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FORECASTING INVESTMENT OPPORTUNITIES THROUGH DYNAMIC SIMULATION

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ABSTRACT

Outcomes of this modeling research are the ability to facilitate comparisons of investment alternatives or strategies; regarding primary targets, possible annual revenues, promotion incentives, operating budgets, and "other" capital expenses. The analyst will have a simulator to evaluate multiple courses of action when considering opportunities regarding possible future investments or "Walmart" locations.

The results are described visually, allowing the client or customer the capability to view the model through animation support. This allows the customer the opportunity to fully understand the strategies associated with various financial opportunities, and explore "what-if" and "why-not" analysis.

As part of the approach, a symbolic network representative language was implemented which combines the continuous variable features of system dynamics and the discrete event features of conventional simulation techniques.

The contribution of this research is a prescribed method for the strategic analyst to simulate cash flow profiles which can be used to analyze and assess investment opportunities with great accuracy and confidence in building strategies to support corporate growth.

1 INTRODUCTION

NEXCOM, a hypothetical communications corporation, is currently undergoing extensive research and analysis to determine new areas to dominate the market in the communications sector. New advances in digital communications has resulted in the quick antiquity of current analog systems. NEXCOM is undergoing extensive analysis into new investment opportunities to use the analog equipment in other market areas.

It is hypothesized that areas of economic opportunity are in relocation of existing analog systems into areas not currently dominated by the competition. For example, Boise, Idaho may be a possibility where cellular analog may be an easy in, capturing the market before another competitor can perform a similar strategy.

Therefore, the challenge in this research opportunity was to produce a decision support mechanism to assist the NEXCOM staff in evaluating various "Walmart" strategies; to define and rank opportunities where Cellular is NOT. The term "Walmart" represents the unusual success of the WALMART retail chain in establishing a high rate of success in establishing new stores in various undeveloped locations.

Because of the high level modeling effort, incorporating a large amount of direct and indirect relationships, including all sources of income and expenses, simulation was chosen as the mechanism to perform the analysis.

Such a mechanism should be based on sound analytical methodologies, and produce accurate results to support the staff in formulating and evaluating future prospective markets. Inflation indexes, pay increases, automated investment increases, and financial uncertainties can be imported into the scenarios, continually updating the detail of the model, thus depicting the "real world".

This paper proposes a solution to this dynamic challenge by integrating system dynamics, combined simulation, and engineering economics. The result is a more suitable methodology to adequately predict and control a proper balance of the corporation's goals, identifying shortfalls, and helping to develop the necessary strategies to support the base for future operations.

Through this proposed technique, a more accurate representation of the variability and uncertainty of business proposals or strategies can be modeled. By combining the proposed methodology, successful market penetration can occur at minimum risk. Corporate goals can be achieved, along with accurate assessments of capital gains and losses over time.

2 SOLUTIONS THROUGH INTEGRATION

2.1 System Dynamics & Combined Simulation

The objective of system dynamics, as utilized in this paper, is to study the causal relationships bearing on the cellular market, and effectively identify the variables which will effect proposed economic alternatives. (Parker 1994).

The application of system dynamics to problem solving entails several important features not usually found in standard open loop simulation architecture.

First, such problems are looked at as being dynamic, involving quantities which continually change over time. Next-event simulation alone may not accurately portray the constantly changing variables or quantities under investigation (Pritsker 1986). Such quantities are expressed in terms of graphs of variables over time. The oscillating levels of various population parameters, including population densities, by type and attribute, fixed and variable income and expenses, over a projected time period are non-linear and dynamic. Cash flow is a dynamic problem, continually anticipating future opportunities, based on past experience, coupled with additional complications such as new equipment, changing strategies, and economic uncertainties. Typical static approaches, such as linear programming, to solving such allocation problems often cannot be used where the problem scenario changes continuously through time.

These and similar questions can only be answered efficiently with a simulation method which can cope with delays, flows of information, and material, obviously lending itself to the study of transient phenomena.

When such a simulation model is developed, the state variables are continuously changing and their time variation may depend on other state variables, both discrete and continuous. The dynamic behavior of these variables describes the real system and their computational relationship is critical to achieving reliable results.

