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Toward the Implementation of Augmented Reality Training

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The United States Air Force (USAF) trains C-130H Loadmaster students at Little Rock Air Force Base (AFB) through a civilian contract. The Aircrew Training System (ATS) contractor utilizes a Fuselage Trainer (FuT) to provide scenarios for the Loadmaster students to practice loading and unloading a simulated aircraft. The problem was the USAF does not have enough training devices and these devices are not at a high enough fidelity to accomplish many of the aircraft functions to meet the training objectives before flying on the actual aircraft. The ATS has moved the pilot's initial training into the Weapon System Trainer (WST). The WST has nearly eliminated all the aircraft flights for pilot initial instrument training because the simulator is life-like enough to accomplish the training tasks to qualify the students in the device. The Loadmaster student flights are scheduled based upon the pilot's flight training, thus forcing the Loadmaster students to utilize some other type of simulator device for their initial training.

The goal was to investigate an efficient and effective AR training system to instruct Loadmaster skills before they train on the aircraft. The investigation examined the use of a prototype Helmet Mounted Display (HMD) AR device attached to the Loadmaster's helmet. Three scenarios provided a basis to evaluate the different aspects of hardware and software needed to utilize an HMD as a Loadmaster training tool. The scenarios tested how the AR device may improve the C-130H Loadmaster training capabilities to learn normal and emergency procedures to students in the FuT. The results show a way to save the government thousands of dollars in fuel cost savings and open the eyes of the training contractor to a new way of training students using AR.

Acknowledgments

Table of Contents

Appendixes

List of Tables

Tables

List of Figures

Figures

Chapter 1

Introduction

The dissertation examined the potential benefits of an Augmented Reality (AR) tool to train United States Air Force (USAF) Loadmaster personnel in C-130H aircraft flying events. This case study used a mixed methods research design that includes surveys and interviews to collect quantitative and qualitative data (Creswell & Plano-Clark, 2007; Yin, 2009). The questionnaires were based on Kirkpatrick's four levels of evaluating a training program. Kirkpatrick's methods helped answer some of the research questions in evaluating a new tool for instructing Loadmaster students and in comparing the learning outcome of the students who used the tool with students who were not exposed to AR (Kirkpatrick & Kirkpatrick, 2006). But first, an introduction is needed to understand where a Loadmaster works and how he trains in the C-130H world.

Context

An aircraft capable of delivering cargo on a short dirt runway, in a hostile area, at night, with no visible lights on the field, is a job for the C-130 Hercules. A C-130H model is a high wing, four-engine, propeller driven cargo aircraft, flown with a crew of five; an Aircraft Commander, Pilot, Navigator, Flight Engineer, and a Loadmaster. Loadmasters are the cargo handling and rigging experts on the aircraft. They are responsible for loading and unloading the cargo, rigging the parachutes for airdrop missions, preparing

Army troops for personnel airdrop missions, and are charged with the safety and security of the cargo compartment.

The USAF trains C-130H students at Little Rock AFB, Arkansas, through a government funded civilian contract. The civilian contractors are hired to instruct the academic and simulator portions of the curriculum in accordance with the Aircrew Training System (ATS) contract guidelines. The current ATS contractor, Lockheed Martin Global, Training and Logistics (LMGTL), is also tasked to maintain a variety of training devices used to teach each of the crew positions. Desktop computer stations help students practice using the software installed on the aircraft. Simulated cockpits, known as Part Task Trainers (PTTs), display dials and switches enabling crewmembers to practice and familiarize themselves with limited instrument and switch location functionality. One such PTT is the Cockpit Procedural Trainer, which allows pilots to practice instrument procedures, but does not display any visual scenes. Students do not receive any flying skill credit for training in the lower-level non-integrated PTT devices. The C-130H Weapon Systems Trainers (WSTs) do allow flying skill credit for certain crew positions when training specific maneuvers in this device (HQ AMC/A3TA, 2010). In fact, some of the emergency procedures practiced in the simulator are not performed on the aircraft or in operational training (Stewart, Johnson, & Howse, 2008). Many of the C-130H training devices are geared toward pilot training, but over the last few years more effort has been made to develop training devices for the remainder of the crew.

To support Loadmaster training, the USAF took four older C-130E model aircraft, removed the wings, stripped the tail off down to the fuselage and permanently mounted the aircraft in a hangar, referred to as a FuT (Fuselage Trainer). The FuTs provide

scenarios for Loadmaster students to practice various cargo configurations in a real aircraft. Lockheed Martin instructors currently use the four FuTs to train Loadmaster procedures for loading and unloading the aircraft, rigging procedures for airdrop missions and aircraft emergency procedures (Desnoyer, 2010). Some Loadmaster emergency procedures do not lend themselves to full motion simulation, as the WST does for the pilots, or to real-life aircraft scenarios. For example, the AF frowns upon starting fires in a training aircraft just for practice, therefore, an alternative tool to support training was investigated to incorporate instructional strategies that are different from traditional Loadmaster training devices (Stewart, et al., 2008).

Problem Statement

The problem was that the existing Loadmaster training, for operational procedures, was deficient in providing a platform to familiarize students with each flying training event they are required to perform before they start the procedures on the job (Gardley, 2008; Stone, Caird-Daley, & Bessell, 2009). In the C-130E FuT, training was limited to procedures that do not involve a reaction from the aircraft. For example, there was no process for practicing engine starts, no process to practice extinguishing a fire in the cargo compartment and no process to practice cargo extraction or to deal with associated malfunctions. Loadmaster students still require aircraft flights to finish their initial training, unlike pilots, which have moved most of their initial training into the WST (Jean, 2009; Mayberry, 2010). Pilot WST sorties have nearly eliminated all the aircraft flights for initial instrument training because the simulator is life-like enough to

accomplish the flying training tasks in the device, thus forcing the Loadmaster to achieve their required training with fewer aircraft flights (Desnoyer, 2010; LMSTS, 2008; White, 1991). The Loadmaster's flying training schedules are based solely upon the number of sorties a student pilot receives during his initial training. Loadmaster students are matched up with pilot students when being trained on the aircraft (HQ AETC/A3RA, 2011).

Unlike the WST, the FuT does not move or have any external visual systems to simulate flight. Loadmaster students are now forced to utilize some other type of simulator device for their initial training. Stewart, et al., (2008) show that low cost simulators can be an effective training tool when appropriate training strategies are employed. The USAF does not have enough fuselage training devices and are not at a high enough fidelity to train critical, safety of flight objectives before flying on the actual aircraft (HQ AETC/A3RA, 2011). The USAF investigated an AR technical solution over an increase in aircraft training devices, because of the limitation of aircraft fuselage availability; or virtual reality (VR) training, to overcome some of the costs and training environment limitations for Loadmaster training (Conger, 2008). Stewart, et al., (2008) suggests that skills learned in lower-level training environments will transfer to a higher-fidelity environment such as the aircraft. The transfer of knowledge and skills has been proven in the C-130H community as pilot training has pushed more of the flying skills needed into the WST. This was especially true for practicing emergency procedures with the crew.

Goal

  The goal was to put into place an efficient and effective AR training system to instruct

Loadmaster students in Crew Resource Management (CRM) skills during critical times

on the ground or in-flight before they train on the aircraft. The efficiency of the training

device will enable students to quickly acquire a higher level of productivity throughout

their mission (Fulbrook, Ruffner, & Labbe, 2008). The concept of CRM is used as a tool

to teach students how to avert crisis rather than training crisis scenarios (Hunt &

Callaghan, 2008). The CRM skills include situational awareness, crew coordination,

communications and task management, which are all involved when dealing with

operational and emergency procedures on the aircraft (AF/A3O-AI, 2012; Hunt &

Callaghan, 2008). Situational or spatial awareness gives the student the cognitive ability

to be aware of his location in space both statically and dynamically (Stone, et al., 2009).

Training in the actual aircraft fuselage, for this physically demanding job, further helps

transition Loadmaster students to learn where to stand, kneel, etc. during the mission. In

flying terms, the students are taught to be cognitive of the other crew activities and to

think ahead of the aircraft.

  The lack of available aircraft flights to instruct Loadmaster students in CRM skills

drove a requirement to investigate an alternate method to train Loadmaster students, but

maintain the same high quality of student knowledge and skills. Air Education and

Training Command (AETC) developed a prototype system that combined AR with the

physical reality of a C-130E fuselage (Jaszlics, 2009). The AR C-130 Loadmaster Trainer

(ARCLT) system was developed and tested in a small group try-out (SGTO) at Little

Rock AFB from March through June 2008 (Gardley, 2008; Gay, Mills, & Airasian, 2006; Twogood, 2002). The SGTO led to the conclusion that the ARCLT could feasibly be used as a training tool for C-130 Loadmaster instruction and prepared the Lockheed Martin instructors for the delivery of the training tool to be used on a larger group (Larbi-Apau & Moseley, 2008). AETC launched a study in a Large Group Try-Out (LGTO) using the ARCLT to evaluate the training methodology to ensure that the usability goal of an efficient and effective training system was met (Twogood, 2002; Fulbrook, et al., 2008). The ARCLT allows the trainee to utilize the same equipment used on the aircraft. This type of simulation has great potential for training procedural tasks, especially emergency procedures, which require a realistic haptic feedback during the training (Botden & Jakimowicz, 2008).

Research Questions

1. Why are computer-based simulations insufficient for learning to master CRM skills needed by Loadmasters?

2. How can an AR device be added to the physical training site to complete the training process?

3. Based upon the initial evaluations of the prototype AR system, what adjustments were made to the hardware, software and to instructor scripts?

4. What lessons have been learned about the use of AR devices in training that will ascribe value to other training situations?

Relevance and Significance

    The USAF had an immediate need for a high fidelity training device that would enhance Loadmaster training. Training was being pushed to lower-level simulator training devices because of the high cost of fuel and maintenance for aircraft and the cost of acquiring actual aircraft for training. Technology had caught up with the requirements for light-weight Helmet Mounted Devices (HMDs) with high-speed video rendering and a stable tracking system. The significance of the ARCLT was that the device was tested in an established training program during the LGTO, instead of being assessed in a laboratory. The ability to interact with actual students and instructors for testing allowed first hand reactions from the users that train day-to-day (Yin, 2009).

    This case study was specifically geared to benefit the USAF in training Loadmaster students in larger type aircraft, i.e. C-130s, C-5s, or C-17s. The general use of an AR training device benefits the USAF as a whole by testing the next generation of students using virtual tools corresponding with exposure to virtual games before the students joined the USAF. The scientific benefit to AR was to use a stable tracking system in a confined area. Many AR applications have not experimented with closed-in spaces.

Barriers and Issues

    A barrier to working with contract instruction is the threat of extended contract negotiations and placing the actual work on-contact. In 2006 AETC selected, from a variety of projects, to produce an AR prototype system through the Education Training

Technology Application Program (ETTAP). A project funded by ETTAP must meet specific conditions to go on-contract. A market study was accomplished to verify that small companies had the capability to produce such a system. In 2007 a request for proposal was sent out and only two companies qualified to bid. After source selection, project funds were paid to Pathfinder Systems Inc. to develop, build and install an AR system on the FuT at Little Rock AFB. After many trials and errors in the development phase for camera placement and tracking software, newer cameras were purchased and updated software was reinstalled with additional funds and an extension to the contract. In 2008 AETC's Studies and Analysis Squadron (SAS) tested the training device with a small group of students. The evaluation of the surveys indicated certain improvements were necessary to continue any future research (Gardley, 2008).

Funds from ETTAP were exhausted, so in 2009 additional funds were solicited and approved by the AETC Vice Commander to upgrade the system and conduct the LGTO. The funds covered upgrades to the system, engineering software for tracking, re-installation of the system into the FuT and any expense incurred for the ATS contractor overtime. The ATS contractor did not charge the government for the SGTO, but indicated that a larger number of students would require overtime to run through all the scenarios. Extra time was spent throughout the summer of 2010 setting up a separate contract for the ATS contractor, but after about six months of negotiations, the contractor decided not to charge the government for the remaining time on the contract if the training could be accomplished before the end of December 2010. The reason may have been because the ATS contract came up for rebid in 2010.

In November 2010 a new ATS contract was signed to begin on January 1, 2011, and Lockheed Martin once again won the contract. Pathfinder Systems set up a sub-contract with Lockheed Martin to request Loadmaster instructor participation in the LGTO. Under the new contract Lockheed Martin charged the government for their participation. Several of the instructors were trained to use the ARCLT, tested the tracking system and verified that the virtual scenes had been upgraded. Student training began in August 2011, once written approvals of the IRBs were obtained.

Scope of the Study (Limitations and Delimitations)

Several limitations were present in working with USAF students, contract instructors and flight instructors. The day-to-day operations of the ATS were overseen by a designated government agency at Little Rock AFB that reported to AETC Headquarters in San Antonio, TX. The students in the Loadmaster courses were screened and selected by the USAF. AETC hosts the Programmed Flying Training conference each year to schedule the classes and the number of students requested by the agencies sending students through the C-130H courses (HQ AETC/A3RA, 2011). The student population was determined by the number of students who pass the prerequisite courses required by the USAF.

The contract instructors were chosen by the Lockheed Martin management to participate in the study. Instructors may have been chosen based on interest in the program, work schedule and type of instruction trained to deliver (LMSTS, 2008). The USAF opened the ARCLT training to all instructors interested in running the scenarios.

Flight instructors were assigned to students by the squadron schedulers. As the students finished up the academic and simulator portion of the training, they were assigned to the flying squadron. The scheduler matched up available instructors with students based on the instructor's experience, Temporary Duty (TDY) schedule and student needs. The 714th Training Squadron (TRS) Loadmasters were the Subject Matter Experts (SMEs) in charge of overseeing the training at Little Rock AFB, C-130H schoolhouse. The USAF designated day-to-day oversight to the TRS in overseeing the study in accordance with the proposed plan.

Once all the contracts were in place, the USAF chose class 11-011 to start the LGTO. Approximately 100 participants were planned to be involved with the LGTO using the ARCLT system during the contract time line with Pathfinder Systems. Coordination was conducted with the Lockheed Martin Loadmaster scheduler and the flying squadron Loadmaster scheduler to insure student and instructor personnel were available for interviews during the TDYs to Little Rock AFB. Interviews were conducted about once a month, to gather qualitative data, depending on the TDY schedule. Air Mobility Command (AMC) agreed with the research that showed students using a virtual learning environment could achieve higher learning result and supported AETC in researching ways to lower the cost of training Loadmaster students through AR (Vilkoniene, 2009).

Acronyms

AETC – Air Education and Training Command

AFB – Air Force Base

AFRL – Air Force Research Laboratory

AR – Augmented Reality

ARCLT – Augmented Reality C-130 Loadmaster Trainer

ATS – Aircrew Training System

CBT – Computer Based Training

CDS – Container Delivery System

CRM – Crew Resource Management

ETTAP – Education Training Technology Application Program

FuT – Fuselage Trainer

GAT – Ground Aircraft Trainer

GPS – Global Positioning System

HMD – Helmet Mounted Display

IOS – Instructor Operating System

ISD – Instructional System Design

LGTO – Large Group Try-out

LMGTL – Lockheed Martin Global, Training and Logistics

NSU – Nova Southeastern University

NVGs – Night Vision Goggles

OSD – Optical See-Through Display

PTT – Part Task Trainer

SAS – Statistical Analysis Software

SGTO – Small Group Try-Out

SLMS – Satellite Loadmaster Station

SME – Subject Matter Expert

TDY – Temporary Duty

TRS – Training Squadron

USAF – United States Air Force

VR – Virtual Reality

WST – Weapon System Trainer

Definition of Terms

AMC –Air Mobility Command – Lead command for all heavy aircraft, C-130s, C-17s, KC-135

C-130H – A high wing, four propeller driven cargo aircraft, capable of landing on short unimproved (dirt/gravel) runways, at night in blacked out conditions

Checkride – Flight Evaluation

Crewmembers – Aircraft Commander (AC), Pilot (P), Navigator (N), Flight Engineer (FE), Loadmaster (LM)

Edutainment – Combining educational and entertainment software

Haptic Feedback – Force feedback

Lockheed Martin Global, Training and Logistics – Aircrew Training System contractor

Occlusion – Ability to hide a virtual object behind a real object or hide a real object behind a virtual object

Organization of the Study

Chapter one introduces the context in which USAF Loadmaster students are trained in

the C-130H ATS. The simulation that supports the training was not adequate to prepare

the students for all the in-flight duties. The implementation of an AR device may promote better practiced skills and knowledge both in normal and emergency procedures. The cost savings to the government may be significant when fully implemented. But, dealing with USAF contracts does have its disadvantages. The timeline always seems to move to the right when negotiating and coordinating the work to be done.

Chapter two helps define some of the aspects of using AR in training. Flight simulation has been augmenting reality for many years with training devices that teach students how to fly, but done safely on the ground. Today's technology helped provide better visual systems through HMDs, better tracking and lighter equipment so students are better able to carry the equipment around in the training environment. Other disciplines have utilized AR in training surgical procedures, training solders for urban combat and Navy submarine familiarization training (Botden, Hingh, & Jakimowicz, 2008b; Livingston, Brown, Julier, & Schmidt, 2006; Stone, et al., 2009).

Chapter three shows that the USAF has traditional methods for setting up a training systems and procedures to evaluate the results. This study combined some of the same procedures and the expertise of Donald and James Kirkpatrick to build survey and interview questions to evaluate the training effectiveness of the ARCLT tool. The investigation followed a case study research design relying on a mixed methods research methodology. A balance had to be met for both USAF standards for training and testing students and the University's policies and procedures for a scholarly dissertation.

Results are presented in chapter four. The analysis triangulated data from the surveys, interviews and student records to evaluate any correlation between the student's views, the contractor's views and the flight instructor's views of the ARCLT system. Chapter

five answers the research questions in the conclusion, explores the implications for using an AR tool for flight on other platforms, gives the recommendations for upgrades to the system and finishes with a summary of the study.

Chapter 2

Review of the Literature

This chapter is a review of the literature pertaining to simulation and the use of AR in training. The first section describes how far simulation in training has come over the years. The next section describes some of the learning characteristics of using simulation. The subsequent sections review a brief history of AR and some the current usage of AR devices across different disciplines, what tools are used to put together AR systems and the interface to use the tools. The next section deals with the different applications AR can be used with, followed by some of the limitations for this type of simulation. The last section contains the relationship of the literature to the study.

Simulation in Training

There has been a general acceptance by many historians that the Wright brother's first manned powered flight started the revolution of air travel. From the first wind tunnel simulations the Wright brothers used to help develop the cambered wing of the Kitty Hawk aero plane, to the startup of aviation companies around the world, what the early pioneers of aviation learned about flying came through trial and error (Bradshaw, 1993). Like Lt Benjamin Foulois bringing the first Wright Flyer to Fort Sam Houston in San Antonio TX, his instructions were to take plenty of spare parts and teach yourself to fly (Manning, 2005). Through the experiences of these early pioneers, today's instructors are able to teach basic flying rules that help prevent loss of life while training students to fly.

The Federal Aviation Administration has published Visual Flight Rules and Instrument Flight Rules to regulate flying in visual and instrument conditions (FAA, 2009). The maturity of these flying rules has lead instructors to develop a methodology for teaching students how to fly without any threat to their lives by utilizing training devices.

Flying techniques and aircraft simulator innovations have improved the training methodology to incorporate better flying training devices, which are now used more often than teaching certain procedures in the actual aircraft (Mayberry, 2010; LMSTS, 2008). Some of the early flight simulators started out in a wooden box to capture the *feel* of the controls whenever the pilot made an input. The development of the Link Trainer made it possible for students to sit in a wooden cockpit, shaped as a small aircraft, enabling the student to feel how the aircraft reacts to the movement of the flight controls by actuating the stick and rudder pedals (Killgore, 1989).

Simulation has vastly improved from the wooden cockpits in the early days of flight, to the sophistication of full scale WSTs used to train USAF pilots. The ability to practice low level flight procedures in a training device enables the crew to better familiarize themselves with the mission, practice checklist procedures over and over until the steps are mastered, and practice instrument approaches into unfamiliar fields before venturing out to the actual site (Mayberry, 2010; Stone, et al., 2009). The capability to learn flight procedures in different types of simulation devices has gradually improved. Many of the improvements to the WSTs are due to advances in computing technology which have improved the *feel* of the motion and controls (Samset, Schmalstieg, Vander Sloten, Freudenthal, Declerck, Casciaro, Rideng, Gersak, 2008). Most of the changes to the simulators have been implemented to benefit pilots, since their training is the most

expensive. For example, an aircraft flight, such as a C-130H, cost about $5,976 per hour, (SAF/FMCCF, 1994) depending on the type of aircraft, whereas a simulator, like the C-130H WST, costs only about $700 per hour (Jean, 2009). A variety of projection systems have been used over the past 20+ years to simulate the view of the real world so that the students feel as though they are in the actual environment. Many aircraft weapon systems use WSTs to show virtual scenes through projectors onto a large screen in front of a simulated aircraft cockpit. The cockpit is fully populated with all the instrumentation of the real aircraft, but is surrounded by a metal box and frame which is mounted on six hydraulic legs to support full motion (White, 1991). The visual scene in the WST is limited in scope to the height and width of the screen itself and by the number of projectors tied together to show the virtual picture. Students sit inside the simulated aircraft and view the virtual world through the windows of the cockpit. The WST enables the students to practice a multitude of flight maneuvers replicating the actual view and feel of the real aircraft.

Simulation is the imitation of actual conditions in which students can systemically explore different situations without the consequences of risking lives or destroying equipment, provides rapid and realistic feedback and improves higher-order cognitive processes (Oliva, & Bean, 2008; Ravert, 2008). Simulation can range from a desk top computer system allowing the student to practice instrument approaches to unfamiliar air fields or as sophisticated as incorporating ubiquitous computers imbedded in a training suite designed to monitor body functions or show certain information for the student or the instructor.

Learning Characteristics of Simulations

Simulation is the imitation of something real, such as a condition or behavior of another system which students can systemically explore different situations without the consequences of risking lives or destroying equipment, generally entails representing certain key characteristics of a physical or abstract system, provides rapid and realistic feedback and improves higher-order cognitive processes (Oliva, & Bean, 2008; Ravert, 2008). Researchers have discovered that using simulation for a variety of learning situations stimulates the student's ability to not only learn the material, but help them retain more of the information longer (Bloom, 2009). A simulation provides the student with a greater opportunity to practice procedures or skills in a safe environment before applying the procedures on the job. Simulations attempt to represent the real world with some control over the situation but exclude some aspects of the real world (Dahl, 2010).

Simulation has been used as a training aid throughout many years of developing learning processes for teaching critical skills, such as aviation or surgery (Hunt & Callaghan, 2008). With the advent of faster and more mobile computer components, computer systems are becoming more ubiquitous in the training aids used to train students. The gaming industry has taken advantage of the new computer systems to promote not only entertainment style games, but the edutainment of today's youth (Bloom, 2009). Multimedia companies have made learning fun. Many of the games geared toward younger learners are made so that they achieve the next level in the game as they gain the knowledge needed to defeat the enemy on each level. The integration of

educational computer software hidden in the games enables the student to acquire knowledge without knowing the gaming system is actually teaching them certain skills.

Pilots receive much of their training through simulators and most of the time is spent in extreme conditions (Mayberry, 2010). A simulator allows students to greatly speed up the time required to learn these lessons without the consequences of real-life experiences (Oliva & Bean, 2008). The USAF utilizes simulation to the maximum extent possible. Over the years, training has moved from a large amount of aircraft flights, for learning to takeoff and land, to fewer flights and many more simulated flights, to not only takeoff and land, but to accomplish airland and airdrop missions (Mayberry, 2010). Not all simulators have the ability to replicate the real world in the exact manner as each situation calls for. Some of the first guidelines required students to look beyond the simulator technology and not try to beat the game; the student must set their mental models to how the real world operates and the strategies to deal with each situation (Oliva & Bean, 2008).

Incorporating real world scenarios into a wearable computer allows the user to experience simulation on a personal basis. The ability to make simulation more mobile in training critical skills allows for ubiquitous computing in a training system. The Army has developed an integrated computer system used on fighting gear and weapons. Not only can the students see the virtual target through the scope of the rifle, but can be monitored for physical conditions the student may encounter in the field (Waller, 2006). Tracking the student, monitoring his condition and providing realistic targets in a virtual setting makes the student unaware of the wearable computers and the software integrated into the training environment.

Another type of AR system integration is the use of a simulated patient. A nursing simulator enables students to practice patient care without risk of the patient dying (Ravert, 2008). This type of simulation allows students to assess the changing conditions of a patient and practice critical skills needed to take care of a patient. As the students administer certain procedures for the condition the simulator is set up for, the students can monitor the results of their efforts. If the students administered the incorrect solution to the symptoms, the simulation reacts in a negative manner and may shut down, unless the student corrects the error (Ravert, 2008). If the system shuts down, it can be re-booted so the student can practice the procedure correctly.

Simulation can range from a desk top computer system allowing the student to practice instrument approaches to unfamiliar air fields or as sophisticated as the incorporation of ubiquitous computers imbedded in a training suit to monitor body functions. The use of AR has migrated into many aspects of training students throughout a wide variety of training disciplines.

Augmented Reality Training

Augmented reality (AR) combines a live view of a physical, real-world environment with computer-generated sensory inputs which are interactive in real time and registers in 3-D; AR is not restricted by display technologies, nor limited to the sense of sight and can virtually remove or occlude real objects with virtual ones (Azuma, 1997; van Krevelen, & Poelman, 2010).

To get an idea of where AR fits into the realm of visual displays, many researchers use Milgram's virtuality continuum to show the contrasting ends of the scale (Samset, et al., 2008). Milgram uses a scale to show how AR falls between the physical real world (non-modeled reality) on one end and a completely virtual world (100% modeled reality) on the other, AR falls closer to the real world end of the scale (Samset, et al., 2008; Milgram & Kishino, 1994). AR is where a user is placed in an interactive setting with virtual assets augmenting the real world surrounding him. An example of Milgram's scale would show the real world as someone standing in a museum viewing the bone structure of a dinosaur; the AR view would show a prehistoric fish swimming around in the museum; and the fully virtual world would show the whole museum in a fully digital video game style display (Milgram & Kishino, 1994). AR has been used in television broadcasts, such as the 2008 Summer Olympic, by superimposing the countries flags on the swimming and running lanes and by using the yellow line during the National Football League games to show the first down line (Conger, 2008). Just as virtual pictures can be broadcast on television, digital images can be projected through a device mounted on a helmet.

Brief History

A brief historical overview shows how the concept of AR has developed from 1957 until today:

1957-62: Morton Heilig, a cinematographer, creates and patents a simulator called
      Sensorama with visuals, sound, vibration, and smell (Heilig, 1962).

1965: Ivan Sutherland proposed a head-mounted display which incorporates an all-
powerful computer projecting graphic images exactly as their real-world
counterpart (Hiatt, & Rash, 2009)

1975: Myron Krueger creates Videoplace to combine a participant's live video image with
a computer graphic world for the first time (Krueger, 1977).

1989: Jaron Lanier coins the phrase Virtual Reality and creates the first commercial
business around virtual worlds (Lanier & Biocca, 1992)

1990: Tom Caudell coins the phrase 'Augmented Reality' while at Boeing helping workers
assemble cables into aircraft (Curran, McFadden, & Devlin, 2011).

1992: L.B. Rosenberg develops one of the first functioning AR systems, called Virtual
Fixtures, at the U.S. Air Force Research Laboratory—Armstrong, and
demonstrates benefits to human performance (Rosenberg, 1993).

1993: One of the first major papers on AR system prototype was presented at the
SIGGRAPH '93, Knowledge-based Augmented Reality for Maintenance
Assistance (KARMA) (Feiner, Macintyre, & Seligmann, 1993).

1994: Julie Martin creates the first Augmented Reality Theater production called Dancing
in Cyberspace. Virtual dancers and acrobats are projected onto the same physical
space in real time (Wikipedia: Augmented Reality, 2012).

1998: Spatial Augmented Reality was introduced in the office of the future during
SIGGRAPH '98 (Raskar, Welch, Cutts, Lake, Stesin & Fuchs, 1998).

1999: Hirokazu Kato created ARToolKit at HITLab, where AR was further developed by
other HITLab scientists, demonstrating the ToolKit at SIGGRAPH 2001 (Kato,
Billinghurst & Poupyrev, 2001).

2000: Bruce Thomas and his team extend the desktop game Quake to be used as a mobile outdoor AR game called ARQuake (Thomas, Close, Donoghue, Squires, De Bondi & Piekarski, 2002)

2008: Wikitude AR Travel Guide launches on Oct. 20, 2008 with the G1 Android phone. (Wikipedia: Augmented Reality, 2012)

2009: AR Toolkit was ported to Adobe Flash (FLARToolkit) by Saqoosha, bringing augmented reality to the web browser (Wikipedia: Augmented Reality, 2012).

2012: Natural History Museum in London developed an AR system flexible and robust enough for thousands of people to use (Barry, Thomas, Debenham & Trout, 2012)

Today we are exposed much more to AR without even thinking about what has gone on behind the scenes. Sports programs have developed enhancements to keep the audience more involved as to where the baseball is thrown in the strike zone or if a football running back made it past the first down line on the field (Augmented Reality, 2013). The entertainment industry has driven the requirements for AR out of the training arena and into the homes of television viewers without their knowledge.

Displays

There are basically three ways to present images using augmented reality: video see-through, optical see-through and projective displays (van Krevelen, & Poelman, 2010). The first uses a camera to capture the scene and sends it through the goggles with the virtual scene overlaid on top. The second way is to see through the goggles at the real world and then have the virtual scene superimposed in front of the user's eyes. The third

way is moving toward the Star Trek version of the holodeck, projecting AR overlays onto real objects. Although the holodeck may be far off, researchers have achieved 1000 dots per second into a free space using plasma in the air (van Krevelen, & Poelman, 2010).

Video see-through AR superimposes graphical content on the camera's video, creating the illusion of a merged physical/virtual view. To align the two views, the position and orientation of the synthetic camera is aligned with the video camera (Hill, Schiefer, Wilson, Davidson, Gandy & MacIntyre, 2011), making it the cheapest and easiest to implement the AR scenes. There are several advantages in using this technique: easier to remove objects from reality by replacing them with fiducial markers for virtual objects, easily match the brightness and contract of the real world with the virtual objects and allow for better head tracking registration (van Krevelen, & Poelman, 2010). Disadvantages of video see-through include: under bad lighting conditions the video will degrade the visual perception of reality (Papagiannakis, Singh, & Magnenat-Thalmann, 2008); wearing bulky equipment with limited field of view and a fixed focus camera provides restricted movement and poor eye accommodations (Henderson, & Feiner, 2010). There may even be user disorientation, fatigue and eye strain due to the camera's positioning from the viewer's true eye location, requiring continual adjustments on the part of the user (van Krevelen, & Poelman, 2010). Another disadvantage is the time required to process the video images before it gets to the eye, causing latency. This delay in processing the images can cause simulator sickness to occur during operations (Lindberg, Jones, & Kolsch, 2009).

An optical see-through display (OSD) head-mounted device enables users to view digital images overlaid on the real world. OSDs can be utilized in many ways. Their most

prospective application is as media that display instruction manuals in industrial fields. Most of the recent sophisticated industrial machinery involves a fixed display to give workers task-related information such as present operation status. If such information is presented in front of workers' eyes using OSDs instead of using fixed displays, it is expected that they can refer to it easily and work more efficiently and comfortably (Tanuma, Sato, Nomura, Nakanishi, Salverdy & Smith, 2011). The advantages of using see-through techniques includes being able to see when the power fails, making the device cheaper and parallax-free, no eye-offset to cause discomfort (van Krevelen, & Poelman, 2010). Disadvantages include display limits for field of view, which is not good when interacting with the surrounding environment and images can be washed out when used in outdoor lighting situations (Lindberg, et al., 2009).

Head-Mounted Projective Displays, or HMPDs, require the observer to wear miniature projectors. The projectors beam the synthetic images directly onto the surfaces of the real objects that are within the user's field of view (Bimber, & Raskar, 2007). HMPDs decrease the effect of inconsistency of accommodation and convergence that is related to HMDs. They provide a larger field of view without the application of additional lenses that introduce distorting arbitration (Hiatt, & Rash 2009). They also prevent incorrect parallax distortions caused by IPD (inter-pupil distance) mismatch that occurs if HMDs are worn incorrectly (e.g., if they slip slightly from their designed position). Newer prototypes tend to be smaller and more ergonomically to wear. The integrated miniature projectors offer limited resolution and brightness and might require special display surfaces (i.e., retro-reflective surfaces) to provide bright images (Hiatt, & Rash 2009).

Projective displays project virtual content directly onto the real world. The advantages of this approach include the ability to view an augmented environment without wearing a display or computer (van Krevelen, & Poelman, 2010). Bright projectors combined with relatively reflective task surfaces can make this a good approach for certain domains. However, these systems typically assume that all virtual material are intended to lie on the projected surface, limiting the kind of geometry that can be presented. Stereo projection is possible, in conjunction with special eyewear or the use of optical combiners in the environment, often in conjunction with head tracking, but this removes the appeal of not requiring special eyewear or modifications to the environment (Henderson, & Feiner, 2007).

The advantage to these displays is that they do not require special eye-wear thus accommodating user's eyes during focusing and they can cover large surfaces for a wide field-of-view. Projection surfaces may range from flat, plain colored walls to complex scale models (van Krevelen, & Poelman, 2010). This type of display is limited to indoor use only due to low brightness and contrast of the projected images. Occlusion or mediation of objects is also quite poor, but for head-worn projectors this may be improved by covering surfaces with retro-reflective material. Objects and instruments covered in this material will reflect the projection directly towards the light source which is close to the viewer's eyes, thus not interfering with the projection. (van Krevelen, & Poelman, 2010).

Research and development into new HMDs has been growing steadily over the last few years. AR technology has come a long way since the 1980s and 90s with the advent of smaller computer parts, the increase in the speed of the processors and the ability to

wear the computer has made it easier to incorporate HMDs into student training

(Papagiannakis, et al., 2008). At first, the HMDs were limited to a stationary position

because of the wires that were tethered to the top of the device. In order to push a large

amount of data between the visual and tracking systems to the computers, thicker cables

had to provide the paths, thus, this bulkiness provided a limited amount of head

movement in the cockpit (Regenbrecht, Baratoff, & Wilke, 2005). Rockwell Collins has

developed the SimEye series of HMDs; this type of device enables USAF F-35 pilots to

see out the window with a 40 X 30 degree field of view (Browne, Moffitt, &

Winterbottom, 2009). HMDs provide the user with the ability to access graphical

information immediately, since the view is directly in front of their eyes (Papagiannakis,

et al., 2008). The see-through style HMDs deliver the virtual information seamlessly to

the user through the use of 3D tracking technology, which blurs the distinction between

the physical and the virtual world (Kim & Dey, 2008).

A variety of tests have been used on HMDs to check the fidelity of the devices

themselves along with the perception and performance in the augmented environment

(Jermone & Witmer, 2008). Users benefit from the use of these devices, for instance,

smaller devices using less power provides the ability to attach the computers to a harness,

giving the students more mobility. As computer technology improves, the ability to track

students with lighter and faster devices will also improve.

In an AR setting, the ability to hide objects behind real or virtual objects, known as

occultation or occlusion, enables the software designer to appropriately place virtual

content correctly in the actual environment, giving the scenario an increased sense of

presence (Kim & Dey, 2008). Many of the virtual objects in the augmented world have

the ability to be occluded by real objects and some of the displays have the ability to occlude real objects with virtual objects (dos Santos, Lemos, Lindoso, & Teichrieb, 2012). One way to occlude an object, such as a fire, is to first digitally show the environment in which the virtual picture will be placed. Second, blacken out the object to be in the foreground, like a cargo pallet, and map it with software to note the exact location no matter where the student stands. Third, indicate the type of object to be occluded, in this case a fire. Fourth, combine the pictures to show one object hidden behind another (Jaszlics, 2008b). As the student moves around the object, more of the fire is shown. In an active scenario the fire starts out as a small smoke stream behind the cargo, then over time develops into a raging fire, that is, if the student does not react in time to put the fire out (Kim & Dey, 2008). Overlaying objects in a real-world environment takes careful alignment because the synthetic data can appear closer to the viewer than intended (Samset, et al., 2008).

Overlaying objects on a handheld device has increased in popularity for education and commercial use. The lightweight, high-resolution screens and high-definition camera delivers video see-through AR in a variety of environments (Gervautz & Schmalstieg, 2012). Mixing reality makes the devices suitable for social learning. The interaction between students is seen as a sense of social communication, engagement and learning which is considered useful in the learning process to articulate and debate their position (Liu, Teh, Peiris, Choi, Cheok, Mei Ling, Theng, Nguyen, Qui, & Vasilakos, 2009). Hand-held devices have exploded on the market with different sizes, speeds and capabilities. The AF announced a purchase agreement with Apple to buy up to 18,000 iPads to be used as an electronic flight bag (Smith, 2012). The capability for all flight

crews to carry a hand-held device enables the flight crew to not only research and view flight regulations but be able to carry programs that would help in diagnosing the aircraft malfunctions. The Army has transitioned traditional hard-copy texts to an interactive app on iPad that replaces static map images with animated GIFs and integrates audio, video and interactive graphics to support the mobile Army users to instruct soldiers on how to do their job better (Crowe, 2013).

Spatial Augmented Reality (SAR) uses projectors to display graphical information onto other physical objects. The main difference in this type of display is that it is not part of an individual system; it is used more for a group of users allowing for users to collaborate on a scenario (Broecker, Smith, & Thomas, 2011). An advantage of SAR is that is does not require a head-mounted display or any portable device; disadvantages include not being able to use the device in bright sunlight and the need for a certain kind of surface to project the images onto (Broecker, et al., 2011).

Aural display in AR devices can project sounds in several different ways. Many of the applications use stereo or surround sound headphones and loudspeakers to create the image of a sound source inside the users head (Hiatt, & Rash, 2009). True 3D aural displays are found in higher level simulations such as a flight simulator rated at a Level D device (White, 1991). Turtle Beach has created a wireless headset that incorporates Dolby 7.1 surround sound enhancing the listener's ability to hear in a 360 degree environment giving the impression of feeling the sound, referred to as haptic audio (van Krevelen, & Poelman, 2010).

In addition to the three basic systems, technology has progressed to include some futuristic uses of projecting images for the user. One system developed by the University

of Washington uses a Virtual Retinal Display (VRD) system to draw images directly in

the eye using laser beams without using any intermediary display (Lindberg, et al., 2009).

Another system the Defense Advanced Research Projects Agency (DARPA) is currently

developing uses a contact lens that enhances normal vision to view virtual and augmented

reality images. The researchers at the Washington-based Innovega Inc. created images

that are projected onto a tiny full-color display lens that is on the eye to allow the user to

focus simultaneously on objects close up and far away to improve the ability to interact

with the surrounding environment (DARPA Public Affairs Office, 2012).

Tracking sensors and approach

Real time user tracking has become one of the main concerns in developing an AR

system (Kim & Dey, 2008). Several different tracking approaches have been used for

various purposes, but there has not been a standard set for tracking (Eissele, Kreiser, &

Ertl, 2008). Today the portability of computers is all around us, from smart phones to

netbooks or IPads that incorporate small computers that can use the Global Positioning

System (GPS). Geosynchronous satellites for GPS have made it possible to track the

whereabouts of any mobile user with relatively low uncertainty (Khoury & Kamat, 2008).

