INTEGRATING ENGINEERING WITH TRAINING SIMULATION

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ABSTRACT

AAMRL has uniquely combined engineering and training simulations through the B-1B Engineering Research Simulator (ERS) for Strategic Air Command. Clear and mutual benefits are derived from integrating cockpit engineering and crew training simulations. The best method of integration is the development of a government owned joint Engineering/Training Simulator (E/TS) early in an aircraft program. An E/TS could prototype displays and controls and serve as a prototype for training devices. Engineering changes developed in the E/TS could be evaluated at aircraft main operating bases by qualified aircrews in the E/TS compatible trainers. An E/TS would help produce more reliable cockpit designs and reduce schedule and cost associated with development and software update of training simulators.

INTRODUCTION

Traditional cockpit design is accomplished using static mock-ups of crewstations. Structural layout, instrument arrangement and ergonomics can be quickly and economically determined by such full-scale models. Function of displays and controls is not a critical issue because standard dial instruments and control devices are well understood. Flight dynamics of the aircraft were fixed by aerodynamics and control mechanics. The invariant nature of displays and controls make the static mock-up a sufficient and cost-effective cockpit design tool.

The design of modern aircraft displays and controls has changed dramatically with the incorporation of computers. Cathode-ray tube and other programmable display technologies provide the cockpit designer with a richer media for information portrayal. Flight control systems using computer fly-by-wire systems permit complete specification of aircraft response to control input. These display and control systems are software reprogrammable, therefore display error correction or enhancement is possible without major hardware changes.

Programmable displays and controls have changed cockpit configuration from an initial design task into an ongoing activity over the life of the aircraft.

Contemporary cockpit designers are increasingly relying on computer simulators to assist in the design and maintenance of cockpit configuration. Rapid prototyping systems exist which are capable of creating and exercising cockpit displays (Davis and Pencikowski, 1988; Wilson and Kuperman, 1988). Aircraft development programs have developed specific engineering simulators for specific aircraft (Wykes and Spinoni, 1987). The Air Force Cockpit Automation Technology program is developing computer design tools and mission scenarios to validate cockpit design in simulation (Kulwicki, McDaniel and Guadagna, 1987). Another type of simulator is the ground based engineering laboratory equipped with the actual aircraft avionics.

The principal problem with extensive use of simulators for cockpit design and development is that they are much more expensive than mock-ups. Cost of the simulator is embedded in the aircraft development cost. The advantage of simulation is often overcome by budget constraints. Simulation would be more attractive if the cost could be amortized over more of the aircraft's life cycle.

Design support is actually the minor role for simulators in an aircraft program. The principal use of simulation is for aircrew training. Every major aircraft has an associated training simulator program. The training simulator sometimes lags behind the aircraft's development. The reason for this is that the simulator cannot be built until the aircraft specification is complete. Since the specification could still be evolving even during prototype aircraft construction, the specification could be a 'moving target'. This could result in the aircraft being delivered before delivery of the training simulators. Simulators may not be available during early crew training when they are needed the most.

This time lag between B-1B aircraft and training simulator delivery was exacerbated by that bomber's unusual development schedule. The B-1A flew as a prototype for nearly a decade before being put into production. The abnormal development program prevented a training simulator program from being properly timed.

Strategic Air Command foresaw this problem and determined that it was necessary to build an interim device for the B-1B bomber program. Two ship sets of the Engineering Research Simulator (ERS) were built by Armstrong Aerospace Medical Research Laboratory (AAMRL) with support from Science Applications International Corporation. The ERS has been utilized in engineering and has filled the time-lag in aircraft simulator acquisition. The ERS is a Cockpit Procedures Trainer (CPT) simulation of the B-1B bomber. Fabrication was facilitated by utilizing best commercial practices rather than military specifications. Additionally, the ERS has not been held to configuration control because of its primary role as an engineering device. The simulator was delivered on time and within budget to the B-1B training program at Dyess AFB, where the ERS served as an interim trainer before the first bomber arrived.

The ERS can function in an integrated mode for crew coordination or as four separate crewstation simulations. The ERS has a capability of displaying actual or synthetically generated B-1B Synthetic Aperture Radar (SAR) imagery by utilizing pre-recorded images stored on an optical video disk playback unit. The simulator flight stations have neither a motion base nor an outside-the-window scene generation system. The ERS served as an interim CPT at Dyess AFB until the training simulators were delivered, and is now acting as an interim trainer at Ellsworth and Grand Forks AFBs until the Weapon System Trainers (WSTs) are operational.

