the FWA does not have FLIR or day TV capability but uses the CIG's high resolution channel to provide a heads-up display (HUD) and a 7-kilometer OTW view on the bottom row's center monitor.

The M1 tank device is a real-time simulation of the M1 Abrams main battle tank configured for a crew of four consisting of a driver, a commander, a gunner, and a loader. The device is clocked in real-time at 15 Hz in lockstep synchronization with a dedicated BBN GT-101 CIG. The GT-101 CIG generates eight low-resolution channels [seven are for vision blocks and one is for the gunner's primary sight (GPS)] and emulates most behaviors of a real-world M1. The crew operates in a buttoned-up/closed hatch mode and views the virtual world through 1 power vision blocks which provide vision out to 3500 meters. The GPS is shared by the commander and features selectable 3× and 10× magnification. The device is armed with the 105mm main gun only and is capable of firing high explosive antitank (HEAT) and sabot munitions.

The M2/M3 device is a real time simulation of the M2/M3 BFV and is configured for a crew of three consisting of a driver, a commander, and a gunner. Like the M1 above, the BFV requires a dedicated BBN GT-101 CIG. As with the M1, the CIG generates eight low resolution channels [seven are for vision blocks and one is for the gunner's integrated sight unit (ISU)] and emulates most behaviors of a real-world BFV. The crew operates in a closed hatch mode and views the virtual world though 1 power vision blocks which provide vision out to 3500 meters. The ISU is shared by the commander and features selectable 4× and 12× magnification. The device is armed with a 25mm chain gun capable of firing high explosive and armor piercing ammunition and the tube-launched, optically wire-guided (TOW) missile.

The stealth device is a simulated observation vehicle unrelated to any real-world vehicle. It acts like an invisible eye on the virtual world. A set of controls allows it to move freely over the battlefield or to operate as a slave invisibly tethered to another vehicle so that stealth observers can obtain that vehicle's vantage point unobserved. The stealth is a passive device and it has special flight modes which make it the fastest and most maneuverable vehicle on the data base. It is driven by an MC5600 MASSCOMP computer and is collocated with a PVD. Its graphics are generated from a BBN 120TX/T image generator.

The PVD is powered by an MC5600 MASSCOMP computer and provides high resolution and near real-time displays of data packets received from all vehicles on the network. The PVD allows the user to view the entire data base or zoom in to a defined location and view a single vehicle. The PVD also provides the user with numerous map tools, terrain definition options, intervisibility checks, overlay functions, and it connects to the data logger for remote control of exercise playback.

The SAFOR workstation allows users to interact with the semiautomated forces system and allows for man-in-the-loop supervisory control of air and ground SAFOR. It is built around Symbolics hardware which operates in a Genera software environment and consists of a black-and-white (B&W) monitor, a color monitor, a keyboard, and a mouse. To generate requisite simulation and interface with the local simulation network, it is connected to a MIPS simulation computer. The user can effect such functions as unit creation, menu-style input, message display, and execution of system functions on the B&W monitor. The color monitor is used to display terrain, effects, and units. It provides mouse-sensitive graphics facilities to adjust map scale and resolution, to issue orders to units (including combat instruction sets, boundaries, objectives, and routes), and to establish additional control measures (such as phase lines, firing positions, etc.).

The ADATS device is a real-time simulation of the U.S. Army's line of sight forward heavy air defense system and is configured for a crew of three consisting of a driver, gunner/electro-optical operator, and a squad leader/radar operator. The device requires a dedicated BBN GT-111 CIG which emulates most behaviors of a real-world ADATS. The CIG also provides for such characteristics as a 3500 meter OTW view via four vision blocks for the driver, a FLIR and day TV threat detection range of 7 km, and a laser range of 10 km. Additionally, the device features radar, with a selectable range of either 15 km or 25 km, which is driven by a Concurrent 6600 computer connected to a CIG and the network. The device is armed with eight air defense missiles which can only be launched while the vehicle is stationary.

The NLOS system is a fiber-optic guided forward area air defense and antiarmor missile system which uses both TV and imaging infrared (IIR) missiles. The NLOS simulated at the ATBDSD is the light version which is mounted on the high mobility multipurpose wheeled vehicle (HMMWV), carries six missiles, and is operated by a two-member crew consisting of a driver and a gunner. The system also simulates a single channel ground and airborne radio system (SINCGARS) and an enhanced position location and reporting system (EPLRS). It requires a dedicated BBN GT-111 CIG which emulates most behaviors of a HMMWV and a FOG-M plus provides four channels of low resolution video for a 3500 meter OTW view and one channel of high resolution video to serve as the gunner's video.

The MCC system is responsible for simulating a variety of combat and combat service support functions. These include ammunition trucks, maintenance vehicles, fuel trucks, artillery pieces, mortars, command posts, ground mine emplacements devices, and bombs. The host for the MCC is an MC5600 MASSCOMP computer which incorporates a 68020 microprocessor, two megabytes of memory, a 142-megabyte hard disk, a floppy disk drive, a cartridge tape drive, an Ethernet interface, and an eight-channel RS-232 interface. Users talk to the MCC through six Apple® Macintosh computers which communicate with the MCC via an AppleTalk network and an RS-232 line. The AppleTalk network features an intermediary Macintosh called the bridge which translates between the AppleTalk protocols understood by the Macintosh consoles and the RS-232 signals supported by the MCC host. Brief descriptions of the seven Macintosh computer functions follow:

The SCC are used to start an operation, establish the scenario within which the operation takes place, initially place select vehicles on the terrain, and carry out functions (such replacing destroyed vehicles) normally performed by echelons above the particular battalion to which the user is assigned.

The CAS console directs aircraft, armed with 500-pound dumb bombs, against battlefield targets in either a preplanned or on-call modality.

The fire support console issues orders to one of three 155 howitzer batteries and to a mortar platoon in either a preplanned or an immediate call-for-fire modality.

The combat engineer console allows the user to emplace, breech, or move minefields on the terrain.

The administration and logistics console moves trucks carrying ammunition and fuel.

The maintenance console dispatches maintenance vehicles and recovery teams.

The data logger is an MC5600 MASSCOMP computer with a high-performance Ethernet interface to the simulation networking (SIMNET) network. The data logger can capture the network traffic and place the data packets in a disk or tape file. Given the two data logging mediums of disk and tape, logging a disk file is performed by specifying a medium of disk and logging onto magnetic tape is performed by specifying a medium of tape. The data logger performs the following functions:

Packet recording: It receives packets from the SIMNET network, time-stamps them, and writes them to a disk or tape.

Packet play back: Packets from a recorded exercise can be transmitted in real time or faster than real time. The data logger can also suspend play back (freeze time) and skip backward or forward to a designated point in time. The logger can be controlled directly from the keyboard or remotely from the PVD. Play back is visible to any device on the network (PVD, stealth vehicle, vehicle simulator, etc.).

Copying or converting: Files are copied to another file which can be on the same or a different medium and files from the older version of the data logger can be converted to a format compatible with the current version of the data logger.

Data analysis is performed using the MicroVAX 3600 Computer with VMS operating system and RS1 and DataProbe analysis software. Data is reduced to a tabular form which can then be manipulated into user-specific charts and graphs.

Research Applications: The ATBDSD has been used in a number of studies. Most recent excursions include:

Counter Target Acquisition System (CTAS) Test which featured technology and participants from the joint and combined arenas. The stated purpose of the test was to obtain data on the combat potential of laser weapons in the air defense role and to determine the impact of electro-counter measures on air and ground forces. The ATBDSD was able to generate requisite combatant forces using both semiautomated and manned vehicles, replicate visible light laser systems, accommodate sophisticated head and eye tracker technology and devices, and record data sets for subsequent analysis. Two iterations of this test have been conducted with a third planned in the future.

Non-Line-of-Sight System (NLOS) was evaluated as part of the Forward Area Air Defense System (FAADS) and featured replication of a HMMWV equipped with the FOG-M, manual and automatic queuing, manned and semiautomated combatant forces, and a controlled environment for scenario execution, documentation, and analysis.

Planned Research and/or Improvements: Future improvements envisage upgrades in ATBDSD's data collection, data analysis, and test instrumentation capabilities in preparation for the following tests:

Counter Target Acquisition Systems 2.75 (CTAS 2.75) Test

Air to Air Combat II (ATAC II) Test

Rotary Wing Aircraft (RWA) Test

RAH-66 Comanche Test

ANNEX C, APPENDIX 2, CREW STATION RESEARCH AND DEVELOPMENT FACILITY(CSRDF), MOFFETT FIELD, CA

CSRDF - Crew Station Research and Development Facility'

Location: AFDD at NASA Ames Research Center

Sponsor: AFDD

Purpose: CSRDF has been used to research, develop, and define crew station configurations, pilot HMD symbology, and speech I/O command and recognition systems. The CSRDF has been used train both support and assessment pilots for the LH DEM/VAL program phase. The CSRDF was originally created to answer the crew question for the LHX and since has evolved into a testbed for the the RPA ATTD functional pilot vehicle interface and nap-of-the-earth assessment methodology.

Major components: The major components of the CSRDF include:
1. 3 blue or red team stations,
2. a fiber optic HMD (helmet mounted display),
3. a communications workstation,
4. an experimenter/operator console, and
5. a one or two seat cockpit.

Auxiliary to these facility components are mission planning computers to upload plans, low cost training stations to orient pilots to cockpit layout and symbology, a visual laboratory, a coordinated pilot training development station, and an audio laboratory.

Description: The simulator consists of a two-seat cab on a fixed platform. The pilot's visual imagery is produced by a fiber optic display mounted on his helmet. Wide-angle eyepieces fit closely over the pilot's eyes, producing a large, high-resolution image. The pilot has an instantaneous field of view measuring 67° vertical and 107° horizontal. The motion of the pilot's head is tracked by an infrared device in the helmet to display the correct image wherever he looks. The resulting field of regard is unlimited. The scene the pilot sees is generated by a GE Compuscene IV image generation system, driven by a Gould Multi-SEL computer.

The flight control mechanism is a four axis hand controller. Two hand controllers are available to the pilot if necessary. A DEC VAX 8650 computer coordinates the simulation. Helicopter rotor blades and engine are modeled so that flight characteristics of the aircraft can be rapidly changed. The simulated missions are supported by a tactical center that provides up to 11 other aircraft, 99 threats, 20 moving targets, and communications, command and control. Up to three other operators may control the additional aircraft which may be friends or foes. The experimenter-operator center (EOC) serves as a central data collection point and control center for the simulation. Flexibility is achieved with system editors located in the EOC which allow the pilot's switches, symbology, or threat parameters to be modified while the simulation is in progress.

Research Applications: The CSRDF has been used in a number of studies. The recent studies include:

Initial study on AAMWD for RPA completed

D/NAPS for RPA ATTD hardware ordered and software team assembled. Initial simulations and lab studies in support of D/NAPS and AAMWD completed.

Planned Research and/or Improvements:

CATC2D models to be integrated into CSRDF

APSD sensor models to be modeled with Compuscence IV

D/NAPS and AAMWD models to be integrated into CSRDF

Conduct simulations in support of RPA PVI

Develop, test and evaluate performance measures for assessing contribution of RPA system to aircrew performance.

ANNEX C, APPENDIX 3, SIMULATOR TRAINING RESEARCH ADVANCED TESTBED FOR AVIATION (STRATA) ARI, FT. RUCKER, AL

STRATA - Simulator Training Research Advanced Testbed for Aviation - Formerly the SCTB (Simulator Complexity Testbed)'

Location: ARI, Ft Rucker, Ala

Sponsor: Army Research Institute. ARI list the following research sponsors: PM Trade, USAAVNC, TRADOC Systems Manager, AMSAA, HEL, AVSCOM, PEO-Longbow, NTSC, AF Armstrong Lab, AF Simulation Systems Project Office, Canadian Government, FAA, Commercial - CAE Electronics, CAE Link (Comanche), Charles River Analytics, Sikorsky Aircraft

Purpose: The STRATA, which will be operational in March 1992, is a simulator designed to (a) enable estimation of minimum simulator fidelity requirements to train specified tasks, (b) development of simulator-based training systems and strategies, (c) support war-fighting doctrine development based on man-in-the-loop, and (d) provide device design requirements of advanced training systems.