Farmers now have the ability to track the position of their equipment in the field using

GPS guidance system (Sanatana-Fernandez, Gomez-Gil, & del-Pozo-San-Cirilo, 2010).

The University of South Australia also utilizes GPS in the Tinmith Mobile Outdoor

Augmented Reality System that incorporates a compass and interactive tools which could

be used to wire frame campus building designs, enabling the user to navigate throughout

the campus (Kim & Dey, 2008). Research into Wireless Local Area Networks, Ultra-

Wide Band and Indoor GPS shows each of the tracking methods have certain benefits and

limitations, depending on the use of the device (Khoury & Kamat, 2008). The ability to

track where the student is in the training area and the ability to know what the student

sees, both in the virtual world as well as in the real world, helps the instructor to monitor

the situational awareness of the students' perceived presence.

User interface and interaction

In a haptic learning environment, students and instructors need to be able to interact

with the AR system. Some prototype devices use haptic feedback to experiment with the

student's ability to interact with the virtual objects in a training system. Studies show that

students illustrate a significant improvement in transferring skills learned with haptic

feedback over the same type of students who are not trained with the device (Botden,

Hingh, & Jakimowicz, 2008a). Haptics, referred to as the "science of touch," are

developed to cue the user in such a way as to make the virtual environment seem real to

the touch (Stone, et al., 2009, p. 62). When building an AR tool, designers need to

develop the proper input devices for user feedback. One example of manipulating the

controls of an AR system would be to wear gloves that give direction to the system.

Virtual tracking gloves can be worn to manipulate the commands from a selected menu

structure by pressing the fingers against the thumb and other fingers to provide the

different options or used with hand jesters to input information (Lepouras, 2009). The

tracking gloves may work well for choosing menu items for an outdoor AR system, but

may not work well to simulate surgical procedures.

Using AR in surgical procedures allows the students to improve their eye-hand coordination which may lead to better accuracy with the procedure and an improved margin of safety for the patient (Samset, et al., 2008). Haptic feedback has been around in the gaming world since the development of the gamepad rumbler. The vibration in the gamepad indicates an action that could be a good or a bad reaction to the input from the user (Wikipedia: Gamepad). One of the more memorable feedback devices built for kids in the mid-1960s was the game called Operation, where a loud buzzer would indicate the player had touched the side of the extraction area (Wikipedia: Operation (game)). This type of feedback gets your attention when concentration and accuracy are needed for a game, but may not be the type of feedback needed to practice minimally invasive surgery for laparoscopic suturing where the feel of the instrument is more important than the sound it makes (Botden, et al., 2008a). Other feedback type devices like the CyberGrasp, gives the user the ability to feel the interaction of the device, which may work well for someone who is visually impaired. The CyberGrasp haptic device provides a buzzing effect that lets the user know the cane penetrated an object and a jolt force effect to let the user know when the cane hits an object or the ground (Tzovaras, Moustakas, Nikolakis, & Strintzis, 2009). Learning to use a cane to walk in an unfamiliar environment introduces many hazards that may be able to be practiced using simulation. Other enhancements that contribute to the realism of simulation are the human senses which we use to evaluate our perceived environment. Many people who are visually impaired have developed their hearing to recognize much more of their surroundings. VR and AR generally provide an immersive visual interface, but audio feedback along with a visual interface can be used to create an immersive application for simulated scenarios

(Tzovaras, et al., 2009). These immersive scenarios make it possible for students to incorporate not only the feel of the device, but to hear what has happened because of their input.

There are many tools used to test the hardware and software of an AR device but the field still has not come to a consensus on specific assessment methods to determine the benefits of AR use (Puig, Perkis, Lindseth & Ebrahimi, 2012). Although there are lessons learned confirming some of the basic principles of Instructional Systems Design (ISD). Wampler, Dyer, Livingston, Blankenbeckler, Centric and Dlubac (2006), completed an eight year study focusing on ISD in live, virtual, and constructive training areas. Lessons learned that may be useful in developing a device for aircrew training includes: involving trainers in the design stage of the new equipment, establishing clear, measurable and attainable objectives for the skills that must be acquired from the training and recognizing and accommodating for the diverse backgrounds of the students. These lessons learned in setting up an AR training system and the absence of having a consensus of basic tests (Puig, et al., 2012) to show the benefits of using AR still holds true today for training aircrew members.

AR devices have been used across many disciplines to provide a way to practice procedures that may not otherwise be taught without involving human lives (Samset, et al., 2008). The military has simulated many of the aspects of training warfare into something that can be mastered before the student progresses to the field (Stone, et al., 2009). In setting up an AR system, researchers often underestimate the efforts required to incorporate real world data into the application to train students. The field must carefully identify key people in an innovative role and should closely work with the researcher to

set up an island environment where the study minimizes the users, location and tasks, versus trying to equip hundreds of users wearing an AR system (Regenbrecht, et al., 2005). There has been much more research conducted extensively on VR aspects of training, than on AR. There are advantages and disadvantages for both VR and AR applications. Botden, et al., (2008b) points out that in laparoscopic simulation the advantage of AR over a straight VR device allows the user to utilize the same working environment as used in the operational setting, which is absent in the VR setting. Collecting and analyzing quantitative and qualitative data during testing of a device will help evaluate the advantages or disadvantages of the overall system.

Kim and Dey (2008) describe the use of AR in case studies that integrate custom-built 3D applications for engineering systems, geospace and multimedia. Each area can use AR to shift toward ubiquitous computing making the computer devices more invisible to the user. The capability to be invisible to the user may improve the realistic simulations for the user. A multimodal system may also help the user to control systems more easily by combining the human visual, auditory and tactile senses for user input and output.

Different types of simulation incorporate training in a variety of other areas. The Navy incorporated submarine familiarization by utilizing AR to help teach new seamen to recognize and locate equipment onboard a ship (Stone, et al., 2009). The medical community incorporates simulation with haptic feedback to familiarize new surgeons with suturing procedures. Adapting the actual tools used in surgery with haptic feedback enables the students to practice good fundamentals for laparoscopic surgery (Botden, et al., 2008a). Many of these training disciplines have searched for ways to not only save time in training new members of a team, be it a flight crew, a submarine crew, or a

surgical team, but to look for ways to improve the quality of the training. Some of the
training normally taught in the classroom can now be taught in the actual environment the
student may use in their operational unit, plus have the ability for students to rehearse the
procedures outside of the scheduled training periods (Stone, et al., 2009). AR simulation
research conducted over the last two years has increased considerably compared to the
previous decade. With increased interest in AR, the current research may find ways to
save training funds or reduce training times, but continue to have highly skilled and
knowledgeable students for a variety of missions (Vilkoniene, 2009).

Relationship of the Literature to the Study

The literature shows that simulation has been used in different training situations
across multiple disciplines and there are important aspects to be considered when setting
up training utilizing an AR tool. Many AR systems are still in their infant stage of
development for tracking and displays, with no standards having been set to measure how
well a particular device or system enhances the training. Investigating the use of AR in
other systems allowed this study to build upon the lessons learned and the development
of training tools for different purposes.

When building an AR system for aircrew training, many aspects of the type of device
will be brought forth by the objectives to be taught with a particular training system.
First, how to present the virtual images will need to be explored depending on the
environment in which the device will be used. There are advantages and disadvantages to
each of the displays currently in use. Second, in a head mounted display device, 3D

sound should be part of the overall AR system. If motion is not an option in creating a fully immersed environment, then a good sound system will help create the realism needed to convince the students they are in a real setting. Another consideration is the ability to track the movement of the user. Tracking systems are still being developed and incorporated into the gaming community. Many gamers have experienced the Microsoft Kinect gaming system for sports training (Shum, & Ho, 2012). Consideration should be given to the amount of space needed for the AR system to work. Outdoor systems may be able to use the GPS and inertial navigational equipment for accurate tracking in a wide open space, whereas wide angle cameras and specific software can keep up with a student's movement in a closed in space. Another consideration may be the environment itself. Does the student need to have a haptic feel? Should the student be able to see real objects in their view? Should virtual objects be able to hide behind real objects, or vice versa? Many of these types of questions can be answered in the methodology for setting up an AR type of training tool described in the review of literature.

Chapter 3

Methodology

The problem addressed was the difficulty encountered by the USAF in training new Loadmaster students on how to master operational procedures before actually performing them on the aircraft. The goal was to install and test a prototype AR training tool mounted in a FuT to teach students CRM skills and flight procedures before being trained on the aircraft. A mixed methods design was used to collect and analyze quantitative and qualitative data to see if the ARCLT system was an efficient and effective tool to train Loadmaster students (Creswell, 2003). Quantitative data were drawn from surveys administered to the students and contract instructors. The qualitative data were drawn from the interviews conducted with 21 students who used the AR device, five contract instructors who taught students on the AR equipped FuT and eight flight instructors who flew with these students. The flight instructor interview responses were compared to entries logged in their students' training record. A comparison was made with the students who were trained on the ARCLT to the ones who did not use the AR device (Yin, 2009).

Research Design

This section covers the different approaches to collecting and analyzing data, how this case study used a triangulation design to validate the data, the different types of evaluation methods using qualitative and quantitative research, followed by further

details on how the Kirkpatrick model was used and how the content of the survey and interview questions were validated (Kirkpatrick & Kirkpatrick, 2006).

Triangulation was used to validate the quantitative data from the ARCLT LGTO surveys to show equal importance between the qualitative data collected from the interviews and the students' records and quantitative data (see Figure 1). The limited time set up on the Pathfinder Systems' contract lent itself to a one phase research design where all the data were collected within a few months. The quantitative data were collected from the surveys, analyzed, and the results calculated. The qualitative data were collected from the interview questions and student records, analyzed, and then the results compared

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┌──────────────┐   ┌──────────────┐   ┌──────────────┐
│ Quantitative │   │ Quantitative │   │ Quantitative │
│ Data         │→  │ Data         │→  │ Results      │      ┌──────────────┐   ┌──────────────┐
│ Collection   │   │ Analysis     │   │              │      │ Validate     │   │ Interpretation│
│ from Surveys │   │              │   │              │      │ Quantitative │   │ of           │
└──────────────┘   └──────────────┘   └──────────────┘   →  │ Results with │ → │ Quantitative │
┌──────────────┐   ┌──────────────┐   ┌──────────────┐      │ Qualitative  │   │ and          │
│ Qualitative  │   │ Qualitative  │   │ Qualitative  │      │ Results      │   │ Qualitative  │
│ Data         │→  │ Data         │→  │ Results      │   →  └──────────────┘   │ Data         │
│ Collection   │   │ Analysis     │   │              │                         └──────────────┘
│ from         │   │              │   │              │
│ Interviews   │   │              │   │              │
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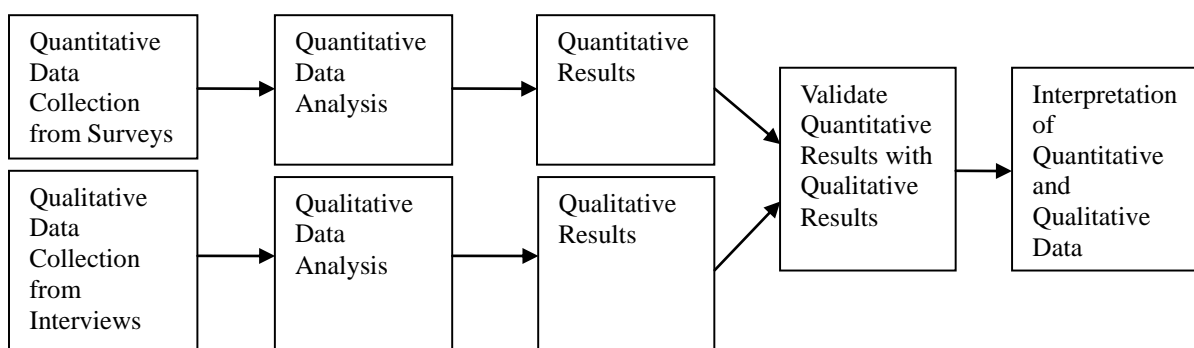
Figure 1. Triangulation Design: Validating Quantitative Data Model. From "Designing and Conducting Mixed Methods Research," by J. W. Creswell and V. L. Plano Clark, 2007, Thousand Oaks, CA: Sage Publications, Inc. Copyright 2007 by Sage Publications, Inc.

to the quantitative results. At that point in the analysis an interpretation was made between the qualitative and quantitative results.

Surveys and interviews are ways to evaluate the effectiveness of training by gathering the students' opinions about a particular lesson, course or flying event. At the C-130H schoolhouse, surveys were administered to the students after certain portions of a course were completed. The data were used to track discrepancies in the training, determine how well new course material was implemented and made changes to the syllabus. In the

business world, training evaluation methods have varied over the years. Often businesses view training as an afterthought when implementing new processes which may help the bottom line, but creates havoc when trying to evaluate how well employees are using the new process (Stackpole, 2008).

Table 1 (Kramer, 2007) shows some of the different types of evaluation methods

Table 1

Training Evaluation Methods

Methodology	Evaluation Elements	Objective
Kirkpatrick	Level 1 – Reaction Level 2 – Learning Level 3 – Behavior Level 4 – Business Results	Provides training data in four areas
Training for Impact	Identify Business Need and Client Form a collaborative relationship Conduct Initial Project Meeting Assessment Conduct Training Collect and Interpret Data Report to Client	Measure results of training in business
Success Case Method	Focus and Plan Study Create an Impact Model Design & Distribute a Survey Interview Prepare Report of Findings	Measures results of training in business to ensure alignment with organizational strategy
Kirkpatrick-Phillips	Level 1 – Reaction Level 2 – Learning Level 3 – Behavior Level 4 – Business Results Level 5 – Return on Investment	Adds a monetary value added versus cost comparison, called Return on Investment (ROI)

Note. From "*Measuring the Effect of E-Learning on Job Performance,*" by Heidi Kramer, 2007, Ann Arbor, MI: ProQuest Information and Learning Company. Copyright 2008 by ProQuest Information and Learning Company.

being used to measure how well training was implemented. Kirkpatrick's method steps through the process of capturing the reaction from the students, evaluating the learning aspect of the training, determining how the student's behavior has changed because of the training, and evaluates the return on expectations (Kirkpatrick & Kirkpatrick, 2007). Training for Impact consists of 12 steps to ensure the business managers understand the business needs, problems, or opportunities (Robinson & Robinson, 1989). The Success Case Method describes the five steps that align the training with the organizational strategy of the company and creates evidence for senior managers that the training was effective (Brinkerhoff, 2005). The Kirkpatrick-Phillips model adds the return on investment to the four levels of evaluating a training system Kirkpatrick created (Phillips & Stone, 2003).

Further details of the Kirkpatrick model (Kirkpatrick & Kirkpatrick, 2006) show that Level-1, Reaction, is used to survey the course content, design, and instruction utilizing a Likert scale of multiple choice and open ended questions such as "How well do you understand what you learned?" and "How will you apply what you learned on the job?" Level-2, Learning, uses a control group to evaluate the knowledge, skills and attitudes both before and after the training. Level-3, Behavior, utilizes observation and checklists where someone actually observes the students on the job and interviews the employees to determine to what degree the new behaviors are being applied on the job. Level-4, Results, establishes what the returns on expectations are, such as: improved quality, increased productivity, fuel cost savings, more student throughput or shorter training time.

The survey and interview questions were modeled after Kirkpatrick's literary works for this LGTO (Kirkpatrick, 1994; Kirkpatrick & Kirkpatrick, 2005; Kirkpatrick & Kirkpatrick, 2006; Kirkpatrick & Kirkpatrick, 2007). Implementing the surveys with reaction sheets evaluated the students' perception of how well the scenario went in relation to the course, the course content, instruction, and relevance to the training, plus the students were made to feel that their individual responses contribute highly to the success of the study (Kirkpatrick & Kirkpatrick, 2007). The student surveys gathered the students' opinion about using the AR tool for mastering Loadmaster skills, how well the tool fits into the objectives of the course and how well the scenarios correspond with the training for their job. Surveying and interviewing the contract instructors helped to evaluate their views on the use of the training tool, how well the tool worked and what improvements may be needed to improve the student's ability to learn. Interviewing the flight instructors and comparing the results with instructor responses recorded in the student's records correlates to a mixed methods research process (Creswell & Plano-Clark, 2007).

The contract instructor surveys addressed how well the tool worked for relaying the course objectives with the training scenarios. The flight instructor interviews focused on the behavioral changes they saw from the students that used the AR device compared to students who did not participate in the study. The resulting data were analyzed to determine if the students had any behavioral change in using what they learned compared to the students whose training did not include the use of the AR tool. The qualitative data gathered from the interviews of the instructors focused on the skills the students learned, usefulness of the tool for training, and how well AR fits into the current curriculum. The

interview questions were structured so that the instructors would have the ability to express their views that could not be expressed on the questionnaires (Gay, et al., 2006).

Mixing the way data were collected helped verify the feedback from the students and instructors by comparing the questionnaires to the interviews (Creswell & Plano-Clark, 2007). The central idea was to contribute to the field of simulation and training aircrew by using an alternate tool for training a select group of students.

A mixed methods design involves a philosophical assumption that guides the direction for collecting and analyzing data by mixing the qualitative and quantitative approaches into one case study (Creswell, 2003; Creswell, & Clark-Plano, 2007; Yin, 2009). The combination of approaches provided a better understanding of the research problem than either approach alone (Creswell & Clark-Plano, 2007; Yin, 2009). The idea was to utilize the strengths and offset the weaknesses of both qualitative and quantitative research to answer the research questions (Creswell, 2003).

Research Questions

The first research question, "*Why are computer-based simulations insufficient for learning to master CRM skills needed by Loadmasters?"* was answered partially by the review of the literature dealing with the need for haptic learning environments. Specific procedural knowledge and skills are better taught in an environment that reinforces the objectives with hands-on learning (Botden & Jakimowicz, 2008). Data collected from the survey questions provided the contract instructor's opinions about specific objectives taught in a hands-on environment. Interviews with the Loadmaster flight instructors

provided data to show the instructors' opinions about learning CRM skills on computer based training (CBT) type lessons (Creswell, 2003).

The second question, "*How can an AR device be added to the physical training site to complete the training process?*" was answered by reviewing the ARCLT contract requirements for hardware and software and through an analysis of the survey and interview questions administered to students, contract instructors, and flight instructors. The final report from the SGTO concluded that an AR system can be a useful tool to train Loadmaster students, but further research was needed to determine its effectiveness and efficiency (Gardley, 2008). The LGTO survey questions addressed some of the underlying issues that lead up to how an AR device could be added to training. The student surveys and interviews gathered data on what the students' reactions were to using the training device, how they felt the tool helped them learn the objects better or faster and their opinions on what they liked most and least about the training tool (Kirkpatrick & Kirkpatrick, 2007). The contract instructor surveys and interviews captured opinions on how well the system worked, how useful the tool proved to be in teaching the procedures and any improvements and new scenarios that could be used to enhance the training. The flight instructor interviews provided information relating to how well the students mastered what was taught using the AR tool, whether the mastery was applied on the job and whether any change in behavior was observed because of the way in which the students were presented the information (Kirkpatrick & Kirkpatrick, 2007). All the data collected were analyzed to determine how an AR device could be used in training Loadmaster skills.

Answers to the third question, "*Based upon the initial evaluations of the prototype AR system, what adjustments were made to the hardware, software and to instructor scripts?*" was taken from the contracted device documentation for running the ARCLT system during the LGTO (Yin, 2009; Jaszlics, 2010). Changes and improvements were taken from the suggestions of the instructors and the students during the SGTO (Gardley, 2008). Interviews with the instructors addressed whether the adjustments made to the AR tool enhanced the overall system or improved the capability for training Loadmaster skills.

The fourth question, "*What lessons have been learned about the use of AR devices in training that will ascribe value to other training situations?*" was answered by comparing the results of this investigation to those reported in the literature about other AR systems. The lessons learned from the development of the ARCLT were compared to research using AR devices in other military applications from the Air Force Research Laboratory, Defense Advanced Research Projects Agency, U.S. Army Training and Doctrine Command and the Naval Research Laboratory. The use of AR in the different military settings, present a wide range of lessons learned that could apply to various learning objectives for other military training. Lessons learned in the medical field will be useful in discussing the development of different HMDs, how tracking is accomplished in each of the devices, whether occlusion comes into play during certain scenarios, as well as the type of feedback the students received when using an AR device. Any insight discovered will be shared with other government agencies to ensure new contracts with vendors exploring the use of AR or VR include specific requirements from lessons learned during the ARCLT LGTO.

LGTO Scenarios

The first scenario enabled the students to practice aircraft engine starts. During the SGTO, the engine start scenario was developed to be administered as an outside unit (Jaszlics, 2008a). The first idea was to use an actual aircraft as a backdrop to align the virtual propellers and engines displayed in the AR goggles, but aircraft availability and the immaturity of the software forced the scenario to relocate. The second attempt used fiducial placards (one foot metal squares painted bright green and orange) placed on the side of a hangar to align the virtual picture of the aircraft. A small camera was mounted on the top of the student's helmet to capture their position in front to the placards. After many trials of trying to provide the students with a stable platform, the Lockheed Martin instructors suggested the engine start scenario would work best in the classroom to give us the most bang for the buck. During the LGTO, the engine start scenario was accomplished in the classroom with the instructor manipulating the different events on a computer connected to a projection system for the aircraft engine starts and emergencies programmed into the system (Jaszlics, 2010).

The second scenario enabled the students to practice procedures for combat offloading of palletized cargo. The C-130H is capable of delivering cargo onto the ground without the use of any type of unloading equipment, such as a forklift (HQ AMC/A37V, 2010b). Hostile areas around the world require cargo to be delivered quickly and as efficiently as possible to allow the crew to spend minimal time on the ground. To avoid being exposed to any danger, the crew must land their aircraft, drop off the cargo and take off again from an airfield, in as short a time as possible. This scenario provided the students with the

ability to practice not only the normal procedures but also the emergency procedures associated with offloading cargo on the ground (Jaszlics, 2010).

The combat offload scenario was set up to virtually show the aircraft on the ground through the AR goggles with engines running and the ramp and door open. An option the instructors had with this scenario was to practice reverse taxiing of the aircraft (Jaszlics, 2010). The student would direct the pilot to maneuver the aircraft to the right or left as he reversed the propellers to back the aircraft up to the offload point. Once at the designated drop-off point the pilot pushed the throttle forward to tilt the aircraft in such a way as to roll the cargo out of the back of the aircraft and onto the flightline. The student not only directed the pilot in the procedure but could see the results of their efforts. When the virtual cargo was dropped off, the ramp and door were shut and the crew stepped through the rest of the checklists to prepare for departure (HQ AMC/A37V, 2010b).

The third scenario represented cargo being airdropped out of the back of the C-130H cargo compartment, with the ramp and door opened, as the aircraft simulated flying over a drop zone (Jaszlics, 2010). The student prepared the actual cargo for extraction, ensuring the parachutes were configured and connected properly. A 20 minute advisory was heard from the Navigator as the aircraft approached the drop zone. All of the checklists were run (called out) with the recorded voices of the crewmembers as the Loadmaster responded with the proper calls. When the one minute advisory was called out, the Loadmaster knelt down at the pallet lock release lever, prepared to pull the handle to release the pallet. At the *green light* call, the Loadmaster saw the green light illuminate in the cargo compartment through his goggles, saw the virtual drogue parachute had released from the bomb rack and opened up to pull the cargo out. Once the

parachute opened up and the locks were released by pulling the release lever, the virtual

cargo was swiftly pulled out on the rollers attached to the floor of the cargo compartment.

Afterwards, the other checklists were run to clean up the aircraft, closed the virtual ramp

and door and escape off of the drop zone (HQ AMC/A37V, 2010b). At any point during

the scenario, the instructor had the ability to pause or restart the scenario in order to point

out or emphasize certain items, or to practice certain procedures repeatedly. An excellent

learning characteristic of the airdrop simulation was the ability to introduce emergency

procedures during the scenario. Not only can the student be trained to recognize normal

procedures, but can practice emergency situations not normally seen during actual flight

training (Fulbrook, et al., 2008).

Instrument Development

How to measure the effects of AR on student learning was a challenge. Another

challenge was introducing a different kind of training tools to enlisted crew members of

the C-130 community. The concept of using up-to-date AR technologies for training was

new for the Loadmaster instructors. They had to be convinced a system like this could

work for teaching specific procedures. The SAS conducted a SGTO validating the

feasibility of using AR as a training tool. The surveys of both the students and contract

instructors showed the ARCLT was an acceptable tool to use as long as the system

operated at a continuous pace (Gardley, 2008). Many of the improvements noted during

the validation phase was incorporated and tested during the LGTO. The SGTO was

limited more in scope as to how well the parts of the system worked rather than how

learning was affected. In the LGTO, the focus was not only about equipment functionality, but also the change in behavior the students displayed after using this kind of training tool.

The survey and interview questions were based on Kirkpatrick's four levels of evaluating a training system that targeted one independent variable, the AR training tool and three dependent variables: a) fit and function, b) instructor performance and c) learning effectiveness. Content validity on the survey and interview questions were established through Kirkpatrick's literature and reviewed by a panel of experts consisting of the 714th TRS SMEs, Lockheed Martin contract Loadmaster instructors and AETC SAS personnel (Polit & Beck, 2006) see Table 2.

Table 2.

Panel of experts

Name	Organization	Expertise
SSgt Dustin Ramaekers TSgt Brandon Stike	714 Training Squadron	Loadmaster Subject Matter Experts
Rich Klindt	Lockheed Martin Global, Training and Logistics	Team Lead for contract Loadmaster instructors
Marvin Gardley	AETC Studies and Analysis Squadron	Studies and analysis expert for AETC

Pathfinder Systems was tasked with setting up a secure laptop computer with the survey questions installed for the students and contract instructors (Jaszlics, 2010). The completed surveys were saved in a folder on the laptop. Each week the 714th TRS Loadmaster SME sent the surveys to Headquarters AETC SAS through the encrypted military email system. Each of the surveys were numbered and prepositioned to be sent via email. The laptop was secured with login privileges for the instructors and the

Loadmaster SME. The survey questionnaires were also stored on an external hard drive in the possession of the Principal Investigator (PI).

Demographics in each of the surveys were the same to make a definite distinction among the student and instructor volunteer information (Botden, et al., 2008a). The first student survey was set up for the engine start scenario. Since this scenario was changed from being an outside unit to inside the classroom, a separate survey was set up to capture the students' views on using an AR tool as a group in the classroom. The next survey for the students was for both the airdrop and combat offload scenarios. The format of the survey allowed the students to identify which scenario was used in training by checking the appropriate box at the top of the survey.

The first three questions on the Airdrop and Combat Offload surveys dealt with the fit and function of the goggles themselves. It was important to evaluate a new piece of equipment during the LGTO to see if any of the improvements from the SGTO worked and also to see if any other improvements needed to be made to the current device (Bin, Ziv, & Ur, 2007). Questions about the fit, comfort and view through the goggles were taken from similar questions used during the SGTO.

The second section used Kirkpatrick's reaction model for the ARCLT learning tool, such as, equipment configuration, smoothness of the computer graphics in the scenario and relevance to the course of study (Kirkpatrick & Kirkpatrick, 2007). The idea was to capture how the student felt about the setup of the scenario, how well the scenario ran during the training and was it relevant to the student's course.

The third section dealt with the instructor's performance based on Kirkpatrick's model for reaction to how well the instructor performed using the tool. Kirkpatrick's literature

(Kirkpatrick, 1994; Kirkpatrick & Kirkpatrick, 2005; Kirkpatrick & Kirkpatrick, 2006; Kirkpatrick & Kirkpatrick, 2007) showed different ways to capture the student's opinion on the instructor's abilities. This section was geared toward the ARCLT to show the importance of knowing if the students received adequate instruction to use the ARCLT system, how knowledgeable the instructor was about the system to run the scenarios and how well the instructor was prepared and organized to operate the system.

The final section focused on the aspect of learning new knowledge and skills, how those skills were applied to the job, if the virtual pictures were appropriate for learning the procedures, if the AR system helped the student retain the checklist actions and if the device contributed to learning Loadmaster procedures (Kirkpatrick & Kirkpatrick, 2007). The review panel modified some of the questions from Kirkpatrick's model to specifically correspond to the ARCLT system (M. Gardley, personal communication, May 20, 2010).

The student surveys were geared toward the usefulness of the device and how the device helped them to quickly learn and retain some of the objectives in the lessons, see Appendix A for the engine start survey and airdrop and Appendix B for the combat offload survey. During indoctrination and in-processing for the course, a Loadmaster SME from the 714th TRS briefed the students and instructors on the research study being conducted using the ARCLT system see Appendix C. The SME explained how the AR training tool was set up in the classroom and in the FuT; how students and instructors would use the tool, then asked for volunteers to participate in the research study (Botden, et al., 2008a). There were two groups of students, those who volunteered and were able to use the ARCLT and those who did not. Training time did not always allow the entire class

who volunteered to participate, because of the limited time scheduled utilizing one of the four FuTs. The students were briefed about the study and the consent form reviewed to ensure each student understood why the research was being done and that their participation was voluntary (Botden, et al., 2008a). Students filled in their email addresses on the survey forms, if they wanted to be contacted about results. The review panel recommended the use of some of the same questions from the SGTO in the first section of the survey to establish data about the actual equipment the students used (D. Ramaekers, personal communication, May 6, 2010). The panel also suggested some modifications to the instructor's performance section of the survey using the Kirkpatrick questions, to relate more to the specific scenarios for Loadmaster training (D. Ramaekers, personal communication, May 6, 2010 & R. Klindt, personal communication, May 19, 2010). The final section incorporated Kirkpatrick's third level of evaluation and learning, by asking the students about being better prepared for flight training and how they felt about the AR tool as an enhancement to the training for checklist and normal procedures (Kirkpatrick & Kirkpatrick, 2007). Again, the panel reviewed the questions and made suggestions as to the wording structure to capture the results for specific Loadmaster training (D. Ramaekers, personal communication, May 6, 2010).

Lockheed Martin employed 19 instructors who taught Loadmaster skills in the FuT. Five of the six LMGLT instructors taught to use the ARCLT were surveyed to capture quantitative data (Appendix D), specifically, to gather their opinions on the usefulness of the device to teach Loadmaster skills within the current curriculum during the treatment period (Kirkpatrick & Kirkpatrick, 2006; Gay, et al., 2006). Many of the instructors had been teaching for over 20 years. Their experience in teaching had developed over the

years from just having the aircraft to teach with, through the development of CBTs and now the beginning of simulation on the FuT. This experience has helped shed some light on the question of why CBTs are not sufficient enough to master CRM skills.

The contract instructor survey demographics remained the same as the other surveys, to keep a consistent distinction among the participants. The review panel felt it was important to capture the instructor's views on the device usage within the following areas: adequate training to use the system, ease of set up, placement of the video images during the scenarios and did the images that were displayed represent actual events in the aircraft (D. Ramaekers, personal communication, May 6, 2010 & R. Klindt, personal communication, May 19, 2010). Modifying the learning aspect of Kirkpatrick's model, the survey asked if the instructors noticed any improvement in the student's ability to retain more of the lesson objectives, if they felt the students were better prepared for flight training and did the students leave the simulation phase of training with a higher level of proficiency (Kirkpatrick & Kirkpatrick, 2007). The final questions dealt with the instructor's opinion on how the system helped utilize their instruction time, what they liked best and what they liked least about the system, which would help establish a basis for improving the overall system for the production model of the ARCLT system.

Interviews were conducted during the LGTO with 21 students who volunteered to use the ARCLT, five Lockheed Martin contract instructors teaching with the AR tool and eight flight instructors that took part in instructing the students who used the ARCLT. The PI interviewed all participants consenting to the study and made every effort to standardize the way the interview questions were presented to each person being interviewed, the way the questions were asked and probed for more complete answers,

recorded the interviews and conducted each interview in a professional manner limiting influence on the students and instructors (Fowler, 2009).

Twenty one students who used the AR tool in their training and who had at least one sortie flying on the aircraft were interviewed. The same type of questions were asked in the interview as in the survey questions (Appendix E), but in an open-ended fashion, in order to capture more of the background and in-depth opinions of the students (Kirkpatrick & Kirkpatrick, 2006). Six of the LMSTS contract instructors were trained to use the ARCLT system. Contract instructor interview questions developed from the survey questions were asked during the interviews in an open-ended fashion to capture their opinions of the system as a prospective training tool (Appendix F). Probing questions followed if simple answers were given to any of the questions (Fowler, 2009).

In order to capture behavioral change of the students during the flying phase of training, interview questions were administered to the USAF Loadmaster flight instructors to see if they noticed a difference in students who received training with the ARCLT tool compared to past and present students who did not (Kramer, 2007). Eight USAF Loadmaster flight instructors, who flew with students trained with the ARCLT tool, were interviewed. The study was explained to the flight instructors and the consent form reviewed. The interview questions were geared to see if the objectives taught using the AR tool improved the students' ability to learn the objectives easier, required less time or less training events per sortie, compared to the students that did not train with the AR device over the last 12 months (Appendix G). This part of the evaluation was designed around Kirkpatrick's third level of evaluating a training program, behavior, to evaluate the students' performance in the intended work environment. The students' electronic

progress reports were reviewed to capture data on each of the students a particular

Loadmaster flight instructor taught. The instructor's past students who did not use the

ARCLT was compared with the students who were taught utilizing the AR scenarios

during this case study (Yin, 2009).

The review panel suggested to not develop or administer survey questions to the

Loadmaster flight instructors, in order to limit the bias they may develop for or against

training with an AR device (M. Gardley, personal communication, May 20, 2010).

Instead, the use of flight instructor interview questions and the students' electronic

progress report were used to evaluate the behavioral aspect of student learning (Yin,

2009). The Loadmaster flight instructors annotated on the electronic progress report all

the aspects of the flight, the mission profile, strengths, area of improvement, unusual

circumstances and recommendations on what they saw during the training. The interview

data were compared to the comments the flight instructor placed on the student's

electronic progress report. This comparison helped construct validity in the instructor's

answers by using multiple sources of evidence to review some of the answers to the

interview questions (Yin, 2009).

Interviews with the students and instructors were scheduled about once a month,

depending on TDY funding. The initial training and conversations with the contract

instructors at the beginning of the study was compared to the interview results near the

end. Over time, the system matured and updates were made. An evaluation of the

interview results were made to see if the system improved over the LGTO time-frame.

The student interviews were conducted when the students were being taught on the

aircraft at the flying squadron. The syllabus called for eight flights to be conducted during

Loadmaster training (Desnoyer, 2010). Aircraft engine starts and an airdrop mission were normally scheduled for each sortie during this phase of training. The combat offload event was only scheduled once during flight training. The best time to interview the students occurred once they had practiced one of the three scenarios on the flightline. Access to the student's records through the Lockheed Martin electronic grading system showed the students' performance and training events as the flight phase of training was accomplished.

Data Collection

The quantitative data were based on the survey questions built on a seven point Likert scale, six choices with a not applicable (N/A) option as the last button. The N/A button was for students or instructors that may not agree or disagree with the statement or the statement may not apply to the training they received. The limit on the scale provided a dividing line between those who agreed and those who disagreed with the statements on the surveys. The C-130H schoolhouse surveyed students multiple times throughout the course of training to see how well the instruction was going. Students sometime got tired filling out the surveys and promptly went down the center of the survey form to quickly finish the task on a five point scale. If the scale does not have a defined center, as in a seven point scale, six choices with an N/A on the end, then students may not have had a tendency to migrate their answers to the center.

The category sections of the surveys were based on Kirkpatrick's model for reaction to new hardware, the learning aspect in the different scenarios, and the behavioral change

the instructors noticed in training with the device. The surveys were set up on a stand-alone laptop computer next to the FuT in the Loadmaster training facility. The surveys were formatted in an Adobe Acrobat form which had radio buttons used to click on and quickly accept the students answer to each of the questions. Once the form was filled out and submitted, the data was stored for delivery. Only the contract instructors, the 714th TRS personnel and the PI had access to the laptop where the surveys were stored.

The interviews were conducted using the established interview questions based on Kirkpatrick's model. The same questions were being asked as the survey questions, but in an open ended format. The interviews were recorded and transcribed for ease of comparison. All the qualitative data collected was loaded onto an Excel spreadsheet for analysis. The analysis helped define categories and trends in the answers received from the interviews. Once the categories were defined, comparisons of the data were made to the quantitative data of the survey questions. An interpretation was made at that point to see if the AR device was an effective training tool.

Format for Presenting Results

There are many different formats for presenting data in research studies. AETC SAS uses a standard format that has worked well in the past and complies with USAF instructions. The format of this study mimics the USAF standards to present a narrative description of the report with embedded figures and charts to show similarities and differences between the quantitative and the qualitative data. The figures and charts are supported by the statistical analysis formulas set up in Excel, Microsoft Office 2010.

The surveys were collected electronically through the military email system. The raw data were transferred to an Excel spreadsheet and analyzed. Each of the questions from the surveys drew quantitative conclusions about the way the students and the instructors answered the questions. The surveys were set up on a six point Likert scale, 1 for Strongly Agree, 2 for Agree, 3 for Slightly Agree, 4 for Slightly Disagree, 5 for Disagree and 6 for Strongly Disagree. A seventh choice was set up as not applicable, in case the question did not apply to that participant. The data was analyzed using the analysis of variance (ANOVA) formula to calculate the mean, standard deviation, threshold and a score. The hypothesis of *the students and instructors generally disagree with statements* in the questionnaire, which established a target of a 4-Slightly Disagree or above, to calculate the score. The scores were compared to the threshold set at a 95 percent confidence level. If the score was higher than the threshold, the hypothesis was rejected, showing the participants answers were statistically positive for that statement. The percentages were used to show how many volunteers either agreed or disagreed with the questions in the surveys.

Interview answers collected through recordings were transcribed to an Excel spreadsheet and analyzed. The Excel software allowed the user to collect the data, formulate key categories, calculate the results and categorize the responses by analyzing the language used in answering the interview questions. The answers to the questions were evaluated to be positive, negative or neutral toward the question being asked. A percentage was calculated and presented for each question. The data collected from the flight instructor interviews were compared to the notes imbedded in the student records. Only eight flight instructors were available for interviews during the programmed TDY

schedule. The student records captured the strengths and areas for improvement on each of the student volunteers. Comparing the students that used the AR system to the ones who did not, encompassed a larger sample of the flight instructors' thoughts about the students' progress through the course during the AR testing phase. The comparison helped to validate the interview data from the limited number of instructor volunteers. Once the data for both quantitative and qualitative were analyzed, a comparison was made as to the results of both methods in this mixed research design.

Attention to all the evidence must be given due consideration when comparing quantitative to qualitative data. Student records were reviewed to complement the flight instructors' responses during the interviews. Research into other uses of AR was compared to the results to address any major rival interpretations of the ARCLT results (Yin, 2009).

The analysis of the survey and interview data focused on answering the main question of, *How can an AR device be added to the physical training site to complete the training process?* Working with the ATS for many years provided an insight to the way the C-130H training world integrates new technologies into training for the other crew positions. We now have an opportunity to update the Loadmaster training with the latest technology using an AR tool to enhance the training at the schoolhouse.