A second feature, and the most critical, to solving problems to which the system dynamics perspective applies involves the notion of feedback. Essentially, feedback is the transmission and return of information. A feedback loop is a closed sequence of causes and effects. A series of interconnected sets of feedback loops is a feedback system. Logistics support to communications systems is an example of a large scale strategic feedback system.

Commitment of resources such as personnel, equipment, to support business strategies depletes the overall logistics inventory, including financial resources. As stocks fall below desired levels, a dynamic look evaluates the time and resource requirements needed to restock or maintain anticipated levels.

The delay of information feedback combined with the delay or time to produce the required assets is an area of great concern. Thus, understanding of the behavior of feedback systems is a goal of the system dynamics approach (Forrester 1961).

2.2 Engineering Economics

Engineering Economic Analysis is typically the basis of a systematic approach that can be used in comparing the economic worth of engineering investment alternatives.

The approach taken to analyze such alternatives defines a set of feasible, mutually exclusive alternatives to be compared. The approach defines the planning horizon for comparison; develops cash flow profiles; specifies an agreed upon Minimum Attractive rate of Return (MARR); compares alternatives using a specified measure of worth, such as Net Present Value (NPV); performs supplementary analyses; and recommends the preferred alternative(s).

Risk Analysis blends into the analysis in developing a methodology to integrate probability distributions for some measure of merit to an investment proposal. Typically, probability distributions are developed for Present Worth (PW) calculations, for each individual investment alternative. Consequently, probability distributions are required for random variables such as cash flows, variable interest rates, population changes, etc.. The cash flow in a given year is often a function of a number of other variables such as selling prices, size of the market, market share, market growth rate, investment required, inflation rates, tax rates, operating costs, fixed costs, and salvage values of assets.

Analytical development of the probability distribution for the measure of merit is not easily achieved in most real-world situations. Thus, simulation is widely used in performing such risk analysis. Risk aggregation is achieved in basically two ways: By using simulation, and solving through analytical means.

An analytical approach is useful for “quick” turnaround when the evaluation is relatively simple and straightforward. When analyzing more complex situations involving a large number of variables and associated relationships, simulation is key to successful integration.

2.3 Exploring Scenarios

Within risk analysis the simulator will employ sensitivity analysis to analyze the effects of making changes in estimating parameter values. Generally one examines the sensitivity of individual parameters one at a time. In

practice, estimation can occur for more than one parameter.

However, the scientific approach is usually to change one variable at a time and "search" the solution set to identify those parameters or changes which bring the greatest response to the overall system. This becomes critical in evaluating the effects due to changes in internal strategy; particularly over long time periods. In evaluating more than one strategy, or alternative, the simulation may lend itself to Break-Even analysis, or the Break-Even point for annual costs to annual receipts lending itself to profit and loss analysis.

The example model in this paper was developed using an industrial standard simulation platform, Ithink™ (HPS 1996). Ithink™ is a continuous simulation language able to evaluate scenarios of high complexity, incorporating standard simulation concepts, and system dynamics. Ithink™ provides adequate capabilities for the analyst to incorporate "flight simulators" to evaluate "what-if" and "why-not" scenarios.

3 MODEL DEVELOPMENT

Figure 1 is a flow diagram to model basic cash flow profiles. A complete model of the system would also include the mathematical relationships describing how the accumulations and flows are calculated. An in depth discussion of the development of level and rate equations and their use can be further described in (Parker 1994) or (Coyle 1977).

This system is characterized in its most simplistic form to better understand the relationships to support much larger modeling initiatives. The quantities in this example are purely hypothetical and are in no way related to actual requirements.

The focus of this model is the level described as "Net Cash Flow". The levels represent the values of the variables under investigation through time. These variables are usually represented as individual financial accounts.