Major components: The major hardware components include:

1. a pilot station (AH-64 initially) with FOHMD
2. copilot/gunner station with a rear screen projection
3. a blue/red station to control aircraft, vehicles or threats
4. an experimenter/operator station
5. a relational database management system workstation
6. an Evans & Sutherland ESIG-1000
7. a visual database workstation

Description: The flight simulator will include software modules based on distributed processing for mission support, experimenter/operator station actions, threats, visual environment, control loading, sensors, navigation and communications, aural cues, and flight aerodynamics. The FOHMD with eye tracking will be used for the pilot stations while the second crew station will use a backlit CRT screen(s). A relational database will be used to create tactical scenarios and control sites, intelligent companions and adversaries, weapons, site interaction with terrain, gaming area weather, and the visual interface. The database is referred to as ITEMS (interactive tactical environment management system).

The STRATA will be unique, versatile, flexible, and reconfigurable. It will encompass the RAH-66 crew station design and flight dynamics.

Research Applications: The research objectives are to (1) determine the least expensive fidelity requirements for future aviation simulation (for training), (2) demonstrate models that trade off realism vs cost for simulation and training devices, and (3) determine training requirements for force-on-force exercises using networked simulators using ALO doctrinal requirements.

Planned Research and/or Improvements: Simulator will be operational in 1992.

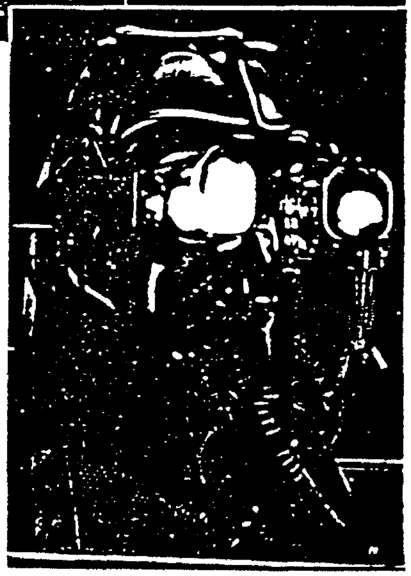
How Complex Should Simulator Visuals Be?

How "real" must simulator imagery be to learn combat skills? That question brought the Army to CAE Electronics Ltd., which is giving the Army a test bed to learn the answer and more.

By Kathleen Kocks
Reporting from Montreal, Canada

THE HELICOPTER flashes past cactus on a low-level flight above a rolling desert landscape. Mountains loom ahead. An upward glance through the canopy reveals blue sky through strobe-like passes of the rotor blades; a look down shows the instrument panel. The pilot pulls a hard left, banking upward, and I watch the ground cartwheel out of sight, feeling a tickle at the change in attitude.

Nice flight, but except for the tickle, nothing is real. The world of this flight is straight from CAE Electronics Ltd., one of the world's most sophisticated simulator manufacturers. The helicopter is the firm's Simulator Complexity Test Bed (SCTB); the scenes come from an Evans & Sutherland ESIG-1000 image generator; and they are projected through CAE's fiber-optic helmet-mounted display (FOHMD).



Wearing a helmet-mounted display (right), a pilot flies CAE's new simulator test bed built for the U.S. Army for research.

The above description doesn't scratch the surface when it comes to explaining what this test bed is all about. Basically, the SCTB is the simulator by which to design combat helicopter simulators—sort of the mother-to-be of those that follow. It will be used by the U.S. Army Research Institute (ARI) to determine just how much visual scene detail pilots need to learn attack-helicopter tasks.

Do simulators have to mirror real-world scenes, with huge projection domes, and have to travel with all imaginable motion before pilots learn? Or can the same goal be accomplished by putting a pilot in a seat that shakes, handing him working controls, and projecting rudimentary scenes before him?

The question is important, particularly to the simulator camp now eyeing the concept of portable simulators. Make the simulator compact enough to haul to the battlefield. Give it a database that allows the pilot to practice the actual mission in the morning and fly it that afternoon. Can it be done?

This February, ARI officials will begin learning the answers to their questions when CAE delivers the SCTB to Fort Rucker, Ala. Lessons will be shared with Canada, which is funding half the cost of this OSD-approved U.S. Canada Defense Development Share Program.

Continued on next page

The word "complexity" in SCTB refers to the simulator's capability to "grow" from a mobile part-task trainer up to the level of an AH-64 Apache combat mission simulator. This is done through a building-block approach to the SCTB's hardware and software.

Block by block

Perhaps the simplest SCTB components are the cockpits; there are two, one for the pilot and one for the copilot/gunner. Both contain instrument panels and flight controls based on the AH-64 Apache, and both are motionless platforms, separate from one another and each having different methods of displaying imagery.

The method in the pilot's cockpit, the FOHMD, is by far sexier technologically, and its use in the SCTB will help address issues of virtual reality. The image is piped in via two bundles of fiber optics, one for each eye, and presented on a semitransparent helmet-mounted display. Remarkably lightweight considering the capability it packs, the device puts before the pilot a high-resolution, color display, which shows what the pilot would see in and out of an actual cockpit.

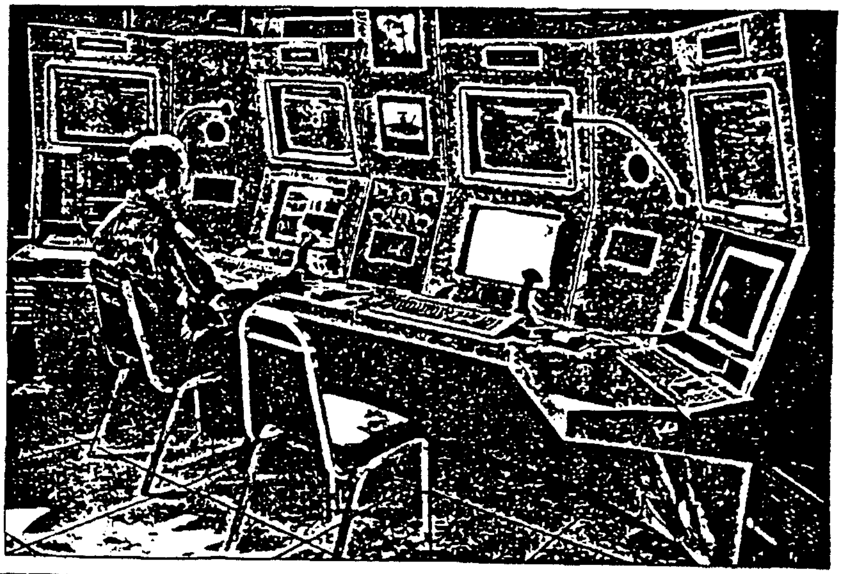
The system uses four channels to generate images. Two of these channels are used to generate approximately a 127° by 66° field-of-view. The remaining two channels generate a high-resolution inset, with a 25° by 19° field-of-view—this area, sometimes called the "area of interest," emulates the eyes' foveal (acute vision) performance.

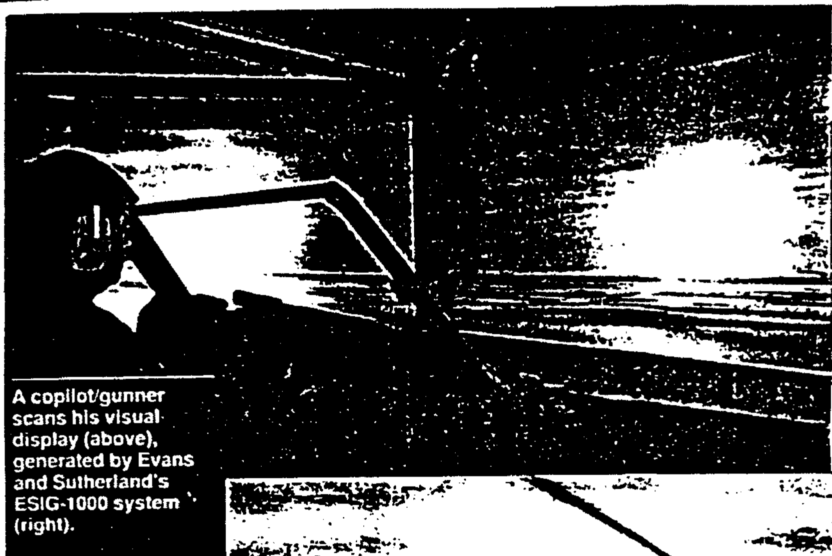
Another key ingredient of the FOHMD is the head- and eye-tracking technology. A series of infrared cameras track head movement by monitoring an LED (light emitting diode) array atop the helmet; further information is gained through rate sensors, also atop the helmet. Eye tracking is accomplished through a sensor mounted on the helmet display. The information is combined with simulator position data, and the imagery corresponds to the pilot's eye or head motion in six degrees of freedom. In this way, the FOHMD provides an unlimited field-of-view.

However, to keep the images from going beyond the cockpit, the computer-image generation contains a three-dimensional cockpit mask, as well as the full aircraft structure. Thus, the entire aircraft is contained within the imagery, even though it is not physically present in the simulator. Finally, because the FOHMD's lenses are semitransparent, pilots can view cockpit instruments simply by looking down. The FOHMD also

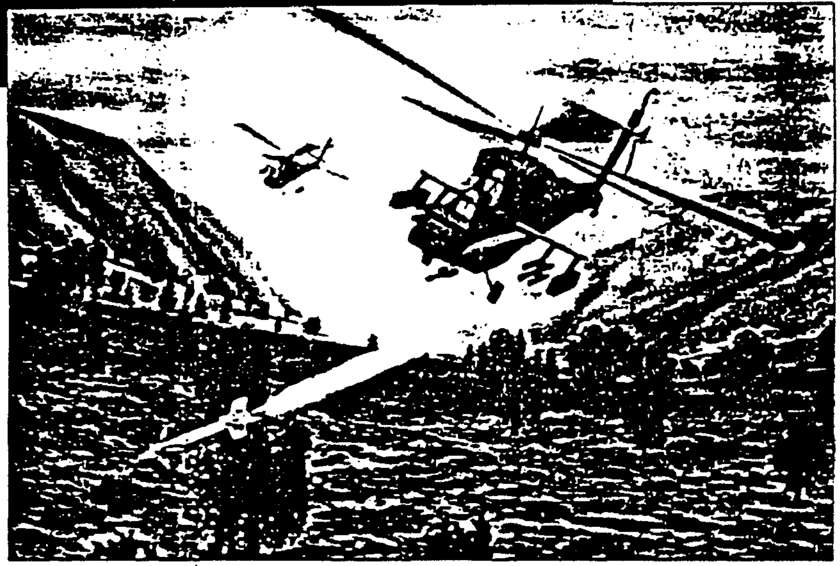
Basically, the SCTB is the simulator by which to design combat helicopter simulators—sort of the mother-to-be of those that follow.

At this station, operators start, monitor, and even influence the simulation session.





A copilot/gunner scans his visual display (above), generated by Evans and Sutherland's ESIG-1000 system (right).



has a capability to generate a headup display, or to present night-vision type displays.

Although the FOHMD seems ideally suited for portable applications, the four large televisions providing the image-generating horsepower are not. Addressing this problem, CAE has developed a less bulky CRT projection system. It, however, delivers a narrower field-of-view (100° by 60°) and a reduction in display brightness. Work continues in these areas.

The display in the copilot/gunner station is projected onto a three-segment, moveable screen that handles a 135° by 38° field-of-view display. Although the pilot sees more in terms of field-of-view and resolution, due to the advanced capabilities of the FOHMD, both pilot and copilot are viewing imagery generated from the same system.

That system is Evans and Sutherland's ESIG-1000. It has the flexibility to generate the three levels of visual fidelity the Army will research: low detail, mid detail, and high detail. The differences in fidelity are reflected in the movement of images in response to pilot inputs, the amount of resolution and textures, and the degree of target modeling. Though this could be further explained in terms of polygons and Hz, suffice it to say the differences among the three levels are significant.

Running the show

Providing the SCTB's brain power is a Fortran-based software program containing the real-time operating system, aircraft systems, and tactical systems modules. The latter includes an interactive tactical environmental management system that creates, controls, and executes the tactical scenarios for training. In turn, contained in the scenario database are site and systems information (such as weapons, communications, and weather), a tactics library, and "rules," covering such data as site doctrine or opponent selection.

