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# SUMMARY OF ABSTRACTS

## Progressive Capital Recovery in Regulated Public Utilities

Jacques Bellemare, Teleglobe Canada

The entry of many new unregulated capital intensive competitors into service areas traditionally reserved to heavily regulated monopolistic Public Utilities is creating a strong challenge for both regulators and Public Utilities managers dealing with complex capital recovery issues.

This paper proposes a comprehensive analytical environment for the depreciation process which is developed around the integrated concepts of Capital Management and Micro-economic analysis. The Straight Line capital recovery pattern is analyzed within that environment and becomes the reference point for the assessment of various other recovery patterns.

The comparative analysis reveals that progressive (or decelerated) recovery patterns may often constitute a better means of achieving the capital recovery objectives than the traditional Straight Line pattern. The paper also suggests the application of a Step-Wise Adjustment (SWA) approach as a more realistic, practical, and efficient management solution to the capital recovery task.

The paper concludes that a major and fundamental change in perception and approach is required in the area of capital recovery management during the next decade. Such a change may necessitate a complete departure from today's highly dominant straight line depreciation methodologies.

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Ted L. Leavitt
Teresa T. Ninh

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In conclusion, we show that this new method can produce a better curve fit based on standard statistical measurements. We further speculate how future observed data may reflect competitive and technological influences.

**Modified Retirement Experience Index For Life Span Life Analyses Using The Simulated Plant-Record Method**

Ronald G. Lucas, Federal Energy Regulatory Commission

When using the Simulated Plant-Record (SPR) method for life analysis of relatively new utility property, often a depreciation analyst will realize that according to a computed retirement experience index, the data lack sufficient history to produce a reliable life forecast. Studies involving life span calculations require a different computation of retirement experience because the property being observed will not live to a normal end, but will end suddenly and concurrently at a certain date. This paper focuses on the development of a modified retirement experience index for life span analysis.

**Streamlined Depreciation Studies for Small Local Exchange Carriers**

John H. Rudd, Michigan Public Service Commission

Depreciation is becoming the most significant expense for many telecommunications companies and in today's environment determining appropriate depreciation rates can be a very complex task. Despite the complexities small companies are not exempt from the importance of using appropriate rates or from the need to perform periodic studies to determine what those rates should be. This paper describes the steps the staff of the Michigan Public Service Commission (MPSC) took to address that burden for the small local exchange carriers (LEC).

***Discussion Papers***

**Incentive Regulation: Hidden Disallowance Through Slow Depreciation**

Thomas A. Nousaine, Ameritech Services, Inc.
Jay M. Blomquist, Ameritech Services, Inc.

Regulated LECs face a two-pronged risk under incentive regulation schemes such as Price Caps because the depreciation rate setting process remains unchanged. Most forms of alternative regulation folow a similar pattens: prices will be fixed for certain market segments, but no reforms have been implemented for the depreciation process. Prices established at the beginning of the change do not adequately recognize the true rate at which it will be consumed in the future. The net result is a hidden disallowance of prudently invested embedded capital and a major risk to investors.

**Managing Depreciation Expense Under Incentive Regulation**

Carl R. Lanterman, GTE California

The determination of depreciation rates in a regulated utility has historically been a labor intensive task, for both the industry and the regulators, and more recently for consumer advocates. The thesis to be developed herein is that management of depreciation expense under incentive regulation lies with the management of the company, the same as if the company were not regulated. Beginning with the major issues of the past two decades and a description of the price cap formula, the role of depreciation is discussed in terms of depreciation accounting objectives and financial reporting objectives. The correlation between depreciation expense and pricing is developed under both the rate of return and economic concepts. Finally, the changing role of the regulator is discussed briefly, as emphasis is moved from setting of depreciation rates to monitoring the correlation of annual depreciation expense to long term capital programs.

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# Progressive Capital Recovery in Regulated Public Utilities

**Jacques Bellemare †**

## I - Introduction

The November 1989 inaugural issue of the Journal of the Society of Depreciation Professionals included a paper titled "The Theory and Practice of Depreciation Accounting Under Public Utility Regulation" written by Ronald E. White, Ph.D. This paper was refreshing, timely and stimulating for all of those who are deeply interested in the rigourous development of the capital recovery practices applied by the capital intensive public utilities, regulated or not.

In concluding his paper as it applies to the regulated utilities more or less subject to some form of competition, Dr. White mentions that "the emergence of competition presents a new set of challenges in setting depreciation rates for regulated utilities. The solution, however, does not lie in shorter service lives, identification of assets by equal-life groups or other measures intended to more nearly achieve cost allocation over service life. The threat of competition must be met with depreciation methods that will nearly achieve cost allocation in proportion to the consumption of service capacity. It is pointless to haggle over minor differences in service life and net salvage estimates if competitive pricing will not permit the recovery of revenue requirements based on straight-line depreciation."

Because we tend to agree with the overall critical analysis made by Dr. White in his own paper, the present paper is an attempt to define a new reference framework that could hopefully be helpful in the pursuit of the very stimulating search for analytical and managerial improvements in the field of capital recovery.

Although some of the ideas and comments presented in this paper may appear somewhat fundamental to the depreciation specialist, may we emphasize that the "new set of challenges" referred to by Dr. White are in fact dealing themselves with the very fundamental aspects of the depreciation process and practices.

No real progress is likely to be made until a wide consensus is reached amongst capital recovery professionals about the appropriate framework of reference required to permit the exercise of a rigorous and efficient debate on the many fundamental issues confronting the profession at the turn of the 21st century.

Part II of this paper outlines our proposal for an appropriate analytical environment for the depreciation process. This environment should be as broad as necessary and our proposal is being developed around the overall concepts of Capital Management and Micro-economic analysis.

In Part III, the Straight Line capital recovery pattern is being illustrated and analysed along the lines of the analytical environment set out in Part II. The Straight Line pattern then becomes the reference against which other recovery patterns are being assessed thereafter.

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Degressive (or accelerated) and progressive capital recovery patterns are then described and illustrated along the parameters set in Part II. An attempt is then made to establish the distinction between the degressive/accelerated and the progressive recovery patterns in relation to the Straight Line reference one.

Part III also includes a brief description of the "Step-Wise Adjusted Progressive" (SWAP) capital recovery management approach.

In Part IV, we elaborate on our perception of the Capital Recovery challenge of the next decade and we are discussing a few important and fundamental aspects related to that challenge such as the notions of "service capacity" and "service life", the revenue-expense matching principle, and the necessity to integrate the financial, technological and commercial dimensions into the capital recovery process.

Finally, Part V stresses the need for Corporate and Regulatory acceptance of the gradual application of innovative, progressive capital recovery methodologies in the management of Public Utilities.

The paper concludes that a major and fundamental change in perception and approach will be required in the area of capital recovery management during the next decade and that such a change may necessitate a complete departure from today's highly dominant straight line depreciation methodologies.