The level symbol is depicted as a rectangle. The amount contained in a level is calculated as an equation, represented by the symbol is:

$$x_{i,t} = x_{i,t-1} + DT \times \left(\sum_{j=1}^{M} rate.in_{ji,t-1} - \sum_{k=1}^{N} rate.out_{ik,t-1} \right) \qquad (1)$$

where

$x_{i,t}$ = state variable level i at time t
$x_{i,t-1}$ = state variable level i at time t-1
DT = delta time interval
$rate.in_{ji,t-1}$ = flow rate j into level i at time t-1 where j=1,...,M and M is Integer
$rate.out_{ik,t-1}$ = flow rate k out of level i at time t-1 where k=1,...,N and N is Integer.

Levels are calculated at each of the closely spaced solution intervals, DT. In financial modeling, DT, is evaluated monthly to depict the interest rate associated with the amount of cash held in the levels.

The equation for the level symbol states that $x_{i,t}$, the present value of x_i at time t (time now), is equal to the previously computed value $x_{i,t-1}$ (time last), plus the difference between the inflow rate, *rate.in*, during the last time interval and the outflow rate, *rate.out*, the difference in rates multiplied by the length of time DT during which the rates persisted. This level receives resources or capital from the input rate "Total Income". This level additionally depletes or subtracts resources or commodities by use of the output rate "Total Expenses".

The rate symbol is used to depict the rate of flow. The rate equations are of great importance in that the changes to all the levels in the model are attributed to some form of the rate equation. The rate equations associated with this symbol are usually found either entering or leaving a level node. The flow rate may be a function of several variables. Flows into a level node are positive (+), and flows out of a level node are negative (-).

The input rate equation "Total Income" contains multiple sub flows which make up the total of the input rates. In keeping with the equation set described in (1),

$$\text{Total Income} = \sum_{j=1}^{M} \text{Total Revenues}. \qquad (2)$$

"Income 1 Fixed" and "Income 2 Variable" are auxiliary equations. Each may be a fixed amount, $600.00 per month, or a variable amount, NORMAL (600., 50.) which translates to sampling from a normal distribution with a mean of $600.00 and a standard deviation of $50.00. Sampling can additionally be drawn from tables, graphs, or independent equations.

Similar to the input equations, the output rate equation "Total Expenses" contains multiple sub flows which make up the total of the output rate. Therefore,

