PILOT TRAINING STUDY

W. E. Mooz

April 1969

P-4070

PILOT TRAINING STUDY

William E. Mooz*

The RAND Corporation, Santa Monica, California

INTRODUCTION

The purpose of the Pilot Training Study is to produce tools with which to analyze the pilot training process of the Air Force in terms of the resources required to train pilots and the cost of pilot training. These tools allow examination of the training courses themselves, and also of the policy factors which drive the need for pilots.

The study originated at the request of the Air Force, whose help and support have provided important ideas and data. The results of the study are available to all interested offices of the Air Force, and we have provided many of these with completed portions of the work. Because of the wide range of problems which can be addressed with our results, we have found interest at every level, from the Air Staff of Headquarters USAF to individual training bases.

TOOLS

The tools developed consist largely of mathematical simulation models which can be exercised on a computer. Two general types of model are involved. The first type is primarily a decision model, and the second type is a parametric resource and cost model. By a decision

---

*Any views expressed in this paper are those of the author. They should not be interpreted as reflecting the view of The RAND Corporation or the official opinion or policy of any of its governmental or private research sponsors. Papers are reproduced by The RAND Corporation as a courtesy to members of its staff.

This paper was prepared for presentation at the Fourth DOD Cost Research Symposium in Washington, D.C. on March 17, 1969 and also the NATO Conference for Mathematical Models for the Management of Manpower Systems at Ofir, Portugal on September 1-5, 1969.

model, we refer to a mathematical simulation of real world events that is built around a series of decisions--what percentage of pilot requirements should be filled from which source; is there sufficient training capacity to handle the projected load; is expansion of the training establishment allowed; is there sufficient time to expand the training capacity; what is the forecast size of the pilot requirements for each aircraft system; and similar questions requiring answers reflecting policy or preference.

By parametric resource and cost model, we refer to a mathematical simulation of an existing operation, such as a training school. In this simulation, quantitative information about the course syllabus, instructor workloads, aircraft flying hours, A/C maintenance-manhour factors, and other such relationships are used to construct a mathematical simulation of the training activity, and to express the quantities of facilities, equipment and personnel involved.

The construction of these models is generally limited by the amount of detail that can be included, and by the validity of the mathematical and statistical relationships which are used. Our purpose in building the models is to provide a tool for long-range planning, that is, to answer broad questions concerning pilot training in a time context up to 20 years in the future. We did not aim at the production of a device which could adequately address day-to-day management questions. With our models, interesting areas of research can be addressed broadly; then when situations of further potential are identified, these may be subjected to more detailed analysis than the model will allow. In keeping with this philosophy, mathematical and statistical relationships can be used with confidence. These relationships are the type that express the general numerical relationship between the numbers of administrative or support personnel and the numbers of operational and maintenance personnel, or the dollar amount of maintenance materials required for each hour of flight of an aircraft. The use of these relationships expresses the average situation as it has appeared in history, and as it is projected into the future. It is proper and desirable to use these in parametric models, and usually improper to use them in the solution of detailed problems, simply because they reflect statistically average situations.

PILOT TRAINING

A number of different training programs make up the total which an officer must undergo before he becomes an operationally qualified pilot. These training programs can be considered in isolation from each other and a resource and cost model could be constructed for each program. If this is done, important contextual relationships are lost. Therefore, we have represented the context of pilot training as shown in Fig. 1, which describes the flow of pilots through the training process, into a career, and eventually out of the Air Force. We have patterned a dynamic model of the flow of pilots in the Air Force after that shown in Fig. 1. The model has as inputs, the requirements for pilots in cockpit-associated jobs over time, and also the appropriate or desired factors to express the magnitude of the various flows. These inputs produce output information describing the number of graduates which are required from each training activity each year, and in turn, these required graduates become the driving inputs for the appropriate resource and cost models as shown in Fig. 2. The outputs of the resource and cost models are statements of the facilities, equipment, and personnel required by year, and the annual cost of each training activity. The framework of our complete study is similar to Fig. 2, and allows the examination of questions concerning the effect of personnel policy decisions upon the resources required for training and the cost of training, and also allows consideration of changes in the individual training programs to produce effects on training time, resources, and costs.

DISCUSSION OF MODELS

PILOT Model

The PILOT model is a decision model which simulates the flow of pilots through the Air Force as illustrated in Fig. 1. The primary input to the model is the requirement for pilots, and this input is

