

APPENDIX 5 – CASE STUDY MODEL DOCUMENTATION

Appendix 5 contains the model documentation for the HTS Vensim Model.

.Control

Simulation Control Parameters

(002) FINAL TIME = 520

Units: Week

The final time for the simulation.

(003) INITIAL TIME = 0

Units: Week

The initial time for the simulation.

(004) SAVEPER =

TIME STEP

Units: Week [0,?]

The frequency with which output is stored.

.HTS CONTRACTS & STAFF

(006) Ability to Attract Staff=

TI Effect of Corporate Reputation on Recruiting(Corporate Reputation)

Units: Dmnl

This variable represents the ability of the firm to attract new staff. It is measured as a percentage of employment offers

accepted. Reference is 75% - based on current experience.

- (007) Ability to Retain Staff=

$$\frac{\text{TI Effect of Corporate Reputation on Staff Attrition}}{\text{Corporate Reputation}}$$
)
 Units: Dmnl
 This variable represents the ability of the firm to retain existing staff. It is measured in employee turnover, the percentage of total employees who terminate per week. Reference is 17%/year, .33%/week.
- (008) Acquire New Contracts=

$$\text{NEW CONTRACT PROPOSALS} * \text{Effect of Contract Performance on New Proposal Wins}$$
 Units: contracts/Week
 This variable represents the firms acquisition of new contracts.
- (009) Attrition Rate=

$$\frac{\text{HTS Non IT Staff}}{\text{HTS Staff Average Tenure}} * \text{Ability to Retain Staff}$$
 Units: FTE/Week
 This variable represents the attrition rate of the firms staff, specifically people leaving to pursue other opportunities.
- (010) Average Contract Completion Time=

$$\frac{26}{\text{Week}}$$
 Units: Week
 This variable represents the average duration of a contract at HTS - 26 weeks.
- (011) Avg Weekly Revenue per Contract=

$$\frac{37462}{\text{Contract/Week}}$$
 Units: Dollars/Contract/Week
 This variable represents the average revenue per contract at HTS and is estimated based on data provided by the financial

management of the firm.

(012) Base Input=

1

Units: contracts/Week

This variable is used to convert the output of the test generator into a dimensionally correct input.

(013) Complete Contracts=

$(\text{HTS Contracts}/\text{Average Contract Completion Time}) * \text{Contract Performance}$

Units: contracts/Week

This variable represents the number of contracts completed each week by the firm.

(014) Contract per Non IT HTS Staff=

2.7

Units: contracts/person

This variable represents the average number of active contracts per HTS employee, and is used to calculate the desired number of HTS staff based on the current level of active contracts.

(015) Contract Performance=

$(\text{HTS Core Business Performance Capability} * \text{IT IMPACT TO CONTRACTS}) + (1 - \text{IT IMPACT TO CONTRACTS})$

Units: Dmnl

This variable represents the ability of the firm to perform to contracts. It represents the impact of information technology on the growth and earnings of the firm. It is a function of the Core Business Capabilities of the firm; drives the firms revenues and the growth of the firm through staff attraction and retention, and through new proposal wins.

(016) Contracts In Process=

5000

Units: contracts

This variable represents the initial number of active contracts- it is the initial value for the variable HTS Contracts. [Acquire New Contracts*Average Contract Completion Time]

(017) Corporate Reputation=

Contract Performance

Units: Dmnl

Corporate reputation is directly attributed to contract performance, and this intermediate variable is used to clarify the relationship between contract performance and staff retention/attraction.

(018) Data Storage Effect=

1

Units: 1

This variable is used as part of a management flight simulator to evaluate various scenarios.

(019) DATA STORAGE RATIO=

Data Storage/Desired Data Storage

Units: Dmnl

This is the ratio between actual data storage and desired data storage. When the ratio is 1, the system is in equilibrium, the desired data storage is equal to the actual data storage. When this ratio is close to one, the effect of data storage on the firms core business capability is minimal. As the ratio decreases, that is when the gap between desired and actual data storage expands this function has a greater impact on the firms capability.

(020) Delivery Delay Effect=

1

Units: 1

This variable is used to vary the effect of the delivery delay on the system when doing sensitivity analysis.

(021) DELIVERY DELAY RATIO=

$$\text{Delivery Delay} / \text{Target Ticket Completion Time}$$

Units: Dmnl

This variable is the ratio of how long it takes IT to close the average service ticket (delivery delay) to the target ticket completion time.

(022) Desired HTS Staff=

$$\text{HTS Contracts} / \text{Contract per Non IT HTS Staff}$$

Units: person

This variable represents the firms desired staff and is a function of the firms contracts and the number of staff people required per contract.

(023) Effect of Contract Performance on New Proposal Wins=

$$\text{Contract Performance}$$

Units: Dmnl

This variable represents the impact that information technology and contract performance has on the growth of new business. If information technology causes contract performance to fall, it also causes the firm to win fewer new contracts - this is modeled through this function.

(024) Effect of Data Storage=

$$\text{Data Storage Effect} * \text{Effect of Data Storage on Core Business Performance}$$

Units: 1

This variable represents the effect that data storage in the system has on the firms capabilities.

- (025) Effect of Data Storage on Core Business Performance=
 TI Effect of Data Storage(DATA STORAGE RATIO)
 Units: Dmnl
 This variable represents the effect that data storage in the system has on the firms capabilities.
- (026) Effect Of Delivery Delay=
 Delivery Delay Effect*Effect of Delivery Delay on Core Business Performance
 Units: 1
 This variable represents the effect that delivery delay is expected to have on HTS Core Business Performance Capabilities.
- (027) Effect of Delivery Delay on Core Business Performance=
 TI Effect of Delivery Delay(DELIVERY DELAY RATIO)
 Units: Dmnl
 This variable represents the effect the delayed closing of IT service tickets has on the core business performance of HTS.
- (028) Effect of Operational IT Systems=
 Effect of Operational IT Systems on Core Business Performance*Operational Systems Effect
 Units: Dmnl
 This variable represents the effect that operational IT systems has on the performance capabilities of the firm.
- (029) Effect of Operational IT Systems on Core Business Performance=
 TI Effect of Operational IT Systems(OPERATIONAL IT SYSTEMS RATIO)
 Units: Dmnl
 This variable represents the effect that operational IT systems has on the performance capabilities of the firm.
- (030) Effect of Processor Power=
 Processor Power Effect*Effect of Processor Power on Core Business Performance

Units: Dmnl

This variable represents the effect that processor power has on core business capabilities. If the processors in the system are generally functioning correctly there is little effect on capabilities, however if processor power collapses, then business capability is strongly effected.

- (031) Effect of Processor Power on Core Business Performance=
TI Effect of Processor Power(PROCESSOR POWER RATIO)

Units: Dmnl

This variable represents the effect that processor power has on core business capabilities. If the processors in the system are generally functioning correctly there is little effect on capabilities, however if processor power collapses, then business capability is strongly effected.

- (032) Hire Rate=
HTS Staff Gap/Time to Hire non IT Staff

Units: person/Week

This variable represents the rate of hiring new non IT staff at HTS. It is driven by the gap between desired staff and actual staff, and controlled by the time to hire non IT Staff.

- (033) HTS Contracts= INTEG (
Acquire New Contracts-Complete Contracts,
Contracts In Process)

Units: contracts

This variable represents the current active contracts in the organization.

- (034) HTS Core Business Performance Capability=
Effect Of Delivery Delay*Effect of Operational IT Systems*Effect of Processor Power
*Effect of Data Storage

Units: Dmnl

This variable represents the function of information technology in the core business capabilities of the firm. There are several drivers of this function, these are the effects from data storage, processor power, operational IT systems and the time it takes to complete service tickets. At equilibrium each of these variables is assumed to be 1, and the core capability of the firm is 1. Each of these variables can negatively effect the capability of the firm. Using extreme condition test scenarios, if the firm had no processor power available, it would be significantly impacted and unable to perform many of the most basic functions of delivering product to the customer.

(035) HTS Non IT Staff= INTEG (
Hire Rate-Attrition Rate,
1850)

Units: FTE

This variable represents the total number of non IT Staff in the organization.

(036) HTS Staff Average Tenure=
260

Units: Week

Average Tenure at HTS equals 5 years or 260 Weeks

(037) HTS Staff Gap=
Desired HTS Staff-HTS Non IT Staff

Units: FTE

This variable represents the gap between the staff desired/required to complete existing contracts and the actual non-IT staff in the enterprise. It drives the hiring rate of the firm.

(038) HTS WEEKLY REVENUES=

Contract Performance*Complete Contracts*Avg Weekly Revenue per Contract

Units: Dollars/Week

This variable models the total revenue of the firm in

dollars/week. It is a function of the average revenue per contract times the total number of contracts times the contract performance variable which represents the impact of information technology on the growth and revenue of the firm.