$$\text{Total Expenses} = \sum_{k=1}^{N} \text{Total Costs}. \qquad (3)$$

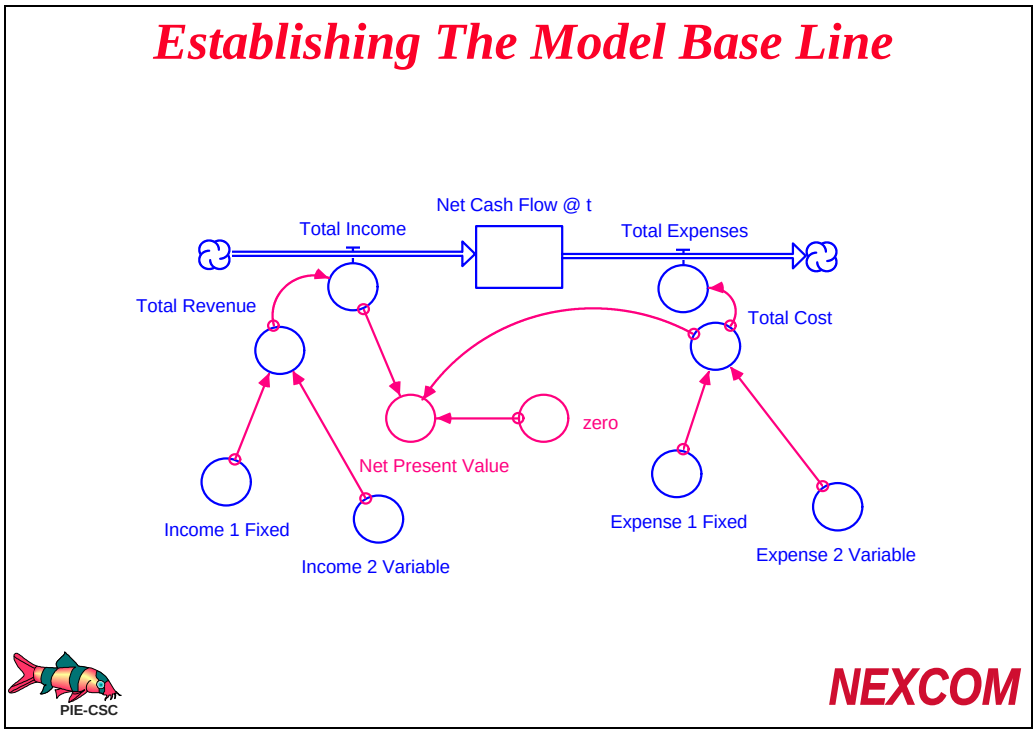

Figure 1: Modeling Basic Cash Flow Profiles

4 ANALYSIS

4.1 Base Case

The first simulation run is portrayed in several outputs or responses as viewed in Figure 2.

The initial conditions in this simplified simulation example are summarized below in Table 1.

Variable Name	*$ Dollars*
Net Cash Flow (Level)	-50,000 @ time = 0.0
Income 1 Fixed (Rate)	+20,000 @ time = 1 to 5
Income 2 Variable (Rate)	0.0
Expense 1 Fixed (Rate)	0.0
Expense 2 Variable (Rate)	0.0

Table 1: Initial Conditions for Base Case Model

The goal of this model is to accurately portray the levels and rates (cash flows) of a single investment opportunity to verify the economic capabilities of combined simulation. As with basic examples in use of discrete simulation languages, such as the "Bank Teller" example (Pritsker 1986), this initial base case serves as the model to establish creditability for economic investment alternatives and can be found in (White, Agee, & Case 1989). As Table 1 depicts, and visually displayed along with a cash flow profile in figure 2, the investment requires an initial capital investment of $-50,000 and expects to profit $20,000 per year over the next five years. Variability for income and expenses has been "zeroed" for this example. Additionally the Minimum Attractive Rate of Return (MARR) is set for 15%. The solution variable for this investment alternative is evaluated with a final Net Present Value (NPV) equal to $17,043.10.

Similarly, using standard economic formulations (White, Agee, & Case 1989) the same result can be calculated as

$$\text{NPV}(15\%) = -50\text{K} + 20\text{K}\ (\text{P} \mid \text{A}\ 15, 5). \qquad (4)$$
$$\text{NPV}(15\%) = \$17{,}043.10.$$

Note the Net Cash Flow profile is graphically portrayed at each time interval.

These results are viewed from a static profile. Although this example may appear to be extremely simplistic, the modeling effort soon becomes very large and complicated as the "real world model" incorporates multiple relationships. Thus, one of the many benefits of implementing simulation over spread sheet models is realized as the complexity of the models variables and relationships continues to increase. Using combined simulation will allow large system changes in seconds.