## II - The Micro-Economic Analytical Framework

The Public Utilities of interest in the context of this paper are capital intensive businesses. In general, they have a Fixed Asset base that could range anywhere between 2 to 3 times their Annual Operating Revenue base, and between 40% to 50% of their total revenue requirements are generated by the "Capital Consumption" process.

This is the case for most of the regulated telecommunications carriers in North America.

A typical micro-economic profile for such a situation is illustrated in Figures 1 and 2. Figures 1 and 2 are idealized illustrations. Their prime purpose is to permit size-up and understanding of fundamental issues. Figure 1 shows a visual representation of the fundamental micro-economic equation for a typical capital intensive Public Utility. It reflects the basic Revenue-Cost relationship of the business. It fits into the micro-economic analytical environment because it applies the revenue-cost relationship to a specific accounting period or service production period and the figures shown are all relative - (100%, 60%, etc.) - to highlight order of magnitudes.

Figure 2 shows a typical micro-economic profile for a capital intensive Public Utility. Again the numbers shown indicate relative measures and the profile is drawn to scale to permit a better visualization of the order of magnitude of the various components. The typical profile is idealized for the case where the current ratio is 1.0 (i.e. Short-term liabilities = Short-term assets).

Figures 1 and 2 are examples of illustrative accounting and are relating to the formal accounting statements of the firm.

This paper also situates the capital recovery process within the much broader management process of the capital resources of the firm. This overall framework of reference is shown as the Capital Management Framework illustrated in Figure 3. It shows that within a capital intensive business the capital management process should be a basic concern at all times: before and after capital resources are invested.

Before capital is invested the emphasis is placed on the management of the capital expenditures program of the firm. That management function however cannot be performed adequately without consideration of the future consequences of committing capital expenditures that are translating into capital consumption costs immediately after being effectively recorded in the Fixed Asset book.

After capital is invested, as shown on Figure 3, the capital consumption process translates itself into two distinct but highly interdependant cost segments:

- the "capital recovery" cost segment, and
- the "capital remuneration" cost segment.

In our opinion, it is not possible to make a proper assessment of the appropriateness, the reasonableness, and the efficiency of a capital recovery system without keeping in mind the duality of the capital consumption process: recovery and remuneration.

The capital recovery cost segment deals with the determination of the amount of loss in the value of a capitalized asset which should be allocated to the production cost of various service units in each of the accounting periods during which the service capacity of such asset is effectively consumed.

The capital remuneration cost segment deals with the remuneration of a capital remuneration base, generally the net asset base requiring effective funding by the capital structure of the firm.

|Capital Remuneration Base = Gross Asset Base |
| - Accumulated Depreciation |
| - Deferred Tax Liability |

Figure 1 shows that the "capital remuneration cost" can be assimilated to the firm's pre-tax composite cost of capital. This cost segment includes the interest charges, the net income and the income-tax provision (paid plus deferred). It therefore takes into account the specific capital structure of the firm.

Figure 2 also shows how the capital recovery and capital remuneration costs segments do relate to the capital recovery and capital remuneration bases of the firm.

The capital recovery and capital remuneration costs segments are accounting measures related to the Income Statement for a specific accounting period. On the other hand, the capital recovery and capital remuneration bases are accounting measurements taken from the Balance Sheet of the firm and averaged over the same accounting period as the capital consumption costs segments to which they relate.

The capital remuneration cost (defined as the corporate pre-tax composite cost of capital) and the capital recovery cost can therefore be considered micro-economic cost measures to the extent that they constitute direct basic elements of the cost of production of services, and consequently, of the total revenue requirements of the firm.

Figure 1 represents what, in our opinion, is the fundamental micro-economic equation for a capital intensive public utility, regulated or not, totally or partially.

|Total operating revenue requirements = Total cost of service production |

The consumption of capital contributes a substantial part of the cost of production and of the total revenue requirements of the firm (to be derived from the sale of its services through its commercial operations).

The consumption of capital implies two distinct consequences in the financial operations of the company, which translates themselves into two distinct but highly interrelated micro-economic cost elements: capital recovery and capital remuneration.

|Capital Consumption Cost = Capital Recovery Cost|
| + |
| Capital Remuneration Cost |

The capital recovery and the capital remuneration costs segments are intimately interrelated because the effective pattern of expense applied to fully recover the consumed capital base directly determines the magnitude of the net capital base to be remunerated, and consequently the absolute amount of such remuneration.

In the following parts of this article, the focus is placed on the description and assessment of various capital recovery methodologies. However, the capital recovery process is not examined in isolation; our analysis is done in full consideration of the tight linkage that exists between the capital recovery and capital remuneration dimensions within the overall capital consumption process.

## III-Capital Recovery Methodologies - Back to Basics

In this section various capital recovery patterns are analyzed and compared on the basis of the micro-economic analytical environment that has been described in the previous part. Therefore, for each recovery pattern being considered, the capital recovery, the capital remuneration and the total capital consumption costs are calculated and illustrated; the recovery reserve and the net carrying amounts are also illustrated.

The fiscal effects derived from the application of Capital Cost Allowances (CCA) rates in the Canadian Income Tax context have also been calculated and included in the comparative analysis. It is reasonable to assume that similar effects would be resulting from the application of the US fiscal treatment.

The following assumptions have been made for the purpose of the comparative developments:

- the initial capital amount to be recovered is $15,000
- the capital remuneration rate is 15%
- the corporate income tax rate is 36%
- the Capital Cost Allowance for the asset class is 20%

For each recovery pattern, the comparative data is calculated and illustrated for a capital recovery period of 15 years.

### The Straight Line Recovery Pattern - The Reference

The Straight Line recovery pattern data for a 15 year recovery period is shown on Figure 4 excluding any fiscal impact and, on Figure 5, including the Deferred Tax Liability fiscal impact.

Appendix A illustrates the detailed calculation of the fiscal impact of the Capital Cost Allowance (CCA) on the capital remuneration cost for the Straight Line pattern in the Canadian fiscal context.

Appendix B provides the various formulas used to obtain the data shown on the diagrams illustrated in Figures 4 and 5 for the Straight Line pattern. The Microsoft EXCEL software was used for that purpose.

As can be seen from Figures 4 and 5, the basic feature of the Straight Line recovery pattern is that the initial cost is being recovered uniformly (in equal amounts) through the recovery period.

*Said differently, the capital recovery cost is the same for* each accounting period. In our example, the capital recovery cost is therefore equal to $1,000 per year as shown on diagrams 4.3 and 4.5. The recovery (or depreciation) reserve builds up linearly from zero $ to the full recovery amount of the $15,000 initial cost (no more, no less) at the end of the last accounting period as shown on diagram 4.6.

In the absence of any fiscal impact due to deferred taxes, the capital remuneration base (the "net carrying amount" shown on diagram 4.2) is decreasing linearly from $15,000 (initial cost) to zero $ at the end of the récovey period. When the capital remuneration rate is applied to that remuneration base, a linearly decreasing "capital remuneration cost" is *obtained as shown on diagram 4.4.*

The total "capital consumption cost" profile for the Straight Line pattern (diagram 4.5) is the sum of both the capital recovery cost (diagram 4.3) and the capital remuneration cost (diagram 4.4). The dark costs segments on diagram 4.5 are corresponding to the costs segments shown on diagram 4.4 and the white segments on diagram 4.5 correspond to the costs segments shown on diagram 4.3.