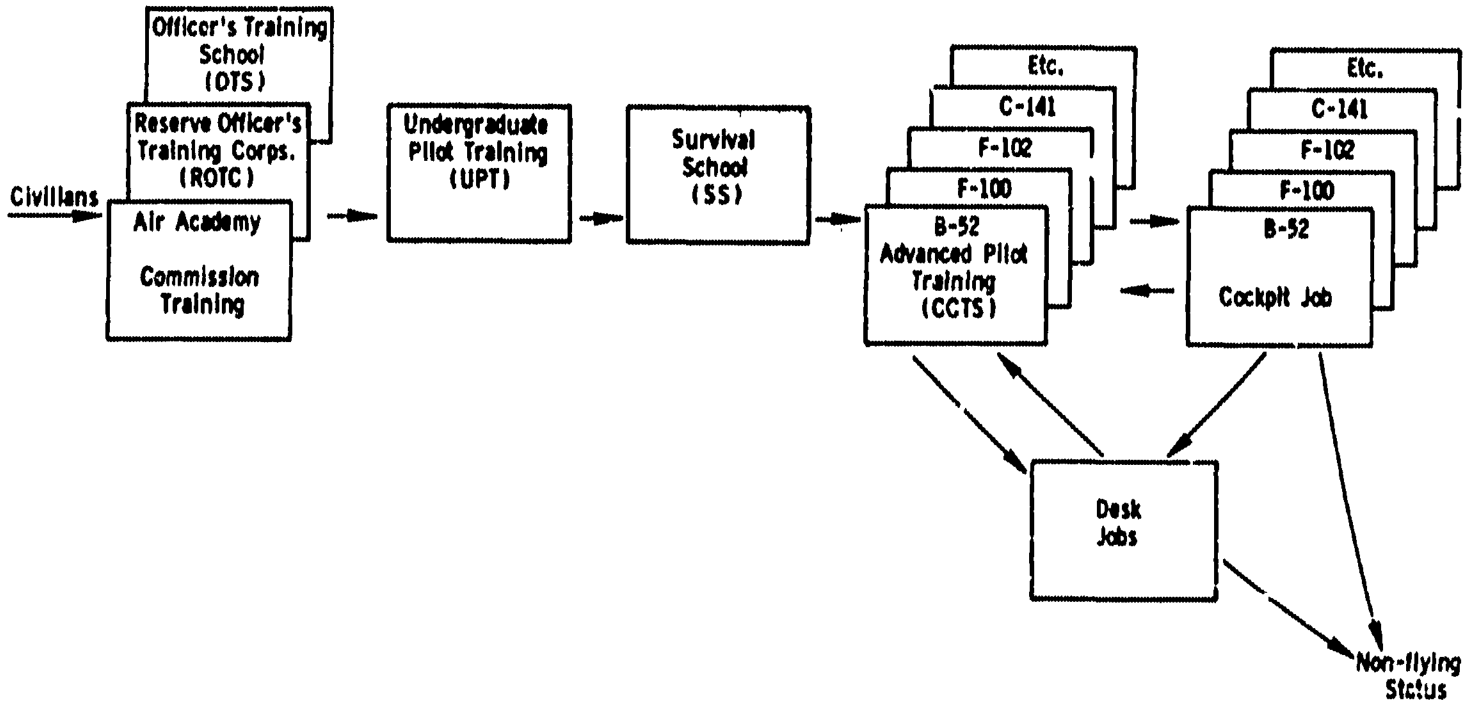

Fig. 1—Pilot flow

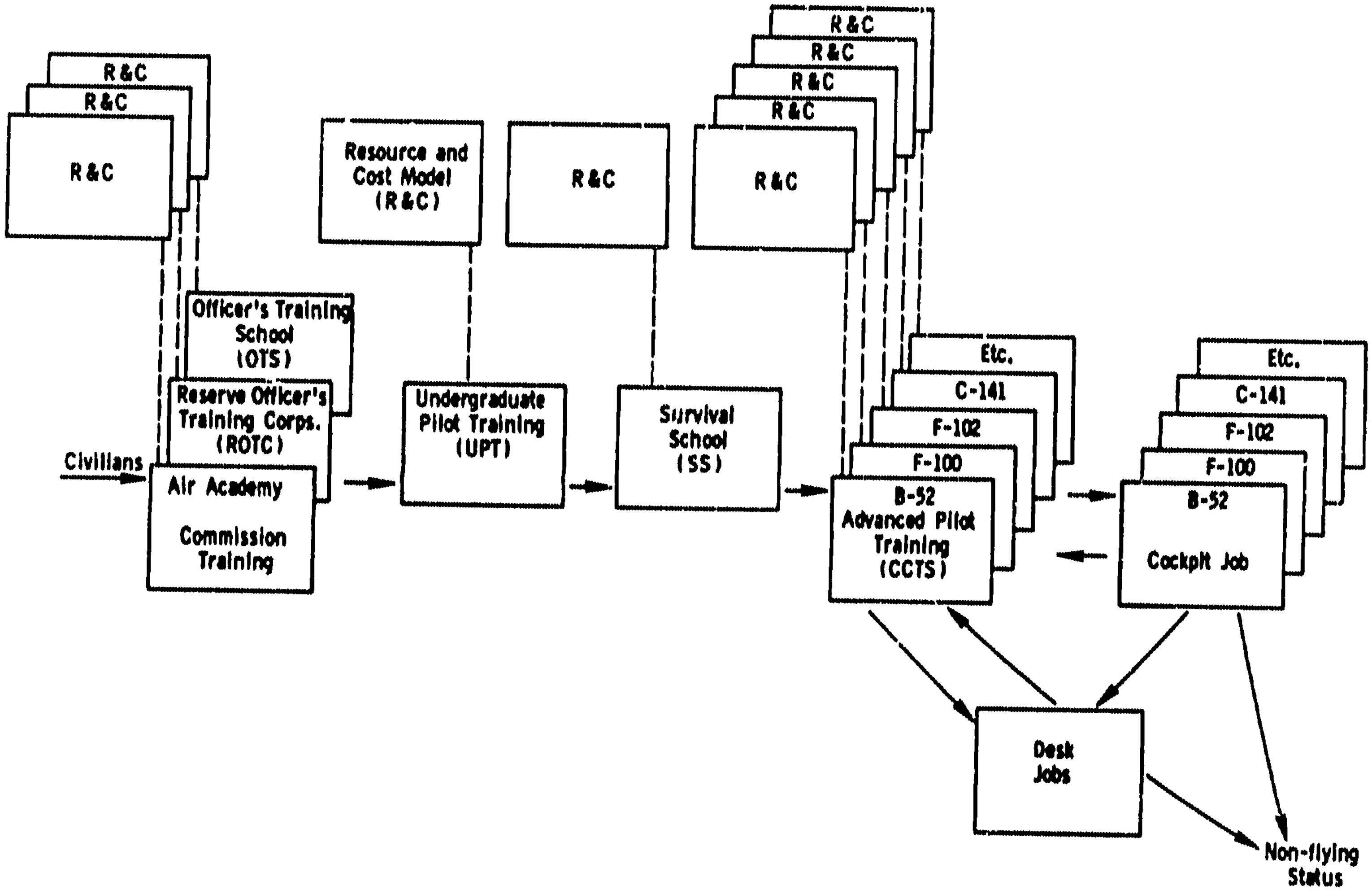

Fig. 2—Overall structure of pilot study

described by aircraft system, type of pilot, and year. A maximum of 80 aircraft systems, 3 types of pilot, and 20 years may be accommodated, thereby providing for examination of a broad range of future force possibilities. Factors are included to express the losses of pilots from flying status, due primarily to retirement and resignation, but also including a variety of other causes. These factors are also described in terms of aircraft system, type of pilot, and year, so that differences in loss rates between aircraft systems and over time may be expressed properly. Factors are also included to allow for the rotation of pilots from flying jobs to desk jobs and back again as part of their normal career development. Again, these factors may be input in terms of aircraft system, type of pilot, and year. A variety of other information must also be input, and is mostly concerned with student loss rates and course lengths of the various training activities.

The PILOT model includes an upgrading routine to simulate the real life situation where co-pilots are upgraded to fill pilot (aircraft commander) vacancies when these exist. Within the model net requirements for aircraft commanders are first filled by as many co-pilots as are present in the system, and then the initial aircraft commander and co-pilot requirements are readjusted to reflect this upgrading.

The time required for each training activity plays an important role in the PILOT model. Requirements for pilots in any year are translated into requirements for graduates from advanced pilot training, survival school, undergraduate pilot training, and precommissioning education (ROTC, Academy, OTS). The point in time at which the pilot must complete each of these training events is dependent upon their length, and the amount of travel and leave between training events. Because advanced pilot training courses for differing aircraft vary in length from less than a month to almost a year, officers may have to be commissioned in as many as three different years to fill pilot requirements in a single later year.

A second aspect of training time concerns the ability to make decisions affecting pilot requirements. Changes in force structure in the near future may not be feasible because the lead time required by the training process may exceed the amount of time available. The PILOT model treats such constraints explicitly.