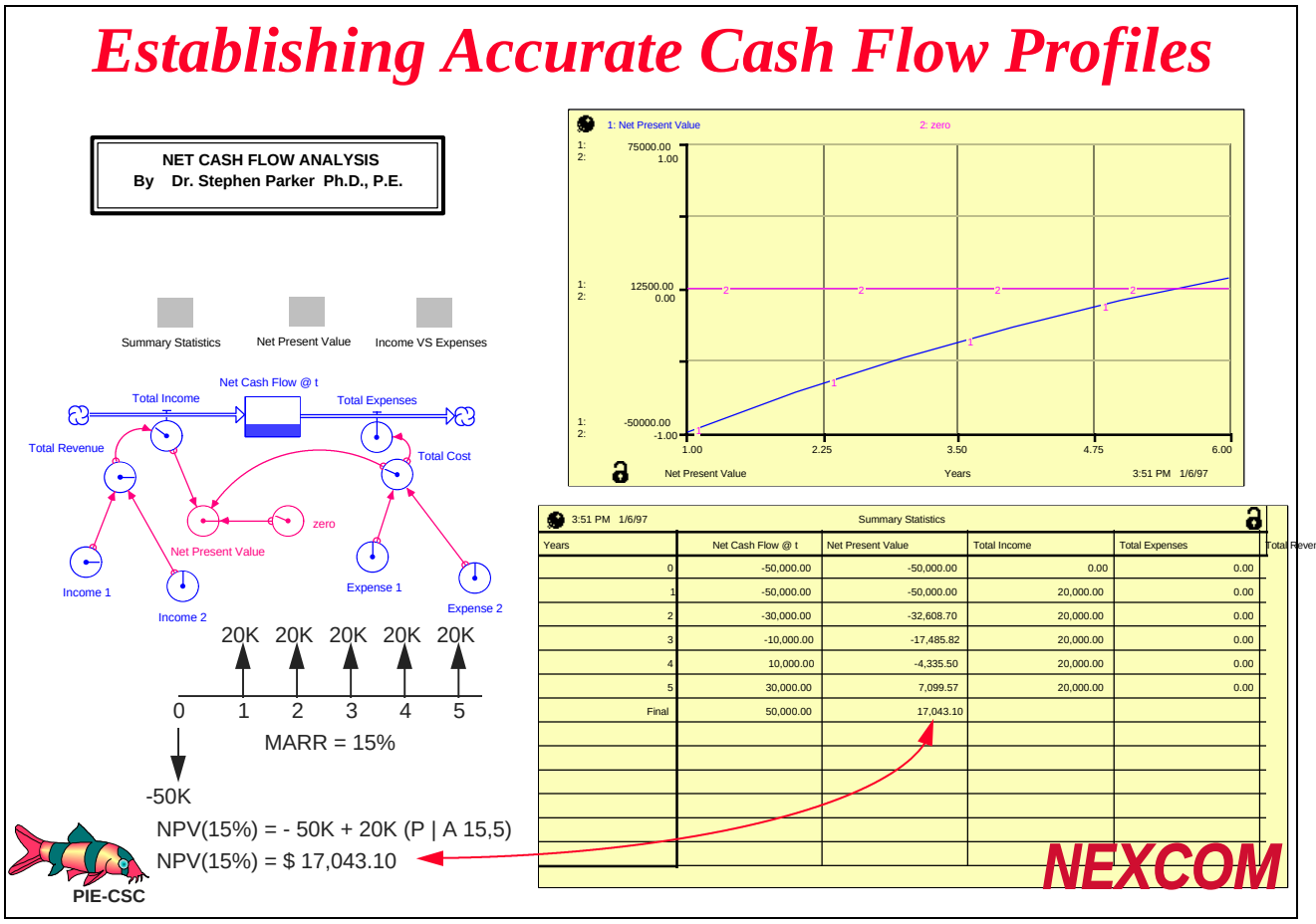

Figure 2: Modeling Cash Flow Profile for Base Case Scenario

4.2 Adding "Random Sampling" to the Scenario

The base case example has been slightly modified to model a set of future events from a random perspective. Table 2 depicts the changes which have been made to the base case scenario.

Variable Name	*$ Dollars*
Net Cash Flow (Level)	-50000 @ time = 0.0
Income 1 Fixed (Rate)	+20000 @ time = 1 thru 5
Income 2 Variable (Rate)	RANDOM (3500, 5000)
Expense 1 Fixed (Rate)	PULSE (-20000,3,5)
Expense 2 Variable (Rate)	RANDOM (-5000,-10000)

Table 2: Base Case Model "Random Sampling"

The previous model runs provided insight into new modeling capabilities regarding the use of level and rate equations. Simulation offers the opportunity to incorporate dynamic characteristics of commodity flows and to include the random nature of future events. Figures 3 and 4 depict these changes. Portions of the initial investment scenario remain the same. The startup cost is still $-50,000 and the expected returns are fixed at $20,000 per year over the next five years.

The first change is in the addition of income described by

$$\text{Income 2 Variable} = \text{RANDOM}(3500, 5000). \quad (5)$$

"Income 2 Variable" samples from a uniform distribution with a lower bound of $3500 and an upper bound of $5000.