Diagrams 5.4 and 5.5 of Figure 5 show the impact of including the Deferred Tax effects (CCA) in the calculations of the Capital Remuneration Cost and the total Capital Consumption Cost.

In this article, we are looking at the Straight Line *recovery pattern as the basic reference* for the rest of our analytical treatment for a few important reasons:

a) the Straight Line pattern corresponds to the first level of rationalization in attempting to deal with the capital recovery "problem". It is the first criteria of rationality that comes to mind when attempting to justify a recovery pattern especially if the recovery process is analyzed in isolation or in abstraction of any of its interrelated dimensions: financial, technological and commercial.

b) in its simplest form it is relatively easy of application, at least in theory, because it only requires the determination of a specific life estimate for the asset which, once translated mechanically into a recovery rate, is applied uniformly to the *initial cost to be recovered throughout the recovery period.*

c) it is the pattern which is the most widely applied in the Public Utility environment, despite incredibly complex intellectual girations that makes it less and less linear in its practical applications, to such an extent that many depreciation specialists are experiencing great difficulties (or simply refuse by principle) to even consider that alternative patterns may be as "rational" at a more global level and may be worth looking at.

d) although the Straight Line recovery pattern generates *a constant flow of recovery costs (or depreciation* expenses), it does produce an uneven spread of total capital consumption costs (or revenue requirements) in the various accounting periods, with the largest cost impact occurring in the early span of the recovery period as indicated by diagrams 4.5 and 5.5 on Figures 4 and 5.

e) being characterized by a constant recovery rate applied throughout the recovery period, the Straight Line pattern can therefore serve as a good base of comparisons for other recovery patterns that can thereafter be analyzed in relation to their deviation from that reference pattern.

Other recovery patterns can then be classified in two categories as follows:

i) the degressive (or accelerated) recovery patterns: those where the initial cost is recovered faster than in the reference straight line pattern during the initial phase of the recovery period,

and

ii) the progressive recovery patterns: those where the initial cost is recovered less rapidly than in the reference straight line pattern during the initial phase of the recovery period.

### Degressive (or Accelerated) Recovery Patterns

A degressive (or accelerated) recovery pattern can therefore be defined as a pattern where the recovery rate decreases gradually over the recovery period and the recovery reserve is building up faster than in the straight line pattern.

The "Declining Balance" and the "Sum of the year digits" (SOYD) depreciation methods are two examples of degressive recovery patterns.

The SOYD pattern is characterized by a linearly decreasing "recovery cost" pattern. Figures 6 and 7 show similar profile data for the SOYD pattern as Figures 4 and 5 do for the reference straight line pattern. As can be seen, a degressive pattern accelerates the recovery process in the early years of the recovery period. The Capital Consumption Costs (revenue requirements) are therefore much larger in the early years and consequently lower in the later years of the recovery period than they are in the reference pattern. However, because of the recovery acceleration process, the total revenue requirements generated over the entire recovery period are less than those generated by the reference pattern. This would also be true for the application of any Degressive (or Accelerated) recovery pattern.

### Progressive Recovery Patterns

On the other hand, a progressive recovery pattern can be defined as a pattern where the recovery rate gradually increases over the recovery period and the recovery reserve is building up less rapidly than in the straight line reference pattern.

Progressive recovery is presently rather uncommon in the current management and regulation of Public Utilities, but it is a financial management mechanism commonly applied in other sectors of the capitalistic system. The best illustration of a progressive recovery mechanism is the well-known mortgage reimbursement system applied by financial institutions where both the capital remuneration cost (interest payment) and the capital recovery cost (principal repayment) are paid by means of a constant periodic amount collected throughout the recovery (or repayment) period.

The mortgage reimbursement system is a "Constant Capital Consumption Cost" progressive capital recovery pattern. The profile of a "mortgage type" progressive capital recovery pattern is illustrated in Figures 8 and 9 along the same parameters used to describe the previous patterns. Figure 8 shows the pattern characteristics in the absence of any fiscal effect caused by deferred income-tax measures (CCA) and Figure 9 includes the fiscal effect of applying a 20% CCA rate to the original cost of the asset.

The "Constant Capital Consumption Cost" (or 4-C) feature of the "mortgage type" pattern is well illustrated on diagram 8.5. As can be seen on diagram 8.3, a constant capital consumption cost (4-C) pattern is also characterized by the application of a different "recovery rate" in each one of the accounting period constituting the whole recovery period. There is also a slow build-up of the recovery reserve (accumulated recovery) in the early years of the recovery period followed by an acceleration of the reserve build-up in the last phase of the recovery period as indicated on diagrams 8.6 and 9.6. Diagram 9.5 illustrates that the inclusion of the fiscal CCA effects into the calculations is causing the Capital Consumption Cost pattern to adopt a saucer shape through the recovery period.

Figure 10 illustrates the particular recovery reserve profiles for various capital recovery patterns. It clearly shows how the traditional "straight line" recovery pattern can serve as a good "reference base" or "dividing line" to qualify other recovery patterns as being "Degressive" or "Progressive" in relation to that reference.

The area below the straight line recovery path can be defined as the Progressive Capital Recovery Area and those recovery patterns that follow a recovery path within this area can be qualified as being Progressive Recovery Patterns.

The area above the straight line recovery path can be defined as the Degressive Capital Recovery Area and those recovery patterns with recovery path within this area can be qualified as being Degressive Recovery Patterns.

### Step-Wise Adjusted Capital Recovery Patterns

Figure 11 illustrates two typical profiles of Step-Wise Adjusted (SWA) Capital Recovery Patterns: a degressive one (or SWAD type) situated in the degressive recovery area above the straight line reference profile, and a progressive one (or SWAP type) situated in the progressive recovery area below the straight line reference profile.

A SWA pattern is characterized by the fact that the full recovery of the total amount to recover is accomplished by a succession of straight line recovery patterns each applicable during a specific span of the recovery period.

Under a SWA pattern, the full recovery of the capitalized amount is achieved by adjusting the recovery rate at specified interval during the recovery period. Adjustment intervals could well vary from 3 to 5 years for assets with recovery periods extending from 10 to 30 years or more.

For a short recovery period of, say, five years, a succession of five yearly adjustments could well constitute a SWA profile. In the context of this paper, yearly adjustments of the recovery rate for recovery periods exceeding 10 years would not fall within the spirit of a SWA pattern. Nevertheless, at the limit, any pattern resulting from a number of discrete adjustments to the capital recovery rate (CRR) could be considered as a SWA pattern.