Resources

Little Rock AFB is home to the C-130H schoolhouse. In 1988 the schoolhouse went from being manned by USAF personnel to an ATS contract. There have been several companies that have run the academic and simulator training over the years. Presently, Lockheed Martin handles the academic and simulator portions of the training which include writing and updating the lessons and overseeing the maintenance of the training devices (LMGTL, 2010). The USAF flight instructors conduct the flying portion of the training using the C-130H aircraft after Lockheed Martin has insured the students understand and can perform the objectives taught in the academic/simulator phase of training (Mayberry, 2010).

Each of the crew positions i.e., Aircraft Commander, Pilot, Navigator, Flight Engineer, and Loadmaster, go through the C-130H academics and simulator training with Lockheed Martin. The Loadmaster students used in this research were attending both the initial and mission qualification courses (HQ AETC/A3RA, 2011). The Loadmaster Initial Qualification course includes the basics in loading and unloading the aircraft, calculating weight and balance of the aircraft and engine start procedures (Desnoyer, 2010). The Loadmaster Mission Qualification course includes training students to prepare heavy equipment cargo, container delivery system type cargo and other platforms for airdrop missions, plus any emergencies that may arise for each situation, during the day and at night, using night vision goggles (Desnoyer, 2010).

Part of the training administered by Lockheed Martin includes teaching lessons in the FuT. The FuT is an actual aircraft permanently mounted in a hangar. Many of the airdrop

procedures are *walked through* verbally using the appropriate checklists during a FuT lesson, but the device is limited in experiencing actual aircraft movement. Normally there were eight to ten students in a class (HQ AETC/A3RA, 2011). The students selected for this study were randomly selected volunteers who used the ARCLT. Students receive a *checkride* on the actual aircraft by USAF evaluators before they are released to their units. The evaluation includes the basics of Loadmaster qualification and spot checks most of the training received, but is limited normally to one aircraft flight and to whatever cargo is scheduled (HQ AMC/A37V, 2010a).

Under a new contract in 2010 with Pathfinder Systems, the AR equipment was re-installed in FuT number two located at the Little Rock AFB, C-130H schoolhouse. Pathfinder Systems was tasked to set up the training system within 30 days of contract award and teach the Lockheed Martin instructors how to use the hardware and software for each of the scenarios (Jaszlics, 2010).

The USAF conducted a SGTO of 30 students during the initial start-up of the ARCLT from March through June 2008. The new contract tasked Pathfinder Systems to rework many of the discrepancies found with the system developed in 2007 and the USAF conducted a LGTO using guidance from the AF ISD manual (Jaszlics, 2009; Twogood, 2002). Pathfinder Systems was responsible for setting up the means to transfer the survey data for evaluation. A device discrepancy tracking system was used to track the faults/problems with the hardware and software, plus gather any suggestions the instructors have about the device or the scenarios (Jaszlics, 2010).

Lockheed Martin schedules the classes for the USAF. In a six month period there were 16 classes and each of the classes was expected to be filled with eight to ten students per

class (HQ AETC/A3RA, 2011). Scheduling restrictions limited the number of students available to use the AR tool in the FuT. Because of the scheduling restrictions, some volunteers were not able to use the ARCLT. The students' schedule worked around the contract negotiated timeline, but the goal was to survey and interview 100 participants during the testing of the AR equipment. The students were tracked throughout each of the scenarios and continued to be tracked during the flying phase of training, to include their aircraft evaluation checkride.

Summary

This case study evaluated the use of an AR training tool to teach Loadmaster objectives to new students on the C-130H aircraft. A mixed methods research design captured quantitative and qualitative data and compared and interpreted the data to see if ARCLT was an efficient and effective training tool for Loadmaster students. The results indicate that students and instructors were open to this new way of training which may result in fewer sorties but maintain the same highly skilled and knowledgeable students the schoolhouse currently produces.

This LGTO was the primary step in evaluating such a drastic change in enlisted training. Knowledge gained from this study will hopefully spark interest in other training devices for enlisted crewmembers training on cargo aircraft. Lead Command, AMC, is waiting on the results before committing funds toward a production model of the training tool. The fundamental practice of simulated training for pilots has overshadowed enlisted training for many years. The lack of funding has limited upgrades to Loadmaster training

devices. This research shows that enlisted simulation devices will benefit the student's learning ability before flying on the actual aircraft.

New technology has brought greater insight into building a relatively inexpensive device that can track a user in closed-in spaces. The ability to improve tracking of these devices is continually being researched. This project had limited time and funds to expand the research for better solutions. The next step should be to incorporate a lighter, wider field of view glasses or visor, not goggles, which can be tracked using fewer cameras with greater accurately in a smaller area.

Chapter 4

Results

Overview

The goal was to install an AR system to teach Loadmaster procedures and CRM skills to the students, before being trained on the aircraft. The USAF C-130H schoolhouse does not have enough fuselage trainers to support the number of Loadmaster students each year and the devices are not at a high enough fidelity to give the students the knowledge or the skills to count as a flight sortie.

The data analysis in this chapter shows the steps used to gather volunteers to use the system, reviews the demographics of the students, contract instructors and flight instructors, discusses the surveys, the interviews, the student grade book data and summarizes of the data collected. The chapter begins with an overview of how the system implementation was delayed getting everyone to agree to the terms of the contracts and the timing of the development of the system itself.

There was a delay in obtaining an agreement between the two contractors involved in the project, Lockheed Martin and Pathfinder Systems, following the SGTO in 2008. Further funding was solicited from HQ AETC to continue with a LGTO. The funds used coincided with the end of the year buy-in 2009. It took over a year to explain, clarify and put on contract the procedures of the study, how many students and instructors would participate and the amount of time required by the contract instructors to use the ARCLT system after permission was granted to upgrade the system. During the negotiations, the

714th TRS expressed concern over the guaranteed student clause in the contract. The clause states that the students will be ready for the training on the aircraft when they leave the academics and simulators portion of the training provided by the contractor (LMGTL, 2012). If they are not ready, one option is to send them back through the training at no cost to the government. The concern was that the AR tool would be introducing new technology to train students, but not all the students would have an opportunity to use the system, because of the limited time on the fuselage trainer. If all the students do not have equal access, the contractor could not guarantee the students would be ready for the flightline training. As a group, a decision was made to utilize the ARCLT outside the normal classroom or simulator time in order to conduct the study. The volunteers understood that they would be learning the same procedures as the other students, but would be able to practice the procedures in a training device outside the normal curriculum.

A contract between Lockheed Martin and Pathfinder Systems was signed on September 22, 2010. In January 2011 Nova Southeastern University (NSU) IRB approved the study (Appendix H) followed by the AF IRB approval in May 2011 (Appendix I). The first class to be briefed started in June 2011, followed by the rest of the classes until November 2011. The actual usage of the devices started in August 2011, after the instructors were taught to use the system and felt comfortable being able to set up and run the device. Both contractors agreed to run the system until the Christmas break. Interviews started in November 2011 after the students had flown at least one sortie practicing a combat offload or a heavy equipment airdrop. The interviews were conducted about once a month through February 2012. The AF Research Laboratory

closed the research project in June 2012 (Appendix J) followed by NSU-IRB accepting

the closing report in Jan 2013 (Appendix K).

Volunteer Process

Initially, 100 volunteers were planned to participate in the study, to include:

Loadmaster students enrolled at the USAF C-130H schoolhouse, Lockheed Martin

contract instructors teaching with the AR tool and USAF flight instructors at Little Rock

AFB, AR. To come up with the amount of time and cost for LMGTL contract Loadmaster

instructor participation, an estimate of 100 students was used to calculate a cost. With the

restrictions of being taught in a four month period, the number of students in each class,

class frequency, and fuselage trainer availability, LMGTL estimated that six instructors

could do the task over a four month period. Lockheed Martin had 19 instructors

employed at the time, but not all of them were interested in volunteering to work with the

AR system, so only six volunteers were trained to use the system. The USAF had about

45 Loadmaster flight instructors in the flying squadron at the time. Only interviews, no

surveys, were conducted with the flight instructors to minimize the bias that may have

developed. The TDY schedule from Randolph AFB to Little Rock AFB allowed visits

about once a month. In a seven month period, with the timing of the students flying at

least a few sorties with flight instructors, an estimate of 10 flight instructor interviews

were expected. The total number of volunteers would equal 100: 10 USAF flight

instructors and 6 contract instructors, which would leave 84 students. The AF IRB

approved the use of 100 participants in May 2011.

Student Volunteers

The C-130H Loadmaster student volunteers were scheduled by AETC/A3R to attend the classes at the ATS schoolhouse, Little Rock AFB, AR. There are 32 classes scheduled each year with eight to ten students in each class; a new class starts about every 12 working days (HQ AETC/A3R, 2011). The three scenarios scheduled for this try-out included engine start, combat offload and heavy equipment airdrop. The following steps were used as a guide to process the volunteers through the study beginning in June 2011.

Step 1. On the first day of class, indoctrination and in-processing of the course in the classroom, a Loadmaster SME from the USAF Training Squadron briefed the students and the instructors on the research study using the AR tool. The SME explained how the AR training tool was set up in the classroom and in the FuT, how the students would use the tool, and then asked for volunteers, as he handed out the consent forms.

There were two groups of volunteer students in the classroom, those who got to use the AR training tool and those who did not. All students received the same training from the ATS contractor, but the students who volunteered to use the AR system were allotted additional training time to help them visualize the combat offload and airdrop procedures in the FuT.

Step 2. The SME reviewed the consent form with the students and had all the volunteers sign the form. The SME collected the signed forms during indoctrination and stored them in a secure location in the 714th TRS office until collected. The SME utilized the registrar's locked file cabinet containing other student records in the 714th TRS building. During TDYs to Little Rock AFB, the forms were secured until shipped to Air

Force Research Laboratory (AFRL) via secure tracked transport. AFRL will keep the original forms indefinitely.

Step 3. Administering the engine start scenario in the classroom was the first scenario to be tested. All the volunteers in the classroom viewed the virtual aircraft on a projection screen; listened to the recorded voices stepping through the checklist as each engine starts, while the instructor controls each step of the scenario. The scenario ran for about eight minutes, but the instructor went back and taught the students emergency procedures for engine start. Approximately 50 minutes were used to teach this lesson.

Step 4. Each student filled out an electronic survey after the class on a secure standalone laptop. The second and third scenarios (combat offload and airdrop) were scheduled later in the program. A separate survey was administered for each scenario.

Once the students finished the classroom portion of the course, they practiced Loadmaster procedures on the FuT. Normally, the students cannot practice all the procedures physically; some are presented verbally. With the AR tool, the instructors showed the students what an extraction of the cargo looked like, how it sounded going out of the aircraft and practiced the steps necessary to interact with the crew to accomplish the mission. Unfortunately, only one of the four FuTs was set up with the AR system. That meant not all the volunteers had an opportunity to use this portion of the system in the FuT.

Step 5. Student volunteers were scheduled to use the AR tool. Once the students donned the harness and helmet with the AR device, the second scenario was set up to proceed with the combat offload checklist. This procedure placed the cargo on a designated spot on the ground, instead of dropping the pallet in flight on a designated

drop zone. Normal procedures were taught at first, but with the instructor teaching the

emergency procedures for this scenario, the lesson took about 50 minutes.

Step 6. After the combat offload scenario was complete, the students filled out another

survey for that particular scenario using the same secure laptop.

Step 7. Later in the course the third scenario, heavy equipment airdrop, was run. The

scenario started out at the 30 minute advisory, but to save time, the instructor pushed the

scenario to the ten minute advisory once the student had prepared the cargo for airdrop.

Step 8. After this scenario, the students filled out the final survey. For the students,

there were three surveys, one for each scenario. The combat offload and airdrop surveys

were the same, except for the button at the top of the survey identifying which scenario

was used. All surveys were accomplished on the secure laptop computer after the training

or by the end of the training day. Survey data were emailed to AETC/SAS at Randolph

AFB through the secure military email system.

Contract Instructor Volunteers

A separate survey was set up for the contract instructors who used the AR tool to teach

students. During the instructors' initial training on the AR system in July 2011, the 714th

TRS Loadmaster briefed them on the use of the AR tool and asked for their participation

in the research. All the instructors taught to use the AR system filled out a consent form

letting them know how the data collected from the surveys and the interviews would be

stored and used.

Step 1. Contract instructors were taught to use the AR system in the classroom and on

the fuselage trainer. Consent forms were collected from the instructors who volunteered

to be trained on the AR system and stored in the 714th TRS office until collected.

Step 2. The trained instructors were matched up with the student volunteers to instruct the scenarios. After the instructors ran the scenarios several times, they filled out a survey on a secure laptop.

Step 3. Contract instructors were tasked to write up any discrepancies noted with the AR system which was tracked separately for maintaining the system. Contractor surveys were filled out at the beginning and near the end of the study. A comparison was made as to the problems they had encountered using the system, the improvements made to the system and any suggestions for the production model of the AR system.

Flight Instructor Volunteers

Interviews took place throughout the LGTO, usually once a month starting in November 2011. The contract instructors, students and flight instructors were all interviewed. The consent forms covered both the surveys and the interviews. The flight instructors signed the consent forms at the beginning of the interviews. An explanation was given to the flight instructors as to what the study entailed, how the data would be used in the final report and how no personal data would be associated with the interview data in the report.

Step 1. Gathered the signed consent forms from the volunteers to be interviewed, that have not been collected thus far.

Step 2. Scheduled an appointment to meet with the flight instructors.

Step 3. Numbered the interview on the questionnaire form that corresponded to the number on the consent form and on the recording to be transcribed into an Excel

spreadsheet at a later date.

Step 4. Conducted the interviews in a private location and insuring the recording device was operational.

Surveys for flight instructors were not used, to minimize the risk of biasing the results of the LGTO. The instructors were tracked to see how many times they taught students who used the AR system.

The C-130H ATS used an electronic grade book system to track grades for each of the students. A comparison was made using the grade book data from the students who used the AR system matched to the ones who did not get a chance to use the training tool, to see if any differences in training skills, knowledge or training time was noticed. Consent to use the data from the students' records was collected during the initial briefing and signing of the consent form. Personal information about students was removed and replaced with the signed consent form numbers in the analysis process. The students who did not use the AR system were only identified by the PI.

Interviews were recorded and transcribed onto an Excel spreadsheet for analysis. Each person interviewed was assigned a number corresponding to the consent form. Only the number and the raw data were transferred and analyzed. The digital recordings were moved from the recording device to an external hard drive and kept in the possession of the PI. The data were transcribed onto an Excel spreadsheet on the external hard drive. The entire interview data were de-identified from the person being interviewed. A mixed methods research design calls for in-depth data; research shows that surveys alone will not show the same depth of understanding (Creswell & Plano-Clark, 2007; Yin, 2009).

Pathfinder Systems Inc. was put on contract to develop and install an AR system as a

training tool in a FuT at Little Rock AFB, C-130H schoolhouse. Lockheed Martin was on contract to teach all C-130H crew positions academics and simulators at the schoolhouse under the ATS contract. During the LGTO, Lockheed Martin felt they would need to pay overtime during the four months estimated to teach 84 students with the AR training tool. There was no time left during normal class hours to implement the training on a test basis. The scenarios for the AR tool were done after class for the volunteer instructors, thus the overtime. The instructors were not directly paid for their participation, but were paid for their overtime accumulated during the week of using the AR tool. The payment was made to the Lockheed Martin instructors through an agreement between Pathfinder Systems and Lockheed Martin for the number of hours used toward training with the AR tool. All government funding was transferred to Pathfinder Systems with the stipulation that they pay for the training time for Lockheed Martin participation.

Contracted ATS training consists of classroom academics, simulator training devices, and fuselage training devices followed by flight training on the aircraft with the USAF flight instructors. The difference with the AR training was that the volunteers practiced on the fuselage device wearing the AR goggles for a few more hours, after class, than other students, but the contracted training was the same. The contractor agreed to test the system, but did not want to interfere with the ATS contract obligations with AMC. The only disadvantage for the students would be to have them stay after class to practice with the AR scenarios. The volunteers using the AR system got to practice Loadmaster procedures before flying on the aircraft. The non-AR students represented a sample of the students going through the schoolhouse during the last 12 months. The instructors were

asked to compare the students they trained in the past to the students who used the AR tool. Non-AR student data were taken from the volunteer's grade book entries.

Demographics

The demographic data on the students and the contract instructors were collected through the surveys and the flight instructor data were collected during the interviews. The student surveys were set up so that immediately after the scenario, the survey was taken. The first scenario, engine start, was used in the classroom. Many of the contract instructors liked using this scenario at different times in the training, first to introduce the procedures to the classroom, then later on in the training to practice the procedures before going out to a static aircraft on the flightline to practice without actually starting the engines. When the students were first introduced to the engine start scenario, is when the instructors had the volunteers fill out the survey. There were 50 surveys completed for the engine start scenario. The student ages ranged from 18 to 42. The ATS had the same course for the older students who had to come back through the course for re-qualification, but 80% of the students were younger than 26 years old. There were 44 males and 6 females who participated: 90% were USAF students with the rest from the US Marine Corps (USMC). The AF duty status divided the group up as 68% active duty, 22% Air National Guard and 10% AF Reserve students.

Not all of the same students were able to participate in all the scenarios, but 47 students completed the Combat Offload surveys. Their ages ranged from 18 to 42, with 87% of the students less than 26 years old. There were 40 males and 7 females and a

majority of the students were in the USAF, 96%, with one from the Army and one from the USMC. By duty status, the group was divided up as follows: 62% active duty, 21% Air National Guard and 17% AF Reserve.

The airdrop scenario had 47 student participants with ages ranging from 19 to 49, 89% less than 26 years old, but without the two civilians who had participated, the oldest student was 37. Two instructors from the C-130J schoolhouse, located next to the C-130H schoolhouse, were interested in viewing the AR system from a student's point of view and commented positively on their experience using the AR tool. There were 38 male and 9 female participants, with 98% from the USAF and one student from the USMC. The duty status of the group was divided up as follows: 62% active duty, 21% Air National Guard, 13 % AF Reserve and 4% civilians.

Four contract instructors filled out 17 surveys, some at the beginning and others close to the end, to see if the system had improved over time. Unfortunately, there was not enough time to make significant changes in the software or the hardware for any of the scenarios. Their ages ranged from 43 to 61. The average flight experience of the instructors was over 5,300 flying hours and they had an average of 22.1 years as an instructor. The instructors were all male and retired from the USAF and were working in a civilian status employed by LMGTL.

The flight instructor demographic data were collected during the interviews as part of the initial questions. Of the eight instructors interviewed, the average age was 31 years old, with an average flying time of 2183 hours and had an average of 4.7 years as an instructor. All of the participants were male active duty AF members assigned to the 62nd Airlift Squadron, Little Rock AFB.

Survey Data

The survey data were set up in Microsoft Excel spreadsheets. The calculations used analysis of variance formulas to calculate the Z-score, standard deviation, threshold and the percentage of students and instructors that agreed with the questions. The hypothesis of *the students and instructors generally disagree with the question* was used to determine if the data was statistically significant at a 95 percent confident level. The data was also divided by the percentages of the responses that agreed, responses 1, 2, and 3, or disagreed, responses 4, 5, and 6, with the questions see appendix L – O.

Student Engine Start Survey Fit and Function

The Engine Start Survey showed in the fit and function area, the students indicated Question 1, the system did not take too long to set up or adjust, a Z-score of 2.36, Question 2, the system ran smoothly throughout the scenario, a Z-score of 2.14, and Question 3, the scenario was relevant to the course of study, a Z-score of 2.78, which are all above the threshold of 1.64. Comparing the Z-score with the percentage that agreed with the statement shows that, 92% of the students agreed with Question 1, 94% agreed with Question 2 and 96% had a positive reaction to Question 3. See appendix L for calculations.

Student Engine Start Survey Instructor Knowledge

The Engine Start Survey showed in the instructor knowledge and preparation area, the students felt the instructors were knowledgeable of the system, Question 4, a Z-score of

1.88. Question 5, the instructors were well prepared to run the system in the classroom, a Z-score of 3.29. Both responses showed above the threshold of 1.64. Comparing the Z-score with the percentage of students that were positive toward the statements showed that 94% of the students felt that the instructors were knowledgeable enough to instruct with the AR system in Question 4 and 100% agree that the instructors were prepared to run the scenarios in Question 5. See appendix L for calculations.

Student Engine Start Survey Knowledge and Skills

The Engine Start Survey showed the students felt they learned new knowledge, but statistically barely below the threshold of 1.64, at a Z-score of 1.63 for Question 6. Question 7 - learned new skills, Question 8 – applied knowledge they learned, and Question 9 - applied the skills, all showed above the threshold, Z-scores of 1.67, 2.75 and 2.46 respectfully. The corresponding percentages for each question showed that in Question 6, 88% agreed they learned new knowledge with 98% indicating the students could apply the knowledge to the job in Question 8. The surveys showed that in Question 7, 88% learned new skills and 96% showed they could apply the new skill to the job in Question 9. See appendix L for calculations.

Student Engine Start Survey Behavioral Change

The Engine Start Survey showed in the behavioral change area, the students felt the scenario helped prepare them for flightline training, Question 10, a Z-score of 1.68. The other questions did not show a high enough score to reject the hypothesis above 1.64, a Z-score of 1.33 for Question 11 - being an excellent enhancement, 1.50 for Question 12 - helping them retain more of the procedures and 1.57 for Question 13 - being an effective

way for them to learn. The surveys showed most of the students agreed with the behavioral change, just not at a very high level, Question 10 - 88%, Question 11 - 86%, Question 12 - 86% and Question 13 - 90% respectively. See appendix L for calculations.

Consolidated view of what students liked best/least about the engine start scenario

Each survey had two open ended questions that tried to draw out what the students liked best about the AR system and what they liked least. As per figure 2, the start engine surveys showed students liked the visual aspect of seeing the action of the checklist, the interaction with the recorded voices of the crew, the knowledge the system presented to them, hearing the checklist being run by the whole crew, and how realistic the scene looked. Other comments included: the variations the system could present in the scenario and the aircraft references as to where to stand, followed by the system running smoothly and the ability to discuss the scenario at any time by pausing the scene.
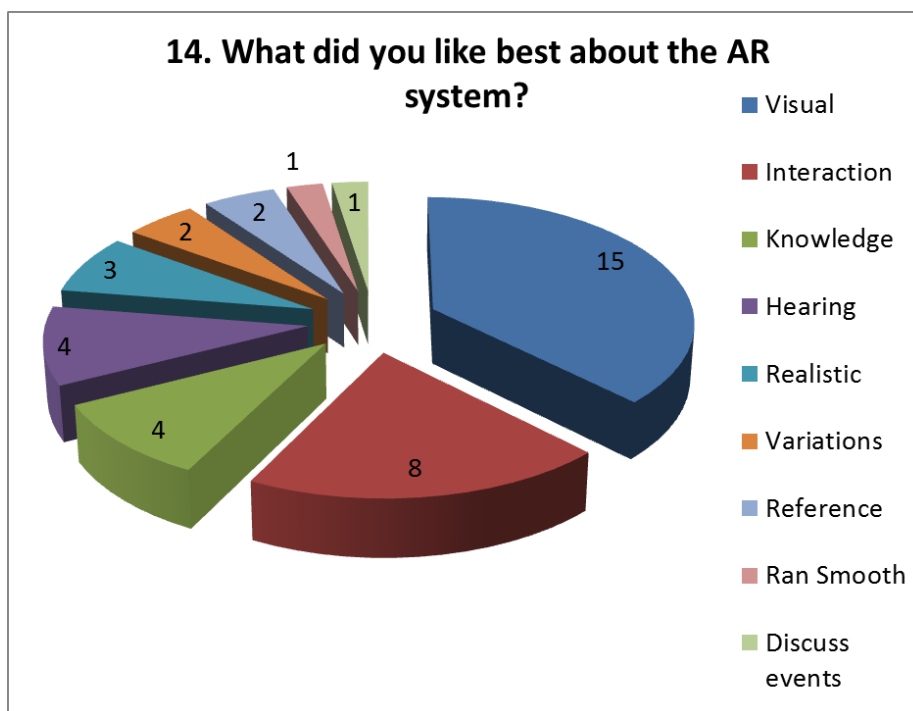
Figure 2. Consolidated view of what students liked best about the engine start scenario

As per figure 3, the category of what the students liked least, the majority of the students did not find anything wrong with this scenario. There were comments on the graphics not being quite right, the crashes and malfunctions of the system during the scenarios, not being real hands-on training and the scenario being redundant training. The last categories only had 1 comment each.
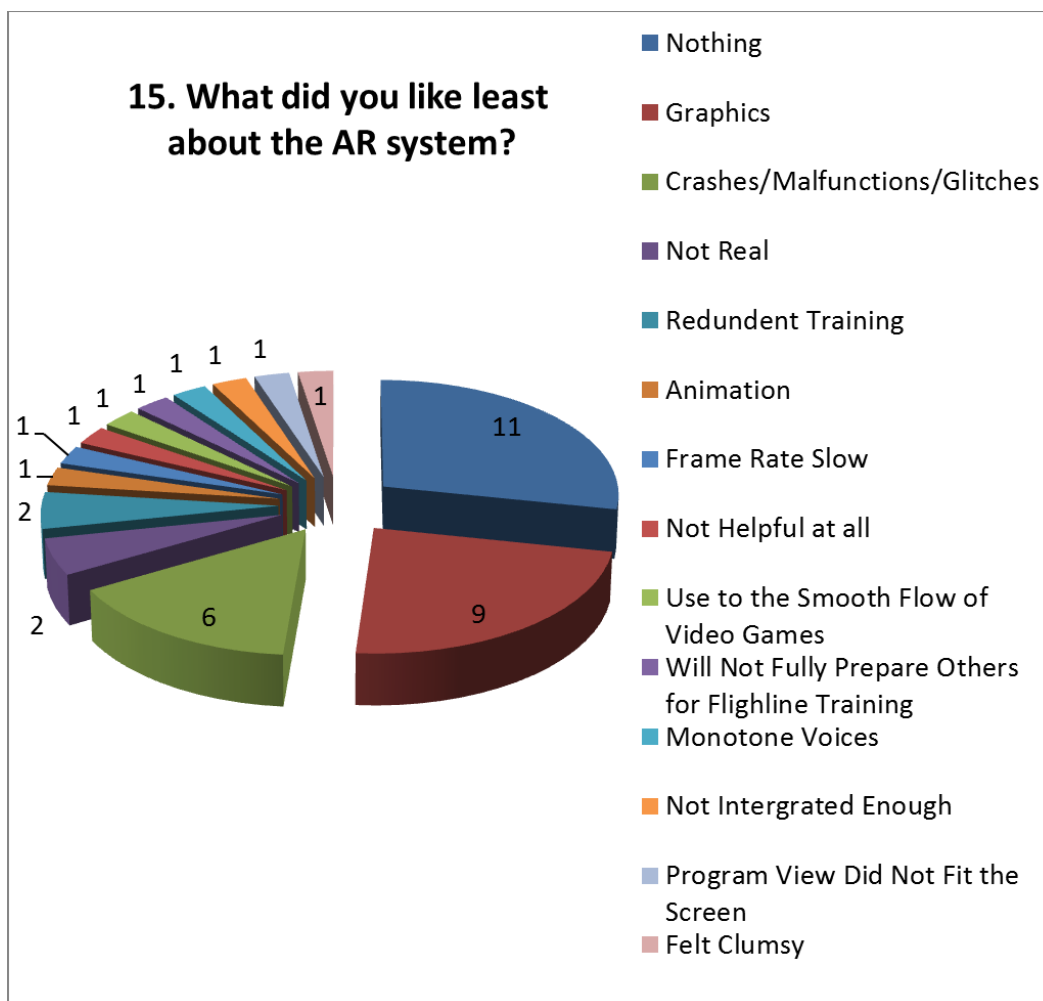
Figure 3. Consolidated view of what students liked least about the engine start scenario

Student Combat Offload Survey questions relating to fit and function

The student combat offload survey showed in the fit and function area, the students indicated the system did not reach the threshold of 1.64 for any of the six questions.

Question 1 - the goggles fitting well on the helmet, a Z-score of 1.22, Question 2 - the goggles being comfortable to wear, a Z-score of 0.81, and Question 3 - for the student's eyes easily adjusting to the view through the goggles, a Z-score of 1.11. Question 4 - for the system not taking too long to set up or adjust scored 1.01, Question 5 - the system running smoothly throughout the scenario scored 0.62 and Question 14 - the images remaining in the relative position during the scenario scored 0.85. These scores corresponded to the number of students that agreed with the questions: Question 1, fits well – 83%, Question 2, comfortable to wear – 66%, Question 3, easily adjusted – 81%, Question 4, did not take long to adjust – 74%, Question 5, ran smoothly throughout the scenario – 62% and Question 14, the images remained in position – 79%. See Appendix M for calculations.

Student Combat Offload Survey Instructor Knowledge

The student combat offload survey showed in the instructor knowledge area, the students felt confident about the instructor's ability to train with the AR tool, way above the threshold of 1.64. The Z-score for the students receiving adequate orientation was 2.12 for Question 7. For Question 8, the instructor's knowledge about the AR system was 3.54 and for Question 9, the instructor's preparedness to run the system showed 3.73. These scores correlate to the percentage of students who agreed with the questions. In each area the percentages were very high, Question 7 showed 94%, Question 8 showed 98% and Question 9 showed 100% respectively. See appendix M for calculations.

Student Combat Offload Survey Knowledge and Skill

   The student combat offload survey showed in the knowledge and skills area, the students did not think they learned new knowledge, for Question 10, Z-score of 0.98 or they could apply the knowledge to the job, Question 12, Z-score of 1.15. The skills category shows the same results, for Question 11, the students felt they did not learn any new skills, a Z-score of 1.04 or for Question 13; they could not apply the skills to the job, a Z-score of 1.58, all below the threshold of 1.64. The percentages were also low for the number of students that agreed with the questions: 85% for Question 10 learned new knowledge, 83% for Question 11 learned new skills, 87% for Question 12 applied the knowledge to the job and 89% Question 13 applied the skills to the job. See appendix M for calculations.

Student Combat Offload Survey Relating to Learning

   The student combat offload survey showed in the learning area, the students thought the scenario was, Question 6 - relevant to the course, a Z-score of 3.84. The questions that dealt with their confidence in preparing them for the flightline - Question 15, providing an excellent enhancement to the courseware - Question 16, helping them retain more of the checklist procedures - Question 17 and was an effective way for them to learn - Question 18, all fell below the threshold of 1.64, 0.56, 0.73, 1.22, and 1.28 respectively. The number of students that agreed with the statements corresponds to the Z-score results: Question 6 - 98%, Question 15 - 68%, Question 16 - 70%, Question 17 - 81% and Question 18 - 81%. See appendix M for calculations.

Consolidated view of what students liked best/least about the Combat Offload scenario

   As per see figure 4, in the open ended question about what the students liked about the Combat Offload scenario, students commented that physically seeing what was going on, although in a virtual mode, was the top observation. The next category showed the students liked the idea of communicating with the automated crew and hearing the rest of the checklist run over their headsets. Students commented they liked the ability to run through the checklist in real time. Not all the students received training using the reverse taxi scenario, but 4 students did comment they liked it. The following categories had 3 comments each, re-enforced the knowledge they had learned in the classroom, the scenario ran smoothly during their time in the FuT and they got a better feel for how the whole scenario would play out in the aircraft. The rest of the categories had 2 or less comments.
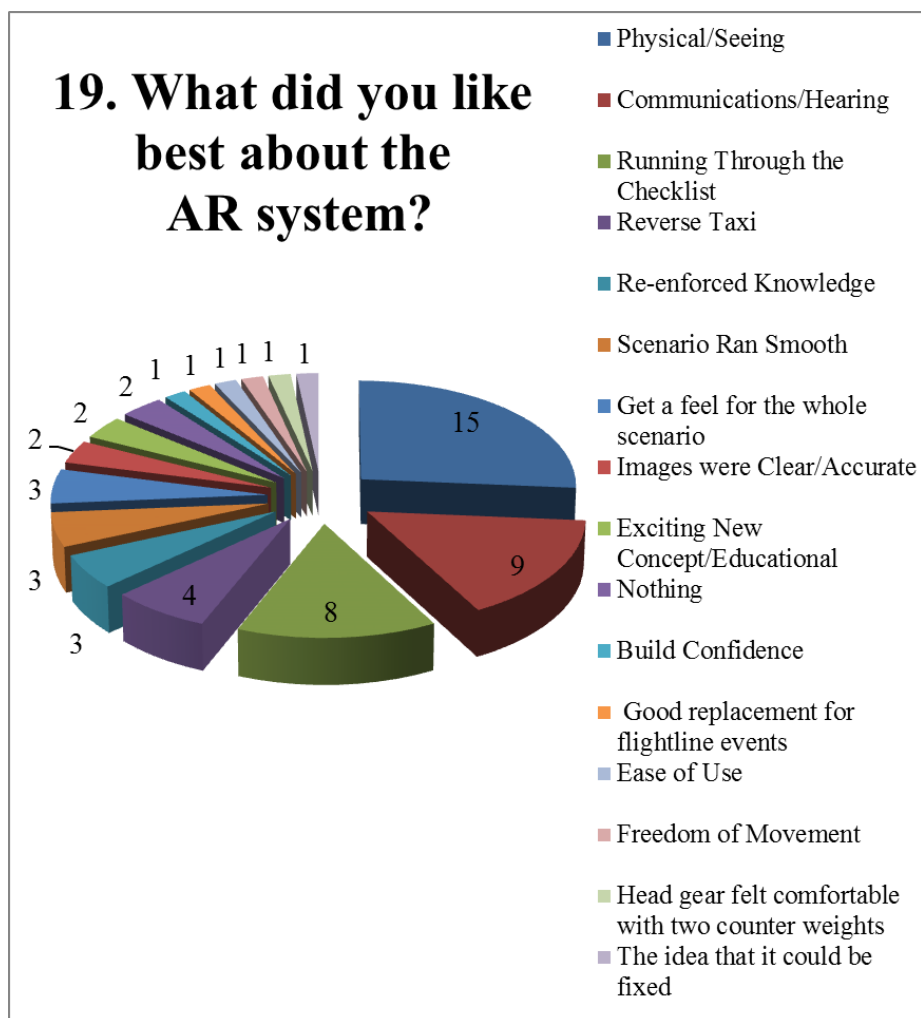
Figure 4. Consolidated view of what students liked best about the Combat Offload scenario

As per figure 5, showed the open ended question about what the students did not like about the system. The limitation on the goggles was the top complaint. The tracking was also a problem for many of the students, when it was their turn in the FuT. The computer glitches were a close third with 12 comments. A few of the students complained that the helmet was uncomfortable to wear. The rest of the categories yielded 1 comment each.
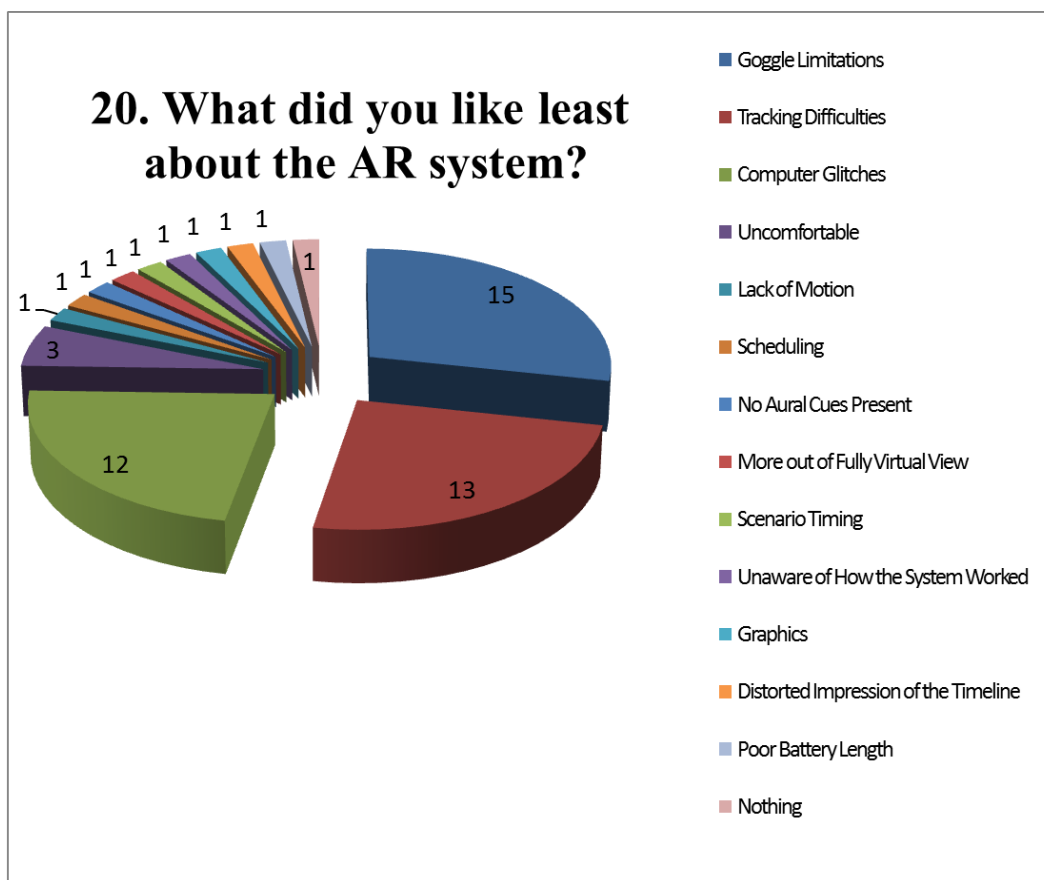
Figure 5. Consolidated view of what students liked least about the Combat Offload scenario

Student Heavy Equipment Airdrop Survey Fit and Function

The student airdrop survey showed in the fit and function area, the students indicated the system did not reach the threshold of 1.64 for any of the questions. The following are the results of the Z-score analysis: Question 1 - the goggles fit well on the helmet, 1.22; Question 2 - the goggles comfortable to wear, 0.98; Question 3 - the student's eyes easily adjusting to the view through the goggles, 1.39; Question 4 - the system not taking too long to set up or adjust, 1.24; Question 5 - the system running smoothly throughout the scenario, 0.79; and Question 14 - the images remaining in the relative position during the scenario, 1.05. The Z-scores correspond to the number of students that agreed with the

statements, Question 1, fit well – 77%, Question 2, comfortable to wear – 70%, Question
3, easily adjusted – 87%, Question 4, did not take long to adjust – 79%, Question 5, ran
smoothly throughout the scenario – 70% and Question 14, the images remained in
position – 77%. See appendix N for calculations.

Student Heavy Equipment Airdrop Survey Instructor Knowledge

The student airdrop survey showed in the instructor knowledge area the students felt
confident about the instructor's ability to train with the AR tool, way above the threshold
of 1.64. The Z-score for Question 7, the students receiving adequate orientation was 1.99,
Question 8, for the instructor's knowledge about the AR system was 2.87 and Question 9,
the instructor's preparedness to run the system showed 2.87. The Z-scores correspond
well to the percentage of students who agreed with the statements, Question 7 - 94%,
Question 8 - 98% and Question 9 - 98% respectively. See appendix N for calculations.