Similarly the expense equations incorporate changes. "Expense 1 Fixed" is described by the PULSE function

$$\text{Expense 1 Fixed} = \text{PULSE}(-20000,3,5). \quad (6)$$

This PULSE function describes the above equation equal to -$20,000 starting at time period three (month three), and repeating every five time periods thereafter. This function may be used to model a periodic maintenance or repair policies associated with the ongoing support and operations of the system.

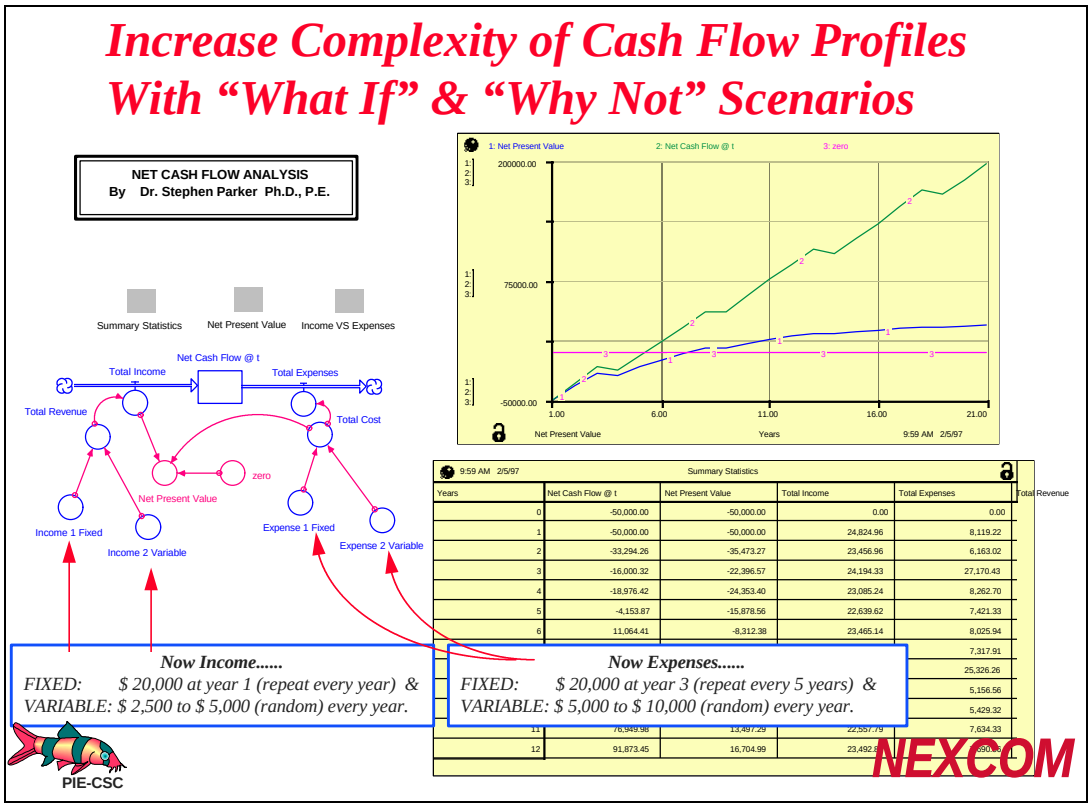

Figure 3: Modeling Variability for Income and Expenses

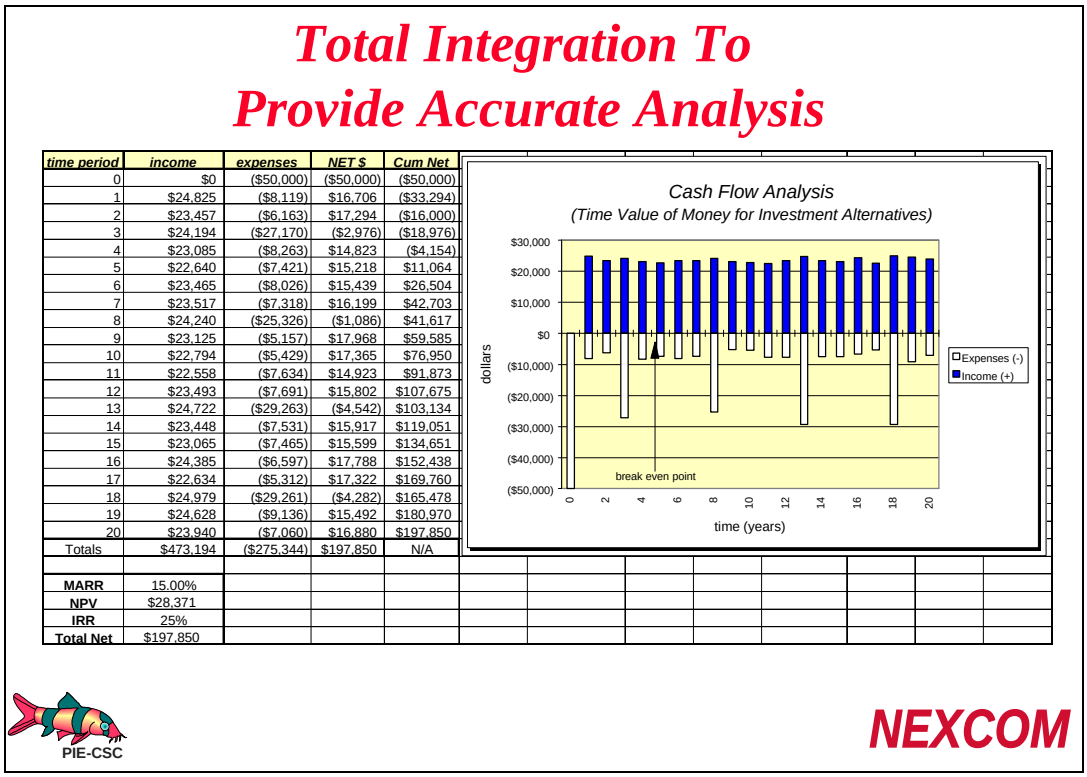

Figure 4: Integrated Output Analysis Support Using Financial Functions

The last expense equation,

Expense 2 Variable = RANDOM(-5000, -10000) (7)

will draw monthly from a uniform distribution, a variable expense with a lower bound equal to $-5000, and an upper bound equal to $-10,000.

In viewing the results of adding the variability described in Table 2, notice the Net Present Value (NPV) of the investment project, and the Net Cash Flow through time. The NPV is more detailed and provides the analyst the information regarding the value of the particular investment at various increments or steps through time. Depending on the length of the investment opportunity, five years, ten years, for example, the analyst can accurately compare and contrast several investment opportunities using this simulation strategy.

Note in figure 4 the output data has been dynamically linked into a industrial standard spreadsheet. Thus, the he output can further be analyzed with additional analysis. Here, the spreadsheet depicts the cash flow profile over time, and incorporates the MARR, the NPV, and the Internal Rate of Return (IRR) to further evaluate the investment.

