COMPUTER AIDED SYSTEM FOR THE DEVELOPMENT OF AIRCREW TRAINING (CASDAT)
A GENERIC APPROACH TO COST-EFFECTIVE ISD

Dr. PATRICK E. SMITH, AND STEVEN A. MURRAY
Veda Incorporated

INTRODUCTION

The effectiveness of current instructional development systems in the military cannot be argued. Unfortunately, neither can the great cost of the formal procedures used to design such systems. Instructional systems development (ISD) has expanded in scope during the past few years as ever-new applications are found for this approach to training design. More recent, however, are cost-reduction efforts in the form of automated aids to the ISD process. These aids include computerized systems for developing task lists, for writing behavioral objectives, for structuring syllabi, etc., and they vary in terms of their complexity, cost, and the extent to which they assist the ISD developer to create and then manage his instructional program.

Veda Incorporated is presently under contract to the Naval Training Equipment Center (NTEC) to design and implement one such automated aid for the development of aircrew training. This system, Computer Aided System for the Development of Aircrew Training (CASDAT) will be described in this paper, with an emphasis on the unique, generic feature of the underlying task model. This generic structure applies across all types of aircraft, missions, and flight crew positions, and possesses several important advantages for instructional development, management, and research. Having taken the step to automate the methods of ISD, it appears to be time for examining these methods to establish just what it is we wish to automate.

BACKGROUND

The CASDAT system began as an effort to assess the feasibility of automating steps of the ISD process with the use of data bases, taking advantage of existing aircrew training programs to provide inputs into new programs. Present ISD methods for the military are prescribed by instructional documents specific to each service; MIL-T-29053 stands as the Navy guide, although procedures are parallel for all ISD efforts. Each development project begins with a task analysis, or description of activities for the job being trained. This resulting task listing is then converted into statements which can be used to establish instruction, called behavioral objectives. These objectives are then clustered systematically into instructional units which are then arranged into a syllabus, and appropriate media are selected to form the training materials of each lesson. Finally, each lesson is arranged into a logical flow of events by writing a lesson specification, leaving actual creation of instructional materials and lesson authoring as the final phase of the development effort.

How could data bases help to abbreviate the time and resources needed for these steps? The Veda project began with a comparison of existing programs, step by step, starting with task listing documents. One observation was immediately clear: although every ISD program had ostensibly referred to the same MIL-T specification, none of the resulting lists looked similar, even for closely related aircraft (e.g., F-4 and F-14). The original intention had been to identify similarities--or "links"--between parts of existing ISD programs and to use them as organizational rules in a data-based system. Obviously, these documents had to be made comparable if any such links were to be found. For this reason, the Veda project staff proceeded to force comparability by an analysis of underlying structures in the task listings.

The first point of correspondence between ISD documents was found by conducting a "syntactic analysis" of individual task statements. Basically, this involved a reduction of each statement to its fundamental parts, without consideration for differences in sentence style or needless specificity; a task such as "preflight engines" has a precise meaning to a helicopter, prop, or jet pilot, although there is nothing in the statement itself which is so specific that it cannot be used in all three task lists. A great many tasks were thus found to be quite common across all types of aircraft.