For the purpose of our comparative analysis of the various capital recovery patterns, the impact of applying a SWAP pattern to the recovery of the $15,000 asset example is illustrated in Figures 12 and 13 in the same format already used for the prior patterns. The step-wise adjustments of the "depreciation" or "recovery" rates are reflected by the step-wise profile of the Capital Recovery Cost shown on diagram 12.3. The resulting patterns of Capital Consumption Costs and Recovery Reserve build-up are shown on diagrams 12.5 and 12.6 respectively.

It should be noted that, under a "straight line" capital recovery process, a SWA type recovery pattern is effectively created every time a change in the "life expectancy" of an asset is made and is reflected by making a corresponding change to the "straight line" recovery rate (depreciation rate) required to achieve the full recovery of the initial cost over the remaining life of the asset. Figure 14 illustrates that process.

In Figure 14, an asset is initially put into service with an expected service life of 25 years and it is "depreciated" at 4% per year under a straight line regime so that 20% of the initial cost is being recovered after 5 years. At that time a life study indicates the total life of the asset is reduced to 20 years, and that the 80% of unrecovered cost should be recovered over the 15 years remaining life at a 5.4% recovery rate. Finally, at year 10 another study indicates a revised remaining life estimate of 5 years (total life of 15 years) and a further change of "depreciation rate" is made to 10.6% in order to recover the last 53% of original cost before the final retirement of the asset from service at the end of year 15.

All of the changes in the capital recovery treatment illustrated in Figure 14 are made within the framework of a "straight line" capital recovery regime. Nevertheless, the resulting recovery pattern can, by no means, be qualified of being a Straight Line recovery pattern. The result is, in fact, a SWAP recovery pattern over the real 15 years capital recovery period.

In Figure 14, the notions of "theoretical" recovery reserve and of "reserve deficiencies" are also illustrated. Within a Straight Line recovery environment, a "theoretical" reserve level corresponds to the % recovery level that would have been reached if a current view of the estimated asset life had been known at the start of the recovery period and if the corresponding recovery rate had been applied throughout the real recovery period.

A "reserve deficiency" is the difference between the "theoretical" reserve level and the "actual" reserve level. In a straight line recovery environment, reserve deficiencies occur in a situation where an asset service life is overestimated initially. A SWAP pattern generally leads to "reserve deficiency" situations when compared with a pure straight line recovery pattern objective as indicated in Figure 14.

Figure 15 illustrates the case of a SWAD pattern resulting from an initial underestimation of the service life of an asset. A SWAD pattern generally leads to "reserve excess" situations when compared with the pure straight line recovery objective over the life of the asset.

In this paper we are suggesting that, under current capital recovery practices, pure straight line recovery patterns seldom exist for all practical purposes. In fact, because of the many corrections that are made to the "depreciation rates" during the service life of an asset by the application of so-called "straight line" methodologies, the real resulting recovery patterns are SWA type patterns, SWAP or SWAD.

## IV - The Capital Recovery Challenge

In Part II of this paper we have attempted to describe our vision of what constitutes an appropriate analytical environment for the capital recovery process within a capital intensive Public Utility. Such an environment clearly situates the Capital Recovery process as only one of the many interdependent activities related to the broader Capital Management process.

In Part III we have attempted to illustrate (through the development of simple examples) some of the fundamental implications of applying various Capital Recovery Patterns in that broader analytical environment.

As a result of this first level of analysis, it appears evident to us that the widely applied Straight Line Recovery Pattern does not satisfy a high level of rationalization but merely corresponds to a first order of rationality in which the capital recovery process is considered in complete isolation from the other capital management realities of the firm.

We believe this is the greatest intellectual challenge that is now confronting the capital recovery professionals, because it is forcing a complete reevaluation of the validity and appropriateness of the basic principles supporting the current day to day depreciation accounting practices. In this short paper we do not pretend to offer an exhaustive answer to that challenge. We rather intend to express views and ideas that will stimulate the debate towards a full recognition of the challenge by all professionals involved in the Capital Recovery discipline. In that perspective, we believe it is now useful to elaborate further on the following aspects:

a) the notion of "service capacity" of an asset,
b) the revenue-expense matching principle,
c) the integration of the financial, technological and commercial dimensions into the capital recovery process.

### The notion of "Service Capacity" of an asset

In part II of his paper, Dr. White deals with the Fundamentals of Depreciation Accounting. He then summarizes as follows the definitions and objectives of depreciation accounting provided by cost allocation and accounting theory:

- "Depreciation is a measurement of the service capacity of an asset that is consumed during an accounting period. This is the relevant concept of depreciation which underlies the accounting process."

- "Ideally, the service capacity of an asset should be measured as the present value of the net revenue (revenue less expenses exclusive of depreciation and other non-cash expenses) or cash inflows attributable to the use of that asset alone."

- "Depreciation expense is an estimate of the cost of the service capacity of an asset that is consumed during an accounting interval. It is the estimate of the cost of obtaining the net revenue attributable to the use of an asset during an interval in which income is earned."

- "The goal and objective of depreciation accounting is cost allocation over the service life of an asset in proportion to the consumption of service capacity."

- "The pattern of cost allocation that best approximates the net-revenue contribution method should be selected."

We do not dispute the validity of these definitions and objectives - in fact they are guiding us in our attempts to arrive at practical means of approaching the "ideal" situations described in Dr. White's summary.

It can be seen from the summary that the notion of "service capacity" is fundamental to the significance of most of the stated definitions and objectives.

However, the great difficulty of measuring the "service capacity" of assets used in capital intensive P.U. along an "ideal" parameter such as a net-revenue contribution pattern is also well recognized by Dr. White.

On our part we feel that the "ideal" measurement proposed by Dr. White (net-revenue contribution) is too remote from the operational realities of modern Public Utilities to be used in any practical manner into an efficient management system. It is an "ideal" in principle. It can only be used to determine how well other practical and efficient measurements are performing in approaching it.

In recent years the accounting profession has gone a long way to improve its understanding and treatment of the notion of "service capacity" for an asset especially in the context of capital intensive Public Utilities. By example, in May 1989, the Accounting Standards Committee of the Canadian Institute of Chartered Accountants (CICA) issued an EXPOSURE DRAFT of Proposed Accounting Recommendations dealing with the appropriate accounting treatment for the measurement, presentation, and disclosure of property, plant and equipment including both tangible and intangible items.

The proposals included in the Exposure Draft also deal with the unique characteristics of rate-regulated property, plant and equipment.

The following statements related to the object of this paper are of interest in the accounting standards proposed by the CICA:

- "Property, plant and equipment should be charged to income over their useful lives in a rational and systematic manner appropriate to their nature and use. Useful lives of intangible properties are not to exceed 40 years."

• "Amortization policies and estimates of useful lives and residual amounts should be reviewed regularly and at least every five years."

• "Rate-regulated property, plant and equipment is acquired for or employed in operations meeting both of the following criteria:

i) the rates for regulated services or products provided to customers are established by or are subject to approval by an independant, third-party regulator or by a governing board empowered by statute or contract to establish rates charged to customers; and

ii) the regulated rates are designed to recover the specific costs of providing the regulated services or products."

