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THE BASIC DYNAMIC MODEL OF THE AIRLIFT SERVICE INDUSTRIAL FUND OF THE MILITARY AIRLIFT COMMAND

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FINAL REPORT
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Air Force Office of Scientific Research
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Project 821

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16. Abstract

This report describes in detail the model developed of the Military Airlift Command Industrial Fund. This report begins with a description of the Industrial Fund, its objectives and its constraints. The model variables are then identified and their interrelationships described. The modeling technique utilized is "Industrial Dynamics" which provided a method for simulating the time varying behavior of the real system. The completed model is provided in the Appendix.

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Industrial Dynamics, Simulation, Computer Simulation, System Analysis, Operations Research, System Design, Modeling

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THE BASIC DYNAMIC MODEL

The purpose of this report is to describe what will be referred to as the basic dynamic model of the Airlift Service Industrial Fund (ASIF). This basic model is the result of our Analysis of the Industrial Fund System and utilizes the "Industrial Dynamics" approach to model the dynamic characteristics of the Industrial Fund. (For detailed explanation of the Industrial Dynamics approach to system analysis see J. W. Forrester's book, Industrial Dynamics, M.I.T. Press, Cambridge, Massachusetts, 1961.) This model will be used to simulate the dynamic characteristics of the real system and to test proposed system modifications. The end result will hopefully be better understanding of the dynamics of the real system and increased confidence in the probable benefit of proposed system modifications.

This model is the result of many hours of discussion between the analyst and the managers of the Industrial Fund and is a representation of the Industrial Fund system at the present time.

Background

This project was initiated during the summer of 1967 when the analyst was working with the Military Airlift Command's Operations Analysis office at Scott Air Force Base, Illinois. During this period the analyst became acquainted with ASIF and proposed its analysis using the "Industrial Dynamics" approach. At that time it was thought that the model could be developed fairly quickly and then be used to analyze the dynamics of the Industrial Fund.

While the project proposal was accepted and the development of the model began, the resulting basic model has been achieved slowly. Interim reports were presented in the spring of 1968 and in April of 1969.

The modeling technique utilized has been one developed by J. W. Forrester of M.I.T. called "Industrial Dynamics". The industrial dynamics technique utilizes a compiler program called "Dynamo". Dynamo enables the researcher, after describing his model in nemonic language and quantifying the many variables, to simulate the system dynamics on a computer. In April of 1969, the "Dynamo" Compiler was just being completed for the IBM 360/67 equipment used by the Iowa State University Computation Center. The programming of the "Dynamo" Compiler for the current IBM equipment had taken longer than anticipated and the model building activities had been delayed.

Method of Analysis

The method of analysis being utilized in studying the industrial fund proceeds according to the following five steps.

First: Identify the system variables and their interrelationship.

The analyst has spent many hours in discussion with ASIF personnel to identify the significant variables within the ASIF system and their interrelationships as a part of a dynamic system. This phase of the procedure is continually in operation as further steps are completed and discussed by the ASIF managers and the analyst.

Second: Develop a basic model of the ASIF System.

This basic model is described in this report. The report identifies the variables selected and quantifies the relationships between the different variables. The system is assumed to be a closed system operating continuously with linear relationships between the variables over very short time intervals.

Third: Simulate the ASIF system on a computer using the basic model.

This step is in progress and the analysis and conclusions will be the subject of a later report.

Fourth: Test system changes or modifications via simulation on a revised basic model.

Proposed system changes or modifications will be studied by revising the basic model to incorporate the proposed modification. This step will be incorporated in the report referenced in step three.

Fifth: Propose system changes.

Based on the conclusions reached in steps three and four, proposed system changes may be recommended.

It must be clearly understood that the purpose of this model is to represent the dynamic aspects of the real system and enable the analyst to manipulate and study the model, thereby gaining valuable insight into the real system. The model, for obvious reasons, must be, and is, a simplification of the real system. However, it must identify the significant variables with their interrelationships so that the model dynamics realistically represents the real system.

The simpler the model, while still representative of the real system, the better from a model building and analysis standpoint. The model may later be made more sophisticated as deemed necessary for analysis purposes as outlined in steps three and four.

The Industrial Fund

The Airlift Industrial Fund (ASIF) is a MAC management tool established to:

a) provide an effective means for controlling the costs of airlift capability,

b) provide for the rational recovery of airlift costs from airlift users, and

c) motivate users toward prudent use of airlift capability supplied by MAC.

A number of problems are encountered by the ASIF when attempting to develop a tariff structure which fulfills the following objectives:

a) Allow for the strategic disposition of the Military Force;

b) Provide equitable rates to users;

c) Recognize utilization of airframe capabilities;

d) Provide for a revenue-expense breakeven at specified time intervals on both PAX and Cargo shipments;

e) Charge premium rates for premium service;

f) Maintain tariff stability; and

g) Motivate efficient user usage.

The Basic ASIF Model

In developing the basic ASIF model a general description was obtained from ASIF personnel regarding the operation of the Fund. System boundaries and system variables were identified and a description was obtained of the significant cause-effect relationships. The model was developed from a general description of the system and the system variables and became more sophisticated as different variable interrelationships were deemed significant and included in the model.

The ASIF is responsible for the determination of airlift tariffs. These tariffs are established with the goal of recovering airlift costs from airlift users. The users are billed for the airlift service providing revenue (or income) to the Industrial Fund. The tariff is influenced by forecasted airlift costs, and forecasted airlift demand. Airlift costs are based on aircraft availability, utilization, and maintenance, as well as administrative and operational support functions.

As airlift services are provided, revenue is generated as well as expenses. If total revenue exceeds or lags actual expenses, the tariff may need revision to enable the ASIF to break even at the end of a specified time period.

The model which has been developed, and is described in this report, represents the forecasting system by which demand and costs are estimated and incorporated with airlift capacity to yield a forecasted tariff rate; the determination of airlift capacity and its allocation to customer demand; the billing activity initiated by the movement of material or passengers and influenced by the tariff; the accounting and payment of expenses generated by ASIF activities; and the determination of total revenue and total costs and any out of balance condition resulting.

In developing the model, four classifications of customer demand were recognized as each influenced the tariff calculations in a particular way. Customer demand is classified as Cargo, PAX (passengers), SAAM (special assignment airlift missions), or Exercises. Cargo and PAX may be moved by contract with commercial airlines. While SAAM's may utilize commercial aircraft in the real system, its use is limited and not represented in the model at this time.

The users of MAC move material and passengers over specified routes generating Ton-miles or PAX-miles of usage. The modeling of this aspect of the real system has required some simplifying assumptions. For simplicity, we have assumed that customer demand is in Ton-miles/week or PAX-miles/week. This demand, however, needs to be identified as outgoing (from CONUS) or incoming (to CONUS) for airlift capability required has bee· assumed to be twice the larger demand. For example, when outgoing is larger, the planes will return empty or partially loaded.

In summary, the model represents the following activities:

a) The customer's demand and movement of Cargo, PAX, SAAM, and Exercise.

b) The Industrial Fund manifesting and billing fo. services pr. vided.

c) The determination of military airlift capability and commercial requirements and their allocation to customer demand.

d) The generation of expenses within the ASIF.

e) The cash flow due to payment of expenses and receipt of revenue.

f) The forecasting of customer demand and ASIF expenses to generate a new tariff rate.

g) The determination of revenue-expense differences leading to a decision to change the tariff rate.

In the following discussion each figure represents a segment of the basic model of the total ASIF system. Each variable in the system is identified and the variable equation given. The identification of each variable is by nemonic language. A variable may be identified as part of the Cargo, PAX, SAAM, or Exercise system by the number 1, 2, 3, or 4, respectively, in the variable name.

Each variable is also assigned a number which identifies the variable and the figure which shows that variable's interrelationships with other variables. Thus, variable 6.09 identifies variable 09 of Figure 6 and variable 11.22 identifies variable 22 of Figure 11. This will assist in the identification and location of the different variables when necessary during study and analysis.

Following the industrial dynamics terminology, three points in time, J, K, and L, are identified. "J" represents a point in time in the immediate past, "K" is the present time and "L" a point in time in the immediate future. Each point in time is separated by the time interval DT. Variables, called rate variables, which identify the rate of change over the time interval DT and between J and K are identified by "JK" in the variable name and the rate of change between K and L is noted by a "KL" in the variable name. A "K" or "J" in the variable name identify the magnitude of a level or auxiliary variable at that point in time.

In the figures, a solid line will represent the flow of material, paper work (manifests, bil , etc.) or cash, while a dotted line indicates the influence of information. A dotted line into a variable would indicate that the value of that variable would be influenced by information from the variable or variables originating the dotted line. All flows are in the direction of the arrow. For more detail on the flow diagrams see Chapter 8 of 'Industrial Dynamics" by J. W. Forrester.

Figure 1

The Military Airlift Command moves cargo and passenger per customer demand and in Figure 1 the movement of cargo per customer demand has been modeled. Customer demand is assumed to be an exogenous variable and influenced by facto · outside the ASIF. This may be revised later to show a feedback effect ... customer demand by ASIF tariffs if it is deemed significant.

1.01 D1G Customer Demand-Cargo-Outgoing (Ton-Miles/week)

1.02 D1C Customer Demand-Cargo-Incoming (Ton-Miles/week)

It is assumed that material moved to MAC terminals during an interval of time is equal to customer demand at the beginning of that time interval. Rate equations 1.05 and 1.06 are written to represent the movement of material to the terminals.

1.05 IS1G.KL = D1G.K

1.06 IS1C.KL = D1C.K

IS1G = Incoming shipment rate (to terminals)-Cargo-Outgoing (Ton-Miles/week)

IS1C = Incoming shipment rate (to terminals)-Cargo-Incoming (Ton-Miles/week)

Terminal inventory at a point in time is equal to the terminal inventory at the last time period plus incoming shipments and less outgoing shipments over that time period. Level equations 1.07 and 1.08 are written to represent these variables.

1.07 IN1G.K = IN1G.J + (DT)(IS1G.JK - S1C.JK)

1.08 IN1C.K = IN1C.J + (DT)(IS1C.JK - S1C.JK)

IN1G = Terminal Inventory-Cargo-Outgoing (Ton-Miles)

IN1C = Terminal Inventory-Cargo-Incoming (Ton-Miles)

Shipments from the terminal are assumed to be determined by the terminal inventory (IN1G and IN1C) and the policy to move any material received within a specified time limit. The basic model is based on the policy to ship material from the terminal within two days after receipt of the material. Because of the nature of the modeling technique and the need to later allocate military and commercial capability to cargo movement, we have written the following equations.

We identify two variables as follows:

1.09 S1GT.K = IN1G.K(1/D17)

1.10 S1CT.K = IN1C.K(1/D17)

S1GT = Shipping Rate-Cargo-Outgoing-Tested (Ton-Miles/week)

S1CT = Shipping Rate-Cargo-Incoming-Tested (Ton-Miles/week)

1.61 D17 = Delay in shipping (Weeks)

1.62 D18 = Delay in shipping (Weeks)

The shipping rate over time period KL is then represented as follows:

1.03 S1G.KL = S1GT.K

1.04 S1C.KL = S1CT.K

S1G = Shipping Rate-Cargo-Outgoing (Ton-Miles/week)

S1C = Shipping Rate-Cargo-Incoming (Ton-Miles/week)

Military capability is allocated to cargo movement and commercial requirements are utilized to cover any deficits in capability. Variables 1.11 through 1.16 in Figure 1 model this aspect of the system. The capacity of the airframe is not utilized 100%, so the material moved (S1GT and S1CT) is divided by the utilization of the airframe to give the total airframe capability required.

1.65 U1G = ACL Utilization-Cargo-Outgoing (%)

1.66 U1C = ACL Utilization-Cargo-Incoming (%)

1.11 C1G.K = (S1GT.K)/U1G

1.12 C1C.K = (S1CT.K)/U1C

C1G = Required Capability-Cargo-Outgoing (Ton-Miles/week)

C1C = Required Capability-Cargo-Incoming (Ton-Miles/week)

It is assumed that airframes moving material outgoing will return with incoming material. Therefore, the total capability allocated to cargo movement will be twice the capability required to move either outgoing or incoming shipments, whichever is the larger.

This is determined in the model by variable 1.14 and its equation is written as follows.

1.14 MX1.K = MAX (C1G.K, C1C.K)

MX1 = Maximum Demand (Ton-Miles/week)

Then the capability required is

1.13 TC1.K = 2 * MX1.K

TC1.K = Total Required Capability-Cargo-(Ton-Miles/week)

The available military capability is applied to this requirement and the balance is covered by a commercial buy (CB1).

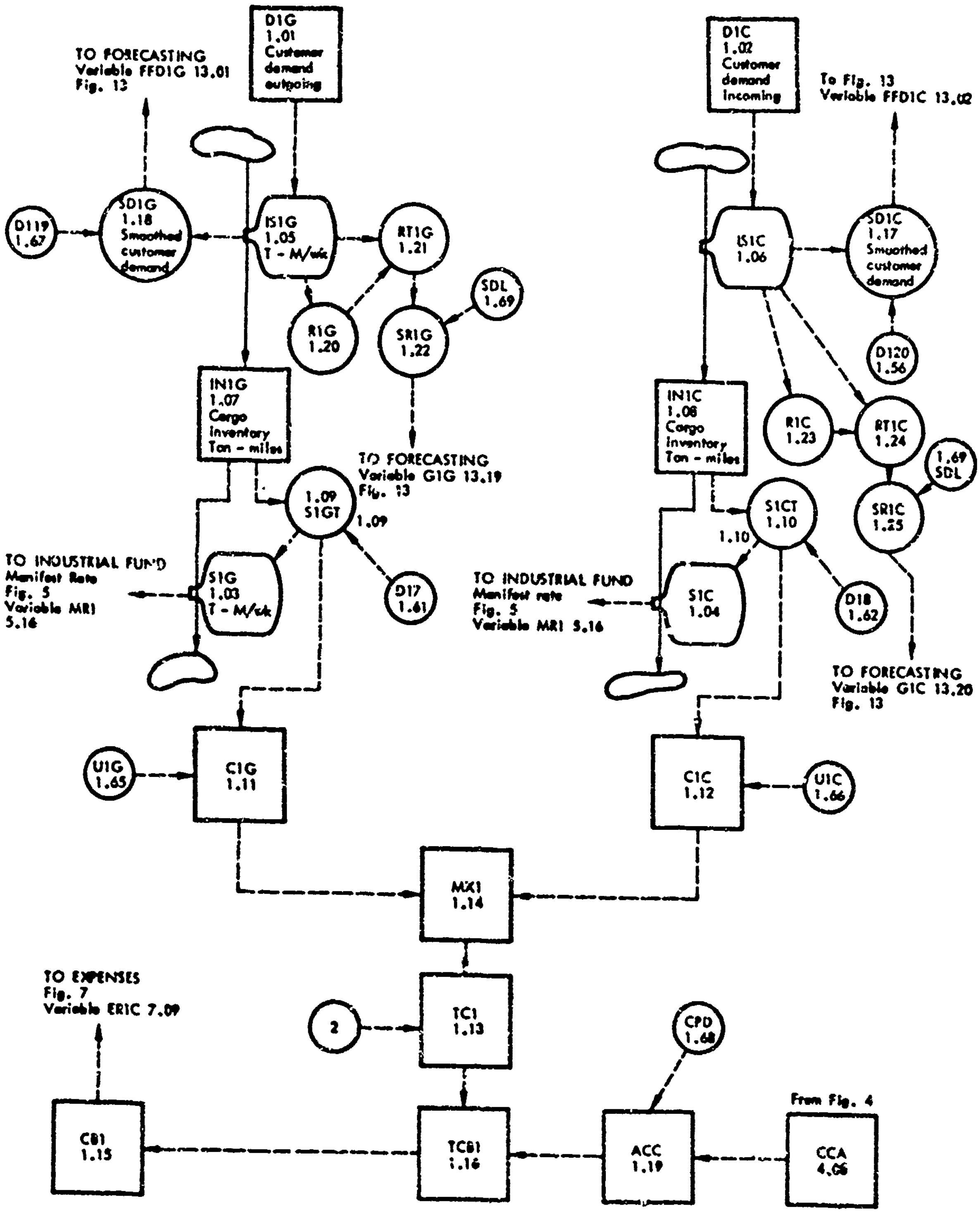

Figure 1, Model of Cargo Movement.

The military capacity available is determined in Figure 4 and results in variable 4.08 identified as the Cargo Capability Available. Because of the need for positioning and depositioning of aircraft, the quantity actually available for use is something less than this. This is accomplished by a multiplier (CPD) of less than one.

1.19 ACC.K = CCA.K * CPD

1.68 CPD = 0.907

ACC = Actual Cargo Capacity Available-(Ton-Miles/week)

CPD = Cargo Positioning-Depositioning Multiplier

The commercial buy can never be less than zero. If the military capacity is more than sufficient, it is used to move the customer's demand. That is, the total military capability available is used regardless of the quantity demanded and commercial requirements are purchased only if needed.

This is represented in the model by a clip function as follows:

1.16 TCB1.K = TC1.K - ACC.K

TCB1 = Tested Commercial Buy (Ton-Miles/week)

1.15 CB1.KL = CLIP (TCB1.K, 0, TCB1.K, 0)

CB1 = Commercial Buy (Ton-Miles/week)

This is interpreted as follows. If TCB1 is equal to or greater than 0 then CB1 is set equal to TCB1. However, if TCB1 is less than 0, which means no commercial buy is required, CB1 is set equal to 0.

In another segment of the model we need to determine the forecasted customer requirements. We have hypothesized that this forecast is influenced by the customer's previous demand and the rate of change in this demand. These variables and their modeling will need to be described.

It is assumed that the forecasted customer demand is determined by the average demand over a past period of time. We have utilized exponential averaging in our model which means the most recent occurrence will be given greater weight in determining the average customer demand. (See pg. 406 of the Forrester text) We have also assumed that this averaging occurs over a six-month time period. In other words, the forecasted customer demand is a function of the actual demand over the past six months.

The average customer demand is determined by a smoothing equation as follows:

1.18 SD1G.K = SD1G.J + (DT/D119)(IS1G.JK - SD1G.J)

1.17 SD1C.K = SD1C.J + (DT/D120)(IS1C.JK - SD1C.J)

1.67 D119 = Delay in smoothing (weeks)

1.56 D1?? = Delay in smoothing (weeks)

SD1G = Smoothed Customer Demand-Cargo-Outgoing (Ton-Miles/week)

SD1C = Smoothed Customer Demand-Cargo-Incoming (Ton-Miles/week)

The rate of change in demand is also assumed to be an average of the rate of change over a period of time the immediate past. Again it has been assumed that the most immediate past rate of change will have the greatest influence.

If we let R1G equal the customer's demand over the previous time period in Ton-Miles/week, then

1.20 R1G.KL = IS1G.JK

The rate of change in demand RT1G during the previous time period can then be written as follows:

1.21 RT1G.K = (1/DT)(IS1G.JK - R1G.JK)

In this equation R1G.JK is equal to IS1G in the time period JK - 1.

The average rate of change over the past SDL weeks is written as a smoothing equation (Exponential smoothing utilized).

1.22 SR1G.K = SR1G.J + (DT/SDL) (RT1G.J - SR1G.J)

SR1G = Smoothed rate of growth over the past SDL weeks (Ton-Miles/week/week)

1.69 SDL = Smoothing time period (weeks)

Initially we have assumed the smoothing time period (SDL) over which the rate of growth is determined is 20 weeks.

The above equations represent the modeling of the rate of change in customer demand for moving outgoing Cargo. In the same manner we needed the rate of change in demand for incoming Cargo.

1.23 R1C.KL = IS1C.JK

1.24 RT1C.K = (1/DT) (IS1C.JK - R1C.JK)

1.25 SR1C.K = SR1C.J + (DT/SDL) (RT1C.J - SR1C.J)

R1C = Customer Demand-Past time period - (Ton-Miles/week)

RT1C = Rate of Growth over previous time period (Ton-Miles/week/week)

SR1C = Smoothed Rate of Growth over the past SDL weeks (Ton-Miles/week/week)

The above equations complete the modeling of customer demand for and the movement of cargo out of and into CONUS with the resulting allocation of military capability to this demand and the determination of needed additional commercial requirements.

A list of all variables identified in Figure 1 and their corresponding initial conditions and parameters is given in Appendix I.

Figure 2

The movement of passengers (PAX) by Military Airlift Command is modeled in Figure 2. The customer, in the same manner as with Cargo, moves PAX out of and into CONUS. The modeling of this activity is practically identical to the modeling of Cargo movement.

The equations which follow represent the customer's demand for movement of PAX (outgoing and incoming), the movement of PAX to terminals and their shipment, with the appropriate allocation of commercial and military capability to this demand. The variables are therefore identified in the same manner as Cargo variables except the number "2" is used to represent PAX movement in place of the "1" representing Cargo movement.

2.01 D2G Customer Demand-PAX-Outgoing (PAX-Miles/week)

2.02 D2C Customer Demand-PAX-Incoming (PAX-Miles/week)

2.05 IS2G.KL = D2C.K

2.06 IS2C.KL = D2C.K

IS2G = Incoming PAX requirements-Outgoing (PAX-Miles/week)

IS2C = Incoming PAX requirements-Incoming (PAX-Miles/week)

2.07 IN2G.K = IN2G.J + DT(IS2G.JK - S2G.JK)

2.08 IN2C.K = IN2C.J + DT(IS2C.JK - S2G.JK)

IN2G = Terminal Inventory-PAX-Outgoing (PAX-Miles)

IN2C = Terminal Inventory-PAX-Incoming (PAX-Miles)

2.12 S2GT.K = IN2G.K/D27

2.14 S2CT.K = IN2C.K/D28

S2GT = Shipping Rate - PAX-Outgoing-Tested (PAX-Miles/week)

S2CT = Shipping Rate - PAX-Incoming-Tested (PAX-Miles/week)

2.60 D27 = Delay in shipping (weeks)

2.61 D28 = Delay in shipping (weeks)

2.13 S2G.KL = S2GT.K

2.15 S2C.KL = S2CT.K

S2G = Shipments-PAX-Outgoing (PAX-Miles/week)

S2C = Shipments-PAX-Incoming (PAX-Miles/week)

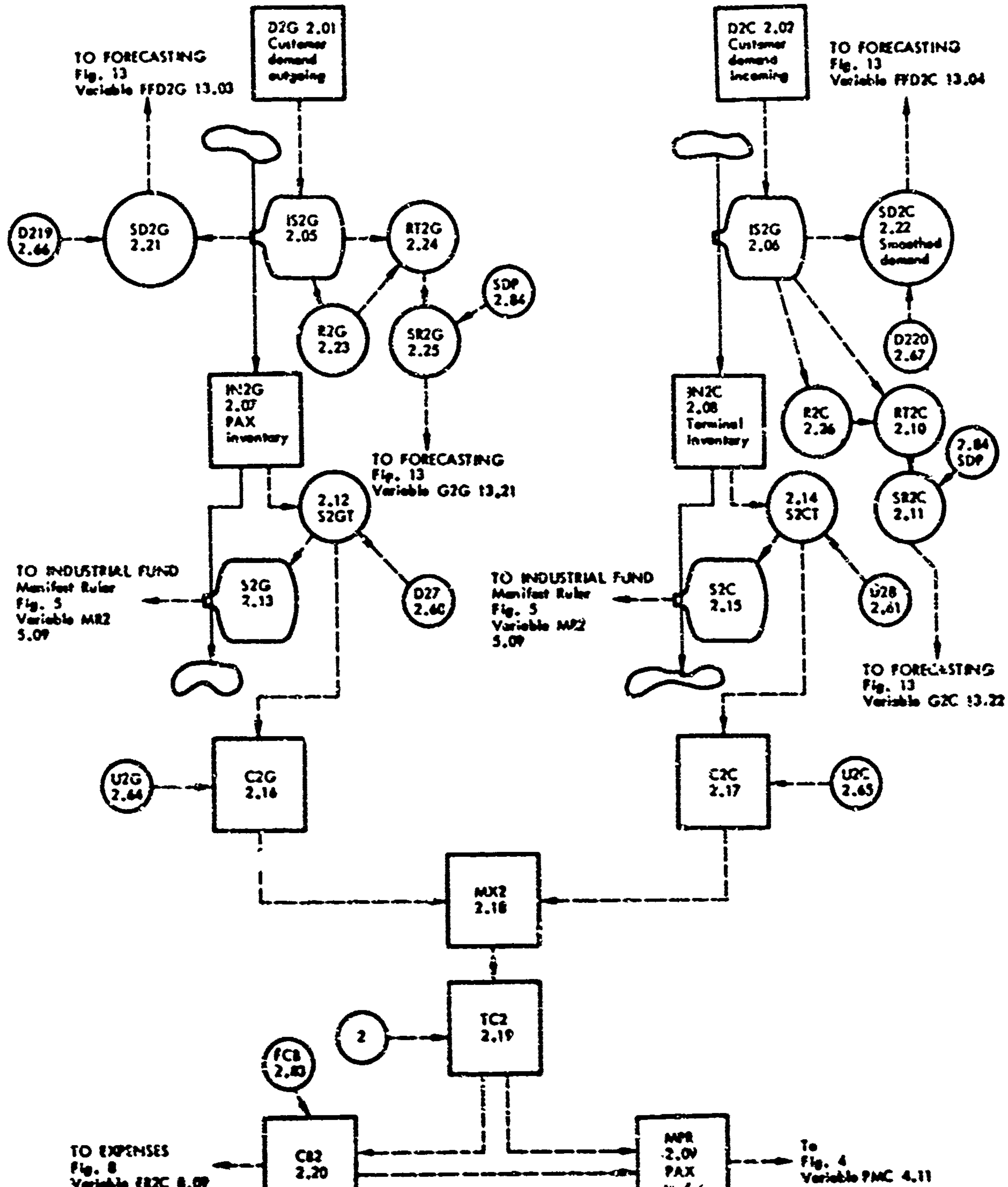

Figure 2. Model of PAX Movement.

2.64 U2G = ACL utilization-PAX-Outgoing (%)

2.65 U2C = ACL utilization-PAX-Incoming (%)

2.16 C2G.K = S2GT.K/U2G

2.17 C2C.K = S2CT.K/U2C

2.18 MX2.K = MAX (C2G.K, C2C.K)

2.19 TC2.K = 2 * MX2.K

C2G = Required capability-PAX-Outgoing (PAX-Miles/week)

C2C = Required capability-PAX-Incoming (PAX-Miles/week)

MX2 = Maximum demand (PAX-Miles/week)

TC2 = Total capability required - PAX (PAX-Miles/week)

In the case of PAX movement, it is assumed that commercial capability is bought to cover the majority of the demand with military capability being utilized for the balance.