Once the task statements were converted in this way, a common task structure was simple to establish. This was, really, an averaging operation, picking and choosing the best or most common task arrangement rules from the available documents. Again, a structure was fashioned in this way which could accommodate all types of aircraft--a "generic" task listing. A sample of this listing is displayed in Figure 1.
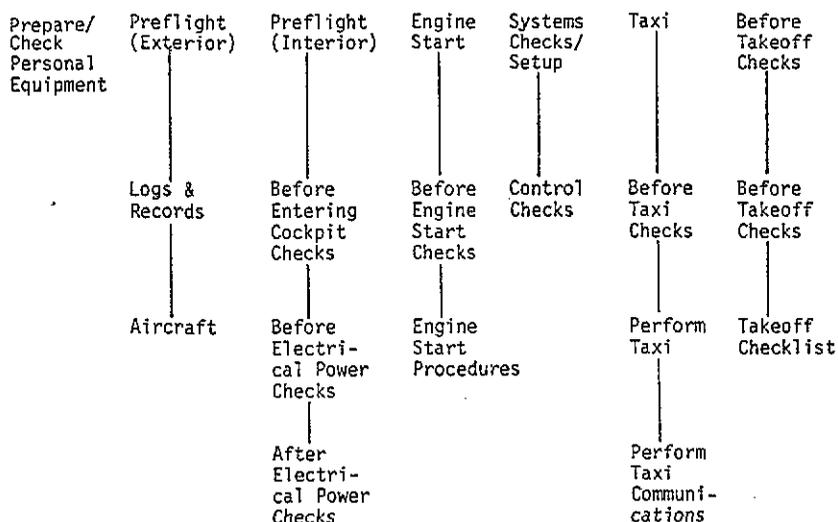
Figure 1. Generic Task Listing - Prelaunch

Prepare/Check Personal Equipment	Preflight (Exterior)	Preflight (Interior)	Engine Start	Systems Checks/Setup	Taxi	Before Takeoff Checks
Logs & Records		Before Entering Cockpit Checks	Before Engine Start Checks	Control Checks	Before Taxi Checks	Before Takeoff Checks
Aircraft		Before Electrical Power Checks	Engine Start Procedures		Perform Taxi	Takeoff Checklist
		After Electrical Power Checks			Perform Taxi Communications	

It was apparent that additional work would be necessary to expand this generic listing, but a tool was available, even at this stage of the project, which could be used to compare training programs across the aviation community, a conceptual "axis" for aircrew ISD.

FINISHING THE TASK MODEL

Now, the task listing was not much use in its original form for any particular aircraft, but aircraft could not be compared productively. Could links, or task families, be determined from further analysis of ISD documents which had been converted to this common structure? This was, in fact, the case. Tasks were found which fell into groups, depending on what dimension was being examined. Task listings, for example, of aircraft which carry ordnance were found to contain specific steps regarding the mission planning for that ordnance, the preflight for the ordnance, the arming and use, and procedures for recovery on land or ship with hung/unexpended ordnance. If any ordnance at all were carried by a particular aircraft, then certain tasks must follow. Furthermore, if the specific type of ordnance were known, additional tasks could be identified which were part of this "family" (e.g., some missiles can only be used in an air-to-air role, while others can also be employed against surface targets; thus, a missile in the latter category would bring additional mission tasks into the family). A set of sixteen such dimensions was found to be the most productive for defining task families. This set was later refined to eleven, with further modifications possible. The strategy which resulted from this approach was one of selecting relevant dimensions from the set, based on known aircraft characteristics, and appending the associated task families to the original generic listing. When this approach was exercised for several existing aircraft, it was found capable of generating approximately 75% of the tasks found in the ISD task listing--generated by traditional methods--for each. This validation of our method was applied to all types of aircraft (jet, prop, helicopter), most major tactical missions (e.g., fighter, attack, anti-submarine warfare, search and rescue, etc.) for all branches of the military services. Although this 75% figure is rough, due to the analysis time available for data collection in this phase, the result is very encouraging. By way of illustration, Figure 2 shows a sample of the task listing which was generated for the F-18, using this method. The tasks are not identical to the original document (using traditional ISD procedures), but are at least their equivalent.