• "Service potential is used to describe the output or service capacity of an item of property, plant and equipment and is normally determined by reference to attributes such as physical output capacity, associated operating costs, useful life and quality of output."

• "Useful life is either:

• the period over which an item of property, plant and equipment is expected to be used by an enterprise; or

• the number of production or similar units expected to be obtained from the item by the enterprise."

• "Expected useful life is normally the shortest of the physical, technological, commercial and legal life of an item of property, plant and equipment. Factors considered in estimating useful lives include expected future usage, the maintenance program, results of studies made by an industry association, studies of similar items retired, and the condition of existing comparable items. For intangible properties, however, the estimate of useful life does not exceed forty years. The amortization of property, plant and equipment is adjusted when a betterment increases the expected useful life."

The CICA also specifically recognizes the rational application of different methods of capital recovery when it specifies the following at Item .32 on page 8 of the May 1989 Exposure Draft.

"Different methods of amortizing property, plant and equipment result in different patterns of recognizing their amortizable amounts in income. The method selected for use will be one that reflects the consumption of service potential of the property, plant and equipment. A straight line method reflects consumption of service potential as a function of time. A units of production method reflects consumption of service potential as a function of usage, when units of input or output can be identified and estimated. An accelerated method may be appropriate in certain situations, for example an increasing charge method may be used when an enterprise can price its goods or services so as to obtain a constant rate of return or a revenue contribution method may be used when there is a direct relationship between the service potential of the item and revenue, and future revenue can be reasonably estimated."

The May 1989 CICA Exposure Draft uses terms such as "consumption of service potential" when dealing with the capital recovery process. This is clear evidence that the notion of "service capacity" is evolving and is now extending to cover the more comprehensive conceptual framework of the production process of the services, more in line with a micro-economic analytical environment such as already been described earlier in Part II of this paper.

In an era of intense technological development and improved manufacturing techniques, many physical assets are enjoying large service capacities and, in fact, most of their "service potential" is likely to be fully exploited towards the end of their physical, technological or commercial service lives rather than at the beginning.

To illustrate this point we can say that the service potential of a train locomotive is certainly higher in the early years than in the last years of its service life. By contrast, the service potential of a high capacity major Fiber Optic trunk cable route is certainly much larger in the later part than in the early part of its service life.

We can see that the notion of "service capacity" of an asset is gradually moving from a direct and linear association with its physical life to a more sophisticated link with its commercial service potential, a notion expressing its capability to contribute to the effective generation of revenues for the enterprise.

In that perspective, the unused "service capacity" of an asset is not contributing to the generation of revenues for the enterprise until it is effectively put to work during the physical service life of that asset.

In most of the public utilities an individual asset is not generating service revenues by itself. Assets of various kinds and vintages need to be aggregated together to form service networks. Individual assets are contributing to the service production process, i.e. the revenue generation process, only to the extent that some of their service capabilities are used to render the services sold.

The "consumption of service potential" pattern for a specific asset unit is certainly a basic and relevant information item to be used in the determination of a pattern of "revenue generation potential" applicable to this asset unit. The "revenue generation potential" of an asset is certainly a notion that could be used as a satisfactory proxy for, and capture the essential spirit of, the "net-revenue contribution" ideal measurement in the case of a Public Utility capital recovery regime.

## Various Levels of Rationality for the Matching Criteria

As stated before from Dr. White's paper, "the goal and objective of depreciation accounting is cost allocation over the service life of an asset in proportion to the consumption of service capacity".

In a statement also cited above and that can be seen as complementary to the goal and objective one, the CICA proposes that assets "should be charged to income [or recovered] over their useful lives in a rational and systematic manner appropriate to their nature and use".

At this point we are entering into a discussion as to what can be considered rational and systematic. Various levels of "rationality" can be visualized that correspond to various levels of perception and/or definitions concerning the task to be accomplished by the capital recovery process.

As we said earlier in setting our own terms of reference in Part II of this paper - we perceive the straight line recovery method as only responding to a first level of rationality whereby the goals and objectives of the capital recovery process are examined and treated in complete isolation from the other distinct but interdependant aspects of the corporate capital management function of a capital intensive business. This first level of rationality consists of achieving the total recovery by the application of an equal recovery amount in each accounting period throughout the service life of the asset.

The straight line recovery pattern in its pure and integral application is certainly a rational and systematic manner of proceeding - but it is only a partial response to a highly constrained vision of the overall micro-economic process of capital consumption in the production of goods and services.

We believe that an appropriate capital recovery pattern for an asset could also be situated at a higher level of rationality and could very well consist in the selection of a recovery pattern that would ensure the best match between the Capital Consumption Costs and the Revenue Generation Potential patterns of that asset over its service life. We are now talking about matching the Costs and Revenue "patterns" over the expected life of the asset.

In this paper, we are suggesting that the total Capital Consumption Costs pattern is a better mean of rationalization for the Cost side of the matching game, and that the Revenue Generation Potential pattern is the more coherent element of rationalization on the Revenue side of the matching game.

When viewed in that perspective, it is the Mortgage Type recovery pattern (illustrated in Figures 8 and 9 in Part II) with its Constant Capital Consumption Costs (4-C) pattern that would ensure the best Cost-Revenue Match in the case of an asset having a uniform Revenue Generation Potential pattern throughout the recovery period (or its service life). In that case, the Constant Capital Consumption Costs recovery pattern (the 4-C or Mortgage Type pattern) appears to satisfy the depreciation accounting "matching principle" in a more appropriate and refined manner. It is also "rational and systematic" but at a higher level of rationality corresponding to the inclusion of a more comprehensive understanding of the capital consumption process affecting a capital intensive business.

In practice, for most of the assets used by modern Public Utilities, the 4-C Mortgage Type capital recovery pattern is certainly much closer to the Revenue Generation Potential or Service Capacity Consumption pattern than is the current widely applied Straight Line pattern. But the 4-C pattern implies the application of a "Progressive" capital recovery pattern through the service life of the asset. This is exactly where the challenge resides for the Depreciation Professionals over the next decade!

In fact, one of the major consequences of applying a Progressive recovery pattern is that the capital is recovered at a less rapid rate than under a Straight Line pattern during the early stage of the asset life. And this appears somewhat in contradiction with the current trend or pressures towards the implementation of accelerated or degressive recovery patterns. Reversing this trend while respecting the fundamental principles of accounting and ensuring a high level of rational justification will require a deep understanding of all the dimensions and consequences of the Capital Recovery activities within the broader scope of the Capital Management process.

The application of the SWAP capital recovery approach that we describe in Part II is a practical attempt to cope with the new challenge. We submit it to the good consideration of the Capital Recovery Professionals community because it appears to achieve the following in relation with the depreciation accounting goals and objectives:

a) It takes into account the high level of uncertainty inherent to the forecasts of the service life especially in the early years of a long-life asset.

The objective of making a precise estimate of the service life right from the start does not reflect a realistic management behavior. Hoping that such an estimate will materialize in the longer term without changes is not any more realistic. The only certainty with an initial precise life estimate for an asset having a 15 to 25 years life expectancy is that such a precise estimate is likely to be wrong.