Student Heavy Equipment Airdrop Survey Knowledge and Skills

The student airdrop survey showed in the knowledge and skills area, the students did
not think they learned new knowledge, Question 10, threshold 1.64, Z-score of 1.42, but
they could apply what knowledge they did learn to the job, Question 12, Z-score of 2.84.
The skills category shows the same results, the students felt they did not learn any new
skills, Question 11, Z-score 1.45, but felt they could apply what skills they learned to the
job, Question 13, a Z-score of 2.84. The percentages were also low for the number of
students that agreed with the statements about new knowledge or skills, 85% for both
Question 10 and 11. For applying the knowledge and the skills they agreed that they

could apply what they learned to the job, 98% for both Question 12 and 13. See appendix N for calculations.

Student Heavy Equipment Airdrop Survey Learning

The student airdrop survey showed in the learning area the students thought that the scenario was relevant to the course, Question 6, Z-score of 3.14. The statements relating to, Question 15, their confidence in preparing them for the flightline and Question 16, providing an excellent enhancement to the courseware fell below the threshold of 1.64, 0.86 and 1.11 respectively. Helping them to retain more of the checklist procedures, Question 17, and showing the AR tool was an effective way for them to learn, Question18, showed above the threshold of 1.64, 1.70, and 1.90 respectively. The number of students that agreed with the statements correspond to the Z-score results, Question 6 - 98%, Question 15 - 77%, Question 16 - 79%, Question 17 - 91% and Question 18 - 89%. See appendix N for calculations.

Consolidated view of what students liked best/least about the Airdrop scenario

As per figure 6, the open ended question about what the students liked best about the airdrop scenario showed students liked this new way of learning, they liked seeing the cargo leave the aircraft, how realistic the scenario looked, how they liked the crew interaction and hearing the checklists read out over their headset. There were 2 or less comments each for the rest of the categories.
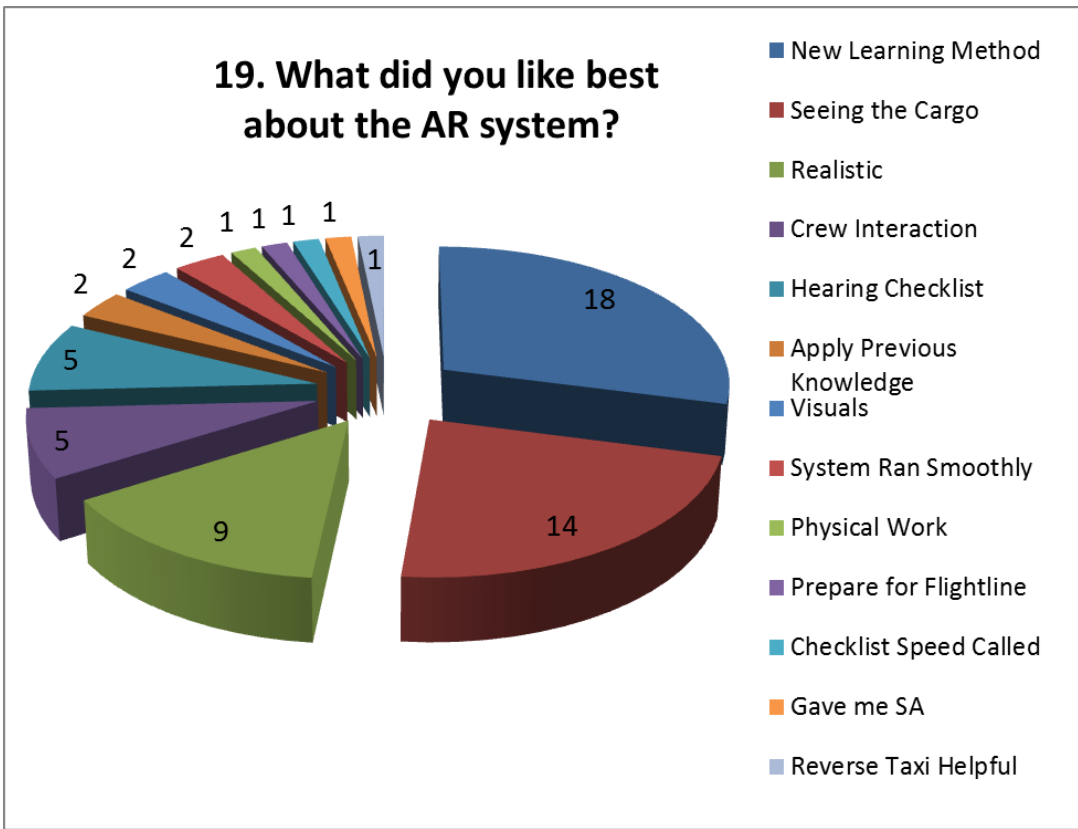
Figure 6. Consolidated view of what students liked best about the Airdrop scenario

As per figure 7, the biggest part of the complaints for the airdrop scenario was the computer gliches and malfunctions. The next highest complaint was donning all the equipment. Some students would like to have seen more detail in the rigging of the parachute. The other categories had three or less comments.
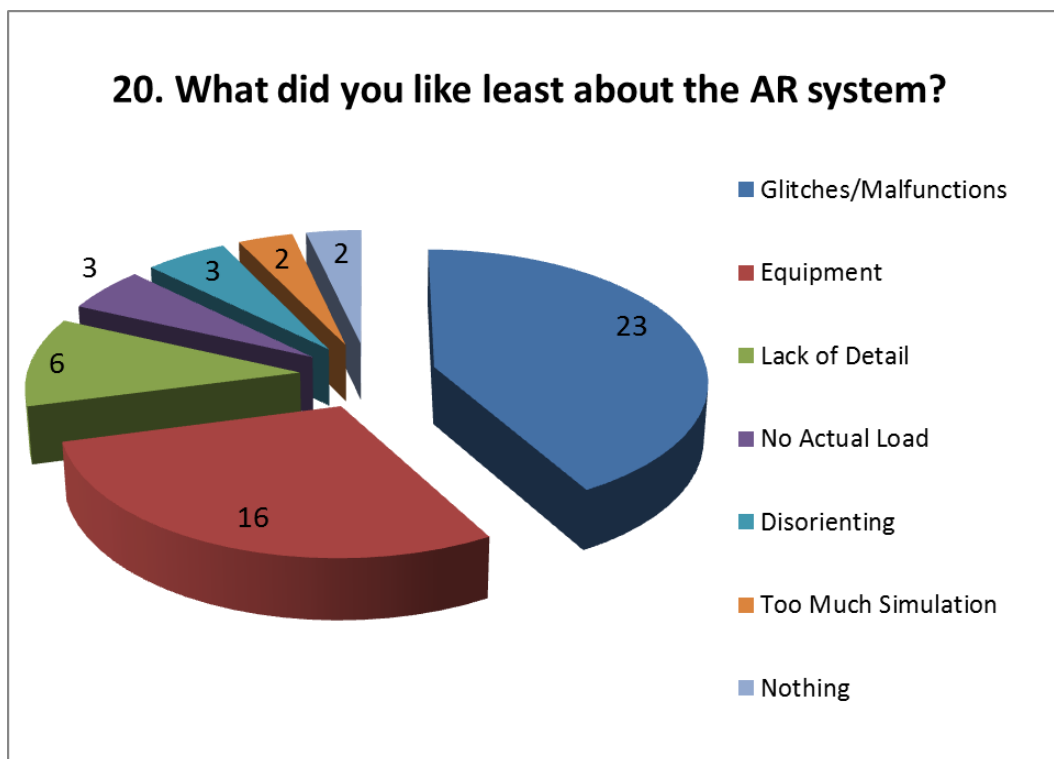
Figure 7. Consolidated view of what students liked least about the Airdrop scenario

Contract Instructor Fuselage Trainer Survey Fit and Function

In the area of fit and function for the contract instructor survey, Question 1, received adequate instruction on how to use the AR system and goggles, showed a T-score of 2.77, above the threshold of 2.13. Question 2, the system was easy to set up, a T-score of 1.17, Question 3, the images remained in the relative position with the students movements, scored 1.09, and Question 9, the AR system helped make the instructional time more productive, a score of 1.84, all fell below the threshold, thus not being able to reject the hypothesis. For Question 4, the AR system provided a realistic portrayal of the actual events in the aircraft, did manage to hit the threshold at 2.13. The same areas for the contract instructor survey, 94% felt they had received adequate instruction on how to use the AR system and goggles, 76% agreed that the system was easy to set up, 76% felt the

images remained in the relative position with the students movements, 88% felt the AR system provided a realistic portrayal of the actual events in the aircraft and 76% agreed the AR system helped make the instructional time more productive. See appendix O for calculations.

Contract Instructor Fuselage Trainer Survey Relating to Student Learning

In the area of student learning, the instructors felt that the AR system did provide an enhancement to the training, Question 5, a T-score of 3.27. The other aspects of student learning did not reach the threshold of 2.14: Question 6 – retained more of the lesson objectives 1.57, Question 7 – better prepared the students for flight training, 0.73 or Question 8 - the students achieved a higher level of proficiency during the training, 1.84, did not score high enough to reach the threshold. In the same area of student learning, 100% of the instructors felt that the AR system provided an enhancement to the training, 53% agreed the students retained more of the lesson objectives, 65% felt the scenario better prepared the students for flight training and 76% agreed the students had achieved a higher level of proficiency during the training. See appendix O for calculations.

Contract Instructor Survey Relating to Crew Resource Management

In the responses to the questions relating to CRM, the instructors did not feel that the AR system improved the students' CRM awareness, Question 10, a T-score of 1.73 and in Question 11, they really thought that CBT lessons could not be used to teach CRM procedures with a score of a -.15, much lower than the threshold of 2.12. In the same responses relating to CRM, 88% of the instructors felt the AR system improved the

students' CRM awareness and 24% agreed that CBT lessons could be used to teach CRM. See appendix O for calculations.

Consolidated view of what instructors liked best/least about the AR system

As per figure 8, not as many instructors participated as students in the surveys, but it was important to capture their point of view for teaching with a new type of training tool. The instructors liked the aspect of enhancing the CRM skills. They felt the students had a better understanding of the checklist procedures followed by reverse taxi, realistic feel and visual references.
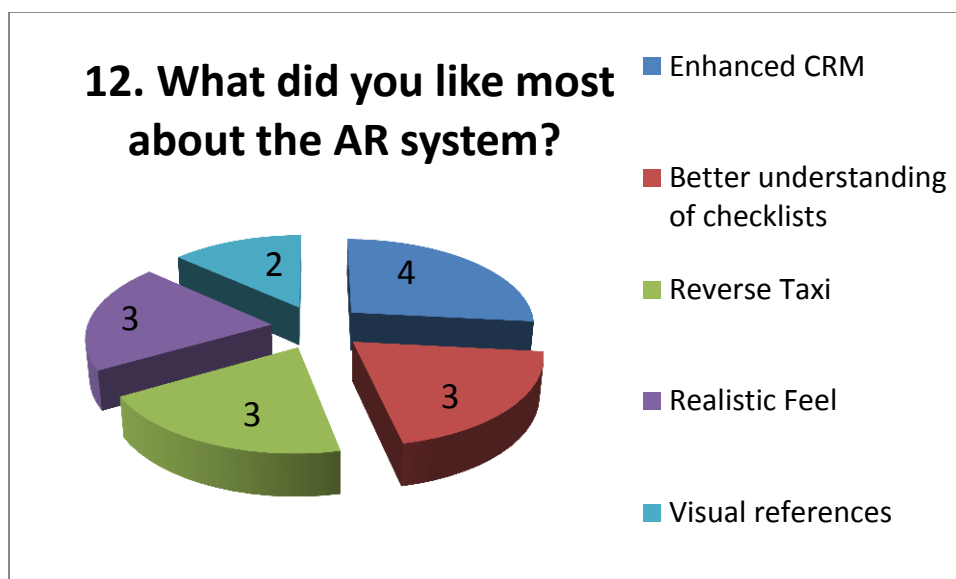
Figure 8. Consolidated view of what the instructors liked best about the AR system

As per figure 9, what the instructors liked least about the overall system was the communication problems encountered when trying to talk to the students, the scenario not matching the current checklist, the computer anomalies that occurred and the timing

in which the checklist was run for each scenario. The other categories had 1 comment each.
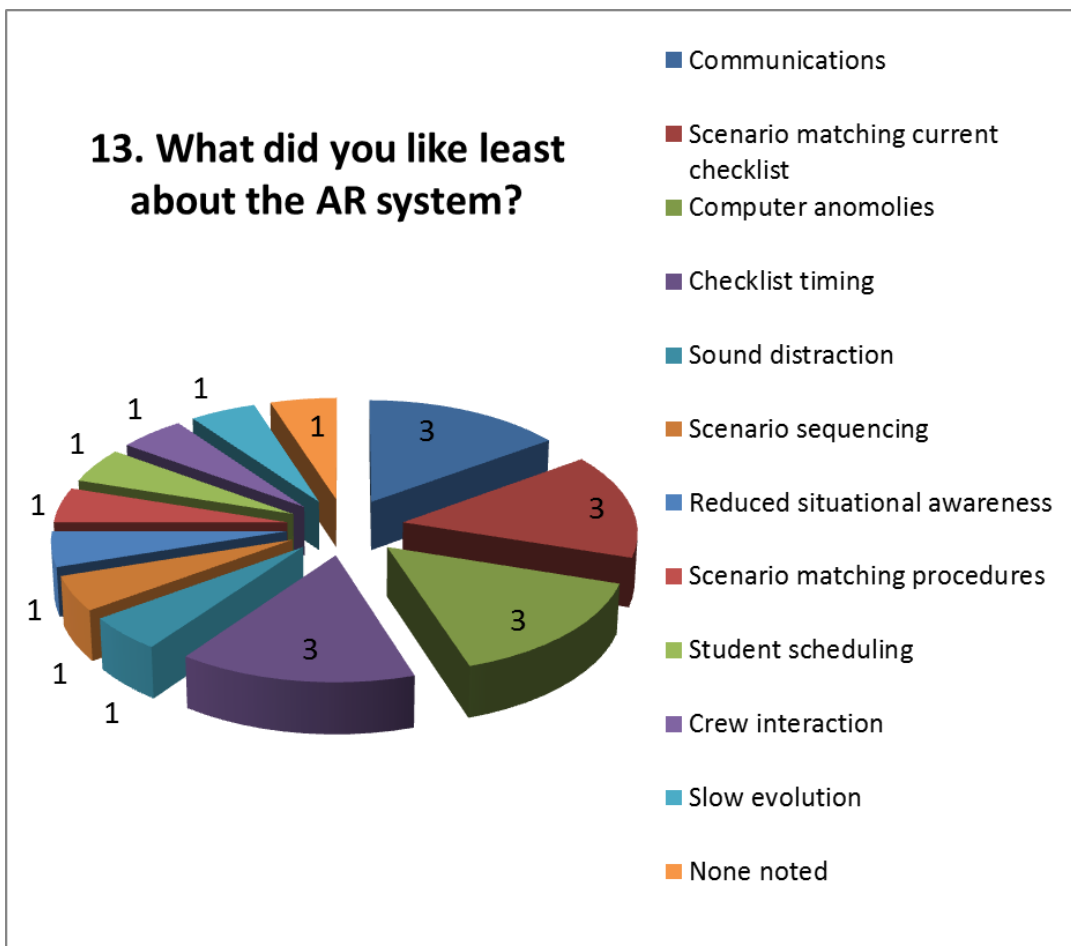
Figure 9. Consolidated view of what the instructors liked least about the AR system

Survey Results

The analysis began by importing the survey data into an Excel spreadsheet to organize the information in the quantitative process shown in Figure 10. Once the student's personal information was removed from the spreadsheet, the analytical formulas were set up to calculate the Z-score for the student data and the T-score for the contract instructor data for each question and to calculate the percentage that agreed or disagreed with the

Quantitative Data Collection from Surveys	→	Quantitative Data Analysis	→	Quantitative Results
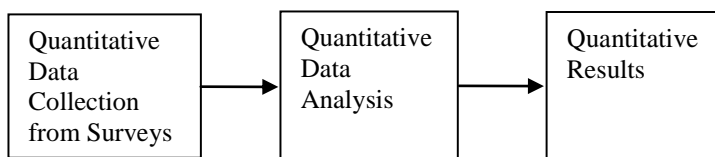
Figure 10. Quantitative Process Triangulation Design: Validating Quantitative Data Model. From "Designing and Conducting Mixed Methods Research," by J. W. Creswell and V. L. Plano Clark, 2007, Thousand Oaks, CA: Sage Publications, Inc. Copyright 2007 by Sage Publications, Inc.

question. The hypothesis for each of the surveys showed the students and the instructors generally *disagreed* with the question. To reject the hypothesis, each question had to score higher than the threshold establish by the statistical analysis formulas used in the Excel spreadsheets. Some analysts suggest using the Z score for more than 30 participants and a T score for less than 30.

Student Engine Start Survey Analysis and Results

The survey questions were divided into groups targeting specific areas about the AR training tool. The start engine scenario was set up in the classroom, so the first three questions were geared toward the fit and function of the system to run in the classroom. Once the students ran through the basics and understood the checklist procedures, the instructors would bring up emergency situations for engine start. The students liked the idea of practicing the emergencies, which was very relevant to the course and the students could hear and see the actions each emergency presented. The data showed the computer system ran smooth during each situation they practiced and did not take too long to set up. The next two questions targeted the instructor's knowledge of the system. The data showed the students were very impressed with how well the instructors were prepared and knew how to run the training tool.

An important aspect of using a different kind of training tool is the ability to instill new knowledge or skills that can be used later in the training. The students felt that much of what they had learned in the scenario had already been covered in some of the other lessons, but what was covered and practiced in the classroom would be used for flight training. Four questions were set up to explore the behavioral changes in the students. In the first question, the data showed 88% of the students agreed the scenario prepared them for flight training, which also showed above the threshold of 1.64. The other three questions were below the threshold but were over the 86% mark for students agreeing that the AR system was an excellent enhancement to the training, helped them retain more of the checklist procedures and was an effective way for them to learn the procedures. See appendix J for calculations.

What stood out from the question about what the students liked best about the AR system for engine start included the visual scenes for both the normal procedures as well as the emergencies. They liked how the system would let them interact with the recorded voices of the crew during the call outs for the different checklists and they liked the knowledge gained and hearing the different crewmembers speak. In the area of what they liked least about the system was rather encouraging, there were 11 comments that there was nothing they disliked about the engine start scenario. But, some of the other significant areas included the graphics and the malfunctions or the computer glitches encountered during the LGTO.

Student Combat Offload and Heavy Equipment Airdrop Survey Analysis and Results

A comparison was made between the combat offload and the heavy equipment airdrop scenario surveys. The idea was to capture the students' experiences using these two scenarios with the same equipment. The results were extremely close in the areas to include the goggles fitting well on the helmet, the goggles being comfortable to wear, eyes adjusted easily to the view, the system running smooth and the images remaining in a relative position, which were all not high enough to reject the hypothesis. The results showed a clear indication that there was still work to be done on the set up of the helmet and the visual aspects of the goggles. See appendixes K and L for calculations.

There was a clear indication from both sets of surveys that the students thought they had received an adequate orientation about what would go on in the FuT using the AR system. They also thought that the instructors were trained well enough to use the system to teach with in the FuT.

In the area of knowledge and skills, the surveys indicated that there was not enough evidence to reject the hypothesis for learning new knowledge or skills. Many of the lessons that were taught in the fuselage trainer had been taught in the classroom and had been run through with the students during the normal curriculum, indicating that most of the knowledge and skills had already been acquired. The difference in the surveys came in the application of what the student had learned. The combat offload scenario did not produce as much of a positive result as the heavy equipment airdrop scenario. The students felt that the airdrop lessons were much more applicable to flight training than the combat offload lessons, although over 87% agreed that both could be applied to flight training. See appendixes K and L for calculations.

Contract Instructor Fuselage Trainer Survey Analysis and Results

The questions for the contract instructors were set up to see how well, from an instructor's point of view, the system worked to train students with an AR system in the FuT. The instructors thought they had received adequate training to use the system and the scenarios portrayed a realistic view of the events they were teaching the students. What did not rate high was the ease of setting up the equipment, the images not remaining in the relative position aligned with the cargo compartment and they did not indicate that their time was more productive using the AR system. The AR system did provide an enhancement to the training, but the students did not retain any more of the lesson objectives than the current training, they were not any more prepared for flight training and they had not achieved a higher level of proficiency indicated from the T-scores. See appendix M for calculations.

In the area of CRM, the instructors did not see any improvement in the student's CRM awareness compared to the classmates who did not get to use the AR system and they were very adamant about the students not being able to use computer based training to learn any of the CRM skills or Loadmaster procedures. When asked what they did like about the AR system overall, there were several comments about the ability to enhance the CRM skills, a better understanding of the checklist procedures and how real the scenario looked with the visual references. What they did not like about the overall system was the communication with the students, the scenarios not matching the current checklist and the timing in which the checklists were run, plus all the computer anomalies that interfered with the training.

Interview Data

Student Engine Start Interview questions relating to fit and function

During the interviews Question 1 showed 87% of the students said it took less than

five minutes to set up the scenario. After a couple of times running the scenario, the

instructors became more familiar with where the lesson was located on the server and

how to run the system, reducing the time required to set up the scene in the classroom.

Question 2 showed 73% said the system ran pretty smooth, no glitches, errors, or delays

in the programming or locating the lesson. Question 3 showed 93% felt the engine start

scenario was relevant to the course they were taking, because the FuT doesn't have wings

to practice engine starts. See appendix P for responses.

Student Engine Start Interview questions relating to instructor knowledge

Question 4 showed 73% of the students felt the instructors were knowledgeable about

how to use the AR tool to train the students. The students felt that the instructors had run

the system a few time before. Question 5 showed 80% thought that the instructors were

well prepared and organized to run the scenario in the classroom, the AR lesson did not

take too long to set up and was easy to run. See appendix P for responses.

Student Engine Start Interview questions relating to Knowledge and Skills

Question 6 showed only 40% of the students felt they learned something new from the

training, like the hand signals used to communicate with the crew chief, but 47% were

negative about learning new knowledge from the training because of what was taught

earlier in the course. Question 7 showed 73% were positive about learning new skills by understanding the flow of the checklist, how far to stand from the aircraft and seeing the correct angles to view the engines during starts. Question 8 showed 86% indicated they could apply the knowledge they learned to the job on the flightline by remembering the calls and knowing what to expect from hearing the other crewmembers. Question 9 showed 77% felt they could apply the skills they learned to the job by knowing what was coming next as far as the cockpit conversations. See appendix P for responses.

Student Engine Start Interview questions relating to behavioral change

Question 10 showed 100% of the students agreed that the engine start scenario better prepared them for flightline training by giving them the confidence to perform the tasks required for engine start. Question 11 showed 93% were positive about the engine start scenario providing an enhancement to the training over some of the other devices used in the Loadmaster course. The students felt the AR lesson in the classroom helped more than viewing the same type of lesson in the WST and much better than the current CBT lessons. Question 12 showed 80% felt positive about the engine start scenario helping them retain more of the checklist procedures because of the interaction involved in seeing what goes on at each step in the checklist and hearing the calls made by the rest of the crew. Question 13 showed 80% felt that the scenario was an effective way for them to learn the procedures, hearing and seeing what goes on instead of just reading about it. See appendix P for responses.

Consolidated view of what the students liked best/least about the AR system

   As per figure 11, when asked what the students liked best about the engine start

scenario in the AR system: they liked seeing the visuals play out during the scenario, felt

the virtual view had a real feel to the situation the student experience on the flightline,

they liked the sounds of the recorded aircraft and hearing the front end crew run through

the checklist, how the training was direct and to the point, with the appropriate timing,

and the students indicated they seemed less nervous training with AR than on the aircraft.
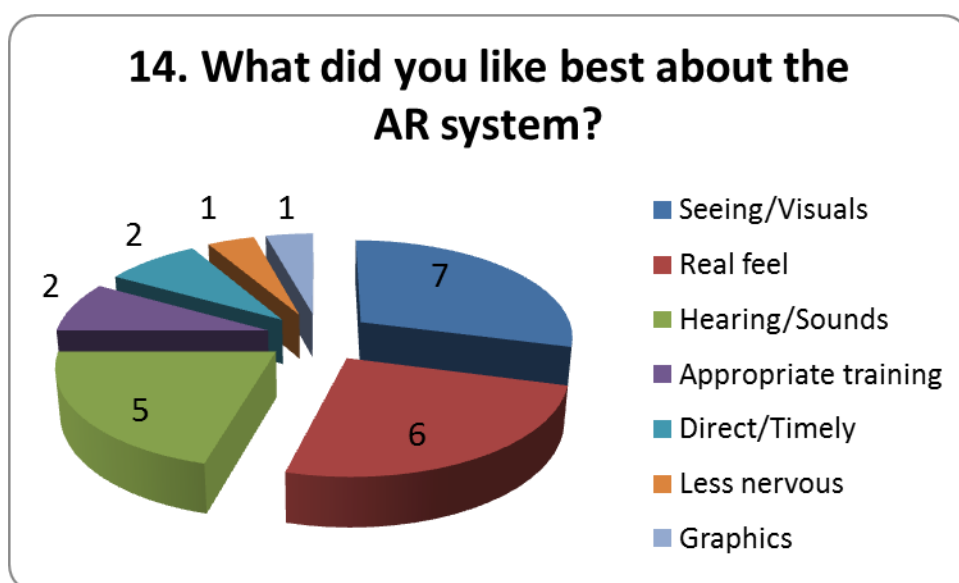
Figure 11. Consolidated view of what the students liked best about the engine start
scenario

   The dislikes were more spread out for the engine start scenario. As per figure 12,

showed the students stated they did not like the lack of the physical involvement with the

aircraft A few comments included: not enough malfunctions programmed into the

scenarios, not enough interaction with the recorded crew members going through the

checklist, the chunkiness of the system itself and some aspects of the graphics like the

props and the basic animation of the crew chief. There was 1 comment for the rest of the categories.
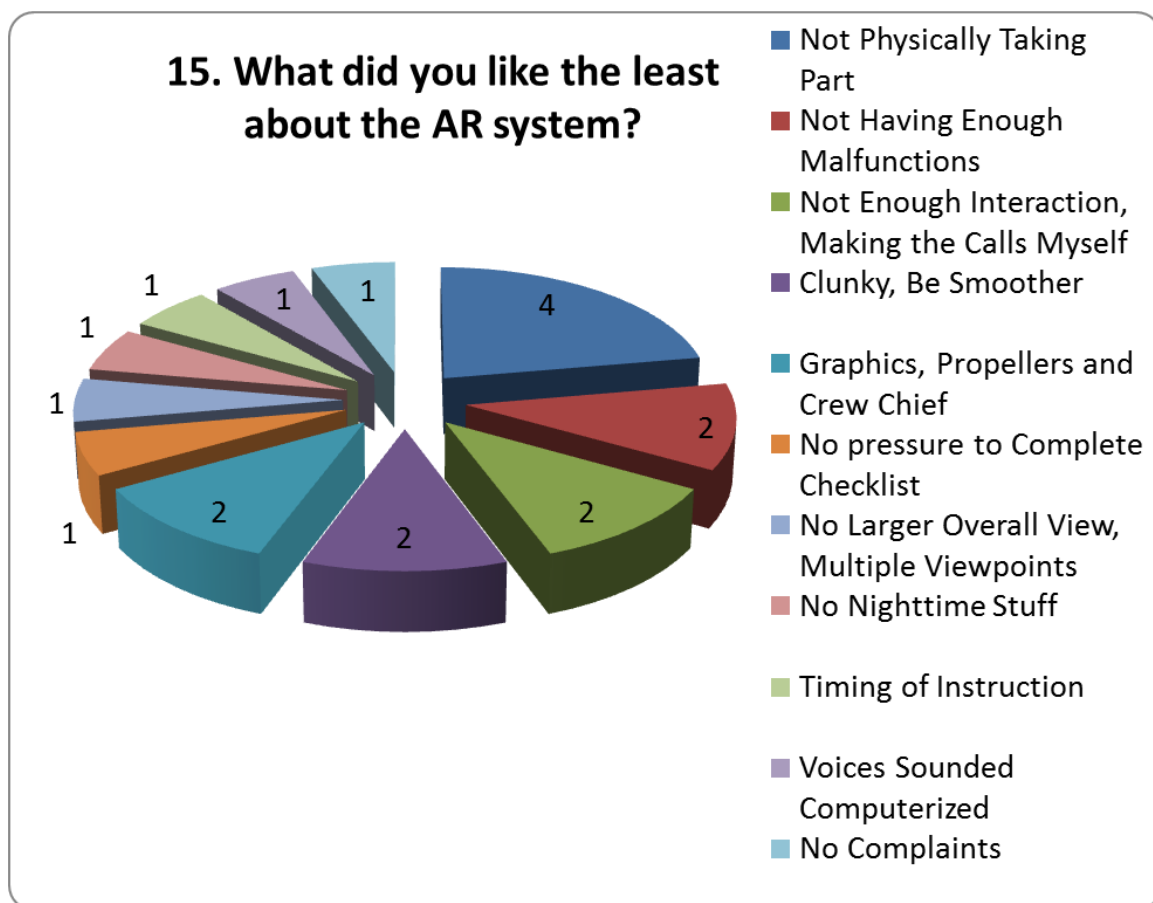
Figure 12. Consolidated view of what the students liked least about the engine start scenario

Student Combat Offload Interview questions relating to fit and function

Question 1 showed 64% of the students felt the goggle fit was satisfactory on the helmet; not too heavy, felt like Night Vision Goggles (NVGs). Some felt they were heavier than normal or did not align properly. Question 2 showed only 36% felt the goggles were comfortable to wear, 45% felt that the goggles did not fit right and a few complained of headaches. Question 3 showed 64% reacted positively for their eyes being able to adjust to the view in the goggles; not perfect, but enough to see the scenario.

Question 4 showed 64% felt the set up and adjustment took less than five minutes to adjust, but others experienced much longer set up times, 10-15 minutes. Question 5 showed 50% felt the scenes in the scenario ran smoothly, but 50% had problems with the scene jumping around in the view. Question 9 showed 50% felt the scenario was set up properly when they were ready to use the AR system, but 50% felt frustrated it took so long to correct the errors in the system to get set up. Question 12 showed 80% were positive toward the scene keeping up with their movement in the FuT, the pallet stayed in the proper position when they walked around virtual scene. See appendix Q for responses.

Student Combat Offload Interview questions relating to instructor knowledge

Question 7 showed 91% of the students were very confident in how the instructor explained what would go on using the AR device. Question 8 showed 91% felt positive about the instructor's knowledge to use of the AR system; comments included: anything that came up, they fixed it; they were able to troubleshoot the problem and get them fixed; he seemed knowledgeable, but the equipment did not want to cooperate. See appendix Q for responses.

Student Combat Offload Interview questions relating to knowledge and skills

Question 11 showed 80% of the students felt they could apply the Combat Offload knowledge and skills of knowing the checklist, having better situational awareness and being able to run the tasks on the trainer from the scenario to flightline training. See appendix Q for responses.

Student Combat Offload Interview questions relating to learning

Question 6 showed 73% of the students felt that the Combat Offload scenario was relevant to the Loadmaster course of study; it was a good opportunity to run through the checklist. Question 10 showed 91% felt the scenario did reinforce the lesson material better than the same lessons they had learned earlier in the classroom, the virtual scenes reinforced the training more. Question 13 showed 80% felt the scenario helped them retain more of the Loadmaster procedures by being able to walk back and forth as if being on the plane. Question 14 showed 64% were confident that this type of training tool helped them learn the lesson objectives by being able to actually run through checklist, being able to learn the speed of the checklist, learn where to stand, learn where to be on the aircraft to flow through the checklist. See appendix Q for responses.

Student Combat Offload Interview open ended questions

As per figure 13, when asked what the students liked best about the AR system referring to the Combat Offload scenario they responded with the following: they liked seeing what was going on in the FuT during the scenario, they liked physically running through the checklist, being able to walk around the plane with the helmet on as if being on the flightline and being able to repeat the procedures as many times as they liked. The rest of the areas had 1 comment each.
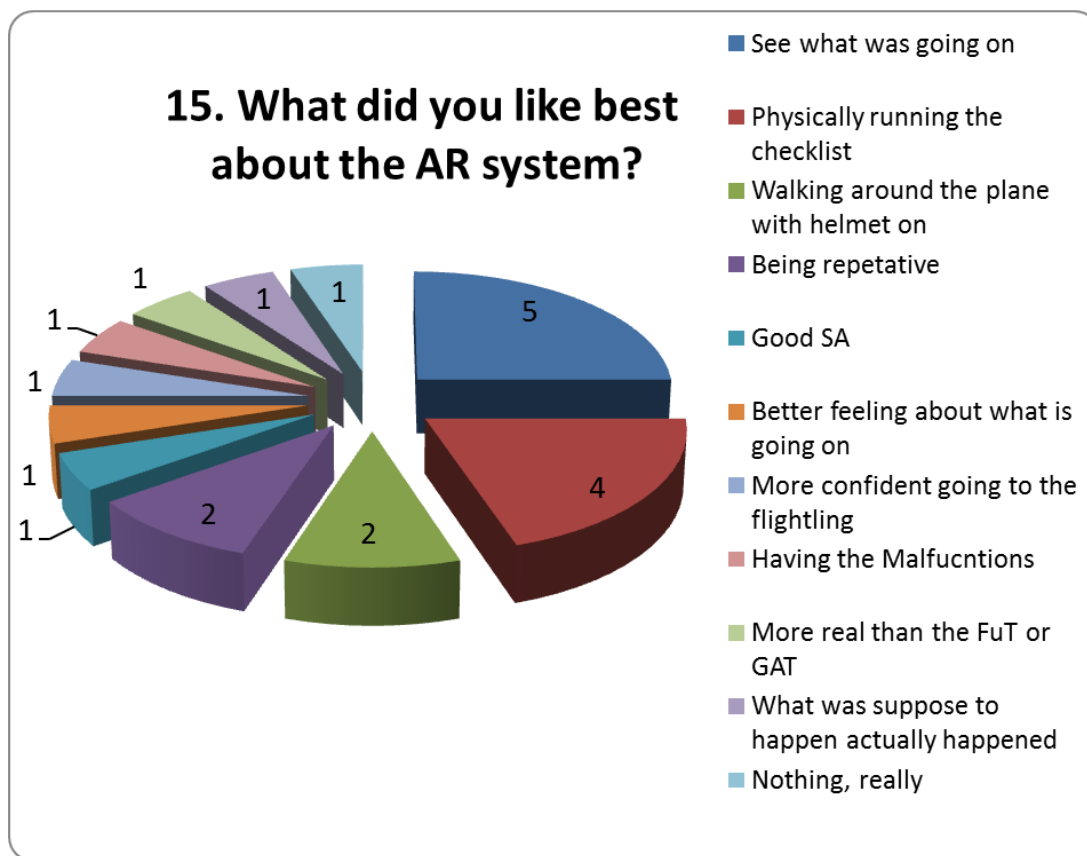
Figure 13. Consolidated view of what the students liked best about the Combat Offload scenario

As per figure 14, the students were asked what they liked least about the AR system during the Combat Offload scenario. They did not like the tracking dead spots when walking up and down the FuT and the many technical issues relating to the overall system. The other areas had 1 comment each.
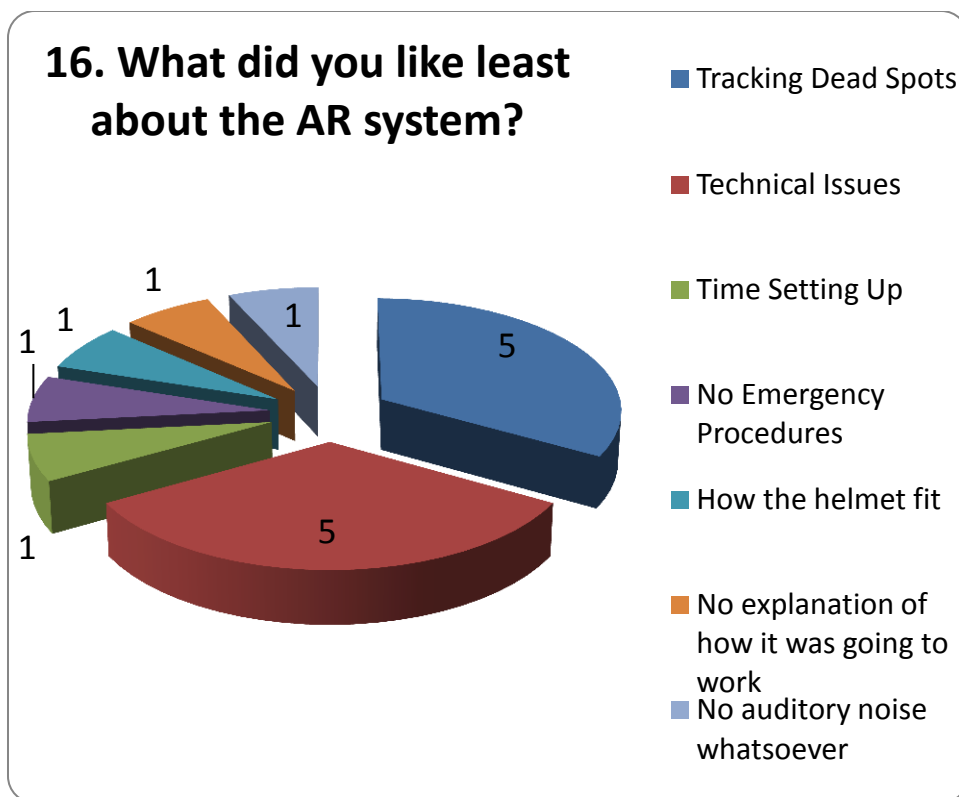
Figure 14. Consolidated view of what the students liked least about the Combat Offload scenario

What other things could we include that would help you out on the flight line

During the interview, other aspects of technology and training came into the conversation. A supplemental question was added to the interview, "W*hat other items could we include in the production model of the AR system that would help you out during your training on the flightline?*" As per figure 15, the students commented they would like to see all of the emergency procedures. They would like to have the actual pallet in the FuT when performing the scenarios, be able to practice reverse taxi and rigging for each of the different platforms on the pallets and practice Mass CDS (Container Delivery System) in the FuT.
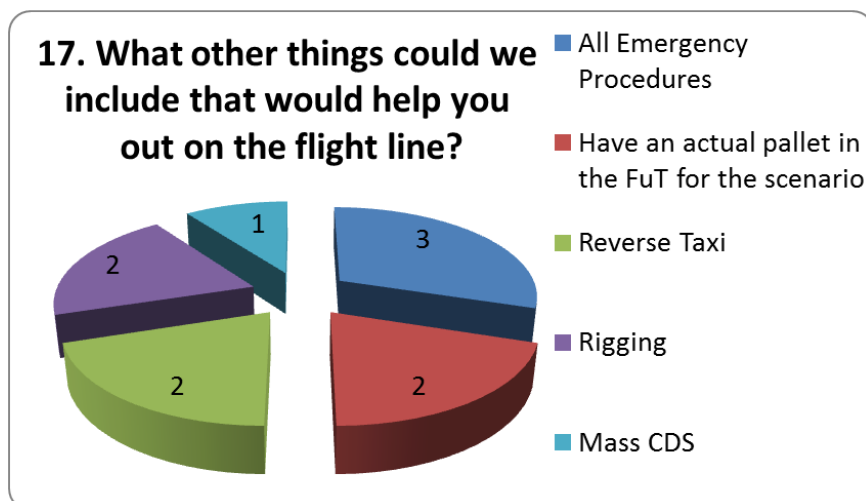
Figure 15. What other things could we include that would help you out on the flight line

Student HE Airdrop Interview questions relating to fit and function

Question 1 showed 70% of the students were positive about the goggles fitting well on the helmet, comments included: the goggles seemed like NVGs, most of the students had no problems, but a few felt they were bulky. Question 2 showed 70% felt the goggles were comfortable to wear, like NVGs, but may be a little heavier. Question 3 showed 80% felt positive that they could adjust the goggles view for their eye sight, easy to adjust but a few had problems getting the scene to come up in view. Question 4 showed 80% felt it did not take too long to set up the scenario, usually less than 10 minutes. Question 5 showed 40% felt positive about the scene running smoothly during the airdrop scenario, but 60% commented they had problems with the scene jumping around or not showing up at all sometimes during the lesson. Question 9 showed 70% felt the scenario was set up and ready to go by the time the students entered the FuT, but others had to wait a while for the system to reboot. Question 12 showed 78% felt positive that the scene followed them around the FuT during the scenario, but others had problems with the pallet disappearing from view. See appendix R for responses.

