Graduate Project Report

NAVAL AIR TRAINING COMMAND

RESOURCE PLANNING SYSTEM

DISTRIBUTION MODULE

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ABSTRACT

The Resource Planning System (RPS) provides the Chief of Naval Air Training (CNATRA) with the capability to determine the resources required to produce a specified number of Naval Aviators quickly and efficiently. Utilizing planning factors and a predetermined Pilot Training Rate (PTR), the system determines the number of students that must enter the pipeline and the number of support personnel, instructors, and aircraft required to meet the training objectives. Shifts in policy established by higher authority keep the Naval Air Training Command (NATRACOM) in a state of flux in regard to the number of personnel that must be trained and the utilization and production rate of each squadron.

Using a predetermined set of rules, the distribution module of RPS divides the phased PTR among the squadrons that perform a specific type of training. The old system is dependent upon the technical expertise of a programmer to make changes or modifications to the distribution plan. The objective of this project was to design and write a new distribution program. This new program contains options for multiple distribution plans and can accommodate changes to these plans without necessitating a computer program change.
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I. INTRODUCTION

The Chief of Naval Air Training (CNATRA) has the primary responsibility to provide undergraduate pilot training for the Navy, Marine Corps, Coast Guard, and selected foreign nationals. CNATRA trains four different types of pilots (Strike, Maritime, Helicopter, and E2C2) each having its own individualized curriculum. To accomplish this mission, CNATRA is responsible for overall management functions including budget submissions to ensure that adequate funds and resources are allocated to conduct all required training and operations.

Chief of Naval Operations (CNO) provides CNATRA the number of Student Naval Pilots that must be trained to meet operational readiness criteria. This is commonly referred to as the Pilot Training Rate (PTR). CNATRA translates the PTR into required inputs and outputs to the various phases of training. It also calculates the number of flight hours, aircraft, flight instructors, and support personnel required. The formulas used to calculate these required resources employ parameters called planning factors. Planning factors consist of established values such as availability of aircraft, availability of instructors, average weeks to train, student attrition rate and instructor turnover. These factors are determined by empirical data, equations, and straightforward derivations.

If done manually, the preparing of resource requirements, predictions,
projections and "what if" questions, is an extremely labor intensive and
tedious task. In 1981 LCDR Joe Trevathan and LT Randy Davis wrote a collection
of simple programs that did the redundant calculations required to compute both
the required resources and planning factor values. LT Davis tied the programs
together in 1982 to produce the first version of the Resource Planning System
(RPS). This system was used to produce required reports, but since it did not
readily allow for changes to input values the system could only be run by LT
Davis. LT Davis attempted to make the system "user friendly" but was unable to
finish this task prior to his transfer from the area.

Using the formulas developed by LCDR Trevathan and LT Davis and studying
the logic attempted by LT Davis, I designed a new version of RPS. This new
version utilizes screen input routines and alternative selections of proposed
PTR and planning factors. The system is utilized by the CNATRA resource
planning division on a daily basis. It has significantly reduced manpower
efforts and greatly improved accuracy. It's major shortcoming was that it
still required the expertise of a programmer to make changes to the planned
distribution of PTR among squadrons. This requirement severely limited the
planning division's ability to explore the effects of different distribution
plans.

This project involved designing and programming a new distribution module
that would allow any planner to modify the distribution plan without requiring
a program change.
II. SOLUTION APPROACH

This project involved writing a new distribution module to replace the existing module in RPS. This new module performs two operations. First, it allows staff planning personnel to select up to three different options to be used to distribute PTR among the different training squadrons. Second, it allows the planners to easily change the distribution plan.

The first step to arrive at a solution was to determine a standard algorithm that could be used to compute the PTR records for any squadron. Figures 2.1 through 2.4 list the pseudocode that was used to write the distribution subroutines for the different phases of training.