The SWAP depreciation approach explicitly recognizes that reality with a low recovery rate being applied in the early years of the service life with no real attempt to achieve a predetermined specific life estimate. At that stage it should be sufficient to know that we are in presence of a long-life rather than a short-life asset.

b) It proposes to achieve the total recovery of capital by making a series of periodic "adjustments" to the depreciation rates applied throughout the service life of the asset. These adjustments could be made every three to five years and, each time an adjustment is made, a new judgment is passed on the expected remaining life of the asset, but always in recognition of an uncertain environment.

This periodic adjustment process is illustrated on Figure 16. It can be seen that the path to the full recovery of consumed capital can be gradually modified as more specific information on the ultimate asset service life is gained throughout its service history. Under such an approach the capital recovery decisions are always taken on a prospective analysis basis very much integrated to the financial, commercial and technological strategic business plans.

c) It approaches the results of the more "ideal" mortgage type recovery pattern (the 4-C pattern) in a step-wise manner. In fact, for an asset with an uncertain long life expectancy, the 4-C pattern is also subject to certain deviation from an ideal situation. Unlike a real mortgage situation where the interest rate (capital remuneration) and the repayment period are fixed in advance by contract, in the case of a 4-C pattern, the recovery period is subject to uncertainty and the capital remuneration rate is also subject to many possible variations of the firm's pre-tax composite cost of capital throughout the recovery period.

In addition, even in its purest form with fixed terms (life and remuneration rate), the 4-C pattern also requires an annual adjustment of the recovery (depreciation) rate. The SWAP approach eliminates the need for annual recovery rate adjustments.

d) Most of the assets used in modern Public Utilities are characterized by Service Capacities and Revenue Generation Potential patterns that are progressive or increasing with time. A SWAP recovery pattern would ensure a better match between the total Capital Consumption Cost and the Revenue Generation Potential patterns for these assets. Typical matching profiles are illustrated on Figure 17.

The declining CCC solid line pattern illustrated in diagram A of Figure 17 is a typical Straight Line profile as already illustrated in diagrams 4.5 or 5.5 of Figures 4 and 5. The Revenue Generation Potential (RGP) profile represented by the other solid line in diagram A is typical for most of the long-lives assets used by P.U. The CCC pattern shown as a dotted line would constitute a better matching proposal for the RGP pattern indicated on diagram A than the solid line one. In fact, the solid line which corresponds to a Straight Line recovery pattern can even be qualified as a "mismatch" profile when compared to the dotted line one.

Diagrams B and C are examples of "matching" profiles. Diagram B would reflect the case of an asset having a declining Service Capacity with time; diagram C reflects the situation of an asset with a constant Service Capacity (or Revenue Generation Potential) through its service life.

**Integration of the Financial, Technological and Commercial Dimensions**

As indicated earlier, a modern capital intensive P.U. requires the placement of a large capital asset base to perform its commercial business operations. In this paper we are suggesting that the capital recovery process is an integral part of the broader capital resource management process illustrated in Figure 3. We also suggest that the Capital Management process is one that should integrate the technological, financial and commercial dimensions of the P.U. business operations.

We perceive the capital recovery decisions as forward-looking activities very much related to the business Capital Expenditures Program planning process, and we are likely to hear more and more about "technology turnover management" in the future.

The recent applications of the Fisher-Pry and other models by recovery specialists in attempting to cope with the technology turnover problem is symptomatic of a fundamental need for change in capital recovery methodologies. It appears to be more a question of emphasis and realism than of fundamental theoretical validity.

By example, in his paper, Dr. White uses the cases of vehicles to illustrate the application of sound and very likely valid theoretical accounting principles. But the vehicles are short-life assets and furthermore their specific contribution to "net revenue" is assumed to be known for the covered accounting periods.

However, the investment reality of modern capital intensive P.U. is quite different. Their operating networks are vast aggregates of very diversified long-lived assets used to provide more and more sophisticated services in a rapidly changing technological and managerial environment. Furthermore, unlike the vehicle example used by Dr. White, the expected contributions of each of these network's segments to the business profitability (net revenue contribution) are generally unmeasured or unknown and would be of very little practical significance on a current accounting period basis. In fact, it is the profitability of specific "services" which is of current management significance to the business.

Figure 18 illustrates the fundamental concept by which a SWAP capital recovery methodology can be rationally and systematically integrated with new technology introduction planning information to constitute a Technology Turnover Management Strategy. The SWAP recovery approach specifically recognizes the high level of uncertainty inherent to an original life estimate in the case of a long-life asset. As can be seen from the two top diagrams on Figure 18, the accelerated recovery of the capital invested in technology A is realized in the last phase of its life (1980-85), at the same time as technology "B" is initially installed. But, because of inherent life expectancy uncertainty, technology B is being recovered at a low rate in the initial phase of its technological service life, which coincides with the period 1980-85.

The remaining life expectancy of technology A in the last phase of its life (1980-85) is not subject to the same level of uncertainty as it was in the early years of its life. In fact, the remaining life estimates for a technology under replacement shall be much more precise because of the need to have specific Capital Expenditures planned in the business' construction program to ensure the placement of the replacing technology B.

The two last diagrams on Figure 18 illustrate how the decision affecting the recovery rates for technology B could match the decisions to implement technology C earlier or later. Again, planning information related to the introduction of the new technology C would affect the specific recovery pattern applied to the prior technology B. And, for the same reasons as for technology B, the initial recovery of technology C would be realized at a low rate during the initial phase of its service life, and at a faster rate at the end of that life, under a SWAP approach.

Again, to summarize, the low rate of recovery applied in the initial years fulfills two objectives:

i) it takes into account the level of uncertainty inherent to the estimation of the service-life expectancy for long-life assets, and

ii) it permits to levelize the total Capital Consumption Cost pattern to ensure a better match with the Revenue Generation Potential pattern in the case of assets with flat or rising "service capacity" patterns.

Another area of integration lies in the introduction of market data considerations in the determination of appropriate recovery patterns. Figure 19 illustrates "Unit Capital Consumption Cost" (Unit CCC) profiles for various recovery patterns (Declining Balance, Straight Line, SWAP, and 4-C Mortgage type) in the case of a $15,000 capital asset serving an annual market potential growing from 100 to 400 service units over a 15 years interval.

The Unit CCC for each recovery pattern and for each accounting period is calculated by dividing the Total Capital Consumption Cost shown in diagrams 5.5, 7.5, 9.5 and 13.5 by the number of Service Units in each year of the Market Forecast shown in diagram 19.1. The resulting Unit CCC data is shown on diagram 19.2 together with an hypothetical Constant Unit Revenue (Unit Price) pattern set at $15.00 throughout the 15 years recovery period (or service life).

