

DEVELOPMENT OF AN INSTRUCTOR STATION DESIGN GUIDE

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Abstract

Training device effectiveness is largely dependent upon the characteristics of the instructional subsystem. In most trainers, this includes the instructor, the instructional software, and above all, the interfaces (both hardware and software) to the other training device subsystems. The primary interface, the trainer IOS, must be designed and supported so that the training device meets not only the training objectives, but also the user requirements. Effective design can only be achieved through identification and understanding of the characteristics of the user and the required training, and then by ensuring that these data are reflected in the design of the station. The design task also requires detailed monitoring of the design effort to ensure that the necessary data are available and input to the design effort. The objective of the guide was, therefore, to identify the tasks involved and the data required during the major training device life cycle events which impact the characteristics of trainer instructor/operator stations. The guide focuses on "what" to do in design, not "how" to do it. A guide which focused on "how" it should be done would soon be outdated since hardware and software technologies are evolving so rapidly.

Background

The Naval Training Equipment Center has conducted a series of studies of Instructor/Operator stations (IOSs) of major training devices over the past few years.^{1,2,3} The studies were initiated following reports of utilization problems from using activities. Two weapon system trainers (WST) were surveyed, Device 2F112, the WST for the F-14A and Device 2F119, the WST for the EA-6B. A third survey was conducted of a part task trainer, Device 2E6, an air combat maneuvering trainer. The studies revealed a wide variety of problems ranging from the lack of application of basic human engineering design criteria to lack of support to ill-defined basic training functions.

As a result, the Naval Training Equipment Center undertook the development of a guide for use in the design of training device IOSs. The guide, now under review, includes a variety of material from design procedures to proposed specifications and standards. The guide departs from a baseline of existing human engineering design data and identifies basic procedures required to ensure the application of these data along with systems design techniques to achieve an efficient, effective and user acceptable interface to the training simulation.

Additional surveys were also conducted to broaden the data base. Land, sea and maintenance trainers were included. The results of these surveys paralleled the earlier results.

IOS Problem Areas

The surveys described earlier revealed the following general problem areas across the variety

of trainers examined.

IOS Layout Problems

From the review of IOS installations, it is clear that insufficient attention is given to console location and layout. In general, it appeared that the typical IOS is located in a main traffic flow pattern, and becomes a meeting place for personnel in the area. While observation of on-going training can contribute to learning, a ready room environment is not conducive to either the training or to beneficial observation. In addition to the congestion problem, the trainees can often get a glimpse of the upcoming simulation being initialized. Light spills onto the displays when doors are opened. Noise interferes with inter-instructor communications.

Arrangement Problems

Most IOS consoles provide a station for each of the instructors as foreseen by the specification and the design. This rarely reflects the use and user needs. One of the major problems occurs in the battle or war problem event. Often, in practice, the instructor is forced to share the displays of the other stations, manipulate the station controls of other instructors, and perform the functions of other instructors.

Display Problems

The CRT display provides the designers the opportunity for displaying literally any simulation data available. In many trainers, this function is over used. The volume of pages often requires the use of index pages.

The quantity of data frequently exceeds the capacity of any instructor to access and utilize it effectively during training and still be able to monitor and evaluate replacement pilot performance. The options cannot be accessed by an instructor who is not trained and proficient or experienced in the IOS operation.

CRT monitor displays on the typical console pose serious problems since the data is not displayed in a manner readily interpreted by the instructor. The displays do not typically parallel either the arrangement or the format used in the actual equipment.

Control Problems

The typical instructor station has two CRT displays along with some repeater displays. The CRTs are operated by selecting the CRT (and sometimes the specific area on the CRT) to be utilized, then selecting the display mode to be accessed and finally paging to the data required. The sequence of steps which involves both switch and light pen operations, for example, is time consuming and requires the instructors' concentrated attentions. Errors, which often occur, typically require repeating the entire sequence of steps.

Light pens are widely used for simulator control. Although light pens are becoming more reliable, they are still unacceptable for time sensitive inputs such as malfunction insertion, weapons launches and training control functions. In the past, poor light pen reliability has severely handicapped console operations.

The typical joystick display-control dynamics involve a step function which renders it unusable for CRT operations. Manual control or flying of targets using the joysticks has proven equally impossible because of the lack of sufficient flight information and because of joystick control axes coupling.