COMPLETING THE CASDAT SYSTEM

An initial formulation of a task listing data base has been described, using a generic task listing structure and data organization rules which correspond to aircraft characteristics (i.e., the dimensions discussed in the previous section). Obviously, a task listing which represents only three-quarters of the activities which really occur is not a satisfactory tool for developing a complete instructional program, so a tutorial device was included to guide the instructional designer through the process of finishing the task list. The CASDAT system currently contains
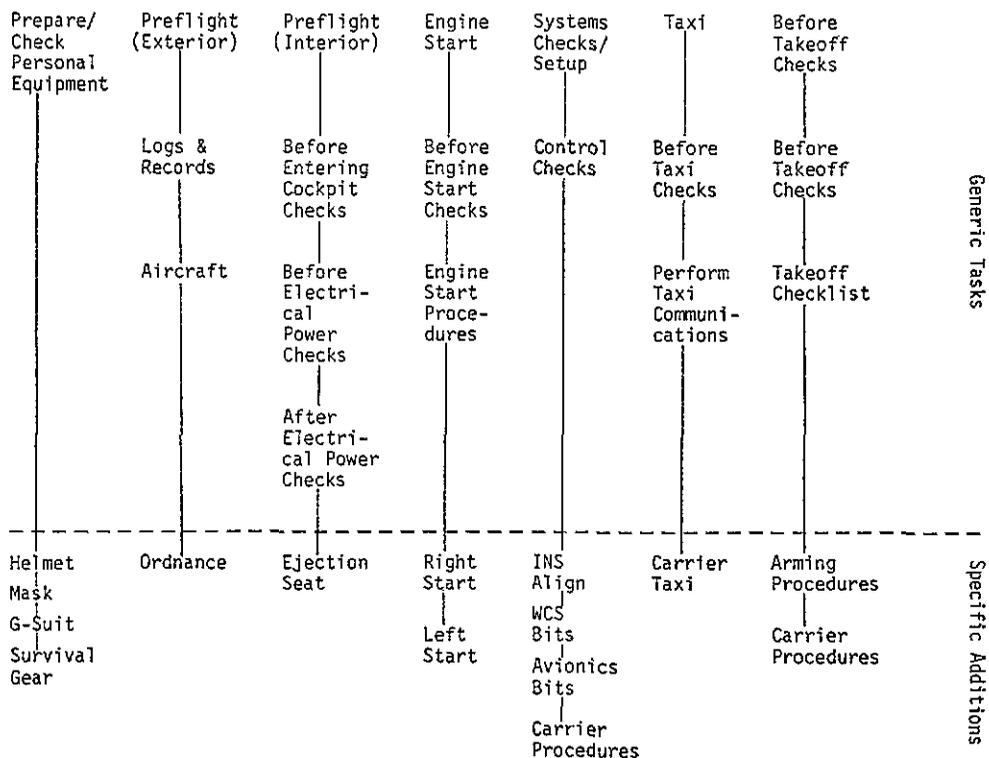
Prepare/Check Personal Equipment	Preflight (Exterior)	Preflight (Interior)	Engine Start	Systems Checks/Setup	Taxi	Before Takeoff Checks	
	Logs & Records	Before Entering Cockpit Checks	Before Engine Start Checks	Control Checks	Before Taxi Checks	Before Takeoff Checks	Generic Tasks
	Aircraft	Before Electrical Power Checks	Engine Start Procedures		Perform Taxi Communications	Takeoff Checklist	
		After Electrical Power Checks					
Helmet Mask G-Suit Survival Gear	Ordnance	Ejection Seat	Right Start Left Start	INS Align WCS Bits Avionics Bits Carrier Procedures	Carrier Taxi	Arming Procedures Carrier Procedures	Specific Additions

Figure 2. Task Listing for F-18.

a preliminary plan for an interactive computer program which assists the user in authoring those additional tasks which are too aircraft-specific to be generated in any other way. Exact features of this program are not defined at this time, but the tutorial package is intended to control: 1) the standardization of the remaining tasks, in that they must be compatible with the pre-existing list structure created by CASDAT, 2) the accuracy of the remaining tasks, because they should conform to the guiding ISD principles of the particular branch of service, and 3) the thoroughness of the tasks, to insure that all activities performed by the flight crew are reflected explicitly in the final task listing. All of these factors can be placed into computer formats, and current efforts are being directed at establishing the minimal amounts of information, which must be provided to the ISD designer at critical decision points, to build the least expensive tutorial program capable of achieving high-quality results.