Student HE Airdrop Interview questions relating to instructor knowledge

Question 7 showed 100% of the students were quite impressed by the instructor's explanation about how they were going to use the device in the FuT. Question 8 showed 100% felt the instructors were very knowledgeable about how to use the AR system itself. See appendix R for responses.

Student HE Airdrop Interview questions relating to knowledge and skills

Question 11 showed 80% of the students felt that they could apply what they had learned to flightline training. The knowledge and skills gained practicing the checklist and emergencies paid off during an actual HE airdrop emergency on a flight. See appendix R for responses.

Student HE Airdrop Interview questions relating to learning

Question 6 showed 80% of the students felt the scenario was relevant to the course they were in. One student commented that it was kind of nice to get an idea of what they would see on a sortie. Question 10 showed 70% felt the airdrop scenario reinforced the material better than the lessons they had learned earlier in the course, it gave them a better understanding of the checklists. Question 13 showed 70% felt the scenario helped them retain more of the procedures being taught, with more practice, the more familiar the checklist becomes and the more you know what to expect during the mission. Question 14 showed 80% felt that this type of training tool helped them learn the objectives better than what was being used in the current curriculum. It painted a picture

better to see the actions of the scenario which enabled them to apply the knowledge

learned from the audio and visual cues. See appendix R for responses.

Consolidated view of what the students liked best and least about the HE airdrop scenario

As per figure 16, the students liked the visuals, hearing the checklist being run and

how realistic and easy it was to learn in the airdrop scenario. There were comments for

providing a good crew perspective or instilling good situational awareness. The rest of

the categories had 1 comment each. What they did not like were the images disappearing

as they walked through the FuT and the blending of the virtual scene with the cargo

compartment. The rest had 1 comment for each area.
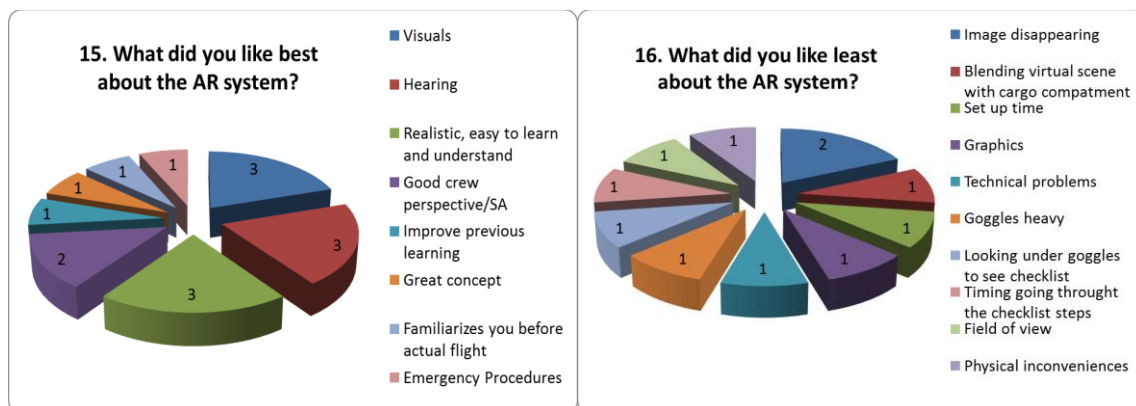
Figure 16. Consolidated view of what the students liked best and least about the HE airdrop scenario

Other areas of training

As per figure 17, the conversation with some of the students continued after the

prepared set questions. The question: "*What other things or training would you like to*

have had in the FuT or the classroom that would help you out on the flightline?" was

added. The students reacted with more emergency procedures practice. They would have

liked to have been able to come after class to try out the scenarios themselves. One thought was to have the checklist brought up in the goggles as the scenario played out and hearing all the calls made by the front end crew throughout the whole airdrop procedure.
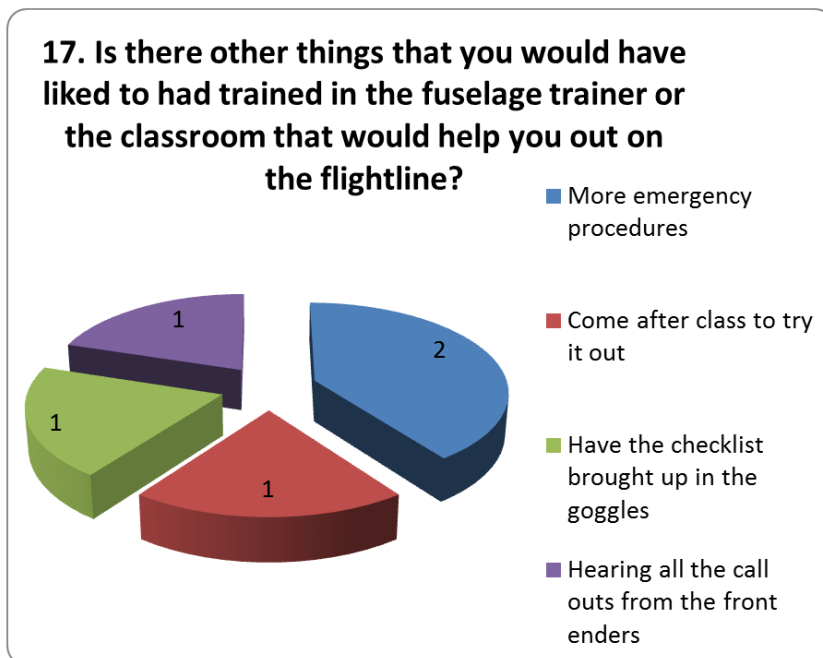
Figure 17. Are there other things that you would of like to have trained in the fuselage trainer and classroom that would help you out on the flightline?

Contract Instructor Interview for the Engine Start scenario relating to Fit and Function

Question 1 showed 100% of the contract instructors were very receptive to learning how to run the start engine scenario, they felt positive about having enough instruction to teach the students with the scenario. Question 2 showed 100% felt the system was easy to setup and run; no computer problems or glitches. Question 3 showed 40% felt the virtual image stayed in the proper position for the students. Question 5 showed 88% felt the graphics portrayed as much of a realistic view as the actual events, some of the graphics could be updated with more detail. See appendix S for responses.

Contract Instructor Interview Questions for the Engine Start Scenario Relating to Student Learning

Question 4 showed 80% of the contract instructors thought the start engine scenario was an adequate training tool. The comments included the scenario as being an enhancement to the lesson, rather than trying to talk through a prop not turning. Question 6 showed 75% felt the AR scenario helped them train the lesson objectives better than the current training, some felt that it was better than just talking through the task, but others felt that the actual CRM aspects are still needed. Question 7 showed 80% felt the students retained more of the lesson objectives by not only seeing but hearing the other crew positions. Question 8 showed 20% felt that the scenario improved the students' procedural abilities before going to the flightline, 60% were neutral towards improvement because at that point in the students training it is hard to judge the students' abilities. Question 9 showed 60% were positive about the students having a higher level of proficiency after practicing the procedures on the flightline during a ground aircraft trainer (GAT) lesson. Question 10 showed 60% thought their time was more productive using the AR system, 40% were neutral with the new type of learning tool. See appendix S for responses.

Contractor Instructor Interview Question for the Engine Start Scenario Relating to Crew Resource Management

Questions 11 showed 80% of the contract instructors were positive that they saw an improvement in the students' CRM awareness, only a few were still confused about the process of starting engines. Question 12 showed only 20% positive for using computer based lessons to teach Loadmaster procedures. They felt the current CBT lessons had no

one to help the students if they had questions and there was not enough interaction the way the lessons were built. See appendix S for responses.

Consolidated view of what the instructors liked best and least about the engine start scenario

As per figure 18, when asked what they liked best about the engine start scenario the instructors commented that the visuals and the CRM with the crew stood out the most. Some of the other areas included the malfunctions that went with the procedures, the realistic view for the engines and props and the relatively easy controls used to teach the lessons with the Instructor Operating Station (IOS). Items that stood out for what they did not like were the checklist currency, the AR checklist procedures needed to match what the students would experience on the flightline. Some of the other areas that could use some improvement included the graphics of the pallets and chutes, the portability to have the lesson taught on a laptop and the lack of interaction with the Loadmaster equipment for the students.
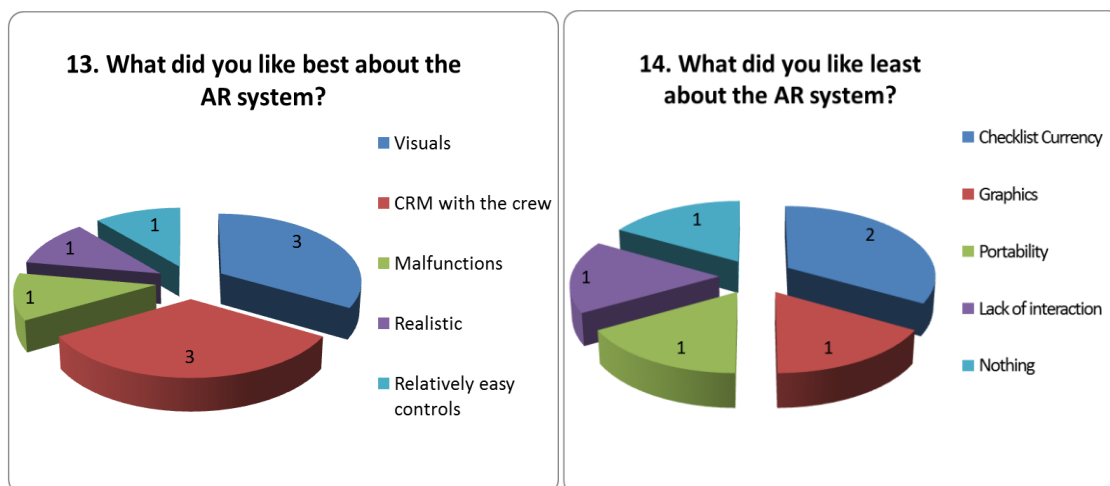
Figure 18. Consolidated view of what the instructors liked best and least about the engine start scenario

Contract Instructor Interview for the Fuselage Trainer relating to Fit and Function

The interview questions for the contract instructors were geared toward finding out what the instructors thought of the overall system used in the FuT. Both the combat offload and the heavy equipment airdrop scenarios were used to determine the effectiveness of the system. Question 1 showed 50% of the contract instructors thought they had received enough information and practice to run the AR system, it seemed very intuitive, but others felt they could have used some more love. Question 2 showed a third of the instructors thought the system was easy to set up and run, but the technical difficulties may not ever be solved completely. Question 3 showed 100% of the instructors were negative with the virtual images staying in the proper position for the students; the tracking was not mature enough to keep a constant tracking of the student's position. Question 5 showed 100% felt positive the graphics looked realistic as though seeing the actual events. Question 10 showed 67% were neutral about the scenarios making their time more productive with the students, depending on how it will be fully employed. See appendix T for responses.

Contract Instructor Interview Questions for the Fuselage Trainer Relating to Student Learning

Question 4 showed 67% of the contract instructors thought the device was an adequate training tool; if the system would work perfectly it would be a great training tool. Question 6 showed 67% felt the AR system scenario helped them train the lesson objectives better than the current training; having the interaction and the scripted interphone was good, but the computer glitches and wait times was not. Question 7 showed 67% felt the students who used the AR system retained more of the lesson

objectives during the training by running through the checklist, but the checklists need to be up to date with the flightline procedures. Question 8 showed 67% were neutral about seeing an improvement in the students' procedural abilities going to the flightline. Question 9 showed 100% neutral about the students being at a higher level of proficiency after using the AR system, no differences noticed. See appendix T for responses.

Contractor Instructor Interview Questions for the Fuselage Trainer Relating to Crew Resource Management

Question 11 showed 67% of the instructors felt positive they saw an improvement in the students' CRM awareness practicing the various checklists. Question 12 showed 67% felt that CBT lessons could be used to teach Loadmaster procedures as long as the lessons were interactive. See appendix T for responses.

Consolidated view of what the instructors liked best and least about the scenarios in the FuT

As per figure 19, what the instructors liked about the FuT scenarios were the interactions with the crew, as they said, "getting the wind in the student's hair" helped tremendously in preparing the students for flight training. Another aspect of the scenario they liked was being able to see what was going on when running through the checklist. What they did not like was the inability to keep the system up to date, especially the checklists, or keeping the system constantly running the scenarios, there were too many computer glitches and limited field of view for the goggles.

13. What did you like best about the AR system?

- ■ Interactive with the crew, get the wind in their hair - virtually
- ■ Seeing what was going on

14. What did you like least about the AR system?

- ■ Keeping everything up to date
- ■ Keeping the system constant
- ■ Computer Glitches
- ■ Goggle field of view
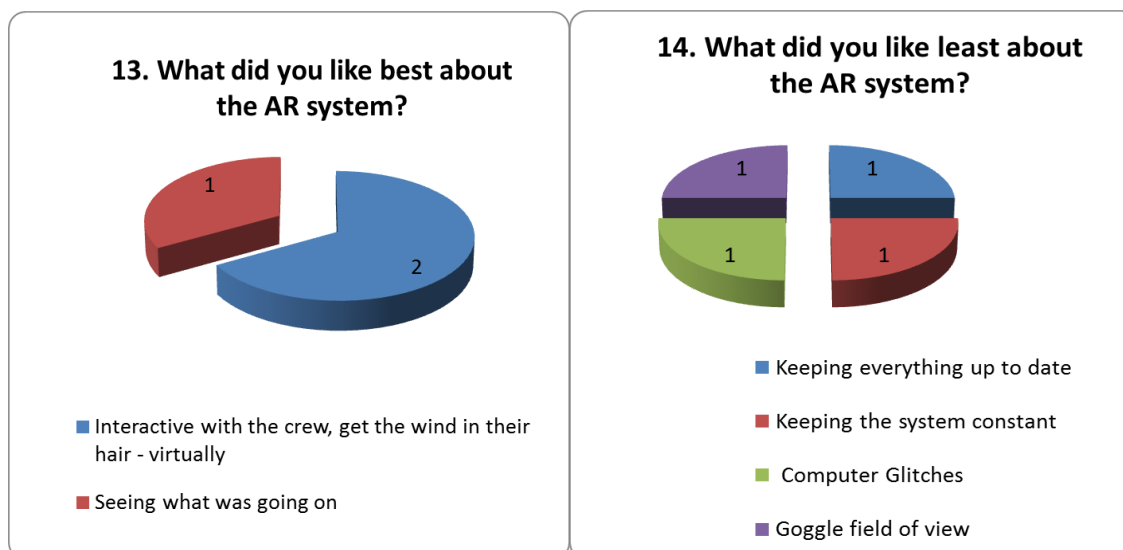
Figure 19. Consolidated view of what the instructors liked best and least about the engine start scenario

Flight Instructor Interviews

The flight instructors were <u>not</u> told about the students using the AR tool until they showed up for the interview, mainly to prevent any undue bias for or against the training tool. Most of the questions were geared to compare students from the past classes such as the non-AR students to the students who had recently used the AR scenarios. At the beginning of the conversation it was explained that the interview was voluntary and their names would not be used in the report. Once the consent forms were reviewed and signed, an explanation was given about how the AR tool was used in the study. The instructors were shown a list of the students who received the training with the AR tool. Question 1 compared the performance of the students in past classes to the students on the list; 43% of the instructors were positive toward seeing any improvement in the student's performances, they seemed more fluid, more comfortable out there than the others, 43% also had a neutral reaction, stating they didn't see any differences. The instructors indicated it was very hard to compare the different types of students going

through the schoolhouse for each class. Some students were brand new airmen, while others were coming from a different type aircraft. See appendix U for responses.

Question 2 compared the differences observed in the recent students' familiarity with engine start procedures compared to previous classes. The target students were the ones who were able to use the engine start scenario; 40% of the instructors showed a positive reaction and 60% showed a negative reaction towards any improvement. Most of the instructors felt they didn't see any difference in the current curriculum used to train initial compared students and the extra training some of the students received with the AR system for engine start. The data showed a bigger difference with the airdrop and combat offload scenarios. See appendix U for responses.

Question 3 linked the differences observed in the recent students' familiarity with airdrop or combat offload procedures compared to the students in the past. The interview data showed that 40% of the instructors were positive towards the students being familiar with airdrop procedures, with 60% neutral. Question 4 showed 0% were positive and 80% were neutral toward the familiarity with combat offload procedures. The important difference was that the combat offload procedures were only preformed twice during the training, whereas the airdrop procedures were performed at least six times during the flying phase. See appendix U for responses.

Question 5 compared the instructors' observation between recent students moving through the course any faster than previous classes. The syllabus allowed students to *proficiency advance* through the course as they showed full knowledge of the procedures. The instructors were split evenly across the board at 33% positive, negative and neutral. See appendix U for responses.

Question 6 compared the instructors' view about the current students having a better handle on CRM procedures compared to students in the past and in what way. The interaction with the crew using CRM procedures is one of the most important aspects to training in a crew type aircraft. Much of the communications occur when going through each of the checklists for that phase of flight; 75% of the instructors did notice that the students who used the AR tool were better able to know when to respond to the checklists. See appendix U for responses.

Question 7 asked about using computer based lessons to learn any of the Loadmaster procedures; 87% of the instructors were positive. The instructors explained that being able to use CBT type lessons, as a base; to start young students out and become familiar with checklist procedures could enhance their training. They explained that interactive lessons with some sort of free play for each of the scenarios using all the checklists, to include the emergency procedures, would enable the students to be more familiar with the procedures when using a variety of training devices, which would lead to better production on the flightline. They felt that if the students were more familiar with the checklists, the student's CRM skills would improve, to include the student's timeliness for acknowledging the checklist steps. See appendix U for responses.

Student and Contract Instructor Interview Analysis and Results

As per figure 20, the analysis of the interview data began by reviewing the recorded conversations and transcribing the responses into an Excel spreadsheet. Only the

Qualitative Data Collection from Interviews	→	Qualitative Data Analysis	→	Qualitative Results
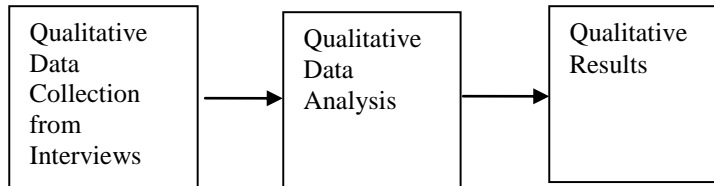
Figure 20. Qualitative Process: Validating Quantitative Data Model. From "Designing and Conducting Mixed Methods Research," by J. W. Creswell and V. L. Plano Clark, 2007, Thousand Oaks, CA: Sage Publications, Inc. Copyright 2007 by Sage Publications, Inc.

numbered consent forms were included for student identification. Each of the questions was evaluated for responses that were positive, negative or neutral. The number of responses and the percentages were calculated using Microsoft Excel. A comparison was made between each of the areas from the students and instructors during the qualitative evaluation.

Engine Start Interview Analysis and Results

In the area of fit and function for the engine start scenario, both the students and the instructors thought this type of training tool worked well in the classroom. The students felt the scenario took less than five minutes to set up, they thought the instructors were well trained and knowledgeable to run the computer system for the scenario. The virtual images stayed in their proper position and the scenario ran well during the training. The scenario was relevant to the course and both the students and instructors enjoyed the way the scenario was set up to practice normal procedures and some of the activity on the flightline, plus being able to practice emergency procedures for engine start.

The next section dealt with the knowledge and skills the students acquired using the AR tool and how much the instructors felt the students had learned the objectives with the tool. Many of the objectives the scenario covered had already been introduced to the students in previous lessons, so the knowledge presented was not new, but the students

did feel that it was good practice for flight training. The instructors were positive toward the use of the tool; they felt the system trained the lesson objectives better than the current training by having the students retain more of the lesson objectives. The instructors were very neutral about the students improving their procedural abilities going to the flightline. The instructors were only somewhat positive about the students having a higher level of proficiency or that the AR tool made their teaching time more productive.

The students were very positive about the engine start scenario better preparing them for flight training. The results showed high marks for the scenario being an enhancement over some of the other devices used to train Loadmaster procedures and showed that the students retained more of the checklist procedures during the training. This lead to the instructors believing the tool helped the students improve their CRM awareness. The students thought highly about this type of training tool being an effective way for them to learn the procedures. But one area that stood out for the instructors was the fact that they were very neutral about computer based lessons being able to teach Loadmaster procedures.

Comparing what the students liked to what the instructors liked about the AR system, the results showed that seeing the visual aspects of the checklist had the most comments. The instructors liked the crew interaction and the malfunctions available in the scenarios. Both the students and instructors liked the realism of the scenario. What the instructors did not like included the currency of the checklist in use and the lack of interaction for the students. The students wanted more of the physical interaction and being able to make the checklist calls themselves, rather than the instructor controlling the next step in the scenario. They also would have liked to have had more of the malfunctions for engine

start. Both were frustrated with the graphics for the propellers and the animated crew chief removing the chocks. Keeping the checklist up to date and providing realistic views in the training scenario are high priorities for the production model.

Student Combat Offload and Heavy Equipment Airdrop Interview Analysis and Results

The combat offload and the heavy equipment airdrop scenarios utilized the same computer equipment, HMDs and tracking cameras in the FuT. Each scenario required the students to access different parts of the training area. Comparing the two scenarios together brought out the sections in which the system needed improvements. The fit and function area of the device showed that the students were fairly positive about the goggles fitting well on the helmet. Overall, the percentage of the students who agreed with the combat offload questions were not as positive toward the airdrop scenario questions. The schedule called for the combat offload scenario earlier in the training than the airdrop scenario. The results showed that after some practice donning the equipment and working with the system, the students felt positive about their eyes adjusting to the view, the goggles not taking too long to don or adjust, the scenes ran smoothly throughout the scenario and the training was ready to go by the time the students had the equipment on. In both scenarios, the scene tracked well to following the students around in the FuT.

The students thought the instructors were well prepared to run the AR system and provided a good explanation as to what would go on during the training using the AR tool. Most of the students felt that they could apply what the scenarios taught them to flight training. The positive comments indicated that most of the students felt the

scenarios were relevant to the course they were taking. The combat offload scenario scored somewhat higher than the airdrop scenario in reinforcing the material better than earlier lessons and helped them retain more of the procedures. In the question about how well an AR type of training tool helped them to learn the objectives, the airdrop scenario scored higher than the combat offload scenario.

What the students liked best about the scenarios was the ability to see what was going on during the procedures. They liked being able to physically run through the checklist, hear the front end crew going through the steps and being able to walk around the FuT as if flying on the real aircraft. A few other areas included: provided them good situational awareness during the checklists, having a better feel for what was going on and what would happen next. What the students criticized was the tracking dead spots, which made the images disappear; the technical issues, which extended the set up time, and how the helmet fit, being that the goggles were too heavy on the helmet. Some of the students didn't have their own helmet, which made it difficult to align the goggles with their eyes if the helmet was not a custom fit.

An additional question was added during the interviews about what other things could have been included that would have helped during flight training. The biggest response was for all of the emergency procedures to be included in the scenarios. The students also felt that if the device were available after class, they could practice on their own. One suggestion was to have the checklist brought up in the goggle view as they were going through the steps.

Contract Instructor Fuselage Trainer Interview Analysis and Results

The contract instructors utilized the AR tool to train both the combat offload and heavy equipment airdrop scenarios in the FuT. From the instructors view, half of them felt they were taught well enough to run the system to train the students. They were split evenly about the system being easy to set up or run. The virtual images did not stay in the proper positions for the students and the instructor's time was not more productive using the tool, but the graphics did portray a realistic view of the actual events. They emphasized that the system needed to be stable in order for the students to grasp the concepts and make the instructors time worthwhile, it's important because of the limited time allotted in the schedule for training on the FuT.

Two thirds of the instructors thought the device was an adequate training tool to teach Loadmaster procedures, the students retained more of the objectives, as well as having the scenario train the lesson objectives better than the current training. They were very neutral about the students having improved their procedural abilities or having a higher level of proficiency.

An important factor for crew type aircraft is the interaction between the crewmembers. The instructors were somewhat positive about the students' CRM awareness after using the AR training tool. One of the main questions was to see if computer based training could be used as a stepping stone to learn Loadmaster procedures. The contract instructors were positive about using this type of training but cautioned against using it exclusively.

What the instructors liked about the AR tool was the interaction with the virtual crew. They liked the idea of letting the student "get the wind in their hair" virtually, before

going to the flightline for training. What they didn't like was the checklists in the scenarios not being current, keeping the device running constantly during the training, the computer glitches and the limited view in the goggles. Many of the lessons learned will need to be incorporated into the design for the next generation of AR training tools.

Grade Book Data

Augmented Reality Student Strengths

The student records were set up with different sections to capture the date of the flight, the training period, the overall performance of the student, the flying time accomplished, the mission profile, strengths the student showed, areas for improvement, unusual circumstances and an area for recommendations for the next flight. The data were drawn from the strengths and the areas for improvement from the students who volunteered to use the AR system. Of the 95 student consent forms signed, 79 student records were drawn from the training records database. The data showed that 55 students were able to use at least one of the AR scenarios. Usually a student received eight flights, to include the checkride. The data were taken from all the fights except the checkride. As per figure 21, the top strength for the AR students were their ability to run the in-flight checklists. The instructors commented that the AR students were better than some of the other classes for Combat Offload procedures. Overall general knowledge about the Loadmaster duties and responsibilities received the third highest comment. The students' CRM skills showed nearly the same number of comments for strengths. Pre-flight checks showed positive comments, whereas reverse taxi and situational awareness both received the

same number of comments. The coordination brief preformed in the aircraft showed

fewer comments. The last three areas that stood out were for emergency procedures,

airmanship and airdrop preparation.
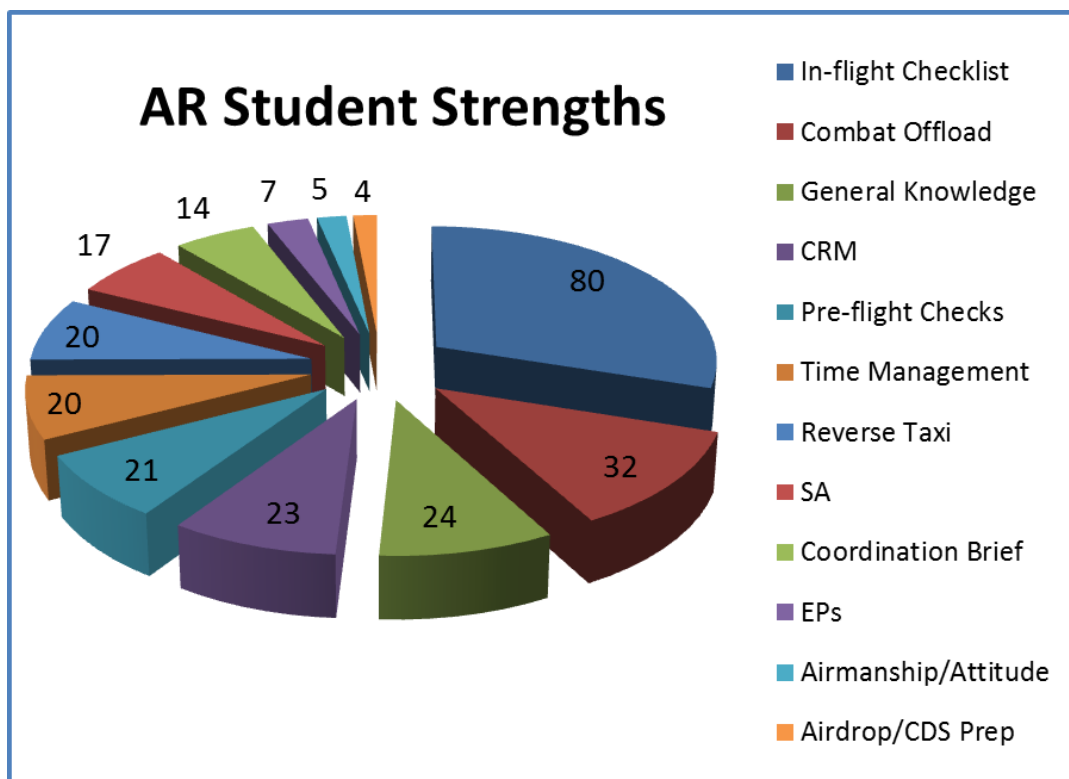
Figure 21. Augmented Reality Student Strengths

Augmented Reality Student Areas for Improvement

   As per figure 22, in the areas for improvement, the AR students had the top comments

for their in-flight checklist procedures. Next was their time management, followed by

comments for improvement of general knowledge, communications with the crew and

flight partner, situational awareness, emergency procedures, crew resource management

skills, crew coordination brief and the final comments for their preflight techniques.
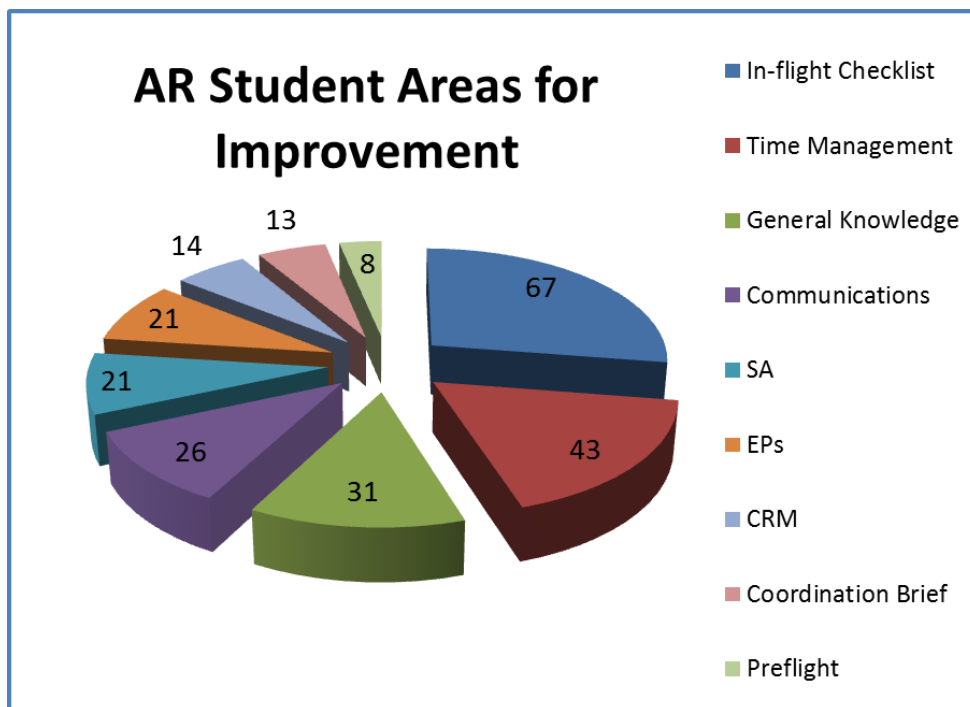
Figure 22. Augmented Reality Student Areas for Improvement

Non-Augmented Reality Student Strengths

As per figure 23, 24 of the volunteer students were not able to use the AR tool. The top comments for strengths was in-flight checklist, followed by crew resource management, time management and general knowledge, situational awareness, Combat Offload, reverse taxi, pre-flight checks, coordination brief, airdrop preparation, and for emergency procedures and airmanship.

Non-AR Student Strenghts

Legend:
- In-flight Checklist
- CRM
- Time Management
- General Knowledge
- SA
- Combat Offload
- Reverse Taxi
- Pre-flight Checks
- Coordination Brief
- Airdrop/CDS Prep
- EPs
- Airmanship/Attitude

Values shown: 40, 22, 12, 12, 10, 9, 6, 5, 3, 2, 1, 1
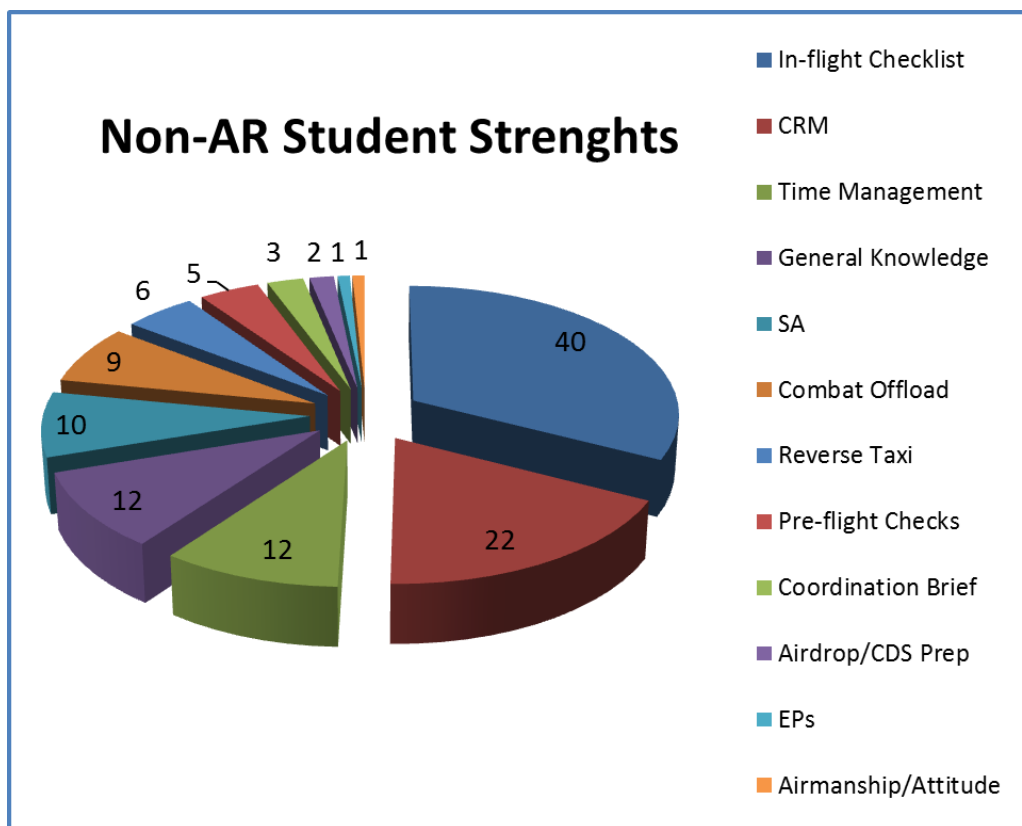
Figure 23. Non-Augmented Reality Student Strengths

Non-Augmented Reality Student Areas for Improvement

As per figure 24, the areas for improvement for the students who did not use the AR tool showed the top comment for the in-flight checklist, followed by comments for emergency procedures, time management, communications, crew resource management, general knowledge, coordination brief, situational awareness, student confidence and preflights.
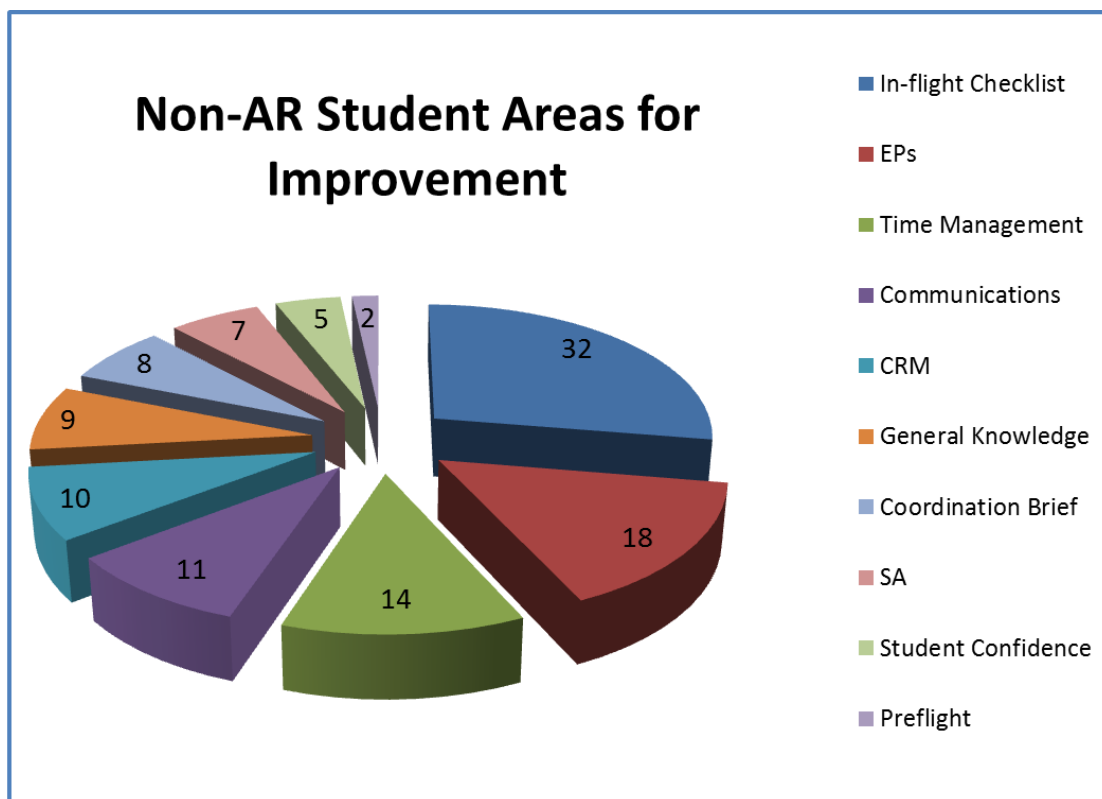
Figure 24. Non-Augmented Reality Student Areas for Improvement

Flight Instructor Interview and Student Grade Book Analysis and Results

Limiting the flight instructor's knowledge about what the student volunteers were doing with the AR tool allowed them to present an honest opinion about what they had observed in the students' behavior. Comparing the comments from the interviews to the student records revealed areas that were enhanced and areas that needed improving. The instructors did not indicate that the students' performance had improved, in fact comparing the strengths for both AR students and non-AR students, the instructors had some of the same comments for both sets of students. The inflight checklist comments were about the same, verifying the instructor's neutral response.