(039) Input=

1+STEP(Step Height,Step Time)+

(Pulse Quantity/TIME STEP)*PULSE(Pulse Time,TIME STEP)+

RAMP(Ramp Slope,Ramp Start Time,Ramp End Time)+STEP(1,Exponential Growth Time

)*(EXP(Exponential Growth Rate*Time)-1)+

STEP(1,Sine Start Time)*Sine Amplitude*SIN(2*3.14159*Time/Sine Period)+STEP

(1,Noise Start Time)*RANDOM NORMAL(-4 , 4 , 0 , Noise Standard Deviation

, Noise Seed)

Units: Dimensionless

The test input can be configured to generate a step, pulse,

linear ramp, exponential growth, sine wave, and random variation. The initial value of the input is 1 and each test input begins at a particular start time. The magnitudes are expressed as fractions of the initial value.

(040) IT IMPACT TO CONTRACTS=

1

Units: 1

This variable is used in the control panel to "Turn off" The effect of IT on the firms performance.

(041) NEW CONTRACT PROPOSALS=

190+(Base Input*Input)

Units: Contract/Week

The growth of the firm is not specifically part of the problem being modeled and is therefore treated as an exogenous variable. This growth is created using a test input generator to demonstrate the impact of various growth patterns.

- (042) Operational IT Systems= INTEG (
 Acquire New Technology+Recovery Rate-Transfer Rate,
 Initial IT Technology Systems)
 Units: Systems
 This is the number of systems in the information technology infrastructure that are operational at any given moment.
- (043) OPERATIONAL IT SYSTEMS RATIO=
 Operational IT Systems/Total IT Systems
 Units: 1
 This variable is the ratio of operational IT Systems and Non Operational IT Systems.
- (044) Operational Systems Effect=
 1
 Units: 1
 This variable is used to vary the effect of the Operational IT Systems on the system when doing sensitivity analysis.
- (045) Processor Power Effect=
 1
 Units: 1
 This variable is used to vary the effect of the Processor Power on the system when doing sensitivity analysis.
- (046) Standard Time to Hire=
 16
 Units: Week

Standard time to hire equals 12 weeks

- (047) Time to Hire non IT Staff=
 Standard Time to Hire/Ability to Attract Staff
 Units: Week
 This variable presents the time to hire non IT Staff as a ratio
 of the standard time to hire/ability to attract staff.
- (048) TI Effect of Corporate Reputation on Recruiting(
 [(0,0)-(1,1)],(0,0),(0.05,0.01),(0.1,0.025),(0.15,0.035),(0.2,0.045),(0.25,
 0.065),(0.3,0.088),(0.35,0.11),(0.4,0.1278),(0.45,0.155),(0.5,0.189),(0.55
 ,0.23),(0.6,0.288),(0.65,0.35),(0.7,0.42),(0.75,0.497),(0.8,0.576),(0.85,0.68
),(0.88,0.75),(0.9,0.785),(0.95,0.9),(1,1))
 Units: Dmnl
 Percentage of employment offers accepted by candidates,
 reference mode is 75%.
- (049) TI Effect of Corporate Reputation on Staff Attrition(
 [(0,0)-(1,1)],(0,0),(0.05,0.033),(0.1,0.06),(0.15,0.09),(0.2,0.12),(0.25,
 0.15),(0.3,0.18),(0.35,0.21),(0.4,0.24),(0.45,0.27),(0.5,0.3),(0.55,0.335)
 ,(0.6,0.375),(0.65,0.417),(0.7,0.468),(0.75,0.519),(0.801223,0.609649),(0.840979
 ,0.710526),(0.88,0.83),(0.908257,0.890351),(0.95107,0.951754),(1,1))
 Units: Dmnl
 Measured in Employee Turnover Percentage/week. Represents the
 effect Corporate Performance has on Staff Attrition.
- (050) TI Effect of Data Storage(
 [(0,0)-(2,1)],(0,0),(0.1,0.4),(0.2,0.45),(0.3,0.5),(0.4,0.55),(0.5,0.6),(
 0.6,0.65),(0.7,0.75),(0.8,0.85),(0.9,0.93),(1,1),(1.1,1))
 Units: Dmnl
 This table variable represents the effect that data storage has
 on Core Business Performance.

(051) TI Effect of Delivery Delay(
 [(0,0)-(6000,2)],(0,1.1),(1.8,1),(4.8,0.95),(14.4,0.9),(28.8,0.86),(43.2,
 0.82),(72,0.78),(100.8,0.75),(144,0.7),(288,0.65),(435,0.6),(864,0.5),(1296
 ,0.5),(1728,0.5),(2592,0.5),(5256,0.5))

Units: Dmnl

This table variable represents the effect that delivery delay
 has on Core Business Performance.

(052) TI Effect of Operational IT Systems(
 [(0,0)-(2,1)],(0,0),(0.1,0.3),(0.2,0.45),(0.3,0.6),(0.4,0.7),(0.5,0.78),(
 0.6,0.85),(0.7,0.9),(0.8,0.95),(0.9,0.99),(1,1),(1.1,1))

Units: **undefined**

This table variable represents the effect that operational IT
 systems has on Core Business Performance.

(053) TI Effect of Processor Power(
 [(0,0)-(2,1)],(0,0),(0.1,0.6),(0.2,0.7),(0.3,0.8),(0.4,0.85),(0.5,0.9),(0.6
 ,0.95),(0.7,0.97),(0.8,0.98),(0.9,0.99),(1,1),(1.1,1))

Units: Dmnl

This table variable represents the effect that processor power
 has on Core Business Performance.

(054) Total HTS Staff=
 TOTAL IT STAFF+HTS Non IT Staff

Units: person

This variable is the total HTS staff an is the sum of the IT
 Staff and the non IT Staff.

.HTS DATA STORAGE GROUP

(056) Acquire Additional Data Storage=

Desired Data Storage Acquisition Rate*Impact of budget Availability on IT Expenditure

Units: Gigabytes/Week

This variable represents the acquisition of additional data storage facilities in the form of disk drives, disk arrays, NAS, and SAN devices.

(057) Average Cost per Gigabyte=
2.98

Units: Dollars/Gigabyte

This is the average cost per Gigabyte of data storage. It is estimated to be \$2.98 based on current experience of the firm.

(058) Cost of Additional Data Storage=
Acquire Additional Data Storage*Average Cost per Gigabyte

Units: Dollars/Week

This variable is a function of the average cost of data storage and the amount of data storage equipment purchased. It drives the expense loop which then governs how much budget is available in future periods.

(059) Data Storage= INTEG (
Acquire Additional Data Storage,
30000)

Units: Gigabytes

This variable represents the total amount of data storage in the system at any given time. Measured in Gigabytes, initial value is 30000 Gigabytes.

(060) Data Storage Gap=
MAX(0, Desired Data Storage-Data Storage)

Units: Gigabytes

This variable governs the acquisition of new data storage facilities, it is the gap between desired data storage and

actual data storage. The max function is used to prevent the gap from dropping below zero, as in reality data storage never really goes away, having too much data storage is not considered a problem.

(061) Desired Data Storage=

$\text{Data Storage} + \text{Pressure from Business Apps for Additional Data Storage} + \text{Pressure from Production Apps for Additional Data Storage}$

Units: Gigabytes

This is the amount of data storage desired within the infrastructure. It is a function of the data storage required by business applications plus the data storage required by production applications.

(062) Desired Data Storage Acquisition Cost=

$\text{Desired Data Storage Acquisition Rate} * \text{Average Cost per Gigabyte}$

Units: Dollars/Week

This variable is the amount of the data storage facilities acquired in any time period multiplied by the average cost per unit to model the cost of this acquisition which then drives the budget / expenditure loop and governs spending in future time periods.

(063) Desired Data Storage Acquisition Rate=

$\text{Data Storage Gap} / \text{Time To Close Data Storage Gap}$

Units: Gigabytes/Week

This function is the ratio of the data storage gap and the time to close the data storage gap. It represents how long the model takes to close the gap between desired and actual data storage.

(064) Effect of New Technology on Business Apps Data Storage=

$\text{TI Effect of Total IT Systems on Business Apps on Data Storage} (\text{Total IT Systems}$

)

Units: Gigabytes

This variable represents the effect new technology has on business applications data storage requirements. It is thought that new business technology requires additional data storage, but not at the same rate as new production technology.

- (065) Effect of New Technology on Production Apps Data Storage=
TI Effect of IT Systems on Production Apps Data Storage(Total IT Systems)

Units: Gigabytes

This variable represents the effect new technology has on production applications data storage requirements. It is thought that new production technology requires additional data storage, at a much greater rate than new business technology. Some of the application that drive this requirement include mapping and the geo firm initiatives.