An important element of the SCTB's programming is CAE's rotor model, which replicates actual rotor performance by simulating the aerodynamic forces on each blade. The major benefit is the model's ability to mimic rotor performance at critical moments in the flight regime, such as at the edges of th flight envelope—a regime familiar t combat pilots.

All missions can be recorded, store in the database, analyzed, and, if th mission contained valuable lesson reenacted for another pilot. The SCT also has a database management work station, equipped with a "user-friendl software program (C-based using X Wir dows) that allows an experimenter (o an Army tactics expert) to write ne missions.

There are three other workstations two experimenter operation station (EOS), and the Blue/Red Team statior (BRT). All experiments are generated controlled, and monitored at the EOS. I is here that operators wield th power to trans form SCTB capa bilities from the simplest to the most complex o simulators.

For example, ar EOS operator car generate a simple mission whereby the pilot navigates from point to poin through bac weather. Or, he could introduce a single tank driving along the roac as a target; it could have nc reactive ability and the experiment would focus on the pilot's flying angles anc weapons tactics. At the other end of the scale, the mission could have numerous targets, all fully intelligent and armed the experimenter can also control the targets in reaction to the pilot's attack.

The human element can further be introduced into the equation at the BRT. Its operators can join the aircrew's simulator session, using a computer equipped with a joystick to perform their part of the mission. They can be either a friendly element (Blue) or a foe (Red). An interactive battle could become quite intense, as the SCTB can simultaneously introduce up to 44 six-degree-of-freedom models—air, ground, or whatever—into the fight.

During a simple demonstration, the Apache pilots were joined by Blue scout helicopters to engage Red tanks and attack helicopters. In this simulation, the SCTB's database relied on standard

(Continued on next page)

Soviet doctrine to depict the Red Team's actions. Blue scouts were controlled by the pilot at the BRT.

As communications between the Apache and scout pilots were heard, monitors at the EOS stations showed over-the-shoulder views of Apache crew actions in the cockpit, the simulation they saw (including weapons firings), plus a real-time "God's eye" view of the unfolding battle. (The Blue Team won.)

The research task

How does the SCTB fit into Army plans? It is part of a broad-based program named STRATA (Simulator Training Research Advanced Testbed for Aviation). STRATA is researching human performance; mission tactics, techniques, and procedures; simulator design; and simulator training. The work is being carried out by four research teams—simulator training, portable training systems, new systems training, and aviation and safety performance.

The immediate goal of SCTB research is to address three major issues:

- What level of fidelity is required to achieve training objectives?
- How can flight simulation technology be most effectively used to gain and maintain combat readiness?
- How do you define the best use of new operational equipment, tactics, techniques, and procedures in a realistic threat environment?

To answer these questions, 12 experienced AH-64 pilots will fly a scenario comprising eight segments representing typical tasks during an attack mission. Each pilot will fly these segments repeatedly under varying degrees of simulator complexity. For example, a pilot will fly Mission A using the low-level imagery, then fly the same mission using the Evans & Sutherland ESIG-1000 at full capability (high level).

The word "complexity" in SCTB refers to the simulator's capability to "grow" from a mobile part-task trainer up to the level of an AH-64 Apache combat mission simulator.

The research will also include a control group with no simulator training.

This first experiment concerning issues of fidelity will last about four months. Afterward, the Army has many plans for the SCTB that will keep the device busy for at least the next five years. Among the upcoming research activities are:

- Safety training—how pilots recognize aircraft malfunctions and their reactions to them during various types of missions;
- Crew coordination—the best way to train crews of tandem-seat combat helicopters;
- Skill retention—how simulators are best used to retain piloting and weaponry skills;
- Modularity—how can simulators be made portable and still retain the capability to provide high-level training; and
- Networking—studying the value of not only introducing different players—aircraft, tanks, etc.—into the simulator scenarios, but of networking simulators in different locations. For example, linking up a portable simulator at the battlefield with the Apache Combat Mission Simulator at Fort Rucker and the Crew Station Research and Development Facility (CSRDF) at the Army's Aeroflight Dynamics Directorate at NASA Ames, Calif.

Add to these about 25 more tasks, and it's obvious that future combat helicopter simulators will be able to trace their designs to the Army's new Simulator Complexity Test Bed. ■

ANNEX C, APPENDIX 4, ROTORCRAFT AIRCREW SYSTEMS CONCEPTS AIRBORNE LABORATORY (RASCAL), MOFFETT FIELD, CA

RASCAL - Rotorcraft Aircrew Systems Concepts Airborne Laboratory'

Location: Ames Research Center

Sponsor: AFDD/NASA

Purpose: RASCAL is a long-term research facility capable of flight investigation and validation of advanced control, display, and guidance concepts.

Major components: The RASCAL aircraft is a JUH-60 Bla' 'Hawk helicopter. The UH-60 replaced the CH-47B in 1989. The Black Hawk is being modified to include:

1. Programmable panel- and helmet-mounted displays,
2. Digital, programmable flight control system,
3. Instrumentation and inertial navigation sensors,
4. Passive and active ranging sensors,
5. System operator/researcher station, and
6. Extensive computing and modern architecture
7. Safety pilot & evaluation pilot cockpits.

Description: The UH-60 is being upgraded using a phased improvement program which will allow the vehicle to concurrently support ongoing research programs such as SCAMP, RAPID, Auto NOE, LH, HIMARCS, APT, etc. The phase 0 includes instrumentation and display upgrade is to be completed by end of year in 1991, phase 1, which is to add high bandwidth flight control system and low altitude guidance, will be complete in 1995, phase 2 will add rotor state feedback and NOE guidance capability, phase 3 will add programmable RPM control, and phase 4 will add higher higher harmonic and individual blade control.

The RASCAL will provide flexible and powerful research systems which will allow integration and examination of developing technologies. The RASCAL will provide the Army, NASA, and industry a flight verification of ground-based simulation results. The RASCAL will be the only US government-owned rotorcraft in-flight simulator.

The RASCAL on-board will include a full authority fly-by-wire flight control system with a mechanical backup, state-of-the-art computers and sensors including rotor state measurements, and integrated helmet-mounted and panel mounted displays. In a later phase integrated flight/propulsion control will also be included.

Research Applications: When fully instrumented the RASCAL will be uniquely equipped to perform flight validation of wide ranging control and display concepts for the enhancement of handling qualities and mission effectiveness. Research programs planned for flight on RASCAL include the development of methodologies for highly integrated, high -performance control design to improve rotorcraft maneuverability and agility beyond what is being implemented for LH. It is planned to demonstrate integrated flight/fire control and improved pilotage through advance display symbology and to continue development of handling qualities criteria through in-flight simulation.

The CH-47B in-flight simulator from 1982 to 1989 flew 450 flight hours and produced 25 technical papers.

Planned Research and/or Improvements: The RASCAL will be used primarily to support the following research programs

1. SCAMP (superaugmented Controls for agile maneuvering performance). This program will promote advancement and flight verification of state of the art control integration methods and solve the Army need for highly agile and maneuverable rotorcraft for NOE and air combat flight.

2. Auto NOE (automated nap-of-the-earth). This program will promote development and flight verification of optimal guidance algorithms, pilot displays, and real-time vision-based sensor processing as well as provide significant advances in adverse weather NOE flight capability.

3. Rapid (Army rotorcraft agility and pilotage improvement demonstration program). The purpose of this program is to flight validate improvements in platform technology, including flight envelope, pilot-vehicle interface, and mission effectiveness. This program is directed toward the Army-identified barriers such as high agility and maneuverability, carefree maneuvering, slung load operations, and integrated flight/fire control operations.

4, CONDOR (covert night-day operations for rotorcraft). This program will use Nunn-Quayle amendment funds in a joint program with the UK. The basic ingredient is an advanced helmet oriented display which is used in a program to investigate the interaction between night vision displays, symbology, and flight control system response.

ANNEX C, APPENDIX 5, DISPLAY TECHNOLOGY RESEARCH SIMULATORS (DTRS), NASA LANGLEY RESEARCH CENTER, VA

DTRS - Display Technology Research Simulators'

Location: NASA/Army

Sponsor: Langley Research Center

Purpose: The DTRS programs are aimed at improving display technologies; current programs include 1) research on thin film electroluminescense (TFEL) display media, 2) advanced graphics engines for display generation techniques, and 3) integrated control panels, multifunction keyboards, and cockpit-integration media.

Major components: The DTRS facility is a combination of the Ambient Lighting Simulator (ALS) and several part task simulators. ALS is domed simulator into which several different cockpits can be inserted. Adverse lighting effects on the displays can be studied.

Description:

Research Applications:

Planned Research and/or Improvements:

ANNEX C, APPENDIX 6, VERTICAL MOTION SIMULATOR WITH INTERCHANGEABLE CABINS (VMS/ICABS), MOFFETT FIELD, CA

VMS/ICABS - Vertical Motion Simulator with Interchangeable Cabins'

Location: A- - Research Center, Moffett Field, CA

Sponsor: NASA

Purpose: The VMS is used to investigate handling qualities of advanced rotorcraft performing Army mission tasks. In addition, it is used to investigate landing, takeoff, and general handling qualities of STOL and VTOL aircraft and other advanced aircraft of interest to NASA such as Space Shuttle landing and High Speed Transport aircraft studies.

Major components: The primary VMS components are:

1. Interchangeable cabins with virtual image TV display,
2. Panel, center, and overhead instruments,
3. A hydraulic control loader system
4. Autothrottles
5. An aircraft sound generation system.

Description: The VMS may be used with any one of the interchangeable cabins as a moving base simulator. Conversely, an individual ICAB can be used on part-task studies as a fixed based simulator. The VMS can accommodate both a pilot and copilot. There are 4 cabins which may be uniquely configured to model different aircraft and cockpit layouts. Once a cabin is installed on the VMS it is capable of undergoing large vertical and lateral motions. The VMS generates a cabin roll of ±22°, pitch from +26° to -24°, a yaw of ±29°, a vertical movement of ±30 ft, a longitudinal motion of ±2.5 ft, and lateral motion of ±20 ft. Similarly, acceleration and velocities in the six degrees of freedom are allowed. The vertical motion is powered by 8 servo motors. The VMS is supported by two equilibrator columns which are internally pressurized to provide a smooth ride and rapid accelerations. The lateral motion is powered by 4 servo motors which drive the carriage on the vertical platform through pinion gears. A CAE hexapod motion system mounted on top of the lateral carriage provides motion in the pitch, roll, yaw, and longitudinal axes.

Research Applications:

1. UH-60 ground/flight
2. Apache initial checkout
3. LH/ADS-33 yaw attitude quickness simulation-HQ
4. Simval visual and motion lags
5. ANOE v & V & demo
6. ANOE/STAR guidance, control, display laws
7. evaluation of STOVAL fighter
8. UH-60 validation
9. UH-60 accident investigation simulations
9. Helicopter maneuvering/agility envelop simulations (HELMEE)

9. First Apache simulations
10. RASCAL failure monitoring requirements
11. R/C specification development
12. Helicopter stability for NOE
13. Tiltrotor certification
14. Terrain following/terrain avoidance
15. Wide angle sensor projection (WASP)
16. Visual/motion synchron
17. Time delay effects Simulation
18. Higher order math model of UH-60 for FCS analyses

Planned Research and/or Improvements

1. Refine/validate Apache simulations
2. Apply automated adversary for air-to-air combat simulation
3. HIMARCS agility/maneuverability simulations
4. Carefree maneuvering simulation
5. Comanche support
6. Support Army R&D simulations for LH, APT, NG/NS, fielded systems.

ANNEX C, APPENDIX 7, HELICOPTER HUMAN FACTORS RESEARCH FACILITY (HFRF), MOFFETT FIELD, CA

HFRF - Helicopter Human Factors Research Facility '

Location: Ames Research Center

Sponsor: Army/NASA

Purpose: The HFRF is a laboratory which contains several part task simulators aimed at improving or understanding how pilots orient themselves to the immediate environment and extract dynamic information from direct visual cues, light-intensification systems, thermal imagery combined with computer-generated flight symbology, or cockpit displays.