It can be seen that in the case of a rising market or a rising Revenue Generation Potential, it is still the Mortgage type pattern that minimizes the variations from a "Constant Unit Price" situation when compared with the Straight Line or other Degressive recovery patterns. We also see that the SWAP pattern approximates very well the Mortgage Type pattern. Again it is the matching relation between patterns which is of interest.

**The "Net Revenue Contribution" Concept**

In Dr. White's summary of definitions and objectives of depreciation accounting cited earlier, he says:

"The pattern of cost allocation that best approximates the net-revenue contribution method should be selected."

The "net-revenue contribution" notion is itself defined in Dr. White's summary as part of the definition of the service capacity of an asset "which should be measured as the present value of the net revenue or cash inflows attributable to the use of that asset alone", where net revenue means "revenue less expenses exclusive of depreciation and other non-cash expenses".

That type of definition based on present-worth estimates of future cash-flow, or discounted cash-flow financial analysis (DCF) appears as another means of saying that any loss in the commercial or market value of an asset incurred in a specific accounting period should be recovered in that same accounting period.

Such an approach is certainly theoretically valid and fully legitimate. By example, a capital investment in land is generally not subject to depreciation (or capital recovery) because the "market" value of a piece of land is normally increasing with time and consequently there is no "capital consumption" in its use to perform a business operation.

But the "net-revenue contribution" is an ideal way of looking at the capital recovery task. It would be a satisfactory process if there was an easy and practical way of determining on a continuous basis the fair "market" value of each item, constituting the complex network of interworking assets of a "public utility".

But the assets that are being considered under the scope of the present paper are those who are losing most of their value in the course of their service-life within the Public Utilities. They are not normally reused after removal from service and they can be considered as having zero salvage value for the sake of the present analysis. We believe this is a fair assumption for the bulk of the depreciable assets of most of the regulated public utilities.

Furthermore, we don't believe it would be feasible or practical to attempt to measure the "market value" of the various asset items and it is doubtful that there would even exist a "market" to determine a fair value for such items. This vacuum of practical and significant measurement explains why we are promoting the idea of matching a Revenue Generation Potential profile with a Capital Consumption Cost profile for a given asset item as being a valid alternative proposal for a practical and manageable mean of achieving a "pattern of cost allocation that best approximates the net-revenue contribution method".

As it is now being defined, the net-revenue contribution of an asset is some kind of continuous residual (or remaining) profitability measure for that asset alone. In the development of the broad "Capital Management" analytical framework that we are proposing, we are suggesting that the Revenue and Cost profitability parameters are well taken into consideration and captured by the imputation of the Capital Remuneration cost segment into the matching game.

Therefore, the "ideal" statement of objective for the capital recovery process of a capital intensive Public Utility could be reformulated as follows: "To assign Capital Recovery costs in order to obtain the best match between the Revenue Generation Potential pattern and the Capital Consumption Cost pattern of an asset".

**Revenue Requirements considerations are legitimate and essential**

In Sections III and IV of his own paper, dealing with "Depreciation under Regulation" and "Depreciation under Changing Economic Conditions", Dr. White recognizes that:

"A major concern of regulation in recent years has been the revenue requirement impact of ratemaking proposals that would shift the timing of depreciation expense or the burden of capital recovery to different classes of ratepayers."

A few other statements from Dr. White are worth citing at this point, on the question of Regulation and Competition:

"Regulation has for the most part adopted the accounting standard of cost allocation over service life as the proper measurement of depreciation expense. Little attention, however, has been given to the second objective of the dual accounting standard (i.e. cost allocation in proportion to the consumption of service capacity) which is admittedly more difficult to apply to a regulated firm,"

"Regulatory practices which deliberately defer the recognition and recovery of depreciation are not necessarily inequitable nor in conflict with generally accepted accounting principles as long as the opportunity for capital recovery is preserved by the absence of significant competition."

In our opinion, Revenue Requirements considerations are legitimate and essential to achieve the efficient capital management of a public utility, regulated or not, and operating or not in a competitive market environment.

If an unregulated competitor to a regulated P.U. is also a capital intensive entity, he will be subject to a similar micro-economic profile as illustrated in Figures 1 and 2 of this paper and his own revenue requirements base will equate his Cost of Service base which in turn includes the Capital Consumption Cost element as a major contribution.

The unregulated capital intensive competitor does not enjoy full freedom of action in terms of his own pricing policies; he also has to be concerned by his corporate and services profitability, of which both the Capital Recovery and the Capital Remuneration costs segments are a good part.

Unlike Dr. White, we do not believe that services offered by unregulated competitors can be "priced without regard to an assumed pattern of depreciation expense". Sound management implies knowledge and understanding of service production costs in the development of competitive pricing strategies and service production costs include Capital Recovery as a major concern. Of course, regulation also has to recognize the pertinence of sound Capital Recovery practices when dealing with pricing decisions affecting competitive services.

## V - Summary and Conclusion

In this paper we have attempted to make a positive contribution to the profound debate that is required to ensure the evolution of the Capital Recovery profession over the next few years.

The advent of competition in many service areas traditionally reserved to heavily regulated monopolistic Public Utilities and the entry of many new unregulated capital intensive competitors into the same service markets are creating a strong challenge to both regulators and P.U. managers.

Many capital recovery specialists now agree that the time has come to go back to our basic working assumptions, to improve our knowledge and understanding of the overall Capital Management process.

Of course, this paper remains a limited contribution.

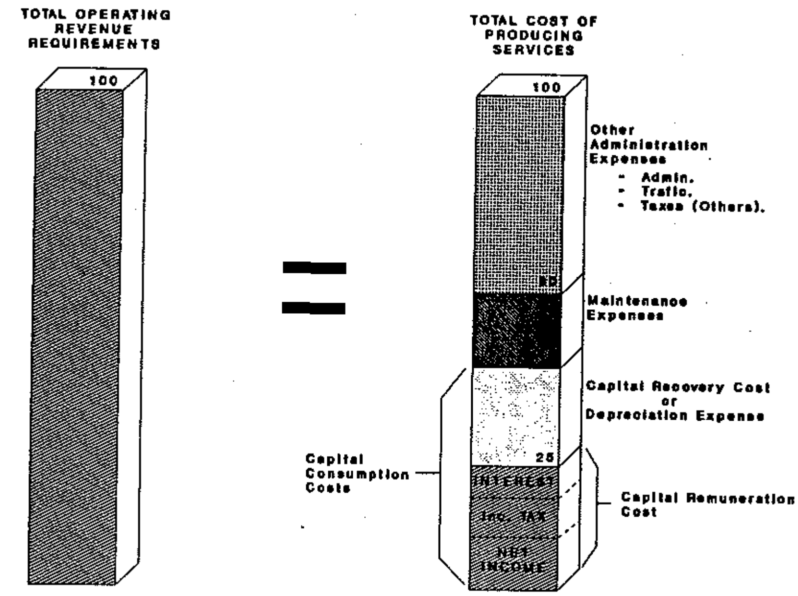
The issues at stake are just too broad in scope to be covered in a short paper.