Communication options controls on most IOSs have proven so time consuming to use and so error producing that the options are not utilized. The control panel is left in "over-ride".

Operating Problems

Manual modes of trainer operation have generally proven difficult to utilize even though required for many events. The major problem is one of knowing on what page and in which display mode the relevant data is available, and when accessed, how to edit and what the impact will be on inter-related parameters. The task is beyond the "novice" user.

Programming or formulating methods requires extensive training and recent experience to utilize. This requirement cannot be met by the typical instructor. The procedures on most IOSs do not provide an "interface" between the instructor and the mission programmer.

Target creation is normally accomplished in simulation parameters rather than in user terminology. Thus, targets are created in terms of "small fighter" with an "IR" missile and a spot jammer, for example, rather than in terms of a Badger or Backfire or Muffcob. The result is that the instructor does not generally know what the displayed target represents or how to evaluate the aircrews' tactics relative to the target.

The problems identified above occurred on a recurring basis as virtually every IOS surveyed was examined. It is apparent that certain key design steps were either not accomplished or were done in a cursory fashion. The rationale for the design guide resulted directly from the IOS deficiencies identified. We must stress that the guide describes what design tasks to perform and not how the IOS should be designed.

Trainer Life Cycle Events

The life cycle of a major training device consists of three distinct phases, the requirements definition or pre-contract phase, the acquisition phase and the support phase. The pre-contract phase begins with the promulgation of the trainer operational requirement and ends with the selection of the development contractor. The acquisition phase begins with the award of the development contract and concludes when the trainer is ready for operational training. The support phase begins with the acceptance of the trainer for training and concludes when the trainer is "retired".

Figure 1 summarizes the tasks required in the overall trainer life cycle in flow chart format. Although depicted as sequential, many of the tasks,

especially in the support phase, are iterative in nature.

Not all of the tasks illustrated are directly relevant to IOS design. For example, some of the early tasks in the pre-contract phase can occur prior to promulgation of a trainer requirement statement. Others only indirectly reflect the IOS, such as those involved in conducting support reviews or in the reporting of trainer utilization. However, they are shown to illustrate the major overall life cycle events. The tasks formed the point of departure for the development of IOS life cycle tasks.

Each of the tasks identified were analyzed in terms of inputs, action(s) required and resultant output(s) whether a requirement, a design, or a test product. Since the tasks are in general sequential, the output of each task tends to constitute the input to the next. Thus a defect in the output of a specific task has ramifications which generally extend far beyond the immediate task.

A variety of terms have been utilized in analyzing and discussing IOSs, often resulting in confusion. Therefore one of the first tasks involved the development of a set of definitions. The definitions developed are pragmatic in character and serve to distinguish not only between the IOS and the computer operating console, but also between the different stations utilized for the operation of the trainer during the training exercises. The term "instructor/operator station" for example, was used to include all stations which are utilized in training as distinct from, for example, the computer operating console or terminal which is utilized only in "powering up" the computer system, loading programs, running computer system diagnostics and tests, powering down and non-training operations utilizing the computer system.

The next step was to identify subsets of IOS life cycle tasks in the three phases of the trainer life cycle, especially those which related to the problems identified in the surveys. The objective was to identify the critical analysis, development, implementation and support tasks which directly establish the effectiveness and acceptability of the trainer instructor/operator station (IOS). Those actions which must be taken during the design and development of a trainer to ensure that an effective and operable IOS is implemented were identified. The guide is intended to be used by all personnel and activities directly involved in major training device instructor/operator console design, development, evaluation, modification and update efforts.

IOS Design Tasks

IOS Pre-Contract Phase Tasks

As illustrated in Figure 1, the pre-contract phase for a trainer includes all of the analyses and documentation steps involved in translating the trainer operational requirement into a procurement or design/performance specification. Figure 2 outlines the pre-contract phase tasks which specifically concern the IOS subsystem. The tasks are outlined in a flow chart which is generic in nature. The detailed task flow for any training device IOS will vary with the specific requirements and training objectives involved.