The commercial buy is then determined by the following equation:

2.20 CB2.K = TC2.K * FCB

CB2 = Commercial Buy for PAX (PAX-Miles/week)

2.83 FCB = Portion of total requirement covered by Commercial.

FCB will be between zero and one and is assumed in the basic model to be 0.92. This then means 92% of the total PAX requirements are moved by commercial aircraft under contract with MAC.

Military requirements then are

2.09 MPR.K = TC2.K - CB2.K

MPR = Military Capability required (PAX-Miles/week)

The average demand for PAX movement and the rate of change in PAX movement is modeled by equations similar to those described for Cargo movement. They are shown below.

2.21 SD2G.K = SD2G.J + (DT/D219)(IS2G.JK - SD2G.J)

2.22 SD2C.K = SD2C.J + (DT/D220)(IS2C.JK - SD2C.J)

2.66 D219 = Delay in smoothing (weeks)

2.67 D220 = Delay in smoothing (weeks)

SD2G = Smoothed customer PAX requirements-Outgoing (PAX-Miles/week)

SD2C = Smoothed customer PAX requirements-Incoming (PAX-Miles/week)

2.23 R2G.KL = IS2G.JK

2.26 R2C.KL = IS2C.JK

2.24 RT2G.K = (1/DT)(IS2G.JK - R2G.JK)

2.10 RT2C.K = (1/DT)(IS2C.JK - R2C.JK)

2.25 SR2G.K = SR2G.J + (DT/SDP)(RT2G.J - SR2G.J)

2.11 SR2C.K = SR2C.J + (DT/SDP)(RT2C.J - SR2C.J)

2.84 SDP = Smoothing Delay (weeks)

R2G = Customer demand-Past time period-Outgoing (PAX-Miles/week)

R2C = Customer demand-Past time period-Incoming (PAX-Miles/week)

RT2G = Rate of Change-over previous time period-Outgoing (PAX-Miles/week/week)

RT2C = Rate of Change-over previous time period-Incoming (PAX-Miles/week/week)

SR2G = Smoothed Rate of Change over past SDP weeks-Outgoing (PAX-Miles/week/week)

SR2C = Smoothed Rate of Change over past SDP weeks-Incoming (PAX-Miles/week/week)

The above equations complete the modeling of customer demand for and the movement of PAX out of and into CONUS, with the commercial buy requirements generated by this movement and the military capability required for the balance.

A list of all variables identified in Figure 2 and their corresponding initial conditions and parameters is given in Appendix II.

<u>Figure 3</u>

Customer demand for and the movement of designated SAAM and Exercise requirements are modeled in Figure 3. This segment of the total model is similar to the Cargo and PAX segments of Figures 1 and 2. The equations are also similar and will utilize the numbers "3" and "4" to represent SAAM's and Exercises, respectively.

3.01 D3S = Customer demand for SAAM (Ton-Miles/week)

3.02 D4E = Customer demand for Exercises (Ton-Miles/week)

As before, the movement rate to MAC terminals is assumed to equate the customer demand, which is the exogenous variable.

Therefore,

3.05 IS3.KL = D3S.K

3.06 IS4.KL = D4E.K

IS3 = Incoming SAAM requirements (Ton-Miles/week)

IS4 = Incoming Exercise requirements (Ton-Miles/week)

The movement of SAAM and Exercise requirements is represented, in this case, by third order delay functions. This provides for more realistic simulation of the planning and lead time allowed in SAAM and Exercise movement.

3.07 IN3.K = IN3.J + DT(IS3.JK - S3S.JK)

3.09 S3S.KL = Delay3(IS3.JK, D34)

3.62 D34 = Delay in SAAM movement (weeks)

S3S = Shipment of SAAM Requirements (Ton-Miles/week)

IN3 = Inventory of Planned SAAM movement (Ton-Miles/week)

3.08 IN4.K = IN4.J + DT(IS4.JK - S4E.JK)

3.10 S4E.KL = Delay3(IS4.JK, D316)

3.63 D316 = Delay in Exercise movement (weeks)

IN4 = Inventory of Planned Exercise Movement (Ton-Miles)

S4E = Shipment of Exercise Requirements (Ton-Miles/week)

Both SAAM and Exercise requirements are smoothed for forecasting purposes in the model. The rate of change in the demand for SAAM and Exercise requirements is also determined.

3.64 D312 = Delay in smoothing SAAM (weeks)

3.65 D38 = Delay in smoothing Exercises (weeks)

3.11 SD3.K = SD3.J + (DT/D312)(IS3.JK - SD3.J)

3.12 SD4.K = SD4.J + (DT/D38)(IS4.JK - SD4.J)

SD3 = Smoothed demand for SAAM's (Ton-Miles/week)

SD4 = Smoothed demand for Exercises (Ton-Miles/week)

3.15 R3.KL = IS3.JK

3.16 R4.KL = IS4.JK

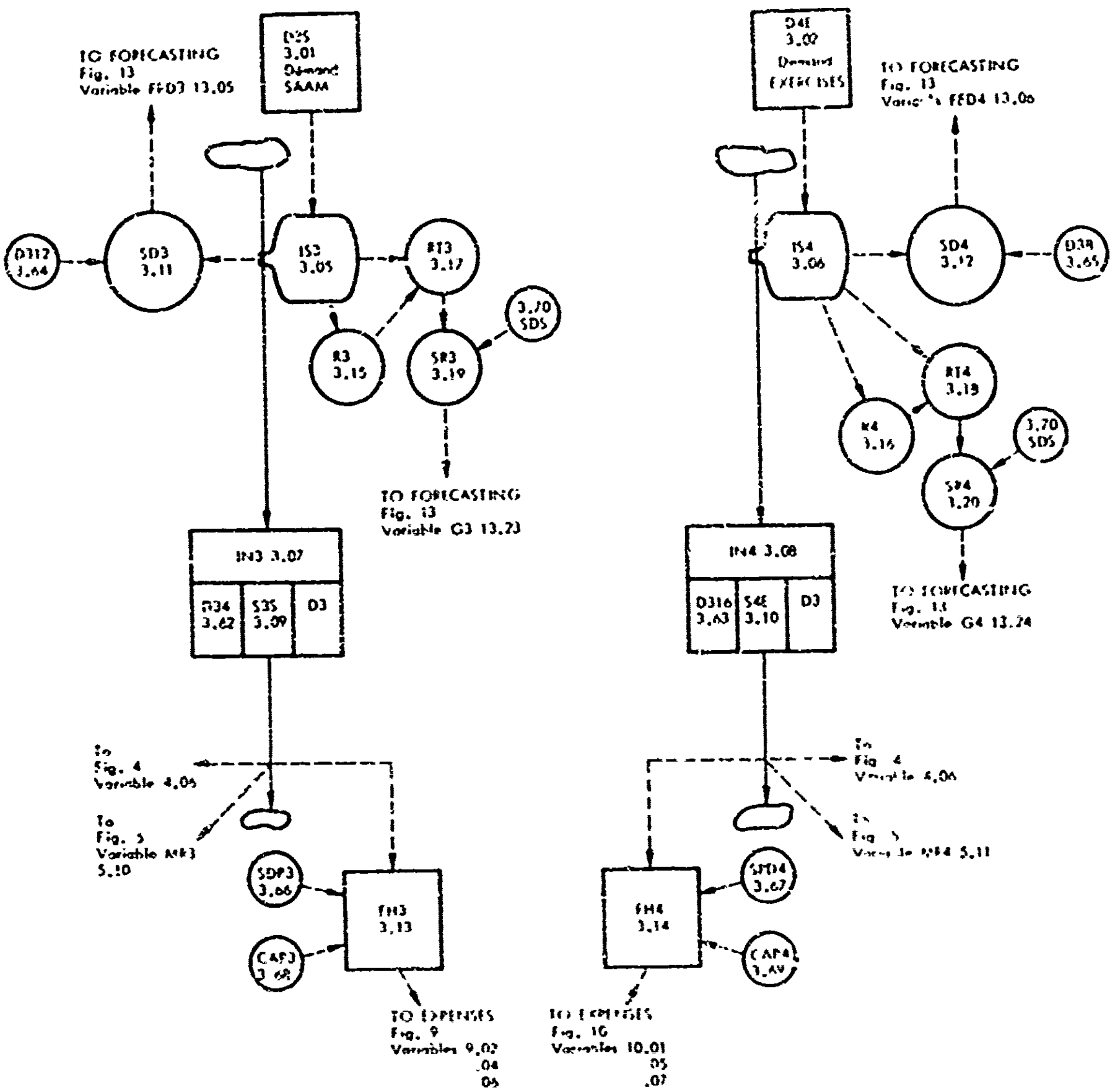

Figure 3. Model of SAAM and Exercise Movement

R3 = SAAM movement over previous time period (Ton-Miles/week)

R4 = Exercise movement over previous time period (Ton-Miles/week)

3.17 RT3.K = (1/DT)(IS3.JK - R3.JK)

3.18 RT4.K = (1/DT)(IS4.JK - R4.JK)

RT3 = Growth Rate in SAAM Demand over past DT (Ton-Miles/week/week)

RT4 = Growth Rate in Exercise Demand over past DT (Ton-Miles/week/week)

3.19 SR3.K = SR3.J + (DT/SDS)(RT3.J - SR3.J)

3.20 SR4.K = SR4.J + (DT/SDS)(RT4.J - SR4.J)

SR3 = Smoothed Rate of Growth over past SDS weeks (Ton-Miles/week/week)

SR4 = Smoothed Rate of Growth over past SDS weeks (Ton-Miles/week/week)

3.70 SDS = Smoothing Delay (weeks)

It is assumed that the movement of SAAM's and Exercise requirements is accomplished by military capability only. The military capability required for SAAM and Exercise movement is determined and allocated first with the remaining military capability utilized for Cargo and PAX movement. The modeling of this series of decisions is shown in Figure 4.

The SAAM and Exercise flying hours utilized in later expense calculations is modeled as a segment of Figure 3. The flying hours generated is determined by dividing the ton-miles flown by the speed of the aircraft and its capacity. Both SAAM and Exercises are billed on a total capacity basis.

$$\text{Flying hours} = \frac{\text{Material Moved (Ton-Miles)/Week}}{\text{Speed Capacity} \frac{\text{(Miles)}}{\text{(Hour)}} \text{(Tons)}}$$

The equations are therefore

3.66 SPD3 = Speed of Aircraft (MPH)

3.67 SPD4 = Speed of Aircraft (MPH)

3.68 CAP3 = Capacity of Aircraft (Tons)

3.69 CAP4 = Capacity of Aircraft (Tons)

3.13 FH3.K = S3S.JK/((SPD3)(CAP3))

3.14 FH4.K = S4E.JK/((SPD4)(CAP4))

FH3 = Flying hours rate for SAAM (Flying-hours/week)

FH4 = Flying hours rate for Exercise (Flying-hours/week)

This completes the modeling of customer demand for MAC services which are billed under the Industrial Fund. Figures 1, 2, and 3 represent these segments of the total model of the Industrial Fund.

A list of all variables identified in Figure 3 and their corresponding initial conditions and parameters is given in Appendix III.

Figure 4

We now turn to that segment of the model which represents the determination of total military capability and allocates it to PAX, Cargo, SAAM, and Exercise movement requirements. This is modeled in Figure 4 which also includes the determination of flying hours for PAX and Cargo movement. The flying hour information with that from Figure 3 is used as input in that segment of the model where ASIF expense rates are modeled.

For simplification purposes we assume that MAC flies only the C141. The total flying hours available per week is then calculated as follows:

4.01 TFHC.K = TAF.K * UTAF

TFHC = Total Flying Hours Capability (Flying-hours/week)

TAF = Total Air Frames Available

UTAF = Utilization of Air Frames (Flying-hours/week)

The total air frames available is an exogenous input and may be constant or varied over time. The equation for TAF is written as follows:

4.03 TAF.K = TAFI + AFI.K

TAFI = Initial Air Frames Available

AFI = Increased Air Frames put in service

AFI represents a variable which increases or decreases the number of air frames available if so desired by the analyst. Initially, we have provided for a growth of air frames available by the following equation.

4.02 AFI.K = RAMP(RMP, 5)

RMP = Rate of Growth of Air Frames (Air Frames/week)

The total flying hour capability is now converted to a ton-mile/week capability by multiplying it by speed and capacity factors.

4.04 TCAP.K = TFHC.K * SPD * CAP

$$\text{Ton-Miles/week} = \frac{\text{Flying hours}}{\text{Week}} * \frac{\text{Miles}}{\text{Hour}} * \text{Tons}$$

TCAP = Total Military Capability Available (Ton-Miles/week)

4.55 SPD = Speed of Aircraft (MPH)

4.56 CAP = Capability of Aircraft (Tons)

The first demand on military capability is for training and testing requirements (TRN).

Training and testing requirements are assumed to be constant unless the total commercial buy drops below a specified amount. When this occurs there is an increase in te- ing and training requirements until the commercial buy has been increased to the desired minimum level. This represents a system boundary condition for the model. MAC makes a commitment to use a specified minimum amount of commercial aircraft. As this minimum figure is approached, military usage is increased so as to require the need for the minimum contract figure.

Variables ER1C and ER2C represent the expense rate for the commercial buy for Cargo and PAX requirements in dollars/week. This expense rate is smoothed (averaged) over time periods DXC and DXP to yield variables SX1 and SX2. In the initial model the smoothing time period for DXC and DXP is 25 weeks.

The sum of SX1 and SX2 gives a smoothed average weekly commercial cost. This figure is now compared to the minimum average weekly commercial buy allowable (CEG) to determine whether training and testing requirements need to be increased.

The following equations represent this decision series.

4.15 SX1.K = SX1.J + (DT/DXC)(ER1C.JK - SX1.J)

4.16 SX2.K = S 2.J + (DT/DXP)(ER2C.JK - SX2.J)

SX1 = Smoothed commercial expense rate-Cargo (dollars/week)

SX2 = Smoothed commercial expense rate-PAX (dollars/week)

4.71 DXC = Delay in smoothing (weeks)

4.72 DXP = Delay in smoothing (weeks)

4.17 SXX.K = SX1.K + SX2.K

SXX = Smoothed Total Commercial Expense Rate ($/week)

4.18 RTO.K = SXX.K/CEG

RTO = Ratio Actual Expense to Minimum Allowed

4.69 CEG = Minimum Allowable Commercial Buy Rate ($/week)

It is assumed that if RTO is equal to or greater than 1 no increase is necessary for testing and training requirements (TRN). If RTO is less than 1, TRN will be increased by a multiplier MLT. For the purposes of the basic model

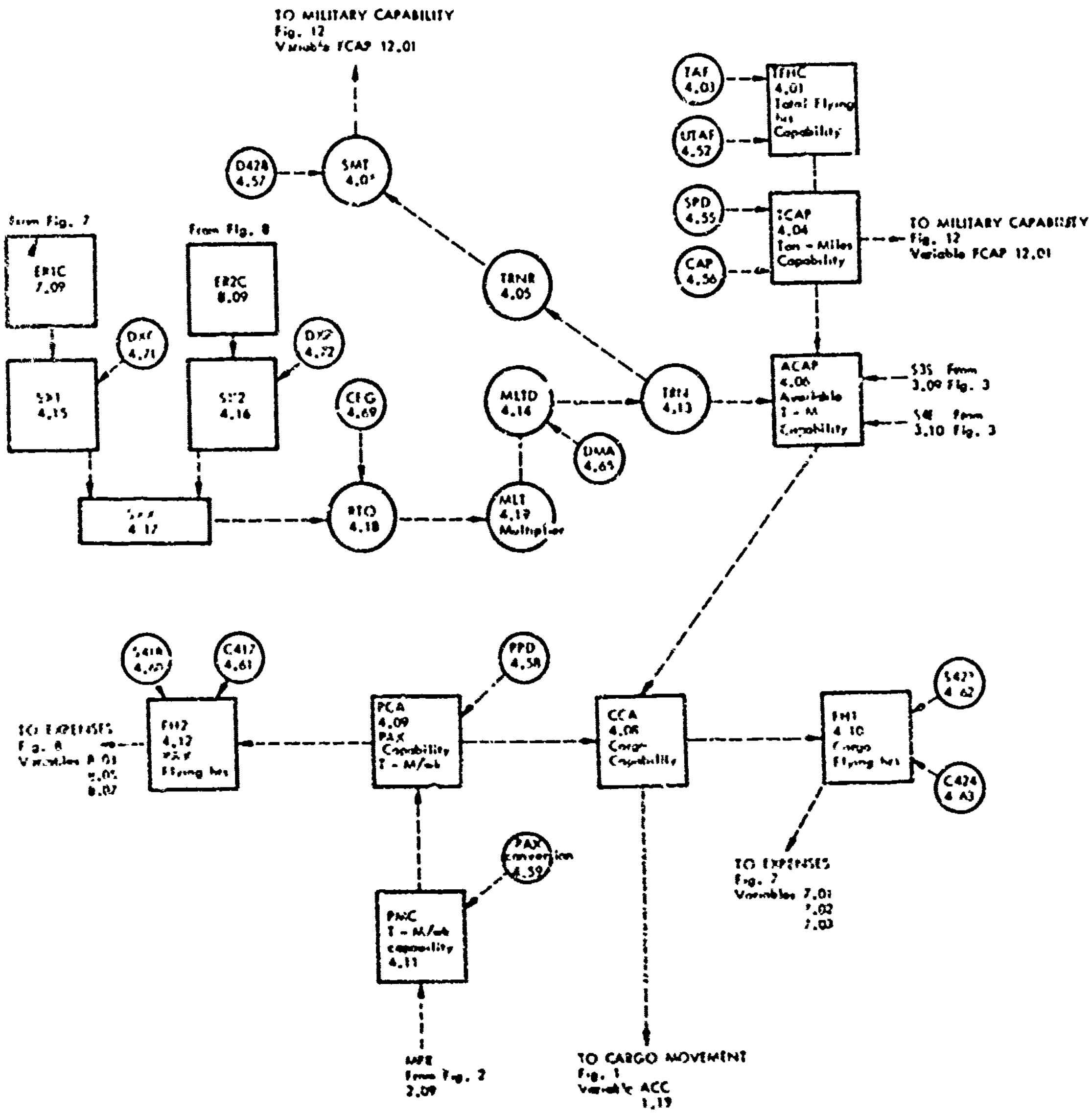

Figure 4. Mo:el of Military Capabiliŧy Allocation.

the following relationship between RTO and the multiplier MLT is assumed.

When RTO equals	1	or greater, MLT equals		1
" " "	0.9	MLT equals		1.1
" " "	0.8	"	"	1.3
" " "	0.7	"	"	1.5
" " "	0.6	"	"	1.6
" " "	0.5	"	"	1.8
" " "	0.4	"	"	2.0
" " "	0.3	"	"	2.3
" " "	0.2	"	"	2.5
" " "	0.1	"	"	3
" " "	0	"	"	5

It is also assumed that the actual decision to change testing and training requirements would be based on the average multiplier, so the multiplier is smoothed over a one-week interval.

4.14 $$MLTD.K = MLTD.J + (DT/DMA)(MLT.J - MLTD.J)$$

MLTD = Multiplier delayed

4.65 DMA = Delay (weeks)

The equation for TRN, testing and training, is now represented as follows:

4.13 $$TRN.K = TRNI * MLTD.K$$

TRN = Testing and Training Requirement (Ton-Miles/week)

TRNI = Initial TRN Requirements (Ton-Miles/week)

The actual training rate is then

4.05 $$TRNR.KL = TRN.K$$

TRNR = TRN Rate (Ton-Miles/week)

For forecasting purposes an averaged (smoothed) testing and training rate is calculated.

4.07 $$SMT.K = SMT.J + (DT/D428)(TRNR.JK - SMT.J)$$

SMT = Smoothed Testing and Training Requirements

4.57 D428 = Delay in Smoothing (weeks)

The actual military capability now available for moving Cargo and PAX requirements is the total capability (TCAP) less that capability allocated to SAAM (S3S), Exercise (S4E) and testing and training (TRN). This equation is written as follows:

4.66 $$ACAP.K = TCAP.K - S3S.JK - S4E.JK - TRN.K$$

ACAP = Available Military Capability (Ton-Miles/week)

This quantity is now reduced by the capability allocated to PAX movement, variable MPR of Figure 2. This variable dimensionally was PAX-Miles/week and must first be converted to an equivalent Ton-Miles/week. This is modeled as follows:

4.11 PMC.K = MPR.K * PAX

PMC = Military Capability Allocated to PAX (Ton-Miles/week)

4.59 PAX = Conversion Factor (Ton-Miles/PAX-Miles)

This capacity is now reduced further by a PAX positioning and depositioning factor (PPD).

4.0° PCA.K = PMC.K * PPD

PCA = Total Military Capability required for PAX (Ton-Miles/week)

The Military Capability available for Cargo movement is now

4.08 CCA.K = ACAP.K - PCA.K

CCA = Military Cargo Capability (Ton-Miles/week)

This variable, referenced earlier, is an input to Figure 1 to cover Cargo demand.

The MAC flying hours generated by PAX and Cargo movement are now calculated by converting Ton-Miles/week to flying hours by dividing by speed and capacity variables.

4.12 FH2.K = PCA.K/((S418)(C417))

4.10 FH1.K = CCA.K/((S423)(C424))

FH2 = Flying Hours-PAX - (Flying hours/week)

FH1 = Flying Hours-Cargo - (Flying hours/week)

4.60 S418 = Speed of Aircraft (MPH)

4.62 S423 = Speed of Aircraft (MPH)

4.61 C417 = Capacity of Aircraft (Tons)

4.63 C424 = Capacity of Aircraft (Tons)

This completes the identification of variables and equations for that segment of the model represented by Figure 4. This segment of the model has determined the military capability available and allocated it according to ASIF priorities to testing and training, SAAM, Exercise, PAX, and Cargo requirements.

A list of all variables identified in Figure 4 and their corresponding initial conditions and parameters is given in Appendix IV.

Figure 5

After a service has been provided by MAC, either moving cargo or passengers, the customer is then billed according to a tariff structure. Tariffs are calculated so as to provide income to the Industrial Fund sufficient to recover all Industrial Fund expenses. As noted earlier, the Industrial Fund is charged with "breaking even" over a two-year period.

In Figure 5 those variables which model the Industrial Fund manifesting and billing procedure are identified.

The Industrial Fund manifests covering cargo or passenger movement are initiated within the originating terminal at the time the material or passengers are shipped. The shipping rate for Cargo, PAX, SAAM, and Exercise as modeled in Figures 1, 2, and 3, is utilized to model the initiating of the flow of manifests from the terminal to the Numbered Air Force, and then to MAC Headquarters where customer billing takes place.

The processing of Industrial Fund manifests is assumed to be the same for Cargo, PAX, SAAM, and Exercise, so the modeling of each is similar. The Industrial Fund manifest rate is initiated by the shipment and is therefore equal to the shipping rate.

5.16 MR1.KL = S1GT.K + S1CT.K

MR1 = Manifest rate-Cargo (Ton-Miles/week)

The terminal processes these manifests and sends them on to the Numbered Air Force.

5.01 TP1.KL = DELAY 3(MR1.JK, D513)

5.50 D513 = Delay in processing (weeks)

TP1 = Terminal processing rate-Cargo (Ton-Miles/week)

The Numbered Air Force, after processing, forwards the manifest on to MAC Headquarters for billing.

5.02 FP1.KL = DELAY 3(TP1. K, D516)

5.51 D516 = Delay in processing (weeks)

FP1 = Air Force processing rate-Cargo (Ton-Miles/week)

At MAC Headquarters the customer billing is performed based on manifests received from the Numbered Air Force.

5.03 MP1.KL = DELAY 3(FP1.JK, D519)

5.52 D519 = Delay in processing (weeks)

MP1 = MAC billing rate-Cargo (Ton-Miles/week)

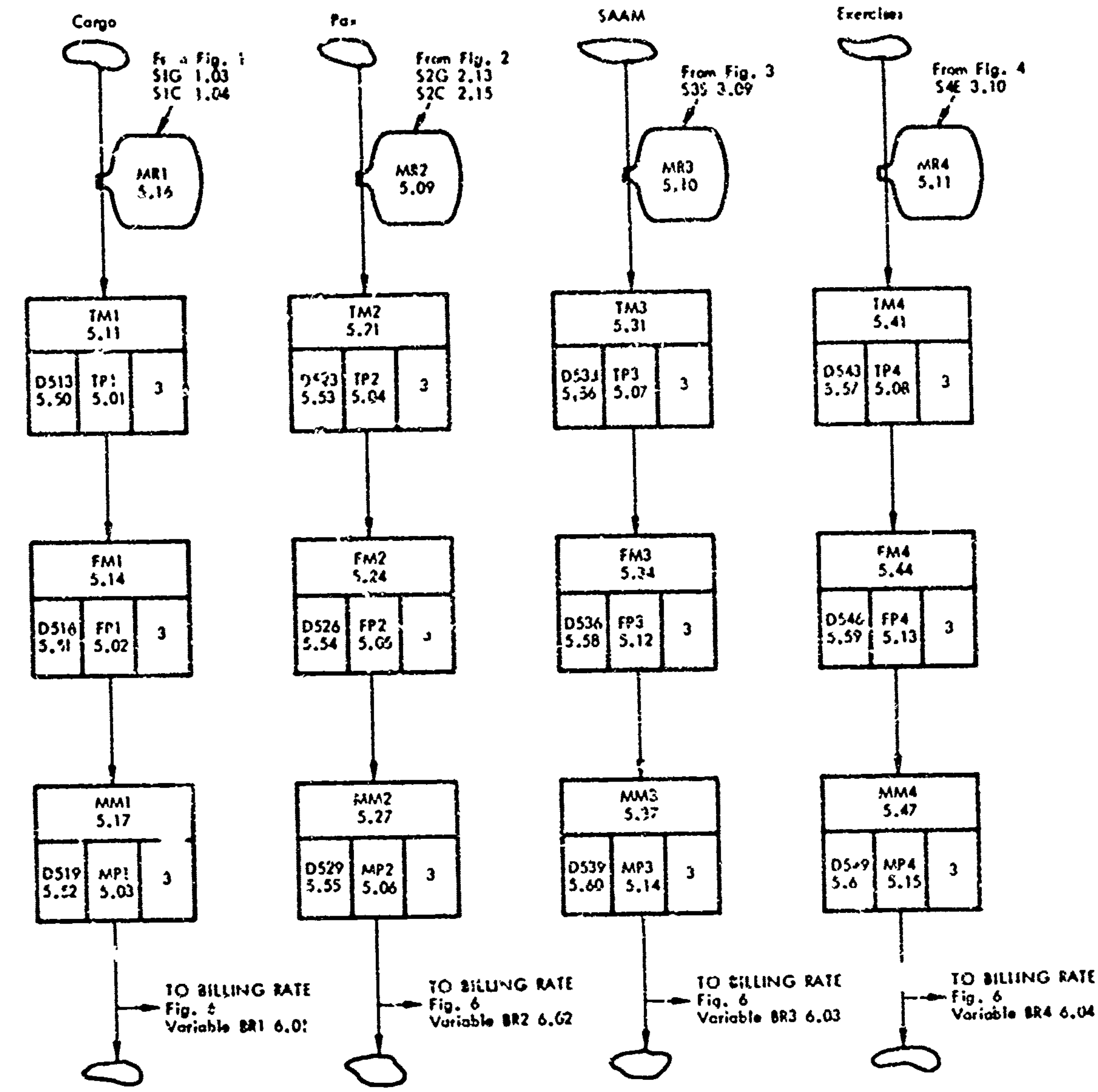

Figure 5. Model of Manifesting of Shipments

In each case it is assumed that a third order delay will replicate the relationship between work input rate ai ɹ the dispersion of the work output rate.