- (066) Pressure from Business Apps for Additional Data Storage=
Effect of New Technology on Business Apps Data Storage

Units: Gigabytes

This variable represents the pressure that business applications (as opposed to production applications) puts on the demand for additional data storage.

- (067) Pressure from Production Apps for Additional Data Storage=
Effect of New Technology on Production Apps Data Storage

Units: Gigabytes

This variable represents the pressure that production applications (As opposed to business applications) puts on the demand for additional data storage.

- (068) Time To Close Data Storage Gap=

12

Units: Week

This variable represents how long it takes to close the gap between desired data storage and actual data storage, all else being equal. It is a constant set to 12 Weeks.

- (069) TI Effect of Data Storage on Ticket Arrival Rate(
 [(0,0)-(1e+008,200)],(0,0),(50000,12.8),(100000,21.4),(200000,32.4),(250000,36),(300000,38.8),(350000,39.6),(400000,40),(450000,40.2),(500000,40.6),(550000,40.8),(600000,41),(650000,41.2),(700000,41.4),(1e+006,43),(1.1e+006,43.5),(1.5e+006,44),(2e+006,45),(3e+006,46),(4e+006,47),(5e+006,48),(6e+006,49),(7e+006,50),(8e+006,51),(1e+007,53),(1e+008,140))

Units: Tickets/Week

This variable represents the effect that data storage has on the ticket arrival rate. It represents the number of service tickets which are generated solely as the results of additional data storage in the system.

- (070) TI Effect of IT Systems on Production Apps Data Storage(
 [(0,0)-(120,8e+006)],(0,0),(5,30000),(10,30000),(20,30000),(30,30000),(40,30000),(50,30000),(66,60000),(72,120000),(78,240000),(84,480000),(90,960000),(96,1.92e+006),(102,3.84e+006),(108,7.68e+006))

Units: Gigabytes

This variable represents the non linear effect that IT Systems have on Production application data storage requirements. The data storage requirements of production application are considerably higher than the data storage requirements of business applications.

- (071) TI Effect of Total IT Systems on Business Apps on Data Storage(
 [(0,0)-(400,800000)],(0,0),(5,3000),(10,3000),(20,3000),(30,3000),(40,3000),(50,3000),(66,6000),(72,12000),(78,24000),(84,48000),(90,96000),(96,192000),(102,384000),(108,768000))

Units: Gigabytes

This variable represents the non linear effect that IT Systems

have on business application data storage requirements. The data storage requirements of production application are considerably higher than the data storage requirements of business applications.

.HTS FINAL MODEL

This is the final model of HTS Information Technology Alignment.

.HTS IT BUDGET

(074) Available IT Budget= INTEG (IT Budget Funds Input-IT Funds Annual Budget Clear-IT Funds Used, Initial IT Budget)

Units: Dollars

This variable is the available IT budget. Budget is allocated annually, used monthly, and refreshed at the end of 52 weeks. (Money not spent in one year does not carry over to the next year.)

(075) Available IT Expenditure Rate= XIDZ(Available IT Budget, Time to end of Year, 0)

Units: Dollars/Week

This variable represents money that can be spent for the remainder of the year in support of new technology initiatives.

(076) Initial IT Budget= 4.255e+006

Units: Dollars

The initial IT budget for the model is \$4,255,000

- (077) IT Budget Funds Input=

$$\text{HTS Non IT Staff} * \text{Per Capita Allocation}$$
Units: Dollars/Week
This is the input into the stock of the available IT budget funds. It is a function of the HTS non IT staff times the per capita weekly allocation.
- (078) "IT Expenditure - Available to Desired Ratio"=

$$\frac{\text{Available IT Expenditure Rate}}{\text{Total Desired IT Costs}}$$
Units: Dmnl
This variable is the ratio of the available IT expenditure rate and the desired IT expenditure rate. It is used to govern spending on IT initiatives by the budget process.
- (079) IT Funds Annual Budget Clear=

$$\text{Available IT Budget} / \text{TIME STEP} * \text{Year End}$$
Units: Dollars/Week
This variable is the outflow rate variable for the stock of available IT budget. It is used to clear the available budget of any left over money at the end of each year.
- (080) IT Funds Used=

$$\text{Cost of Additional Data Storage} + \text{Cost of Additional IT HW SW} + \text{Cost of Additional Processor Power}$$
Units: Dollars/Week
This variable is the outflow rate variable for the stock of IT funds used. It is a function of the money used to acquire additional data storage, acquire additional HW & Sw and to acquire additional processor power.
- (081) Number of Weeks to Year=
52
Units: Week

This variable is the number of weeks in the year and is 52. It is used in the model to clear the budget at the end of each fiscal year.

(082) Per Capita Allocation=
44.23

Units: Dollars/person/Week

Allocation equals \$2,300 per year, or \$44.23/week. This variable is set endogenously by the firms management. It is a function of the belief that IT is not a critical production function, but is solely a cost to be managed. This is a critical misalignment with the actual organizational structure.

(083) TI Effect of Budget Availability on IT Expenditure(
[(-2e+020,0)-(-2e+020,2)],(-1e+020,0),(-1e+007,0),(-1e+006,0),(-10000,0),(-1000,0),(0,0),(0.428135,0.570175),(0.721713,0.824561),(1,1),(1.38838,1.08772),(2,1.1),(1000,1.1),(10000,1.1),(100000,1.1),(1e+006,1.1),(1e+007,1.1),(1e+008,1.1),(1e+020,1.1))

Units: Dmnl

This table variable captures the nonlinear relationship that budget availability has on IT expenditure.

(084) Total Desired IT Costs=

Desired Data Storage Acquisition Cost+Desired Processor Acquisition Cost+Desired HW SW Acquisition Cost

Units: Dollars/Week

This variable represents the sum of all desired IT costs/expenditures for the period and is compared to the budget available to determine what percentage of spending is acceptable.

.HTS IT EXPERIENCE

- (086) Acquire Experience Through Hiring=
 Average Initial Experience level of new hires*IT Staff Hiring Rate
 Units: 1
 This variable represents the additional experience gained by the IT department when hiring new employees.
- (087) Acquire Experience through IT Staff Training=
 Fractional Experience increase due to training
 Units: person*Week
 This variable represents the acquisition of additional experience through formal training.
- (088) Average Initial Experience level of new hires=
 104
 Units: Weeks/person
 Average initial experience of new hires is 2 years or 104 weeks.
- (089) Effect of Ticket Backlog on IT Staff Training=
 TI of Effect of Ticket Backlog on Staff Training(Normalized Tickets Backlog Per Person
)
 Units: Dmnl
 This variable represents the effect that ticket backlog has on IT staff training. When the ticket backlog is too high, training has to be curtailed in order to reduce the ticket backlog.
- (090) Fractional Experience decay due to new technology=
 Acquire New Technology/Total IT Systems
 Units: 1/Week
 This variable represents the decay in experience because of the implementation of new technology. When new technology is implemented, experience is decayed because the technology is new and unfamiliar.

- (091) Fractional Experience increase due to training=
 "IT Staff - Service"*IT Staff Training*13
 Units: person*Week
 This variable assumes that, on average, employees gain equivalent experience of 13 weeks on the job with each week spent in training.
- (092) Increase in IT Experience from Time on the Job=
 TOTAL IT STAFF*Weeks Worked per Year
 Units: Week
 This variable represents the growth of experience in total IT staff experience as a result of time working at HTS.
- (093) Initial Avg Experience IT Staff=
 400
 Units: Week
 Initial IT Avg Experience equals 400 weeks or 7.5 years
- (094) Initial IT Staff=
 35
 Units: People
 The initial IT staff for the model is 35 people.
- (095) Initial IT Staff Total Experience=
 Initial IT Staff*Initial Avg Experience IT Staff
 Units: person*Week
 This variable represents the initial total experience of the IT staff at HTS it is a function of the total number of staff, times the initial average experience.
- (096) IT Staff Avg Experience=
 IT Staff Total Experience/TOTAL IT STAFF

Units: Weeks/person

This variable represents the average experience of the IT staff and is the ratio of IT Staff Total experience divided by the total IT Staff.

- (097) $IT\ Staff\ Total\ Experience = INTEG ($
 $Acquire\ Experience\ Through\ Hiring + Increase\ in\ IT\ Experience\ from\ Time\ on\ the\ Job$
 $+ Acquire\ Experience\ through\ IT\ Staff\ Training - Lose\ Experience\ through\ Attrition$
 $- Lose\ Experience\ through\ New\ Technology,$
 $Initial\ IT\ Staff\ Total\ Experience)$

Units: person/Week

This variable represents the total experience of the IT Staff.

It is initially the Initial IT Staff Experience, and is increased through acquisition of experience by hiring, by time spent on the job, and by staff training. It is decreased by the attrition rate, and by experience decay due to new technology.