It was not possible to write a single routine that would work efficiently with all phases. This was because there are phases with two different curriculums and phases which have training squadrons at more than one location or Training Air Wing. All routines do use the same logic for opening and closing the squadron files and the outside loop with the case select to process the three types of PTR. The differences are:

1. The Intermediate Strike and Advanced Maritime routines must calculate and divide the PTR based on flight hours because of the E2C2 curriculum.
2. The Primary training routine starts out by recalculating the percentage of total PTR for each squadron because of the requirement of a fixed output PTR at VT-27.

3. The Primary training routine must calculate both primary and intermediate PTRs for each squadron.

4. The Advanced Strike and Intermediate Strike routines required a squadron loop nested in a wing loop. The design of these loops is discussed below.

To make the program logic more symmetrical, the program was designed so that each Strike Training Air Wing contains two squadrons for each intermediate and advanced phase. For those Training Air Wings which have only one intermediate or advanced squadron in actuality, the extra squadron was named VT-X. To assure the correct distribution with the current squadron configuration, all VT-X squadrons must be assigned a PTR of zero percent. If any percentage other than zero is assigned to a VT-X squadron, the PTR calculated is written to a dummy file.

This symmetry in program logic will allow future users a greater flexibility with the current RPS programs since changes may be easily made in the number of squadrons at each Training Air Wing. The only modification required to the program for this is to change the name of the output file in the data line and to change the name of the squadron in the Change Distribution Plan program.
The second step of this project involved determining how to input the different distribution plans. Input methods considered were (1) responding to prompts, the answers to which would determine the next set of questions or prompts or (2) entering values into a spread sheet matrix. The spread sheet input routine was selected because it would allow the planner to view the overall distribution plan for each phase. Spread sheet type screen edit routines for each phase were designed using public domain screen input utilities.

Before the actual coding took place, a determination was made as to how the distribution plan for each squadron would be stored. The three possibilities considered were (1) string variables in which each character is a code for an operation, (2) arrays whose cells contain an operation, or (3) a combination of both of these methods. The logic of the nested loops in the distribution routines made number (2), the array storage, the most feasible.

The distribution plans are stored in two-dimensional numeric arrays. Each array has five rows and from two to eight columns depending on the number of squadrons or Training Air Wings that conduct each phase of training. The first row is the percentage of total flight hours to be assigned to the individual squadron or Training Air Wing. The second through the fifth rows are the percentage of the training requirements for each non-navy service. Advanced Strike and Intermediate Strike phases each have two arrays (one for the Training Air Wings and one for the squadrons). The other two phases, Maritime
and Primary training require only one array for the squadrons since all the training in those phases is conducted at the same Training Air Wing.
ADVANCED STRIKE CODING DISTRIBUTION PLAN

ASSUMPTIONS:  1. USN STRIKE STUDENTS ARE SHIFTED TO BALANCE OUT TOTALS FOR SQUADRONS.
               2. EACH WING HAS TWO ADVANCED SQUADRONS.

SELECT DISTRIBUTION PLAN TO USE.
OPEN EACH SQUADRONS'S PTR FILE.
FOR EACH PTR (RESOURCE, OUTPUT, INPUT)
   GET TOTAL ADV STRIKE PTR.
   FOR EACH WING.
      NOTE: WING % OF EACH SERVICE CHECKED TO EQUAL 100% IN DISTRIBUTION PLAN MODULE.
      FOR EACH SQUADRON.
         COMPUTE SQUADRON PTR = WING PTR * SQUADRON %.
         E2C2 PTR = 0.
         USMC PTR = USMC ADV STRIKE PTR * WING USMC % * SQUADRON USMC %.
         SUBTRACT USMC PTR FROM SQUADRON PTR.
         USCG PTR = USCG ADV STRIKE PTR * WING USCG % * SQUADRON USCG %.
         SUBTRACT USCG PTR FROM SQUADRON PTR.
         FMS PTR = FMS ADV STRIKE PTR * WING FMS % * SQUADRON FMS %.
         SUBTRACT FMS PTR FROM SQUADRON PTR.
         USN PTR = REMAINING SQUADRON PTR.
         SAVE SQUADRON PTR.
      NEXT SQUADRON.
   NEXT WING.
NEXT PTR.
CLOSE SQUADRON PTR FILES.

figure 2.1
INTERMEDIATE STRIKE AND INT E2C2 CODING DISTRIBUTION PLAN

ASSUMPTIONS:
1. USN STRIKE STUDENTS ARE SHIFTED TO BALANCE OUT TOTALS FOR SQUADRONS.
2. EACH WING HAS TWO INTERMEDIATE SQUADRONS.