The variables identified above and their equations represent the modeling of the Industrial Fund processing of Cargo manifests. The processing of PAX, SAAM, and Exercise manifests follow the same procedure and have been modeled in a similar manner. The resulting equations are as follows:

5.09 MR2.KL = S2GT.K + S2CT.K

MR2 = Manifest rate-PAX (PAX-Miles/week)

5.04 TP2.KL = DELAY 3(MR2.JK, D523)

5.53 D523 = Delay in processing (weeks)

TP2 = Terminal processing rate-PAX (PAX-Miles/week)

5.05 FP2.KL = DELAY 3(TP2.JK, D526)

5.54 D526 = Delay in processing (weeks)

FP2 = Air Force manifest processing rate-PAX (PAX-Miles/week)

5.06 MP2.KL = DELAY 3(FP2.JK. D529)

5.55 D529 = Delay in processing (weeks)

MP2 = MAC billing rate-PAX (PAX-Miles/week)

5.10 MR3.KL = DELAY 3(IS3.JK, D34) *

MR3 = Manifest rate-SAAM (Ton-Miles/week)

5.11 MR4.KL = DELAY 3(IS4.JK, D316) *

MR4 = Manifest rate-Exercise (Ton-Miles/week)

* (The manifest rate for SAAM and Exercise is also equal to the shipping rate for each service. See Figure 3 for equations for S3S and S4E.)

5.07 TP3.KL = DELAY 3(MR3.JK, D533)

5.08 TP4.KL = DELAY 3(MR4.JK, D543)

5.56 D523 = Delay in processing (weeks)

5.57 D543 = Delay in processing (weeks)

TP3 = Terminal processing rate-SAAM (Ton-Miles/week)

TP4 = Terminal processing rate-Exercise (Ton-Miles/week)

5.12 FP3.KL = DELAY 3(TP3.JK, D536)

5.13 FP4.KL = DELAY 3(TP4.JK, D546)

5.58 D536 = Delay in processing (weeks)

5.59 D546 = Delay in processing (weeks)

FP3 = Air Force processing rate-SAAM (Ton-Miles/week)

FP4 = Air Force processing rate-Exercise (Ton-Miles/week)

5.14 MP3.KL = DELAY 3(FP3.JK, D539)

5.15 MP4.KL = DELAY 3(FP4.JK, D549)

5.60 D539 = Delay in processing (weeks)

5.61 D549 = Delay in processing (weeks)

MP3 = MAC billing rate-SAAM (Ton-Miles/week)

MP4 = MAC billing rate-Exercise (Ton-Miles/week)

This completes the identification of those level and rate equations which represent the processing of Industrial Fund manifests after the customer's demand for Cargo, PAX, SAAM, or Exercise movement has been completed.

A list of all variables identified in Figure 5 and their corresponding initial conditions and parameters is given in Appendix V.

Figure 6

The final processing of the Industrial Fund manifest results in the customer billing. This is influenced by the tariffs for Cargo, PAX, SAAM, and Exercise movement. The customer billing results in an accounts receivable variable until the customer's payment is received. When payment is received, the Accounts Receivable variable is reduced and cash on hand is increased. The Industrial Fund also pays all expenses which have been generated in providing the MAC service.

In Figure 6 we have modeled this segment of the system. We identify and model the billing function as well as cash flow.

The billing rates from Figure 5 (MP1, MP2, MP3, and MP4) represented the completion of Industrial Fund manifests and were in Ton-Miles/week or PAX-Miles/week. Information from these variables with information about the tariff structure now enables us to determine the billing rates in $/week.

The equations for determining the tariff variables will be described later. At the present time we identify them as follows:

11.69 TRF1 = Cargo Tariff ($/Ton-mile)

11.70 TRF2 = PAX Tariff ($/PAX-mile)

11.71 TRF3 = SAAM and Exercise Tariff ($/Ton-mile)

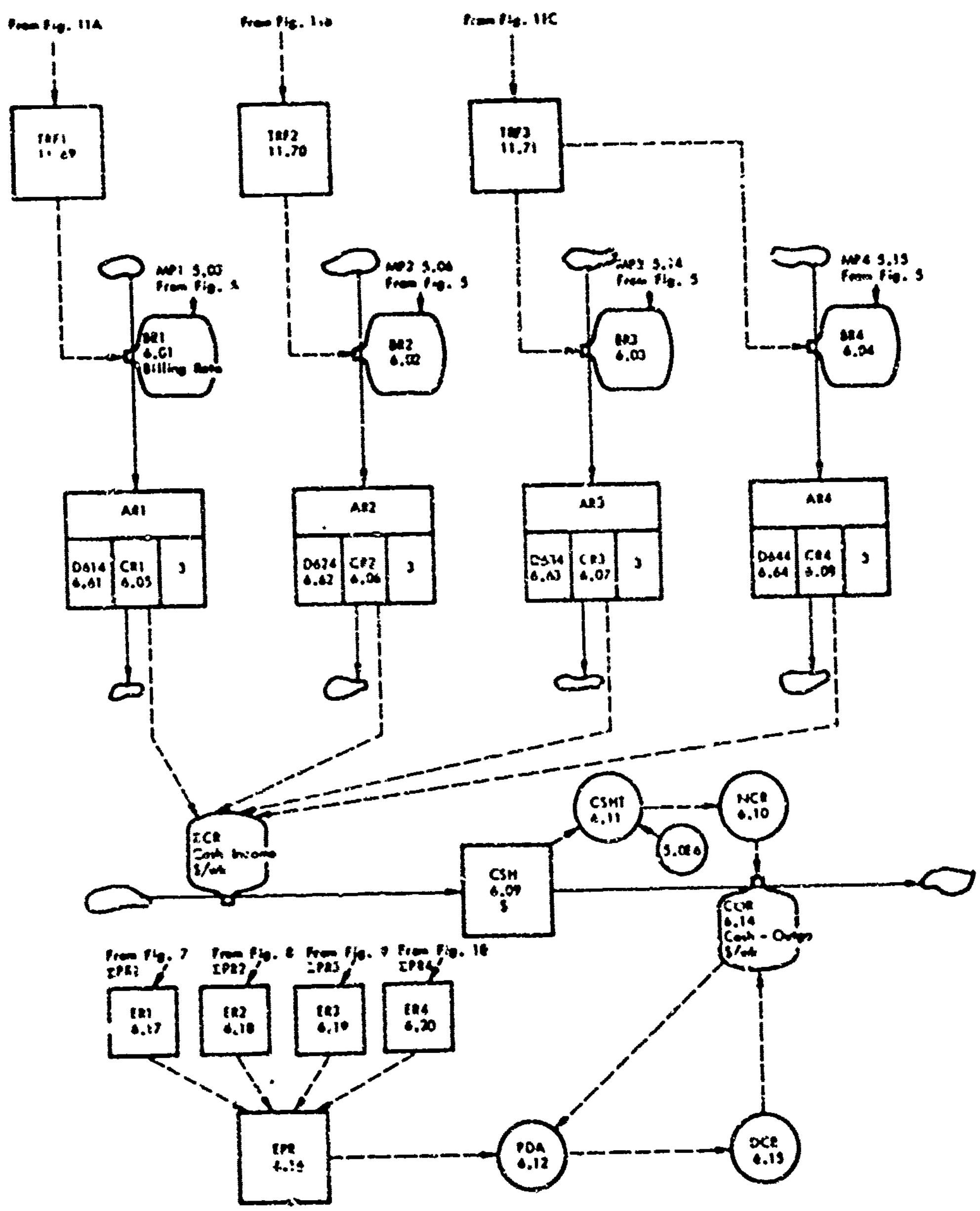

Figure 6. Model of Customer Billing and ASIF Cash Flow.

The customer billing rates in dollars/week are now identified by the following variables and their corresponding rate equations:

6.01 BR1.KL = (TRF1.K)(MP1.JK)

6.02 BR2.KL = (TRF2.K)(MP2.JK)

6.03 BR3.KL = (TRF3.K)(MP3.JK)

6.04 BR4.KL = (TRF4.K)(MP4.JK)

Variables AR1, AR2, AR3 and AR4 represent MAC Accounts Receivables. Rate equations 6.05, 6.06, 6.07 and 6.08 represent the customer's payment rates or cash receipt rate. A third order delay equation is assumed to represent the delay between customer billing and receipt of customer payment. Equations for the accounts receivable variables are not required.

AR1 = Accounts Receivable-Cargo ($)

AR2 = Accounts Receivable-PAX ($)

AR3 = Accounts Receivable-SAAM ($)

AR4 = Accounts Receivable-Exercise ($)

6.05 CR1.KL = DELAY 3(BR1.JK, D614)

6.61 D614 = Delay in payment (weeks)

6.06 CR2.KL = DELAY 3(BR2.JK, D624)

6.07 CR3.KL = DELAY 3(BR3.JK, D634)

6.08 CR4.KL = DELAY 3(BR4.JK, D644)

6.62 D624 = Delay in payment (weeks)

6.63 D634 = Delay in payment (weeks)

6.64 D644 = Delay in payment (weeks)

CR1 = Cash Receipt rate-Cargo ($/week)

CR2 = Cash Receipt rate-PAX ($/week)

CR3 = Cash Receipt rate-SAAM ($/week)

CR4 = Cash Receipt rate-Exercise ($/week)

The Cash Income Rate (CIR = $/week) is the sum of variables 6.05, 6.06, 6.07, and 6.08 and the level of cash is then

6.09 CSH.K = CSH.J + DT(CR1.JK + CR2.JK + CR3.JK + CR4.JK - COR.JK)

CSH = Cash ($)

Equation 6.10 is a control device. The ASIF specifies that cash on hand should never go below $5,000,000. The cash outgo rate can then never be such to reduce cash below this level. This boundary condition is modeled by the following equations.

6.11 CSHT.K = (CSH.K - 5.0E6)

6.10 NCR.KL = (CSHT.K)/DT

CSHT = Cash available to pay accounts ($)

NCR = Negative Cash Rate ($/week)

If there is sufficient cash available, it is assumed that the past due account will be paid in full. If it is not, then the past due account is increased by unpaid accounts and payment tried the next time period.

The past due account at any time then will be a function of the previous past due account plus the sum of all expenses due for payment and less all expenses paid.

6.12 PDA.K = PDA.J + DT(EPR.J - COR.JK)

PDA = Past Due Account ($)

EPR = Expense Payment Rate ($/week)

COR = Cash Outgo Rate ($/week)

The desired cash payment rate is then

6.15 DCR.K = PDA.K/DT

DCR = Desired Cash Payment rate ($/week)

The equation for Cash Outgo Rate (COR) is now the smaller of variables DCR.K and NCR.K.

6.14 COR.KL = MIN(DCR.K, NCR.JK)

The Expense Payment Rate (EPR) will be described after developing the equations and variables identifying the Industrial Fund expense rates, for it is the sum of all expense rates from Figures 7, 8, 9, & 10. (See pg. 39 of this report.)

A list of all variables identified in Figure 6 and their corresponding initial conditions and parameters is given in Appendix VI.

Figure 7

The modeling of that segment of the Industrial Fund system which represents the accounting for expenses and their payment was a difficult assignment. A number of simplifying assumptions have been made with the hope that the significant and dynamic aspects of the real system have not been disturbed.

Expenses are generated by the movement of Cargo, PAX, SAAM, and Exercise. All expenses are identified according to the demand classification and then are further segregated as being an Administrative, Base level, Depot, POL, or Commercial expense. (SAAM and Exercise do not generate commercial expense.)

Expenses are assumed to be a function of the number of flying hours generated and some constant charge each week. This function varies between Cargo, PAX, SAAM, and Exercise and between Administration, Base level, Depot and POL categories.

Figure 7 represents the model for Cargo expenses by expense category. The variables and variable equations for Cargo shipments will first be explained and PAX, SAAM, and Exercise variables and equations will be similar.

We have assumed that the expense rate is a function of a fixed cost and a variable cost which is a function of the flying hours generated. These expense rates generate the accounts payable account which is reduced by an expense payment rate. The expense payment rates are inputs which influence the past due account described and modeled in Figure 6. It has been assumed that the expense payment rates can be represented by 3rd order delay functions.

The accounts payable variable for each expense category is identified in Figure 7 in the following manner.

EP1A = Accounts Payable-Cargo-Administration ($)

EP1B = Accounts Payable-Cargo-Base level ($)

EP1D = Accounts Payable-Cargo-Depot ($)

EP1P = Accounts Payable-Cargo-POL ($)

EP1C = Accounts Payable-Cargo-Commercial ($)

Administrative expenses are assumed to be a fixed cost each week. This cost is an exogenous input.

7.50 E710 = Expense rate ($/week)

The expense rate is then

7.04 ER1A.KL = (E710)

7.05 PR1A.KL = DELAY 3(ER1A.JK, D713)

7.59 D713 = Delay in payment (weeks)

ER1A = Expense rate-Cargo-Administration ($/week)

PR1A = Payment rate-Cargo-Administration ($/week)

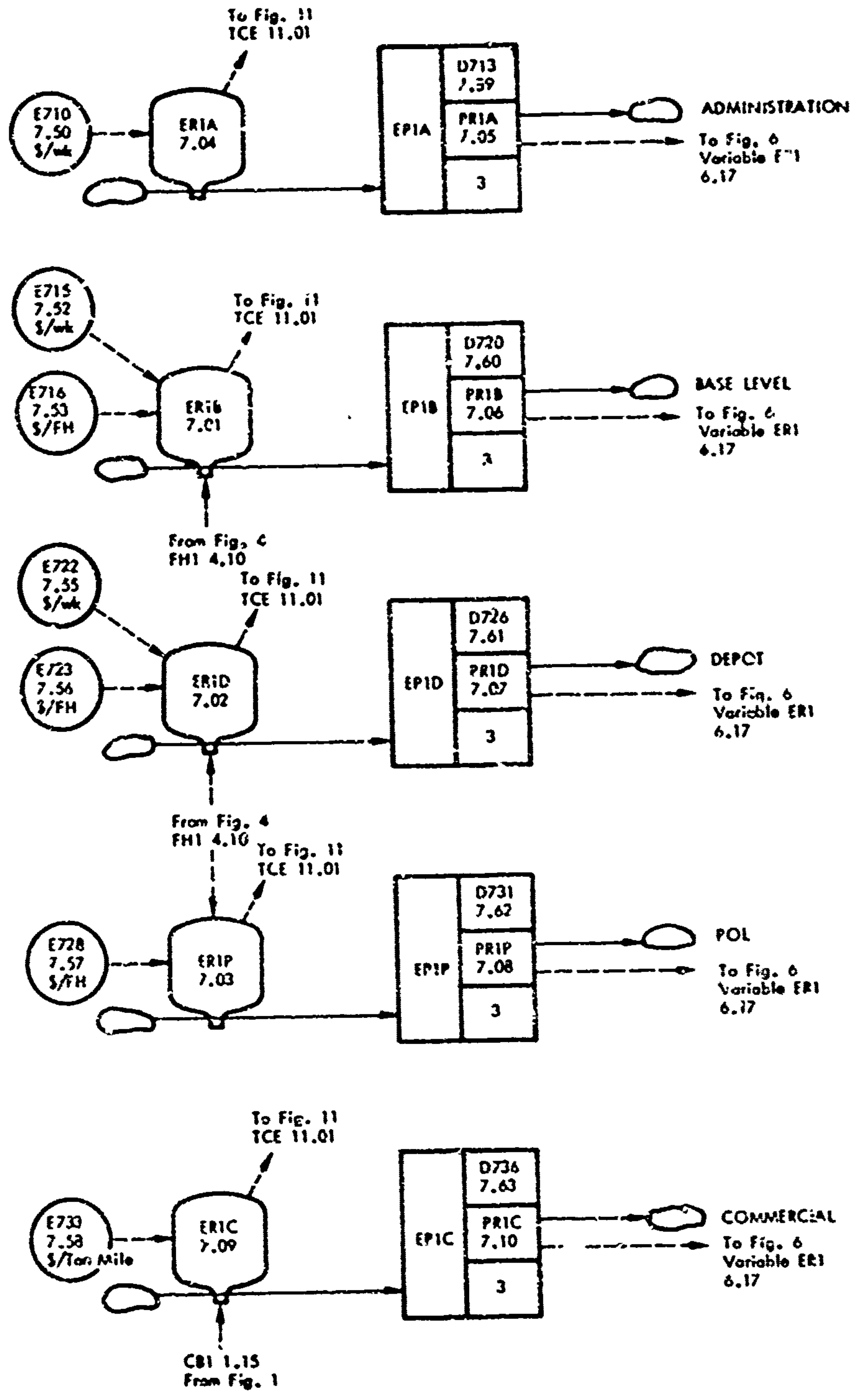

Figure 7. Model of Cargo Expenses

The base level expenses are a function of a fixed cost per week and the number of flying hours flown.

7.52 E715 = Expense rate ($/week)

7.53 E716 = Expense rate ($/flying hour)

The flying hours are obtained from that segment of the model described in Figure 4, equation 4.10.

7.01 ER1B.KL = (E715) + (E716)(FH1.K)

ER1B = Expense rate-Cargo-Base level ($/week)

7.06 PR1B.KL = DELAY 3(ER1B.JK, D720)

7.60 D720 = Delay in payment (weeks)

PR1B = Payment rate-Cargo-Base level ($/week)

Depot expenses are determined in a similar manner.

7.55 E722 = Expense rate ($/week)

7.56 E723 = Expense rate ($/flying hour)

7.02 ER1D.KL = (E722) + (E723)(FH1.K)

7.07 PR1D.KL = DELAY 3(ER1D.JK, D726)

7.61 D726 = Delay in payment (weeks)

ER1D = Expense rate-Cargo-Depot ($/week)

PR1D = Payment rate-Cargo-Depot ($/week)

The POL expenses are assumed to be influenced by only the number of flying hours generated.

7.57 E728 = Expense rate ($/flying hours)

7.03 ER1P.KL = (E728)(FH1.K)

7.08 PR1P.KL = DELAY 3(ER1P.JK, D731)

7.62 D731 = Delay in payment (weeks)

ER1P = Expense rate-Cargo-POL ($/week)

PR1P = Payment Rate-Cargo-POL ($/week)

The commercial expense is assumed to be based on the ton-miles moved by commercial contract.

7.58 E733 = Expense rate ($/ton-miles)

7.09 (ER1C.KL) = (E733)(CB1.JK)

7.10 PR1C.KL = DELAY 3(ER1C.JK, D736)

7.63 D736 = Delay in payment (weeks)

ER1C = Expense rate-Cargo-Commercial ($/week)

PR1C = Payment rate-Cargo-Commercial ($/week)

This completes the identification of those variables and their equations which represent that segment of the model covering expenses generated within the Industrial Fund when moving cargo for its customers. The equations for modeling expenses associated with the movement of PAX, SAAM and Exercise will be similar.

A list of all variables identified in Figure 7 and their corresponding initial conditions and parameters is given in Appendix VII.

Figure 8

Figure 8 shows those variables which represent that segment of the model representing the expenses associated with PAX movement. The equations are the same as for cargo movement (Figure 7) with the exception of the numeral 2, to represent PAX, in place of the numeral 1, which represented Cargo.

The accounts payable variables are

EP2A = Accounts Payable-PAX-Administration ($)

EP2B = Accounts Payable-PAX-Base level ($)

EP2D = Accounts Payable-PAX-Depot ($)

EP2P = Accounts Payable-PAX-POL ($)

EP2C = Accounts Payable-PAX-Commercial ($)

8.50 E810 = Expense rate ($/week)

8.51 E815 = Expense rate ($/week)

8.52 E816 = Expense rate ($/flying hour)

8.54 E822 = Expense rate ($/week)

8.55 E823 = Expense rate ($/flying hour)

8.56 E828 = Expense rate ($/flying hour)

8.57 E833 = Expense rate ($/PAX-miles)

8.01 ER2A.KL = (E810)

8.02 PR2A.KL = DELAY 3(ER2A.JK, D813)

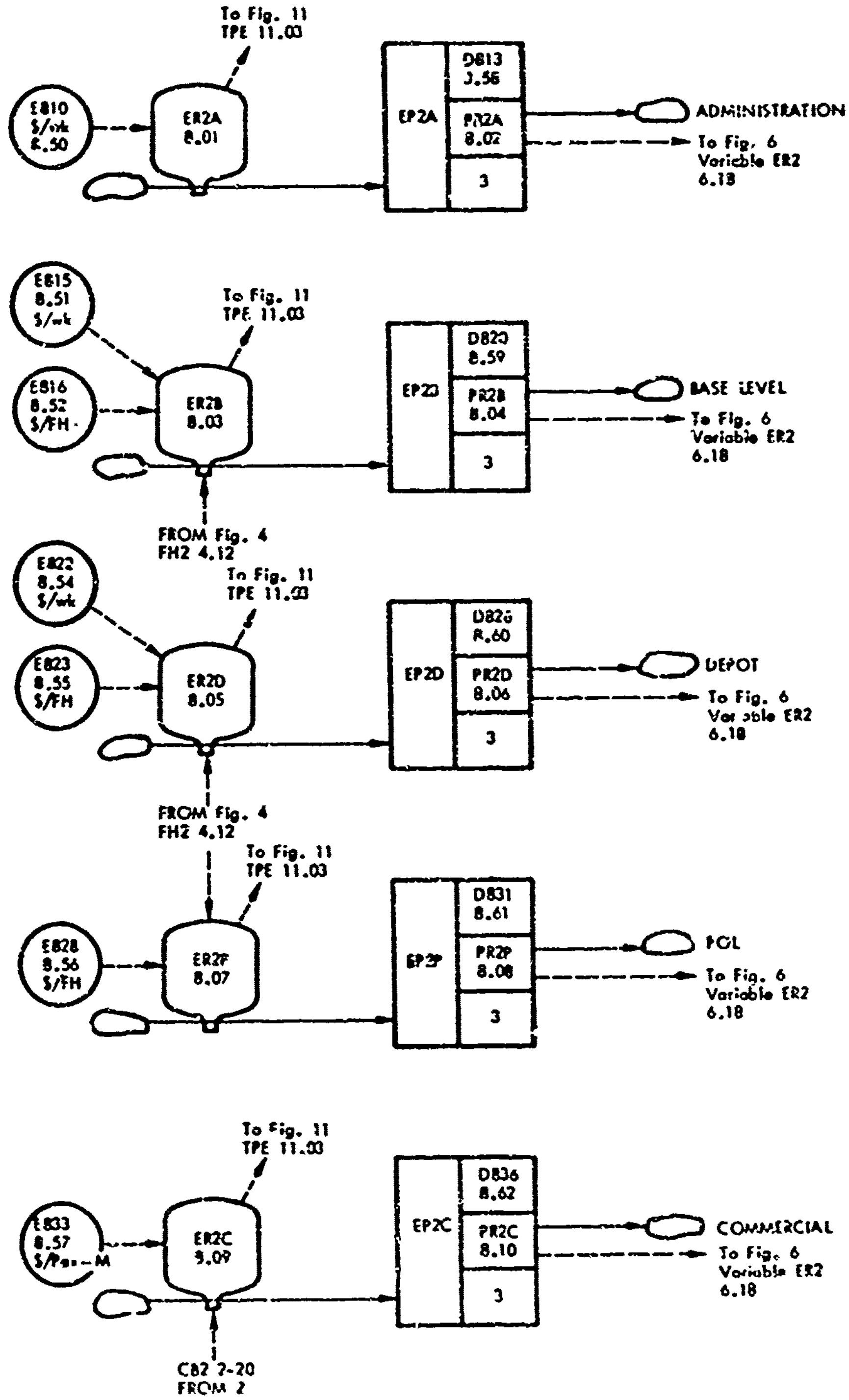

Figure 8. Model of PAX Expenses

Flying hours for PAX movement are obtained from variable 4.12 in Figure 4.

8.03 ER2B.KL = (E815) + (E816)(FH2.K)

8.04 PR2B.KL = DELAY 3(ER2B.JK, D820)

8.05 ER2D.KL = (E822) + (E823)(FH2.K)

8.06 PR2D.KL = DELAY 3(ER2D.JK, D826)

8.07 ER2P.KL = (E828)(FH2.K)

8.08 PR2P.KL = DELAY 3(ER2P.JK, D831)

The commercial buy in PAX-miles is represented by variable 2.20.

8.09 ER2C.KL = (E833)(CB2.K)

8.10 PR2C.KL = DELAY 3(ER2C.JK, D836)

8.58 D813 = Delay in payment (weeks)

8.59 D820 = Delay in payment (weeks)

8.60 D826 = Delay in payment (weeks)

8.61 D831 = Delay in payment (weeks)

8.62 D836 = Delay in payment (weeks)

A list of all variables identified in Figure 8 and their corresponding initial conditions and parameters is given in Appendix VIII.

Figure 9

Figure 9 identifies the variables representing the generation of Industrial Fund expenses associated with the movement of SAAM.

The variable equations differ from Cargo and PAX variables only by using the number 3 in the equations to represent SAAM.