After calculating the time at which students must enter and graduate from each training course for all the aircraft under consideration, the total entries and graduates for each course are summed by year, so that the training loads are obtained. These then become the outputs of the PILOT model, and the driving forces for the resource and cost models. In this calculation, if the training loads exceed the capacity of the training base, the model is built to add sufficient capacity if there is enough time to do so.

The PILOT model has full provisions for cross-training pilots from one aircraft system to another, or from desk jobs into aircraft. It also maintains a running inventory of pilots in desk jobs.

Some words about the level of detail used in the PILOT model may emphasize the uses and limitations of this simulation. The upgrading routine mentioned above has built into it the basic assumption that the second-seat pilots are qualified to move into the aircraft commander's position. The model has no feature to test the proficiency of pilots, nor, in fact, can it keep track of individuals. Similarly, nowhere in the model is the rank of the pilots explicitly treated. It is recognized that many jobs (such as squadron commander) may require a minimum rank, but here again the assumption is made that on the average there will be individuals of the correct rank available. Another example of this concerns advanced flying training. The PILOT model identifies two lengths of Combat Crew Training School (CCTS) course, and assigns pilots to one course or the other based upon a simple rule. In real life the situation is vastly more complex, in that there may be more than two course lengths, and also the rate at which individual students complete the course can vary widely. There is no way to simulate this without making the model substantially more detailed and thereby losing its versatility.

Resource and Cost Models

The parametric resource and cost models are the heart of the pilot training study. These models translate the numbers of graduates required into statements of the facilities, equipment, and personnel required, and also into information on the cost of training. These models are not simply a restatement of aggregated historical information, such as a curve relating historical costs to student loads, but rather are tools which, in essence, "build" a training program in any form desired. This feature allows the models to simulate existing training programs for existing aircraft; it allows simulation of alternate programs for existing aircraft; it allows simulation of proposed training programs for aircraft not yet in the inventory. This type of flexibility not only is important for long-range planning, but also is a necessary feature if the training programs are to be subjected to sensitivity analysis.