- (098) $IT\ Staff\ Training =$
 $Standard\ IT\ Staff\ Training * Effect\ of\ Ticket\ Backlog\ on\ IT\ Staff\ Training$

Units: Week

This variable represents the Staff training in the period, and is a function of the standard IT Staff training of 1.75 hours/person/per week times the effect of ticket backlog on IT Staff training. Fundamentally as the per person ticket backlog goes up, training is reduced. This variable is measured in weeks.

- (099) $Lose\ Experience\ through\ Attrition =$
 $IT\ Staff\ Avg\ Experience * IT\ Staff\ Attrition\ Rate$

Units: 1

This variable represents the loss of experience as is the result of people leaving the organization. It is the IT Staff average Experience multiplied time the IT Staff Attrition rate.

- (100) Lose Experience through New Technology=

$$\text{IT Staff Total Experience} * \text{Fractional Experience decay due to new technology}$$
Units: person/(Week*Week)
This variable represents the loss of relevant experience which is the result of new technologies being implemented in the organization
- (101) Standard IT Staff Training=
0.01041
Units: Week
Standard Training is 1.75 hours/week or 0.01041 Weeks
- (102) TI of Effect of Ticket Backlog on Staff Training(

$$[(-4e+016,0)-(-4e+016,4)],(-1e+016,2),(-1000,2),(-100,2),(-50,1.5),(0,1.5)$$

$$,(1,1),(50,0.822816),(100,0.69897),(150,0.642409),(200,0.607528),(250,0.582975)$$

$$,(300,0.564341),(350,0.54949),(400,0.537244),(450,0.526886),(500,0.517953)$$

$$,(600,0.503191),(700,0.49135),(800,0.481535),(900,0.473197),(1000,0.46598)$$

$$),(10000,0.349485),(2e+016,0.3))$$
Units: Dmnl
This table variable captures the nonlinear relationship that the recent ticket backlog has on IT Staff Training.\!\!
- (103) Total IT Staff Training Hours=

$$\text{IT Staff Training} * 168 * \text{"IT Staff - Service"}$$
Units: person*Week
This variable represents the total IT Staff training hours in a period. It is a simple conversion of IT Staff training from weeks to hours to simplify reading the model.
- (104) Weeks Worked per Year=
0.88
Units: Weeks/person
Weeks worked per year equals 46.52 weeks - 2 weeks vacation - 2

weeks training - 1 week personal - 1 week sick. [this equals .88 weeks/week/person]

.HTS IT STAFF

(106) Available IT Staff Budget= INTEG (
IT Staff Budget Funds Input-IT Staff Funds Annual Budget Clear-IT Staff Funds Used
,
Initial IT Staff Budget)

Units: Dollars

This variable is the available IT budget. Budget is allocated annually, used monthly, and refreshed at the end of 52 weeks. (Money not spent in one year does not carry over to the next year.)

(107) Available IT Staff Expenditure Rate=
XIDZ(Available IT Staff Budget, Time to end of Year, 0)

Units: Dollars/Week

This variable represents money that can be spent for the remainder of the year in support of IT Staff payroll expenses.

(108) Average Cost of IT Staff per employee=
1154

Units: Dollars/Week

This variable represents the average weekly cost of each employee in IT. Is used to calculate the cost of the desired IT Staff.

(109) Avg Time Per Ticket=
0.00774

Units: Week

The average time per ticket is based on service records of the firm, and is converted from minutes to week. Average time for service ticket is 20 minutes, which converts to 0.00774 weeks.

(110) Cost of Desired IT Staff=

Desired IT Staff*Average Cost of IT Staff per employee

Units: Dollars*person/Week

This variable is a function of the average salary of IT staff and the number of additional staff desired. It drives the expense loop which then governs how much budget is available in future periods.

(111) Delivery Delay=

Tickets Backlog/Service Tickets Completion Rate

Units: Week

This variable is a ratio of the number of tickets in the backlog and the service ticket completion rate and represents the average time for a service ticket to be completed.

(112) Desired IT Staff=

MAX(Minimum IT Staff,TOTAL IT STAFF*Effect of Recent Ticket Backlog on Desired IT Staff

*Effect of Recent Workweek on Desired IT Staff

)

Units: person

This variable represents the desired IT Staff required to minimize the delivery delay of service tickets. It is a function of recent tickets backlog, and the effect of fatigue on the staff. This function simulates the management decision process on hiring new IT staff. The CIO would first increase the hours worked each week, then reduce the time spent on each ticket and finally if it is clear that the workload has indeed increased significantly he would hire additional staff.

- (113) Desired Ticket Completion Rate=

$$\text{Tickets Backlog} / \text{Target Ticket Completion Time}$$
Units: Tickets/Week
This function is the ratio of the tickets backlog and the target ticket completion time. It represents the desired number of tickets to be completed each week.
- (114) Effect of Fatigue on Productivity=
Table for Effect of Fatigue on Productivity(IT Staff Fatigue)
Units: Tickets/(Week*person)
This variable represents the effect that fatigue experienced by the IT Staff as they work extended hours has on their productivity.
- (115) Effect of IT Staff Experience on Standard Time per Ticket=

$$\text{TI for Effect of Staff Experience on Standard Time per Ticket(IT Staff Avg Experience)}$$
Units: Dmnl
This variable represents the effect that the experience of the IT staff has on their ability to resolve tickets, and subsequently on the time it takes to resolve those tickets.
- (116) Effect of IT Staff Fatigue on Attrition Rate=

$$\text{TI Effect of IT Staff Fatigue on IT Staff Attrition Rate(IT Staff Fatigue)}$$
Units: Dmnl
This variable represents the effect that IT Staff fatigue has on the attrition rate of the IT Staff. It is assumed that after some extended period of extended hours of work IT staff will get frustrated with the workload and attrition will increase. It is a nonlinear attrition rate governed by the table function.
- (117) Effect of IT Systems on Perceived Opportunities=

TI of Effect of IT Systems on Perceived Opportunities(Total IT Systems)

Units: Dmnl

This variable represents the concept that IT staff perceive their opportunities to be improved with the implementation of new technologies in the system.

(118) Effect of Perceived Opportunities for Professional Growth on Attrition Rate

=

TI Effect of Perceived Opportunities for Professional Growth on IT Staff Attrition Rate
(Perceived Opportunities for Professional Growth)

Units: Dmnl

Perceived opportunities for professional growth is considered a factor in the decision of people in the IT field to stay with the firm, or to leave. When they believe that their opportunities for professional growth are strong, the attrition rate is lower.

(119) Effect of Recent Ticket Backlog on Desired IT Staff=

(Recent Tickets Backlog/Standard Ticket Per IT Staff Person)

Units: person*Week

This represents the effect that the recent ticket backlog has on the desired IT staff. It is attempting to model the management decision process that takes into account the per person ticket backlog as one factor in determining the requirement to hire additional staff.

(120) Effect of Recent Workweek on Desired IT Staff=

TI Effect of Recent Workweek on Desired IT Staff(Recent Workweek)

Units: Dmnl

This represents the effect that the recent workweek has on the desired IT staff. It is attempting to model the management decision process that takes into account the recent workweek as one factor in determining the requirement to hire additional staff.

- (121) Effect of Recent Workweek on Fatigue=
 TI of Effect of Recent Workweek on Fatigue(Recent Workweek)
 Units: Dmnl
 This represents the effect that the recent workweeks have on staff fatigue. It is thought that staff can work extended hours for several weeks prior to the onset of fatigue.
- (122) Effect of Schedule Pressure on Time per Ticket=
 TI for Effect of Schedule Pressure on Time per Ticket(Schedule Pressure)
 Units: Dmnl
 This represents the effect that schedule pressure has on the time per ticket, the greater the schedule pressure the less time available per service ticket.
- (123) Effect of Schedule Pressure on Workweek=
 TI for Effect of Schedule Pressure on Workweek(Schedule Pressure)
 Units: Dmnl
 This represents the effect that schedule pressure has on the workweek, as schedule pressure increases, the workweek increase to relieve the pressure.
- (124) Effect of Staff Training on Perceived Opportunities=
 TI of Effect of Staff Training on Perceived Opportunities(IT Staff Training)
 Units: Dmnl
 It is believed that IT staff are motivated by professional opportunities. One of the primary factors influencing their perception of professional opportunities is the opportunity to attend formal training classes. This variable represents the effect of this training on perceive opportunities for professional growth.

(125) Fatigue Onset Time=

6

Units: Week

Fatigue Onset Time = 6 Weeks

(126) Impact of Budget Availability on IT Staff Expenditure=

TI Effect of Budget Availability on IT Staff Expenditure("IT Staff Expenditure - Available to Desired Ratio"

)

Units: Dmnl

This variable represents the impact of budget availability on staff hiring rate. Staff can only be hired when there is budget available for the position. This governs the hiring of new staff.