The accounts payable variables are

EP3A = Accounts Payable-SAAM-Administration ($)

EP3B = Accounts Payable-SAAM-Base level ($)

EP3D = Accounts Payable-SAAM-Depot ($)

EP3P = Accounts Payable-SAAM-POL ($)

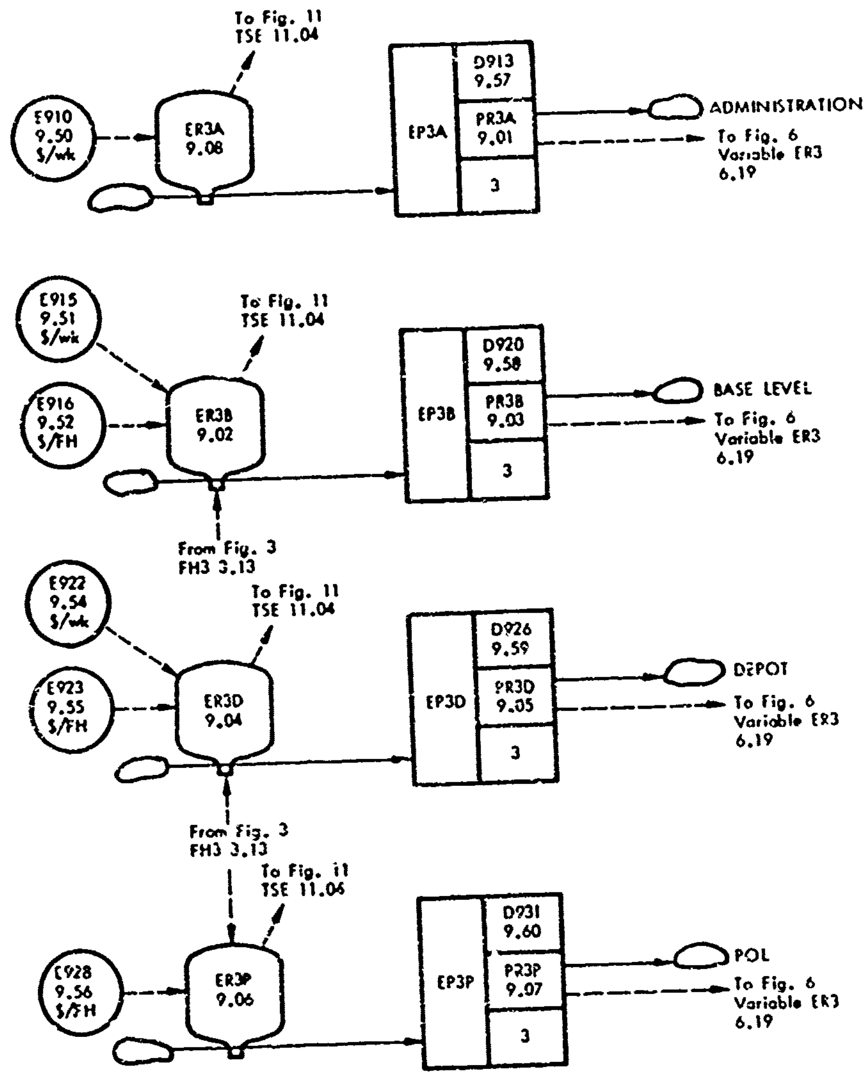

Figure 9. Model of SAAM Expenses

9.50 E910 = Expense rate-SAAM ($/weeks)

9.51 E915 = Expense rate-SAAM ($/weeks)

9.52 E916 = Expense rate-SAAM ($/flying hour)

9.54 E922 = Expense rate-SAAM ($/weeks)

9.55 E923 = Expense rate-SAAM ($/flying hour)

9.56 E928 = Expense rate-SAAM ($/flying hour)

9.57 D913 = Delay in payment (weeks)

9.58 D920 = Delay in payment (weeks)

9.59 D926 = Delay in payment (weeks)

9.60 D931 = Delay in payment (weeks)

9.08 ER3A.KL = (E910)

9.01 PR3A.KL = DELAY 3(ER3A.JK, D913)

Flying hours are obtained from variable 3.13 in Figure 3.

9.02 ER3B.KL = (E915) + (E916)(FH3.K)

9.03 PR3B.KL = DELAY 3(ER3B.JK, D920)

9.04 ER3D.KL = (E922) + (E923)(FH3.K)

9.05 PR3D.KL = DELAY 3(ER3D.JK, D926)

9.06 ER3P.KL = (E928)(FH3.K)

9.07 PR3P.KL = DELAY 3(ER3P.JK, D931)

A list of all variables identified in Figure 9 and their corresponding initial conditions and parameters is given in Appendix IX.

Figure 10

In the same manner, Figure 10 models those variables representing the generation of expenses associated with the movement of Exercises. The number 4 in the equations denotes an "Exercise" movement.

The accounts payable variables are

EP4A = Accounts Payable-Exercises-Administration ($)

EP4B = Accounts Payable-Exercises-Base level ($)

EP4D = Accounts Payable-Exercises-Depot ($)

EP4P = Accounts Payable-Exercises-POL ($)

10.50 ET10 = Expense rate ($/week)

10.51 ET15 = Expense rate ($/week)

10.52 ET16 = Expense rate ($/flying hour)

10.54 ET22 = Expense rate ($/week)

10.55 ET23 = Expense rate ($/flying hour)

10.56 ET28 = Expense rate ($/flying hour)

10.57 ET13 = Delay in payment (weeks)

10.58 ET20 = Delay in payment (weeks)

10.59 ET26 = Delay in payment (weeks)

10.60 ET31 = Delay in payment (weeks)

10.02 ER4A.KL = (ET10)

Flying hours are obtained from variable 3.14 in Figure 3.

10.03 PR4A.KL = DELAY 3(ER4A.JK, DT13)

10.01 ER4B.KL = (ET15) + (ET16)(FH4.K)

10.04 PR4B.KL = DELAY 3(ER4B.JK, DT20)

10.05 ER4D.KL = (ET22) + (ET23)(FH4.K)

10.06 PR4D.KL = DELAY 3(ER4D.JK, DT26)

10.07 ER4P.KL = (ET28)(FH4.K)

10.08 PR4P.KL = DELAY 3(ER4P.JK, DT31)

Earlier the variable EPR (6.16) was identified as the expense payment rate and equal to the summation of all expense rates from Figures 7, 8, 9, and 10.

Having now identified these variables, the expense payment rate (EPR) for Cargo, PAX, SAAM, and Exercise, identified in Figure 6, can now be expressed.

The Cargo expense payment rate (ER1) is the sum of the expense payment rates for Administration, Base level, Depot, POL, and commercial categories.

6.17 ER1.K = PR1A.JK + PR1B.JK + PR1D.JK + PR1P.JK + PR1C.JK

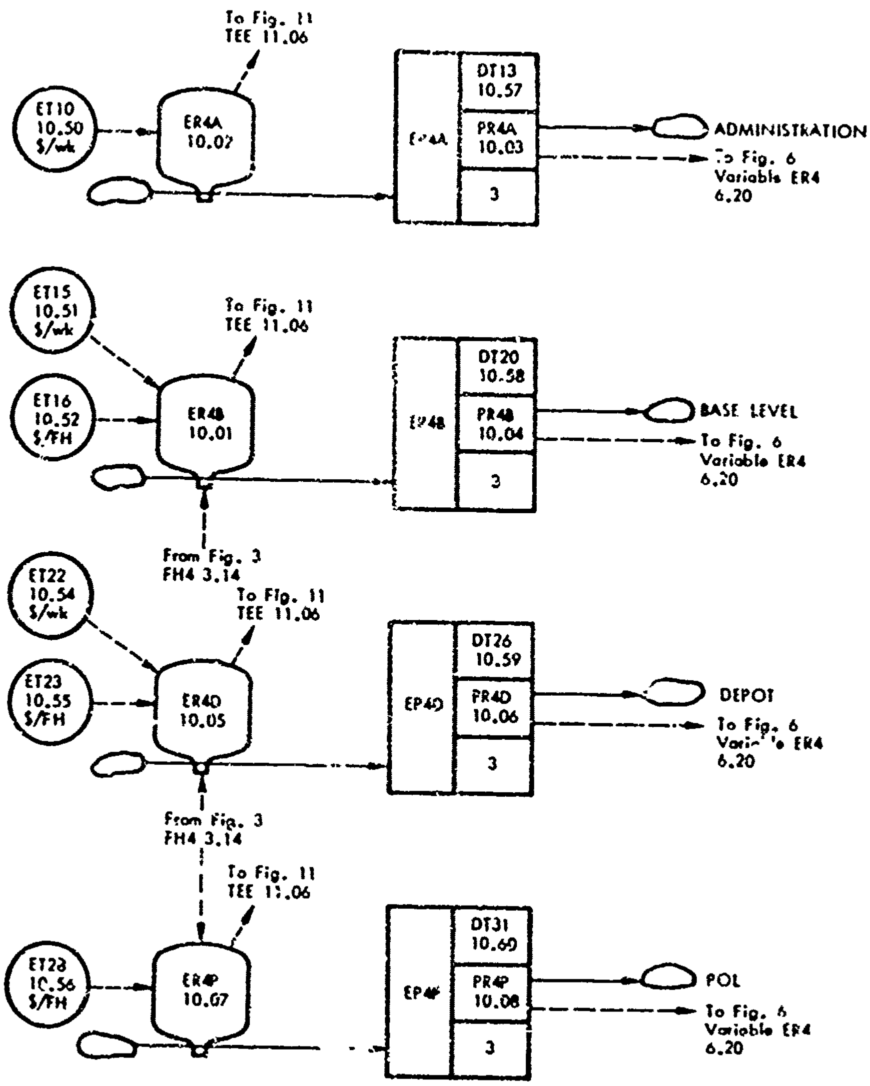

Figure 10. Model of Exercise Expenses

In the same manner

6.18 ER2.K = PR2A.JK + PR2B.JK + PR2D.JK + PR2P.JK + PR2C.JK

6.19 ER3.K = PR3A.JK + PR3B.JK + PR3D.JK + PR3P.JK

6.20 ER4.K = PR4A.JK + PR4B.JK + PR4D.JK + PR4P.JK

ER1 = Cargo expense payment rate ($/week)

ER2 = PAX expense payment rate ($/week)

ER3 = SAAM expense payment rate ($/week)

ER4 = Exercise expense payment rate ($/week)

The expense payment rate for the Industrial Fund is then the sum of the above expense payment rates.

6.16 EPR.K = ER1.K + ER2.K + ER3.K + ER4.K

A list of all variables identified in Figure 10 and their corresponding initial conditions and parameters is given in Appendix X.

Figure 11

The Industrial Fund is charged with recovering ASIF expenses without generating revenue in excess of expenses. While it is impossible and impractical to maintain revenues equal to expenses over short run time periods, the ASIF attempts to balance out total expenses and total revenue at the end of a specified time period. At the present this time period is two years.

In Figure 11 the tariff change decision is modeled. This decision is influenced by many factors and its modeling was difficult to achieve. As presently conceptualized and modeled, it is assumed that the decision to change the tariff is influenced by information from three sources.

First, it is assumed that the tariff will not be changed unless the difference between total revenues and total expenses is greater than some specified amount.

Second, it is assumed that the tariff will not be revised too frequently. That is, the tariff may not be revised oftener than every 3 months or every 6 months. This time period is modeled as a variable so the impact of different time periods may be studied.

Third, it is assumed that the tariff will not be changed unless the amount of change in tariff is greater than some minimum standard. That is, a 1% change in tariff may be deemed too small a change and delayed until it exceeds 2% or some larger figure.

The modeling of the tariff change decision function requires first a recording of total revenue and total expenses from time period 0. This information is derived from the billing function of Figure 6 and the expense rate functions in Figures 7, 8, 9 and 10.

We determine first the total expenses generated for each classification of movement.

11.01 TCE.K = TCE.J + DT(ER1A.JK + ER1B.JK + ER1D.JK + ER1P.JK + ER1C.JK)

TCE = Total Cargo Expenses ($)

11.03 TPE.K = TPE.J + DT(ER2A.JK + ER2B.JK + ER2D.JK + ER2P.JK + ER2C.JK)

TPE = Total PAX Expenses ($)

11.04 TSE.K = TSE.J + DT(ER3A.JK + ER3B.JK + ER3D.JK + ER3P.JK)

11.06 TEE.K = TEE.J + DT(ER4A.JK + ER4B.JK + ER4D.JK + ER4P.JK)

TSE = Total SAAM Expenses ($)

TEE = Total Exercise Expenses ($)

The expense rates in the above equations are variables from Figures 7, 8, 9, and 10 as previously defined.

11.05 TE.K = TCE.K + TPE.K + TEE.K + TSE.K

TE = Total Expenses = All ASIF ($)

Total Income is derived from the same variables used to determine the billing rate.

For modeling purposes we wish to determine the level of income generated by the movement of material and passengers. We therefore utilize information on the manifest rate at the terminals to determine Industrial Fund income.

11.14 MI1.K = (MR1.JK)(TRF1.K)

11.15 MI2.K = (MR2.JK)(TRF2.K)

11.16 MI3.K = (MR3.JK)(TRF3.K)

11.17 MI4.K = (MR4.JK)(TRF4.K)

MI1 = Cargo Income Manifested ($/week)

MI2 = PAX Income Manifested ($/week)

MI3 = SAAM Income Manifested ($/week)

MI4 = Exercise Income Manifested ($/week)

The total income potential is then influenced by the above rates over time.

11.08 TI.K = TI.J + (DT)(MI1.J + MI2.J + MI3.J + MI4.J)

That portion of the total income generated which was due to PAX movement is determined as follows

11.07 TPI.K = TPI.J + DT * MI2.J

TPI = Total PAX Income ($)

TI = Total Industrial Fund Income ($)

The Industrial Fund, charged with breaking even over time, maintains an awareness of the differences between total income and total expenses. This awareness is based on differences in income and expenses generated by both PAX and Cargo (including SAAM and Exercise) movement.

The difference (between income and expenses) generated by PAX movement is determined as follows:

11.13 PD.K = TPI.K - TPE.K

PD = PAX difference ($)

Cargo expenses and income totals are assumed to be the difference between total ASIF expenses and income generated and those expenses and income allocated to PAX movement.

11.09 TECI.K = TI.K - TPI.K

11.10 TCEE.K = TE.K - TPE.K

TECI = Total Cargo & SAAM, Exercise Income ($)

TCEE = Total Cargo & SAAM, Exercise Expenses ($)

The difference (between income and expenses) generated by Cargo movement, including SAAM and Exercise, is now determined.

11.11 CD.K = TECI.K - TCEE.K

CD = Cargo difference ($)

For identification purposes and increased communication, we will refer to the difference between income and expenses as the "Out of Balance Condition", or the OBC. Thus, PD will be the OBC in PAX movement and CD the OBC created by Cargo, SAAM and Exercise movement.

We have assumed that the out of balance position between expenses and revenue for either Cargo or PAX will not influence a decision to revise the tariff unless the OBC exceeds some predetermined figure.

In the model of the Industrial Fund we have assumed that the allowable OBC is a function of the income rate. The ratio of the OBC to the average income is determined to represent this aspect of the decision function.

The average income is identified as the smoothed average income over a specified time period. Exponential averaging is again utilized.

11.18 SCI.K = SCI.J + (DT/DE15)(MI1.J - SCI.J)

11.19 SPI.K = SPI.J + (DT/DE16)(MI2.J - SPI.J)

11.20 SSEI.K = SSEI.J + (DT/DE17)(MI3.J + MI4.J - SSEI.J)

11.21 SCEI.K = SCI.K + SSEI.K

SCI = Smoothed Cargo Income ($/week)

SPI = Smoothed PAX Income ($/week)

SSEI = Smoothed SAAM-Exercise Income ($/week)

SCEI = Smoothed Cargo-SAAM-Exercise Income ($/week)

DE15 = Delay in Smoothing (weeks)

DE16 = Delay in Smoothing (weeks)

DE17 = Delay in Smoothing (weeks)

The computation of a ratio of the OBC and the smoothed income gives an indication of the magnitude of the OBC compared to the average weekly income. In this basic model we have established the maximum OBC as one week of average income or a desired maximum ratio of 100. Variables 11.28 and 11.29 are the computed ratios and 11.139 and 11.140 the desired ratios.

11.28 RC.K = (100) CDX.K/SCEI.K

11.29 RP.K = (100) PDX.K/SPI.K

RC = Ratio-Cargo (%)

RP = Ratio-PAX (%)

11.139 DRC = Desired Ratio-Cargo (%)

11.140 DRP = Desired Ratio-PAX (%)

(Note: The variable CDX used in equation 11.28 is the same absolute quantity as the CD variable 11.11. CD may be positive or negative but in calculating the ratio RC only the absolute OBC is desired. Our model, therefore, includes two additional equations (11.30 & 11.32) to eliminate the possibility of a negative sign. The same is true for PDX and PD and equations 11.31 and 11.33 assure the absolute value of PD being used in the calculation of RP.K.)

It was indicated that the final decision to change the tariff is influenced by three factors.

a) What is the degree of difference between expenses and income?
b) How long has it been since the last tariff change?
c) What magnitude of change is required?

The model must enable each of these three factors to be considered and all three must signal a tariff change before the new tariff is initiated.

The model of this decision function will be described for the Cargo tariff first. Those variables which are a part of this decision function and their relationship is modeled in Figure 11A.

This decision is being made at an instant in time and is assumed to be at time K. In another segment of the model the new proposed tariff has been determined and identified as TR1.K. We are deciding whether to use this tariff rate, or the tariff rate used during the previous time period which is identified as TT1.K.

TT1.K is equal to TRF1 of the last time period, or TRF1.J. The decision options are a) whether the tariff, TRF1.K, during this present time period will be the same as the tariff during the past time period and therefore equal to TRF1.J, or b) whether the tariff, TRF1.K, will be the forecasted tariff and therefore equal to TR1.K. As TRF1.J cannot be used directly in our modeling equations due to the Dynamo Compiler, a new variable, TT1.K, is established to identify the old tariff rate.

11.22 TTR1.KL = TRF1.K

11.25 TT1.K = TTR1.JK

Thus, equations 11.22 and 11.25 in effect establish TT1.K equal to TRF1.J.

In the same manner we calculate variables TT2 and TT3 which are equivalent to TRF2.J and TRF3.J respectively.

11.23 TTR2.KL = TRF2.K

11.26 TT2.K = TTR2.JK

11.24 TTR3.KL = TRF3.K

11.27 TT3.K = TTR3.JK

TT1 = Cargo Tariff rate during past time period ($/Ton-mile)

TT2 = PAX Tariff rate during past time period ($/Ton-mile)

TT3 = SAAM-Exercise Tariff rate during past time period ($/Ton-mile)

The first step in the decision now compares RC with DRC. If RC is less than DRC the difference between total income and total expenses is not excessive and the past tariff rate (TT1.K) will be continued for the next time period. If the difference (RC) exceeds DRC, the new tariff rate (TR1.K) will be tried.

This step is modeled as follows:

11.34 FTT1.K = CLIP(TR1.K, TT1.K, RC.K, DRC)

FTT1 = First Tariff Try - Cargo

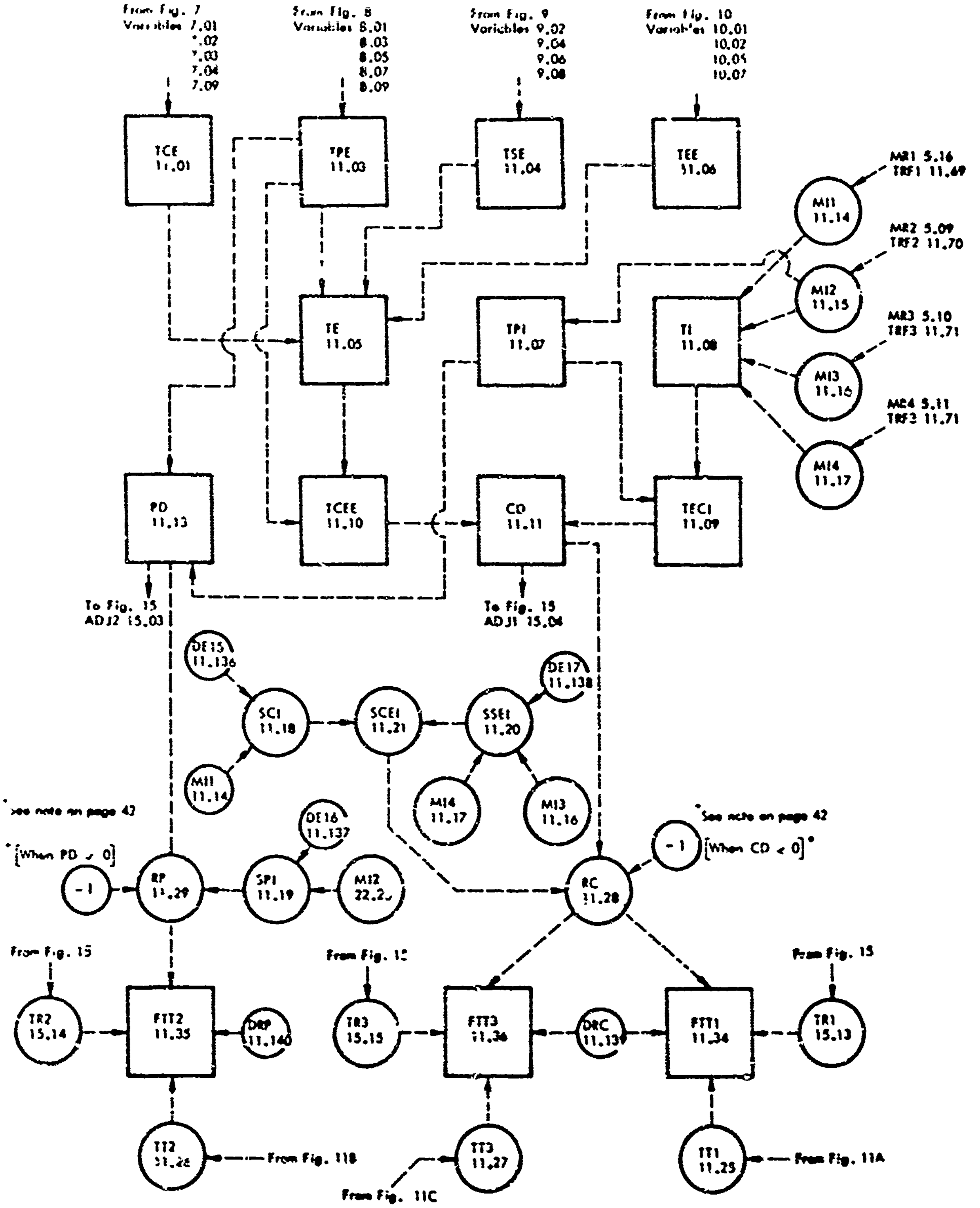

Figure 11. Model of Tarriff Change Decision.

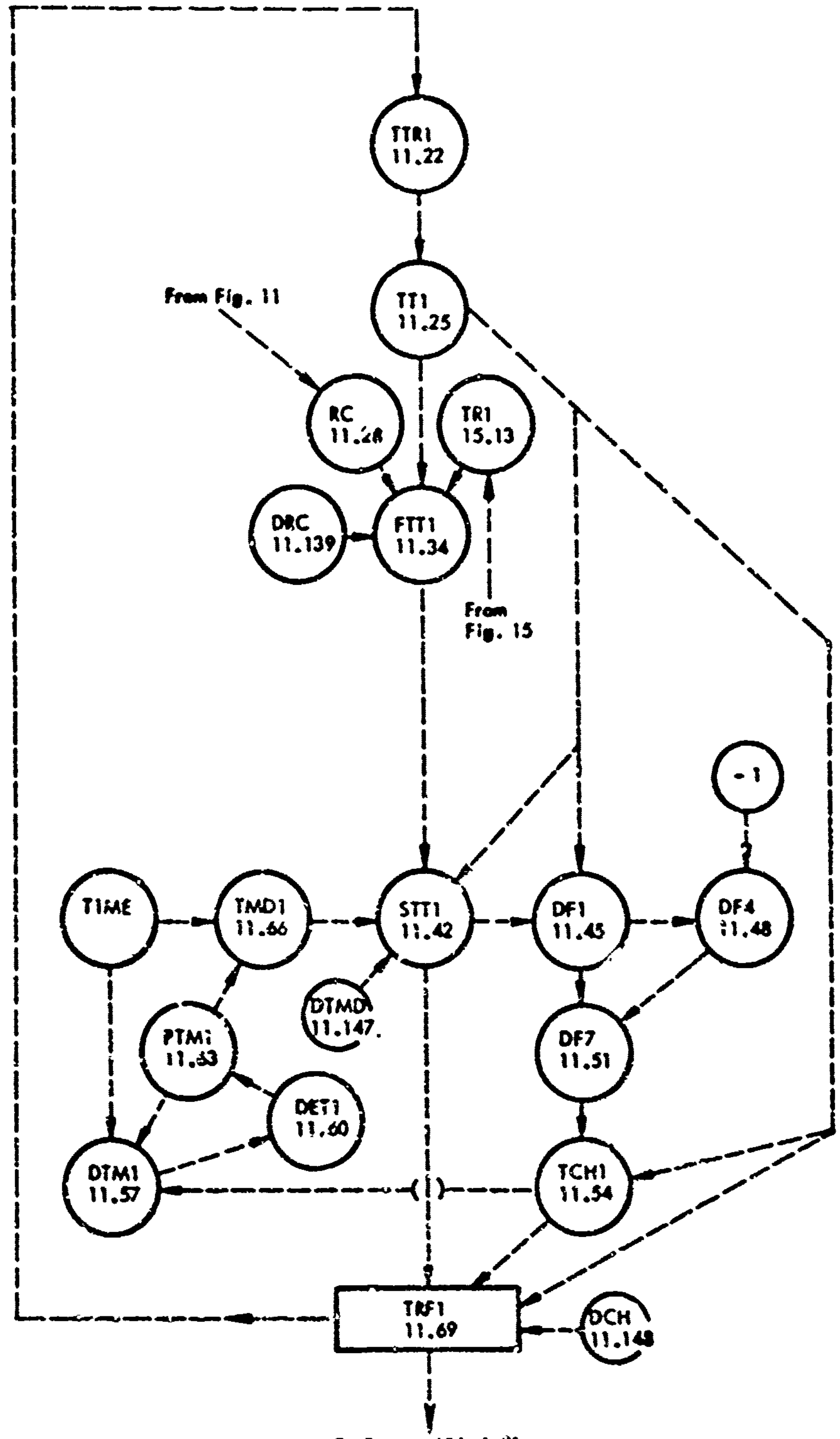

Figure 11A. Model of Cargo Tarriff Change.