With it, any type of training course, whether similar to existing ones or not, may be simulated, allowing the analyst to test the effects of a wide variety of changes in syllabus upon resources and costs. Any type of "what if" questions may be treated, so that ideas for reducing costs or altering course content may be easily tested.

The resource and cost models shown in Fig. 2 are not all of the same level of detail, simply because the degree of analysis required in some training activities is substantially different than that required in others. The basic structure of the models is similar and will be discussed in more detail.

There are three basic types of input to the resource and cost models. The first is the number of graduates which are required. A statement of this quantity is the driving force of the model. The second type of input is information about the curriculum. How many flying hours are required, how many hours of academics are necessary, how much time must be spent in simulators, how long the course is, and other data expressing the size and detail of the course syllabus are necessary to estimate the amount and type of equipment and facilities.

The third type of input consists of a set of estimating relationships, which with the other input data are used to estimate the numbers of maintenance, support, and administrative personnel, the annual cost of personnel, supplies, maintenance materials, and the other resources and costs of the training course.

A typical structure for the resource and cost models is shown in Fig. 3. In this diagram, the driving force of graduates (converted into student load) is shown at the left. This input, together with the course syllabus, provides estimates of the total number of simulator hours, ground school hours and flying hours to be conducted at the school for student instruction. Each of these activities requires instructors, and the total number of hours of instruction to be given, plus an appropriate estimating relationship then yields the estimated number of instructors required. Similarly, statements of the aircraft flying hours and simulator hours may be translated into statements of the numbers of aircraft and simulators required, and of the numbers of maintenance personnel required to keep them operating efficiently. From the number of students, instructors, and equipment maintenance personnel which have been estimated, the number of squadron and wing administrative personnel and the number of support personnel may be estimated. Support personnel are those generally identified with the base housekeeping function, including security, civil engineering, food service, and similar functions. In total, this provides a parametric estimate of the total number of personnel in the training course and of the major pieces of equipment required.

Figure 3 represents the flow of the information to estimate operating costs, and these derive, in the estimating methodology, from the number of personnel and the operation of the equipment. Typical resource and cost categories used in the models are listed in Fig. 4.

Similar structures are used to estimate the incremental investment required. An example of the detail which is built into this type of model is shown in Fig. 5, which illustrates the interrelationships between the many factors which determine whether or not additional