Specifications for the ERS were written in such a manner so that it is capable of displays and controls engineering design and evaluation as well as satisfying interim crew training requirements. Funding for engineering support and testing has been received from both the B-1B and Electronic Warfare System Program Offices (SPOs). Software is developed at AAMRL's local ERS Hot Bench software prototyping facility, which permits testing here at Wright-Patterson or at field installations with qualified B-1B crewmen (Green, Purvis and Marshak, 1989). These studies have proven to be very cost effective, and provide the aircrews with a sense of participation and control in the evolution of their aircraft. Project

engineers from B-1B SPO have also used the ERS to familiarize themselves with the function of aircraft systems. The ERS is a blend of engineering and training applications with significant benefits for both.

The ERS was developed long after the B-1A/B cockpit was specified. Its engineering role has been one of modification evaluation. What if the engineers would have had an ERS-like device early in an aircraft's design? Consider the possibility of building an engineering simulator for a new aircraft during the cockpit design process. The simulator would be fabricated to best commercial practice after static mock-ups. Such a device would permit greater exploration of cockpit function than the traditional mock-up process but with the associated increase in costs.

What if this simulator could also be used as the basis for training devices such as a CPT or a part of the more capable WST? The device would become an Engineering/Training Simulator (E/TS). The cost of the simulator could be amortized against not only the engineering work, but also against the development of the aircrew trainers. The trainers would have a tremendous time advantage because their prototype would be built simultaneous to aircraft definition, eliminating the time-lag due to finalizing aircraft specifications. Project engineers could use E/TS for orientation for greater familiarity with the aircraft systems. Test pilot training could occur in the E/TS. Subsequent operational trainer contracts could require using the E/TS hardware and software, dramatically reducing costs and development time.

The advantages of a joint E/TS do not end with aircraft development. Subsequent modifications or upgrades to the aircraft cockpit should be assessed in the engineering version of E/TS before the Air Force commits to expensive aircraft changes. This mimics the evolving role of ERS for the B-1B. The participation of qualified aircrews in engineering studies has provided valuable insight into proposed B-1B changes when tested in the ERS (Green, Purvis and Marshak, 1989).

An advanced application of the E/TS software could be direct conversion of computer software into aircraft compatible code. Using software engineering principles and advanced languages such as ADA, this portability of code from E/TS to aircraft may be possible. Such a conversion would provide considerable cost savings, even if substantial software changes were still required to tailor E/TS software for the aircraft application.

A more likely software synergy would be between E/TS and the similar field trainers. Since the engineering and training simulators have the same design, these hardware and software changes could be directly ported into the trainers concurrent with the modifications made to the aircraft systems. The engineering E/TS would serve as the development machine for the fielded trainers, eliminating the need to maintain a dedicated development system. The field training E/TS could be updated concurrently with changes in the aircraft. The tendency of trainers to lag behind aircraft modifications would be virtually eliminated.

The E/TS must be a government owned device to maintain control, access and reduce costs. Government ownership permits the E/TS design to be applied to the training simulators. The E/TS should be jointly built and operated by the Aircraft and Training Systems Program Offices, a government human engineering laboratory and the aircraft manufacturer. Program office participation would guarantee both engineering and training are satisfied by the E/TS design. Laboratory participation would create the opportunity for human engineering consultation and alignment of research programs to support aircraft development. The aircraft manufacturer representatives would participate in the E/TS to support design and fabrication of the aircraft. Engineering, training, research and industry dollars could be coordinated to create an effective and responsive combined program.

The integrated Engineering/Training Simulator approach has tremendous potential to enhance new aircraft procurement and sustainability. AAMRL's successful experience with the Engineering Research Simulator provides evidence that this kind of joint venture can succeed. The net cost reduction and enhanced schedule performance for aircraft design, modification and aircrew training should be substantial.

Bibliography

- Davis, M.C. and Pencikowski, P. Reconfigurable cockpit development, Proceedings of NAECON, May 23 1988, pg 840 - 844.
- Green T.B., Purvis, B.D. and Marshak, W.P. Engineering design simulation for the B-1B Bomber, Proceedings of NAECON, May 22 1989, in press.
- Kulwicki, P.V., McDaniel, J.W., Guadagna, L.M. Advanced development of a cockpit automation design support system, AGARD Conference Proceedings No. 417, April 27 1987, pg 19-1 - 19-15
- Wilson, D.L. and Kuperman G.G. Strategic Avionics Battle-Management Evaluation and Research (SABER), Proceedings of NAECON, May 23 1988, pg 844 - 849.
- Wykes, K.M. and Spinoni, M. Towards the next generation fighter cockpit: The EAP experience, AGARD Conference Proceedings No. 425, October 28 1987, pg 23-1 - 23-18.