CASDAT APPLICATIONS FOR OTHER ISD STEPS

Five primary steps for instructional development were mentioned previously. Automated aids for each one are presently being designed by the Veda staff, for implementation with the generic task model, and will be summarized here. It is important to note

that several private companies and some governmental agencies are also involved in the creation of automated aids to ISD. The founding concept of the CASDAT system, however, is the generic treatment of the job category for which instruction is being developed. The advantages of this approach for training design, management, and research will be discussed at length in subsequent sections of this paper.

Once the task analysis is complete, behavioral objectives must be fashioned as the "raw material" for lesson development. Because the CASDAT system employs a generic task model, together with prestored families of tasks, creation of an objectives hierarchy is a simple process and takes place simultaneously with the establishment of the task list. An objectives data base is proposed with this system, which maps each element in the task listing base to a group of behavioral objectives. Thus, when appropriate tasks are assembled and organized during the first step of the ISD process, relevant objectives are also loaded and organized for the second step. A special-purpose tutorial program would need to be included for this phase of development, as well, in order to insure that all required objectives were included for the selected tasks, and that appropriate objectives could be authored for tasks which were

added manually, during the final states of task list development. In a similar fashion to the task list tutorial, the objectives program would guide the user through a standardized series of actions and decisions, resulting in an objectives set which was complete, accurate, and standardized. Because the labor required to manipulate the task listing data base is effectively used twice (to assemble tasks and to pre-load the associated objectives), the time and resource savings of this method would be considerable. Furthermore, the generic structure of the task listing, used to compare the activities of different aircraft types and missions, would be reflected in the objectives hierarchy, thus permitting similar kinds of analyses.

Syllabus structuring is also included in the CASDAT automated design. Several sophisticated algorithms for determining syllabus sequencing are available from both private and government agencies, however, the data processing demands of most such schemes are quire extensive; this is a disadvantage in terms of cost and the expertise requirements of those who will use the system. CASDAT employs another "generic" structure to provide a context into which instructional units will be fitted, consisting of those attributes that are common to all training programs. Basic aircraft systems instruction, for example, always precedes weapon system instruction; basic flight operations precede tactical flight operations; flight simulation events precede applicable flight events and, in turn, both are preceded by academic instruction.

CASDAT is being designed to stratify the results of the objectives-formulation step, ordering these objectives in terms of the complexity of intellectual skills underlying each. This sequencing of objectives forms the initial output of the syllabus operation; before the objectives can be partitioned into lessons and incorporated into the syllabus structure, the data is subjected to a media selection algorithm, which determines a subset of available media which could be used to effectively instruct the particular objective.

The CASDAT algorithm is, again, more simple and straightforward than some other selection schemes available. The special demands and constraints of each instructional design program are considered sufficiently unique to make the use of a more sophisticated algorithm unattractive as an automated aid to ISD. The products of such algorithms are, furthermore, usually quite vague, the result of a weeding-out procedure which yields a group of media candidates and not just one or two choices. Thus, the CASDAT output compares favorably with more complex methods of

selection, and proceeds in the following manner: 1) the system scans a media code group associated with each objective. This code is prestored with the objectives in that data base; 2) these codes, consisting of little more than an academic-trainer-flight partition, are then grouped according to the objectives stratification, described earlier, and presented to the ISD developer for incorporation into a preliminary syllabus, under computer tutorial guidance (see Figure 3). This "first-fit" is necessary because the simulator and flight events usually drive the other (academic) events in an aircrew training program; 3) the academic events, which now are made up of objectives groups, are subjected to another algorithm which narrows the set of usable academic media for each; 4) the final syllabus is established, or fine-tuned, by the ISD developer.

Media and syllabus development interact heavily in the CASDAT scheme, but the initial attractive features of standardization (with a generic syllabus model and media codes for objectives) and accuracy (with tutorial guidance) are still retained. Problems remain concerning the syllabus arrangement of those objectives which were generated manually during the previous step; media and skills codes will have to be determined, in some fashion, for each. Expansion of the tutorial programs is currently viewed as the best solution to these problems.