Major components: The laboratory contains four part task simulators which are to investigate:

1. geographical orientation
2. Visual cues simulator
3. Voice-activated controls
4. Pilot decision-making

Description:

Research Applications: The goal of the geographic orientation study is to develop conceptual designs for electronic maps that depict terrain, planned flight path, significant natural or man-made objects, and current position in a manner that is both perceptually and cognitively compatible with the pilot's internal representations.

Thermal imaging systems allow pilots to fly at very low levels and avoid obstacles in reduced visibility. Despite the use of these sensors little is known about the human capabilities and limitations of these systems. This research is directed improved system specifications and design modifications by identifying the most significant human factors problems.

Research has been conducted to identify tasks for which voice controls offer a workload or performance benefit.

Recent simulation research evaluated the effects of crew planning on subsequent decisions and flight safety.

Identified performance limits with current night vision devices and maps.

Planned Research and/or Improvements:

ANNEX C, APPENDIX 8, FLYING LAB FOR INTEGRATED TEST AND EVALUATION (FLITE), MOFFETT FIELD, CA

FLITE - Flying Laboratory for Integrated Test and Evaluation'

Location: Ames Research Center

Sponsor: AFDD/NASA

Purpose: The primary mission of FLITE is to provide a flight research facility capable of supporting research and validation of man-machine interfaces, audio and visual, in a single and tandem cockpit.

Major components: The FLITE aircraft is a modified AH-1S attack helicopter designated NAH-1S. It contains the following equipment packages:

1. Apache pilot night vision system,
2. reconfigurable voice I/O system,
3. physiological instrumentation,
4. programmable symbol generator (in development), and
5. data acquisition system with 1533 data bus.

Description: The NAH-1S helicopter is a production AH-1S helicopter that was highly modified to accept the AH-64A PNVS system. An instrumentation package has been integrated with the helicopter that includes three IBM 386/486 computers.

Research Applications: The highly modified FLITE vehicle is equipped to act as a research and in-flight simulation facility for both the crew station and man-machine and engineering investigations. The FLITE research facility can/will provide the capability for head down and helmet mounted display systems, voice systems, flight symbology, visual sensor systems, visually coupled systems, head/eye tracking systems, systems integration and algorithm exploration in the flight environment. Instrumentation installed on the aircraft and flight range instrumentation will allow measurement, recording, and data reduction of most flight and cockpit parameters for research personnel.

Planned Research and/or Improvements: The FLITE aircraft will be used to support programs using the following systems:

1. The use of voice input/output systems in the cockpit will be continued.

2. Active Noise Reduction (ANR) systems from RAE Farnborough and BOSE Inc will be evaluated and combined with the voice input/output research.

3. An electronic chart/moving map display being developed by NASA will be installed and pilot navigation and crew coordination will be investigated by NASA and Army personnel.

4. The pilot night vision system (PNVS) will be coupled with a programmable symbol generator to allow researchers to combine various symbology sets and compare them with MIL STD 1295.

5. A high sensitivity daylight TV will be coaxially mounted with the PNVS FLIR system to allow comparison of scene content and interpretation of the FLIR with day TV. This a joint Army/NASA project.

6. The helmet mounted field of view (FOV) limiter is being fabricated and will allow the FOV to be controlled in the high work load environments of nap of the earth flight and air to air combat. The PNVS head tracker will determine effect of limited FOV with head movement.

7. A wider field of view helmet display is being developed for the FLITE vehicle, but it will be several years in development.

ANNEX C, APPENDIX 9, MAN-MACHINE INTEGRATION AND ANALYSIS (MIDAS), MOFFETT FIELD, CA

A^3I-Midas - Army-NASA Aircrew/Aircraft Integration Program - Man-machine Integration Design and Analysis system'

Location: Ames Research Center

Sponsor: Army/NASA, Computational Human Engineering Research Office.

Purpose: Develop model and principle based humans factors methodology to aid in conceptual design of rotorcraft crewstations. Produce prototype design/analysis workstation (MIDAS) which moves MMI from hardware to software. Develop the ability to predict quantitative human performance impacts of increasingly complex missions and equipment. Improve cockpit designs and reduce costs through human factors oriented computer-aided engineering practices.

A^3I is an exploratory program to advance computational representations of human performance and behavior in the design, synthesis, and analysis of manned systems. The major product is MIDAS which provides analysts/engineers with interactive symbolic, analytic, and graphical components which permit early integration and visualization of human engineering principles.

Major components: The major components of MIDAS are an integrated set of computer workstations supporting multiple perspectives containing information about mission, operator and environment in varying levels of detail.

Description: The core of MIDAS is a set of integrated human behavior and performance models which address perception, workload, cognition, task analysis, mission results, anthropometry, training assessment methods, vehicle and equipment representations, mission/task descriptions, cockpit design tools, and world models. The workstation graphics are used to display interactions between cockpit designs, mission, operator performance and behavior, and the dynamics of complex interactions.

Research Applications: Successfully completed phase IV of a fully integrated pilot and equipment model, aero-guidance, and visualization. Conducted a proof-of-concept test on Apache Longbow crewstation evaluation.

Planned Research and/or Improvements: Demonstrate phase V implementation of new cognitive model architecture, integrate perceptual cognitive models and improve the user interface.

ANNEX C, APPENDIX 10, MILLIMETER-WAVE SIMULATION SYSTEM (MSS), MICOM, REDSTONE ARSENAL, AL

MICOM Millimeter-Wave Simulation System (MSS) Hardware-in-the-Loop (HWIL) Facility.

Location: U. S. Army Missile Command, Redstone Arsenal, AL

Sponsor: MICOM

Purpose: The MSS HWIL Facility is used to test tactical missile seeker hardware and software in a real time closed-loop situation over the full missile flight scenario.

Major Components: The primary MSS HWIL components are:

1. Test Article 5-DOF support system
2. Target and clutter signature generators.
3. ECM environment generators.

Description: The MSS HWIL Facility was modified for operation at Ka-band to support LONGBOW seeker development and flight readiness testing. This facility transmits a modulated and delayed sample of the seeker-transmitted signal to produce an RF signal at the seeker antenna which represents the radar return from the selected environment. Tactical seeker hardware and software are tested in a real time closed-loop situation over the full flight scenario. The seeker IMU hardware is bypassed, and simulated accelerometer and gyro signals are provided by a real time 6-DOF missile simulation. Seeker computer guidance commands are fed back to this simulation to provide closed-loop operation. Target and clutter environments are simulated by appropriately modulating the sampled seeker waveform. Various ECM environments can also be represented simultaneously with target and clutter signals.

Research Applications:

1. Verification of test readiness for all seeker flight hardware and software.
2. Evaluation of seeker performance envelope.
3. Parametric performance analyses and algorithm optimization.
4. Independent seeker evaluation by Government agencies.
5. Verification of contractor simulations of seeker hardware and software.

Planned Research and/or Improvements: Support of LONGBOW Full Scale Development program.

ANNEX C, APPENDIX 11, VISUAL TECHNOLOGY RESEARCH SIMULATOR, NAVAL TRAINING CENTER, ORLANDO, FL

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RESEARCH & DEVELOPMENT

PROJECT SUMMARIES

OCTOBER 1991

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AIRCREW COORDINATION TRAINING

Principal Investigator - C. Prince
Code 26 Phone: 407/380-4831
DTIC Agency Accession Number: DN700014

BACKGROUND: Aircraft incidents and accidents caused by human error in the cockpit provide compelling justification for the introduction of more effective aircrew training. Recently, the proportion of incidents and accidents attributed to human error is estimated to be between 60% and 80%. Analysis of these errors reveals that they are not due to a lack of technical knowledge in how to fly a plane, but to failure of the pilot to optimize cockpit resources, particularly aircrew resources. Poor aircrew coordination compromises not only flight safety but also effective mission performance. These two factors, safety and performance, have resulted in a new emphasis on training in cockpit resource management, particularly in response to unusual situations. The aviation industry and military have responded to this need by developing crew coordination programs, but little effectiveness research has been conducted.

OBJECTIVE: The objectives of this work are to develop an integrated, validated methodology for training crews in coordination, develop a proof-of-concept training system, and to establish specifications for aircrew coordination training and for evaluation of that training. This work builds on the aircrew coordination framework and instructional technologies developed under the 6.2 Aircrew Coordination and Performance task.

BENEFITS: The operational benefits from this task will be an improved aircrew coordination resulting in increased mission effectiveness and reduced accident rates in all manned airborne weapons systems. Prevention of a single aircraft accident attributable to poor crew coordination will provide significant return on investment based on the cost of the program compared to saving even a single aircraft.

STATUS: A prototype program of ACT, composed of eight modules, demonstrating the NAVTRASYSCEN methodology has been developed for the CH-46 and for the CH-53. Demonstration of the first three modules of the CH-53 program was conducted at Tustin, MCAS, and a demonstration of the methodology for the program was conducted at New River, MCAS. Needs analyses for the A-6, F-14, and T-44 communities have begun. Interviews have been conducted, training sessions observed, simulators visited, and a survey form for the A-6 and F-14 is being completed. An experiment using table top simulation with the T-44 students and instructors is nearing completion. Its results will provide information on the validity of the identified skills for ACT and on their measurement.

MAJOR MILESTONES:

Phase I Module Demonstrations	FY91
Phase I Evaluation Report	FY91
Phase II Module Demonstrations	FY92
Phase II Evaluation Report	FY93

FORWARD DEPLOYABLE AVIATION SIMULATOR TECHNOLOGY

Principal Investigator - W. Chambers
Code 2B Phone: 407/380-8137
DTIC Agency Accession Number: TBD

BACKGROUND: Aircrews deployed on aircraft carriers lack a facility for recurrent training in critical flight skills and for conducting mission rehearsal exercises. These deployed aircrews must utilize operational aircraft to enhance and maintain skills since current training facilities are confined to large shore based installations. The use of operational aircraft is expensive, provides only limited training opportunities for advanced weapons procedures, and does not provide a significant mission rehearsal capability. The simulator industry does not have test beds to demonstrate integrated multisource components or to evaluate the training effectiveness of the advanced training hardware it develops. The Navy's aviation simulation test beds can demonstrate the feasibility of new design concepts and reduce the risk associated with integrating these concepts.

OBJECTIVE: The objective of this effort is to develop design guidelines for deployable aircrew trainers for critical flight tasks and mission rehearsal. This task will provide integrated demonstrations of key technology components which present risk areas critical to the success of transition to the Deployable Tactical Aircraft Training System (DTATS) planned for FY94. These areas include low cost reconfigurable cockpits and threat simulations for deployed applications, helmet mounted visual displays, simulator networking for interactive crew coordination, and cost effective photo-based image generators.

BENEFITS: Evaluation of advanced technology components will substantially reduce the cost and risk of acquiring DTATS. Furthermore, the hands-on experience provided to aircrews will greatly facilitate the refinement of the performance requirements for DTATS.

STATUS: This is a new start for FY92. The task is utilizing work performed under three tasks that have been consolidated. The three tasks were Carrier Based Training System, Photographic Database Projection, and Hands on Throttle and Stick Part Task Trainer.

MAJOR MILESTONES:

Demonstrate Simulator Concepts	FY92
Evaluate Technology Components for Strike Mission Acceptability	FY92/FY93
Evaluate Mission Computer Simulation/ Stimulation	FY93
Demonstrate Mission Rehearsal Components	FY93

TACTICAL TRAINING INSTRUCTOR COMPONENTS (TACTICS)
Principal Investigator - B. Pemberton
Code 25 Phone: 407/380-4602
DTIC Agency Accession Number: DN700009

BACKGROUND: New concepts are required for effective utilization of tactical training systems of the 90s. A ten-fold increase in the total number of tracks currently simulated for tactical training systems is a requirement. However, no corresponding increase in the number of training system instructors to generate or control training system scenarios using this increased number of tracks is anticipated. The TACTICS task is investigating two new concepts to meet the increasing demand on tactical training system instructors: automatic scenario generation, and automatic scenario control.

OBJECTIVE: The objective of TACTICS is to investigate two concepts and develop two demonstration systems -- 1) Automatic Scenario Generator (ASG), and 2) Automatic Scenario Control (ASC). The ASG objectives are to reduce instructor's time and effort for scenario setup, and make the user-machine interface easy to use. The objectives of the ASC are to reduce instructor workload, allow instructor to monitor more information, and provide real-time performance measurement and feedback.