The flight instructors were asked about each of the scenarios used in the training. There were no comments for engine start in the student record strengths and the instructors were 60% negative about the students' familiarity with the procedure. The combat offload comment did show up more often in the student strengths for the AR students, but the flight instructors were 80% neutral about the students' familiarity with combat offload. The airdrop scenario showed 60% neutral and airdrop procedures were very low on the list of strengths for the students. The instructors expressed that it was tough to pinpoint specific events with all the flights and students they ran through during the time of the study. That may be why they were split on their observation of students not progressing through the course any faster than previous classes.

What the flight instructors did notice was that current students had a better handle on the CRM procedures compared to previous classes. In fact, both the AR and the non-AR student strengths showed quite a few positive comments. The study was limited in training three scenarios, CRM is taught throughout the course during all phases of flight.

One item the flight instructors were all interested in was the use of computer based training to teach Loadmaster procedures to include emergency procedures, the coordination brief and airmanship. All three areas scored low on the list of strengths for all of the volunteer students. What stood out in the areas of improvement for both the AR and non-AR students were the in-flight checklists, time management, emergency procedures and communications with the crew. Again, CRM plays a big role in getting the in-flight checklists completed, dividing up the time to accomplish all the items in the checklist and communicating with the crew where the student is at trying to accomplish the checklist items.

Summary

    As per figure 25, comparing the quantitative data to the qualitative data helped to

validate the responses the volunteers made both in the surveys as well in the interviews

and student records. The engine start scenario taught in the classroom was well received

by both the students and the contract instructors. They felt that this type of training
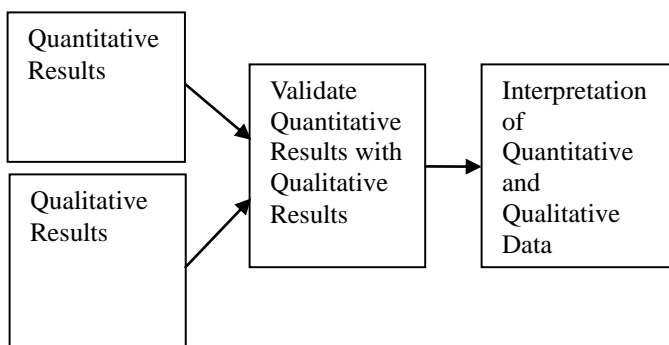
Figure 25. Combined Validation and Interpretation: Validating Quantitative Data Model. From
"Designing and Conducting Mixed Methods Research," by J. W. Creswell and V. L. Plano Clark, 2007,
Thousand Oaks, CA: Sage Publications, Inc. Copyright 2007 by Sage Publications, Inc.

worked well in the classroom to introduce the procedures and to have the availability to

practice the checklists before going to the flightline for training. The system was simple

enough to run and did not take too long to set up or run through each of the steps. The

students did request more interaction with the system itself, in a free play mode, for them

to use after class.

    For the combat offload and the airdrop scenarios, the instructors did receive enough

familiarization training to run the scenarios and emergency procedures without any

problems that could not be corrected quickly. The volunteer instructors were enthusiastic

and eager to learn about the AR training tool. They would like to see the production

model be more portable, in order to take the scenario to a static aircraft and show the

students what to look for during an engine start, preflights or even what a pallet parachute looks like during a malfunction.

During the study, the engine start scenario was not part of the regular curriculum. Some of the information about the checklist was taught in previous lessons. The knowledge and skills were not viewed as being new, but the information gained from the practice of the procedures enabled the students to apply the training on the flightline.

The student interview data coincides with the survey data showing that the AR practice better prepared them for flight training. The other areas of behavioral changes didn't show as high a score, but most of the students felt that this type of training tool was an excellent enhancement to the training, helped them retain more of the checklist procedures and was an effective way for them to learn. The instructors followed the same logic, stating that the scenarios helped the students improve their CRM awareness.

An important aspect of the scenarios dealt with the realism portrayed in the lesson. The students and instructors liked the idea of seeing the props turn, the interaction with the recorded cockpit voices and the visual aspects of all the situations a Loadmaster would see on the flightline. Improvements, captured during the data collection, included better graphics for the crew chief, more detail on the engines themselves, a quicker way to update the checklists to the latest procedures in order to stay current with flightline training and a stable training environment.

Chapter 5

Conclusions, Implications, Recommendations, and Summary

This chapter begins by answering the research questions in the conclusion, then looks at the limitations the study was subjected to during the testing phase, followed by the implications from what was discovered using the AR training tool. Next, there were several recommendations for future research and upgrades to the system. The report ends with a summary of the investigation.

Augmented reality has matured rapidly over the last few years. The application for augmenting the real world has led to an alternate way to teach and learn. Students often carry multiple devices that can utilize the most current technologies available. Teachers can take advantage of these learning devices by providing lesson material readily available to the students. The students can now access the information about the tasks to be done anytime, anywhere.

The ARCLT system also matured during the development and testing phase. The SGTO lessons learned, the LGTO data analysis and the upgraded software and hardware has made the ARCLT tool ready for deployment into an aircrew training system. The results of the surveys show that certain areas need to be improved, but the students and the contract instructors felt that this type of training device would help the students better understand Loadmaster procedures, before they are trained on the aircraft. The flight instructors saw a difference in many of the participants' CRM skills. Students were better able to understand when to listen to the crew for their required response. The students' checklist responses became natural and without hesitation. Practicing in a simulated

environment eliminated the need for the student to look at the instructor for approval before answering the checklist. As one flight instructor said, "We should only be observing what the students were taught on the hill, they have been given everything they need to know, we should be there to help them practice what they know." The problem was the students just do not get enough practice in the FuT to bring them up to speed for flightline training without some type of simulation scenarios.

Conclusions

The research questions helped to guide the study through the different stages of developing a training system. One of the main aspects of a crew aircraft is to establish good CRM. The first question helped enabled the investigator to guide the participants to think about how computer-based training had been set up in the past, what the different levels of CBT lessons are available today and how simulation can improve the skills needed to become a Loadmaster. The second question dealt with the aspect of physically adding to the existing curriculum and equipment currently in use. The third question built upon the results from the initial evaluation from the SGTO for hardware, software and instructor script. The fourth question gathered the lessons learned through this project and presents them for others to use when building similar AR training devices.

Research Question 1 *"Why are computer-based simulations insufficient for learning to master CRM skills needed by Loadmasters?"*

Computer based training faces several challenges to teach CRM skills that include: How to teach teamwork skills with the students sitting in front of a computer and how can the student practice CRM procedures without being integrated into a team building scenario (Kearns, 2009)? Research shows a variety of studies conducted focusing on the transfer of learning CRM skills. Hahn 2010 describes comparisons with desktop flight simulations with computer-based video game training; the results gathered in a high-fidelity simulator showed superior CRM skills transfer with the desktop trainer but showed no difference in technical problem-solving skills between the two groups.

Interactive courseware is a term used to describe computer based training with an emphasis on interactivity. Computer based training has been used for many years in the C-130H schoolhouse. The technology in the early years of the ATS began with the lowest baseline category, using a linear format to present one idea at a time (Yacovelli, 2012). Many of the current contract instructors remember their students using these training aids to quickly run through the lessons by clicking one frame after another without absorbing the objectives. Over time, as new contracts were written for training, the need for interactivity was necessary to put into the contract requirements. Currently, the ATS uses category three interactive courseware as part of the aircrew academic training. This category involves more complex information and allows the student more control of the lesson scenario (Yacovelli, 2012). Interactive lessons have been used to familiarize students with dangerous situations outside the flying arena. One of the lessons used to train miners shows how students should react to a situation involving someone stepping in the wrong direction or approaching a dangerous situation; the buddy concept or crew

concept is crucial to keep everyone safe in the group when descending into a mine (van Wyk & de Villiers, 2008).

The data collected from the surveys at the beginning of the testing phase, indicated the contract instructors were dead set against using any computer-based training to learn CRM skills. They believed the students would not absorb any of the concepts for CRM based upon what they had remembered from past CBT lessons. This corresponds to research on human factors; a linear type CBT lesson regards the students as *sponges* who are passive, waiting to soak up knowledge (Kearns, 2010). Many of the lessons did not give the students an opportunity to practice any of the new knowledge they received. After discussing how the training could be set up with interactive lessons, during the interviews, the instructors were a little more receptive to the idea of introducing CRM concepts to the students using a simulation type of training tool. But they were very insistent about training the objectives, which should not be taught exclusively with computer based lessons. The use of simulation does result in more learning if used as a supplement rather than a standalone system (Hahn, 2010). The instructors felt, in a crew type aircraft, personal interaction works the best for getting young students used to speaking up and acknowledging the checklist items without looking for approval from their instructor.

Lockheed Martin developed an interactive computer based lesson for students to accomplish preflights of the aircraft. They call it the *360 lesson*. The software uses actual pictures of the cockpit, the cargo compartment and the outside of the aircraft so students can virtually walk around the fuselage for the exterior and interior pre-flight checks. The lesson enables the students to control where they desire to go and can zoom in on specific

items in the checklist. For instance, on the exterior pre-flight checklist, the students must ensure the ground refueling valves are in the correct positions. If the student does not know where to look in the wheel well on the right side of the aircraft, a help button is available to show them where the panel is located for the next step in the checklist. Once in the proper position to see the panel, the zoom-in feature shows the student a close up view of the switch positions. They can toggle the switches and the software brings up more information into view about the positioning or moves onto the next step in the checklist.

The interactive 360 lesson could be set up to involve some of the same type aspects as the ARCLT: the voice recordings of the other crew members, physically viewing the aircraft on the flightline by tracking the student's position or having the whole lesson on a portable device for student free play. In this manner the CRM skills required for Loadmaster students could be practiced using computer based training. The evolution to computer systems and the development of better software allows for much more student interaction utilizing computer based learning. Research using Remotely Piloted Aircraft (RPA) students showed new crewmembers, being "Generation Y," were more familiar with CBT modules which enhanced their human factors skills as would the interactive 360 lesson introduced to Loadmaster students (Kaiser, Spiker, Walls, Eberhart, Butler, Montijo, & Vanderford, 2010).

Research Question 2   *"How can an AR device be added to the physical training site to complete the training process?"*

The setup of any training device needs to pinpoint what the purpose of the device will be for training. Specific training objectives should be set by the users, the manufacturer and the evaluators that will test the completed system before building the device. Often, the requirements for the system grows as the capabilities of the device become common knowledge. The use of the AR tool provided an insight as to what the system was capable of and what some of the requirements should be in the production model.

The C-130H ATS has four fuselage trainers set up in a hangar capable of loading and unloading a variety of cargo. The hangar doors are arranged so that loading vehicles such as a forklift, K-loader or rolling vehicles can fit through the doors. In order for the AR tool to be effective, the system wiring harnesses, cameras and control boxes could not interfere with normal operations of loading or unloading the trainer. In order to hide the components, crossbars were manufactured to clamp to the underside of the center top platform inside the cargo compartment, known as the *hog trough*. The hog trough supports many of the wiring harnesses and cables that run the length of the aircraft, positioned about nine feet above the floor rollers. This allowed the cameras to be mounted high enough to be clear of tall cargo and be pointed down enough to cover the training area for tracking students' movement throughout the fuselage. Lessons learned from the SGTO showed where the students needed to reach past the hog trough to complete interior checks. Instructors showed where the cameras or the cross bars would interfere with their training in the fuselage. Drawings were prepared to specify where the best placement would be to satisfy both the tracking requirements but be out of the way of student training.

Two sets of computer racks were used to collect the tracking information from the cameras which provided the video feed for the AR goggles and connected the instructor's IOS to the system. The fuselage tracking cameras were divided up into volumes. Most of the volumes were set up with eight cameras, except the first and last volumes. The end volumes were set up to pinpoint where the Loadmaster student would pull the release handle for the pallet locks in the floor near the front of the cargo compartment or lay down on the ramp to guide the aircraft for reverse taxi at the rear of the aircraft. The computer racks were positioned outside of the FuT, on the left side, and the wiring harnesses were routed from the cameras, behind the insulation, through the wheel well of the aircraft to the computer racks. The cameras used USB connections from the cameras to six eight port hubs which were then used to connect to the computer racks. The power cables for the cameras and hubs were run along the same routes as the video cables. After many hours of troubleshooting the tracking analogies, it was discovered the synchronization of the cameras worked best if the video cabling to each of the volumes were the same length to the USB hub. Plus, the hubs had to be shrink-wrapped in order for the USB plugs to stay connected to the hubs, due to FuT movement from loading and unloading heavy pieces of cargo. Provisions had to be made to beef up many of commercial products for use in a military training arena.

The helmet and goggles were stored on a stand outside the fuselage, ready for the students to don for the lesson. When the two scheduled students showed up for training, they were briefed as to what the scenarios would entail, the procedures used to don the equipment and what to look for in the trainer. A technician would help the students prepare the equipment to ensure the helmet and goggles were in the correct position and

tested the view before going into the training area. As the student entered, the technician ensured the instructor was ready to teach the lessons using the IOS to start and control the scenarios.

As the scenario started, the instructor could quickly evaluate how much the student knew about the checklist he was running. If the student needed more help in locating the proper position, the instructor could talk to the student through the headset at the IOS. A small desk with the IOS laptop and headset was positioned in the forward part of the FuT, out of the way of the training area. This position enabled the instructor to see where the student was walking in the FuT, where he was in the checklist and the IOS allowed him to see what the student was seeing in the goggles with a window on the laptop. As the scenario played out the instructor could freeze the scene or go back to repeat a section of the checklist he needed to emphasize. After running through the normal procedures the instructor would set up an emergency for the student to practice, depending on the amount of time allotted for that set of students.

Through the surveys and the interviews with the students and instructors, the requirements for a production model of the AR system can now be better defined. The questions about the fit and function of the scenarios allowed the volunteers to test the prototype and pinpoint some of the problems encountered. Adjustments were made to accommodate the interference with training or modified to allow better tracking and visual images, but time and funds were limited to make corrections in a suitable manner. As in the other training devices the ATS uses, maintenance time on the AR system will need to be scheduled appropriately.

Research Question 3 "*Based upon the initial evaluations of the prototype AR system, what adjustments were made to the hardware, software and to instructor scripts?*

The original setup for the camera configuration required 16 cameras using two volumes to cover all of the FuT area. The software engineers quickly discovered that more cameras would be required to track each student throughout the training area. Also, specific cameras were needed to cover critical areas used during the training. The final configuration resulted in setting up 38 cameras with six volumes (Mayberry, Jaszlics, Stottlemyer, & Fritz, 2012).

Extra computer blades were added to the computer cabinets to accommodate all 38 cameras in the FuT. A minimum of three cameras were needed for a useable volume, but four or more were common which created a cube shaped tracking volume that worked best in a small area (Mayberry, et al., 2012). There was one blade for each volume in one cabinet, the other cabinet held the network computer, video computer and the tracking computers to condense all the camera information into a simple solution for each student. The systems were reconfigured each time a new tracking solution was tested.

During the SGTO, reflective spherical markers were used on top of the student's helmet, placed in a specific constellation. The cameras would detect each of the student's helmets by emitting an infrared light. A bank of light-emitting diode (LED) lights incorporated into the camera face would flood the area with infrared light, see appendix V. Unfortunately, the light also reflected off the shiny parts of the FuT. This created *infrared noise* that would make the tracking unreliable (Mayberry, et al., 2012). The LGTO replaced the reflective markers with infrared emitting LEDs configured in a

specific constellation to distinguish the students apart. The infrared emitting light on the cameras were simply shut off, eliminating the *infrared noise* and greatly increased the tracking accuracy (Mayberry, et al., 2012).

The C-130H Loadmaster utilizes a communication cord connected from the helmet to the communication panel on the aircraft. The *comm.-cord* is about 50 feet long, enabling the Loadmaster to stand out in front of the aircraft during engine start or have enough slack to move around in the cargo compartment while listening to the crew run through the checklists. Originally a replacement cord was utilized to run the video feed to the ARCLT helmet and still have communications with the virtual crew and the instructor during the SGTO. The replacement comm.-cord was slightly larger in diameter and a bit heavier than the normal comm.-cord. One of the tests conducted by the manufacturer of the ARCLT was to see if the computer generated scenes could be presented in a wireless system, replacing the heavier cord with the normal comm.-cord and use the interphone system of the aircraft to communicate from the IOS to the students.

Through testing of a variety of wireless systems, one was chosen to present the video feed to the student's goggles. The main concern was the ability for the wireless signal to penetrate the skin of the FuT. The high frequencies used in today's wireless networks enable the signal to go through the aluminum frame of the FuT with no interference. The only drawback in using a wireless system was the battery pack the students had to wear in the harness for the receiver unit. Although the receiver unit was small and the batteries were light weight, the battery pack had to be recharged fairly often. It didn't take long to discover when the batteries were low on the system; the video picture would disappear in the goggles.

In the original design of the ARCLT, it was thought that the goggles should be heavy duty in case a student trips and falls in the FuT. LiteEye manufactured the original goggles and mount. The lenses on the goggles were surrounded with a metal frame using the side panel to project the images onto the see-through glass. The frame on the sides of the goggles limited the peripheral view of the user, but did not interfere with the view underneath the goggle, see appendix W. It was important to ensure the view under the goggles was not obstructed to walk over the rollers in the FuT.

The goggles used in the LGTO incorporated the Trivisio version of the see-through lenses, see appendix W. The Trivisio goggles had very little metal surrounding the lenses, thus allowing better peripheral vision. The design of the mount restricted the movement of the goggles to swing out of the way of the student's face when donning the equipment. The donning procedures had to be changed to allow the students to put the helmet on first, and then the goggles would be mounted on the helmet by the technician.

The new goggles only increased the display field of view up to 29 degrees diagonally, but eliminated the tunnel vision effect of the original goggles. The ARCLT combines mostly real-world views with the virtual scene, the Trivisio goggles allowed the students to see reality in a near-normal manner by keeping the AR images appearing in the center of the their vision (Mayberry, et al., 2012).

Instructor script

The engine start scenario started out as an outside unit composed of two computers for tracking and visual, a laptop for the IOS, the helmets and goggles in a rolling cart with a power regulator and a 100 foot extension cord. The unit was set up facing the side of a

hangar. Fiducial markers were used to create the virtual aircraft on the side of the hangar from the view in the goggles. The camera on the student's helmet would pick up the markers set up in a specific configuration in order to track the distance and position the student was from the hangar wall. As the students moved from left to right, the aircraft would stay in the proper position so the student could see the props and engine nasals. The instructor could speak to the student through the headset and helmet communications system. As the checklists were called out by the recorded crew voices, the students would go to the proper location in front of the aircraft to watch each engine start. The instructor had control over each step in the checklist, in case the student needed extra help or the instructor wanted to point out a specific item in the checklist to the student. If the student responded to the checklist in the appropriate way, the instructor would click enter to go to the next step. Once the student learned the normal procedures, emergency procedures were introduced. The scenario was reset with the malfunction and the instructor would run the scenario again.

The problem with the setup for the outside unit was the natural environment surrounding the hangar. The sun would shine on the hangar behind the AR unit, reflect onto the dew in the grass in front of where the student would stand and create a false reading for the camera on top of the student's helmet. This made the virtual aircraft jump around on the hangar wall when the student would walk to the next engine. The best time of the day was in the evening just before dusk or on a cloudy day that had an overcast sky, which limited the utilization time. The instructors liked the idea of being able to show what to look for on each engine start and suggested we move the scenario into the classroom so that 8 to 10 students could experience engine start all at once.

The scenario was reconfigured so the normal engine start would go through the steps in the checklist at a consistent rate as if starting engines on the flightline. That way the instructor could talk through the steps as the scenario played out or he could pause the system in order to point out specific items. The emergency scenarios were set up so that the instructor had control over each step as the students responded. He would step the students through with an explanation for each event during and after the emergency. Once the instructor was satisfied with the class response, he would click enter and the scenario would continue.

Research Question 4   *"What lessons have been learned about the use of AR devices in training that will ascribe value to other training situations?"*

The guaranteed student clause caught us by surprise for testing the scenarios. The contract states that Lockheed Martin will train the students to a certain proficiency level for each crew position. If the flight instructors feel the students are not proficient enough to fly, then they are sent back to the contract at no cost to the government. When testing a smaller group, the interruption from the normal class flow is not much of a factor. When testing a larger group, consideration for the other students and instructors needed to be taken into account. Disrupting the student flow or changing the way the contracted instruction is laid out was considered outside the scope of the contract, which led to extra charges levied on the government. The second best way to test the AR system was to use the same environment as the students use with the contracted training.

The use of the same training environment made it possible to evaluate the training arena in which to employ the AR tool. Knowing the limitations as to where to mount the cameras or run the wires can only be experienced in the actual setting. There were many trials and errors experienced stringing the video and power wires throughout the FuT. At first the cameras were mounted individually and the wires were run to a central location in the wheel well. A small panel behind the insulation in the wheel well was removed to access the computer cabinets outside the FuT. The individual mounted cameras made the process of calibrating the cameras time consuming. The software engineers designed mounting brackets to hold four cameras, two brackets for each volume, eight cameras per volume (Mayberry, et al., 2012). In doing so, the position on the cameras could be calculated beforehand, thus speeding up the calibration time. The cameras still needed to be pointed in the right direction to cover the entire FuT and the camera software had the ability to see where the cameras were pointing. The software engineer coordinated with the instructors to ensure coverage included all the positions the students would be using during the mission training.

Limitations of the Study

Limited time to train and contracting funds played a major role in selecting the scenarios for the SGTO/LGTO. The engineering capability of the small business contractor was put to the test in selecting the engine start and FuT scenarios. With the SGTO the original thought was to align the virtual propellers and engines onto a real aircraft in an outdoor environment. This effort proved to be outside the scope of the

software engineer's capabilities. Once the system was reconfigured, fiducial placards were used on the side of the hangar to replicate an aircraft in a virtual scene, but the weather kept interfering with the helmet mounted camera view, i.e. interference with the position of the sun reflecting off the hangar behind the training area or the sun reflecting off the dew on the grass in front of the placards. So, the engine start scenario was reconfigured to be taught in the classroom limiting the study to only indoor use.

The scenarios were chosen that provided a hardware and software challenge for the Pathfinder Systems engineers and included some of the significant checklists the C-130H Loadmaster would need for aircraft training. The limitation was having the scheduled time to fully develop all the appropriate scenarios and have time to train each student on normal and emergency procedures in the normal course flow. Many of the students commented they would have liked to have seen more of the emergencies for all the checklists.

The students who participated were limited to the volunteers who were within the timeframe of the study. The only screening of the volunteers was based on scheduled availability. Some of the students were able to utilize all three scenarios, but many others could not. The limitation of not implementing the training tool into the normal flow of the curriculum allowed the scheduler to place some of the students into the AR training who had not been through the academic portion of the checklist training. Results indicated that the instructor had to lead the students through each step of the checklists for that scenario. Not much practice for the student, but comments came back that they had a much better idea as to what should go on during the checklists once the lesson was taught in the

classroom. Then, they wanted to go back to the FuT and practice the procedures with the AR tool.

Implications

AR training systems have been used for many years in a variety of disciplines for CRM training or learning specific tasks. Taking the knowledge of how those systems were used and incorporating them into Loadmaster training will not only increase the Loadmasters' abilities to run the checklists, but to be able to better interact with the crew during critical times in flight. The underlining goal of this project was to see if an AR tool could be used to replace flying sorties. In today's financial environment, the government is looking for ways to reduce training flight hours, but not diminish the quality of the students graduating from the schoolhouses. The three scenarios showed the volunteers felt that an AR tool, for CRM and Loadmaster procedures, would work for the C-130H schoolhouse. From the volunteers' feedback about the tested AR system, inferences can be drawn that, with the correct scenarios positioned in the appropriate places in the current curriculum, one to two sorties could be saved by setting up an AR training tool in each of the FuTs.

Recommendations for Future Studies

One aspect of this study was to produce a valid and reliable instrument to measure the efficiency and effectiveness of the ARCLT. Using the Kirkpatrick model as a basis for

the survey and interview questions worked well in bringing out the areas that needed

improvements and what the participants would like to see in the production model. There

were quite a few comments about the tracking system. Future researchers may wish to

consider the use of a tracking system employing a differential GPS. The ability to use

GPS from a known position on the earth and then relate that position to a smaller area in

the training arena may provide down to 1mm of accuracy, which is needed to track

students in a closed-in space (Fong, Ong, & Nee, 2008). The alignment of the cargo

compartment and the virtual scene is critical in immersing the students into the scenario

as if on an aircraft in flight.

Based on the conclusions, findings and limitations, there are several recommendations

for future research.

1. *Involve the users in the system design to include courseware writers, instructors and personnel evaluating the training system*

2. *Incorporate the latest technology to track the students in the area, limit the weight of the equipment the students are required to carry and make the wearable equipment easy to don*

3. *Train the instructors well to insure their time is productive in setting up and running the lessons using an AR tool*

4. *Embrace the technology savvy students in allowing free play of a training system to include outside the classroom learning*

5. *Plan ahead for maintenance and upgrades to the system as technology changes quickly*

These recommendations were developed from the lessons learned in dealing with a

government contracted training systems. Military flight training presents unique

challenges when trying to integrate a new training philosophy. It takes an extra amount of

time to convince the users, the instructors and the leadership to embrace new technology in a well established training system. Plan accordingly.

Summary

Introduction

In 2004 the C-130H training community decided to move as many flying events as possible from the aircraft to the simulator. This would require a change in the way students were taught. In order to make this change, AMC had to change the contract so more of the training was done by the contractor and less by the active duty instructors. To start with, AMC had to upgrade the WSTs, create other desktop trainers for the pilots, upgrade the Flight Engineer's PTTs and change the way instructors taught preflight events on the aircraft for the Loadmaster. It was written into the contract that the Lockheed Martin instructors would use static aircraft on the flightline to teach the aircraft preflights. The whole idea was to eliminate some of the sorties required for flight events and accomplish them with simulation. The ATS was successful, for the most part, in reducing the overall flight profiles.

Problem

But a problem still existed for Loadmaster training. A Satellite Loadmaster Station (SLMS) was manufactured using a Smart Board, which showed the virtual cargo compartment, a floor mounted pallet release handle, to practice kneeling down at the proper location and a wall mounted simulated "T" handle, to manually release the drogue

parachute. The SLMS was connected to the WST through a communications panel, so the Loadmaster could hear and respond to the checklist calls as the Smart Board showed the flight profile. The SLMS was limited in practicing many of the mission profiles, but helped introduce some of the CRM skills needed for flight training. The hands-on training for the Loadmaster in the FuT was still the most used device for mission training procedures.

In 2006 AETC advertised that funds were available, through ETTAP, to build a prototype device for testing new technologies. During the first semester at Nova, the idea of using a virtual picture to simulate an aircraft dropping heavy equipment from a Loadmaster's viewpoint was born. The idea of using an augmented reality solution was presented and accepted by the ETTAP committee. Funds were allocated to conduct market research to ensure a small business could create, manufacture and sustain such a training tool. Two companies qualified to compete for the contract, Pathfinder Systems, Inc. won the bid.

With the $666,978 from ETTAP, it took about one and a half years to design, build, and test the system before setting up the scenarios at Little Rock AFB. The first attempt at creating an engine start scenario proved to be too much of a challenge for the contractor. The software to align the virtual engines and props up to the aircraft was not mature enough to create a stable scene using the aircraft on the flightline. The second thought was to use a fully virtual aircraft and place the student at the proper distance from the aircraft by using fiducial markers on the side of a hangar and a camera on top of the student's helmet. A small group of students tested the scenarios in 2008. But what proved to be overwhelming for an outdoor training tool included the sun reflecting off the

adjacent hangar during specific times of day, whether there was enough cloud cover to help reduce the reflection from the sun or the wind blowing the fiducial markers, creating havoc for the tracking software. All these factors interfered with the tracking to the point where the instructors suggested the scenario be moved to the classroom. With the instructor controlling the scenario, 8 to 10 students could run through the checklist at the same time. The instructor could pause and emphasis the different parts of the checklist and go back and show the students the emergency procedures associated with engine start.

Goal

For the scenarios in the FuT, the idea was to pick the procedures that posed the most challenge for Pathfinder's software engineers and be part of the critical training required for Loadmaster students. Several scenarios were created, heavy equipment airdrop, reverse taxi, combat offload of pallets and even a fire in the cargo compartment, but only the airdrop and combat offload were tested on most of the students. Time was limited on the Pathfinder Systems contract to collaborate with Lockheed Martin on the testing phase timeline and the goal was to not cost the government any extra funds for testing the system outside the ATS contracted training. The concerns from the government's Quality Assurance Representatives were that this effort was out of scope of the current contract. Lockheed Martin could not guarantee that all the students would be ready for flight training, if only some of the students used the AR training tool. The LGTO would incur overtime for the contract instructors if used outside the current contract. In 2010 an additional $784,528 was allocated to upgrade the overall system. These funds provided a

contract between all the parties involved to use the ARCLT outside the normal class schedule and nailed down a timeline to conduct the study. Funding was included to pay for the overtime the Lockheed Marin instructors incurred.

Literature Highlights

Simulation devices are used more often than actual aircraft for training student pilots, especially for emergency situations that involve extreme conditions (Mayberry, 2010). Simulation is less expensive to operate than aircraft (Jean, 2009). Simulation is the imitation of actual conditions that provides a rapid and realistic feedback, improves higher-order cognitive processes (Oliva, & Bean, 2008; Ravert, 2008) which helps to retain more of the information longer (Bloom, 2009) and teaches critical skills (Hunt & Callaghan, 2008).

AR combines a live view of a physical, real-world environment with computer-generated sensory inputs (Azuma, 1997; van Krevelen, & Poelman, 2010). A brief historical overview shows some of the simplest devices such as the Sensorama used by a single person (Heilig, 1962) to the Natural History Museum in London enabling a massive group of people to see the images (Barry, Thomas, Debenham & Trout, 2012). To accommodate a larger group of people the display of the information was set up to be viewed as the people walked by the exhibits. Basically displays have three ways to present images using AR: video see-through, optical see-through and projective displays (van Krevelen, & Poelman, 2010). With the advent of smaller computer parts, the increase in the speed of the processors and the ability to *wear* the computer has made it easier to incorporate HMDs into student training (Papagiannakis, et al., 2008). But to

keep up with what the students sees and what he may need to feel, shows that real time user tracking has become one of the main concerns in developing an AR system (Kim & Dey, 2008). Studies show that students illustrate a significant improvement in transferring skills learned with haptic feedback (Botden, Hingh, & Jakimowicz, 2008a). Many AR systems are still in their infant stage of development for tracking and displays, with no standards having been set to measure how well a particular device or system enhances the training. This study focused on how well an AR tool could be used for Loadmaster training.

Methodology

Triangulation was used to validate the quantitative and qualitative data. Mixing the way data were collected helped verify the feedback from the students and instructors by comparing the questionnaires to the interviews (Creswell & Plano-Clark, 2007). The limited time set up on the Pathfinder Systems' contract lent itself to a one phase research design where all the data were collected within a few months. The survey and interview questions were modeled after Kirkpatrick's suggestions for evaluating a training system (Kirkpatrick & Kirkpatrick, 2007). The research questions that were developed helped guide the study to answer how an AR system could be utilized in an existing training platform. The scenarios provided critical Loadmaster training in an augmented environment that was tested for effectiveness. A panel of experts reviewed the survey and interview questions that utilized Kirkpatrick's work to develop the survey and interview question criteria. Students and contract instructors were surveyed and interview, but the

flight instructors were not notified about the study until the interview, to minimize any bias they may have for or against AR use for training.

During the LGTO testing phase from August to December 2011, the AR system was set up in the FuT on the schedule adjustment days. These adjustment days were preprogrammed days to allow the contractor to catch up students that may be behind or need some extra training. The ARCLT was scheduled to run for eight hours for four months on those days. The students were scheduled for one hour on the trainer for each scenario. There were 47 students that experienced the scenarios in the ARCLT. The upgrades to the system included more cameras, dividing up the FuT into six volumes, added computer blades in the computer racks to accommodate for the extra cameras set up for tracking, updated software to make the camera alignment much quicker and new goggles with a better peripheral view. A wireless system was also tested for the video feed to the student's goggles. It was discovered that the signal was not degraded going through the aluminum skin of the aircraft.

As each new class began training with the ARCLT, the previous classes continued their training on the aircraft. The Loadmaster scheduler set up 21 student interviews from November 2011 until February 2012, after the students had flown at least one sortie. Five of the contract instructors were interviewed along with eight flight instructors. The flight instructors were not told who used the ARCLT until the interview, to prevent any bias for or against this type of training tool. The idea was to capture how others observed the students that used the AR tool for training compared to past classes, or students that did not use the ARCLT, to see if they noticed any differences in the students' behavior.

Major Results

The scenarios reemphasized the lessons taught in the normal curriculum. The data showed for the specific tasks the instructors observed, they did not see any improvement in the procedures that were taught. What stood out with the students that did get to practice the procedures with the AR scenarios was that they came away with a better understanding of what was supposed to happen in the checklist and when to respond. The flight instructors were impressed with the CRM skills the students had developed during the testing timeline. The students were better prepared to respond to the checklist calls without looking at their instructor for approval before answering.

The practice of using and seeing what happens during the checklist helped the students visualize what was coming next during the flight. This type of practice has been beneficial over the years moving more of the flight procedures for pilots to practice in the WST. The ATS is now trying to move events out of the WST into lower level training devices to free up more time in the WST; this in turn will allow more flight profile events to be moved into the simulator.

Practicing the emergency procedures in a simulator has been adopted by much of the aviation community. Often C-130H student pilots get out of the seat of the WST, after practicing numerous emergency procedures, with sweat from their back soaked into their flight suit, because the system was realistic enough to create an emotional response. The ARCLT puts the Loadmaster students in much of the same environment with the added tactile feel of the cargo compartment and the pallets loaded in the FuT during the scenarios.

With the upgrades to the AR system, the students liked the idea of training with something new and different. Being able to see and hear what happens in each step of the checklist enables the student to immerse themselves into the scenario. There would still not be any motion in the FuT, like the WST, but the student can see that they were flying, if they looked out the back of the aircraft or through the windows. The 3-D sound is also an important part of the realism generated by the simulation. Hearing not only the different sounds of flight, but the voices of the other crewmembers enables the scenario to be as close to the actual events as possible.

Using the lessons learned will help in the development of a production model for cargo aircraft. Interviewing the students and instructors revealed they would like to see more of the checklist procedures, especially the emergency procedures, practiced with simulation. The volunteers had additional ideas as to what they would have liked to have seen with the scenarios. For instance, personnel airdrop, the ATS does not teach this procedure, it is taught at their units once they arrive and have some flying experience. The emergency procedure for a hung trooper can now be taught and visualized by using the emergency retraction system on the FuT with a virtual paratrooper being pulled in. This is an event not many Loadmasters see in a career.

Conclusion

Just as any simulation tool, the ARCLT needs to run at a consistent pace. Time should be allowed for maintenance, as with other simulator devices, to be an efficient training tool. A technician should be available when the system is being used to ensure the system is running properly for the instructors. The contract instructors that used the AR tool to

train with did not feel that the way the tool was set up made their time any more efficient, but did mention that they would have liked to have seen more of the emergency procedures while watching the students practice. That way they could see first-hand whether the student understood the procedures before sending them to flight training. These types of lessons are invaluable in developing a production model of the AR.

Appendix A

Student Engine Start Survey Questions

Purpose: AETC is evaluating the Augmented Reality training tool used during this Large Group Try-Out (LGTO) study. This system will be used to train Loadmaster procedures. Your responses are imperative in shaping training programs to meet the needs and interests of future students. Your name will not be released with the survey data.

DO NOT SAVE and email your survey. After completion, please submit your answers by clicking the "Submit Survey" button at the bottom of the survey. This will generate an email for you to send your answers to AETC.

Demographics
Name _____, Age _____,
Gender (M or F) _____,   Branch of service (USAF, USA, USMC, USN, Coast Guard) _____, Duty Status (Active Duty, Reserve, Guard, Civilian) _____,
Unit of assignment _____,
Years as an instructor _____ Flight Hours _____,
Email _____ (if interested in LGTO report)

1. **The equipment did not take long to set up or adjust.**
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

2. **The system ran smoothly throughout the scenario.**
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

3. **The scenario is relevant to my course of study.**
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

4. **The instructor was knowledgeable about the use of the AR system.**
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

5. **The instructor was prepared and organized to run the scenario.**
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

6. **I learned new knowledge from this training.**
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

7. **I learned new skills from this training.**
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

8. **I will be able to apply the knowledge learned in this scenario to my job.**
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

9. **I will be able to apply the skills learned in this scenario to my job.**
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

10. **I feel confident that the AR system will adequately prepare me for flightline training.**
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

11. **I feel the AR system provided an excellent enhancement to Loadmaster training over some of the other training devices.**
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

12. **I feel the AR system helped me retain more of the checklist procedures.**
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

13. **I feel these scenarios were an effective way for me to learn these Loadmaster procedures.**
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

Open ended questions

14. **What did you like most about the AR system?**

15. **What did you like least about the AR system?**

Submit Survey

Appendix B

Student Airdrop Survey Questions

Combat Offload Survey Questions

Purpose: AETC is evaluating the Augmented Reality training tool used during this Large Group Try-Out (LGTO) study. This system will be used to train Loadmaster procedures. Your responses are imperative in shaping training programs to meet the needs and interests of future students. Your name will not be released with the survey data

DO NOT SAVE and email your survey. After completion, please submit your answers by clicking the "Submit Survey" button at the bottom of the survey. This will generate an email for you to send your answers to AETC.

Demographics
Name _____, Age _____,
Gender (M or F) _____,   Branch of service (USAF, USA, USMC, USN, Coast Guard) _____, Duty Status (Active Duty, Reserve, Guard, Civilian) _____,
Unit of assignment _____,
Years as an instructor _____ Flight Hours _____,
Email _____ (if interested in LGTO report)

Please rate the following

1. **The AR goggles fit well on my helmet.**
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

2. **The AR goggles are comfortable to wear.**
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

3. **My eyes easily adjusted to the view through the goggles.**
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

4. **The equipment did not take long to set up or adjust.**
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

5. **The system ran smoothly throughout the scenario.**
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

6. **The scenario is relevant to my course of study.**
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

7. **I received adequate orientation on the use of the AR system and goggles.**
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

8. The instructor was knowledgeable about the use of the AR system.
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

9. The instructor was prepared and organized to run the scenario.
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

10. I learned new knowledge from this training.
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

11. I learned new skills from this training.
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

12. I will be able to apply the knowledge learned in this scenario to my job.
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

13. I will be able to apply the skills learned in this scenario to my job.
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

14. The AR scenarios provided video images that remained in a relative position with my movement throughout the FuT.
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

15. I feel confident that the AR system adequately prepared me for flightline training.
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

16. I feel the AR system provided an excellent enhancement to Loadmaster training over some of the other training devices.
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

17. I feel the AR system helped me retain more of the checklist procedures.
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

18. I feel these scenarios were an effective way for me to learn these Loadmaster procedures.
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

Open ended questions

19. What did you like most about the AR system?

20. What did you like least about the AR system?

Submit Survey

Appendix C

Training Squadron Brief for Participants

Air Education and Training Command is conducting a study on the use of an augmented reality (AR) tool to teach Loadmaster procedures for engine start, heavy equipment airdrop and combat offload. The purpose of the study is to evaluate student learning after using the tool. We are asking for volunteers to use the system during this large group try-out. Your class falls into the timeframe in which we are testing the equipment.