Little is currently envisioned for automated aids for lesson specification development under the CASDAT scheme. Unless costly computer systems are employed--a major pitfall of any automated aid design, which is intended to reduce the costs of current ISD methods-- the benefits of CASDAT fall into the area of providing the instructional designer with a convenient presentation of information in order to facilitate his manual authoring efforts. Thus, an objectives list could be offered for the lesson under development, together with appropriate page headings and other "secretarial" services. A finishing program is an additional possibility, offering the developer a set of reminders to check the format and comprehensiveness of his work. The design of this portion of CASDAT is still in an early stage.

AUTOMATION BENEFITS OF CASDAT

The motivation for designing automated aids to ISD is primarily one of cost. Current manual methods are very time-consuming and require personnel trained in ISD principles. These methods are, furthermore, redundant: similar work is done whenever a new program is initiated and ISD products (e.g., objectives) must be used repeatedly within a program, creating a tracking or "bookkeeping" problem due to volume. Automated aids,
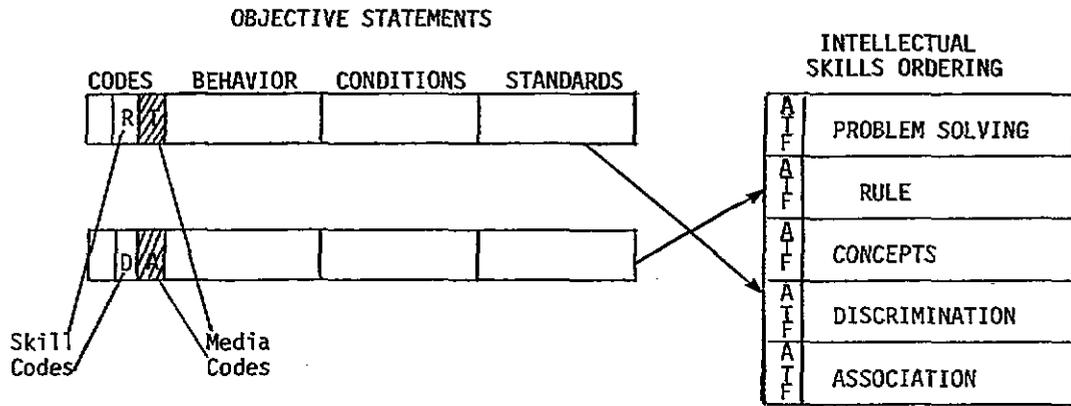
OBJECTIVE STATEMENTS

Figure 3. Media and Syllabus Operations

including CASDAT, contribute greatly to cost reduction by: 1) accessing, organizing, and displaying required information quickly. Automated aids can manipulate large amounts of data rapidly and accurately, while keeping track of the progress of those manipulations; 2) contributing to the decision-making process with automated development strategies. By taking over some of the technical planning duties, automated systems can be designed for use by relatively untrained personnel; 3) making available the products of previous, relevant training programs. By making use of what has already been done (and stored in a data base), the ISD process is abbreviated to those steps which are unique to the current project.

GENERIC BENEFITS OF CASDAT

So far, the CASDAT system shares the advantages of other automated ISD aids or designs. An important difference, however, is that the CASDAT scheme is founded on generic models of both the job to be trained and (to a lesser extent) the syllabus used to train it.

A generic task structure for a job or class of jobs reduces the data handling requirements for an automated system; large groups of tasks, including the basic generic model itself, are accessed in an all-or-none fashion. This reduces the demands on the ISD developer considerably by presenting him with the major part of his task listing immediately and providing him with a context in which to fit remaining, specific tasks under tutorial guidance. The system is, likewise, not required to handle the construction of each individual task, but only those which are needed to complete the last portion of the list, thus reducing the minimum cost of processing software.