The second step in the decision compares the period of time since the last decision to change the tariff with some desired minimum time period. The result of the first decision (FTT1) is again evaluated against the original or previous tariff (TT1). This assures that all three decisions must favor the tariff change before it is finally initiated.

This step is modeled as follows:

11.42 STT1.K = CLIP(FTT1.K, TT1.K, TMD1.K, DTMD)

DTMD = Desired Time Delay in Changing Tariff (weeks)

TMD1 = Time Delay since Last Tariff Change (weeks)

STT1 = Second Tariff Try-Cargo

When the time since the last tariff change is less than that desired, the old tariff (TT1) will remain effective. However, when that time since the last change exceeds the desired time delay, the result of the first decision (FTT1) will be implemented.

The third step in the decision compares the magnitude of the tariff change proposed with some desired minimum change (DCH).

The tariff change being considered is determined by the following equation:

11.45 DF1.K = STT1.K - TT1.K

This variable may be positive or negative but needs to be used as an absolute value for future calculation. Equation 11.48, variable DF4, establishes the opposite sign for the variable DF1 and the positive sign is then selected.

11.51 DF7.K = MAX(DF1.K, DF4.K)

The degree of change proposed is then equal to the ratio of the change proposed to the old tariff.

11.54 TCH1.K = (1/TT1.K)(DF7.K)

TCH = Tariff Change (Fraction)

The new tariff (TRF1) is now established as equal to the old tariff (TT1) if the degree of change (TCH1) is less than a desired minimum (DCH). The tariff (TRF1) will be set equal to the previous decision (STT1) if the tariff change exceeds the desired minimum. This is modeled as follows:

11.69 TRF1.K = CLIP (STT1.K, TT1.K, TCH1.K, DCH)

TRF1 = Cargo Tariff ($/Ton-miles)

The second decision (STT1) will be equal to the old tariff (TT1) unless both the out-of-balance position and the time constraints signaled for a tariff change. Thus, if this last test is passed, the new tariff will be initiated and the time of the last tariff change must be equated to the present time. This is modeled as follows:

11.57 DTM1.K = CLIP (TIME.K, PTM1.K, TCH1.K, DCH)

TIME = TIME into model run (weeks)

PTM1 = TIME of last tariff change (weeks)

Thus, if a tariff change is signaled as TCH1 is greater than DCH, then DTM1 is set equal to the present TIME. Otherwise, it is left equal to the time of the previous change (PTM1). Also,

11.60 DET1.KL = DTM1.K

11.63 PTM1.K = DET1.JK

The time since last change (TMD1) is then

11.66 TMD1.K = TIME.K - PTM1.K

The above equations are replicated to model the decision function for determining whether the PAX tariff needs to be revised. (See Figure 11B) The equations for the PAX decision are as follows:

11.35 FTT2.K = CLIP (TR2.K, TT2.K, RP.K, DRP)

11.43 STT2.K = CLIP (FTT2.K, TT2.K, TMD2.K, DTMD)

11.46 DF2.K = STT2.K - TT2.K

11.52 DF8.K = MAX (DF2.K, DF5.K)

11.55 TCH2.K = (1/TT2.K)(DF8.K)

11.70 TRF2.K = CLIP (STT2.K, TT2.K, TCH2.K, DCH)

11.61 DET2.KL = DTM2.K

11.64 PTM2.K = DET2.JK

11.67 TMD2.K = TIME.K - PTM2.K

In the same manner, equations for replicating the decision function for changing the SAAM and Exercise tariff are determined. (See Figure 11C)

11.36 FTT3.K = CLIP(TR3.K, TT3.K, RC.K, DRC)

11.44 STT3.K = CLIP(FTT3.K, TT3.K, TMD3.K, DTMD)

11.47 DF3.K = STT3.K - TT3.K

11.53 DF9.K = MAX (DF3.K, DF6.K)

11.56 TCH3.K = (1/TT3.K)(DF9.K)

11.71 TRF3.K = CLIP (STT3.K, TT3.K, TCH3.K, DCH)

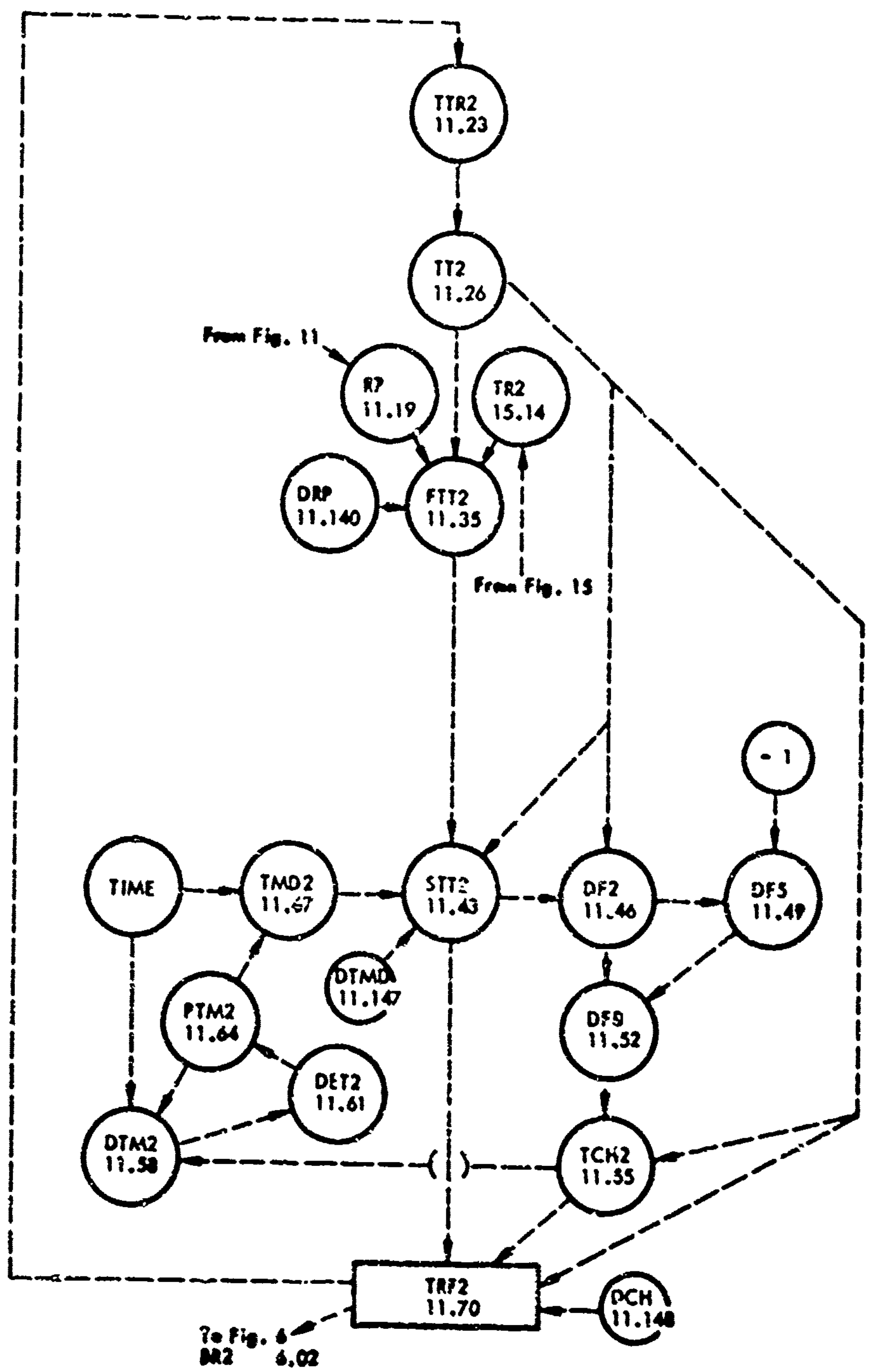

Figure 11B. Model of PAX Tarriff Change.

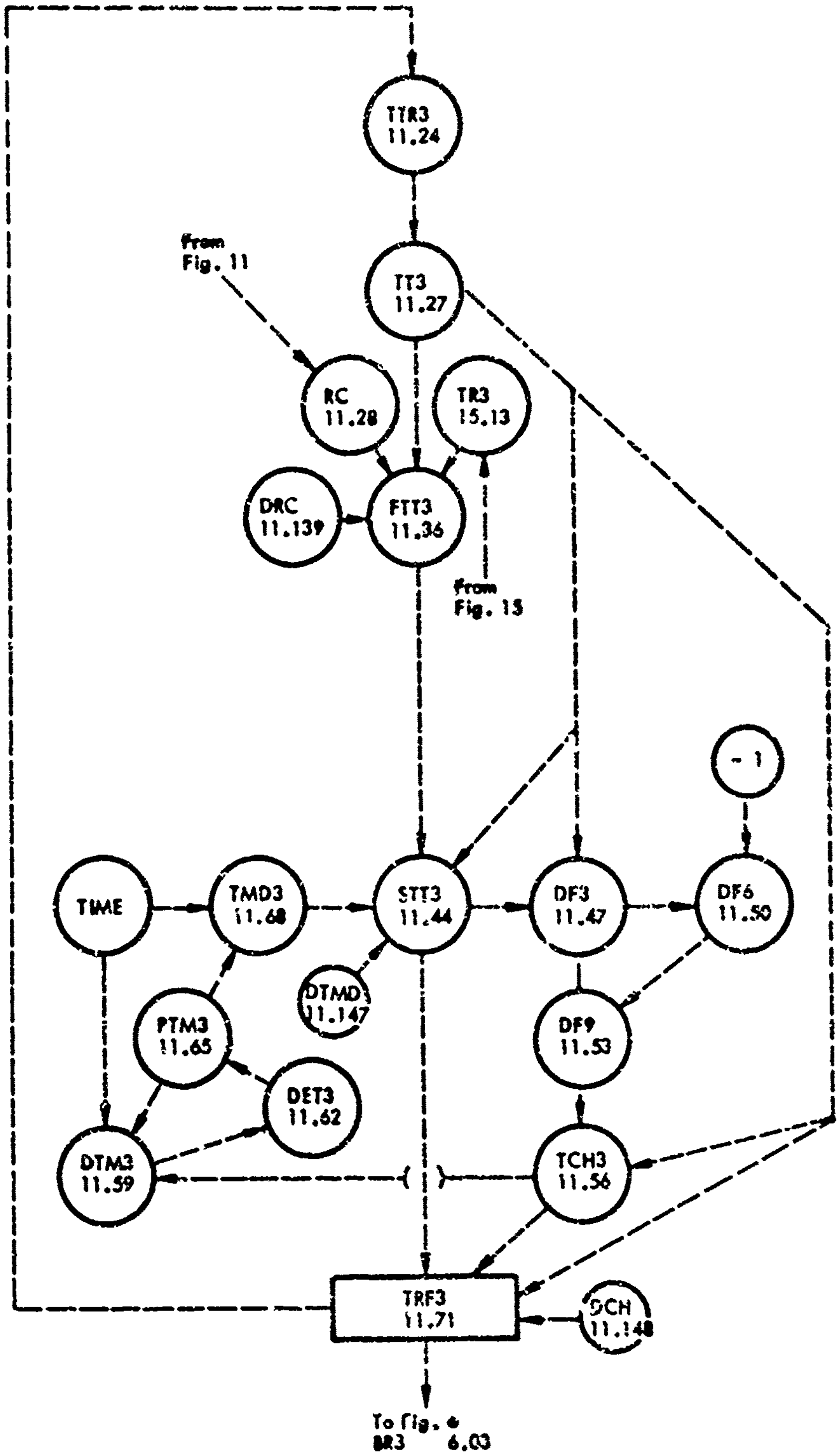

Figure 11C. Model of SAAM and Exercise Tarriff Change.

11.59 DTM3.K = CLIP (TIME.K, PTM3.K, TCH3.K, DCH)

11.62 DET3.KL = DTM3.K

11.65 PTM3.K = DET3.JK

11.68 TMD3.K = TIME.K - PTM3.K

A list of all variables identified in Figure 11 and their corresponding initial conditions and parameters is given in Appendix XI.

Figure 12

The proposed tariffs (TR1, TR2, TR3) are determined after considering the forecasted demand for Cargo, PAX, SAAM and Exercise and allocating forecasted capabilities and expenses to each classification of demand. This has been modeled in three segments, one representing forecasted capability and its allocation, one the forecasted usage or demand, and finally the forecasted expenses. These variables then influence the proposed new tariff.

The modeling of forecasted military capability and its allocation to Cargo and PAX plus the determination of commercial requirements to cover any defects is basically a replication of Figure 4. Military capability is determined and allocated to Cargo and a portion of the PAX requirements (the major portion being covered by commercial buy) with the balance of the Cargo covered by additional commercial buy. This segment of the system is modeled in Figure 12.

The forecast military capability is based on the current capability available (variable 4.04) as modeled in Figure 4. This figure, reduced by forecasted SAAM and Exercise demand and forecasted test and training demand is identified as variable 12.01 and represents the total military capability available for forecast Cargo and PAX usage. (See Figure 13)

12.01 FCAP.K = TCAP.K - SMT.K - FD34.K

FCAP = Forecast Cargo - PAX Capability (Ton-Miles/week)

FD34 = Forecast SAAM-Exercise Requirement (Ton-Miles/week)

TCAP = Total Capability (Ton-Miles/week)

SMT = Smoothed testing and training (Ton-Miles/week)

From Figure 13 we obtain information regarding the portion of PAX requirements which are to be covered by military capability. This information is represented by variable F2A which is the difference between the total PAX forecasted requirements and the portion covered by commercial requirements.

12.05 F2A.K = FD2X.K - FCB2.K

F2A = PAX Demand covered by Military (PAX-Miles/week)

We convert this to ton-miles per week.

12.09 FPR.K = F2A.K/FPAX

FPAX = Conversion factor - (PAX-Miles per Ton-Miles)

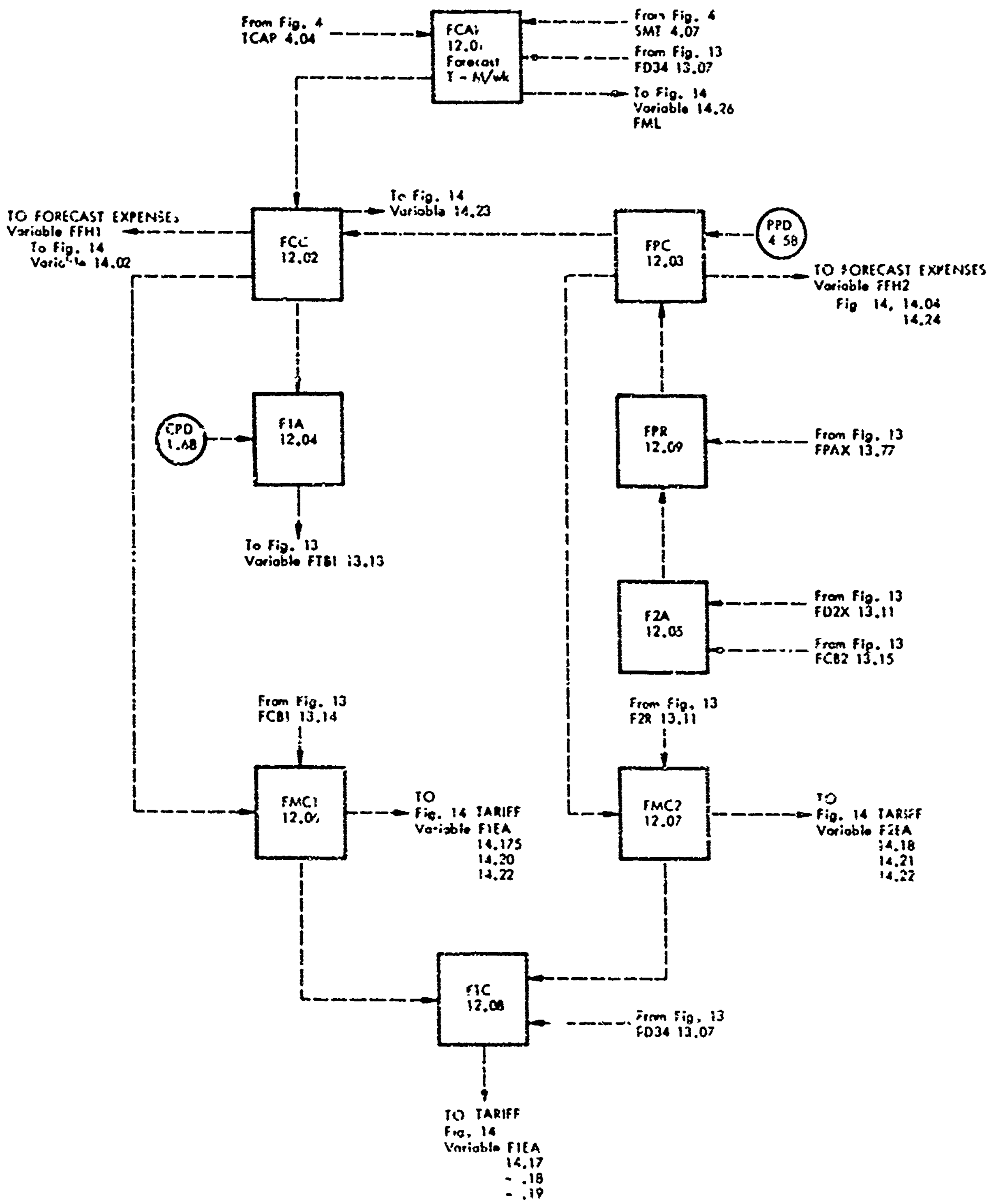

Figure 12. Model of Forecasted Capability Allocation

This requirement is then increased to cover positioning and depositioning time.

12.03 FPC.K = PPD * FPR.K

FPC = Military capability allocated to PAX (Ton-Miles/week)

The military capability allocated to Cargo is now the balance left after covering PAX requirements.

12.02 FCC.K = FCAP.K - FPC.K

FCC = Military Capability allocated to Cargo (Ton-Miles/week)

This is reduced to allow for positioning and depositioning time and the balance is used to cover the forecasted Cargo demand.

12.04 F1A.K = CPD * FCC.K

F1A = Military Capability to cover Cargo Demand (Ton-Miles/week)

Variables 12.06, 12.07, and 12.08 are levels of information needed to calculate the forecasted tariff in Figure 14.

12.06 FMC1.K = FCC.K + FCB1.K

FMC1 = Forecast Military plus Commercial Cargo Capability (Ton-Miles/week)

12.07 FMC2.K = FPC.K + F2R.K

FMC2 = Forecast Military plus Commercial PAX Capability (Ton-Miles/week)

12.08 FTC.K = FMC1.K + FMC2.K + FD34.K

FTC = Forecast Total Commercial plus Military Capability including SAAM and Exercise (Ton-Miles/week)

A list of all variables identified in Figure 12 and their corresponding initial conditions and parameters is given in Appendix XII.

Figure 13

The Industrial Fund tariff is established to recover forecasted expenses and correct the OBC (Figure 11) over time from revenue anticipated from forecasted demand for MAC services. In the Industrial Fund system, forecasts come from the MAC customers. In our model of the system some method was needed to simulate this action. It was decided to assume that the forecasted demand for a service would be a function of

a) the smoothed average demand over the past, and
b) the smoothed average rate of change in demand over the past.

From Figure 1 and variables 1.17 and 1.18 the smoothed customer demand (SDIG and SDIC) is obtained for outgoing and incoming Cargo movement. Also, from Figure 1 information regarding the rate of change in customer demand

(SRIG and SR1C) is obtained from variables 1.22 and 1.23.

The Industrial Fund has a charge to break even (total expense = total revenue) over two-year intervals. It was therefore assumed that the system first attempts to break even when TIME = 2 years and will adjust tariffs as necessary to achieve this objective until TIME = 1 year at which time the system selects a new break even point as TIME = 3 years. The time for breaking even is therefore always between 1 and 2 years in the future. This prevents tariffs from becoming much too high or too low because of a short time interval for correcting the OBC.

Thus, from time 0 until the end of year 1 the adjustment point is the end of year 2. From the start of year 2 until the end of year 2, the adjustment point is the end of year 3. This information is modeled as follows:

The adjustment point in the future is equal to XYZ.

15.18 XYZ.K = XYZI + TIS.K

XYZI = 104 weeks (2 years)

This point is updated each year by TIS, which increases XYZ by 52 weeks at the end of each year, thereby always keeping the adjustment point sometime between one and two years in the future. (See variable 15.19 of Appendix XV)

The forecasted change in demand is now assumed to be the average change from the present until the end of adjustment period. This is given by the variable

13.19 G1G.K = (SR1G.K)(TIM.K)/2

15.01 TIM.K = XYZ.K - TIME.K

TIM = Adjustment Period (weeks)

G1G = Average change in Cargo demand-outgoing- over adjustment period (Ton-Miles/week)

TIME = Present time in simulated run

The forecasted demand rate for the adjustment period is now the average demand plus the change in demand forecasted. This demand is also increased to allow for less than 100% utilization of the air frames capacity.

FD1G.K = (1/FU1G)(SD1G.K + G1G.K)

Forecasts can be in error and so, as to be able to test the sensitivity of the system to forecasting errors, we have introduced a noise function in the forecast. This is accomplished by multiplying the forecast by random numbers from a normal distribution. To dampen out the high frequency noise we then average (smooth) the results. This results in the following equations in place of the one given above for FD1G.

13.01 FFD1G.K = (1/FU1G)(SD1G.K + G1G.K)

13.25 SF1G.K = (FFD1G.K) NORMRN (MEAN, STDV2)

13.31 FD1G.K = SMOOTH (SF1G.K, DEF2)

FD1G = Forecasted Demand-Cargo-Outgoing (Ton-Miles/week)

13.62 DEF2 = Smoothing Time Period

In the above equations NORMRN (MEAN, STDV2) results in the Dynamo Compiler selecting random numbers from a normal distribution with a mean of MEAN and a standard deviation of STDV2. With various specifications for MEAN and STDV2, we are able to simulate random variation in the forecasted demand FFD1G.

The above equations represent the forecast for outgoing Cargo. Incoming Cargo is forecasted in the same manner.

13.20 G1C.K = (SR1C.K)(TIM.K)/2

13.02 FFD1C.K = (1/FU1C)(SD1C.K + G1C.K)

13.26 SF1C.K = (FFD1C.K) NORMRN (MEAN, STDV3)

13.32 FD1C.K = SMOOTH (SF1C.K, DEF3)

G1C = Average Change in Cargo incoming over adjustment period (Ton-Miles/week)

FD1C = Forecasted Demand-Cargo-Incoming (Ton-Miles/week)

13.63 DEF3 = Smoothing Time Period

In the same manner the equations for forecasted PAX outgoing and incoming requirements are determined.

13.21 G2G.K = (SR2G.K)(TIM.K)/2

13.22 G2C.K = (SR2C.K)(TIM.K)/2

13.03 FFD2G.K = (1/FU2G)(SD2G.K + G2G.K)

13.04 FFD2C.K = (1/FU2C)(SD2C.K + G2C.K)

13.27 SF2G.K = (FFD2G.K) NORMRN (MEAN, STDV4)

13.28 SF2C.K = (FFD2C.K) NORMRN (MEAN, STDV5)

13.34 FD2G.K = SMOOTH (SF2G.K, DEF4)

13.33 FD2C.K = SMOOTH (SF2C.K, DEF5)

G2G = Average Change in PAX-Outgoing over adjustment period (PAX-Miles/week)

G2C = Average Change in PAX-Incoming over adjustment period (PAX-Miles/week)

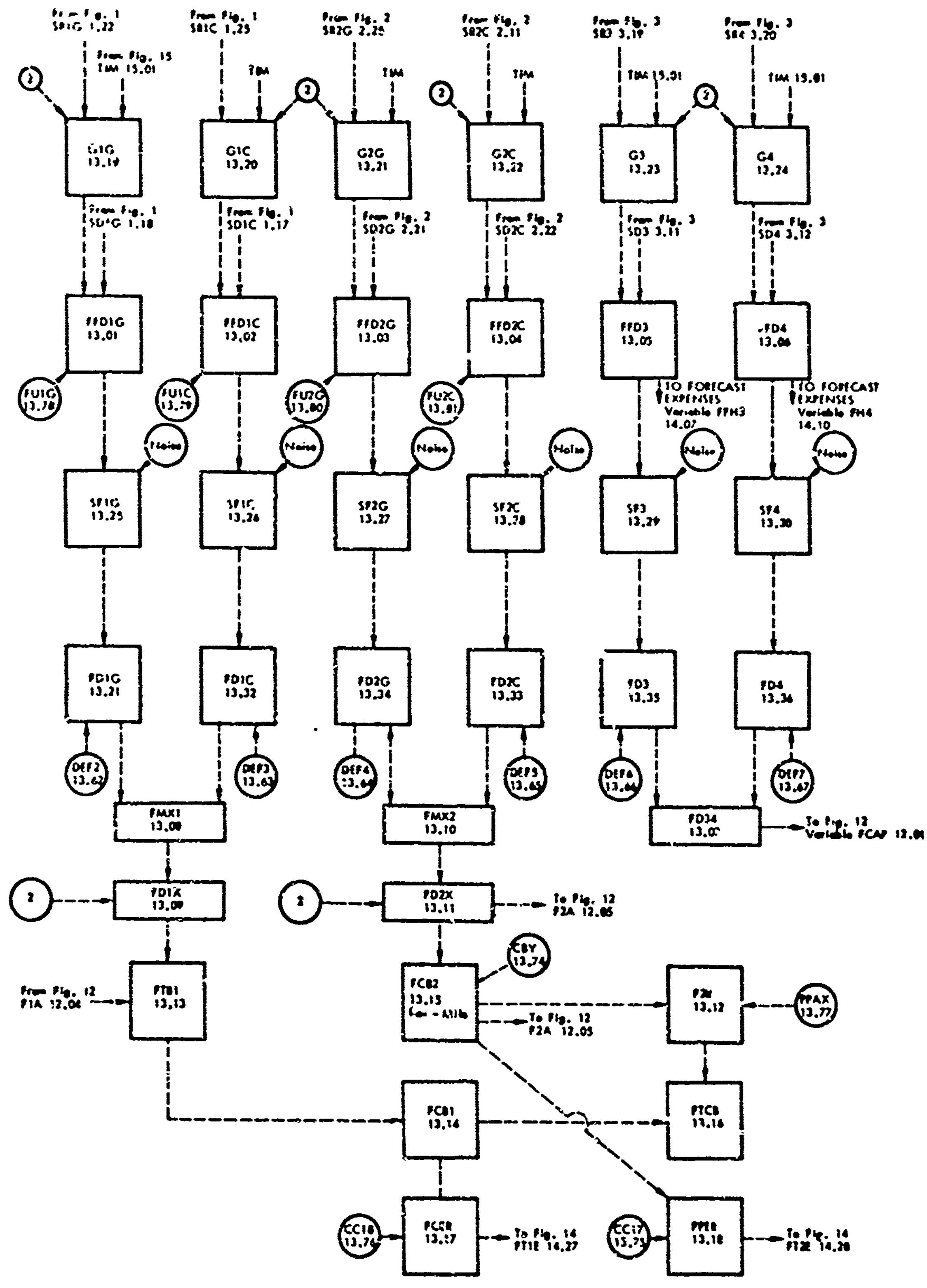

Figure 13. Model of Forecast ⁴ Demand.