BENEFITS: Fleet readiness and mission effectiveness will be enhanced with the automation of the instructor training system functions. Results of this research will provide rapid development and operation of training system exercises that are representative of operational events. The time required to create a typical scenario will be reduced from 6 weeks to 1 week. The amount of information required to specify a scenario will be reduced by over 90%. During control of scenarios, instructors will be provided multiple windows to increase the amount of information monitored, automatic warfare advisors to increase instructor response to rapidly changing tactical situations, and automatic performance measurement and feedback to provide timely evaluations of exercise successes.

STATUS: Significant accomplishments for the TACTICS task for FY91 include: (1) contract for TACTICS ASG completed: Critical Task Analysis Report, System Specification, ScenArio Generation Expert System (SAGES) demonstration system, and Final Report successfully delivered, (2) TACTICS concept paper presented at the 12th Interservice/Industry Training Systems Conference (I/ITSC), (3) ASG demonstration software successfully ported and operational on a Sun Workstation for future incorporation into embedded training applications, (4) NPRDC's Batman and Robin software in process of evaluation for use with ASG, (5) NRL's intelligent platform software in process of evaluation for application to ASC, and (6) HARPOON battle force wargame and HARPOON Scenario Editor investigated for applicability to TACTICS.

MAJOR MILESTONES:

First ASG Demonstration System SAGES Delivered	FY91
Demonstration System Rehosted to Sun Workstation	FY91
Enhancements of ASG	FY92
Demonstration of Automatic Situation Assessment Model for AEGIS and/or Organic Combat Systems Training Technology	FY93

AIRCREW INSTRUCTIONAL SYSTEM (AIS)

Principal Investigator - D. Fowlkes
Code 26 Phone: 407/380-4789
DTIC Agency Accession Number: DN709003

BACKGROUND: The Navy, Air Force and Air National Guard Tactical Aircrew Combat Training System (TACTS)/Aircrew Combat Maneuvering Instrumentation (ACMI) is a telemetry based system at which pilots employ operational aircraft to practice air-to-air, strike, and electronic warfare engagements. Virtually all critical aspects of engagements are recorded for debriefs of aircrews following each exercise. Currently, debriefs of TACTS exercises can only be conducted using the $1M Display and Debrief Subsystem (DDS). The high price of the debrief facility limits the number of aircrews receiving debriefs. The goal of this task is to demonstrate a low-cost, personal, computer-based debrief capability that allows aircrews to receive meaningful debriefs in a timely manner.

OBJECTIVE: The objective is to demonstrate the capability to conduct meaningful and timely debriefs of TACTS/ACMI exercises using a personal computer-based system. This capability will then be adapted to provide trainee performance feedback with flight simulators.

BENEFITS: Expected payoffs include the capability to utilize a low cost system to conduct meaningful and timely debriefs of TACTS/ACMI exercises and the development of specifications for debrief facilities used by aircrews.

STATUS: Debriefs of the exercises are currently conducted on the DDS. While the DDS has proven to be an invaluable training tool, a smaller and less expensive debrief system is required - the Mini-Display and Debrief System (M-DDS). Achievements from this task include the demonstration of an experimental M-DDS. The M-DDS is hosted on commercially available hardware, and the software is written in higher order language. The M-DDS allows timely debriefs, is easy to use, provides graphics and alphanumerics on two CRTs, and includes synchronized voice playback. The M-DDS is currently being evaluated at the Gulfport ACMI by the Air National Guard.

The capabilities developed under AIS have evoked high interest, and briefings and demonstrations have been requested and given to Navy (Air-423), Air Force (Eglin AFB), and Air National Guard (National Guard Bureau) activities responsible for TACTS/ACMI.

MAJOR MILESTONES:

Demonstration of M-DDS to Air National Guard ACMI Ranges	FY91
Demonstration of, and Specifications for, a Low-Cost Debrief Capability for Use by the Joint Service TACTS/ACMI Community	FY92

ORGANIC COMBAT SYSTEMS TRAINING TECHNOLOGY
Principal Investigator - R. Stratton
Code 25 Phone: 407/380-4587
DTIC Agency Accession Number: DN701012

BACKGROUND: Shorebased training systems are becoming more complex and more expensive each year. As a supplement to shorebased training, shipboard embedded training provides a key element of the training continuum. Battle force tactical training is a high priority training requirement that can be met by developing shipboard embedded training systems with flexible ship-to-ship connectivity and at a cost that is affordable for a large number of ships. In addition to embedded training, there is a need for a performance measurement capability at all levels, i.e., individual unit, battle group, and battle force.

OBJECTIVE: The overall objective of this effort is to find ways to reduce the costs associated with all training systems, including embedded and shorebased, and to demonstrate the results. "Cost" in this context refers not only to direct dollar cost for acquisition, but also to other costs such as logistic costs, operational costs, manpower costs associated with operation and support, and other costs not as visible as acquisition costs.

BENEFITS: This task will develop products that will transition embedded training technology to a battle force training systems architecture. The payoff is improved readiness at low cost through innovative technology. It will also reduce trainer costs by identifying reusable software modules, increase trainer efficiencies by development of faster math/simulation models of targets, and increase utilization of trainers by the addition of instructional support enhancements.

STATUS: The Pierside Combat System Team Trainer (Device 205B) software for the FFG-7 class Frigate is being rehosted on Gould 3267 and Motorola 88000 micro-computers. Hardware and software redesign of Device 20B5 Instructor/ Operator Station is underway. Two AN/UYK-43's, peripherals, and control consoles were acquired and installed for hosting the shipboard Combat Direction System (CDS). FFG-7 CDS and simulation system software were installed. Systems integration will be completed in FY92.

MAJOR MILESTONES:

Single Ship Tactical Environment Embedded Training	FY92/FY93
Instructional Features Demonstration	FY93
Performance Measurement and Evaluation System Dev, Test & Eval, and Demo	FY93
Demonstrate Networking Capability	FY93
Multi-ship Capability Demonstration	FY95

VIRTUAL ENVIRONMENT TRAINING TECHNOLOGY
Principal Investigator - D. Fowlkes
Code 26 Phone: 407/380-4789
DTIC Agency Accession Number: TBD

BACKGROUND: Virtual Environment (VE) technology is a newly coined term which encompasses a number of display and transducer technologies designed to make human-computer interfaces more efficient and effective. VE technology differs from conventional training simulator technology in that the human computer interface in a simulator is hardware specific to the real world equipment being simulated. Whereas, the interface in a VE system is designed to be specific to the human user's needs for sensory inputs and control outputs with little or no hardware specific to real world equipment. Ultimately, a single VE interface could provide a user with any training environment for any piece of operational equipment. The VE interfaces the trainee user with a training system using displays and transducers. Displays provide information to the user from the training system computer while the transducers relay information from the user to the training system computer. Displays for VE which currently are being developed for VE applications include visual, audio, tactile, and force. Transducers include position, orientation, speech, and force.

OBJECTIVE: This project will analyze and demonstrate the feasibility of using VE technology to improve the efficiency and effectiveness of military training. VE will be evaluated as a training delivery medium; as a replacement for current training media; as an enhancement to current training media; and as an enabling technology capable of providing training in areas where existing training media are inadequate.

BENEFITS: The utilization of VE in military training applications is expected to be an evolutionary process. Existing VE technology is relatively crude and may have limited cost and training effectiveness benefits. Initially, this project will identify the types of training which will benefit from VE technology at its current level of development and provide design guidelines for advanced development for specific training applications. Experience gained from the initial investigations will result in the specification of performance characteristics and features of display and transducer components which will allow application to additional training areas. As these component performance capabilities are developed, additional training areas will be addressed and transitioned.

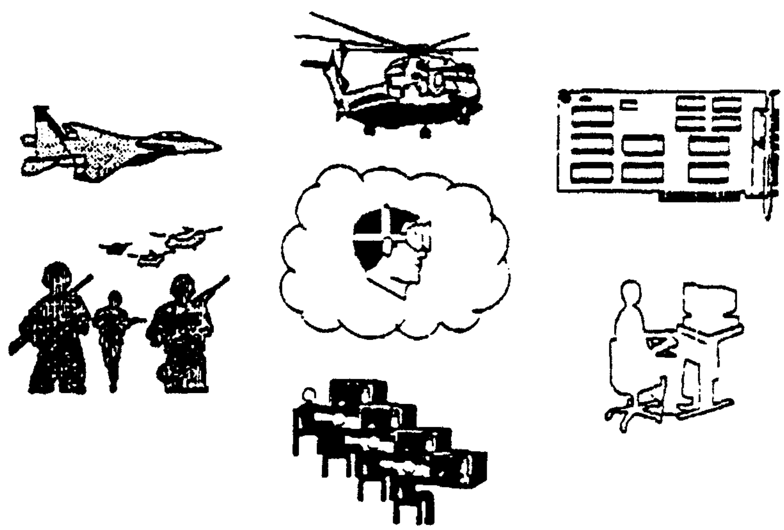
STATUS: During FY91, VE technology was surveyed to determine the current VE technology performance capabilities. Several training applications were identified and a development plan prepared. The planned technical approach involves selecting specific skills which are currently the objective of an existing training system; designing, developing, and fabricating a VE experimental system using available VE displays and transducers; evaluating the capability of a user to perform the specific skill in the VE; developing or modifying an existing instructional system to use the VE delivery system; evaluating the potential training and cost effectiveness of the VE-based training system for the specific training application; and generalizing the results to similar training applications. Throughout the process, deficiencies in the VE training approach will be classified as either deficiencies in the VE interface components or deficiencies in the capability of the training system to utilize the VE.

MAJOR MILESTONES:

Demonstration of VE air-to-air combat debrief/replay	FY92
Evaluation of VE air-to-air training application	FY92

Demonstration & evaluation of VE control panel operation	FY93
Demonstration & evaluation of VE stick/throttle operation	FY94/FY95
Demonstration & evaluation of VE tutor/instructor	FY96/FY97

VIRTUAL ENVIRONMENT TRAINING



TACTICAL DECISION-MAKING UNDER STRESS

Principal Investigators - E. Salas/J. Cannon-Bowers
Code 26 Phone: 407/380-4651

DTIC Agency Accession Number: TBD

BACKGROUND: As a result of recent combat events, a fundamental reassessment of requirements for a wide range of Navy systems is taking place. Emphasis is now beginning to shift to the problems of dealing with low- and mid- intensity conflicts where events fit multiple possible hypotheses with respect to contact identification, intent, available responses and their consequences. At present, state-of-the art, real-time battle management systems are based on doctrine that is well-suited to problems that might be encountered in all-out war, but may not be optimum for the problems inherent in less than full-scale warfare. Recent events, such as the one involving the USS Stark, where the decision not to initiate countermeasures was the incorrect one, and the USS Vincennes, where the opposite decision was the incorrect one, have focussed attention on the human factor in decision-making under low- and mid- intensity conflict. The catastrophic costs of these decisions dictate that improved support must be provided to the tactical decision-maker in these unexpected, highly charged, extremely short-duration, confusing situations where it is not clear who the enemy is, let alone what he intends to do.

OBJECTIVE: The objective of the TADMUS project is to apply recent developments in decision theory, individual and team training, and information display to the problem of enhancing tactical decision quality under conditions of stress. This will be accomplished by a cooperative program in human factors and training involving the Naval Ocean Systems Center and NAVTRASYSCEN as well as Navy, industrial, and academic organizations. The technology will be demonstrated and evaluated in the context of anti-air scenarios.

BENEFITS: The results of this effort will be an enhanced understanding of human decision-making processes and a set of training and simulation principles that will lead to improved individual and team tactical decision-making under conditions encountered in low-intensity conflict situations.

STATUS: Fleet contacts were expanded with multiple visits to: Aegis Training Center, Dahlgren, VA; CSEDS (Combat System Engineering Development Site and Aegis Training Facility), Moorestown, NJ; Fleet Training Unit, Mayport, FL; and Little Creek, VA; COMTRALANT; COMNAVSURPAC; and several Aegis class cruisers. These visits and interviews have been very productive in identifying tactical tasks and operational scenarios for laboratory investigation. They have resulted in strong operational endorsements of the project and have made important contributions to the development of models of decision-making strategies.