SELECT DISTRIBUTION PLAN TO USE.
OPEN EACH SQUADRON'S PTR FILE.
FOR EACH PTR (RESOURCE, OUTPUT, INPUT)
  GET TOTAL INT STRIKE PTR.
  GET TOTAL INT E2C2 PTR.
  FOR EACH WING.
    COMPUTE WING PTR FOR INT STRIKE AND INT E2C2 USING WING %.
    NOTE: WING % OF EACH SERVICE CHECKED TO EQUAL 100% IN DISTRIBUTION PLAN
    MODULE.
    GET HOURS PER STUDENT PLANNING FACTOR FOR INT STRIKE AND E2C2.
    COMPUTE TOTAL HOURS REQUIRED AT WING FOR INT STRIKE AND E2C2.
    FOR EACH SQUADRON.
      COMPUTE HOURS FOR SQUADRON = TOTAL WING HOURS * SQUADRON %.
      COMPUTE E2C2 PTR = ECC2 INT PTR * WING % E2C2 * SQUADRON E2C2 %.
      COMPUTE USMC PTR = USMC STRIKE PTR * WING % USMC * SQUADRON USMC %.
      COMPUTE USCG PTR = USCG STRIKE PTR * WING % USCG * SQUADRON USCG %.
      COMPUTE FMS PTR = FMS STRIKE PTR * WING % FMS * SQUADRON FMS %.
      COMPUTE E2C2, USMC, USCG AND FMS HOURS.
      SUBTRACT E2C2, USMC, USCG, AND FMS HOURS FROM SQUADRON TOTAL
      HOURS.
      COMPUTE USN PTR THAT CAN BE DONE WITH THE REMAINING HOURS.
      USN PTR = REMAINING HOURS / HOURS PER INT STRIKE STUDENT.
      SAVE SQUADRON PTR.
    NEXT SQUADRON.
  NEXT WING.
NEXT PTR.
CLOSE SQUADRON PTR FILES.

figure 2.2
ADVANCED MARITIME AND ADV E2C2 CODING DISTRIBUTION PLAN

ASSUMPTION: USN MARITIME STUDENTS ARE SHIFTED TO BALANCE OUT TOTALS FOR SQUADRONS.

SELECT DISTRIBUTION PLAN TO USE.
OPEN EACH SQUADRON'S PTR FILE.
GET HOURS PER STUDENT PLANNING FACTOR FOR ADV MARITIME AND E2C2.
FOR EACH PTR (RESOURCE, OUTPUT, INPUT)
    GET TOTAL MARITIME PTR.
    GET TOTAL E2C2 PTR.
    COMPUTE TOTAL HOURS REQUIRED AT WING FOR ADV MARITIME AND E2C2.
FOR EACH SQUADRON.
    COMPUTE HOURS FOR SQUADRON = TOTAL HOURS * SQUADRON %.
    COMPUTE E2C2 PTR = E2C2 ADV PTR * SQUADRON E2C2 %.
        COMPUTE E2C2 HOURS = E2C2 PTR * E2C2 P.F.
    COMPUTE USMC PTR = USMC MARITIME PTR * SQUADRON USMC %.
    COMPUTE USMC HOURS = USMC PTR * MARITIME P.F.
    COMPUTE USCG PTR = USCG MARITIME PTR * SQUADRON USCG %.
    COMPUTE USCG HOURS = USCG PTR * MARITIME P.F.
    COMPUTE FMS PTR = FMS MARITIME PTR * SQUADRON FMS %.
    COMPUTE FMS HOURS = FMS PTR * MARITIME P.F.
SUBTRACT E2C2, USMC, USCG, AND FMS HOURS FROM SQUADRON TOTAL HOURS.
COMPUTE USN PTR THAT CAN BE DONE WITH THE REMAINING HOURS.
        DIVIDE REMAINING HOURS BY HOURS PER STUDENT.
SAVE SQUADRON PTR.
NEXT SQUADRON.
NEXT PTR.
CLOSE SQUADRON PTR FILES.