If you volunteer you will be viewing the engine start scenario in the classroom, following the checklist and listening to the crew interactions during engine start. The instructor will also run through some of the emergency procedures during this lesson. The lesson will take about 50 minutes.

During the airdrop and combat offload scenarios, the students will wear the AR equipment in the fuselage trainer (FuT). The goggles are mounted on the helmet with the NVG mount, a harness has been modified to accommodate the connections to the goggles and a light system, for tracking, will be velcroed to the top of the helmet.

There will be two students wearing the AR equipment at the same time during these scenarios, a primary and a secondary Loadmaster. Because the goggles are see-through, the idea is to virtually see the cargo, ramp and door, and the parachute during the extraction process. Sounds accompany the checklist steps as the crew reads off the steps for airdrop or combat offload. With emergency procedures practiced in the FuT, each scenario will take about 50 minutes.

The researcher has taken steps to minimize the risk to participants by insuring the students can see under the goggles when walking throughout the FuT. Unfortunately, we are not paying anyone to participate, but the benefit may be a better understanding of the procedures before going to the flightline.

There are surveys for the participants to fill out after they have seen the scenarios and AETC would like to interview many of the students and instructors. The survey should take less than five minutes and the interviews are set up for 30 minutes sessions. Your names will not be used in the study and your data will be kept confidential to only be used by the personnel conducting the study. Each volunteer will sign a consent form to participate. A review of the consent form will be accomplished for each volunteer. A copy of the signed consent form will be handed back to each volunteer.

We will minimize the risk for confidentiality, privacy and identity by securing the data collected from the survey and interview questions. The data will be destroyed after 36 months from the completion of the study. No degradation to the student's status in the class will result from their participation in the study. And there will be no negative implications if a student or instructor decides not to participate in the study.

Are there any questions?

Toward the Implementation of Augmented Reality Training
FWR20110039H, Version 1.00; Version Date: **17 Jan 11**
AFRL IRB Approval Valid from 4 May 2011 to 3 May 2012

Appendix D

Contractor Instructor Survey Questions

Purpose: AETC is evaluating the Augmented Reality training tool used during this Large Group Try-Out (LGTO) study. This system will be used to train Loadmaster procedures. Your responses are imperative in shaping training programs to meet the needs and interests of future students. Your name will not be released with the survey data.

DO NOT SAVE and email your survey. After completion, please submit your answers by clicking the "Submit Survey" button at the bottom of the last page. This will generate an email for you to send your answers to AETC.

Engine Start   Heavy Equipment Airdrop   Combat Offload

Demographics
Name _____, Age _____,
Gender (M or F) _____,   Branch of service (USAF, USA, USMC, USN, Coast Guard) _____, Duty Status (Active Duty, Reserve, Guard, Civilian) _____,
Unit of assignment _____,
Years as an instructor _____ Flight Hours _____,
Email _____ (if interested in LGTO report)

Please rate the following

    1. I received adequate instruction on how to use the augmented reality (AR) system and goggles.
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

    2. The AR system was easy to set up.
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

    3. The AR scenarios provided video images that remained in their relative position with the student's movement throughout the FuT.
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

    4. The AR system provides a realistic portrayal of actual events in the aircraft.
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

    5. I feel the AR system provided an enhancement to Loadmaster training.
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

    6. I feel my students retained more of the lesson objectives when they used the AR system for airdrop or combat offload scenarios.
Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

7. I feel confident that the AR system adequately prepared my students for flight training.

Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

8. Overall, the AR system allowed my students to achieve a higher level of proficiency than students in the past.

Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

9. The AR system helped make my instructional time more productive.

Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

10. The AR system improved my student's crew resource management awareness for checklist procedures.

Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/NA

11. Computer based lessons could be used to teach the same level of knowledge for CRM skills.

Strongly Agree/Agree/Slightly Agree/Slightly Disagree/Disagree/Strongly Disagree/N/A

Open ended questions

12. What did you like most about the AR system?

13. What did you like least about the AR system?

Submit Survey

Appendix E

Student Interview Questions

PI script, demographics to be collected and questions to be asked: Hi, my name is Randy Mayberry. I work for the Graduate Training section in AETC at Randolph AFB. We are conducting a study to get your reaction to the use of an augmented reality training tool and your consent to use the data collected in this Large Group Try-Out (LGTO). We have your consent form on file when you volunteered on the first day of class. Your honest opinions are very important to us. We need your feedback to help us evaluate this type of training system to instruct Loadmaster procedures. Your responses and comments will help us to plan training programs that meet the needs and interests of future students. Your name will not be released with the survey data. We only need to keep up with who used the training system during the LGTO.

Demographics
Name _____, Age _____,
Gender (M or F) _____,   Date/Time _____,
Unit of assignment _____, Branch of service (AD, ANG, AFRC, USMC, Civ, Etc.) _____, Years as an instructor _____ Aircraft time _____,
Email _____ (if interested in LGTO report)

1. How well did the goggles fit on your helmet?
2. Were the goggles comfortable to wear?
3. Were you able to get your eyes to adjust to the view in the goggles?
4. How long did it take to set up and adjust the goggles?
5. Did the scenes run smoothly throughout the scenarios?
6. Was the scenario relevant to your course of study?
7. Did the instructor give you enough explanation about the device to use the AR system?
8. Was the instructor knowledgeable about the use of the AR system?
9. Was the scenario set up and ready to go by the time you got to the FuT?
10. Did you feel the scenarios reinforced the material better than earlier lessons?
11. Did you apply what the scenarios were teaching you to the flightline?
12. How well did the scene follow you around the FuT?
13. Did the scenarios help you retain more of the procedures?
14. Do you feel this type of training tool helped you learn the objectives?
15. What did you like best about the AR system?
16. What did you like least about the AR system?

Appendix F

Contractor Instructor Interview Questions

PI script, demographics to be collected and questions to be asked: Hi, my name is Randy Mayberry. I work for the Graduate Training section in AETC at Randolph AFB. We are conducting a study to get your reaction to the use of an augmented reality training tool and your consent to use the data collected in this Large Group Try-Out (LGTO). We have your consent form on file when you volunteered on the first day of class. Your honest opinions are very important to us. We need your feedback to help us evaluate this type of training system to instruct Loadmaster procedures. Your responses and comments will help us to plan training programs that meet the needs and interests of future students. Your name will not be released with the survey data. We only need to keep up with who used the training system during the LGTO.

Demographics
Name _____, Age _____,
Gender (M or F) _____,   Date/Time _____,
Unit of assignment _____, Branch of service (AD, ANG, AFRC, USMC, Civ, Etc.) _____, Years as an instructor _____ Aircraft time _____,
Email _____ (if interested in LGTO report)

1. Were you able to run the system well enough to teach the students with the instructions you received?

2. Was the overall system easy to set up? Was it easy to run?

3. Did the virtual images stay in the proper position for the students?

4. Is this device an adequate training tool?

5. Do the graphics portray realistic views of the actual events?

6. Did the AR system scenario help you train the lesson objectives any better than the current training?

7. Do you feel the students that used the AR system retained more of the lesson objectives?

8. Did you see an improvement in the students' procedural abilities going to the flightline?

9. Did the students seem to have a higher level of proficiency after using the AR system?

10. Did the AR system make your time more productive with each student?

11. Did you see an improvement in the student's CRM awareness?

12. Could computer based lessons be used to teach any of the Loadmaster procedures?

13. What did you like best about the AR system?

14. What did you like least about the AR system?

Appendix G

Flight Instructor Interview Questions

PI script, demographics to be collected and questions to be asked: Hi, my name is Randy Mayberry. I work for the Graduate Training section in AETC at Randolph AFB. We are conducting a study to get your reaction to the use of an augmented reality training tool and your consent to use the data collected in this Large Group Try-Out (LGTO). If you would like to volunteer to participate in the study I can go over the consent form with you. Your honest opinions are very important to us. We need your feedback to help us evaluate this type of training system to instruct Loadmaster procedures. Your responses and comments will help us to plan training programs that meet the needs and interests of future students. Your name will not be released with the survey data.

Demographics
Name _____, Age _____,
Gender (M or F) _____,   Date/Time _____,
Unit of assignment _____, Branch of service (AD, ANG, AFRC, USMC, Civ, Etc.) _____, Years as an instructor _____ Aircraft time _____,
Email _____ (if interested in LGTO report)

SAS suggestion:
Get to know the student/instructor relationships. See which flightline instructor had contact with each individual student that used the AR system. Compare specific students the instructor knows to the ones he or she taught in the past.

1.   What improvement in (Jane's, John's, etc.) performance did you observe compared to classes in the past?

2.   What differences did you observe in your recent students (Jane's, John's, etc.) familiarity with the engine start procedures compared to students from previous classes?

3.   What differences did you observe in your recent students (Jane's, John's, etc.) familiarity with the airdrop procedures compared to students from previous classes?

4.   What differences did you observe in your recent students (Jane's, John's, etc.) familiarity with combat offload procedures compared to the students from previous classes?

5.   What differences did you observe between the progress made by your recent students and students from previous classes (e.g., did they move any faster through the flightline phase of training?)

6.   Do current students have a better handle on CRM procedures compared to previous students? In what way?

7.   Could computer based lessons be used to teach any of the Loadmaster procedures? If so, which ones? If not, why?

Appendix H

University Institutional Review Board Approval

NOVA SOUTHEASTERN UNIVERSITY

MEMORANDUM

To: Charles Mayberry, Ed.S.
           Graduate School of Computer and Information Sciences

From: Ana Fins, Ph.D.
           Chair, Institutional Review Board

Date: January 31, 2011

Re: *Toward the Implementation of Augmented Reality Training* – Research Protocol No.
           10131006Exp.

I have reviewed the revisions to the above-referenced research protocol by an expedited procedure. On behalf of the Institutional Review Board of Nova Southeastern University, *Toward the Implementation of Augmented Reality Training* is approved in keeping with expedited review categories #6 and 7. Your study is approved on **January 31, 2011** and is approved until **January 30, 2012**. You are required to submit for continuing review by **December 31, 2011**. **Research with human subjects may not begin until the NSU IRB office has received copies of all approval letters from the U.S. Department of the Air Force.** As principal investigator, you must adhere to the following requirements:

1)   CONSENT: You must use the stamped (dated consent forms) attached when consenting subjects. The consent forms must indicate the approval and its date. The forms must be administered in such a manner that they are clearly understood by the subjects. The subjects must be given a copy of the signed consent document, and a copy must be placed with the subjects' confidential chart/file.

2)   ADVERSE EVENTS/UNANTICIPATED PROBLEMS: The principal investigator is required to notify the IRB chair of any adverse reactions that may develop as a result of this study. Approval may be withdrawn if the problem is serious.

3)   AMENDMENTS: Any changes in the study (e.g., procedures, consent forms, investigators, etc.) must be approved by the IRB prior to implementation.

4)   CONTINUING REVIEWS: A continuing review (progress report) must be submitted by the continuing review date noted above. Please see the IRB web site for continuing review information.

5)   FINAL REPORT: You are required to notify the IRB Office within 30 days of the conclusion of the research that the study has ended via the IRB Closing Report form.

The NSU IRB is in compliance with the requirements for the protection of human subjects prescribed in Part 46 of Title 45 of the Code of Federal Regulations (45 CFR 46) revised June 18, 1991.

Cc: Dr. Ling Wang, Dr. Gertrude Abramson
       Dr. Jaime Arango, Ms. Rita Silverman

Appendix I

USAF Institutional Review Board Approval

DEPARTMENT OF THE AIR FORCE
AIR FORCE RESEARCH LABORATORY
WRIGHT-PATTERSON AIR FORCE BASE OHIO 45433

0 4 MAY 2011

MEMORANDUM FOR HQ AETC/A3ZM (CHARLES MAYBERRY, EdS)
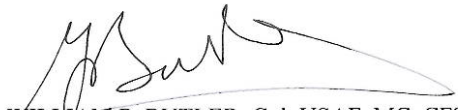
FROM: 711 HPW/IR (AFRL IRB)

SUBJECT: IRB approval for the use of human volunteers in research

1. Protocol title: Toward the Implementation of Augmented Reality Training

2. Protocol number: FWR20110039H

3. Protocol version: 1.00

4. Risk: Minimal

5. Approval date: 4 May 2011

6. Expiration date: 3 May 2012

7. Scheduled renewal date: 3 April 2012

8. Type of review: Initial – Expedited

9. Assurance Number and Expiration Date:
   - AFRL MPA50002: 14 March 2014
   - IIA: Charles R. Mayberry, EdS
   - IIA: Lt Col William P. Mueller
   - IIA: 1Lt David F. Listro
   - IIA: TSgt Brandon M. Stike

10. CITI Training: Completed

11. The above protocol has been reviewed and approved by the AFRL IRB via expedited review procedures. All requirements, as set by the IRB and its legal counsel, have been fully complied with. The study examines the use of an augmented reality training tool (helmet mounted) to teach C-130 Loadmaster procedures. Of the three scenarios used one will be with classroom and smart board and the other two will be with the fuselage trainer. In addition, audio recordings of interviews will be conducted. This protocol therefore meets the criteria for expedited review in accordance with 32 CFR 219.110 (b)(1) and U.S. Department of Health and Human Services categories (6): Collection of data from voice, video, digital, or image recordings made for research purposes AND (7): Research on individual or group characteristics or behavior (including, but not limited to, research on perception, cognition, motivation, identity, language, communication,

cultural beliefs or practices, and social behavior) or research employing survey, interview, oral history, focus group, program evaluation, human factors evaluation, or quality assurance methodologies.

12. HIPAA authorization is not required, since no HIPAA protected information will be recorded in the execution of this protocol.

13. FDA regulations do not apply since no drugs, supplements, or unapproved medical devices will be used in this research.

14. This approval applies to human use research (as defined in 32 CFR 219 and AFI 40-402) portions of this project only. Attitude and opinion surveys associated with this research must be conducted IAW AFI 38-501, AF Survey Program. If the study is being conducted under an IDE or IND, a copy of the FDA IDE or IND approval letter must be submitted by the Principal Investigator to the IRB.

15. Any serious adverse event or issues resulting from this study should be reported immediately to the IRB. Amendments to protocols and/or revisions to informed consent documents must have IRB approval prior to implementation. Please retain both hard copy and electronic copy of the final approved protocol and informed consent document.

16. All inquiries and correspondence concerning this protocol should include the protocol number and name of the primary investigator. Please ensure the timely submission of all required progress and final reports and use the templates provided on the AFRL IRB web site http://www.wpafb.af.mil/library/factsheets/factsheet.asp?id=7496 .

17. For questions or concerns, please contact the IRB administrator, Lt Patricia Brennan at patricia.brennan@wpafb.af.mil or (937) 904-8100. All inquiries and correspondence concerning this protocol should include the protocol number and name of the primary investigator.

WILLIAM P. BUTLER, Col, USAF, MC, CFS
Director, AFRL IRB

cc:
AFMSA/SGE-C

1st Indorsement to HQ AETC/A3ZM (CHARLES MAYBERRY, EdS) Memo, 4 May 2011, Initial expedited approval FWR20110039H

MEMORANDUM FOR 711 HPW/IR (COL BUTLER)

I have reviewed the hardcopy and electronic records and found them to be complete and accurate.

PATRICIA C. BRENNAN, 1 Lt, USAF
Lead Administrator, AFRL IRB

2nd Indorsement to 1st Indorsement to HQ AETC/A3ZM (CHARLES MAYBERRY, EdS) Memo, 4 May 2011, Initial expedited approval FWR20110039H

MEMORANDUM FOR AFMSA/SGE-C

This protocol has been reviewed and approved by the AFRL IRB. I concur with the recommendation of the IRB and approve this research.   0 6 MAY 2011

RICHARD E. BACHMANN, JR.
Colonel, USAF, MC, CFS
Vice Director
711th Human Performance Wing

Appendix J

AFRL IRB closure for the use of human volunteers

DEPARTMENT OF THE AIR FORCE
AIR FORCE RESEARCH LABORATORY
WRIGHT-PATTERSON AIR FORCE BASE OHIO 45433

1 1 JUN 2012

MEMORANDUM FOR AFMSA/SGE-C

FROM: 711 HPW/IR (AFRL IRB)

SUBJECT: IRB closure for the use of human volunteers in research

1. Protocol title: Toward the Implementation of Augmented Reality Training

2. Protocol number: FWR20110039H

3. Risk: Minimal

4. This study looked at the utility of an Augmented Reality (AR) component to loadmaster training. The overall goal of the research was to determine if an AR training tool would be an efficient and effective tool to train Loadmaster procedures. Preliminary findings show that the students and instructors liked the idea of training with AR. The practice they received made them more familiar with the various checklists, crew coordination, and the events that take place on the flightline before they reach that phase of the training. Of 100 potential participants, there were 61 students who participated and 21 of those were interviewed, and there were 6 out of 6 contract instructors who participated, and there were 8 out of 10 flight instructors who participated. Engine start scenario had 50 participants (44 male, 6 female); combat offload scenario had 47 participants (40 male, 7 female); heavy equipment airdrop scenario had 47 participants (38 male, 9 female). Complaints included system malfunction/slowness (main complaint), computer system misalignment, and headache in one student (poorly fitting helmet). There were no adverse events. Data files will be maintained for a minimum of three years.

5. This protocol is now closed for the use of human research.

WILLIAM P. BUTLER, Col, USAF, MC, CFS
Director, AFRL IRB

NSU-IRB Closing Report

**NSU-IRB Closing Report Form for
IRB Approved Studies**
Version 12/2009

Received

JAN 2 4 2013

Institutional Review Board

Instructions: This form is to be completed for all studies approved via expedited or full review procedures. The form must be submitted within 30 days of the conclusion of research activities (intervention/interaction with human subjects AND data analysis have ended). This form should be sent directly to the IRB Office at NSU, Office of Grants and Contracts, 3301 College Avenue, Fort Lauderdale, FL 33314, ATTN: IRB.

Please download this document and fill in the BLUE sections using a word processor. You may expand the size of sections if needed to answer the questions. Do not be concerned about where page breaks fall. Fill in all questions; if not applicable, write NA.

I. General Information
Project Title
Toward the Implementation of Augmented Reality Training
Insert Principal Investigator's (PI) Last Name and Date of Submission in the footer.

IRB Protocol #	Initial IRB Approval Date
10131006Exp	January 31. 2011
Previous Reapproval Date(s)	Current Continuing Review Date
January 31, 2012	January 31, 2013

II. Principal Investigator (PI) Information			
Name	Charles R. Mayberry	Relationship to NSU (Check Applicable)	
Mailing Address (for students)	1113 Sandy Ridge Cir Schertz TX 78154	Faculty	
		Staff	
		Student	X
Daytime Phone	210-652-9658	NSU Center/College/Dept	
Alternate Phone	210-240-1979	GSCIS	
NSU Email Address	mayberry@nsu.nova.edu		
Alternate Email Address	Randy.Mayberry@att.net		

Principal Investigator's Signature: *Charles R Mayberry*   Date: 20 Jan 2013

III. Subject/Participant Information and Study Timelines

Types of Subjects/Participants (complete all that apply)

	Fetus/ abortuses	Newborns/ Infants	Children (2-7)	Children (8-12)	Adolescents (13-17)	Adults (18+)	Pregnant Women
Total # Originally Approved						100	
#Entered in Study to Date*						75	
#Of Screen Failures**						0	
# Completing Stud to Date						75	
#Who Withdrew							

*By Entered the IRB means any subjects who consented to participate in the study.
**By Screen Failure the IRB means an individual who signed the consent form. but later proves not to qualify for the study during screening procedures.

Please provide a detailed description as to why the subjects withdrew or were withdrawn.

The one student that withdrew no longer wanted to participate in the study for personal reasons.

IV. Summary

Please briefly describe in a non-technical manner the purpose of the research.

The goal was to investigate an efficient and effective AR training system to instruct Loadmaster skills before they train on the aircraft. The investigation examined the usc of a prototype Helmet Mounted Display (HMD) AR device attached to the Loadmaster·s helmet. Three scenarios provided a basis to evaluate the different aspects of hardware and softv,arc nccclccl to utilize an IIMD as a Loadmaster training tool. The scenarios tested how the AR device may impnne the C-130H Loadmaster training capabilities to learn normal and emergency procedures to students in the FuT

Please briefly describe any findings.

The underlining goal of this project was to see if an AR tool could be used to replace flying sorties. In today's financial environment, the government is looking for \vays to reduce training flight hours, but not diminish the quality of the students graduating from the schoolhouses. The three scenarios used in the study shows that the volunteers' felt that an AR tool, for CRM and Loadmaster procedures, would work for the C-130H schoolhouse. From the volunteers' feedback about the tested AR system, inferences can be drawn that, with the correct scenarios positioned in the appropriate places in the current curriculum, one to two sorties could be saved by setting up an AR training tool in each of the FuTs.

V. Participant Complaints

enabling students to wear the system in the training area without interfering with the training objectives or practice the procedures repeatedly without breaking down. Further research is still needed before deploying the production model of the AR training tool for Loadmaster procedures.

V. Participant Complaints

Were there any complaints from subjects?	Yes	No
		X

If "Yes," please provide a detailed description of the subjects' complaint(s). If more than one subject complained, please provide the information by subject. For example, "Subject 1: Nature of complaint. Nature of resolution."

Is this study multi-site?	Yes	No
		X

If "Yes," please attach any related reports from the other sites.

VI. Unanticipated Problems/Adverse Events

List ALL adverse events or unanticipated problems (for multi-center studies, from NSU researchers only) and their resolution. (If none, state none). Attach copies of all adverse reaction reports, even if previously reported.

Unexpected/Adverse Reaction and Resolutions

None

Do the results of the study to date suggest that the study risks differ from what was originally described in the research submission?	Yes	No
		X

If "Yes," please describe.

Appendix L

Student Start Engines Survey Calculations

Student Start Engines Survey questions relating to fit and function.													
1=Strongly Agree/2=Agree/3=Slightly Agree/4=Slightly Disagree/5=Disagree/6=Strongly Disagree/7=N/A													
Hypothesis	The Students generally Disagree with the question												
Threshold	1.64												
Target	4												
Question		1	2	3	4	5	6	7	Total	Z-Score	Pass/ Fail	Std. Dev.	Percent Agree
1	Take too long to adjust	14	26	6	4	0	0	0	50	2.36	Reject Null	0.85	92%
2	System ran smooth	15	22	10	2	1	0	0	50	2.14	Reject Null	0.92	94%
3	Relevant to course	24	21	3	1	1	0	0	50	2.78	Reject Null	0.84	96%

Student Survey questions relating to instructor knowledge and preparation													
1=Strongly Agree/2=Agree/3=Slightly Agree/4=Slightly Disagree/5=Disagree/6=Strongly Disagree/7=N/A													
Hypothesis	The Students generally Disagree with the question												
Threshold	1.64												
Target	4												
Question		1	2	3	4	5	6	7	Total	Z-Score	Pass/ Fail	Std. Dev.	Percent Agree
4	Instr knowledge of system	25	16	6	1	1	0	1	50	1.88	Reject Null	1.16	94%
5	Instr prepared to run	23	20	7	0	0	0	0	50	3.29	Reject Null	0.71	100%

Student Survey questions relating to knowledge and skills.

1=Strongly Agree/2=Agree/3=Slightly Agree/4=Slightly Disagree/5=Disagree/6=Strongly Disagree/7=N/A

Hypothesis	The Students generally Disagree with the question												
Threshold	1.64												
Target	4												
Question		1	2	3	4	5	6	7	Total	Z-Score	Pass/Fail	Std. Dev.	Percent Agree
6	Learned new knowledge	17	18	9	1	4	0	1	50	1.63	Not Enough Evidence	1.15	88%
7	Learned new skill	18	18	8	3	3	0	0	50	1.67	Reject Null	1.14	88%
8	Applied knowledge to job	22	18	9	1	0	0	0	50	2.75	Reject Null	0.81	98%
9	Applied skill to job	19	19	10	2	0	0	0	50	2.46	Reject Null	0.85	96%

Student Survey questions relating to behavioral change.

1=Strongly Agree/2=Agree/3=Slightly Agree/4=Slightly Disagree/5=Disagree/6=Strongly Disagree/7=N/A

Hypothesis	The Students generally Disagree with the question												
Threshold	1.64												
Target	4												
Question		1	2	3	4	5	6	7	Total	Z-Score	Pass/Fail	Std. Dev.	Percent Agree
10	Prepared me for flighline training	12	21	11	4	2	0	0	50	1.68	Reject Null	1.04	88%
11	Excellent enhancement	17	16	10	3	2	2	0	50	1.33	Not Enough Evidence	1.31	86%
12	Helped me retain more	15	14	14	3	3	0	1	50	1.50	Not Enough Evidence	1.14	86%
13	Effective way for me to learn	15	19	11	2	2	1	0	50	1.57	Not Enough Evidence	1.15	90%

Appendix M

Student Combat Offload Survey Calculations

Student Combat Offload Survey questions relating to fit and function													
1=Strongly Agree/2=Agree/3=Slightly Agree/4=Slightly Disagree/5=Disagree/6=Strongly Disagree/7=N/A													
Hypothesis	The Students Generally Disagree With the Statement												
Threshold	1.64												
Target	4												
Question		1	2	3	4	5	6	7	Total	Z-Score	Pass/Fail	Std. Dev.	Percent Agree
1	Goggles fit well on helmet	6	23	10	3	4	1	0	47	1.22	Not Enough Evidence	1.18	83%
2	Goggles comfortable to wear	2	17	12	11	3	2	0	47	0.81	Not Enough Evidence	1.18	66%
3	Eyes adjusted easily to view	5	24	9	5	1	3	0	47	1.11	Not Enough Evidence	1.25	81%
4	Not long to set up or adjust	8	21	6	5	6	1	0	47	1.01	Not Enough Evidence	1.34	74%
5	System ran smooth throughout scenario	6	10	13	10	5	3	0	47	0.62	Not Enough Evidence	1.38	62%
14	Images remained in relative position	4	19	14	2	5	3	0	47	0.85	Not Enough Evidence	1.33	79%

Student Combat Offload Survey questions relating to instructor knowledge													
1=Strongly Agree/2=Agree/3=Slightly Agree/4=Slightly Disagree/5=Disagree/6=Strongly Disagree/7=N/A													
Hypothesis	The Students Generally Disagree With the Statement												
Threshold	1.64												
Target	4												
Question		1	2	3	4	5	6	7	Total	Z-Score	Pass/Fail	Std. Dev.	Percent Agree
7	Received adequate orientation	15	27	2	1	1	1	0	47	2.12	Reject Null	0.99	94%
8	Instructor knowledge-able about AR system	20	24	2	1	0	0	0	47	3.54	Reject Null	0.66	98%
9	Instructor prepared to run scenario	18	25	4	0	0	0	0	47	3.73	Reject Null	0.62	100%

Student Combat Offload Survey questions relating to knowledge and skills

1=Strongly Agree/2=Agree/3=Slightly Agree/4=Slightly Disagree/5=Disagree/6=Strongly Disagree/7=N/A

Hypothesis	The Students Generally Disagree With the Statement												
Threshold	1.64												
Target	4												
Question		1	2	3	4	5	6	7	Total	Z-Score	Pass/Fail	Std. Dev.	Percent Agree
10	Learned new knowledge	7	15	18	1	3	3	0	47	0.98	Not Enough Evidence	1.30	85%
11	Learned new skills	7	17	15	2	4	2	0	47	1.04	Not Enough Evidence	1.27	83%
12	Applied knowledge learned to job	14	17	10	2	2	1	1	47	1.15	Not Enough Evidence	1.21	87%
13	Applied skills learned to job	13	21	8	2	2	1	0	47	1.58	Not Enough Evidence	1.14	89%

Student Combat Offload Survey questions relating to learning

1=Strongly Agree/2=Agree/3=Slightly Agree/4=Slightly Disagree/5=Disagree/6=Strongly Disagree/7=N/A

Hypothesis	The Students Generally Disagree With the Statement												
Threshold	1.64												
Target	4												
Question		1	2	3	4	5	6	7	Total	Z-Score	Pass/Fail	Std. Dev.	Percent Agree
6	Scenario is relevant to course	26	19	1	1	0	0	0	47	3.84	Reject Null	0.65	98%
15	Confident AR system prepared me for flight training	3	9	20	5	7	3	0	47	0.56	Not Enough Evidence	1.28	68%
16	Provided excellent enhancement	8	13	12	4	8	2	0	47	0.73	Not Enough Evidence	1.45	70%
17	Helped retain more of the procedures	7	21	10	5	3	1	0	47	1.22	Not Enough Evidence	1.18	81%
18	An effective way for me to learn	14	11	13	7	1	1	0	47	1.28	Not Enough Evidence	1.23	81%

Appendix N

Student Airdrop Survey Calculations

Student Airdrop Survey questions relating to fit and function													
1=Strongly Agree/2=Agree/3=Slightly Agree/4=Slightly Disagree/5=Disagree/6=Strongly Disagree/7=N/A													
Hypothesis	The Students Generally Disagree With the Statement												
Threshold	1.64												
Target	4												
Question		1	2	3	4	5	6	7	Total	Z-Score	Pass/Fail	Std. Dev.	Percent Agree
1	Goggles fit well on helmet	8	20	8	7	4	0	0	47	1.22	Not Enough Evidence	1.18	77%
2	Goggles comfortable to wear	0	12	21	10	4	0	0	47	0.98	Not Enough Evidence	0.89	70%
3	Eyes adjusted easily to view	5	25	11	2	3	1	0	47	1.39	Not Enough Evidence	1.09	87%
4	Not long to set up or adjust	7	24	6	6	3	1	0	47	1.24	Not Enough Evidence	1.20	79%
5	System ran smooth throughout scenario	4	15	14	7	5	2	0	47	0.79	Not Enough Evidence	1.27	70%
14	Images remained in relative position	1	22	13	6	4	1	0	47	1.05	Not Enough Evidence	1.09	77%

Student Airdrop Survey questions relating to instructor knowledge													
1=Strongly Agree/2=Agree/3=Slightly Agree/4=Slightly Disagree/5=Disagree/6=Strongly Disagree/7=N/A													
Hypothesis	The Students Generally Disagree With the Statement												
Threshold	1.64												
Target	4												
Question		1	2	3	4	5	6	7	Total	Z-Score	Pass/Fail	Std. Dev.	Percent Agree
7	Received adequate orientation	8	26	10	1	2	0	0	47	1.99	Reject Null	0.90	94%
8	Instructor knowledge-able about AR system	19	23	4	0	1	0	0	47	2.87	Reject Null	0.78	98%
9	Instructor prepared to run scenario	19	23	4	0	1	0	0	47	2.87	Reject Null	0.78	98%

Student Airdrop Survey questions relating to knowledge and skills

1=Strongly Agree/2=Agree/3=Slightly Agree/4=Slightly Disagree/5=Disagree/6=Strongly Disagree/7=N/A

Hypothesis	The Students Generally Disagree With the Statement												
Threshold	1.64												
Target	4												
Question		1	2	3	4	5	6	7	Total	Z-Score	Pass/Fail	Std. Dev.	Percent Agree
10	Learned new knowledge	7	22	11	3	2	1	1	47	1.42	Not Enough Evidence	1.14	85%
11	Learned new skills	3	23	14	4	1	1	1	47	1.45	Not Enough Evidence	1.03	85%
12	Applied knowledge learned to job	11	25	10	0	0	0	1	47	2.84	Reject Null	0.73	98%
13	Applied skills learned to job	11	25	10	0	0	0	1	47	2.84	Reject Null	0.73	98%

Student Airdrop Survey questions relating to learning

1=Strongly Agree/2=Agree/3=Slightly Agree/4=Slightly Disagree/5=Disagree/6=Strongly Disagree/7=N/A

Hypothesis	The Students Generally Disagree With the Statement												
Threshold	1.64												
Target	4												
Question		1	2	3	4	5	6	7	Total	Z-Score	Pass/Fail	Std. Dev.	Percent Agree
6	Scenario is relevant to course	25	16	5	1	0	0	0	47	3.14	Reject Null	0.76	98%
15	Confident AR system prepared me for flight training	4	11	21	4	6	1	0	47	0.86	Not Enough Evidence	1.17	77%
16	Provided excellent enhance-ment	9	17	11	5	4	1	0	47	1.11	Not Enough Evidence	1.27	79%
17	Helped retain more of the procedures	5	25	13	1	3	0	0	47	1.70	Reject Null	0.94	91%
18	An effective way for me to learn	9	19	14	4	0	0	1	47	1.90	Reject Null	0.93	89%

Appendix O

Contract Instructor Survey Calculations

Contract Instructor Survey questions relating to fit and function													
1=Strongly Agree/2=Agree/3=Slightly Agree/4=Slightly Disagree/5=Disagree/6=Strongly Disagree/7=N/A													
Hypothesis	The Instructors generally Disagree with the question												
Threshold	2.13												
Target	4												
Question		1	2	3	4	5	6	7	Total	T-Score	Pass/Fail	Std. Dev.	Percent Agree
1	Received adequate instruction	2	9	5	0	0	0	1	17	2.77	Reject Null	0.66	94%
2	Easy to set up	0	9	4	1	2	0	1	17	1.17	Not Enough Evidence	1.06	76%
3	Images remained in relative position	0	9	4	2	2	0	0	17	1.09	Not Enough Evidence	1.07	76%
4	Realistic portrayal of events	0	11	4	2	0	0	0	17	2.13	Reject Null	0.72	88%
9	Instructional time more productive	0	7	6	2	0	0	2	17	1.84	Not Enough Evidence	0.72	76%

Contract Instructor Survey questions relating to student learning													
1=Strongly Agree/2=Agree/3=Slightly Agree/4=Slightly Disagree/5=Disagree/6=Strongly Disagree/7=N/A													
Hypothesis	The Instructors generally Disagree with the question												
Critical T-Value (.05)	2.14												
Target	4												
Question		1	2	3	4	5	6	7	Total	T-Score	Pass/Fail	Std. Dev.	Percent Agree
5	provided an enhancement	2	12	3	0	0	0	0	17	3.27	Reject Null	0.61	100%
6	Retained more of the lesson objectives	0	4	5	2	0	0	6	17	1.57	Not Enough Evidence	0.75	53%
7	prepared my students for flight training	0	7	4	0	4	0	2	17	0.73	Not Enough Evidence	1.28	65%
8	achieve a higher level of proficiency	0	7	6	2	0	0	2	17	1.84	Not Enough Evidence	0.72	76%

Contract Instructor Survey questions relating to crew resource management													
1=Strongly Agree/2=Agree/3=Slightly Agree/4=Slightly Disagree/5=Disagree/6=Strongly Disagree/7=N/A													
Hypothesis	The Instructors generally Disagree with the question												
Critical T-Value (.05)	2.12												
Target	4												
Question		1	2	3	4	5	6	7	Total	T-Score	Pass/Fail	Std. Dev.	Percent Agree
10	improved student CRM awareness	4	6	5	2	0	0	0	17	1.73	Not Enough Evidence	0.99	88%
11	CBT lessons could be used	2	1	1	1	11	1	0	17	-0.15	Not Enough Evidence	1.52	24%

Appendix P

Student Engine Start Interview Questions

Student Engine Start Interview Questions	Percentage of the students that felt the same way		
1. How long did It take for the instructor to set up the scenario?	Positive	Negative	Neutral
I don't remember it taking any lengthy period of time. I watched it two or three times, it didn't take that long. Relatively a short amount of time. I think it was a couple of minutes. I don't remember it taking too long. After we sat down he fired it up. A couple of minutes. It came right up in two or three minutes, it was pretty quick. I think it was already up when I came into the classroom. Probably just a couple of minutes. I remember it not working a time or two. It only took a while one time 'cause the instructor, he really didn't know where it was, but another instructor, came in, he knew where it was and it popped up instantly. Just a few moments. Once the start time for the class happened, it was about 5 minutes. It was pretty quick on that one, probably a couple of minutes. That one didn't take very long.	87%	13%	0%
2. How well did the scenario run during the training?	Positive	Negative	Neutral
The scenario ran fine in the classroom, no glitches or errors. He didn't have to stop it for any errors. All the visual cues were there sound were there all the audio cues from the pilots, nav, they were all there. Yea, from what I remember it ran pretty smoothly. He ran through the whole thing at once, it ran fine. It ran pretty smooth. I think it ran pretty decent every time. It went from before engine to just before taxi, but it seemed fine. I thought it ran pretty well. Yea, we ran it just like the checklist. It ran pretty well. Yea, it ran all the way through just fine, there were no issues. The program ran great actually; I don't remember any delays or anything. We just sat there and watched it, and it did its thing.	73%	0%	27%
3. How relevant was the scenario to the course you're taking?	Positive	Negative	Neutral
Very relevant, got to see what happens outside the aircraft. I would say it is helpful here because the fuselage trainer in the schoolhouse doesn't even have wings. Yeah, I guess. I mean, that's as much as you can get without going out to the flightline. Absolutely, and I thing especially people coming through that haven't had any experience being out on the planes. Very relevant, I mean, this is something I do every time I go fly. Yea, I think it did pretty good approximation. Yes, once I finally got out there I had kind of an idea of what was going on. Yes, especially for running checklist. I think it was pretty decent, it's obviously going to be different when you're actually out there, but it wasn't too far off. I didn't see it helping much. It was pretty close. Yea, for the engine start it is fairly relevant. Yea, actually that one was. I think that's why it was helpful because it let you see where to stand.	93%	7%	0%
4. How knowledgeable was the instructor about the use of the AR tool to run the engine start scenario?	Positive	Negative	Neutral
Knew the system well enough to run it without any problems, clearly he had run the system before. I did the before starting engines with two different instructors, I don't remember either one of them having problems. Yea, it seemed like he had done it once or twice. He had clearly done it before. He seemed to be navigating it pretty well. We just ran straight through it and kind of followed the checklist for what they were doing. It seemed like it was new to most of them. No, I don't believe so. Yea, I could tell he had run it before. It seemed like he knew what he was doing. Yes, he did fine.	73%	7%	20%
5. What gave you an indication that the instructor was prepared and organized to run the scenario?	Positive	Negative	Neutral
He didn't have any problems. It didn't crash. Ran through it pretty quickly. We just didn't have any problems with it, didn't take long to boot up. A couple of the instructors were a lot quicker with it, like would open quicker. After he found where the program was located, he pretty much knew how to do it. Yea, for the most part. It look like he kind of had trouble getting it set up at first, but then it did not seem to be a problem. It went on the screen, and he just talked about it.	80%	7%	13%