The laboratory simulation testbed, called Decision Making Evaluation Facility for Tactical Teams (DEFTT), has been installed at NAVTRASYSCEN and NOSC. DEFTT simulates shipboard AAW scenarios and consists of networked workstations for the CO, TAO, AAWC, TIC, IDS, and EWS.

Several performance measures and scales (e.g. descriptive, diagnostic, process and outcome measures) for tactical teams were defined and formulated with guidance from TACTRAGRUPAC and Fleet Training Unit, Mayport.

Progress has been made in defining and selecting task-related and environmental stressors for experimental manipulation. An innovative matrix has been formulated that highlights relationships between training strategies and training content areas.

MAJOR MILESTONES: Products of this effort will include:

A definition and description of the specific decision-making tasks that will be the object of decision support and training interventions to be developed in later in the program	FY92
An understanding of why and how decisions are made in targeted tasks, and identification of decision biases exhibited in these tasks	FY92
Laboratory facilities, providing a realistic experimental environment	FY92
A strong measurement capability to assess tactical decision-making by individuals and teams	FY93
A baseline of decision-making performance under varying levels of stress	FY93

AEGIS DISPLAY SYSTEM
CONSOLE OPERATORS

WEAPONS TEAM ENGAGEMENT SIMULATION

Principal Investigator - A. Marshall
Code 25 Phone: 407/380-4653

BACKGROUND: This task represents one phase of a broad effort to improve the effectiveness and realism of training a weapon fire team in a simulator environment. Currently, simulator-based team trainers use technology which restricts both realism in tactical training situations and ability for thorough performance measurements. The overall goal of this task is to introduce new technology and techniques which can improve current team training system technology. These new developments include interactive aggressor targets and a high speed weapon tracking system. NAVTRASYSCEN has developed an experimental model which allows two trainees to engage aggressor targets which are presented on a large video projection screen.

OBJECTIVE: The objective of this task is to develop new technology and techniques to improve current team training systems.

BENEFITS: A typical trainee can expend over 5,000 rounds of ammunition during one week of live fire training, which is estimated to cost $905.00. In addition to the savings in ammunition, other benefits are savings in the cost of facilities, ranges, fuel, and transportation to and from the live fire ranges. Safety is also a concern, since the WTET uses no live ammunition, the dangers of an inadvertent weapon discharge or lead poisoning is eliminated.

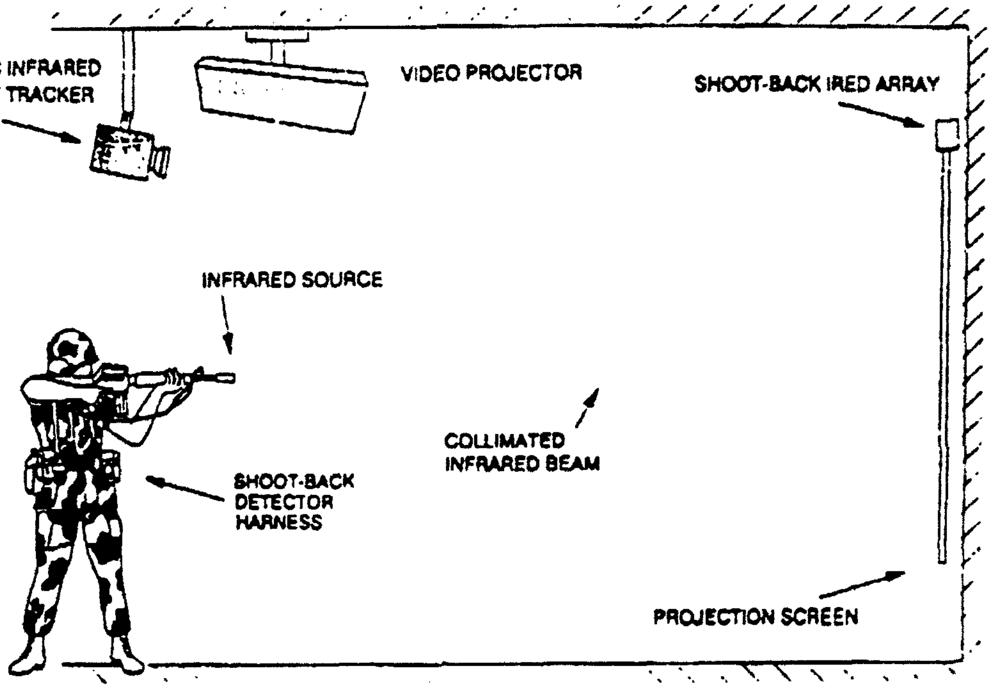
Continuously tracking weapon aiming points for all members of a fire team expands performance measurement and playback capabilities. Training effectiveness and realism are also increased by instantly removing disabled aggressors from the training scenario, and requiring trainees to take appropriate cover when an aggressor returns fire. This results in an increase in communication and awareness between members of the team. In contrast, previous training systems did not require trainees to seek appropriate cover. Also, aggressor targets were not removed from the progressing training scenario when they were successfully engaged and disabled by trainees.

When completed, the system will include tracking trainees' movements to both control shoot-back and enhanced feedback, video recording of the trainees, an expert system to control the video scenarios, and an analysis of the results for debriefing using an expert system.

STATUS: The increased realism and effectiveness in simulator-based weapons team training technology was developed under a 6.2 task, and will be demonstrated and tested for interservice use in FY92 and FY93. A test model was developed that will allow two trainees to practice and rehearse close combat training exercises. These exercises include low intensity conflict, light infantry, SWAT, and security operations, with an unsurpassed level of realism and feedback. Typical events might include security operations, hostage rescue, shoot-no-shoot, ambush training situations, and routine law enforcement operations in a common team scenario environment. In the model, aggressor targets are instantly removed from a training scenario as they are disabled by weapon fire from trainees. An array of infrared emitting diodes was placed above the projection screen and a detector harness was developed to detect a modulated infrared beam from this array. This increased tactical realism in training by requiring trainees to seek appropriate cover when engaged by the aggressor targets. An innovative weapon tracking system which generated accurate weapon position data at over 300 Hz was designed and constructed. This device is capable of continuously tracking weapon aiming points for up to 9 trainees.

MAJOR MILESTONES:

Demonstrate 2-man Weapon Team Trainer	FY91
Demonstrate 9-man Weapon Team Trainer with Advaned Features	FY92



Weapons Team Engagement Trainer Configuration

ANNEX C, APPENDIX 12, AIR COMBAT MISSION ENHANCEMENT (ACME), WILLIAMS AFB, AZ

No data available for this facility.

ANNEX C, APPENDIX 13, INSTITUTE FOR SIMULATION AND TRAINING (IST), UCF, ORLANDO, FL

Location: University of Central Florida, Orlando, FL

Sponsor: Darpa, PM Trade, ARI, NTSC, DOT

Purpose:

Major Components: The IST Elements Include:

1. Networking Laboratory
2. Simulated Forces Laboratory
3. Visual Systems Laboratory
4. Aviation Systems Laboratory
5. Advanced Learning Technology Transfer Center

Description:

Research Applications:

1. Incremental improvements in current simulation networking technologies such as ethernet variations, token ring, or token bus.

2. Incorporation of next generation network technologies into networked simulations such as fiber optics based and open system interconnection protocols.

3. Development of approaches for compression of digitized voice data over communications networks.

4. Development of software programs to model simulator networks.

5. Automated forces simulation research for
   a. Rapid prototype capability for different AF components, terrain reasoning algorithms, mission spec languages, and protocols.
   b. Evaluation of wide area mine algorithms and dismounted infantry approaches.
   c. Prototype development of dismounted infantry.
   d. Prototype development of enhanced user interface.
   e. 10x improvement in performance to cost ratio.
   f. Improved logging and after action review methods.
   g. Development of standards.
   h. Development of enhanced network interface methods.

6. Visual Systems Lab
   a. Development of dynamic terrain.
   b. Prototype development of critical VR components.
   c. Physical modeling for graphics systems.

7. Aviation Laboratory
   a. Development of enhanced models of simulators.
   b. Development of data acquisition system to support simulator performance and operator performance.
   c. Development of fidelity metric and measurement methods.
   d. Development of enhanced simulator testing methods.

8. Advanced Learning Technology Transfer Center
   a. Developed an advanced technology classroom to integrate and evaluate innovative educational training technologies.
   b. Developed intelligent instructional aids to include embedding intelligent tutoring.
   c. Prototype interactive graphics/animation and simulation.
   d. Developed computer based communication skills training.
   e. Developed networked instructional technologies for exploratory problem solving, situational awareness, and team/group decision makers.
   f. Conducting major project for Army National Guard in distance learning.

Planned Research and/or Improvements:

1. Major research efforts in support of DIS continue in:
   a. Automated Forces
   b. Dynamic Terrain
   c. Protocol Standards
   d. Open System Interface

2. Research continues in:
   a. Developing fidelity metric and measurement methods.
   b. Interfacing disimilar simulators (Proof of Principle).
   c. Prototype development "eye phones" (HMD) for 3D stereo visuals.
   d. Advanced learning technologies

3. Planned research:
   a. Develop a test bed to integrate and evaluate Virtual Reality (VR) components to support future, training/ Educational and Operational requirements.
   b. Design and implement a new school system for "American SY2000" based on current and future technologies.
   c. Develop a research base to support future modeling requirements i.e., V&V and accredited, fidelity levels, etc.

ANNEX C, APPENDIX 14, GEORGIA INSTITUTE OF TECHNOLOGY SIMULATOR LAB (FLIGHT SIM), ATLANTA, GA

Flight SIM - Georgia Institute of Technology Simulator Laboratory'

Location: Georgia Institute of Technology, Atlanta, Georgia

Sponsor: PM-Trade, ARI, and IST (UCF)

Purpose: Flight SIM is a laboratory and organization developed to interact with UCF's IST. It was established to provide a university-based unique man-in-the-loop real time rotorcraft flight simulator for training, evaluation, and integrated mathematical model development.

Major components: The major simulation components of Flight SIM are

1. Analytic model of elastic rotor and complex flight control system. The blade element is based on GENHEL element.
2. Rapid evaluation of proposed design criteria and quick feedback to the design process.
3. Cockpit integration of man-machine interface, multi-function displays, virtual cockpit, HUD configurations and symbology, RPA.
4. Multiple pilot workstations,
5. Utilize DMA data for training simulation
6. digital control loading,
7. Interface with SIMNET and CSRDF

Description:

Research Applications:

Planned Research and/or Improvements: The 4 phase, 5 year development of Flight SIM began in 1990. It is closely coupled with IST program.

ANNEX C, APPENDIX 15, FMS-SIKORSKY FULL MISSION SIMULATOR

Location: Stratford, Conn

Sponsor: Sikorsky Aircraft Corporation

Purpose: The FMS represents the air vehicle, crewstation, and MEP designs for the purpose of evaluating the RAH-66 system during development. The FMS addresses total mission environment, future threat environment, system effectiveness, subsystem performance, levels of automation, and pilot workload and performance.

Major components: The full mission simulator includes a domed moving base simulator networked to a domed fixed base simulator. The dome is 20 feet in diameter. The visual image generator is providing two Compuscene IVs. The motion based dome undergoes ±30° angular displacement and ±3 feet of translational motion. The FMS has the capability to integrate flight controls, handling qualities, crewstation, and MEP/armament systems.

Description: The major components include

1. 20' moving base dome
2. 24' fixed base dome
3. Domed fixed base simulator
4. Compuscene IV-plus image generators
5. Test director station
6. Tactical simulation center
7. Red/blue team station
8. tactical gaming station
9. GENHEL math models with a library of models and databases including GENWORLD, GENDATA, GENMEP

Research Applications: Comanche development program

Planned Research and/or Improvements: Integrated with a fixed based simulator.

ANNEX C, APPENDIX 16, McDONNELL DOUGLAS HELICOPTER COMPANY, MESA, AZ

McDonnell Douglas Helicopter Company (MDHC) Full Mission Simulation Facility

Location: Mesa, AZ

Sponsor: MDHC

Purpose: The MDHC operates a simulation facility for the purposes of supporting engineering development and training. The facility houses the Longbow Apache Simulator, the D/NAPS Simulator, the MDX simulator (under construction) and a rapid prototyping lab. The lab is used for rapid development and evaluation of controls and displays, flight models and engine models in a flight environment.