(127) IT Service Staff Ratio=

0.333

Units: Dmnl

This variable represents the relationship between the IT Service Staff and the Rest of the IT Staff. The IT Service staff equal 1/3 of the total staff. The total staff includes, developers, project managers, management staff.

(128) "IT Staff - Other"= INTEG (

+IT Staff Other Hiring Rate-IT Staff Other Attrition Rate,
Initial IT Staff*(1-IT Service Staff Ratio))

Units: person

This variable represents the rest of the IT staff, other than those people regularly performing service functions, that is closing service tickets. The total staff includes, developers, project managers, management staff.

(129) "IT Staff - Service"= INTEG (

IT Staff Service Hiring Rate-IT Staff Service Attrition Rate,
Initial IT Staff*IT Service Staff Ratio)

Units: person

This variable represents the IT servicestaff, those people regularly performing service functions.

- (130) IT Staff Attrition Rate=
 ("IT Staff - Service"/IT Staff Average tenure)*Effect of IT Staff Fatigue on Attrition Rate
 *Effect of Perceived Opportunities for Professional Growth on Attrition Rate
 Units: FTE/Week
 The IT Staff Attrition rate represents the quit rate of the total IT Staff.
- (131) IT Staff Average tenure=
 260
 Units: Week
 IT Staff Average Tenure = 5 years or 260 weeks
- (132) "IT Staff Expenditure - Available to Desired Ratio"=
 Available IT Staff Expenditure Rate/Cost of Desired IT Staff
 Units: 1/person
 This is the ratio of the Available IT Staff Budget and the cost of the desired staff.
- (133) IT Staff Fatigue=
 Effect of Recent Workweek on Fatigue
 Units: Dmnl
 Represents the fatigue of the IT Service staff which is a function of the hours that the staff works.
- (134) IT Staff Gap=
 MAX(0,Desired IT Staff-TOTAL IT STAFF)
 Units: FTE
 This is the gap between the Desired IT Staff and the Total IT Staff

- (135) IT Staff Hiring Rate=
 $(\text{IT Staff Gap}/\text{Time to IT Hire Staff}) * \text{Impact of Budget Availability on IT Staff Expenditure}$
 Units: FTE/Week
 This is the hiring rate for IT Staff. It is the ratio of the IT Staff Gap and the Time to hire IT Staff, times the impact of budget availability on the IT Staff Expenditure.
- (136) IT Staff Other Attrition Rate=
 $\text{IT Staff Attrition Rate} * (1 - \text{IT Service Staff Ratio})$
 Units: person/Week
 The IT Other Staff Attrition rate represents the quit rate of the IT Staff not working in the service department.
- (137) IT Staff Other Hiring Rate=
 $\text{IT Staff Hiring Rate} * (1 - \text{IT Service Staff Ratio})$
 Units: person/Week
 This is the hiring rate for IT Other Staff. It is the ratio of the IT Staff Hiring Rate times 1 minus the IT Service Staff Ratio.
- (138) IT Staff Service Attrition Rate=
 $\text{IT Staff Attrition Rate} * \text{IT Service Staff Ratio}$
 Units: person/Week
 The IT Staff Service Attrition rate represents the quit rate of the IT Service Staff.
- (139) IT Staff Service Hiring Rate=
 $\text{IT Staff Hiring Rate} * \text{IT Service Staff Ratio}$
 Units: person/Week
 This is the hiring rate for IT Service Staff. It is the ratio of the IT Staff Hiring Rate times the IT Service Staff Ratio.

- (140) Maximum Ticket Completion Rate=

$$\text{Tickets Backlog} / \text{Minimum Ticket Completion Time}$$
Units: Tickets/Week
This is the ratio of the tickets backlog in the system divided by the minimum ticket completion time.
- (141) Minimum IT Staff=

$$\text{HTS Non IT Staff} / 55$$
Units: person
This variable represents the minimum IT Staff for the firm. It is the ratio of the HTS Total Staff/55.
- (142) Minimum Ticket Completion Time=
0.01
Units: Week
Minimum Ticket Completion Time is 10 minutes or .1665 hours or .000992 weeks. In order to accommodate vensim integration limitations this variable is set at 0.01 weeks, 100 minutes.
- (143) Mngt Perception Delay Time=
8
Units: Week
8 Week delay before management accepts need to hire new staff
- (144) Normalized Tickets Backlog Per Person=

$$\text{Ticket Backlog per Person} * \text{Standard Ticket Per IT Staff Person}$$
Units: Tickets*Tickets/(Week*person*person)
Normalized Tickets Backlog Per Person = Ticket Backlog per Person (Capacity)*Standard Ticket Per IT Staff Person (Capacity Utilization)
- (145) Perceived Opportunities for Professional Growth=
Effect of Staff Training on Perceived Opportunities*Effect of IT Systems on Perceived Opportunities

Units: Dmnl

This variable represents the perceived opportunities for professional growth and is the product of the effect of training and the effect of new IT systems.

(146) Potential Ticket Completion Rate=

"IT Staff - Service"*Workweek*Effect of Fatigue on Productivity/Time per Ticket

Units: Tickets/Week

This is the potential ticket completion rate and is the ratio of the IT Service Staff times the workweek times the effect of fatigue on productivity over the time per ticket.

(147) Recent Tickets Backlog=

SMOOTH(Tickets Backlog, Mngt Perception Delay Time)

Units: Tickets

Recent tickets backlog is a smooth function of the tickets backlog. It essentially smoothes out and delays the variance in tickets backlogged and is used as an input to the desired IT Staff.

(148) Recent Workweek=

SMOOTH(Workweek, Fatigue Onset Time)

Units: Week

Recent workweek is a smooth function of the workweek. (An Information delay) It essentially smoothes out and delays the variance in workweeks and is used as an input to the desired IT Staff.

(149) Recent Workweek Hours=

Recent Workweek*168

Units: Week

This variable is the conversion of the recent workweek in weeks to hours and is used to make the model more readable.

- (150) Schedule Pressure=
 Desired Ticket Completion Rate/Standard Ticket Completion Rate
 Units: Dmnl
 Schedule Pressure = Desired Ticket Completion Rate/Standard
 Completion Rate
- (151) Service Tickets Completion Rate=
 MIN(Maximum Ticket Completion Rate, Potential Ticket Completion Rate)
 Units: Tickets/Week
 This is the actual service ticket completion rate for the period
 and is the minimum of either the maximum ticket completion rate
 or the potential ticket completion rate.
- (152) Standard Ticket Completion Rate=
 "IT Staff - Service"*Standard Workweek/Standard Time per Ticket
 Units: FTE*hours/hours
 Standard Completion Rate = IT Staff*Standard Workweek/Standard
 Time per Ticket
- (153) Standard Ticket Per IT Staff Person=
 5.8
 Units: Tickets/person/Week
 Standard Ticket per IT Staff Person is used to normalize the
 ticket backlog against varying staff populations. It equals 5.8
 tickets/person/week.
- (154) Standard Time per Ticket=
 Effect of IT Staff Experience on Standard Time per Ticket*Avg Time Per Ticket
 Units: Week
 Standard time per ticket is the effect of IT Staff Experience
 times the average time per ticket and represents the concept
 that as the experience level of the staff increases, the

efficiency of the staff increases, and the time per ticket decreases.

- (155) Standard Time per Ticket Hours=
 $\text{Standard Time per Ticket} * 168$
 Units: Week
 This variable is the conversion of the standard time per ticket in weeks to hours and is used to make the model more readable.
- (156) Standard Workweek=
 0.2381
 Units: Week
 Standard Workweek = 40 hours or .23952 weeks.
- (157) Standard Workweek Hours=
 $\text{Standard Workweek} * 168$
 Units: Week
 This is the conversion of standard workweek to hours to simplify reading the model.
- (158) Table for Effect of Fatigue on Productivity(
 $[(0,0)-(1,1)],(1,1),(0.9,0.9),(0.8,0.8),(0.65,0.65),(0.5,0.5),(0.4,0.4),(0.3,0.3),(0.2,0.2),(0.1,0.1),(0.09,0.09),(0.08,0.08),(0.07,0.07),(0.06,0.06)$
))
 Units: Tickets/(Week*person)
 This table captures the non linear effect fatigue has on staff productivity.
- (159) Target Ticket Completion Time=
 0.01
 Units: Week
 Target Ticket Completion Time is .5 hours OR .00298 WEEKs. It is captured at 100 minutes in the model in order to accommodate

vensim integration limitations.