5 SUMMARY

The previous modeling efforts provide proof and insight into how to use simulation to model investment alternatives. A major contribution is in the realization that simulation can incorporate industry standard economic methods to produce analysis and draw conclusions into various investment opportunities. In the NEXCOM example, the income and expense nodes were extremely detailed and rather complex in that the model included intricate detail down to and including seasonal changes in utility costs, leasing changes, tax rates, etc.. Thus, the Net Cash Flow profiles and the Net Present Value calculations became very critical in comparing an investment alternative in one location to a competing alternative location. Figure 4 further defines the analysis by visualizing a single cash flow profile opportunity with data imported from the simulation run.

Notice the spreadsheet incorporates the results with a cash profile along with critical information such as NPV and Internal Rate of Return (IRR) for that particular scenario or simulation run.

Profiles for each opportunity are “run” and ultimately compared by the NPV, and IRR. Once the basic simulation model was established as a baseline, we could then perform risk analysis on various investment opportunities or “Walmart” locations. Profiles were established and compared with the aid of a decision analysis software package. In this particular analysis, the NPVs of all possible scenarios were evaluated. The highest NPVs were rank ordered for further consideration.

ACKNOWLEDGMENTS

NEXCOM is a hypothetical corporation and bears no resemblance in whole or in part to any existing corporation.

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