Major Components. This section provides the major components of the Longbow Apache full mission simulator. The D/NAPS and MDX simulations use some or all of the components adapted for there specific aircraft.

A. 20 foot diameter display domes
B. GE C IV/ESIG 1000 Image generation system.
C. Wide field of regard/view head tracked projection system.
D. Pilot and Copilot stations (one in each dome)
E. System Control Station
F. Performance Measurement/Data Collection System
G. Four Auxiliary Player Stations
I. Two Communications Player Stations
G. Tactical Mission Computer System

Description. The simulation facility consists of two high bays, each with an associated computer and control area, and the various simulation equipment development laboratories. A third high bay (with accommodations suitable for a large displacement, six-degree-of-freedom motion system) is currently vacant. Each populated high bay contains multiple 20 foot diameter domes (five total) with single-place, fixed-base crewstations. As of January 1992 three crewstations were in use - Longbow Apache (LBA) Pilot, LBA Copilot-Gunner, and an MH-60 Pilot station used for D/NAPS simulation.

Out-the-window and sensor visual images are created by either an Evans and Sutherland ESIG 1000 (four channels) or one of two Compuscene IVs (six channels each); outputs are matrixed so that, based on specific requirements, the relative strengths of either system may be optimally applied. Out-the-window scenes are displayed on the dome's surface through a Servo Optical Projection System (SOPS). The SOPS facilitates projection of two channels of head-slaved imagery; a background channel (120^{o} x 90^{o}) and a high-resolution, area of interest channel (40^{o} x 30^{o}). Ownship sensor images are post-processed to account for transmitter, receiver, and meteorological effects before being routed to the crewstation for display on MFD and/or helmet mounted displays.

Aircraft and environmental modeling is handled through a distributed microprocessor architecture using primarily 68020/30 and IRIS processors. Real-time data communication is achieved over a separate modified Ethernet network. Typical simulations contain:

VME Host - provides interface to image generation and display subsystems, ownship physical systems modeling (turrets, pylons, electrical, etc.), control laws processing, and aero modeling (when requirements dictate a very high fidelity aero model, this function is normally offloaded to a dedicated computer (e.g. AD100).

Tactical Mission Computer System (TMCS) - provides for all battlefield management/coordination functions for up to 46 players including unmanned player sensor and fire control functions, player-to-player line-of-sight calculations, weapons projectile fly out models (6DOF), and verbal/digital communications modeling.

Avionics - mission equipment package software processing (fire control, mission management, etc.) and handling of the pilot-vehicle interface; capability includes ability to internally generate controls and display video symbology or, when requirements dictate, may provide for integration of brassboard and/or aircraft systems (display processor, moving map, etc.)

The forward portion of each crewstation (everything the pilot can touch/see) replicates actual aircraft design. Where conventional cyclic/collective controls are used, McFadden control loaders provide for appropriate "feel" characteristics. The crewstations also house equipment required for basic operation (power supplies, video switchers, etc.) and typically contain all VME processors related to the ownship simulation. This configuration allows for limited stand-alone operation (useful in integration tasks) and provides for interchangability from dome-to-dome, cockpit-to-cockpit.

Moderate-fidelity Auxiliary Players are available for use in simulation testing/studies. These IRIS-based systems allow for additional man-in-the-loop players on either the blue or the red force. The Aux Player displays include an out-the-window scene (fully correlated to domed data base) and two generic and versatile multi-function displays. A four-axis joy stick allows for normal pilot control of the "aircraft."

The Simulation Control Station (SCS) provides for consolidated operation/oversight of simulation operations and houses the data collection/analysis systems. Manipulation of friendly/foe player movement, ownship fault conditions, and data collection is accomplished in the SCS. The SCS also contains a Tactical Situation Display that allows personnel to monitor (in a "God's eye" tactical sense) the progress of each simulation mission and the status of each player.

Research Applications. The facility has been used in several CRAD and IRAD studies. These include:

LH Recon and Attack Part Task Studies
LH Sensor Location Study
LH AAWWS Study
Apache MSIP Navigation Study
Longbow Apache Crew Station Design Validation Tests 1,2
Obstacle Avoidance System Study 1,2
Day/Night Adverse Weather Pilotage System
IRAD Texture Study
Performance Measurement IRAD
701C Engine Study

Planned Research and/or Improvements

Longbow Apache Crewstation Design Validation Test 3
Longbow Apache Full Mission Test
Longbow Apache Army Operational Assessment (TTP development)

Longbow Apache Interim Contractor Training
Improved Apache Engineering Studies
MDX Engineering Development
MDX Training and Marketing Support
Rotorcraft Pilot Associate Program
Ishida Flight Model Development
Piasecki Flight Model Development

ANNEX C, APPENDIX 17, BELL HELICOPTER COMPANY, FT. WORTH, TX

ASDC - AVIONICS AND SIMULATION DEVELOPMENT CENTER

Location : Fort Worth, Texas

Sponsor : Bell Helicopter Textron Inc.

Purpose : The ASDC has been created with an objective to provide support to all engineering programs at Bell during concept definition, design iteration, development, and flight test phases of the company's new products.

Major Components : The ASDC has two fixed base simulators. The major components of each are as follows:

Full Mission Simulator

Projection System	4 Channel CRT projectors in a 30 ft. dome.
Field of View	240°x60°.
Image Generation	Evans & Sutherland CT6+, Color, Day/Night CGI system.
Processors	(a) VAX-8800 Host. (b) AD-100 Parallel Processor. (c) Gould-32 (2).
Force Feel	Fokker Digital Control Loading.
Displays	(a) MFD - IRIS Graphics Generators. (b) Dial Instruments - Electro-mechanical.
Sound	Digital Sound/Tone System.
Cabs	(a) Large Transport Type - 2 place. (b) Medium Helicopter - 2 place. (c) Gunship - 1 place.

Part Task Simulator

Projection System	3 Channel Beam Splitter Projectors.
Field of View	160°x40°.
Image Generation	VITAL IV - Dusk/Night CGI System.

Processor	(a) VAX-8800 host (b) AD-100 Parallel Processor
Force Feel	Electrical
Displays	MFD - IRIS Graphics Generators.
Sound System	Digital Sound/Tone System.
Cab	(a) Medium Helicopter - 2 place. (b) Gunship - 1 place

Software

A Generic Tilt Rotor Simulation program.
A Generic Helicopter Simulation program.

CT6 data base	(a) European Theater (b) High density urban data base for commercial application simulation.

Additional Features

Moving Models	(a) Ground Models - Tanks, AA Artillery, Missile Launchers etc. (b) Air Vehicles - Fighters, Utility Helicopters, Gunships, Tilt Rotor Aircraft, UAV etc. (c) Ships - Carrier, Destroyers, LPH etc.
Test Control	(a) Test Director Station. (b) Test Monitor Station. (c) Real time digital data acquisition with post processing in standard flight test format.
Mission Sim.	(a) Emulate MEP - Nav., Comm., Digital Moving Map, FLIR, INS etc. (b) Emulate obstacle avoidance displays. (c) Fulda gap terrain data base in the infra red spectrum. (d) Head tracked HMD integrated with the IRIS display generator for projecting flight symbology/FLIR video overlay on the visor.

Description : The ASDC at Bell actively participates in support of all engineering development programs and has been used in a number of major programs, notably, the JVX/V22, the Tilt Rotor UAV, ARTI, LH and various IR&D design studies. The main thrusts of the programs have been to assist in developing the control laws, analyse the flying qualities of the vehicle and provide support to the aircraft's qualification tests. It is frequently used for rehearsing critical maneuvers in support of the vehicle's flight test program. Typically, the latter have included establishing autorotational boundaries, OEI procedures when operating from elevated helipads, and analysing recovery techniques after system failures. Additional usage of the simulator involves representation of avionics, sensors, and armaments to the vehicle simulation and support projects invloving avionics integration with prototype hardware.

The ASDC has two fixed based simulators each driven by a VAX 8800 with an AD-100 parallel processor linked when needed on programs requiring high fidelity rotor representation. Both simulators have Silicon Graphics IRIS systems for cockpit displays and a sound/tone system for audio and warning cues.

The Full Mission Simulator is a fixed base simulator with Day/Night Computer Generated Image system. The scene content is highly detailed and textured to provide maximum cues necessary for typical low level rotorcraft maneuvers. It is projected as a contiuous view 240° wide and 60° high. This arrangement results in a dual capability to present uninterrupted cross cockpit viewing, for pilot/copilot operation, during simulation of large transport helicopters and also provides a panoramic view during simulation tests of single place gun ship helicopters.

The Part Task Simulator has a 3-channel Night/Dusk VITAL-IV CGI. The virtual image optics is arranged to provide 160°x 40° FOV, which are mounted independant of the cabs to facilitate quick replacement of cabs for different programs.

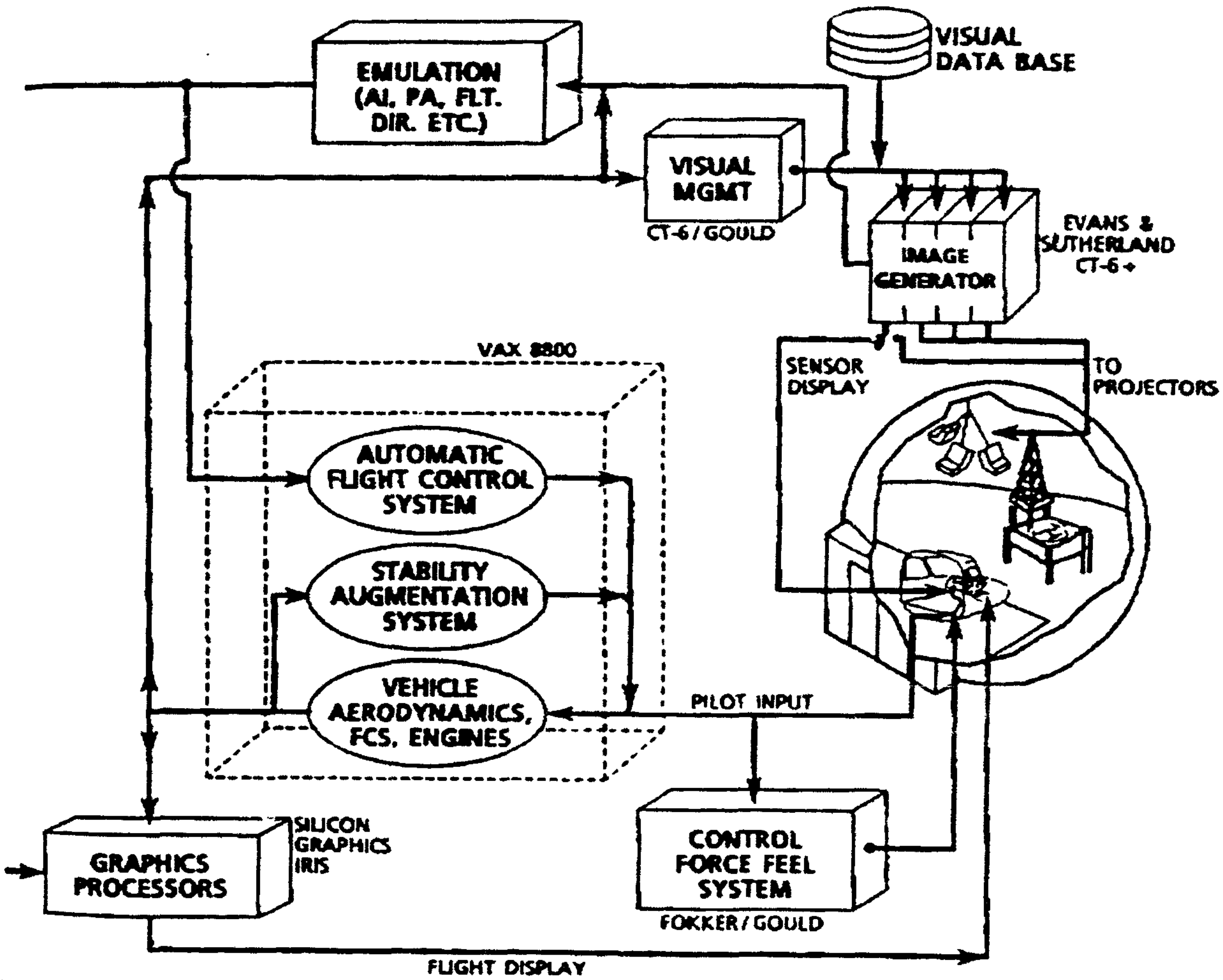
Research Applications : The ASDC has been used in a number of studies. Some of the notable ones are:

JVX/V22 - Predesign and FSD phases of the development program.
ARTI - Advanced Rotorcraft Technology Integration Contract.
LH - Bell/MDHC LH control law development during DEM/VAL
CTR - An IR&D study of a Commercial Tilt Rotor Aircraft.
UAV - NAVAIR contract to support design of a ship board UAV.
Bell 222 - An IR&D study of the Category-A operations.