FD2G = Forecasted Demand-PAX-Outgoing (PAX-Miles/week)

FD2C = Forecasted Demand-PAX-Incoming (PAX-Miles/week)

13.64 DEF4 = Smoothing Time Period

13.65 DEF5 = Smoothing Time Period

SAAM and Exercise Demand is treated in this same manner.

13.23 G3.K = (SR3.K)(TIM.K)/2

13.24 G4.K = (SR4.K)(TIM.K)/2

13.05 FFD3.K = SD3.K + G3.K

13.06 FFD4.K = SD4.K + G4.K

13.29 SF3.K = (FFD3.K) NORMRN (MEAN, STDV6)

13.30 SF4.K = (FFD4.K) NORMRN (MEAN, STDV7)

13.35 FD3.K = SMOOTH (SF3.K, DEF6)

13.36 FD4.K = SMOOTH (SF4.K, DEF7)

G3 = Average Change in SAAM over adjustment period (Ton-Miles/week)

G4 = Average Change in Exercise over adjustment period (Ton-Miles/week)

FD3 = Forecasted Demand-SAAM-(Ton-Miles/week)

FD4 = Forecasted Demand-Exercise-(Ton-Miles/week)

13.66 DEF6 = Smoothing Time Period

13.67 DEF7 = Smoothing Time Period

The forecasted demand for SAAM and Exercise is then

13.07 FD34.K = FD3.K + FD4.K

FD34 = Total SAAM-Exercise Demand (Ton-Miles/week)

[This information (FD34) was utilized in Figure 12 to determine total military capability available for Cargo and PAX (FCAP).]

The forecasted Cargo capability is now assumed to be twice the larger demand between outgoing and incoming.

13.08 FMX1.K = MAX(FD1G.K, FD1C.K)

13.09 FD1X.K = 2 * FMX1.K

13.10 FMX2.K = MAX(FD2G.K, FD2C.K)

13.11 FD2X.K = 2 * FMX2.K

FD1X = Forecasted military capability demanded-Cargo (Ton-Miles/week)

FD2X = Forecasted military capability demanded-PAX (PAX-Miles/week)

The Industrial Fund covers the major portion of PAX demand by commercial buy. Thus,

13.15 FCB2.K = FD2X.K * CBY

FCB2 = Forecasted Commercial Buy-PAX (PAX-Miles/week)

13.74 CBY = % of Demand covered by Commercial Buy

The forecasted cost of the commercial buy is now

13.18 FPER.K = CC17 * FCB2.K

FPER = Forecasted cost of PAX buy ($/week)

13.75 CC17 = Commercial cost ($/PAX-Mile)

The Cargo demand (FD1X) is covered by military capability (F1A from Figure 12) and the additional required, covered by commercial buy. If no commercial is required, the total military capability is utilized for the forecasted demand.

13.13 FTB1.K = FD1X.K - F1A.K

13.14 FCB1.K = CLIP (FTB1.K, 0, FTB1.K, 0)

The above two equations assure us that our model will purchase commercial time only when the demand (FD1X) exceeds the military capability (F1A).

FCB1 = Forecasted Commercial Buy-Cargo (Ton-Miles/week)

The total commercial buy in ton-miles per week is now computed by converting PAX buy to ton-miles per week and adding this to the Cargo commercial buy.

13.12 F2R.K = FCB2.K/FPAX

13.77 FPAX = Conversion Factor PAX-Miles/Ton-Miles

F2R = Forecasted PAX Commercial Buy (Ton-Miles/week)

13.16 FTCB.K = FCB1.K + F2R.K

FTCB = Forecasted Total Commercial Buy (Ton-Miles/week)

The forecasted cost for Cargo commercial buy is found as follows:

13.17 FCER.K = CC18 * FCB1.K

FCER = Forecasted commercial cost-Cargo ($/week)

13.76 CC18 = Commercial Tariff ($/Ton-mile)

A list of all variables identified in Figure 13 and their corresponding initial conditions and parameters is given in Appendix XIII.

Figure 14

In Figures 14, 14A, and 15 we model that segment of the Industrial Fund system which determines the forecasted tariffs (TR1, TR2, TR3) at a point in time based on the forecasted customer usage, the forecasted expenses, and the Industrial Fund's total expense-revenue balance (OBC).

The forecasted customer usage has been modeled and described in Figure 13. From Figure 12 and the model of military capability allocation we obtain the forecasted military capability allocated to Passenger demand (FPC) and the forecasted military capability allocated to Cargo demand (FCC). From Figure 13 we obtain the forecasted SAAM requirements (FD3) and the forecasted Exercise requirements (FD4). These variables (FPC, FCC, FD3, FD4) influence the forecasted expenses associated with filling this forecasted demand.

The modeling of forecasted expenses (Figure 14A) is a replication of the modeling of actual expenses, the only difference being the use of forecasted flying hours rather than generated flying hours.

The flying hours are determined by dividing the military capability allocated by speed and capacity factors. Thus,

$$\text{Forecasted Flying Hours} = \frac{\text{Forecasted Capability}}{\text{(speed) (capacity)}}$$

$$\text{Hrs./Week} = \frac{\text{Ton-Miles/week}}{\text{(Miles/hr.) (Tons)}}$$

14.04 FFH2.K = FPC.K/((S418)(C417))

14.02 FFH1.K = FCC.K/((S423)(C424))

14.07 FFH3.K = FD3.K/((SPD3)(CAP3))

14.10 FFH4.K = FD4.K/((SPD4)(CAP4))

FFH1.K = Forecasted Flying Hours allocated to Cargo (Flying Hours/week)

FFH2.K = Forecasted Flying Hours allocated to Passengers (Flying Hours/week)

FFH3.K = Forecasted Flying Hours allocated to SAAM (Flying Hours/week)

FFH4.K = Forecasted Flying Hours allocated to Exercise (Flying Hours/week)

S418, S423, SPD3, & SPD4 = Speed of Aircraft (Miles/Hour)

C417, C424, CAP3, & CAP4 = Capacity of Air Frame (Tons)

The forecasted expense rate per week is then the costs per flying hours multiplied by the flying hours per week plus the fixed costs per week.

The forecasted expense rate for Cargo is then

14.03 FHE1.K = FFH1.K (E716 + E728 + E723)

14.01 F1E.K = E710 + E715 + E722 + FHE1.K

FHE1.K = Forecasted Variable Cargo Expenses ($/week)

F1E.K = Forecasted Total Cargo Expenses ($/week)

The forecasted expenses for PAX, SAAM and Exercise movement is similarly modeled.

14.05 FHE2.K = FFH2.K (E823 + E816 + E828)

14.06 F2E.K = E810 + E815 + E822 + FHE2.K

14.08 FHE3.K = FFH3.K (E916 + E923 + E928)

14.09 F3E.K = E910 + E915 + E922 + FHE3.K

14.11 FHE4.K = FFH4.K (ET16 + ET23 + ET28)

14.12 F4E.K = ET10 + ET15 + ET22 + FHE4.K

FHE2 = Forecasted Variable PAX Expense ($/week)

FHE3 = Forecasted Variable SAAM Expense ($/week)

FHE4 = Forecasted Variable Exercise Expense ($/week)

F2E = Forecasted Total PAX Expense ($/week)

F3E = Forecasted Total SAAM Expense ($/week)

F4E = Forecasted Total Exercise Expense ($/week)

The total forecasted expense rate for all military capability is then

14.13 FFTE.K = F1E.K + F2E.K + F3E.K + F4E.K

The above variable does not allow for possible errors in forecasting, as the expense rates used are actual rates not known in actuality until after the fact. Possible forecasting error or noise is introduced by a noise function (see Figure 14) as follows:

14.14 FTE.K = (FFTE.K) NORMRN (MEAN, STDV1)

FTE = Forecasted Total Military Expense ($/week)

MEAN = Mean of Error Deviation

STDV1 = Standard Deviation of Error

So as to prevent the forecasted expense from fluctuating with high frequency, as it would using the above equation, we smooth the results of the above equation to give the quantity used in forecasting the tariff.

14.15 SFTE.K = SMOOTH (FTE.K, DEF1)

SFTE = Smoothed total expense rate ($/week)

14.52 DEF1 = Smoothing time interval (weeks)

The above equations now allow the analyst to introduce error in that portion of the model yielding the forecasted military expense rate. The sensitivity of the model, and possibly the system, to errors in expense forecasting may now be studied.

The total forecasted military expenses are now divided into three parts and each appropriately identified as either administrative expense rate, terminal expense rate, or direct expense rate. This is modeled with each variable considered a percentage of the total expense.

14.30 DTE.K = SFTE.K * PCT4

14.31 ADE.K = SFTE.K * PCT2

14.16 TEX.K = SFTE.K * PCT3

ADE = Forecasted Administration expense rate ($/week)

TEX = Forecasted Terminal expense rate ($/week)

DTE = Forecasted Direct expense rate ($/week)

14.53 PCT2 = % of total expense to Administration

14.54 PCT3 = % of total expense to Terminal

14.55 PCT4 = % of total expense to Direct

In addition to the above forecasted military expenses, the forecasted commercial expense rate for Cargo (FCER) and Passengers (FPER) has also been determined in that segment of the model described in Figure 12.

The Industrial Fund determines the proposed tariff for each of the four types of demand by allocating costs to each classification of demand and recovering this cost based on the forecasted demand. The allocation of expenses to each demand classification is proportional to the capability allocated to that demand.

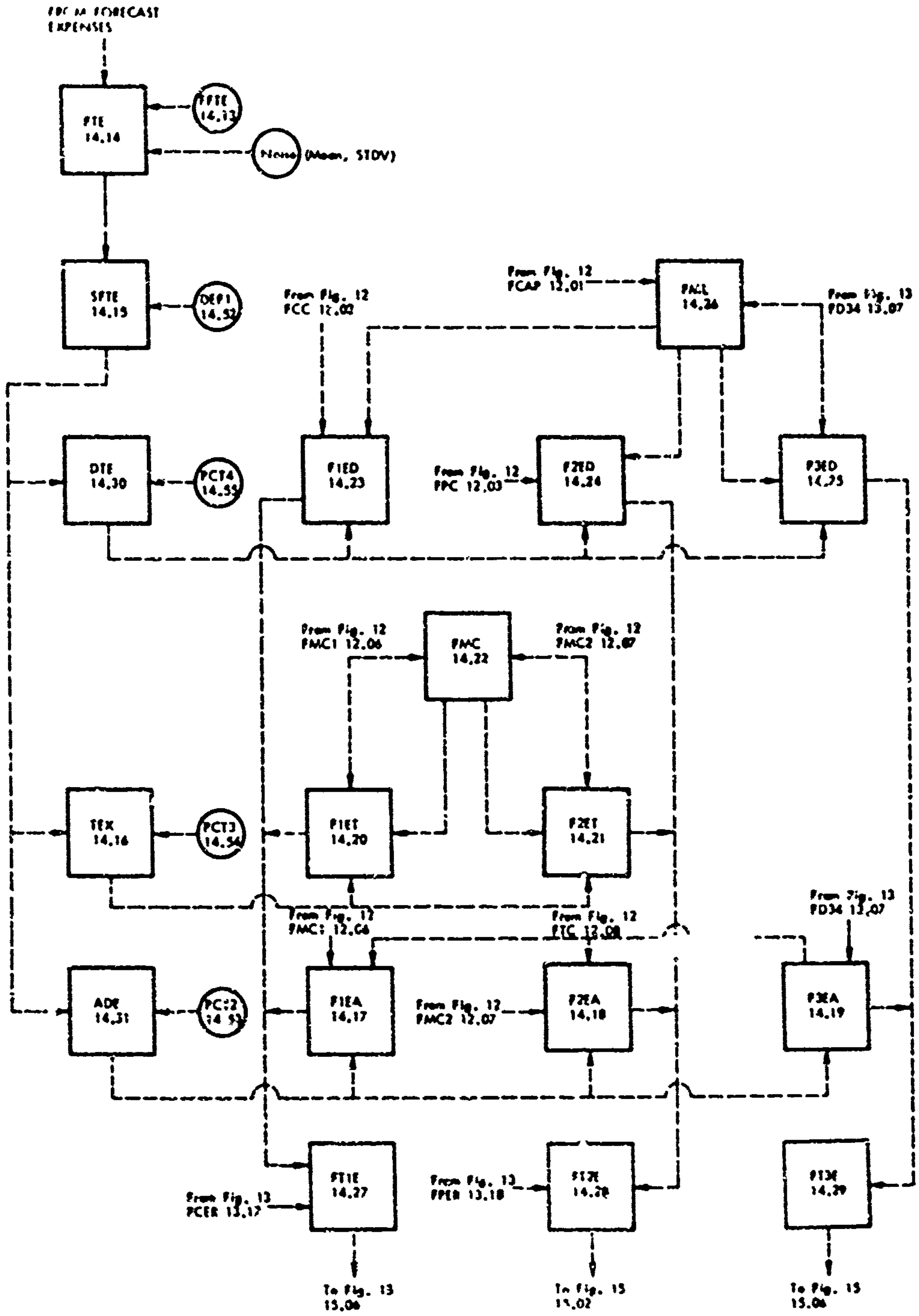

Figure 14. Model of Expense Allocation.

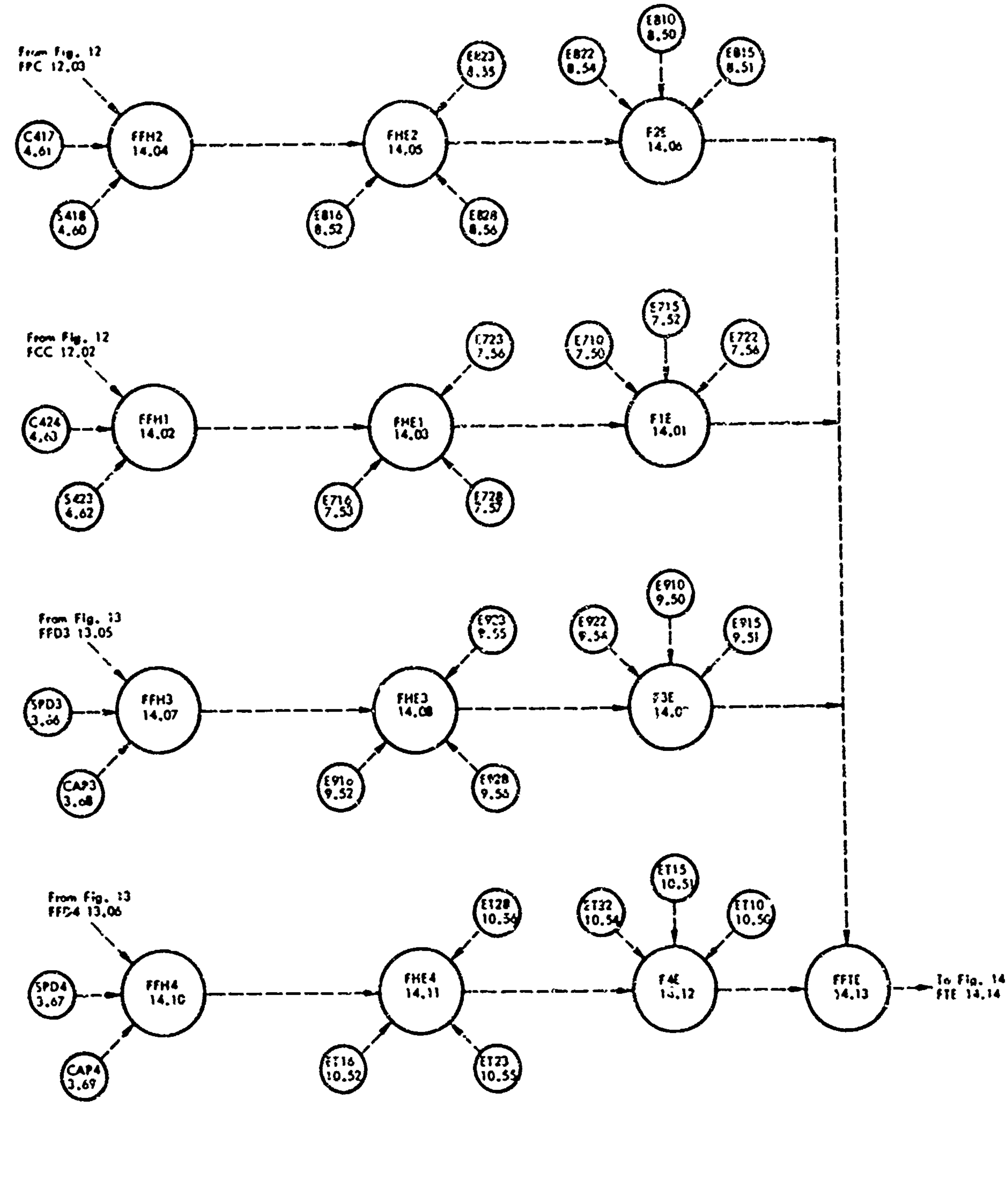

Figure 14A. Model of Forecasted Expenses

The modeling of this decision function within the system has been accomplished through the variables described in Figure 14 and 15 and their equations.

The following information on military and commercial capability is first determined from data within the system.

14.26 FML.K = FCAP.K + FD34.K

FML = Total Military Capability Allocated to all classified demand

14.22 FMC.K = FMC1.K + FMC2.K

FMC = Total Military plus commercial capability allocated to Cargo and PAX demand

12.08 FTC = Total Military and commercial capability allocated to all classified demand

The allocation of expenses to PAX, Cargo or SAAM-Exercise is a function of the expense variable (Administrative, Terminal, or Direct) and the capabilities allocated to the particular classified demand.

Administrative expenses are allocated to each demand classification (Cargo, PAX, SAAM-Exercise) according to that portion of total capability (Commercial + Military)(FTC) allocated to that demand classification.

14.17 F1EA.K = ADE.K(FMC1.K/FTC.K)

14.18 F2EA.K = ADE.K(FMC2.K/FTC.K)

14.19 F3EA.K = ADE.K(FD34.K/FTC.K)

Terminal expenses are allocated to the classified demand according to allocated Cargo and PAX capability. (Military + Commercial)(FMC)

14.20 F1ET.K = TEX.K(FMC1.K/FMC.K)

14.21 F2ET.K = TEX.K(FMC2.K/FMC.K)

Direct expenses are allocated to the classified demand according to the military capability required for each demand classification.

14.23 F1ED.K = DTE.K(FCC.K/FML.K)

14.24 F2ED.K = DTE.K(FPC.K/FML.K)

14.25 F3ED.K = DTE.K(FD34.K/FML.K)

F1EA = Forecast Expense Rate-Cargo-Administrative ($/week)

F2EA = Forecast Expense Rate-PAX-Administrative ($/week)

F3EA = Forecast Expense Rate-SAAM-Exercise-Administrative ($/week)

F1ET = Forecast Expense Rate-Cargo-Terminal ($/week)

F2ET = Forecast Expense Rate-PAX-Terminal ($/week)

F1ED = Forecast Expense Rate-Car -Direct ($/week)

F2ED = Forecast Expense Rate-PAX-Direct ($/week)

F3ED = Forecast Expense Rate-SAAM-Exercise-Direct ($/week)

The estimated expense rate for each demand function (Cargo, PAX, SAAM) is now the summation of these allocated expense rates.

14.27 FT1E.K = FCER.K + F1EA.K + F1ET.K + F1ED.K

14.28 FT2E.K = FPER.K + F2EA.K + F2ET.K + F2ED.K

14.29 FT3E.K = F3EA.K + F3ED.K

FT1E = Forecast Total expense rate-Cargo ($/week)

FT2E = Forecast Total expense rate-PAX ($/week)

FT3E = Forecast Total expense rate-SAAM & Exercise ($/week)

A list of all variables identified in Figure 14 and their corresponding initial conditions and parameters is given in Appendix XIV.

Figure 15

The forecasted tariff is now based on recovering the forecasted expenses over the forecasting time period plus or minus an adjustment expected to correct the OBC by the end of the forecasting time period.

The forecasting time period (TIM) has been described and utilized earlier as a segment of Figure 13 and the modeling of forecasted customer demand. (See pg. 53)

The Industrial Fund plans to correct the out of balance condition (OBC) between PAX expenses and income (PD) over the time period TIM. The same is true for any out of balance condition between Cargo and SAAM expenses and income (CD). This adjustment is then subtracted from the expense rate for that classified demand.

15.04 ADJ1.K = CD.K/TIM.K

15.03 ADJ2.K = PD.K/TIM.K

ADJ1 = Adjustment due to Cargo-SAAM-Exercise income-expense difference ($/week)

ADJ2 = Adjustment due to PAX income-expense difference ($/week)

The expense rate for PAX movement over time period TIM is then

15.02 FAE2.K = FT2E.K - ADJ2.K

FAE2 = Forecasted net PAX expense rate ($/week)

The actual forecasted demand for PAX movement is then determined by multiplying the capability allocated by the utilization factors.

15.11 FD2.K = (FD2G.K)(FU2G) + (FD2C.K)(FU2C)

FD2 = Forecasted PAX Demand-actual (PAX-Miles/week)

The tariff is now determined to recover expenses (FAE2) from the customer demand (FD2).

15.14 TR2.K = FAE2.K/FD2.K

TR2 = Forecasted PAX Tariff ($/PAX-Miles/week)

The SAAM-Exercise and Cargo tariffs are determined together so that a premium charge can be allocated to SAAM-Exercise demand to cover the higher non-channel expenses associated with this demand.

First, the total Cargo-SAAM-Exercise expense rate is determined.

15.06 SFE.K = FT1E.K + FT3E.K - ADJ1.K

SFE = Forecasted net expense rate for SAAM-Exercise and Cargo movement ($/week)

The resulting expense rate (SFE) is then allocated to Cargo and SAAM-Exercise Expense based on the amount of military capability allotted to each but with SAAM-Exercise charged a 15% premium for extra costs associated with special handling.

15.07 STR.K = FD34.K/FML.K

15.09 F3AE.K = (SFE.K)(1.15)(STR.K)

15.10 F1AE.K = SFE.K - F3AE.K

STR = Forecasted expense rate-Cargo-SAAM-Exercise ($/week)

F3AE = Forecasted net expense rate-SAAM-Exercise ($/week)

F1AE = Forecasted net expense rate-Cargo ($/week)

The SAAM-Exercise forecasted tariff is now determined to recover SAAM-Exercise expenses (F3AE) from the demand for SAAM-Exercise (FD34).

15.13 TR3.K = F3AE.K/FD34.K

TR3 = Forecasted SAAM-Exercise Tariff ($/Ton-Mile)

The actual forecasted Cargo demand is determined as follows: (See Tables 13.01 and 13.02)

15.12 FD1.K = (FD1G.K)(FU1G) + (FD1C.K)(FU1C)

FD1 = Forecasted Cargo Demand-Actual (Ton-Miles/week)

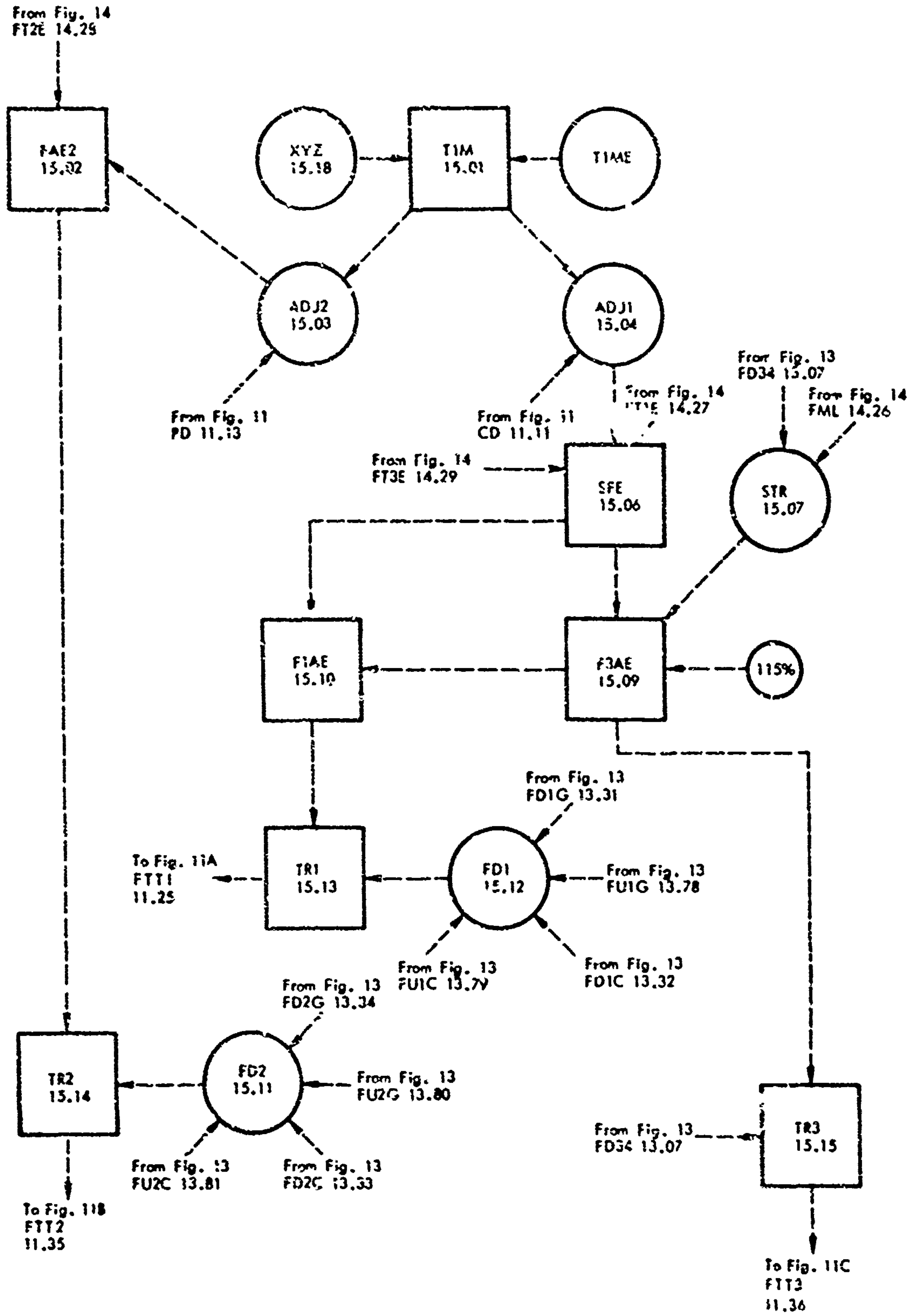

Figure 15. Model of Forecasted Tariff Calculation

The tariff is now determined to recover Cargo expenses (F1AE) from Cargo Demand (FD1).