A generic task or syllabus model maintains the quality standards of the final

products by insuring that certain ISD principles are observed. In this case, decisions regarding the task hierarchy, task statement format, numbering or coding systems, and syllabus development strategies are implicit in the model and not subject to the diverse interpretations of ISD designers. The result is a consistent product, in keeping with the policies of instructions such as MIL-T-29053. By reducing the need to make key ISD decisions, these generic models confine the design effort to those aircraft-specific areas which can be best handled by subject matter experts; in most cases, such personnel (e.g., flight instructors in training squadrons) are less expensive resources to employ in a design effort.

It was mentioned earlier that the generic aircrew model forms an "axis" around which different flight jobs can be compared. This is because the tasks involved in the listing proceed from those which are common to all aircraft, through those which are defined by discrete dimensions of equipment or mission, to those which are unique to a particular aircraft. What this means is that many of the differences between training programs--based on their respective task listings--are unnecessary, that training need only differ where a definable dimension separates task families between aircraft. The cost savings from this point of view of training could be quite significant. Aviation communities which share a tactical mission could benefit from a single, thorough study of the instruction required for that mission; an avionics system could be taught from a single program, disseminated to all communities which used that system; the general strategies for hovering flight could be used by all helicopter training squadrons, with specific modifications as necessary for the model of aircraft used. The military service would benefit from the cost savings of having done the instructional design only once. It is understood that there exists an interaction between a specific aircraft, a common mission or system, and the instructional

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methods used to teach them; the generic approach described above is, indeed, idealistic. The orientation toward training development, however, is quite practical and it seems quite reasonable to advocate a process which begins from a generic standpoint, and justifies each step toward more specific training methods.

The comparability of task structures and syllabi between aircraft communities has an advantage for training management, as well. If, through training or combat performance measurement, it is found that a particular program of instruction is especially effective, then the concepts behind this program could be rapidly incorporated into any other training program which shared the relevant characteristics of the job under examination. Even if such a program existed presently, the analysis and instructional design changes necessary to implement the superior program into other communities would involve prohibitive costs. If the change were, in fact, incorporated for other aircraft, the differences in task models would prevent an accurate assessment of the reasons for its success or failure; the tracking tools would not be available, as they would be if both communities were working from a common task structure.

CONCLUSIONS

The implementation of automated aids for ISD have been discussed in terms of a current system design called CASDAT. Like all attempts to automate parts of the instructional development process, CASDAT is capable of reducing the cost and time involved in developing training resources.

Unlike some other approaches, CASDAT rests on a generic concept of aircrew task performance, which holds significant potential for improving the quality of training development, increasing the efficiency of training management, and augmenting the research and development capabilities of instructional analysts.

The example used for the system discussion was aircrew training. Significant new territory for generic task modelling lies, however, in the areas of maintenance training, technical training, and military "preparatory" programs (e.g., basic aviation, electronics, reading skills, etc.).

ABOUT THE AUTHORS

DR. PATRICK E. SMITH is a Senior Instructional Psychologist with Veda Incorporated and is the Project Manager for the CASDAT program. He is responsible for coordinating the design and validation of all phases of this data-based ISD system and also serves as the review authority for all instructional materials produced by the Veda staff. He has previously been involved with F-14 aircrew training development and has participated in the design of instructional materials for the community college faculty. Dr. Smith has earned his Ph.D. and M.N.S. degrees from Arizona State University, and his B.A. degree from Central Washington State College.

MR. STEVEN A. MURRAY is an Instructional Psychologist with San Diego Division of Veda Incorporated. He is currently working on the design and implementation of a data-based system for automating steps of the ISD process. Mr. Murray has participated in previous projects concerned with behavioral modeling of the landing signal officer's job, aircrew training for the F-14, performance assessment for flight simulators, and operational evaluation programs of flight simulators. He has earned a B.A. degree in psychology from Eckerd College and an M.A. degree in psychology from San Diego State University.