The task flow in Figure 2 also fails to illustrate both the interaction of the tasks in terms of data and analyses and the iterative nature of the tasks. The results of most of the tasks must be

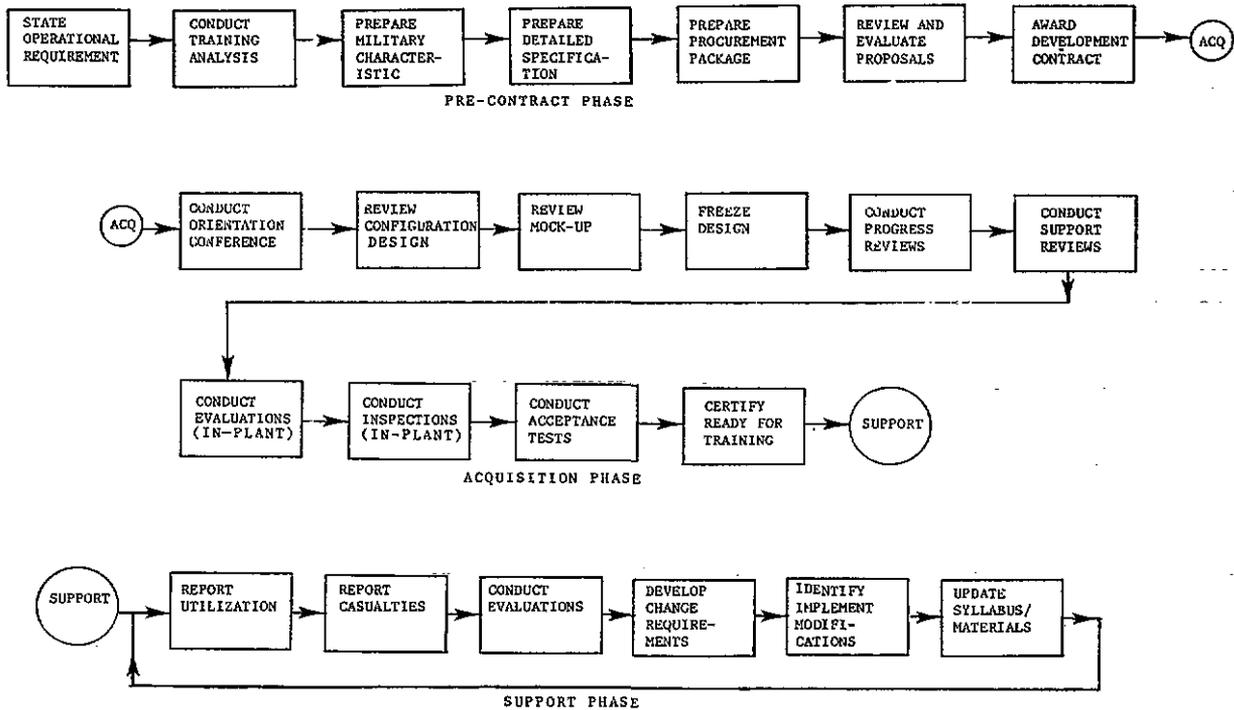


Figure 1. Major Trainer Life Cycle Events

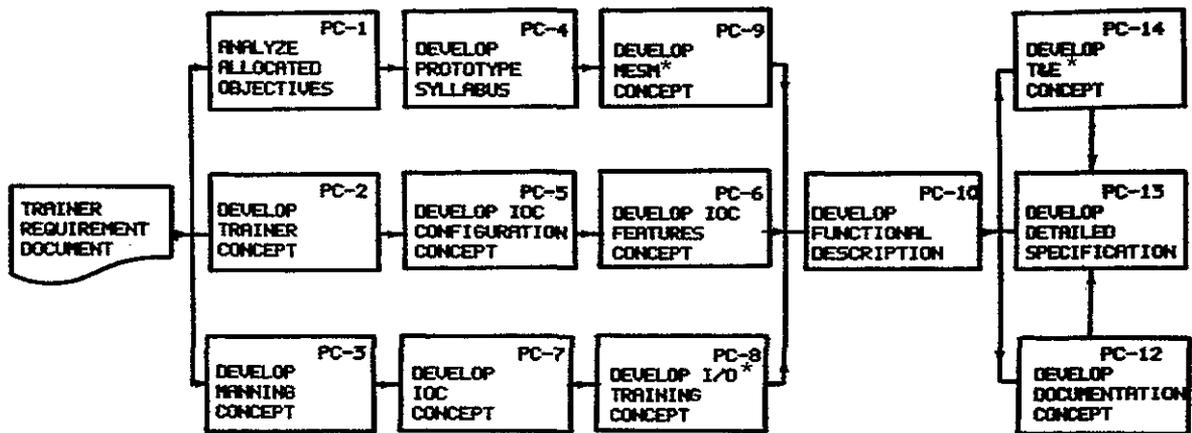


Figure 2. IOS Precontract Phase Tasks

*I/O = Instructor/Operator
 *MESM= Minimum Essential System Matrix
 *T&E = Test & Evaluation