15.13 TR1.K = F1AE.K/FD1.K

TR1 = Forecasted Cargo Tariff ($/Ton-mile)

A list of all variables identified in Figure 15 and their corresponding initial conditions and parameters is given in Appendix XV.

Input Variables

This completes the description and explanation of the basic model. The exogenous input to the system is primarily the customer demand. We have written demand equations which will allow the model to be massaged by a step input, a ramp input, a sine input, or a noise input. These equations are identified in this manner.

1.01 D1G.K = D1GI + ISTA.K + IRPA.K + ISNA.K + INOA.K

1.02 D1C.K = D1CI + ISTB.K + IRPB.K + ISNB.K + INOB.K

2.01 D2G.K = D2GI + ISTC.K + IRPC.K + ISNC.K + INOC.K

2.02 D2C.K = D2CI + ISTD.K + IRPD.K + ISND.K + INOD.K

3.01 D3S.K = D3SI + ISTE.K + IRPE.K + ISNE.K + INOE.K

3.02 D4E.K = D4EI + ISTF.K + IRPF.K + ISNF.K + INOF.K

D1GI = Initial Value-Customer Cargo Demand-Outgoing

D1CI = Initial Value-Customer Cargo Demand-Incoming

D2GI = Initial Value-Customer PAX Demand-Outgoing

D2CI = Initial Value-Customer PAX Demand-Incoming

D3SI = Initial Value-Customer SAAM Demand

D4EI = Initial Value-Customer Exercise Demand

The step input is provided by the following variables.

1.26 ISTA.K = STEP (XA,5)

1.27 ISTB.K = STEP (XB,5)

2.04 ISTC.K = STEP (XC,5)

2.05 ISTD.K = STEP (XD,5)

3.03 ISTE.K = STEP (XE,5)

3.04 ISTF.K = STEP (XF,5)

The ramp input is provided by the following variables:

1.28 IRPA.K = RAMP (YA,5)

1.29 IRPB.K = RAMP (YB,5)

2.27 IRPC.K = RAMP (YC,5)

2.28 IRPD.K = RAMP (YD,5)

3.21 IRPE.K = RAMP (YE,5)

3.22 IRPF.K = RAMP (YF,5)

The sine input is provided by the following equations:

1.30 ISNA.K = STEP (SNA.K,5)

1.31 SNA.K = X1G * SIN ((6.3 * TIME.K)/PER1)

1.32 ISNB.K = STEP (SNB.K,5)

1.33 SNB.K = X1C * SIN ((6.3 * TIME.K)/PER1)

2.29 ISNC.K = STEP (SNC.K,5)

2.30 SNC.K = X2G * SIN ((6.3 * TIME.K)/PER2)

2.31 ISND.K = STEP (SND.K,5)

2.32 SND.K = X2C * SIN ((6.3 * TIME.K)/PER2)

3.23 ISNE.K = STEP (SNE.K,5)

3.24 SNE.K = X3X * SIN ((6.3 * TIME.K)/PER3)

3.25 ISNF.K = STEP (SNF.K,5)

3.26 SNF.K = X4X * SIN ((6.3 * TIME.K)/PER4)

The noise input is provided by the following equations:

1.34 INOA.K = STEP (NOA.K,5)

1.35 NOA.K = IX1 * NORMRN (NAEM, STV1)

1.36 INOB.K = STEP (NOB.K,5)

1.37 NOB.K = IX2 * NORMRN (NAEM, STV2)

2.33 INOC.K = STEP (NOC.K,5)

2.34 NOC.K = IX3 * NORMRN (NAEM, STV3)

2.35 INOD.K = STEP (NOD.K,5)

2.36 NOD.K = IX4 * NORMRN (NAEM, STV4)

3.27 INOE.K = STEP (NOF.K,5)

3.28 NOE.K = IX5 * NORMRN (NAEM, STV5)

3.29 INOF.K = STEP (NOF.K,5)

3.30 NOF.K = IX6 * NORMRN (NAEM, STV6)

Initial Values

Each variable in the model has been identified in terms of other variables and constants. The variables must all be given an initial value before the model will be operational. The Dynamo Compiler requires that the value of all level equations be identified and the value for the majority of the auxiliary and rate equations will be computed by the Compiler. All variables and their initial equations are identified by figure number and a listing given in the Appendices. All initial values have been appropriately selected so the model will be in steady state. Any dynamics in the model caused by a change in a variable or due to a change in input can then be attributed to that specific change and the structure of the system as concerned.

Output Information

The Dynamo Compiler enables us to request information regarding the value of any variable through the length of the model run.

The specification card for each run looks something like this:

SPEC DT = 0.1/LENGTH = 100/PRTPER = 2/PLTPER = 3

This indicates that each variable will be computed every 0.1 week in our model as the basic time period has been specified as a week. The length of the simulation run will be 100 weeks and we have requested it to print information on the value of specified variables every 2 weeks and plot specified variables every 3 weeks. The information on the Spec Card can be changed to provide the output information necessary for an appropriate analysis.

For the basic model we have requested information on those variables which we believe to be most significant in our analysis. This information is listed in Appendix XVI.

Summary

This report has presented a graphical description of the basic model of the ASIF in Figures 1 through 15. A verbal description of the model with an explanation of the reason for selecting each variable and the rationale for each variable relationship has accompanied each figure. The appendices finally list all the variables, their initial values, and the input variables which may be used for model testing. The output information to be requested has also been identified.

The model has been tested for logic errors and is found to be logically correct. At this time the Analyst feels this model is a reasonable representation of the ASIF system and will replicate the dynamics of the ASIF system created by various input data.

APPENDICES

I THROUGH XVI

APPENDIX I

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NOTE          FIG.01  CARGO MODEL
  A   D1G.K=D1GI+ISTA.K+IRPA.K+ISNA.K+INOA.K          1.01
  A   D1C.K=D1CI+ISTB.K+IRPB.K+ISNB.K+INOB.K          1.02
  R     S1G.KL=S1GT.K                                  1.03
  R     S1C.KL=S1CT.K                                  1.04
6R    IS1G.KL=D1G.K                                    1.05
6R    IS1C.KL=D1C.K                                    1.06
1L    IN1G.K=IN1G.J+(DT)(IS1G.JK-S1G.JK)               1.07
1L    IN1C.K=IN1C.J+(DT)(IS1C.JK-S1C.JK)               1.08
44A   S1GT.K=(IN1G.K)(1/D17)                           1.09
44A   S1CT.K=(IN1C.K)(1/D18)                           1.10
20A   C1G.K=S1GT.K/U1G                                 1.11
20A   C1C.K=S1CT.K/U1C                                 1.12
12A   TC1.K=(2)(MX1.K)                                 1.13
56A   MX1.K=MAX(C1G.K,C1C.K)                           1.14
  R    CB1.KL=CLIP(TCB1.K,0,TCB1.K,0)                  1.15
7A    TCB1.K=TC1.K-ACC.K                               1.16
3L    SD1C.K=SD1C.J+(DT)(1/D120)(IS1C.JK-SD1C.J)       1.17
3L    SD1G.K=SD1G.J+(DT)(1/D119)(IS1G.JK-SD1G.J)       1.18
12A   ACC.K=(CPD)(CCA.K)                               1.19
6R    R1G.KL=IS1G.JK                                   1.20
  A    RT1G.K=(1/DT)(IS1G.JK-R1G.JK)                   1.21
3L    SR1G.K=SR1G.J+(DT)(1/SDL)(RT1G.J-SR1G.J)         1.22
6R    R1C.KL=IS1C.JK                                   1.23
  A    RT1C.K=(1/DT)(IS1C.JK-R1C.JK)                   1.24
3L    SR1C.K=SR1C.J+(DT)(1/SDL)(RT1C.J-SR1C.J)         1.25
  A   ISTA.K=STEP(XA,5)                                1.26
  A   ISTB.K=STEP(XB,5)                                1.27
  A   IRPA.K=RAMP(YA,5)                                1.28
  A   IRPB.K=RAMP(YB,5)                                1.29
  A   ISNA.K=STEP(SNA.K,5)                             1.30
  A   SNA.K=X1G*SIN((6.3*TIME.K)/PER1)                 1.31
  A   ISNB.K=STEP(SNB.K,5)                             1.32
  A   SNB.K=X1C*SIN((6.3*TIME.K)/PER1)                 1.33
  A   INOA.K=STEP(NOA.K,5)                             1.34
```

```
  A   NOA.K=IX1*NORMRN(NAEM,STV1)                                 1.35
  A   INOB.K=STEP(NOB.K,5)                                        1.36
  A   NOB.K=IX2*NORMRN(NAEM,STV2)                                 1.37
                    INITIAL CONDITIONS AND PARAMETERS
6N    D1C=D1CI                                                    1.50
6N    D1G=D1GI                                                    1.51
6N    IN1G=IN1GI                                                  1.52
6N    IN1C=IN1CI                                                  1.53
    N SD1C=SD1CI                                                  1.54
    N SD1G=SD1GI                                                  1.55
C     D120=24                                                     1.56
C     D1GI=40000000                                               1.57
  C   XA=0                                                        1.58
C     D1CI=40000000                                               1.59
  C   XB=0                                                        1.60
C     D17=0.3                                                     1.61
C     D18=0.3                                                     1.62
C     IN1GI=12E6                                                  1.63
C     IN1CI=12E6                                                  1.64
C     U1G=0.81                                                    1.65
C     U1C=0.81                                                    1.66
C     D119=24                                                     1.67
C     CPD=0.907                                                   1.68
C     SDL=20                                                      1.69
  C   YA=0                                                        1.71
  C   YB=0                                                        1.72
  C    NAEM=0                                                     1.73
  C    IX1=0                                                      1.74
  C    IX2=0                                                      1.75
  C    STV1=0                                                     1.76
  C    STV2=0                                                     1.77
C      X1G=0                                                      1.78
C      X1C=0                                                      1.79
C      PER1=26                                                    1.80
  C    SD1CI=40E6                                                 1.81
  C    SD1GI=40E6                                                 1.82
    N SR1G=SR1GI                                                  1.83
```

```
C SR1GI=C                                                   1.84
N SR1C=SR1C1                                                1.85
C SR1CI=0                                                   1.86
```

APPENDIX II

```
NOTE           FIG.C2  PAX MODEL
  A   D2G.K=D2GI+ISTC.K+IRPC.K+ISNC.K+INOC.K                  2.01
  A   D2C.K=D2CI+ISTD.K+IRPD.K+ISND.K+INOD.K                  2.02
  A   ISTC.K=STEP(XC,5)                                       2.03
  A   ISTD.K=STEP(XD,5)                                       2.04
6R    IS2G.KL=D2G.K                                           2.05
6R    IS2C.KL=D2C.K                                           2.06
1L    IN2G.K=IN2G.J+(DT)(IS2G.JK-S2G.JK)                      2.07
1L    IN2C.K=IN2C.J+(DT)(IS2C.JK-S2C.JK)                      2.08
7A    MPR.K=TC2.K-CB2.K                                       2.09
  A    RT2C.K=(1/DT)(IS2C.JK-R2C.JK)                          2.10
3L    SR2C.K=SR2C.J+(DT)(1/SDP)(RT2C.J-SR2C.J)                2.11
44A   S2GT.K=(IN2G.K)(1/D27)                                  2.12
6R    S2G.KL=S2GT.K                                           2.13
44A   S2CT.K=(IN2C.K)(1/D28)                                  2.14
6R    S2C.KL=S2CT.K                                           2.15
20A   C2G.K=S2GT.K/U2G                                        2.16
20A   C2C.K=S2CT.K/U2C                                        2.17
56A   MX2.K=MAX(C2G.K,C2C.K)                                  2.18
12A   TC2.K=(2)(MX2.K)                                        2.19
12A   CB2.K=(TC2.K)(FCB)                                      2.20
3L    SD2G.K=SD2G.J+(DT)(1/D219)(IS2G.JK-SD2G.J)              2.21
3L    SD2C.K=SD2C.J+(DT)(1/D220)(IS2C.JK-SD2C.J)              2.22
6R    R2G.KL=IS2G.JK                                          2.23
  A   RT2G.K=(1/DT)(IS2G.JK-R2G.JK)                           2.24
3L    SR2G.K=SR2G.J+(DT)(1/SDP)(RT2G.J-SR2G.J)                2.25
6R    R2C.KL=IS2C.JK                                          2.26
  A   IRPC.K=RAMP(YC,5)                                       2.27
  A   IRPD.K=RAMP(YD,5)                                       2.28
  A   ISNC.K=STEP(SNC.K,5)                                    2.29
  A   SNC.K=X2G*SIN((6.3*TIME.K)/PER2)                        2.30
  A   ISND.K=STEP(SND.K,5)                                    2.31
  A   SND.K=X2C*SIN((6.3*TIME.K)/PER2)                        2.32
  A   INOC.K=STEP(NOC.K,5)                                    2.33
  A   NOC.K=IX3*NORMRN(NAEM,STV3)                             2.34
```

```
  A   INOD.K=STEP(NOD.K,5)                                    2.35
  A   NOD.K=(IX4)*NORMRN(NAEM,STV4)                           2.36
                    INITIAL CONDITIONS AND PARAMETERS
6N    D2G=D2GI                                                2.50
6N    D2C=D2CI                                                2.51
6N    IN2G=IN2GI                                              2.52
6N    IN2C=IN2CI                                              2.53
    N SD2C=SD2CI                                              2.54
    N SD2G=SD2GI                                              2.55
C     D2GI=10E7                                               2.56
  C   XC=0                                                    2.57
C     D2CI=10E7                                               2.58
  C   XD=0                                                    2.59
C     D27=0.2                                                 2.60
C     D28=0.2                                                 2.61
C     IN2GI=20E6                                              2.62
C     IN2CI=20E6                                              2.63
C     U2G=0.81                                                2.64
C     U2C=0.81                                                2.65
C     D219=24                                                 2.66
C     D220=24                                                 2.67
  C   YC=0                                                    2.68
  C   YD=0                                                    2.69
  C    IX3=0                                                  2.70
  C    IX4=0                                                  2.71
  C    STV3=0                                                 2.72
  C    STV4=0                                                 2.73
C      X2G=0                                                  2.74
C      X2C=0                                                  2.75
C      PER2=26                                                2.76
  C    SD2CI=100E6                                            2.77
  C    SD2GI=100E6                                            2.78
    N SR2G=SR2GI                                              2.79
    C SR2GI=0                                                 2.80
  N    SR2C=SR2CI                                             2.81
    C SR2CI=0                                                 2.82
C      FCB=0.92                                               2.83
```

2.84

C SDP=2C

APPENDIX III

```
NOTE          FIG.C3   SAAM & EXERCISE MODEL
  A   D3S.K=D3SI+ISTE.K+IRPE.K+ISNE.K+INOE.K                     3.01
  A   D4E.K=D4EI+ISTF.K+IRPF.K+ISNF.K+INOF.K                     3.02
  A   ISTE.K=STEP(XE,5)                                          3.03
  A   ISTF.K=STEP(XF,5)                                          3.04
6R    IS3.KL=D3S.K                                               3.05
6R    IS4.KL=D4E.K                                               3.06
1L    IN3.K=IN3.J+(DT)(IS3.JK-S3S.JK)                            3.07
1L    IN4.K=IN4.J+(DT)(IS4.JK-S4E.JK)                            3.08
39R   S3S.KL=DELAY3(IS3.JK,D34)                                  3.09
39R   S4E.KL=DELAY3(IS4.JK,D316)                                 3.10
3L    SD3.K=SD3.J+(DT)(1/D312)(IS3.JK-SD3.J)                     3.11
3L    SD4.K=SD4.J+(DT)(1/D38)(IS4.JK-SD4.J)                      3.12
42A   FH3.K=S3S.JK/((SPD3)(CAP3))                                3.13
42A   FH4.K=S4E.JK/((SPD4)(CAP3))                                3.14
6R    R3.KL=IS3.JK                                               3.15
6R    R4.KL=IS4.JK                                               3.16
  A   RT3.K=(1/DT)(IS3.JK-R3.JK)                                 3.17
  A    RT4.K=(1/DT)(IS4.JK-R4.JK)                                3.18
3L    SR3.K=SR3.J+(DT)(1/SDS)(RT3.J-SR3.J)                       3.19
3L    SR4.K=SR4.J+(DT)(1/SDS)(RT4.J-SR4.J)                       3.20
  A   IRPE.K=RAMP(YE,5)                                          3.21
  A   IRPF.K=RAMP(YF,5)                                          3.22
  A   ISNE.K=STEP(SNE.K,5)                                       3.23
  A   SNE.K=X3X*SIN((6.3*TIME.K)/PER3)                           3.24
  A   ISNF.K=STEP(SNF.K,5)                                       3.25
  A   SNF.K=X4X*SIN((6.3*TIME.K)/PER4)                           3.26
  A   INOE.K=STEP(NOE.K,5)                                       3.27
  A   NOE.K=IX5*NORMRN(NAEM,STV5)                                3.28
  A   INOF.K=STEP(NOF.K,5)                                       3.29
  A   NOF.K=IX6*NORMRN(NAEM,STV6)                                3.30
                 INITIAL CONDITIONS AND PARAMETERS
6N    D3S=D3SI                                                   3.50
6N    D4E=D4EI                                                   3.51
6N    IN3=IN3I                                                   3.52
```

```
6N    IN4=IN4I                  3.53
6N    SD3I=D3SI                 3.54
6N    SD4I=D4EI                 3.55
C     D3SI=24000000             3.56
  C   XE=0                      3.57
C     D4EI=685000               3.58
  C   XF=0                      3.59
C     IN3I=12000000             3.60
C     IN4I=2055000              3.61
C     D34=0.5                   3.62
C     D316=3                    3.63
C     D312=24                   3.64
C     D38=24                    3.65
C     SPD3=462                  3.66
C     SPD4=462                  3.67
C     CAP3=24.6                 3.68
C     CAP4=24.6                 3.69
C     SDS=20                    3.70
  C    IX5=0                    3.71
  C    IX6=0                    3.72
  C    STV5=0                   3.73
  C    STV6=0                   3.74
C      X4X=0                    3.75
C      PER4=26                  3.76
C      X3X=0                    3.77
C      PER3=26                  3.78
    N  SR3=SR3I                 3.79
    C  SR3I=0                   3.80
    N  SR4=SR4I                 3.81
    C  SR4I=0                   3.82
    N  SD3=SD3I                 3.83
    N  SD4=SD4I                 3.84
  C   YE=0                      3.85
  C   YF=0                      3.86
```

APPENDIX IV

```
NOTE          FIG.04  AVAILABLE & DISTRIBUTED MILITARY CAPASITY
12A  TRFC.K (TAF.K)(UTAF)                                        4.01
47A  AF .K=RAMP(RMP,5)                                           4.02
7A   TAF.K TAFI+AFI.K                                            4.03
13A  TCAP.K=(TRFC.K)(SPD)(CAP)                                   4.04
6R   TRNR.KL=TRN.K                                               4.05
9A   ACAP.K=TCAP.K-S3S.JK-S4E.JK-TRN.K                           4.06
3L   SMT.K=SMT.J+(DT)(1/D428)(TRNR.JK-SMT.J)                     4.07
7A   CCA.K=ACAP.K-PCA.K                                          4.08
12A  PCA.K=(PPD)(PMC.K)                                          4.09
42A  FH1.K=CCA.K/((S423)(C424))                                  4.10
12A  PMC.K=(MPR.K)(PAX)                                          4.11
42A  FH2.K=PCA.K/((S416)(C417))                                  4.12
12A  TRN.K-(TRNI)(MLTD.K)                                        4.13
3L   MLTD.K=MLTD.J+(DT)(1/DMA)(MLT.J-MLTD.J)                     4.14
  L   SX1.K=SX1.J+(DT)(1/DXC)(EX1C.JK-SX1.J)                     4.15
  L   SX2.K=SX2.J+(DT)(1/DXP)(ER2C.JK-SX2.J)                     4.16
  A   SXX.K=SX1.K+SX2.K                                          4.17
   A  RTD.K=SXX.K/CEC                                            4.18
  A   MLT.K=TABLE(TAB,RTD.K,0,1.5,0.1)                           4.19
              INITIAL CONDITIONS AND PARAMETERS
    N SX2=SX2I                                                   4.46
  N    SX1=SX1I                                                  4.47
  N   SMT=TRNI                                                   4.48
  N    MLTD=MLTDI                                                4.49
6N    TAF=TAFI                                                   4.50
6N    TRN=TRNI                                                   4.51
C     UTAF=52                                                    4.52
C     TAFI=176                                                   4.53
C     RMP=0                                                      4.54
C     SPD=462                                                    4.55
C     CAP=24.6                                                   4.56
C     D428=52                                                    4.57
C     PPD=1.069                                                  4.58
C     PAX=0.235                                                  4.59
```

```
C     S416=462                                                    4.60
C     C417=24.6                                                   4.61
C     S423=462                                                    4.62
C     C424=24.6                                                   4.63
C     MLTDI=1                                                     4.64
C     DMA=1                                                       4.65
C     TRNI=13.4E6                                                 4.66
   C    SX1I=6.8E6                                                4.67
   C    SX2I=5.7E6                                                4.68
   C    CEG=10E6                                                  4.69
   1  TAR=5/3/2.5/2.3/2.0/1.8/1.6/1.5/1.3/1.1/1.0/1/1/1/1/1       4.70
   C  DXC=25                                                      4.71
   C  DXP=25                                                      4.72
```

APPENDIX V

```
NOTE           FIG.65  INDUSTRIAL FUND MANIFEST MODEL
39R  TP1.KL=DELAY3(MR1.JK,D515)                       5.01
39R  FP1.KL=DELAY3(TP1.JK,D516)                       5.02
39R  MP1.KL=DELAY3(FP1.JK,D519)                       5.03
39R  TP2.KL=DELAY3(MR2.JK,D523)                       5.04
39R  FP2.KL=DELAY3(TP2.JK,D526)                       5.05
39R  MP2.KL=DELAY3(FP2.JK,D529)                       5.06
39R  TP3.KL=DELAY3(MR3.JK,D533)                       5.07
39R  TP4.KL=DELAY3(MR4.JK,D543)                       5.08
7R   MR2.KL=S2GT.K+S2CT.K                             5.09
6R   MR3.KL=DELAY3(IS3.JK,D34)                        5.10
6R   MR4.KL=DELAY3(IS4.JK,D316)                       5.11
39R  FP3.KL=DELAY3(TP3.JK,D536)                       5.12
39R  FP4.KL=DELAY3(TP4.JK,D546)                       5.13
39R  MP3.KL=DELAY3(FP3.JK,D539)                       5.14
39R  MP4.KL=DELAY3(FP4.JK,D549)                       5.15
   7R  MR1.KL=S1GT.K+S1CT.K                           5.16
               INITIAL CONDITIONS AND PARAMETERS
C    D513=3                                           5.50
C    D516=0.3                                         5.51
C    D519=2                                           5.52
C    D523=3                                           5.53
C    D526=0.3                                         5.54
C    D529=2                                           5.55
C    D533=2                                           5.56
C    D543=2                                           5.57
C    D536=0.3                                         5.58
C    D546=0.3                                         5.59
C    D539=2                                           5.60
C    D549=2                                           5.61
```

APPENDIX VI

```
NOTE          FIG.06  CASH FLOW MODEL
12R  BR1.KL=(TRF1.K)(MP1.JK)                                      6.01
12R  BR2.KL=(TRF2.K)(MP2.JK)                                      6.02
12R  BR3.KL=(TRF3.K)(MP3.JK)                                      6.03
12R  BR4.KL=(TRF3.K)(MP4.JK)                                      6.04
39R  CR1.KL=DELAY3(BR1.JK,D614)                                   6.05
39R  CR2.KL=DELAY3(BR2.JK,D624)                                   6.06
39R  CR3.KL=DELAY3(BR3.JK,D634)                                   6.07
39R  CR4.KL=DELAY3(BR4.JK,D644)                                   6.08
2L   CSH.K=CSH.J+(DT)(CR1.JK+CR2.JK+CR3.JK+CR4.JK-COR.JK+0)       6.09
20R  NCR.KL=CSHT.K/DT                                             6.10
7A   CSHT.K=CSH.K-5.0E6                                           6.11
1L   PDA.K=PDA.J+(DT)(EPR.J-COR.JK)                               6.12
6N   PDA=PDAI                                                     6.13
54R  COR.KL=MIN(DCR.K,NCR.JK)                                     6.14
20A  DCR.K=PDA.K/DT                                               6.15
9A   EPR.K=ER1.K+ER2.K+ER3.K+ER4.K                                6.16
10A  ER1.K=PR1A.JK+PR1B.JK+PR1D.JK+PR1P.JK+PR1C.JK+0              6.17
10A  ER2.K=PR2A.JK+PR2B.JK+PR2D.JK+PR2P.JK+PR2C.JK+0              6.18
9A   ER3.K=PR3A.JK+PR3B.JK+PR3D.JK+PR3P.JK                        6.19
9A   ER4.K=PR4A.JK+PR4B.JK+PR4D.JK+PR4P.JK                        6.20
               INITIAL CONDITIONS AND PARAMETERS
6N   TRF1=TRF1I                                                   6.50
N    TRF2=TRF2I                                                   6.51
N    TRF3=TRF3I                                                   6.52
 N    SSEI=SSEII                                                  6.53
  N   CSH=CSHI                                                    6.54
  C   TRF1I=0.095                                                 6.55
  C   TRF2I=0.03                                                  6.56
  C   TRF3I=0.128                                                 6.57
 C    SSEII=2.078E6                                               6.58
  C   CSHI=25.E6                                                  6.59
  C   PDAI=0                                                      6.60
   C  D614=2                                                      6.61
   C  D624=2                                                      6.62
```