- (160) Ticket Backlog per Person=

$$\text{Tickets Backlog} / \text{"IT Staff - Service"}$$
 Units: Tickets/person
 This variable is the ratio of the Tickets backlog over the IT Staff Service and represents the tickets in the backlog per service person.
- (161) Tickets Backlog= INTEG (

$$\text{Service Tickets Arrival Rate} - \text{Service Tickets Completion Rate},$$
 25)
 Units: Tickets
 This variable, Tickets Backlog, represents the number of tickets in the IT service Queue, and is used to represent the workload demanded of the IT organization in support of the rest of the company.
- (162) Time per Ticket=

$$\text{Standard Time per Ticket} * \text{Effect of Schedule Pressure on Time per Ticket}$$
 Units: Week
 Time per ticket is the standard time per ticket times the effect of schedule pressure on the time per ticket. Service tickets represent orders in this system. In order to meet demand for service the organization can respond in one of three ways. 1.) Vary the time spent on each ticket. 2.) Vary the workweek. 3.) Vary the staff. This represents the average time spent per ticket during the period, and accounts for the response of varying the time per ticket to meet demand.
- (163) Time to end of Year=

$$52 - \text{modulo}(\text{Time}, \text{Number of Weeks to Year})$$
 Units: Week

This variable is used to calculate the number of weeks remaining until the end of the year when the budget will be restarted.

(164) Time to IT Hire Staff=

5

Units: Week

This variable captures the average time to hire new IT Staff. It is constant at 5 weeks in this model.

(165) TI Effect of Budget Availability on IT Staff Expenditure(

$[(-10000,0)-(10000,2)],(-10000,0),(-1000,0),(-100,0),(-10,0),(0,0),(0.428135,0.570175),(0.721713,0.824561),(1,1),(1.38838,1.19298),(1.99388,1.21053),(10,1.25),(100,1.25),(1000,1.25),(10000,1.25))$

Units: Dmnl

This table variable captures the nonlinear relationship that budget availability has on IT staff expenditure.

(166) TI Effect of IT Staff Fatigue on IT Staff Attrition Rate(

$[(0,0)-(1,1)],(0,0),(0.1,0.01),(0.2,0.02),(0.3,0.03),(0.4,0.04),(0.5,0.065),(0.6,0.1),(0.7,0.15),(0.8,0.2),(0.9,0.25),(1,0.3))$

Units: Dmnl

This table captures the nonlinear effect of IT Staff Fatigue on the IT Attrition rate.

(167) TI Effect of Perceived Opportunities for Professional Growth on IT Staff Attrition Rate

(

$[(0,0)-(6,0.4)],(0,0.1),(0.5,0.1),(1,0.1),(1.5,0.1),(2,0.1),(2.5,0.107018),(3,0.12),(3.5,0.14),(4,0.16),(4.5,0.2),(5,0.25))$

Units: Dmnl

This table captures the nonlinear effect of perceived opportunities for professional growth on the IT Attrition rate.

(168) TI Effect of Recent Workweek on Desired IT Staff(

[(0,0)-(1,0.4)],(0,0),(0.1,0.025),(0.2,0.05),(0.3,0.075),(0.4,0.1),(0.5,0.125),
(0.6,0.15),(0.7,0.175),(0.8,0.2),(0.9,0.2),(1,0.2))

Units: Dmnl

This table captures the non-linear effect of the recent workweek on desired IT Staff.

- (169) TI for Effect of Schedule Pressure on Time per Ticket(
[(-2e+020,0)-(2e+020,2)],(-1e+020,1.4),(-10000,1.4),(0,1.4),(1,1),(1.5,0.85),
(2,0.75),(3,0.62),(4,0.57),(5,0.52),(1000,0.52),(2000,0.515),(3000,0.51),
(4000,0.505),(5000,0.5),(1e+020,0.5))

Units: Dmnl

This table captures the nonlinear effect of schedule pressure on time per ticket.

- (170) TI for Effect of Schedule Pressure on Workweek(
[(-2e+020,0)-(2e+020,2)],(-1e+020,0.8),(-10000,0.8),(0,0.8),(1,0.8),(1.5,
1),(2,1.2),(3,1.4),(4,1.6),(10000,1.6),(1e+020,1.6))

Units: Dmnl

This table captures the nonlinear effect of schedule pressure on workweek.

- (171) TI for Effect of Staff Experience on Standard Time per Ticket(
[(0,0.6)-(800,2)],(0,1.08),(50,1.07),(100,1.06),(150,1.05),(200,1),(250,0.9),
(300,0.85),(350,0.8),(400,0.76),(450,0.72),(500,0.7),(550,0.68),(600,0.66),
(650,0.66))

Units: Dmnl

This table captures the non linear effect staff experience has on standard time per ticket.

- (172) TI of Effect of IT Systems on Perceived Opportunities(
[(0,0)-(800,4)],(0,0),(25,2),(50,2.30103),(75,2.47712),(100,2.60206),(200,
2.69897),(300,2.77815),(400,2.8451),(500,2.90309),(600,2.95424),(700,3))

Units: Dmnl

This table captures the nonlinear effect of IT implementing new IT Technologies on perceived opportunities for professional growth.

- (173) TI of Effect of Recent Workweek on Fatigue(
 [(0,0)-(1,1)],(0,1),(0.238,1),(0.297,1),(0.357,0.9),(0.417,0.8),(0.476,0.65
),(0.536,0.5),(0.595,0.4),(0.655,0.3),(0.714,0.2),(0.774,0.1),(0.833,0.09
 ,(0.893,0.08),(0.952,0.07),(1,0.06))

Units: Dmnl

This table captures the nonlinear effect of the recent workweek on staff fatigue.

- (174) TI of Effect of Staff Training on Perceived Opportunities(
 [(0,0)-(0.06,2)],(0,0.85),(0.005,0.92),(0.01,0.99),(0.0104,1),(0.015,1.25
),(0.02,1.5),(0.025,1.7),(0.03,1.8),(0.035,1.85),(0.04,1.9),(0.045,1.95),(
 0.05,2))

Units: Dmnl

This table captures the non linear effect that staff training has on their perception of their professional opportunities.

- (175) TOTAL IT STAFF=
 "IT Staff - Other"+"IT Staff - Service"

Units: person

This variable is the sum of the IT Service Staff and the IT Staff other. It represents all of the IT Staff in the organization. It is a driver of the IT Staff budget.

- (176) Workweek=
 Standard Workweek*Effect of Schedule Pressure on Workweek

Units: Week

Workweek is the standard workweek times the effect of schedule pressure on the workweek. Service tickets represent orders in this system. In order to meet demand for service the

organization can respond in one of three ways. 1.) Decrease the time spent on each ticket. 2.) Increase the workweek. 3.) Increase the staff. This represents the actually hours worked during the period, and accounts for the response of increasing the workweek to meet demand.

(177) Workweek Hours=

Workweek*168

Units: Week

This is the conversion of the workweek from weeks to hours and is used to simplify reading the model.

.HTS IT SYSTEMS

(179) Acquire IT Hardware Software=

Desired HW SW Acquisition Rate*Impact of budget Availability on IT Expenditure

Units: Systems/Week

This variable represents the acquisition of additional IT Hardware and Software, specifically the replacement of user devices, PC's, Laptops, Monitors, Software Licenses.

(180) Average Cost per IT System per employee=

7.26

Units: Dollars/system/person

Average Cost per employee for new IT systems = \$1889 amortized over 5 years = Weekly cost = 7.26

(181) Avg Cost of New IT Systems=

Average Cost per IT System per employee*HTS Non IT Staff

Units: Dollars/system

This variable represents the average cost of the new IT hardware

and software systems.

(182) Cost of Additional IT HW SW=

Acquire IT Hardware Software*Avg Cost of New IT Systems

Units: Dollars/Week

This variable is a function of the average cost of IT hardware and software and the amount of IT hardware and software equipment purchased. It drives the expense loop which then governs how much budget is available in future periods.

(183) Desired HW SW Acquisition Cost=

Desired HW SW Acquisition Rate*Average Cost per IT System per employee*HTS Non IT Staff

Units: Dollars/Week

This variable represents the acquisition cost of the desired hardware and software required to fill the gap between desired and actual hardware/software.

(184) Desired HW SW Acquisition Rate=

IT Hardware Software Gap/Time to Close HW SW Gap

Units: Systems/Week

This variable is the ratio of the IT Hardware Software gap and the time to close the gap. It represents the how long it will take the model to close the gap between desired and actual Hardware Software.

(185) Desired IT Hardware Software=

Operational IT Systems+Replace Existing IT Hardware Software

Units: Systems

This function represents the total desired IT Hardware systems and is the addition of Operational IT systems with the equipment required to replace existing, retiring systems.

(186) Disposal Rate=

$1/0.000577$

Units: Week

25% of IT HW SW is replaced each year, or 0.481% each week. 3% of IT HW/SW is retired each year or .000577/week

(187) Dispose of IT Hardware Software=

IT Hardware Software/Disposal Rate

Units: Systems/Week

This variable represents that 25% of IT HW SW is replaced each year, it is the ratio of Total IT Hardware Software and the disposal rate.