figure 2.3
PRIMARY/INTERMEDIATE CODING DISTRIBUTION PLAN

ASSUMPTIONS: 1. USN STUDENTS ARE SHIFTED TO BALANCE OUT TOTALS FOR SQUADRONS.
               2. VT-27 HAS A FIXED TOTAL PRI PTR.
               3. % OF EACH SERVICE DONE IN PRI THE SAME IN INT.

SELECT DISTRIBUTION PLAN TO USE.
COMPUTE % PTR FOR EACH SQUADRON.
   GET TOTAL PRIMARY OUTPUT PTR.
   GET VT-27 TOTAL PRI PTR.
   GET VT-2, VT-3, AND VT-6 % OF REMAINING PTR.
   VT-27 % = VT-27 PRI PTR / TOTAL PRI PTR.
   REMAINING PRI PTR = TOTAL PRI PTR - VT-27 PRI PTR.
   VT-2 % = VT-2 % OF REMAINING * REMAINING PTR PRI / TOTAL PRIMARY PTR.
   VT-3 % = VT-3 % OF REMAINING * REMAINING PTR PRI / TOTAL PRIMARY PTR.
   VT-6 % = VT-6 % OF REMAINING * REMAINING PTR PRI / TOTAL PRIMARY PTR.

OPEN EACH SQUADRON'S PTR FILES.
FOR EACH PTR (RESOURCE, OUTPUT, INPUT)
   GET TOTAL PRIMARY AND INTERMEDIATE PTR.
   FOR EACH SQUADRON.
      PRIMARY.
      COMPUTE SQUADRON PTR = TOTAL PRI PTR * SQUADRON %.
      USMC PTR = USMC PRI PTR * SQUADRON USMC %.
      SUBTRACT USMC PTR FROM SQUADRON PTR.
      USCG PTR = USCG PRI PTR * SQUADRON USCG %.
      SUBTRACT USCG PTR FROM SQUADRON PTR.
      FMS PTR = FMS PRI PTR * SQUADRON FMS %.
      SUBTRACT FMS PTR FROM SQUADRON PTR.
      USN PTR = REMAINING SQUADRON PTR.
      COMPUTE % OF USN PRI = USN PTR / TOTAL USN PTR.
      SAVE SQUADRON PRI PTR

      INTERMEDIATE.
      USN PTR = USN INT PTR * SQUADRON USN %.
      E2C2 PTR = E2C2 INT PTR * SQUADRON USN %.
      USMC PTR = USMC INT PTR * SQUADRON USMC %.
      USCG PTR = USCG INT PTR * SQUADRON USCG %.
      FMS PTR = FMS INT PTR * SQUADRON FMS %.
      SAVE SQUADRON INT PTR.

NEXT SQUADRON.
NEXT PTR.
CLOSE SQUADRON PTR FILES.

figure 2.4
III. DISTRIBUTION MODULE

The Distribution Module consists of two programs. The distribution program and the change distribution plans program.

The distribution program divides the PTR among the specific squadrons based upon the planner's selection of the distribution plan and hours per student from the planning factors. The output from this program is a PTR file for each squadron with the squadron's input, output, and resource PTR's.

The change distribution plans program allows the planner to enter and review three different distribution plans. The purpose of the program is to allow updates to the distribution plans file which is used by the distribution program.

The Distribution Module software is written in BASIC-2 and designed to operate on a Wang 2200 MVP minicomputer installed at CNATRA headquarters, NAS Corpus Christi, TX. Selection of programming language was based solely on compatibility with the current system and availability of hardware.
IV. DISTRIBUTION PROGRAM

The distribution program divides the PTR from the files produced by the phasing program. It divides PTR among the squadrons based upon the distribution plan and planning factors selected. The output from this program is a PTR file for each squadron that is used by the resource program. Figure 4.1 is a flow chart of the main line of the distribution program and figure 4.2 is a flow chart of the subroutine for the Intermediate Strike phase.