Planned Research and/or Improvements :

V22 - Analyse proposed design improvements.
CTR - Support TERPS criteria development for V/STOL aircraft.
AWS - Assess Advanced Weapon System capabilities.

FULL MISSION SIMULATOR



ANNEX C, APPENDIX 18, BOEING HELICOPTER COMPANY, PHILADELPHIA, PA

Facility: Boeing Helicopters Simulation Laboratory

Location: Philadelphia, PA

Sponsor: Boeing

The Boeing Helicopters Simulation Laboratory occupies approximately 10,000 square feet of the Boeing Helicopters Engineering Laboratories Building in Eddystone, Pennsylvania. A staff of 40 engineers and computer analysts provide the experience and expertise in simulation necessary to support the varied program requirements placed on the simulation facility. The Flight Simulation Laboratory is an engineering flight simulation facility designed to support a wide range of engineering disciplines in the design and testing of rotorcraft systems. The full mission simulator (FMS) capabilities provide a flexible engineering simulation environment for the development and testing of aircraft control laws, pilot workload measurement, crew station design, the analysis of aircraft mission effectiveness, and the other aircraft design activities.

The simulation facility out-the-window visual systems include two 30' dome visual displays and two CRT based folded optic displays. The domes provide pilots with the large out-the-window field of view required for aggressive NOE flight, navigation, target acquisition, and other flight critical tasks. The field of view of the domes is approximately 90 degrees up, 60 degrees down and 110 degrees to both the left and right. Both domes are full color with a resolution of 17 arc minutes per optical line pair.

The two wide field displays, the two CRT displays, and two Image Generator eye points together with the four available simulator cockpits, allows for the development and integration of software and hardware in one cockpit without disturbing the configuration of another cockpit being used for formal testing. Use of the FMS facility in this manner allows many programs to be supported simultaneously.

The four visual display systems are driven by an Evans & Sutherland CT6 computer image generator. The Boeing Helicopter CT6 has 2 eye points each with four channels, giving the Simulation Laboratory the ability to simultaneously conduct two independent simulations. These simulations can be completely independent or can represent multiple aircraft within the same mission scenario. For instance, the two simulations may represent a lead aircraft and wingman, or two aircraft engaged in air-to-air combat. The CT6 provides extensive control over the representation of the visual environment. Features include line-of-site calculations, collision detection, adverse weather effects including lightning, and rendering of the out-the-window scene at any time of the day or night.

The gaming area of the CT6 is 300 × 300 nautical miles. The Boeing Helicopters Visual Data Bases include mountainous terrain, farm land, ocean and coast line, rolling hills and high density areas designed for NOE flight. Fulda Gap is one of the areas modeled for the CT6. The CT6 feature library includes many building, aircraft, and ground vehicle models that may be included in any mission scenario. The CT6 also includes modelling tools that facilitate design and constructing of new data bases as well as models of new aircraft, ground vehicles and other visual features.

One of the two domes includes a 6-degree-of-freedom motion system. The motion system has been designed and tuned for helicopter simulation and greatly improves the usable cue environment available to the pilot. The motion system is capable of producing 1.5 g accelerations in any combination of the 6 degrees of freedom with a frequency response of 3.5 Hz. Total travel of the motion platform is +/– 15 inches in the translational degrees of freedom and +/– 19 degrees in the rotational degrees of freedom. This motion system performance greatly enhances the fidelity of many tasks performed in the simulator, particularly in the area of handling qualities research.

Four simulator cockpits configurations are available for use in the simulation facility. All of these cockpits are interchangeable on the motion system platform and within the various visual systems described previously. One of these cockpits is a two place side-by-side arrangement currently configured to replicate the V-22 Osprey tiltrotor aircraft. This cockpit may also be configured to support simulations of the Boeing 234, 360, CH-46 Sea Night and the CH-47 Chinook series including the CH-47E. The V-22 cockpit instrumentation currently includes multi-function displays (MFDs) with touch sensitive surfaces, MFD bezels and data entry keypads. Flight controls in this cockpit consist of throttle and cyclic sticks for each of the two seats. These controls are hydraulically backdriven.

A two place tandem cockpit configuration is available with side stick controllers and conventional collective sticks. Instrument consoles for the tandem cockpit are interchangeable with the other cockpits providing the ability to perform development work in another cockpit and then to quickly move into the tandem cockpit and dome for formal experiments. The tandem cockpit is currently configured to replicate the LH cockpit. The single place cockpits are used primarily for simulation development and are generally configured with the CRT visual displays.

The symbology for the various display devices in the simulator cockpits is provided by several graphic workstations. These workstations provide the cockpits with MFD symbology, digital map displays, and flat panel symbology. The symbology workstations have the capability for three dimensional rendering which can be applied to display such as 3D digital maps.

Aircraft math model computation is carried out by three main frame computers. Two Concurrent 3280 and one Alliant VFX-80 perform all the real time computations associated with aircraft airframe, engines, rotors and control systems. These computers also execute many of the models associated with the full mission environment. These include threat behavior models, missile flyout calculations and navigation system models such as a Global Positioning System model. The two concurrent computers are generally configured to execute math models for two independent simulations.

The simulation facility also includes 4 player stations, or desktop simulators, that may participate as other aircraft or moving ground vehicles in a simulated mission scenario. These player stations consist of computer workstations with high resolution monitors. Attached to each player station are a set of flight controls including a 3-axis side arm controller and a collective control. Displayed on the screen of each player station is an out-the-window view, or flight instruments, or some combination of both as selected by the pilot. With the player stations, a total of 8 pilot-in-the-loop simulated aircraft can interact within a single mission scenario.

ANNEX D

DDR&E SCIENCE AND TECHNOLOGY PANEL 6, SIMULATION

OFFICE OF THE DIRECTOR OF
DEFENSE RESEARCH AND ENGINEERING
WASHINGTON, DC 20301-3030

January 21, 1992

MEMORANDUM FOR MR. JOHN M. BACHKOSKY

SUBJECT: S&T PANEL #6 TECHNOLOGY DEMONSTRATIONS

Attachment (1) is the information on S&T panel technology demonstrations you requested on 14 Jan 1992. In addition, Attachment (2) is a copy of the Blue Team's presentation given to Dr. Reis on 14 January 1992. At the conclusion of the Blue Team meeting, Dr. Reis said he wanted to establish a Defense Science Board Task Force on the subject of covered by the Blue Team. Subsequently, he has asked Colonel Jack Thorpe (DARPA) to prepare the appropriate paperwork. I will keep you informed as the plans for a DSB Task force progress.

James S Shiflett

James Shiflett
Colonel, USA
Chairman Panel 6

TECHNOLOGY DEMONSTRATION PROJECT
S & T PANEL #6

1. TITLE: Synthetic Environments for Electronic Battlefields

2. GRAPHIC DEPICTION: Being Developed with DAPRA

3. DESCRIPTION: Advances in simulation technology make it possible to link dissimilar simulations together in order to conduct very large, joint military operations which ordinarily would not be possible during peacetime. These operations can be conducted at a fraction of the cost of alternative approaches, without buying vast new tracts of land, and at a level of realism and fidelity heretofore unachievable during peacetime. The concept is based on "beaming" warfighters onto "synthetic battlefields" of the size of Desert Storm. This will be accomplished by using common data exchange protocols for networking simulators, wargames, and instrumented combat vehicles from ranges such as the National Training Center, Red Flag, etc.

The proposed technical development and demonstration will focus Service programs towards a common vision. This demonstration will integrate emerging simulations, modeling, and communications technologies. It will progressively demonstrate in a phased manner that physically separated naval, ground, and air forces can be brought together in a comprehensive and realistic joint operation using simulation and modeling technology. Specifically, these multi- phased demonstrations will provide (a) the integration of ranges, simulations, and real systems into a "free-play" battlefield environment, (b) the ability to electronically prototype future warfighting capabilities, (c) preview the impact of standards and policy on training, system development, operations, and readiness. When completed, this demonstration will provide a powerful capability that will fundamentally change many aspects of how the DoD does business in the coming decades. Representative technologies that will be involved in these demonstrations are:

(a). Integration & Linkage Technology,to Represent Hardware, People, & Operations

(b). Technology for Modeling, Simulation & Wargaming Networks, Leading to Protocols and Standards Needed for Interoperability of Synthetic Environments

(c). Short & Long-Haul Communications Networking Technology,

(d). Man-in-the-Loop Interoperability Technology, Including Embedded-Training Software, Hardware, & Operational Procedural modeling

(e). Terrain Databases Including Environment Variations & Cultural Features Augmentation

(f). Automated Fusion & Real-Time Digitizing of Sensor Information (visual, radar, etc.)

(g). Low-Cost High-Resolution Display Systems, Advanced Instrumentation, and Virtual Interface Techknologies

(h). Accurate, Rapid Ability For Computer Representation of Platform and Weapon Dynamics

(i). Computer Image Generation & Graphics

(j). Force Representation & Collective Behavior

4. LEAD AND OTHER SERVICES/AGENCIES INVOLVED: DARPA will serve as the technical lead and will coordinate Service programs in this area. Colonel Jack Thorpe will serve as the DARPA point of contact. The Office of the Joint Chief of Staff (J-7) will be asked to define and coordinate the operational demonstration needs of the CINCs, and the Services. Each of the Services will serve as a lead Service for a particular demonstration. The Army would like to be the first (operational) demonstration in 1994. The Joint Technology Coordinating Group's simulation and training subcommittee should be asked to take responsibility for the coordination of their R,D,T&E (simulator and training device) mission areas.

5. MILESTONES:

1993 Linkage and Integration of real/simulated sensors, systems, and people. Scale 10K - 100K objects that take into consideration (a) heterogeneity of object classes, (b) a number of sites and objects per site, and (c) the mix of generation techniques for objects. Initiate demonstration of existing and emerging instrumentation techniques.

1994 Phase I of the Synthetic (electronic) Battlefield building on the Army's LA maneuvers Initiate demonstration of Human System Integration (HSI) assessment and redesign methods. Continue demonstration of emerging instrumentation techniques.

1996 Phase II of the Synthetic Battlefield incorporating improved capabilities to digitally represent warfighting sensors, threats, logistics, and weapon systems. Initiate demonstration of capability to generate dynamic RFP's. Continue demonstration of Human Systems Integration methods.

1999 Phase III of the Synthetic Battlefield with emphasis on intelligent gateways and semi- automated forces (SEMIFOR). Continue HSI evaluation with real-time feedback and forward into SEMIFOR. Continual demonstration of ways to develop dynamic RFP's and initiate demonstration of evaluation of RFP responses.

TECHNOLOGY DEMONSTRATION PROJECT
S & T PANEL #6

2004 Final demonstration of using synthetic environments for simulating (a) total warfighting capability anytime/any place, (b) prototype systems being considered for military procurement, (c) standards, protocols, methods, and techniques that will allow such technologies to be transported and utilized world-wide to meet all possible military needs.

6. Funding by FY in $M:

FY 1993:	40.0
FY 1994:	58.0
FY 1995:	73.0
FY 1996:	95.0
FY 1997 - 2004	250.0

(Note: This is the estimated projections based on the draft DDR&E FY 93 S&T budget memo)

7. PROGRAM ELEMENT(S):

603226E (DARPA)
602618A
602624A
602727A (PM TRADE)
602233N (NAVAIR: NTSC)

Related Program Elements:

604722S (OSD prototyping used to be DDR&E now in FM&P)
603007A (ARI) CFY
603003A (PM TRADE)
604715A (PM TRADE)
603733N (NTSC)
603227F (Armstrong Lab; Williams AFB)
604227F (USAF SIMSPO)