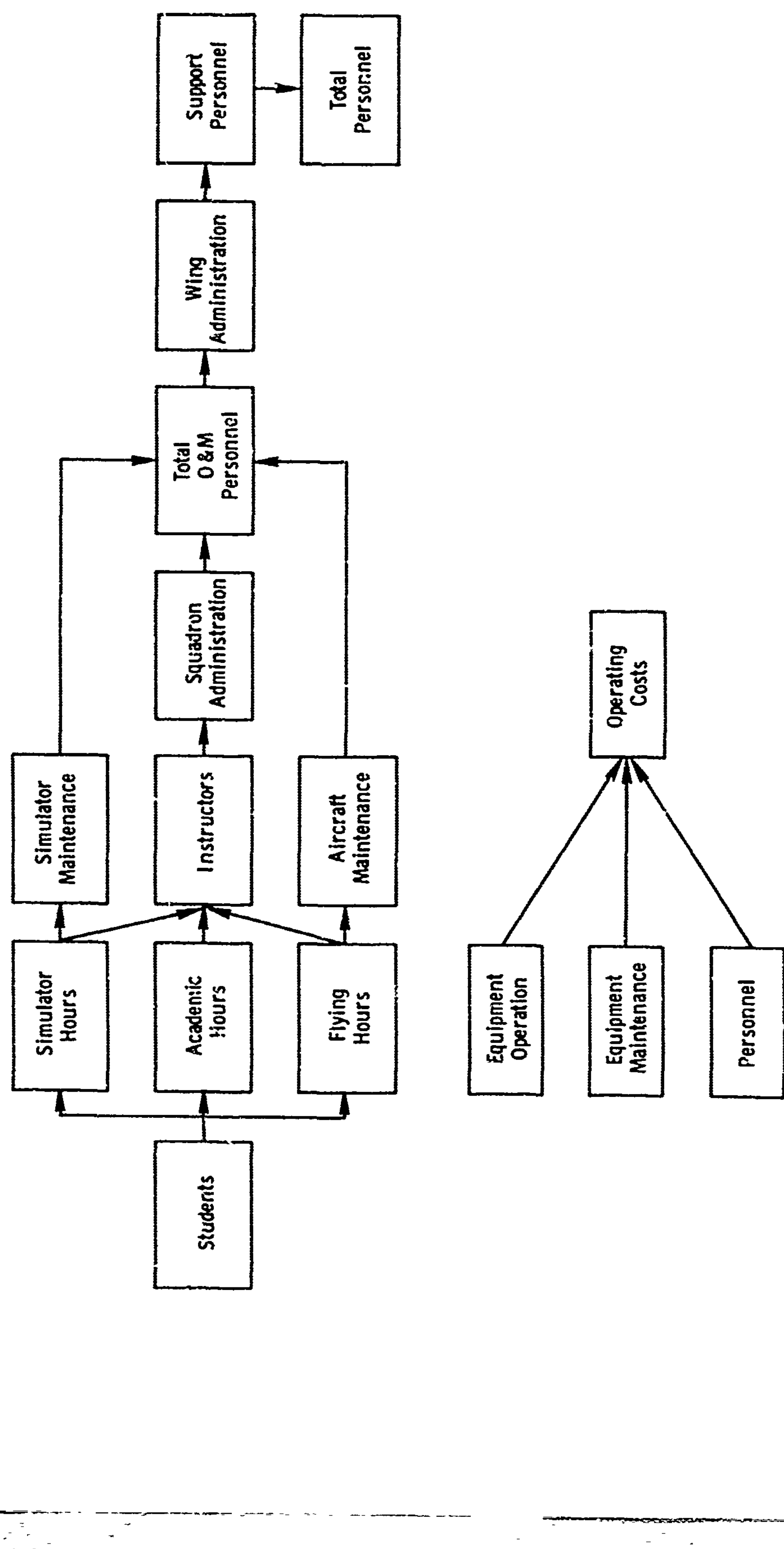

Fig. 3—Typical resource and cost model structure

Resources	Costs
Aircraft	R&D
Simulators	Investment
Runways	Operating
Bases	
Classroom Area	Equipment O&M
Airspace	Base O&M
Personnel	Personnel Pay and Allowances
Stocks	Travel
Spares	Supplies and Service
	Stocks
	Spares

Fig. 4—Typical resource and cost categories

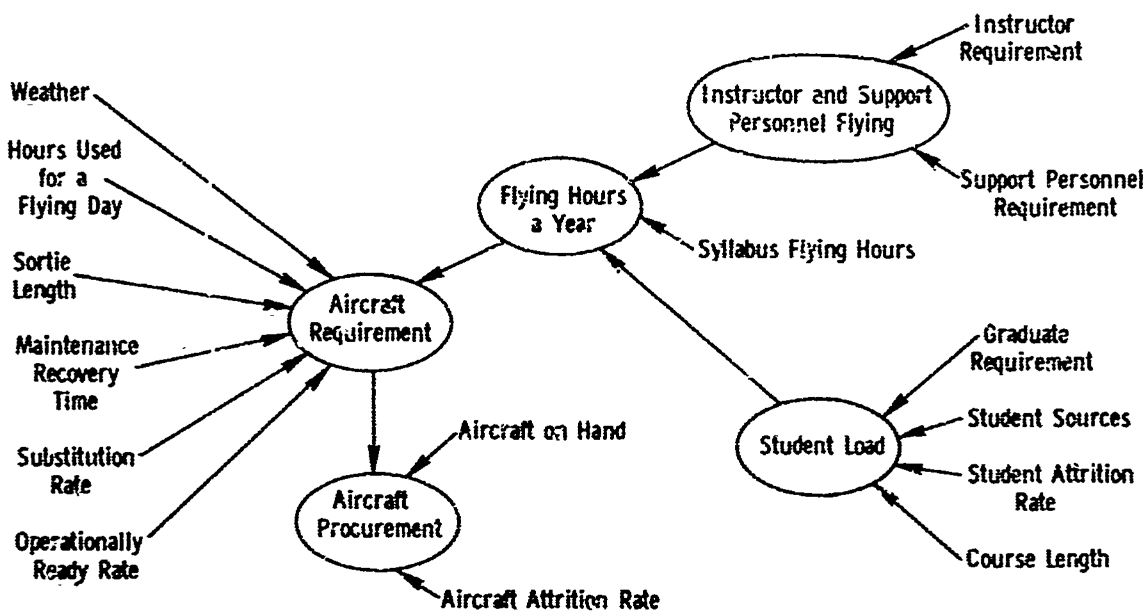

Fig. 5—Typical detail of resource and cost model

aircraft must be procured. Each of the factors shown in Fig. 5 may be varied freely by the analyst, as an example of the ability to vary inputs for the purposes of analysis.

While the structure of the resource and cost models may appear to be straightforward, there are numerous problems which were encountered, and which the analyst must continually address. For example, the problem of fixed cost allocation occurs in many instances whenever more than one operation is conducted on the training base. In cases where this happens, the analyst must make decisions concerning fixed cost allocation that are dependent upon the context of his analysis. Joint costs exist whenever more than one person is being trained in the same equipment at the same time. Here again, proper division of the equipment operating costs can be a major factor in determining pilot costs, and this division may also be dependent upon the context of the problem. In our models we have recognized this problem of context, and it is necessary that the analyst provide the proper inputs concerning allocation of these costs. The question of the capacity of a training base always presents problems, and identifying that point at which no more students may be accommodated without facility expansion can be difficult, especially with regard to advanced training, where the Replacement Training Unit (RTU) concept can allow expansion without investment.

USES OF MODEL

We have developed the models so that they will be analytical tools. Each of the resource and cost models can be used to analyze current, postulated, and future training programs with regard to capacity, resources required, and costs. Tradeoff analyses may be performed, and the cost of each portion of pilot training may be estimated. Using all portions of the model together will allow testing of the effect of personnel policy on cost and training level. Typical items that can be investigated are the effects of altered pilot loss rates due to career incentives or longer cockpit tours, the effect of changing the career development rotation program, and changes in policy regarding the size of the supplement.