The input files are the phased completion PTR file ("COM-PTR") and phased resource PTR file ("RES-PTR") both from the phasing module. These files each contain four records, one for each type of student (Strike, Maritime, Rotary, E2/C2). Each record contains 3 to 5 arrays of 6 elements containing the PTR for each phase. Completion PTR is the number of students that must graduate or complete a phase in a given year. Resource PTR is used to compute the resources required throughout the Naval Air Training Command, (e.g. aircraft, instructors, support personnel, etc.). Since flight training is a continuous flow process with students starting and graduating each week, resource PTR accounts for training that takes place in years other than the completion year.

The output from the distribution module is a file with three PTR records for each of twenty squadrons. The records are squadron resource PTR, squadron
completion/output PTR, and squadron input PTR. Each record is composed of one 15 element array which contains the squadron PTR for each service and the non-PTR training requirements from another module. (Non-PTR requirements are constant for each squadron and not directly affected by changes in distribution.) Input PTR is the number of students that start a phase in a given year. This number is equal to the completion PTR of the phase of training prior (e.g. the completion PTR from an intermediate phase equals the input PTR to the advanced phase in the same pipeline).

To compute squadron PTR requirements the distribution program uses the distribution plan and data from the planning factor files.

At those Training Air Wings which administer squadrons that train aviators using two curricula with different amounts of flight time, the total flight hour requirements must be computed before dividing the PTR among the squadrons. To compute these flight hours, the planning factor value of hours per student is required. Each squadron has its own particular planning factor file which has one record with three arrays. Selecting an array allows three choices of planning factor sets.

The distribution plans are stored as records in the file named "DistPlan". The file contains one record with the reference names of the distribution plans and three records with the distribution plans for each phase. Selecting a record allows three choices of distribution plans. Each record contains six
arrays with the distribution plans for each phase. The Advanced Strike and Intermediate Strike phases each have two arrays, one for the different wings and one for the various squadrons. The other two phases, Maritime and Primary training, have one array each for the squadrons since all the training in the phase is done at the same Training Air Wing.

The following is an example of how the distribution plan and planning factors are used to distribute the PTR among two squadrons:

EXAMPLE OF HOW THE DISTRIBUTION PLAN AND PLANNING FACTORS ARE USE TO COMPUTE THE PTR FOR TWO SQUADRONS.

Given:

2 Squadrons VT-A and VT-B

Distribution Plan: Each squadron does 50% of the wing flight training.
   VT-A will do 100% of the USMC training.
   VT-B will do 100% of the E2C2 training.

Planning Factors: 75 hours per student for USMC and USN.
                  50 hours per student for E2C2.

PTR for the year: 100 USN
                  25 USMC
                  30 E2C2

Compute the PTR for each type of student at each squadron.

Total Wing flight hours = (75 * (100 + 25)) + (50 * 30) = 10875

Squadron VT-A
   Squadron hours = 10875 * 50% = 5437.5
   E2C2 PTR = 30 * 100% = 30
   E2C2 hours = 30 * 50 = 1500
   USMC PTR = 25 * 0% = 0
   USN hours = 5437.5 - 1500 - 0 = 3937.5
   USN PTR = 3937.5 / 75 = 52.5
   PTR VT-A: USN = 52.5, USMC = 0, E2C2 = 30
Squadron VT-B

Squadron hours = 10875 * 50% = 5437.5
E2C2 PTR = 30 * 0% = 0
E2C2 hours = 30 * 0 = 0
USMC PTR = 25 * 100% = 1875
USN hours = 5437.5 - 1875 - 0 = 3562.5
USN PTR = 3562.5 / 75 = 47.5
PTR VT-B : USN = 47.5, USMC = 25, E2C2 = 0
V. CHANGE DISTRIBUTION PLANS PROGRAM

The Change Distribution Plans program is used to enter and review three different distribution plans. The purpose of the program is to update the distribution plan arrays used by the distribution program.