(188) Initial IT Hardware Software=

50

Units: Systems

The initial IT Hardware systems for the model is 50 systems.

(189) IT Hardware Software= INTEG (

Acquire IT Hardware Software-Dispose of IT Hardware Software,
Initial IT Hardware Software)

Units: Systems

This variable represents the IT hardware and software in the system and is used in a section of the model which represents the fact that IT HW & SW is replaced on a regular schedule.

(190) IT Hardware Software Gap=

MAX(0,Desired IT Hardware Software-IT Hardware Software)

Units: Systems

This is the gap between the Desired IT Hardware Software and the IT Hardware Software in place.

(191) Replace Existing IT Hardware Software=

IT Hardware Software*0.00481

Units: Systems

25% of IT Hardware Software is replaced every year or .00481%
per week

(192) Time to Close HW SW Gap=

6

Units: Week [0,40]

This is how long it takes to close the gap between desired and
actual IT Hardware & Software. 6 Weeks

.HTS IT TECHNOLOGY GROUP

(194) Acquire New Technology=

New Information Technology Initiatives

Units: Systems/Week

This variable represents the acquisition of new information
technology systems.

(195) Base Input 2=

1

Units: Systems/Contract

This variable is used to maintain dimensional consistency when
converting the growth of the firm, measured in contracts per
week, to growth in information technology, measured in systems
per week.

(196) Disaster=

PULSE(Trigger, 1)

Units: 1/Week

This variable is a disaster trigger, it is used to simulate a
disaster within the IT infrastructure. Currently the disaster is

triggered in week 246, and is used to simulate a complete failure of the IT Infrastructure.

(197) Initial IT Technology Systems=
50

Units: Systems

Initial IT Technology Systems in the Infrastructure is equal to 50 systems.

(198) New Information Technology Initiatives=
Acquire New Contracts*0.0003*Base Input 2

Units: Systems/Week

This is the primary growth variable for the IT functions. It is a function of the growth of the firm, a ratio of the acquisition of new contracts. It equals Acquire New Contracts*0.0003. It is also multiplied by Base Input 2 which is used to convert the new contracts which are the measure of company growth, to new systems which are the measure of IT Growth.

(199) "Non-Operational IT Systems"= INTEG (Transfer Rate-Recovery Rate,
0)

Units: Systems

This is the number of systems in the information technology infrastructure that are not operational at any given moment.

(200) Recovery Delay=
20

Units: Week

This variable represents the time it takes for the IT staff to fully recover the IT systems after a system failure. It is set at 20 weeks.

(201) Recovery Effort=

1

Units: 1/Week

This variable represents the effort IT Staff puts forth in recovering non operational systems. It is set at a constant of unity, which represents 100% effort.

(202) Recovery Rate=

"Non-Operational IT Systems"/Recovery Delay*Recovery Effort

Units: Systems/Week

This variable is the ratio of the Non-operational IT systems over the recovery delay times the recovery effort and varies the recovery of IT systems from non-operational status to operational status.

(203) TI Effect of IT Systems on Ticket Arrival Rate(

[(0,0)-(200,2)],(0,0),(10,0.1),(20,0.2),(30,0.3),(40,0.4),(50,0.5),(60,0.6),
(70,0.7),(80,0.8),(90,0.9),(100,1),(110,1.1),(150,1.5),(200,2))

Units: Tickets/Week

This table captures the non linear effect new technology initiatives (new Systems) has on the arrival of service tickets in the organization.

(204) Transfer Rate=

Disaster*Operational IT Systems

Units: Systems/Week

This variable represents the average experience of the IT staff and is the ratio of IT Staff Total experience divided by the total IT Staff.

(205) Trigger=

-10

Units: 1

This variable is used in the model to trigger a disaster. At initiation it is set at -10 which is before the model initial time step. It can be varied using a slider on the control panel which enables us to trigger a disaster at any time during the 10 year model simulation.

.HTS PROCESSOR POWER

- (207) Acquire Additional Processor Power=
 $\text{Desired Processor Acquisition Rate} * \text{Impact of budget Availability on IT Expenditure}$
 Units: GHZ/Week
 This variable represents the acquisition of additional processor power in the infrastructure, generally it represents the acquisition of additional servers.
- (208) Average Cost per Processor GHZ=
 919.86
 Units: Dollars/GHZ
 The average cost per gigahertz of processor power is estimated to be \$919.86 based on current experience of the firm.
- (209) Cost of Additional Processor Power=
 $\text{Acquire Additional Processor Power} * \text{Average Cost per Processor GHZ}$
 Units: Dollars/Week
 This variable is a function of the average cost of additional processor power (servers) and the amount of servers purchased. It drives the expense loop which then governs how much budget is available in future periods.
- (210) Desired Processor Acquisition Cost=
 $\text{Desired Processor Acquisition Rate} * \text{Average Cost per Processor GHZ}$

Units: Dollars/Week

This variable is the amount of the processor facilities acquired in any time period multiplied by the average cost per unit to model the cost of this acquisition which then drives the budget / expenditure loop and governs spending in future time periods.

(211) Desired Processor Acquisition Rate=
Processor Power Gap/Time to Close Processor Gap

Units: GHZ/Week

This function is the ratio of the processor power gap and the time to close the processor gap. It represents how long the model takes to close the gap between desired and actual processor power.

(212) Desired Processor Power=
(Pressure from Business Apps for Additional Processor Power+Pressure from Production Apps for Additional Processor Power

)+Processor Power

Units: GHZ

This is the amount of processor power desired within the infrastructure. It is a function of the processor power required by business applications plus the processor power required by production applications.

(213) Effect of New Technology on Business Apps Processor Power Requirements

=

TI Effects of IT Systems on Business Apps Processor Power(Total IT Systems

)

Units: GHZ

This variable represents the effect new technology has on business applications processor power requirements. It is thought that new business technology requires additional processor power at a much greater rate than new production

technology. Some of the application that drive this requirement include the ERP and CRM applications.

(214) Effect of New Technology on Production Apps Processor Power Requirements

=

TI Effects of IT Systems on Production Apps Processor Power(Total IT Systems

)

Units: GHZ

This variable represents the effect new technology has on production applications processor power requirements. It is thought that new production technology requires additional processor power, at a much lower rate than new business technology.

(215) Impact of budget Availability on IT Expenditure=

TI Effect of Budget Availability on IT Expenditure("IT Expenditure - Available to Desired Ratio"

)

Units: Dmnl

This variable represents the impact of budget availability on the acquisition of new equipment and services, which can only be acquired when there is budget available for the equipment and services.

(216) Pressure from Business Apps for Additional Processor Power=

Effect of New Technology on Business Apps Processor Power Requirements*100

Units: GHZ

This variable represents the pressure that business applications (as opposed to production applications) puts on the demand for additional processor power.

(217) Pressure from Production Apps for Additional Processor Power=

Effect of New Technology on Production Apps Processor Power Requirements*

100

Units: GHZ

This variable represents the pressure that production applications (as opposed to business applications) puts on the demand for additional processor power.

- (218) Processor Power= INTEG (
Acquire Additional Processor Power,
386000)

Units: GHZ

This variable represents the total amount of processor power in the system at any given time. Measured in Gigahertz the onitial Value = 386000 GHZ

- (219) Processor Power Gap=
MAX(0,Desired Processor Power-Processor Power)

Units: GHZ

This variable governs the acquisition of new processors (servers), it is the gap between desired processors and actual processors. The max function is used to prevent the gap from dropping below zero, as in reality servers never really go away, having too many servers is not considered a problem.

- (220) PROCESSOR POWER RATIO=
Processor Power/Desired Processor Power

Units: Dmnl

This is the ratio of the processor power to the desired processor power. When the ratio is one the desired processor power equals the actual processor power and the system is in equilibrium. As the ratio decreases the greater the impact of processor power on the ability of the firm to perform.

- (221) Time to Close Processor Gap=

12

Units: Week

This variable represents how long it takes to acquire new processor power and close the processor gap. It equals 12 Weeks.

- (222) TI Effect of Processor Power on Ticket Arrival Rate(
 [(0,0)-(1e+006,80)],(0,0),(16000,5),(32000,11),(48000,17),(64000,21),(80000,25),(96000,29),(112000,33),(128000,37),(144000,41),(160000,43),(176000,45),(192000,47),(208000,49),(224000,50),(240000,51),(256000,52),(272000,52),(288000,53),(304000,53),(320000,54),(336000,54),(352000,55),(368000,55),(384000,55),(394495,56.1404),(412844,56.4912),(428135,57.193),(452599,57.5439),(492355,58.2456),(544343,58.9474),(605505,60),(669725,60.3509),(730887,61.4035),(795107,62.1053),(871560,62.807),(932722,63.5088),(978593,64.5614),(1e+007,59),(1.5e+007,60))

Units: Tickets/Week

This table captures the nonlinear effect that processor power has on the ticket arrival rate.