considered in the other analytical tasks which must in turn be revalidated based on other inputs. The necessity for validating preceding analyses following subsequent analyses and data cannot be overemphasized. A PERT (Program Evaluation Review Technique) style of flow chart should be created for each project to relate the outputs of the tasks to subsequent tasks and to indicate the flow of data

between tasks. Critical paths can be created once completion time data have been developed.

The Fleet Project Team (FPT) which is established for each weapon system and trainer provides a major input to this phase in terms of user requirements, training concept, manning concept and subject matter expertise, both in weapon system and related

trainer characteristics. The FPT is defined and established in accordance with Navy Department Chief of Naval Operations Instruction 1551.7 "Fleet Participation in Development and Acceptance of Operational Flight/Weapon System Trainers (OFT/WSTs) and Other Major Aviation Operational Training Devices."

Each of the tasks outlined in Figure 2 was analyzed in terms of its objectives, inputs, actions, outputs, and impact on trainer IOS acquisition and support. Contingency subtasks which must be completed if the required inputs are not available are also described. These subtasks are not a substitute for the basic task requirements in terms of inputs and should only be utilized where the input data is missing and insufficient time remains to complete the preceding tasks. However they do not provide the full set of inputs required. When utilized, subsequent verification and validation of the results of the task must be undertaken as soon as possible.

The top row of tasks is concerned primarily with the development of tests or prototype syllabi based on the training objectives and with the identification of the trainer functional subsystem required to support training syllabus events or exercises.

The center row of tasks address the problem of identifying the IOS functional requirements including the configuration and the instructional and operational features.

The bottom row of tasks structure the IOW manning concept and I/O (instructor/operator) training concept for input to the functional description.

The pre-contract phase concludes with the development of the IOS functional specification and its translation into the IOS portion of the trainer specification.

IOS Acquisition Phase Tasks

The IOS related acquisition phase tasks are outlined in Figure 3. The tasks are depicted in a generic flow chart. The detailed flow may vary for any specific IOS development effort. The flow begins with the first task in the development effort and is based on and utilizes the data developed in the pre-contract phase.

The tasks defined are the responsibility of the Training Device Development and Acquisition Activity (TDD/AA) as defined in OPNAV Instruction 1551.7, and in particular, the training/human factors technical monitor for the project. They also provide guidance to the trainer developer insofar as the tasks identify data and results which will be evaluated by the TDD/AA.

IOS Support Phase Tasks

Figure 4 outlines the IOS related tasks which occur during the support phase of the trainer's life cycle. Most of the tasks as shown are repeated regularly during this phase of the trainer life cycle. In general, the basic tasks involve identifying changes required to enhance and update the training program as well as the updating of all of the documentation effected by the system change and modification. Four decision blocks are shown, three of which trigger the initiation of tasks related to ensuring that the IOS subsystem is updated and modified as required. These decisions blocks result in tasks related to the type of support event

involved and include:

- trainer change - a procedure for modifying or updating the trainer to incorporate weapon system changes or training changes such as syllabus changes, manning changes, training method modifications and performance criteria changes,

- quality assurance and revalidation (QA&R) - a periodic evaluation of trainer quality and configuration,

- training effectiveness evaluation (TEE) - a periodic evaluation of the trainer's effectiveness in the training program,

- trainer retirement - the end of the trainer's operational life.

The trainer users and the FPT provide essential inputs to the tasks and must be utilized to ensure that the task objectives are met and reflect the operational training needs. The objectives of the tasks depicted in Figures 2-4 are generally described by their titles with the following possible exceptions:

Task PC-3 Develop Manning Concept

Objective: To establish the trainer IOS manning philosophy and constraints and to provide a manning concept to guide IOS functional description.

Task PC-9 Develop Minimum Essential System Matrix Concept

Objective: To identify the degraded trainer performance training/requirements capabilities.