All distribution plan arrays are stored as a record in the file named "DistPlan". This file contains three records, each representing a different distribution plan. Selecting a record allows the option of three distribution plans. A fourth record in the file contains only the reference names of the distribution plans.

The program is interactive and menu driven with a spread sheet type matrix display for reviewing and inputting plans. Figure 5.1 is a flow chart of the main line of the program used to select the plan and the edit routines for each phase.

Each phase has its own screen edit routine since the number and dimension of the arrays are different for each phase. Values entered in the edit routines are: the percentage of the total flight hours for all students for each wing, the percentage of the total training requirements for non-navy students for each wing, and the percentage that each squadron receives of the total wing requirements. There is no entry required for navy students. This
data is computed by the distribution program based upon total training
requirements for the year. Once entered non-navy numbers are considered
"fixed", navy students are used to balance out the loading totals among the
wings and squadrons.

The edit screen utility subroutines were developed by an R&D branch of the
Federal Goverment. This collection of public domain utilities are available
for use by Wang MVP programmers in development of interactive screen input
programs. The utility routines consist of the marked subroutines DEFFN '120
through '125. These subroutines are merged with the program as lines 7900 to
7999 when the program is run.

A summary of the utility subroutines used:

DEFFN '120 Loads the file that contains the screen mask and displays
the mask.
DEFFN '121 Inputs character data to a screen field variable.
DEFFN '122 Displays the contents of a screen field variable.
DEFFN '123 Changes the attribute and then displays the contents of a
screen field variable.
DEFFN '124 Inputs numeric data to a screen field variable.
DEFFN '125 Displays Message at bottom of screen.
The exception routines that handle the key inputs are also part of the utility package. The calculations required to relate the screen field position and the index of the array are located in the subroutines to edit each screen. The program flow in each screen edit routine is totally controlled by the interaction of the operator with the keyboard. These routines allow the operator to move about the screen and change values in fields. The code that does this appears confusing and spaghetti like to a programmer unfamiliar with the Wang MVP system. Actually the code is efficient and the routine is user friendly.

The Wang MVP system does not have formal while-do and do-until constructs. If-then-else constructs require the use of GOTO statements to perform multiple statements. The result is that screen input routines lack the structured programming rule of "one in, one out" because of actions that must take place to change the flow of the program. Take for example, the operator who is making changes in the wing array at the top of the screen. Instead of stepping through each position in the array in the pre-determined sequence, he may move down to the bottom of the screen using the DOWN key. The program must keep track of the field on the screen the operator is in and the indexes of the array which contains the value for the field.

Each time a value is changed, the marked subroutine '90 is used to check the distribution plan. If the total of the value of any line does not equal 0 or 100 percent, the line is highlighted and a message displayed.
CHANGE DISTRIBUTION PLANS

START

INITIALIZE GET SYSTEM DATE

SELECT DISTRIBUTION PLAN

LOAD DISTRIBUTION PLAN SELECTED

WHILE \( \neq \) END

GET KEY INPUT

SELECT

ADVANCED STRIKE '81
INTERMEDIATE STRIKE '82
ADVANCED MARITIME '83
PRIMARY '84
OTHER DEEP

SAVE DISTRIBUTION PLAN

END

Figure 5.1
VI. SUMMARY AND CONCLUSIONS

The program was tested by inputting the distribution plan that is currently being utilized by the Naval Air Training Command. The few output differences that were found between this and the old system were traced to minor errors in the old system. This module has now replaced the old distribution programs. It is being utilized on a daily basis by the CNATRA planning division.

The module was designed to accommodate the type of plans that were used in the past and the most likely possibilities of those to be used in the future. Unforeseen changes in the methods that Naval aviators are trained could make the program obsolete, but that is highly unlikely.

The program should be a vital tool to NATRACOM planners for many years to come. The only complicating factor will be converting the program to run on whatever computer system replaces the Wang system at CNATRA headquarters in the future. The program was deliberately coded with numerous remarks explaining the function of each block of code so that any programmer can easily adapt the program to a different language.
REFERENCES AND BIBLIOGRAPHY