```
C   Db34=1          6.63
:   Db44=4          0.64
```

APPENDIX VII

```
NOTE            FIG.67  CARGO EXPENSE MODEL
  R    ER1B.KL=E715+FH1.K*E716                                7.01
R      ER1D.KL=(1)(E722)+(E723)(FH1.K)                        7.02
12R    ER1P.KL=(E728)(FH1.K)                                  7.03
6R     ER1A.KL=E710                                           7.04
39R    PR1A.KL=DELAY3(ER1A.JK,D713)                           7.05
39R    PR1B.KL=DELAY3(ER1B.JK,D720)                           7.06
39R    PR1D.KL=DELAY3(ER1D.JK,D726)                           7.07
39R    PR1P.KL=DELAY3(ER1P.JK,D731)                           7.08
12R    ER1C.KL=(E733)(CB1.JK)                                 7.09
39R    PR1C.KL=DELAY3(ER1C.JK,D736)                           7.10
                   INITIAL CONDITIONS AND PARAMETERS
C      E710=134500                                            7.50
C      E715=239.4E3                                           7.52
C      E716=126                                               7.53
C      E722=111.8E3                                           7.55
C      E723=53                                                7.56
C      E728=244                                               7.57
C      E733=0.1770                                            7.58
C      D713=4                                                 7.59
C      D720=4                                                 7.60
C      D726=4                                                 7.61
C      D731=4                                                 7.62
C      D736=1                                                 7.63
```

APPENDIX VIII

```
NOTE          FIG.08  PAX EXPENSE MODEL
6R    ER2A.KL=E810                                        8.01
39R   PR2A.KL=DELAY3(ER2A.JK,D813)                        8.02
  R   ER2B.KL=E815+FH2.K*E816                             8.03
39R   PR2B.KL=DELAY3(ER2B.JK,D820)                        8.04
R     ER2D.KL=(1)(E822)+(E823)(FH2.K)                     8.05
39R   PR2D.KL=DELAY3(ER2D.JK,D826)                        8.06
12R   ER2P.KL=(E828)(FH2.K)                               8.07
39R   PR2P.KL=DELAY3(ER2P.JK,D831)                        8.08
12R   ER2C.KL=(E833)(CB2.K)                               8.09
39R   PR2C.KL=DELAY3(ER2C.JK,D836)                        8.10
                INITIAL CONDITIONS AND PARAMETERS
C     E810=10200                                          8.50
C     E815=18125                                          8.51
C     E816=125                                            8.52
C     E822=8451                                           8.54
C     E823=53                                             8.55
C     E828=244                                            8.56
C     E833=0.0252                                         8.57
C     D813=4                                              8.58
C     D820=4                                              8.59
C     D826=4                                              8.60
C     D831=4                                              8.61
C     D836=1                                              8.62
```

APPENDIX IX

```
NOTE           FIG.09  SAAM EXPENSE MODEL
39R  PR3A.KL=DELAY3(ER3A.JK,D913)                      9.01
  R   ER3B.KL=E915+FH3.K*E916                           9.02
39R  PR3B.KL=DELAY3(ER3B.JK,D920)                      9.03
R    ER3D.KL=(1)(E922)+(E923)(FH3.K)                   9.04
39R  PR3D.KL=DELAY3(ER3D.JK,D926)                      9.05
12R  ER3P.KL=(E928)(FH3.K)                             9.06
39R  PR3P.KL=DELAY3(ER3P.JK,D931)                      9.07
6R   ER3A.KL=E910                                      9.08
               INITIAL CONDITIONS AND PARAMETERS
C    E910=57100                                        9.50
C    E915=101.6E3                                      9.51
C    E916=126                                          9.52
C    E922=47.4E3                                       9.54
C    E923=53                                           9.55
C    E928=244                                          9.56
C    D913=4                                            9.57
C    D920=4                                            9.58
C    D926=4                                            9.59
C    D931=4                                            9.60
```

APPENDIX X

```
NOTE           FIG.10  EXERCISE EXPENSE MODEL
 R     ER4B.KL=ET15+FH4.K*ET16                                     10.01
6R     ER4A.KL=ET10                                                10.02
39R    PR4A.KL=DELAY3(ER4A.JK,DT13)                                10.03
39R    PR4B.KL=DELAY3(ER4B.JK,DT20)                                10.04
R      ER4D.KL=(1)(ET22)+(ET23)(FH4.K)                             10.05
39R    PR4D.KL=DELAY3(ER4D.JK,DT26)                                10.06
12R    ER4P.KL=(ET28)(FH4.K)                                       10.07
39R    PR4P.KL=DELAY3(ER4P.JK,DT31)                                10.08
                    INITIAL CONDITIONS AND PARAMETERS
C      ET10=2000                                                   10.50
C      ET15=3625                                                   10.51
C      ET16=126                                                    10.52
C      ET22=1701                                                   10.54
C      ET23=53                                                     10.55
C      ET28=244                                                    10.56
C      DT13=1                                                      10.57
C      DT20=1                                                      10.58
C      DT26=1                                                      10.59
C      DT31=1                                                      10.60
```

APPENDIX XI

```
NOTE          FIG.11  TARIFF DECISION MODEL
 L   TCE.K=TCE.J+DT*(ER1A.JK+ER1B.JK+ER1D.JK+ER1P.JK+ER1C.JK)  11.01
 L   TPE.K=TPE.J+DT*(ER2A.JK+ER2B.JK+ER2D.JK+ER2P.JK+ER2C.JK)  11.03
52L  TSE.K=TSE.J+(DT)(ER3A.JK+ER3B.JK+ER3D.JK+ER3P.JK)         11.04
9A   TE.K=TCE.K+TPE.K+TSE.K+TEE.K                              11.05
 L   TEE.K=TEE.J+(DT)(ER4A.JK+ER4B.JK+ER4D.JK+ER4P.JK)         11.06
1L   TPI.K=TPI.J+(DT)(MI2.J+C)                                 11.07
52L  TI.K=TI.J+(DT)(MI1.J+MI2.J+MI3.J+MI4.J)                   11.08
A    TECI.K=TI.K-TPI.K                                         11.09
A    TCEE.K=TE.K-TPE.K                                         11.10
 A   CD.K=TECI.K-TCEE.K                                        11.11
7A   PD.K=TPI.K-TPE.K                                          11.13
12A  MI1.K=(MR1.JK)(TRF1.K)                                    11.14
12A  MI2.K=(MR2.JK)(TRF2.K)                                    11.15
12A  MI3.K=(MR3.JK)(TRF3.K)                                    11.16
12A  MI4.K=(MR4.JK)(TRF3.K)                                    11.17
3L   SCI.K=SCI.J+(DT)(1/DE15)(MI1.J-SCI.J)                     11.18
3L   SP1.K=SP    (DT)(1/DE16)(MI2.J-SP1.J)                     11.19
4L   SSEI.K=S[illegible].J+(DT)(1/DE17)(MI3.J+MI4.J-SSEI.J+0+0+C)  11.20
A    SCE1.K=SCI.K+SSEI.K                                       11.21
7R   TTR1.KL=TRF1.K                                            11.22
7R   TTR2.KL=TRF2.K                                            11.23
7R   TTR3.KL=TRF3.K                                            11.24
7A   TT1.K=TTR1.JK                                             11.25
7A   TT2.K=TTR2.JK                                             11.26
7A   TT3.K=TTR3.JK                                             11.27
A    RC.K=(100)(CDX.K)/SCE1.K                                  11.28
44A  RP.K=(100)(PDX.K)/SPI.K                                   11.29
A    RCX.K=(-1)(CD.K)                                          11.30
A    RPX.K=(-1)(PD.K)                                          11.31
A    CDX.K=CLIP(CD.K,RCX.K,CD.K,C)                             11.32
A    PDX.K=CLIP(PD.K,RPX.K,PD.K,0)                             11.33
51A  FTT1.K=CLIP(TR1.K,TT1.K,RC.K,DRC)                         11.34
51A  FTT2.K=CLIP(TR2.K,TT2.K,RP.K,DRP)                         11.35
A    FTT3.K=CLIP(TR3.K,TT3.K,RC.K,DRC)                         11.36
```

```
51A   STT1.K=CLIP(FTT1.K,TT1.K,TMD1.K,DTMD)                 11.42
51A   STT2.K=CLIP(FTT2.K,TT2.K,TMD2.K,DTMD)                 11.43
51A   STT3.K=CLIP(FTT3.K,TT3.K,TMD3.K,DTMD)                 11.44
A     DF1.K=STT1.K-TT1.K                                    11.45
A     DF2.K=STT2.K-TT2.K                                    11.46
A     DF3.K=STT3.K-TT3.K                                    11.47
A     DF4.K=(-1)(DF1.K)                                     11.48
A     DF5.K=(-1)(DF2.K)                                     11.49
A     DF6.K=(-1)(DF3.K)                                     11.50
  A   DF7.K=MAX(DF1.K,DF4.K)                                11.51
  A   DF8.K=MAX(DF2.K,DF5.K)                                11.52
  A   DF9.K=MAX(DF3.K,DF6.K)                                11.53
A     TCH1.K=(1/TT1.K)(DF7.K)                               11.54
A     TCH2.K=(1/TT2.K)(DF8.K)                               11.55
A     TCH3.K=(1/TT3.K)(DF9.K)                               11.56
51A   DTM1.K=CLIP(TIME.K,PTM1.K,TCH1.K,DCH)                 11.57
51A   DTM2.K=CLIP(TIME.K,PTM2.K,TCH2.K,DCH)                 11.58
51A   DTM3.K=CLIP(TIME.K,PTM3.K,TCH3.K,DCH)                 11.59
7R    DET1.KL=DTM1.K                                        11.60
7R    DET2.KL=DTM2.K                                        11.61
7R    DET3.KL=DTM3.K                                        11.62
A     PTM1.K=DET1.JK                                        11.63
A     PTM2.K=DET2.JK                                        11.64
A     PTM3.K=DET3.JK                                        11.65
7A    TMD1.K=TIME.K-PTM1.K                                  11.66
7A    TMD2.K=TIME.K-PTM2.K                                  11.67
7A    TMD3.K=TIME.K-PTM3.K                                  11.68
51A   TRF1.K=CLIP(STT1.K,TT1.K,TCH1.K,DCH)                  11.69
51A   TRF2.K=CLIP(STT2.K,TT2.K,TCH2.K,DCH)                  11.70
51A   TRF3.K=CLIP(STT3.K,TT3.K,TCH3.K,DCH)                  11.71
                  INITIAL CONDITIONS AND PARAMETERS
6N    TCE=TCEI                                              11.100
6N    TPE=TPEI                                              11.101
6N    TSE=TSEI                                              11.102
6N    TEE=TEEI                                              11.104
6N    TE=TEI                                                11.105
6N    TPI=TPII                                              11.107
```

```
6N    TI=TII                                   11.108
6N    SCI=SCII                                 11.109
6N    SPI=SPII                                 11.110
N     TT1=TT1I                                 11.112
N     TT2=TT2I                                 11.113
N     TT3=TT3I                                 11.114
N     TMD1=TMD1I                               11.115
N     TMD2=TMD2I                               11.116
N     TMD3=TMD3I                               11.117
N     TCH1=TCH1I                               11.118
N     TCH2=TCH2I                               11.119
N     TCH3=TCH3I                               11.120
N     PTM1=PTM1I                               11.121
N     PTM2=PTM2I                               11.122
N     PTM3=PTM3I                               11.123
N     DTM1=DTM1I                               11.124
N     DTM2=DTM2I                               11.125
N     DTM3=DTM3I                               11.126
C     TCEI=0                                   11.127
C     TPEI=0                                   11.128
C     TSEI=0                                   11.129
C     TEEI=0                                   11.130
C     TEI=0                                    11.131
C     TPII=0                                   11.132
C     TII=0                                    11.133
C     SCII=12E6                                11.134
C     SPII=5E6                                 11.135
C     DE15=8                                   11.136
C     DE16=8                                   11.137
C     DE17=8                                   11.138
C     DRC=100                                  11.139
C     DRP=100                                  11.140
C     DTMD=12                                  11.147
C     DCH=0.01                                 11.148
   C  TT1I=0.095                               11.149
   C  TT2I=0.05                                11.150
   C  TT3I=0.128                               11.151
```

```
C     TMD1I=0                                                 11.152
C     TMD2I=0                                                 11.153
C     TMD3I=0                                                 11.154
C     TCH1I=0                                                 11.155
C     TCH2I=0                                                 11.156
C     TCH3I=0                                                 11.157
C     PTM1I=0                                                 11.158
C     PTM2I=0                                                 11.159
C     PTM3I=0                                                 11.160
C     DTM1I=0                                                 11.161
C     DTM2I=0                                                 11.162
C     DTM3I=0                                                 11.163
```

APPENDIX XII

```
NOTE            FIG.12  MILITARY CAPABILITY MODEL
8A    FCAP.K=TCAP.K-SMT.K-FD34.K                          12.01
7A    FCC.K=FCAP.K-FPC.K                                  12.02
12A   FPC.K=(PPD)(FPR.K)                                  12.03
A     F1A.K=(FCC.K)(CPD)                                  12.04
7A    F2A.K=FD2X.K-FCB1.K                                 12.05
7A    FMC1.K=FCC.K+FCB1.K                                 12.06
7A    FMC2.K=FPC.K+F2R.K                                  12.07
8A    FTC.K=FMC1.K+FMC2.K+FD34.K                          12.08
A     FPR.K=F2A.K/FPAX                                    12.09
```

APPENDIX XII

```
NOTE           FIG.12  MILITARY CAPABILITY MODEL
8A    FCAP.K=ICAP.K-SMT.K-FD34.K                        12.01
7A    FCC.K=FCAP.K-FPC.K                                12.02
12A   FPC.K=(PPD)(FPR.K)                                12.03
A     F1A.K=(FCC.K)(CPD)                                12.04
7A    F2A.K=FD2X.K-FCB2.K                               12.05
7A    FMC1.K=FCC.K+FCR1.K                               12.06
7A    FMC2.K=FPC.K+F2R.K                                12.07
8A    FTC.K=FMC1.K+FMC2.K+FD34.K                        12.08
A     FPR.K=F2A.K/FPAX                                  12.09
```

APPENDIX XIII

```
NOTE           FIG.13  DEMAND FORCASTING MODEL
  A    FFD1G.K=(1/FU1G)(SD1G.K+G1G.K)                    13.01
  A    FFD2G.K=(1/FU2G)(SD2G.K+G2G.K)                    13.02
  A    FFD1C.K=(1/FU1C)(SD1C.K+G1C.K)                    13.03
  A    FFD2C.K=(1/FU2C)(SD2C.K+G2C.K)                    13.04
  A    FFD3.K=SD3.K+G3.K                                 13.05
  A    FFD4.K=SD4.K+G4.K                                 13.06
7A    FD34.K=FD3.K+FD4.K                                 13.07
56A   FMX1.K=MAX(FD1G.K,FD1C.K)                          13.08
12A   FD1X.K=(2)(FMX1.K)                                 13.09
56A   FMX2.K=MAX(FD2G.K,FD2C.K)                          13.10
12A   FD2X.K=(2)(FMX2.K)                                 13.11
20A   F2R.K=FCB2.K/FPAX                                  13.12
7A    FTB1.K=FD1X.K-F1A.K                                13.13
A     FCB1.K=CLIP(FTB1.K,0,FTB1.K,0)                     13.14
12A   FCB2.K=(CBY)(FD2X.K)                               13.15
7A    FTCB.K=FCB1.K+F2R.K                                13.16
12A   FPER.K=(CC17)(FCB2.K)                              13.17
12A   FCER.K=(CC18)(FCB1.K)                              13.18
44A   G1G.K=(SR1G.K)(TIM.K)/2                            13.19
44A   G1C.K=(SR1C.K)(TIM.K)/2                            13.20
44A   G2G.K=(SR2G.K)(TIM.K)/2                            13.21
44A   G2C.K=(SR2C.K)(TIM.K)/2                            13.22
44A   G3.K=(SR3.K)(TIM.K)/2                              13.23
44A   G4.K=(SR4.K)(TIM.K)/2                              13.24
  A   SF1G.K=FFD1G.K*NORMRN(MEAN,STDV2)                  13.25
  A   SF1C.K=FFD1C.K*NORMRN(MEAN,STDV3)                  13.26
  A   SF2G.K=FFD2G.K*NORMRN(MEAN,STDV4)                  13.27
  A   SF2C.K=FFD2C.K*NORMRN(MEAN,STDV5)                  13.28
  A   SF3.K=FFD3.K*NORMRN(MEAN,STDV6)                    13.29
  A   SF4.K=FFD4.K*NORMRN(MEAN,STDV7)                    13.30
  A     FD1G.K=SMOOTH(SF1G.K,DEF2)                       13.31
  A     FD1C.K=SMOOTH(SF1C.K,DEF3)                       13.32
  A     FD2C.K=SMOOTH(SF2C.K,DEF5)                       13.33
  A     FD2G.K=SMOOTH(SF2G.K,DEF4)                       13.34
```

```
A     FD3.K=SMOOTH(SF3.K,DEF6)                         13.35
A     FD4.K=SMOOTH(SF4.K,DEF7)                         13.36
              INITIAL CONDITIONS AND PARAMETERS
N     FD1G=FD1GI                                       13.50
N     FD1C=FD1CI                                       13.51
N     FD2G=FD2GI                                       13.52
N     FD2C=FD2CI                                       13.53
N     FD3=FD3I                                         13.54
N     FD4=FD4I                                         13.55
C     FD1GI=40E6                                       13.56
C     FD1CI=40E6                                       13.57
C     FD2GI=10E7                                       13.58
C     FD2CI=10E7                                       13.59
C     FD3I=24E6                                        13.60
C     FD4I=685E3                                       13.61
C     DEF2=1                                           13.62
C     DEF3=1                                           13.63
C     DEF4=1                                           13.64
C     DEF5=1                                           13.65
C     DEF6=1                                           13.66
C     DEF7=1                                           13.67
C    STDV2=0                                           13.68
C    STDV3=0                                           13.69
C    STDV4=0                                           13.70
C    STDV5=0                                           13.71
C    STDV6=0                                           13.72
C    STDV7=0                                           13.73
C    CBY=0.92                                          13.74
C    CC17=0.0252                                       13.75
 C   CC18=0.1770                                       13.76
C  FPAX=3.92                                           13.77
C   FU1G=0.81                                          13.78
C   FU1C=0.81                                          13.79
C   FU2G=0.81                                          13.80
C   FU2C=0.81                                          13.81
```

APPENDIX XIV

```
NOTE           FIG.14  ASIF EXPENSE FORCASTING MODEL
A     F1E.K=E710+E715+E722+FHE1.K                          14.01
42A   FFH1.K=FCC.K/((S423)(C424))                          14.02
A     FHE1.K=(FFH1.K)(E716+E728+E723+0)                    14.03
42A   FFH2.K=FPC.K/((S418)(C417))                          14.04
A     FHE2.K=(FFH2.K)(E816+E828+E823+0)                    14.05
A     F2E.K=E810+E815+E822+FHE2.K                          14.06
42A   FFH3.K=FD3.K/((SPD3)(CAP3))                          14.07
A     FHE3.K=(FFH3.K)(E916+E928+E923+0)                    14.08
A     F3E.K=E910+E915+E922+FHE3.K                          14.09
42A   FFH4.K=FD4.K/((SPD4)(CAP4))                          14.10
A     FHE4.K=(FFH4.K)(ET16+ET28+ET23+0)                    14.11
A     F4E.K=ET10+ET15+E722+FHE4.K                          14.12
  A    FFTE.K=F1E.K+F2E.K+F3E.K+F4E.K                     14.13
  A   FTE.K=FFTE.K*NORMRN(MEAN,STDV1)                     14.14
  A     SFTE.K=SMOOTH(FTE.K,DEF1)                         14.15
  A    TEX.K=(SFTE.K)(PCT3)                               14.16
44A   F1EA.K=(ADE.K)(FMC1.K)/FTC.K                         14.17
44A   F2EA.K=(ADE.K)(FMC2.K)/FTC.K                         14.18
44A   F3EA.K=(ADE.K)(FD34.K)/FTC.K                         14.19
44A   F1ET.K=(TEX.K)(FMC1.K)/FMC.K                         14.20
44A   F2ET.K=(TEX.K)(FMC2.K)/FMC.K                         14.21
7A    FMC.K=FMC1.K+FMC2.K                                  14.22
44A   F1ED.K=(DTE.K)(FCC.K)/FML.K                          14.23
44A   F2ED.K=(DTE.K)(FPC.K)/FML.K                          14.24
44A   F3ED.K=(DTE.K)(FD34.K)/FML.K                         14.25
7A    FML.K=FCAP.K+FD34.K                                  14.26
9A    FT1E.K=FCER.K+F1EA.K+F1ET.K+F1ED.K                   14.27
9A    FT2E.K=FPER.K+F2EA.K+F2ET.K+F2ED.K                   14.28
7A    FT3E.K=F3EA.K+F3ED.K                                 14.29
  A    DTE.K=(SFTE.K)(PCT4)                               14.30
  A    ADE.K=(SFTE.K)(PCT2)                               14.31
                 INITIAL CONDITIONS AND PARAMETERS
 N     SFTE=SFTEI                                         14.50
  C     SFTEI=4331.8E3                                    14.51
```

```
C     DEFA=1
 C   PCT2=0.047
 C   PCT3=0.080
 C   PCT4=0.873
C    STDV1=0
C    MEAN=1.00
```

APPENDIX XV

```
NOTE          FIG.15  TARIFF FORCASTING MODEL
7A    TIM.K=XYZ.K-TIME.K                                  15.01
7A    FAE2.K=FT2E.K-ADJ2.K                                15.02
48A   ADJ2.K=PD.K/(XYZ.K-TIME.K)                          15.03
48A   ADJ1.K=CD.K/(XYZ.K-TIME.K)                          15.04
A     SFE.K=FT1E.K+FT3E.K-ADJ1.K                          15.06
A     STR.K=FD34.K/FML.K                                  15.07
13A   F3AE.K=(SFE.K)(1.15)(STR.K)                         15.09
7A    F1AE.K=SFE.K-F3AE.K                                 15.10
A     FD2.K=(FD2G.K)(FU2G)+(FD2C.K)(FU2C)                 15.11
A     FD1.K=(FD1G.K)(FU1G)+(FD1C.K)(FU1C)                 15.12
  A    TR1.K=F1AE.K/FD1.K                                15.13
  A    TR2.K=FAE2.K/FD2.K                                15.14
20A   TR3.K=F3AE.K/FD34.K                                 15.15
7A    XYZ.K=XYZI+TIS.K                                    15.18
10A   TIS.K=TI1.K+TI2.K+TI3.K+TI4.K+TI5.K+TI6.K           15.19
45A   TI1.K=STEP(52,52)                                   15.20
45A   TI2.K=STEP(52,104)                                  15.21
45A   TI3.K=STEP(52,156)                                  15.22
45A   TI4.K=STEP(52,208)                                  15.23
45A   TI5.K=STEP(52,260)                                  15.24
45A   TI6.K=STEP(52,312)                                  15.25
                 INITIAL CONDITIONS AND PARAMETERS
6N    XYZ=XYZI                                            15.50
N     TI1=TI1I                                            15.51
N     TI2=TI2I                                            15.52
N     TI3=TI3I                                            15.53
N     TI4=TI4I                                            15.54
N     TI5=TI5I                                            15.55
N     TI6=TI6I                                            15.56
C     XYZI=104                                            15.60
C     TI1I=0                                              15.61
C     TI2I=0                                              15.62
C     TI3I=0                                              15.63
C     TI4I=0                                              15.64
```

```
C     T151=0                                                15.65
C     T16Y=0                                                15.66
```

APPENDIX XVI

SPECIFICATIONS, PRINT, PLOT -- INFORMATION

```
NOTE   BASIC MODEL
PRINT  1)IS1G,S1GT,SD1G,SR1G,G1G,FD1G
PRINT  2)IS1C,S1CT,SD1C,SR1C,G1C,FD1C
PRINT  3)IS2G,S2GT,SD2G,SR2G,G2G,FD2G
PRINT  4)IS2C,S2CT,SD2C,SR2C,G2C,FD2C
PRINT  5)IS3,S3S,SD3,SR3,G3,FD3
PRINT  6)IS4,S4E,SD4,SR4,G4,FD4
PRINT  7)MR1,MP1,BR1,CR1,PD,CD
PRINT  8)MR2,MP2,BR2,CR2,ADJ1,ADJ2
PRINT  9)MR3,MP3,BR3,CR3,TE,TI
PRINT  10)MR4,MP4,BR4,CR4,CSH,PDA
PRINT  11)SMT,FTCB,FH1,FH2,FH3,FH4
PRINT  12)TCAP,S3S,S4E,TRN,PCA,CCA
PRINT  13)TC1,TC2,CB1,CB2,FTE,COR
PRINT  14)TR1,TRF1,TR2,TRF2,TR3,TRF3
PLOT   D1G=G,D1C=C,S1G=1,S1C=2,SD1G=X,SD1C=Y/SR1G=3,SF1C=4/CB1=B/CCA=M
PLOT   D2G=G,D2C=C,S2G=1,S2C=2,SD2G=X,SD2C=Y/SR2G=3,SR2C=4/CB2=B/MPR=M
PLOT   D3S=S,SD3=N,S3S=3/D4E=E,S4E=4,SD4=X/FH1=A/FH2=B/FH3=C/FH4=D
PLOT   ER1=1,BR1=A,CR1=X/ER2=2,BR2=B,CR2=Y/ER3=3,BR3=C,CR3=Z/CSH=$
PLOT   TCAP=T/CCA=C,FCC=1/PCA=P,FPC=2/TRN=N,SMT=5/S4E=E/S3S=S,FD34=F
PLOT   TR1=1,TR2=2,TR3=3,TRF1=A,TRF2=B,TRF3=C(0,0.20)/CD=K,PD=P/TE=E,TI=I
PLOT   ER1C=1,SX1=A,FCER=F/ER2C=2,SX2=B,FPER=E/SXX=$/ER4=4,BR4=D,CR4=X
PLOT   FD1G=C,FD1C=1/FD2G=P,FD2C=2,FCB2=F/FD34=3,FCB1=E/FFTE=$,SFTE=S
PLOT   SFTE=$/ADJ1=1,ADJ2=2/FPER=Y,FT2E=P/FT1E=C,F1AE=D/FT3E=S,F3AE=I/FCE
X    R=X
SPEC   DT=0.1/LENGTH=10/PRTPER=2/PLTPER=2
```