Task AQ-1 Review Configuration Report

Objective: Verify that the design configuration meets the requirements and concepts developed in the Training Requirements Analysis, the Military Characteristics and the trainer performance specification.

The report explains all tasks in detail, including their objectives.

Miscellaneous

In addition to identifying the major subtasks involved throughout the IOS life cycle, data were generated for application to design. A proposed set of standard display, control and panel abbreviations were developed. A list of features to support instructing and operating functions were identified and described. Finally, a taxonomy of instructor/operator functions was developed for use in IOS design.

Summary and Recommendations

Over the recent years, it has become clear that the increasing utilization of training devices has exposed deficiencies in instructor/operator interface design - the Instructor/Operator Station. The problems reflect not only inadequate human engineering design but more importantly, the failure to address training functional requirements and user characteristics. The Naval Training Equipment Center undertook the development of an IOS design guide for use throughout the life cycle of a training device. The guide identifies the key subtasks involved and describes the steps which should be taken to ensure the design, development and support of an effective instructor/operator station for major training devices.

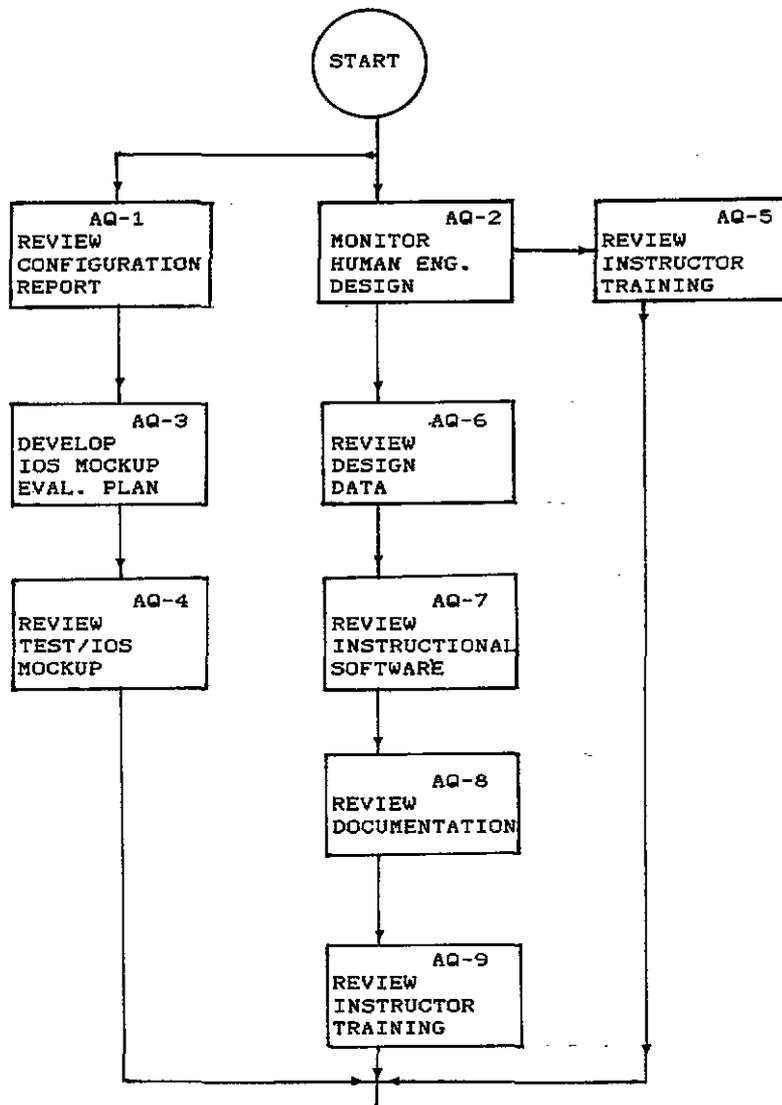


Figure 3. Acquisition Phase Tasks (Page 1 of 2)

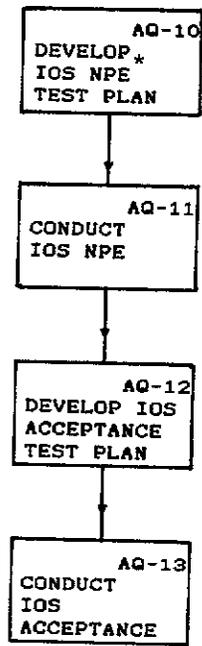


Figure 3. Acquisition Phase Tasks (Page 2 of 2)
 * N/E = Navy Preliminary Evaluation