- (223) TI Effects of IT Systems on Business Apps Processor Power(
 [(0,0)-(200,200)],(0,0),(5,5.5),(10,10),(15,16),(20,26),(25,36),(30,56),(35,78),(40,110),(45,141),(50,180),(60,190),(70,200),(80,200),(90,200),(100,200),(110,200),(200,200))

Units: GHZ

This variable represents the non linear effect that IT Systems have on business application processor power requirements. The processor power requirements of business applications are considerably higher then the processor power requirements of production applications.

- (224) TI Effects of IT Systems on Production Apps Processor Power(
 [(0,0)-(200,100)],(0,0),(5,5.1),(10,5.2),(15,5.5),(20,6),(25,8),(30,12),(35,18),(40,26),(45,48),(50,80),(60,90),(70,100),(80,100),(90,100),(100,100),(150,100),(200,100))

Units: GHZ

This variable represents the non linear effect that IT Systems have on production application processor power requirements. The processor power requirements of business applications are considerably higher than the processor power requirements of production applications.

(225) Total IT Systems=
Operational IT Systems+"Non-Operational IT Systems"

Units: Systems

This variable is the total number of IT systems in the infrastructure and is the sum of operational systems and non-operational systems.

.HTS SERVICE TICKETS

(227) Effect of Data Storage on Ticket Arrival Rate=
TI Effect of Data Storage on Ticket Arrival Rate(Data Storage)

Units: Tickets/Week

This variable represents the effect that data storage has on the arrival rate of IT service tickets in the firm.

(228) Effect of HTS Staff On ticket Arrival Rate=
0.123

Units: Tickets/person

This variable represents the effect that HTS staff has on the ticket arrival rate. It is assumed to be a linear relationship with each staff person generating the same number of tickets.

(229) Effect of IT Systems on Ticket Arrival Rate=
TI Effect of IT Systems on Ticket Arrival Rate(Total IT Systems)

Units: Tickets/Week

This variable represents the effect of IT systems on ticket arrival rates. More systems means more complexity, means more interfaces, means tickets.

(230) Effect of Processor Power on Ticket Arrival Rate=

$$TI \text{ Effect of Processor Power on Ticket Arrival Rate}(\text{Processor Power})$$

Units: Tickets/Week

This variable represents the effect that processor power has on the ticket arrival rate. The greater the amount of processor power in the system, the more tickets will arrive at the IT service queue.

(231) Service Tickets Arrival Rate=

$$\text{Ticket per HTS Staff} + \text{Effect of Data Storage on Ticket Arrival Rate} + \text{Effect of Processor Power on Ticket Arrival Rate}$$

Units: Tickets/Week

This variable is the input rate variable to the tickets backlog stock. It represents the varying rate of ticket arrivals in the service ticket queue. It is driven by four effects. 1.) The amount of processor power in the infrastructure. 2.) The amount of data storage in the infrastructure. 3.) The total number of staff in the organization. 4.) The new technology initiatives undertaken by the organization.

(232) Ticket per HTS Staff=

$$\text{Effect of IT Systems on Ticket Arrival Rate} * \text{Effect of HTS Staff On ticket Arrival Rate}$$

*HTS Non IT Staff

Units: Tickets/Week

 .HTS TEST GENERATOR

(234) Exponential Growth Rate=

0

Units: 1/Day

The exponential growth rate in the input.

(235) Exponential Growth Time=

0

Units: Day

The time at which the exponential growth in the input begins.

(236) Noise Seed=

1000

Units: Dimensionless

Varying the random number seed changes the sequence of realizations for the random variable.

(237) Noise Standard Deviation=

4

Units: Dimensionless

The standard deviation in the random noise. The random fluctuation is drawn from a normal distribution with min and max values of +/- 4. The user can also specify the random number seed to replicate simulations. To generate a different random number sequence, change the random number seed.

(238) Noise Start Time=

0

Units: Day

The time at which the random noise in the input begins.

(239) Pulse Quantity=

0

Units: Dimensionless*Day

The quantity added to the input at the pulse time.

- (240) Pulse Time=
0
Units: Day
The time at which the pulse increase in the input occurs.
- (241) Ramp End Time=
1e+009
Units: Day
The end time for the ramp input.
- (242) Ramp Slope=
0.45
Units: 1/Day
The slope of the linear ramp in the input.
- (243) Ramp Start Time=
0
Units: Day
The time at which the ramp in the input begins.
- (244) Sine Amplitude=
25
Units: Dimensionless
The amplitude of the sine wave in the input.
- (245) Sine Period=
156
Units: Day
The period of the sine wave in the input.
- (246) Sine Start Time=
0

Units: Day
 The time at which the sine wave fluctuation in the input begins.

(247) Step Height=
 0
 Units: Dimensionless
 The height of the step increase in the input.

(248) Step Time=
 0
 Units: Day
 The time at which the step increase in the input occurs.

(249) TIME STEP = 0.0078125
 Units: Week [0,?]
 The time step for the simulation.

 .IT STAFF BUDGET

(251) Annual IT Staff Budget=
 2e+006
 Units: Dollars
 This is the annual budget allocated to staffing the IT
 Organization at HTS.

(252) Initial IT Staff Budget=
 2e+006
 Units: Dollars
 The initial IT Staff Budget for the model is \$2,000,000

(253) IT Staff Avg Standard Compensation=

1153

Units: Dollars/Week/person

Avg Standard Compensation is assumed to be \$60K/year =
\$1,153/week

(254) IT Staff Budget Funds Input=

Weekly IT Staff Budget*IT Staff Budget Increase

Units: Dollars/Week

This is the input into the stock of the available IT staff budget funds. It is a function of the weekly staff budget times and the annual budget increase.

(255) IT Staff Budget Increase=

$$1 + \text{STEP}(0.04, 52) + \text{STEP}(0.04, 104) + \text{STEP}(0.04, 156) + \text{STEP}(0.04, 208) + \text{STEP}(0.04, 260) + \text{STEP}(0.04, 312) + \text{STEP}(0.04, 364) + \text{STEP}(0.04, 416) + \text{STEP}(0.04, 468)$$

Units: Dmnl

This is a step function in which the IT budget is increased each year by 4% over the previous year.

(256) IT Staff Compensation=

("IT Staff - Service" + "IT Staff - Other")*IT Staff Avg Standard Compensation

Units: Dollars/Week

This variable represents the IT staff compensation, it equals the IT Staff times the average standard compensation.

(257) IT Staff Funds Annual Budget Clear=

Available IT Staff Budget/TIME STEP*Year End

Units: Dollars/Week

This variable is the outflow rate variable for the stock of available IT Staff budget. It is used to clear the available budget of any left over money at the end of each year.

(258) IT Staff Funds Used=

Total IT Staff Compensation

Units: Dollars/Week

This variable is the outflow rate variable from the available IT Staff Budget. It represents the total IT Staff costs each period.

(259) IT Staff Overtime Compensation=

$$\text{MAX}(0, \text{IF THEN ELSE}((\text{Workweek} * \text{"IT Staff - Service"}) > (\text{Standard Workweek} * \text{"IT Staff - Service"}), ((\text{Workweek} * \text{"IT Staff - Service"}) - (\text{Standard Workweek} * \text{"IT Staff - Service"})) * \text{IT Staff Standard Overtime Rate}, 0))$$

Units: Dollars

This variable is IT staff overtime compensation for each period.

(260) IT Staff Standard Overtime Rate=

$$(\text{IT Staff Avg Standard Compensation} / 40) * 1.5$$

Units: Dollars/(Week*person)

This variable represents the standard overtime compensation for the IT Staff. It equals the standard compensation times 1.5.

(261) Total IT Staff Compensation=

$$\text{IT Staff Compensation} + \text{IT Staff Overtime Compensation}$$

Units: Dollars/Week

This variable is the total IT staff compensation. It is the sum of the IT Staff compensation plus the IT staff overtime compensation.

(262) Weekly IT Staff Budget=

$$\text{Annual IT Staff Budget} / \text{Weeks per Year}$$

Units: Dollars/Week

Annual Budget is \$2,000,000 converted to weekly = \$38,461

(263) Weeks per Year=

52

Units: Week

There are 52 weeks per year.

(264) Year End=

IF THEN ELSE(modulo(Time,52)<TIME STEP,1,0)

Units: Dmnl

This variable represents the end of the year, and is used to clear the budget at the end of the fiscal year, modeling the behavior that the budget moneys do not carry over each year.