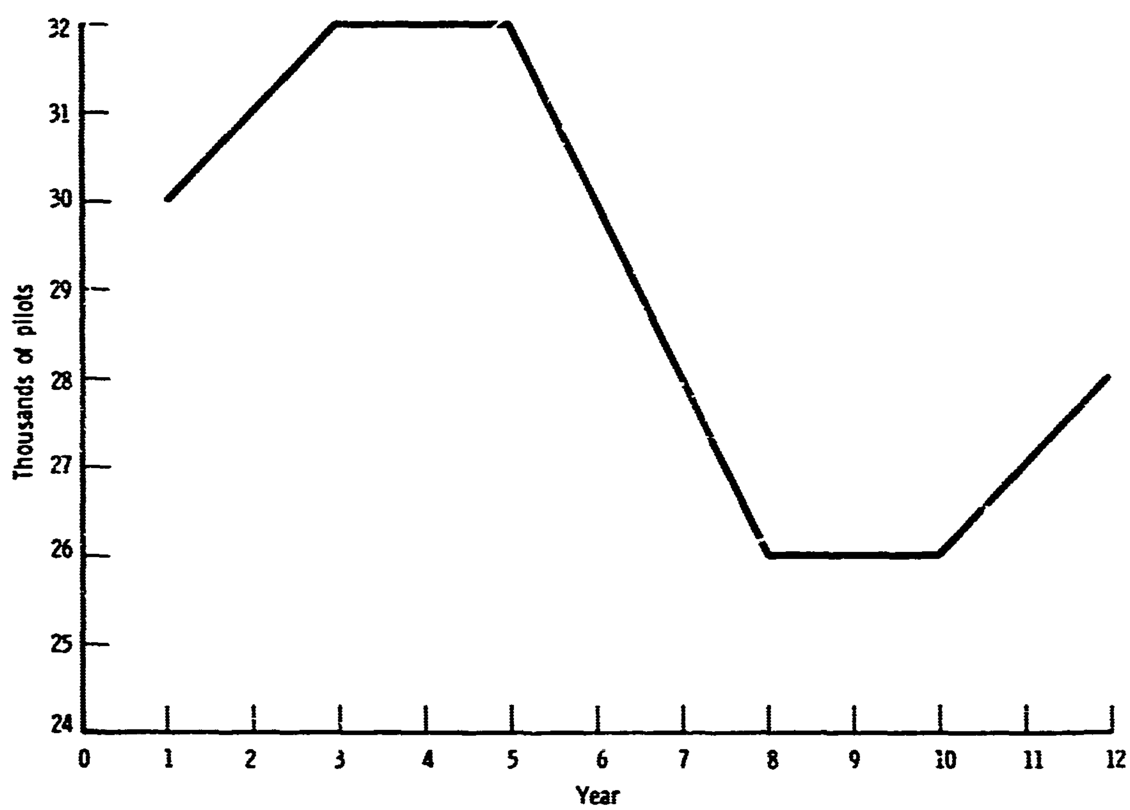

Fig. 6—Requirements for pilots in cockpits

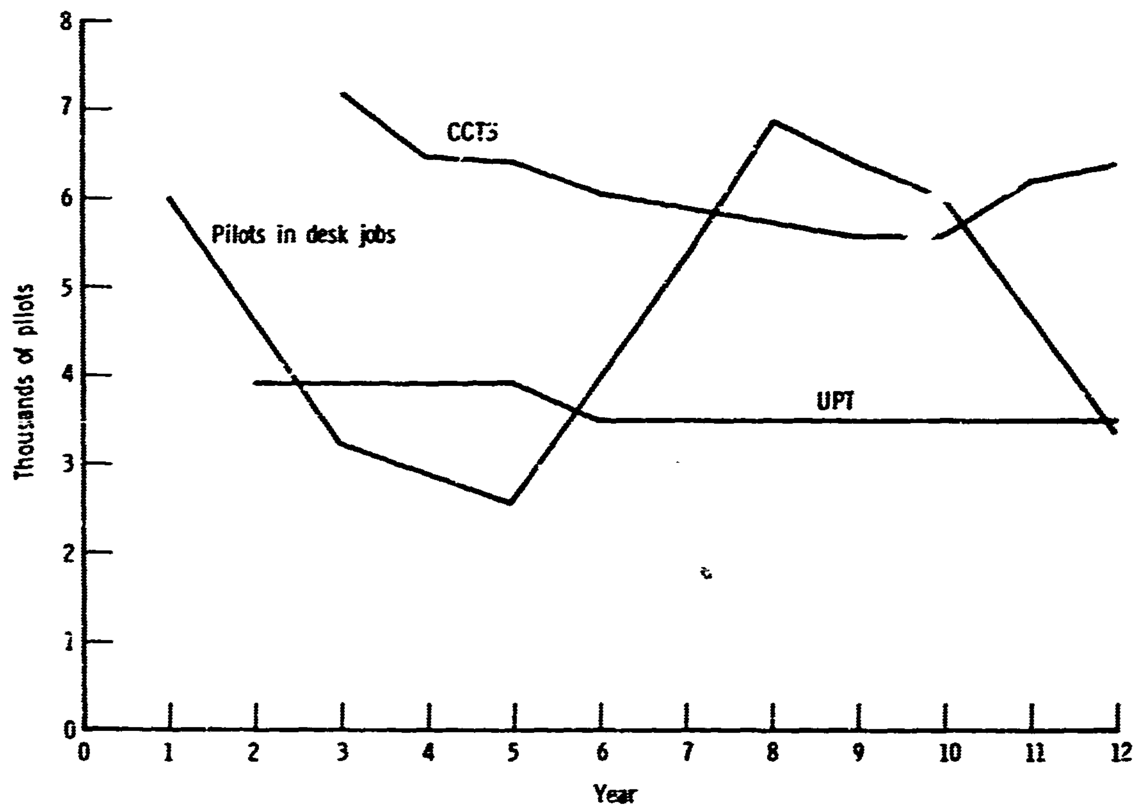

Fig. 7—Training requirements through undergraduate and advanced pilot training

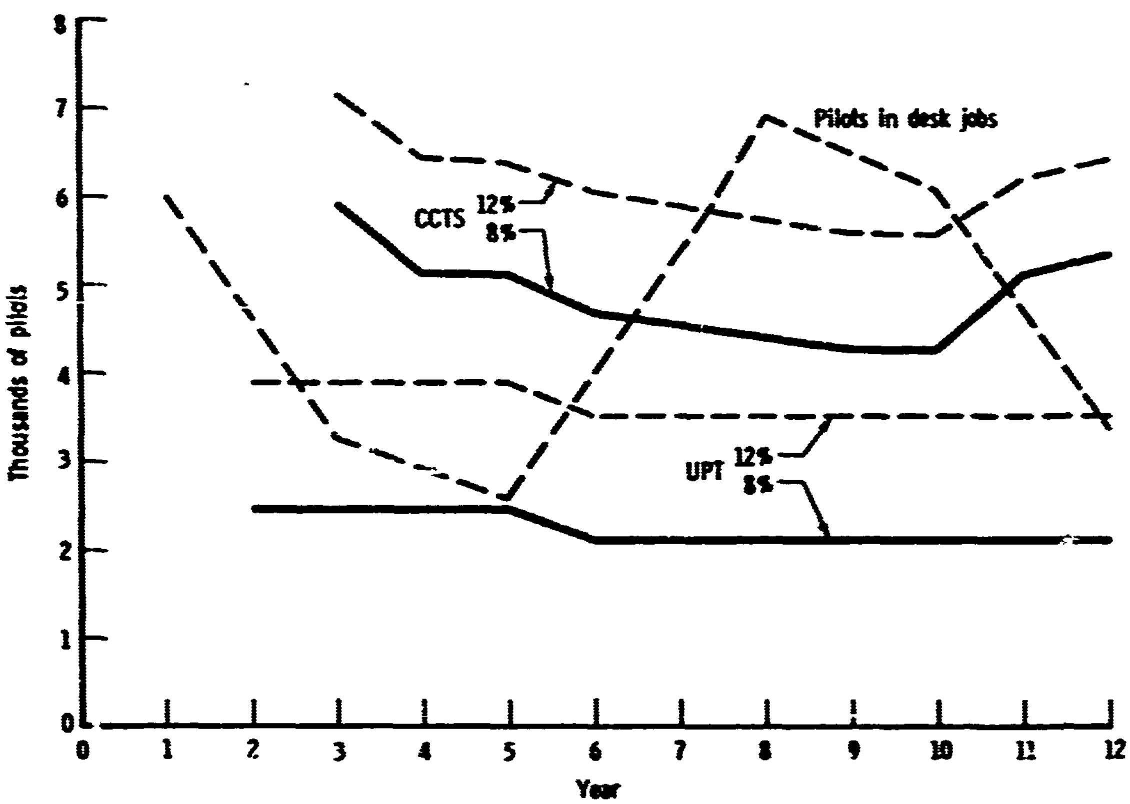

Fig. 8—Comparison of training requirements at 8% and 12% pilot loss rates

In addition, while the individual resource and cost models can provide estimates of the cost of each training step, the entire model can provide estimates of the total cost to the Air Force of pilot training under any selected set of conditions.

EXAMPLES

The versatility of the models can best be demonstrated through the use of simple cases which exercise individual resource and cost models, or the decision model. Three cases have been chosen as illustrative. The first of these utilizes the decision model as a means to demonstrate the effect upon training loads caused by a change in pilot retention rates. The second case involves the CCTS resource and cost model in several cost sensitivity tests. The third case exercises the UPT resource and cost model in a test of the capacity of the UPT system as a function of several parameters.

Use of PILOT Model

Figure 6 illustrates a hypothetical requirement for pilots in cockpits as a function of time. This information, together with other appropriate inputs, can be used with the PILOT model to obtain the statement of training loads through UPT and CCTS shown in Fig. 7, together with the numbers of pilots in desk jobs. Suppose that we are interested in knowing what the effect upon the training loads would be if the pilot loss rate could be altered from 12 percent per year, as used in this case, to 8 percent per year. Figure 8 illustrates the effect. The marked decrease in UPT and CCTS training requirements shown in Fig. 8 are translated directly into resource and cost savings if the appropriate resource and cost models are used in conjunction with the PILOT model.