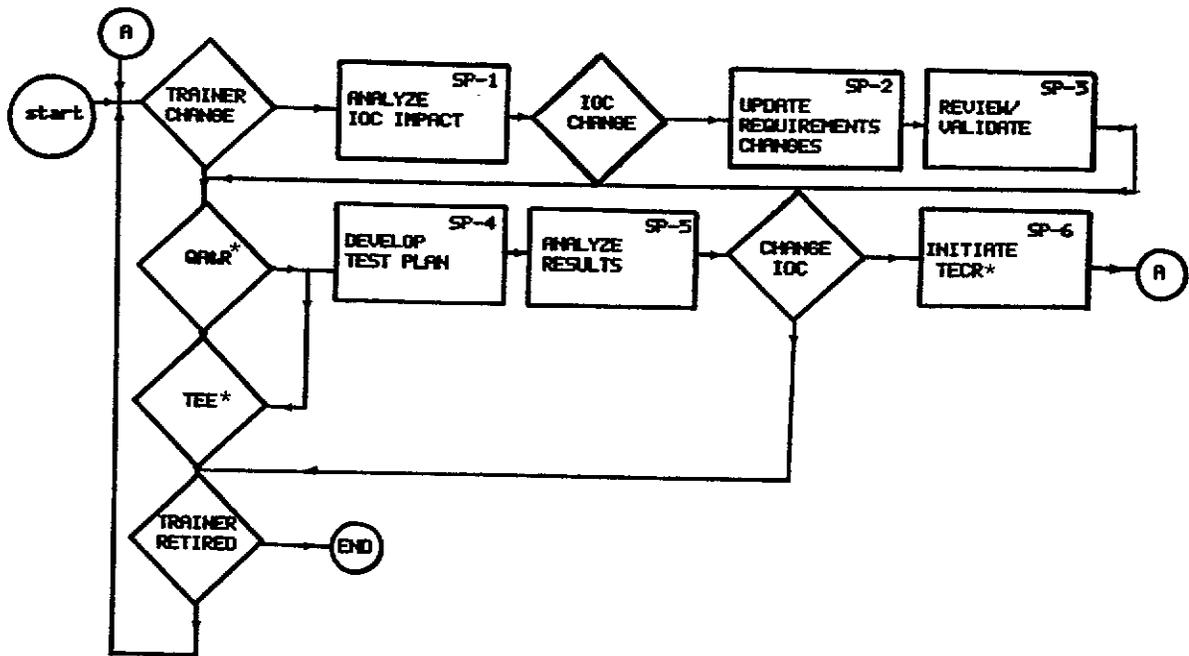


Figure 4. Support Phase Tasks

- * QA&R = Quality Assurance and Revalidation
- * TEE = Training Effectiveness Evaluation
- * TECR = Trainer Engineering Change Request

IOS design cannot be an afterthought if the station is to be useful. The same work which goes into hardware and software design for the trainee station must also be applied to the IOS design. The subtasks described here may seem too numerous and/or complex for most IOS design projects. However, we believe that to the degree these subtasks are at least considered, if not actually accomplished, the IOS will prove to be an effective instructional tool. We recommend that resources be set aside early in the project to address the subtasks and their implications.

References

¹Charles, John P., Device 2F119 (EA-6B WST) Instructor Console Review. Technical Report NAVTRAEQUIPCEN 81-M-1083-1, Naval Training Equipment Center, Orlando, FL, November 1982.

²Charles, John P., Device 2F112 (F-14A WST) Instructor Console Review. Technical Report NAVTRAEQUIPCEN 82-M-1121-1, Naval Training Equipment Center, Orlando, FL, December 1983.

³Charles, John P., Device 2E6 (ACMS) Air Combat Maneuvering Simulator Instructor Console Review. Technical Report NAVTRAEQUIPCEN 82-M-0767-1, Naval Training Equipment Center, Orlando, FL December 1983.

About the Authors

Dr. John P. Charles has over 30 years of experience in Human Factors analysis and training system design. As both a Naval Officer and training system contractor, he has been intimately involved in the analysis, design, and evaluation of training device instructor operator stations.

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