6. What new knowledge did you learn from this training?	Positive	Negative	Neutral
Hearing the lingo lets you know you should be doing something. I would say hearing the pilots on the head set and stuff, would be the benefit right there. Seeing how that goes, what they're going to say. Yeah, I mean, it showed the crew from a global crew standpoint. Stuff for props versus stuff from jet engines. New knowledge, no, but I did feel like I got a little more confident than the knowledge I had. At that point I hadn't actually been out to a real GAT. Maybe just how it look and basically what was going to happen, maybe the hand signals were better explained in the video as opposed how they explain the classroom. But, other than that, not anything new. Yes, because before that, I hadn't really ever seen a visual picture of what the start kind of looked like. For the newer guys that kind of helps them along. Probably just a little bit more about how the actual process works. The new knowledge I learned was incorporating the hand signals to the crew chief. The only thing that I think that could be improved upon it, would be to give like a downward view of the plane and where to stand, in relation to the engines and how long you should stand there and what to look for. I came off previous airplanes so I didn't really learn a whole heck of a lot. Knowledge, not really, engine start is pretty straight forward, not a whole lot to it.	40%	47%	13%
7. What new skills did you learn from this training?	Positive	Negative	Neutral
The process was new to me at the time. The same scanning techniques you use on prior airframes. I'd say yea, one thing, I got more of the flow of the checklist. As far as skills, standing away from the aircraft, seeing the right angles. Yea. I guess how far to stand from the engine. I wouldn't say it taught me any new skills, but it got me acclimated to what it's actually like. We go over what area you are going to be standing over. Um, probably a little bit. It was a lot better than like just trying to go out there and "wing it." It kind of gave you a basic idea of approximately where you should be in relation to at what point in the checklist is running. Um, what I learned was a decent spot to stand to get more of a visual on where I have to stand. Not really, no. Yea, it was good to get a visual where they had you moving out, the engines turning. It made me a little bit more prepared when I went out to start engines on the plane.	73%	20%	7%
8. How would you apply this knowledge you learned in this scenario to the job?	Positive	Negative	Neutral
I had the concept down, it's pretty much what you do out on the flightline. You kind of have that faith of it. It gave me that general knowledge of what it looks like, how long you're going to wait and what side you're going to go to after that. Prompted me to get to remember the calls. It went exactly how I would have expected it. More than anything actually hearing responses. I remembered the picture on the screen. He ran through it once, after it was through we talked it over again.	86%	7%	7%
9. How would you apply the skills you learned in this scenario to the job?	Positive	Negative	Neutral
I had the concept down. I never thought I'd have to go off headset to help the crew chief to push the cart out of the way. Having a good angle to see the engines. Knew what was coming next as far as cockpit conversations. Knowing where to look and what to look for. Knowing the steps in their checklists, I was thinking, "Where am I going to be next?" I don't honestly know, because I don't know if it came from seeing that, or from past airframe experience. Not really, it wasn't very specific as to where to stand or what you are looking at. I didn't really, not really no, but I'm sure it kind of helped. It wasn't really a distance thing, it was kind of a "this is what this looks like with wings."	77%	15%	8%
10. Do you feel the engine start scenario will better prepare you for flight line training?	Positive	Negative	Neutral
I knew the procedure as to what was about to happen next, it just gave me more assurance in certain things. I felt pretty confident to get out there for engine start. Yea - because you actually have things moving, it gives you the general location where to move yourself. Sure - being able to run through the checklist. Yea the instructor was still there, but you are just making all the calls and just hearing those ques. Yea, I would say so, it helped me know a little bit more as to what to expect. Yea - I would say it helped me adapt quicker.	100%	0%	0%

	Positive	Negative	Neutral
11. Do you feel the engine start scenario provided you an enhancement to Loadmaster training over some of the other training devices?	Positive	Negative	Neutral
Definitely over the CBTs, maybe not as real-time as the WST but definitely better than CBTs. It was more of a compliment to everything that was there, it prepared me for following along in the checklist. Yea - because it gives you actual stuff actually moving. Yea - definitely helped in the fact that you could actually see it. Yes, absolutely, I think that the thing we did in the classroom helped more than the WST. Yea - I think the actual visual in the classroom is better than the WST at some points. Yes - the CBT goes through the engine start but they look pretty old and everyone make fun of them. Yea a little bit more than the WST, it wasn't all that great. Yea - it was closer to you actually doing it, instead of just reading about it. Yeah - because it was short, it showed you what to do; it wasn't a long drawn-out thing.	93%	7%	0%
12. Do you feel the engine start scenario helped you retain more of the checklist procedures?	Positive	Negative	Neutral
By seeing it and by hearing it. Yea, those cues meet every one of the areas of learning that people have. Yes, the first one on the GAT, I felt like I didn't need to look at my checklist too much or reference it as much. Yes, I think so, because you kind of have that interaction too, you know, running through. Yea, definitely, what's coming next because you could see it? I'm more of a visual learner so seeing it helped me. You learn when you do stuff. Yes, because it's…if I recall right, in the virtual reality training, you hear the calls. Just that you knew what steps were coming next? Yea, cause you're getting more of the visual. Absolutely, seeing it and knowing what I am supposed to say and when to say it helps.	80%	13%	7%
13. Do you feel the scenario was an effective way for you to learn these Loadmaster procedures?	Positive	Negative	Neutral
For me it's all the way around, I've got to get some audio/visual, actual hands on doing it. Yes I do actually, it just helps set in my memory before, it kind of helped mental muscle memory. Yea, I'm a visual learner. It helped me a lot to be able to see it and hear it, instead of just reading the checklist. Just running through the way the C-130 does the checklist, hearing the steps, and figuring out when hear those questions when I'm supposed to respond? Yea, I'm more hands-on, so I feel it was easier to get the visuals. Yes, cause it went pretty much in order and it had a pretty good flow. Yea, I'm more of a visual learner. It helped me in terms of actually seeing the prop turning, instead of, hey the prop going to turn at this point in the checklist. Yeah, it was definitely helpful, in doing it because you could see it.	80%	7%	13%

Appendix Q

Student Combat Offload Interview Questions

Student Combat Offload Interview Questions	Percentage of the students that felt the same way		
1. How well did the goggles fit on your helmet?	Positive	Negative	Neutral
The goggles fit well on the helmet; it's just kind of adjusting them so that it wasn't blurry. It was a little heavier than normal, not too bad, just like having NVGs on. It was a little big, but it worked fine. They fit on the helmet well enough; of course they're uncomfortable, but not much worse than NVGs. They weren't aligned properly, but I attribute that the fit of the helmet. It was just like wearing a set of NVGs, it really didn't bother me. They fit fine, no problems. No, nothing fit, nothing worked.	64%	36%	0%
2. Were the goggles comfortable to wear?	Positive	Negative	Neutral
It felt like wearing NVGs. I would have to say not very comfortable, I had a headache after the one we had the other day. Pretty much the same as the NVGs. We were not in them long enough to really affect us. They're a little front heavy. I didn't care for the harness part of it...but the helmet was fine. Yea, as comfortable as they could be. I wouldn't say comfortable. The goggles didn't work, they weren't dialed in right, everything was crooked and I got a headache.	36%	45%	18%
3. Were you able to get your eyes to adjust to the view in the goggles?	Positive	Negative	Neutral
I did a little bit just like NVGs. As soon as the scenario started, it would kind of go away and I would have to tilt back. I think I had it, because it was tweaked. Yea, they adjusted well to the scene. My eyes didn't have any problems adjusting to them. It was fine for me. We actually had problems with that. It was not all that great in terms of being on the FuT. I could actually see through it, not perfectly, but decent enough to see not to run into things.	64%	36%	0%
4. How long did it take to set up and adjust the goggles?	Positive	Negative	Neutral
It didn't take very long to put stuff on, but it took a while to get the system to boot up. No, it adjusted just fine. Getting it relatively comfortable to where I could see it, did take a while. Maybe four or five minutes, not too long. Not long, it was pretty much fitted. Not very long at all. Probably only took a couple minutes to set up. Probably 10-15 minutes at the most. No, it didn't take very long to adjust. Just getting the equipment on and walking, not long, like two minutes maybe. We got everything on, tried to make it work, it didn't work.	64%	36%	0%
5. Did the scenes run smoothly throughout the scenarios?	Positive	Negative	Neutral
There was a little bit of jumping around. But it seemed to run pretty smooth. Most of the time they run smoothly. That day it was pretty bumpy. Yea, from what I can remember, it ran pretty smooth. It looked really good. It did go out a couple of times. I don't remember any "jumping", but I remember we had to go backwards once, because the progress of the checklist isn't timed at all, it's just it being read. It disappeared at one point on a couple of different occasions. I do remember they had to pause it a few times. I think it worked alright, once it finally worked.	50%	50%	0%

6. Was the scenario relevant to your course of study?	Positive	Negative	Neutral
Yea, it felt like it. Definitely, as the scenario went it was a good opportunity to run through the checklist. Well, what the problem was that the combat offload the other day was scheduled before we could actually learn combat offload. Yes. I remember the combat offload actually helping me to do it in real life. Yea, it is kind of important; it actually helped walking back and forth. It helped a lot for the combat offload, when we did it. I think it could be, yes. If it was better, it probably would have been relevant, but because there were so many problems with it, it didn't help. Yes, you go back and you talk about it in the classroom. Not at the time, it wasn't, we hadn't gone through the combat offload checklist in the classroom, when we did it, and it was all brand new.	73%	27%	0%
7. Did the instructor give you enough explanation about the device to use the AR system?	Positive	Negative	Neutral
Yea. I felt like I was prepared to handle the system. Yea. He kind of told me about it, but didn't really explain how it was to work. He went over it, but it is not that complicated. Yes. Yeah, we had a brief before we even went out there that kind of explained. Yes, the pallet and how to exit the aircraft. Yes, it was explained thoroughly. Yea, I knew. Yes, they tried; it just didn't make a lot of sense at the time.	91%	9%	0%
8. Was the instructor knowledgeable about the use of the AR system?	Positive	Negative	Neutral
Yea, we went through it twice. Definitely, and they were able to troubleshoot the problems we were having. Both times he actually ran it manually, instead of letting the scenario just go and it worked better when he ran it manually. He definitely seemed to know what he was taking about. I don't think he had problems with anything. Anything that came up they fixed it. Yeah, they got it, he had pause and play. I couldn't give you a good answer on that, because we didn't talk much about it. He seemed knowledgeable, just seemed like the equipment didn't want to cooperate. Oh yea, he knew what he was doing. I guess, I mean, it worked, after a while, it finally worked.	91%	0%	9%
9. Was the scenario set up and ready to go by the time you got to the FuT?	Positive	Negative	Neutral
No, it didn't take long to get everything to get going. Most of the time, there was one time we were having a battery pack failure or issue, but that got corrected pretty quickly. I think it took a little while to workout, to get it running. Yes it was. Yea, it was all running. I think it was then my goggles went out when I started. Yea, they already had everything set up before we got there. Yes, I believe it was. I know they had to stop and restart, it happened three or four times, it was just kind of choppy, didn't flow very well. Actually no, they were having problems with the cameras.	50%	50%	0%
10. Did you feel the scenarios reinforced the material better than earlier lessons?	Positive	Negative	Neutral
Yea, it gives you a better understanding of the checklist. Honestly, I think the virtual definitely reinforced the training more. Yes, and I think it made it move and felt smoother and more familiar. I definitely applied the knowledge that we have learned previously. Yea. It still got me into the mode of OK this is like being on a real plane versus sitting in the classroom reading that. Definitely, the combat offload. I guess it gave us a better understanding of the process of it. It might have helped a little bit, but I didn't see any of that crap. I actually didn't have combat offload until after the scenario, but he walked me through it. I think so; I think it would be helpful.	91%	9%	0%

11. Did you apply what the scenarios were teaching you to the flightline?	Positive	Negative	Neutral
Yea, it helps with the checklist, going through the checklist, situational awareness. Doing the VR training without having to trip over the pallet was actually great help. Yea, once again it's as close as you can get to actually doing it. I definitely think it helped for preparing me for the flight line. The combat offload was helpful. Yea, being able to run it on the trainer and walk to the back, which helps. Yeah, I kind of have at least the gist of how it's supposed to go. No, actually it didn't. No, cause one it was too long ago and two it didn't work. Yea, I did.	80%	20%	0%
12. How well did the scene follow you around the FuT?	Positive	Negative	Neutral
Oh, I was at 245, I had set in the perfect spot and couldn't move. When I was able to see the pallet, it was always in the proper place. The camera that hangs over the right hand rails a little bit and does some funny things. It stayed fine, it didn't seem like it disappeared too often. It seemed like it was a little bit jumpy, like it flickered a little bit, but it stayed where it was suppose to stay. It was fine. Yeah, as far as the load always stayed where it was supposed to. We didn't get to see the picture because it was all over the place. I don't remember any problems with it, if there were any they were minor. It did alright, the ramp and door was fine, and the pallet did some weird stuff.	80%	20%	0%
13. Did the scenarios help you retain more of the procedures?	Positive	Negative	Neutral
Yea, once I ran through it. Yea, it helped a little bit, it helped the muscle memory. I think so. Yes, definitely, because you are running through them you are getting to see what happens. Honestly not so much. Yea, being out there and walking back and forth like you really would be out on the plane. Yeah, they definitely did, especially the combat offload helped a lot. Yes, the auditory part of it. Yea, definitely. Maybe, it's hard to say, being there and seeing the stuff shift around was giving me a headache.	80%	20%	0%
14. Do you feel this type of training tool helped you learn the objectives?	Positive	Negative	Neutral
Yes, but also I bet this tool cost a lot of money. Definitely, getting to actually run through it, being able to learn the speed of the checklist, learn where I need to stand, learn where I need to flow through the checklist and be on the plane, which actually helped a lot. If you can work the bugs out, I think it would be really valuable. Yes, I'm a visual learner; it's definitely going to help me in that. Yea, if we had more repetition it would help, that's how I learn. Physically going through it instead of just going over it in the classroom. Yeah, I think it helped a lot more than just doing it in class. Possibly, it was a monotonous, just steady drone on of checklists. No not really. Yea, I think a good combination of classroom, going through it, and then actually getting to see it would actually help more than just reading it and talking about it. Now that I know about it, I would probably say no, I liked the classroom one; I didn't like that one at all.	64%	18%	18%

Appendix R

Student HE Airdrop Interview Questions

Student HE Airdrop Interview Questions	Percentage of the students that felt the same way		
1. How well did the goggles fit on your helmet?	Positive	Negative	Neutral
The goggles, they fit fine. Fit well I guess. The slipped right on. Oh yeah they were fine. Seem like NVGs. Yeah, they were fine. No problems. Um, they were kind of bulky. They fit well; it was just that, as far as that screen goes, it didn't cover the vision that well. Um, 50/50.	70%	20%	10%
2. Were the goggles comfortable to wear?	Positive	Negative	Neutral
I would say, probably little more comfortable than NVGs. I would guess heavier than NVGs. It felt like wearing NVGs. They fit like NVGs pretty much having them on there. Yea, I didn't have any issues. I would not want to wear it for hours at a time. They were fine. Yea, they were fine, similar to NVGs. They weren't bad; they were just like wearing night vision goggles.	70%	20%	10%
3. Were you able to get your eyes to adjust to the view in the goggles?	Positive	Negative	Neutral
Yes, I really didn't have a problem with it. That particular day I remember we had a lot of trouble getting the right screen to come up for a while. As far as the equipment I think it worked fine. I did a little bit just like NVGs. Yea, I had to adjust it onto my helmet, but other than that, it was right where my eye sight was. That seemed like the NVGs, simple. Simple adjustments. I didn't know there was an adjustment; I put them on and went through just fine. Yea, all the adjustments were there. They showed us how to adjust it, and everything and so once we figured out how to adjust it, they were just fine. For the most part, like no, but there are times on the airplane where it started not to sink up.	80%	20%	0%
4. How long did it take to set up and adjust the goggles?	Positive	Negative	Neutral
No time, it wasn't anything difficult. Actually putting on the gear in all that, eight to 10 minutes tops. It didn't take very long to put stuff on, but it took a while to get the system to boot up. A couple of minutes tops. It was very quick. No, it was fine. The adjustments were just fine for me. It was fairly quick, so, maybe five minutes the first time. About five or six minutes. They were having technical difficulty with the computer systems. The helmet interacting with the computer system linking up. So, it took about a half hour.	80%	10%	10%
5. Did the scenes run smoothly throughout the scenarios?	Positive	Negative	Neutral
There were some places where the helmet didn't pick up where you were. It did not quit, it was the sensors picking up where I was. There was a little bit of jumping around. But it seemed to run pretty smooth. It was consistent; the only thing was if you went too far left you would get a blank out screen. There are a few angles; I guess it depends on where you're at in the fuselage that the motion sensors don't pick it up. No, that was really inconsistent. For me about 20% of the time I was having problems seeing anything on the viewfinder. That was the one thing that was not good about it... sometimes an image would just disappear. Sometimes the pallet was there and sometimes it wasn't. Once it got running, it was alright.	40%	60%	0%

6. Was the scenario relevant to your course of study?	Positive	Negative	Neutral
I didn't feel like it really added anything. Not so what do you, kind of the run we would do on a GAT or FuT. Yea, it felt like it. Considering I have never flown before it was definitely kind of nice to get an idea of what you will be seeing. Oh yea, I had just learned about airdrop and all that so, it helped out that I get to practice it. I think it's nice to be able to apply what you're learning before you actually fly. It was definitely relevant. Both times it was relevant to my training. Yea, I don't think the visual parts so much as the audio. The audio helps a lot, because it's difficult in the plane to listen to what is going on in the cockpit, we never get an opportunity to hear their checklist. That helps a lot.	80%	20%	0%
7. Did the instructor give you enough explanation about the device to use the AR system?	Positive	Negative	Neutral
He seemed very familiar with it, he was helpful. I guess so in general this is what should be doing. But yea, he explained it pretty well, as far as what to expect. The instructor explained it, what I should be looking for, like how I should kind of set myself up. Yeah, that was all fine. He pretty much briefed everything you would see. I'd never seen anything like it, but they gave us a brief before the first time they used it. Oh yea. Yea, he did.	100%	0%	0%
8. Was the instructor knowledgeable about the use of the AR system?	Positive	Negative	Neutral
He seemed very knowledgeable. They didn't seem too confident with the system itself, and they were too busy trying to work that out. Yea, he knew what he was doing. I think initially starting a when we first got there, there was a little bit of a hick up, but after that everything was fine. I was all fine. Yea, absolutely. Yes, they were very knowledgeable about using it. Yea, he was pretty good at pausing and stuff. Yea he had done it for 6 or 7 people before me.	100%	0%	0%
9. Was the scenario set up and ready to go by the time you got to the FuT?	Positive	Negative	Neutral
Once it started going, it worked. It didn't take nearly as long to get the program up and running with the visuals. No, it didn't take long to get everything to get going. We actually had to wait a while for other people, but other than that it was all fine. I stepped right in and was ready to go. Yes, the load was there and it was fast. We had everything at one end, it started then it stopped. They had to reboot the system and go back and wait and reboot again. It took about a half and hour.	70%	20%	10%
10. Did you feel the scenarios reinforced the material better than earlier lessons?	Positive	Negative	Neutral
Not necessarily, no. I don't really think it, well it partially reinforced it really didn't add any more knowledge, technique, or skill. Yea, it gives you a better understanding of the checklist. Yea, helps you figure out what you're looking for "green light." I mean all the steps were there. It definitely went through what you would have to do in flight. I would think so, seeing the actual picture, how we would actually be doing it, so a lot better than some words on the piece of paper. That's good what we did but also may be another option could be like running the in-flight checks, because they stress that so much here. I think the scheduling for that could be a little bit better. Getting them towards the tail end of their LMQ or the middle of their LMQ, once they have any kind of airdrop knowledge. Yes, because of the same as the engine start, it gives you a visual reference as to what you're going to actually see. Again, the audio stuff, I think visually just watching the video of an airdrop is kind of enough visually, but I think just being able to hear, it waits for your checklist response. I think it is a great concept, but there are too many quirks to where I don't think it was effective for me.	70%	30%	0%

11. Did you apply what the scenarios were teaching you to the flightline?	Positive	Negative	Neutral
Overall I would say the heavy equipment was less helpful than the before starting engines one. Not so much. Yea, it helps with the checklist, going through the checklist, situational awareness. Yea, the thing I remember most was the emergency procedure. Yes it did, it was actual practice more so than messing around with everything being simulated. Yes, it is roughly the same except for the simulated stuff. Absolutely, I think it did a relatively good job, cause, I've never seen doors open inflight. Yes, it helped being able to know how everything's going to flow. For the combat offload, yea; for the heavy, no the heavy was so different. Yes, because actually in the heavy equipment scenario we had a malfunction which reinforced everything that I learned right then. I thought that was really, really good.	80%	20%	0%
12. How well did the scene follow you around the FuT?	Positive	Negative	Neutral
Oh, I was at 245, I had set in the perfect spot and couldn't move, or else I could see the scene. Yea, it was smooth; it just had a couple of blackouts here and there. There are only a few blind spots up by 245, but other than that it's drawn very well. Yes, it stayed roughly in the spot. Yea, I didn't see any jumping, when I was walking over the rails near the platform, that's when it seemed a little out of place from the perspective wise for me. When it worked, it worked fine, the only problem was every once in a while it would cut out, or the load would completely disappear. Mainly the pallet that kept disappearing, but usually the outside stayed there. The stuff on the inside would kind of disappear. For the most part, the pallet moving a little bit.	78%	11%	11%
13. Did the scenarios help you retain more of the procedures?	Positive	Negative	Neutral
No. Yea, Once I ran through it. Yea, more procedures to familiarize yourself again with what to expect. I think so; it was more like practical than just going over and over it. I think that like the first time I was kind of confused, the second time it helped a lot more. Like running it through the second time was good. At the appropriate time I think it would definitely. Yes, I would say so, because the only thing I can keep saying is that it gives you the visual reference. I don't think so really, I think just the visual stuff doesn't really help at all. Once the course is working, absolutely, I think it will be a really effective tool.	70%	30%	0%
14. Do you feel this type of training tool helped you learn the objectives?	Positive	Negative	Neutral
It was parallel with them, it was the same objectives, but I don't feel that it helped me on that. Maybe not in its current state, because I spent a lot of time just trying to focus on trying to see the picture, but at the same time I had constantly watch my footing. Yes, but also I bet this tool cost a lot of money. I think it would if it was, if you get it more often. Yeah, it made it a lot clearer. It just painted the picture better; I got to actually see it in action. It made it a lot easier to understand, comprehend it. Yeah I did, I mean, you run your checklist like they teach you and then they show you pointers, you do them again, and then you apply them. Yes, instead of just reading through a checklist and practicing it in the classroom, you are applying the knowledge that you learned in the classroom to a real live hands-on scenario, getting audio and visual cues from the program. Yes, because it helps you, you're not just sitting there looking at your checklists. Yea, it helped a little.	80%	20%	0%

Appendix S

Contractor Instructor Engine Start Interview Questions

Contractor Instructor Engine Start Interview Questions	Percentage of the students that felt the same way		
1. Were you able to run the system well enough to teach the students with the instructions you received?	Positive	Negative	Neutral
Yes, he run through it, occasionally it was more of a computer problem that anything to get it going. I feel very comfortable with that. Yea. Adequate enough. Wonderful, works like a champ; I had no trouble operating it.	100%	0%	0%
2. Was the overall system easy to set up? Was it easy to run?	Positive	Negative	Neutral
Yea. Yes, I didn't have any problems finding it. Not too bad, it was pretty easy. Yeah, and it doesn't have the hiccups that the one out there has. Not glitches after we put it on the hard drive.	100%	0%	0%
3. Did the virtual images stay in the proper position for the students?	Positive	Negative	Neutral
The viewpoints themselves, everything was in a position where they position you for the engine start. I know you can't see the APU on this one. Yes, they were good. It does seem a little crowded. Yes, it's good, I needed to look one way or another it kind of panned over in that direction, and so you could see the crew chief and the power unit.	40%	60%	0%
4. Is this device an adequate training tool?	Positive	Negative	Neutral
It's an enhancement, it's better. Its real time, instead of us just talking through it with the propellers not turning. I think it is an enhancement for them to, when we're talking about that checklist to be able to show them something on the screen while we are doing it instead of just trying to talk through it. More like an enhancement. My opinion, I don't think it helps any more than the video we've been using of Steve Lewis for the past 15 years.	80%	20%	0%
5. Do the graphics portray realistic views of the actual events?	Positive	Negative	Neutral
Yea, everything except the crew chief. Other than the crew chief back there I think the rest of the graphics look pretty realistic. It was reasonable. As real as you can do on the cheap. The only thing, on the engine startup, it starts spinning real quick, too quick.	88%	12%	0%
6. Did the AR system scenario help you train the lesson objectives any better than the current training?	Positive	Negative	Neutral
I do, I think this gives them a visual, instead of just sitting here talking about it. I think so, because all we really have right now, other than the video, which is not really courseware, is just talking through the checklist. The malfunction you have in there are quite an enhancement. I don't know that it's any better, because you need that real; CRM is the biggest part of it. Yes.	75%	25%	0%
7. Do you feel the students that used the AR system retained more of the lesson objectives?	Positive	Negative	Neutral
Yea, they seem too. I think so, not only are they seeing, they are also hearing the other crew positions. Yes, pretty good. No, not really, the thing that they remember was stuff that was taught them in the classroom.	80%	20%	0%

8. Did you see an improvement in the students' procedural abilities going to the flight line?	Positive	Negative	Neutral
Yea, well I mean it's kind of hard to, again I think being able to see it and everything like that ingrains the procedures. I've got really nothing to base that on personally speaking. No, I haven't observed any; they go through a whole lot more academics before they get to the flightline these days. If I had a choice of using that or just standing someone on a comcord and saying, "Imagine two wings," I'd have them imagine. Yes, the practice and the communication coordination with the front end crew, or hearing the checklist responses.	20%	20%	60%
9. Did the students seem to have a higher level of proficiency after using the AR system?	Positive	Negative	Neutral
During the engine start phase of it, it did, when we are doing the GATs, we have to pull them off the GAT and come in here and go and do it. They seem to know, as far as their positioning, where they are supposed to be and the calls they are supposed to make over inter-phone. Yes, of course, it's more interactive; the students have to get involved--there's something required. What I do prepares them enough to go do it the first time. Yes, they knew what their responses were for and they kind of knew where to stand for each engine that they were starting.	60%	0%	40%
10. Did the AR system make your time more productive with each student?	Positive	Negative	Neutral
Yea, there's less to explain. That's a good tool. Sure, I'd like to see the group go through it first, then the 1-1 later. Yes, just more knowledgeable of what that checklist is doing.	60%	0%	40%
11. Did you see an improvement in the student's CRM awareness?	Positive	Negative	Neutral
Yea. Absolutely. Yes, keep it current, looks good. No, they all seem to be confused about a few little things.	80%	20%	0%
12. Did you see an improvement in the student's CRM awareness?	Positive	Negative	Neutral
That's the thing about computer based training is that if they don't understand something, if they have a question, there is no one there to talk to, and so you can't get into any other specific outside the checklist. I think it would be better personally to have something to be interactive that the instructor can, pause it and talk about that segment. I don't know, hadn't thought about it. They would rather just go out there cold, after doing their homework, and get their hands dirty, and then go, "Ah, that's what that means!" rather than look at the little picture on the screen and go, "What does that even mean?", "Why do I care? Yes.	20%	20%	60%

Appendix T

Contractor Instructor FuT Interview Questions

Contract Instructor FuT Interview Questions	Percentage of the students that felt the same way		
1. Were you able to run the system well enough to teach the students with the instructions you received?	Positive	Negative	Neutral
Once you get use to it, it was a pretty simple process. As far as working the system itself, I don't think I would have any problems with it. What makes the IOS hard, is the terms that they use on the IOS, they are not very intuitive. As far as the overall interface, that could use some more love too.	50%	25%	25%
2. Was the overall system easy to set up? Was it easy to run?	Positive	Negative	Neutral
By the time I got up there he had it all set up and running. All I had to do is put the headset on and hit start. Yea I think so. The biggest technical hurdle is that I don't think you'll ever be able to say it's 100%.	34%	33%	33%
3. Did the virtual images stay in the proper position for the students?	Positive	Negative	Neutral
You know sometimes the load was disappearing and there are plenty of glitches to overcome when it comes to the fuselage trainer. The last time we did it we had that little blind spot at 245. Not perfect, I think when they took the time to go ahead and align everything it was better.	0%	100%	0%
4. Is this device an adequate training tool?	Positive	Negative	Neutral
If everything work perfectly it would be a great training tool, but if it doesn't, it is counterproductive. I think it is a valuable tool as long as it stays functioning. I think the combat offload one had a ton of merit from the reverse taxi option, but for the actual pre-slowdown checklist, it's more of a hindrance.	67%	33%	0%
5. Do the graphics portray realistic views of the actual events?	Positive	Negative	Neutral
I guess for the most part. There needs to be some improvement on it, on the actual heavy equipment picture itself. Yea, I think for the most part. The parachute's not bad; the combat offload pallet is not bad at all. Once again, I might use something a little different; a little larger than one of our training loads out here.	100%	0%	0%
6. Did the AR system scenario help you train the lesson objectives any better than the current training?	Positive	Negative	Neutral
For this test right here, with all of the glitches and everything, I would say, I would have to say no, because I can't talk to every step in the checklist. Yes, here again having that interaction, I know it was a script over interphone, but still having that. We can talk through a combat offload checklist. I think it could be a very good tool for using that reverse taxi a 5-min add-on to one of our GATs as far as reverse taxi goes, I think it's wonderful.	67%	33%	0%

|	Positive	Negative	Neutral
7. Do you feel the students that used the AR system retained more of the lesson objectives?	Positive	Negative	Neutral
Yea, most definitely. If everything worked properly and again everything was kept up to date. Yes. I think if you saw that happen, with the checklist running, you would better understand it, but on the flip side, if I just went out with a video camera and videotaped the crew, and did that, which would be possibly better.	67%	0%	33%
8. Did you see an improvement in the students' procedural abilities going to the flight line?	Positive	Negative	Neutral
From the one minute advisory on, the ramp and door opens up, the load goes out, they go back and clear the ramp and door and call it clear to close, while running it real time with the flight crew checklist, that part is better. I had such limited exposure; I really can't answer the question. As far as saying they're any more prepared to go to the flightline, I don't have any tangible way to judge that.	33%	0%	67%
9. Did the students seem to have a higher level of proficiency after using the AR system?	Positive	Negative	Neutral
I really didn't notice a difference. I really don't have that much to gage. I can't give you a yes or no, a maybe--I can't give an answer to that, because there's no way for me to define it.	0%	0%	100%
10. Did the AR system make your time more productive with each student?	Positive	Negative	Neutral
If you are talking about replacing one of our air events with it, if it would be more productive, I would have to say no. I don't know how to answer that, depending on your class size; I don't know how much time we are going to have to work with each person. Where I tried to gain productivity out of it was, I'd have one person perform it, and on person watch it-virtually, on combat offloads. I find this works in just about anything.	0%	33%	67%
11. Did you see an improvement in the student's CRM awareness?	Positive	Negative	Neutral
Yes, it's a definite improvement in running the in-flight checklist with the front end crew. Absolutely. That checklist that you have running on there is the most benign, drawn out, everybody's voice sounds similar on that.	67%	33%	0%
12. Could computer based lessons be used to teach any of the Loadmaster procedures?	Positive	Negative	Neutral
Gosh I don't know. To me I would think if you were going to do it you would do it as a virtual reality trainer, not necessarily a CBT to run an in-flight checklist. I think that would be difficult. Sure, I think it would be helpful, you bet. As long as it was interactive, I think it would almost be more beneficial than what we saw out there, as long as they were doing something.	67%	0%	33%

Appendix U

Flight Instructor Interview Questions

Flight Instructor Interview Questions	Percentage of the students that felt the same way		
1. What improvement in (Jane's, John's, etc.) performance did you observe compared to classes in the past?	Positive	Negative	Neutral
Well, some students seem more fluid, more comfortable out there than others. For the heavy equipment, the airdrops I really have noticed a difference, in the last few months. The students listed here do seem to have a good sense about what to expect next, what to do. I saw a lot more fluidity, a lot more checklist discipline during the airdrops. I've had to instruct less during the actual procedure. Once they get to the airdrop portion, and they don't do any of the airland stuff again, they lose it. So we spend probably three hours just going through every checklist with them. Asking them basic information about every checklist and showing them what they need to check. It would be hard for me to say improvement. When they actually get out there, they kind of feel like they know what they're doing. They stand out to me as being good with the airdrop, I think I got them for heavy, either way, their checklist was fine, amazing, as far as new students. Overall I'd say that the majority of the students, their knowledge didn't seem to be as high as some of their predecessors. From what we have seen a few guys here and there compared to some of them that had been through the virtual reality and some of them that haven't, it is really hit or miss on either end.	43%	14%	43%
2. What differences did you observe in your recent students (Jane's, John's, etc.) familiarity with the engine start procedures compared to students from previous classes?	Positive	Negative	Neutral
A lot of it depends on your students, you have your good students, but also you have your bad students. There are some students when they get out there they can run through with no issues, other students, once you get that engine turning and the noise places a real big distraction to some, as opposed to others. I'd say yes, you get them out there, and they're ready to go…they're listening up on the headsets, kind of knowing where to stand, what do do…stuff like that. They kind of know what to expect. As far as engine starts, that's not too cosmic, nothing stood out. They seemed to be able to sift through the chatter, like they knew what they were looking for.	40%	0%	60%
3. What differences did you observe in your recent students (Jane's, John's, etc.) familiarity with the airdrop procedures compared to students from previous classes?	Positive	Negative	Neutral
For the most part, with your in-cord of better students, they know once it goes out, call load complete and go back. I think it still comes down to how much they put into it. They do airdrop and they're so wide-eyed, they're just ready to see something shoot out of the back of the airplane, they kind of get caught up in a lot of the stuff, I'd say, it's a little bit harder to judge and then too, depends on the student. They got up and knew what to do and they ran the checklist like the way they were supposed to; like they'd done it before. There's no one who really stand out. I can't give accurate feedback for airdrop, starting engines or combat offload.	40%	0%	60%
4. What differences did you observe in your recent students (Jane's, John's, etc.) familiarity with combat offload procedures compared to the students from previous classes?	Positive	Negative	Neutral
It's hard to tell because it also depends on the quality of instructor they are getting as well and how well he goes over the information with them again beforehand. It is kind of a crap shoot with some students. Nothing really stood out to me--it was pretty typical. Combat offloads never really had any problems. Did they come through any more dedicated, as far as studying? Negative...that's a big negative. The students nowadays definitely feel that we owe them something, they can show up and not feel good, and we're supposed to be understanding.	0%	20%	80%

	Positive	Negative	Neutral
5. What differences did you observe between the progress made by your recent students and students from previous classes (e.g., did they move any faster through the flightline phase of training?)	Positive	Negative	Neutral
You haven't had anybody progress any faster or less time? Instr: Nope. It is hard to pin point all the time who you're weaker and stronger students were. I think with the two I have, one being a non-prior flier, they spend a lot of time working together. So, not only is he getting the information from the instructors here, but then there are going into some areas working together. Not really, you still have your bad apples out there. Yes, I think so, but you'd have to catch the right student. The only proficiency advances we've done were prior service guys. I would say that most people leave here with a Q1, but getting a Q1 with no discrepancies, that's even better.	33%	33%	34%
6. .Do current students have a better handle on CRM procedures compared to previous students? In what way?	Positive	Negative	Neutral
In terms of CRM and SA, I've noticed a big jump in the last two months. Yea, so actually I've seen a jump in SA and CRM discipline and skills in the last few months with these students. The first flight I would probably say no, cause of shock and ahu, first time actually running the checklist, first time running combat entry, knowing what calls for combat entries, just basically situational awareness. I would say that they are both doing well. The first flight was better than I expected. They're more in tuned to paying attention, they're starting to realize, hey, there's a crew concept--you have to listen at all times to what's going on. It might be a little better, compared to ones in the past, not as apprehensive to speak up. Yes, I do, they both interact with the crew just fine, if I didn't know any better, I'd say they've been doing it for longer than just two or three flight. I think that everything that you're talking about here could be helping the student, but it's up to the instructor. Like this guy is doing great, I'm just impressed, always thinking ahead, not too far to get overwhelmed or ahead of himself. I think if they went through it a little more before they came down here, maybe it would be something that would stand out more.	75%	13%	12%
7. Could computer based lessons be used to teach any of the Loadmaster procedures? If so, which ones? If not, why?	Positive	Negative	Neutral
Oh absolutely, 100 percent, because most Loadmasters learn better by seeing rather than by reading, by actually doing, involving themselves more in the process. I don't know if I would do away with the CBT entirely, because they still need to retain the book knowledge, I think the interaction part is very crucial. Obviously anything you can see visually that describes what being done will make it better. The new guys coming in that have never been on a 130 before, have never dealt with flying before, any source of familiarization would be good. I think it depends how soon, the time span between when they receive it, training, and stepping to the flight line. Personally, I don't really agree with CBTs, because mostly, they just want to get to the end. PI: What about something for heavy equipment airdrop in a lesson like 360? Ans: That would be good, because a lot of the time, what we use is a piece of paper with a crude picture on it where you're trying to talk about stuff, because it's one thing to talk about it, but another to put your hands on it. I'm a hands-on type of guy, for CBTs I just click through them. I'll read it, but it may not make sense to me, but if I see it, AND I've read it, I'll make the connection. If you had it interactive enough that the voices were there and it would stop when you were waiting on a Loadmaster response, yeah, I think that would work out a lot. PI: If we have the iPad and each of the students have it, you can send them stuff, "Okay, let's talk about this"...then you can load the planes up. Would that help? Ans: I'm going to go out on a limb and say definitely. Absolutely, I think the closest you can get to being out on the plane. Actually seeing it for what it is and how it actually looks like a 360 view, have an actual plane. Yea, that would help.	88%	12%	0%

Appendix V

LED Light and OptiTrack Camera
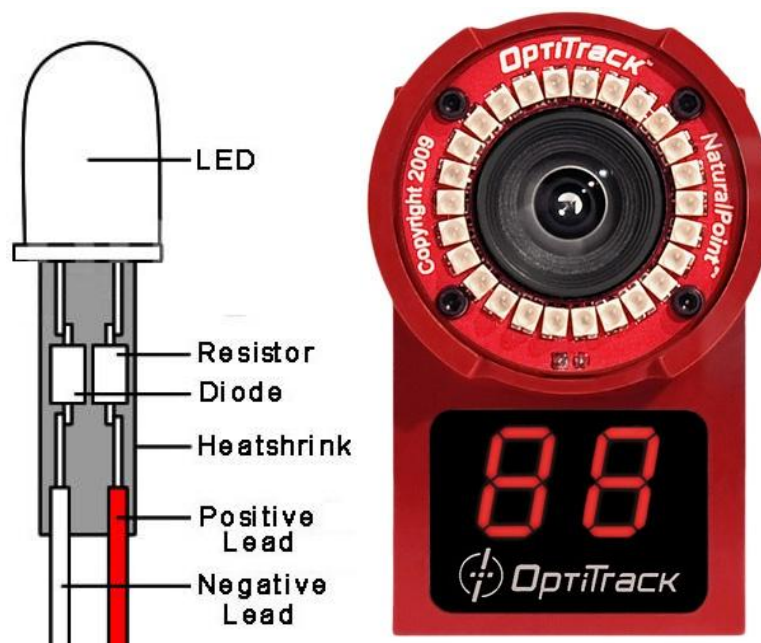
Appendix W

Old and New HMDs

Liteye – FOV 24°
@ 640 x 480, VESA (VGA/SVGA)

Trivosio - 29° diagonal (4:3, 23°
(horiz), 17° (vert)), DVI-D

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