Use of the Advanced Training Model

In this example, a training course for a hypothetical bomber was examined. First a base case was established, and then various inputs were varied to test the cost sensitivity of the training course to these inputs. The results are illustrated in Fig. 9, and demonstrate that the cost of training each graduate is relatively insensitive to all inputs tested except flying hours.

Use of the UPT Model

The number of graduates possible per year were examined in a base case, and then the sensitivity of this number was tested against variations in the sortie length, launch interval, syllabus flying hours, number of flying days per week, and the percentage of takeoffs aborted. Results of these tests are illustrated in Fig. 10, and demonstrate the flexibility of the model in the examination of non-cost aspects of training.

CONCLUSIONS

The models developed in this study have broad utility in the analysis of pilot training. Individual training activities may be analyzed with regard to syllabi, course lengths, productive capacity, resources necessary, and course costs. In addition, the pilot training process may be analyzed in terms of the factors which cause the need for pilots. Included in these are policy variables relating to force size, rotation of pilots for career development, pilot loss rates, and cross training from one aircraft to another.

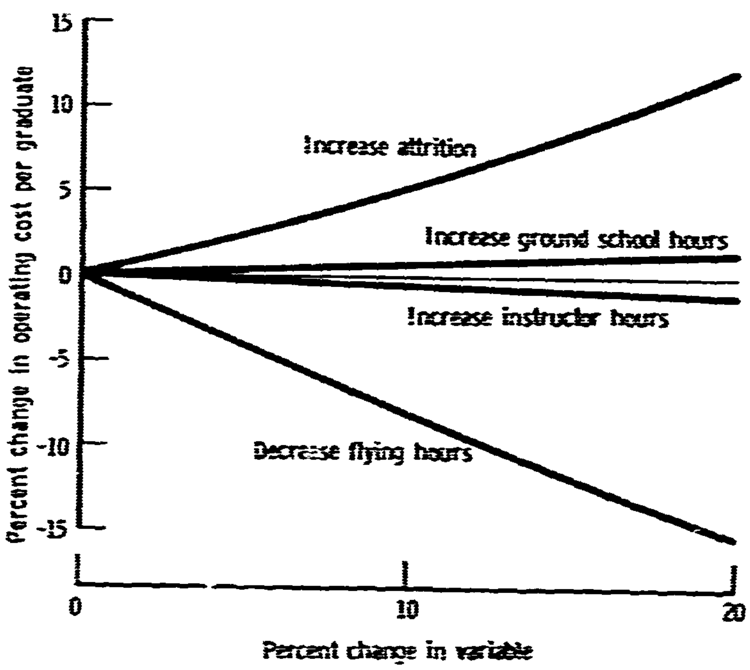

Fig. 9—Advanced pilot training-bomber
Sensitivity analysis

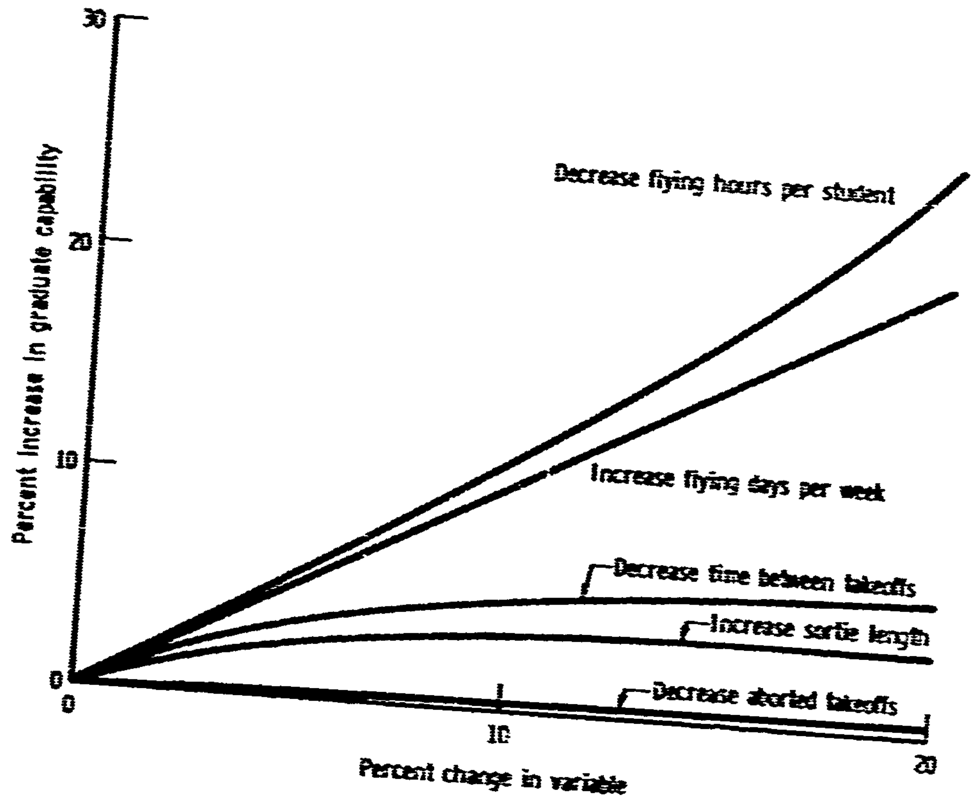

Fig. 10—Sensitivity analysis — UPT