And time is required to assimilate the material exchanged and confront the various perceptions, digest and debate. We have not hesitated to enter into the paradox! At a time where it is generally well perceived by P.U. managers to push for accelerated depreciation, our own reflexion and analysis indicates that it may not always be appropriate to do so. We are suggesting that there may be strong merit to the application of "progressive" capital recovery methods. We even suggest that Straight Line depreciation may become the exception rather than the rule. For reasons related to realism and manageability we are recommending the application of a SWAP capital recovery process. Nevertheless, as we conclude this paper, we firmly believe that a major and fundamental change in perception and approach will be required in the area of capital recovery management during the next decade and that such a change may necessitate a complete departure from today's highly dominant straight line depreciation methodologies .

We hope to have positively contributed to such a change.

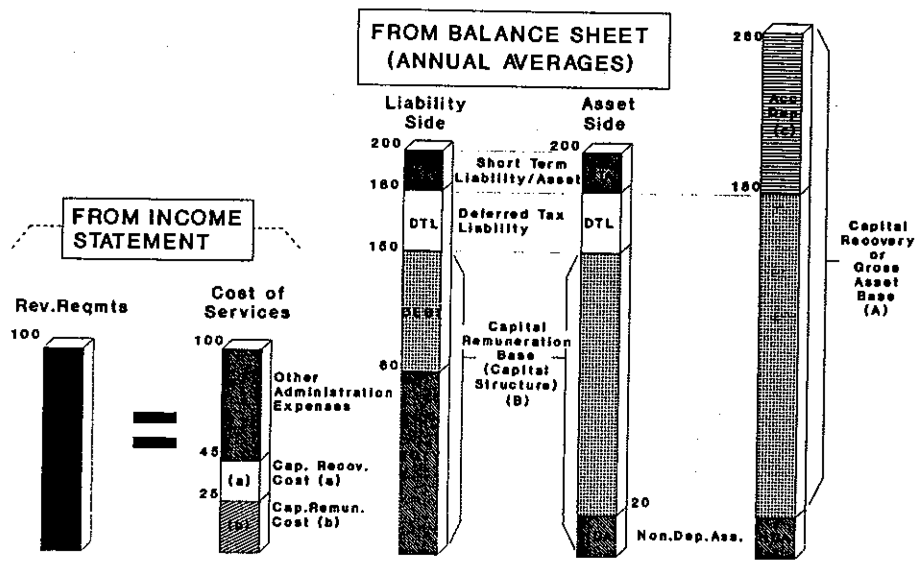
## Figure 1

FUNDAMENTAL MICRO-ECONOMIC EQUATION OF A CAPITAL INTENSIVE UTILITY




## Figure 2

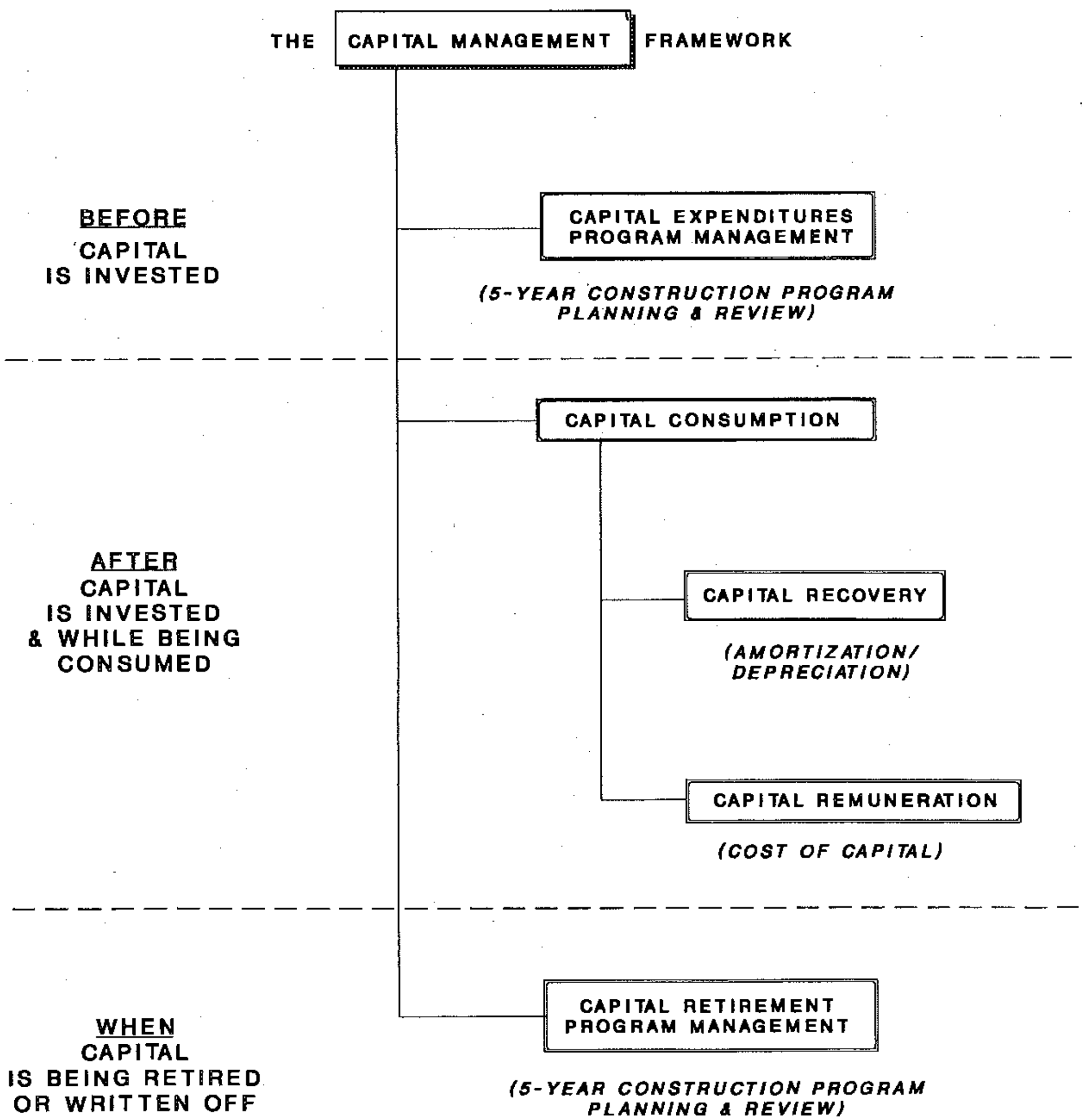
TYPICAL MICRO-ECONOMIC PROFILE OF A CAPITAL INTENSIVE UTILITY




- Capital Remuneration Rate (%)......... : (b/B) x 100 = (25/150) x 100 = 16.7%
- Capital Recovery Rate (%) ............... : (a/A) x 100 = (20/240) x 100 = 8.3%
- Overall Depreciation Reserve .......... : (c/A) x 100 = (80/240) x 100 = 33.3%

# Figure 3

THE CAPITAL RESOURCE MANAGEMENT PROCESS

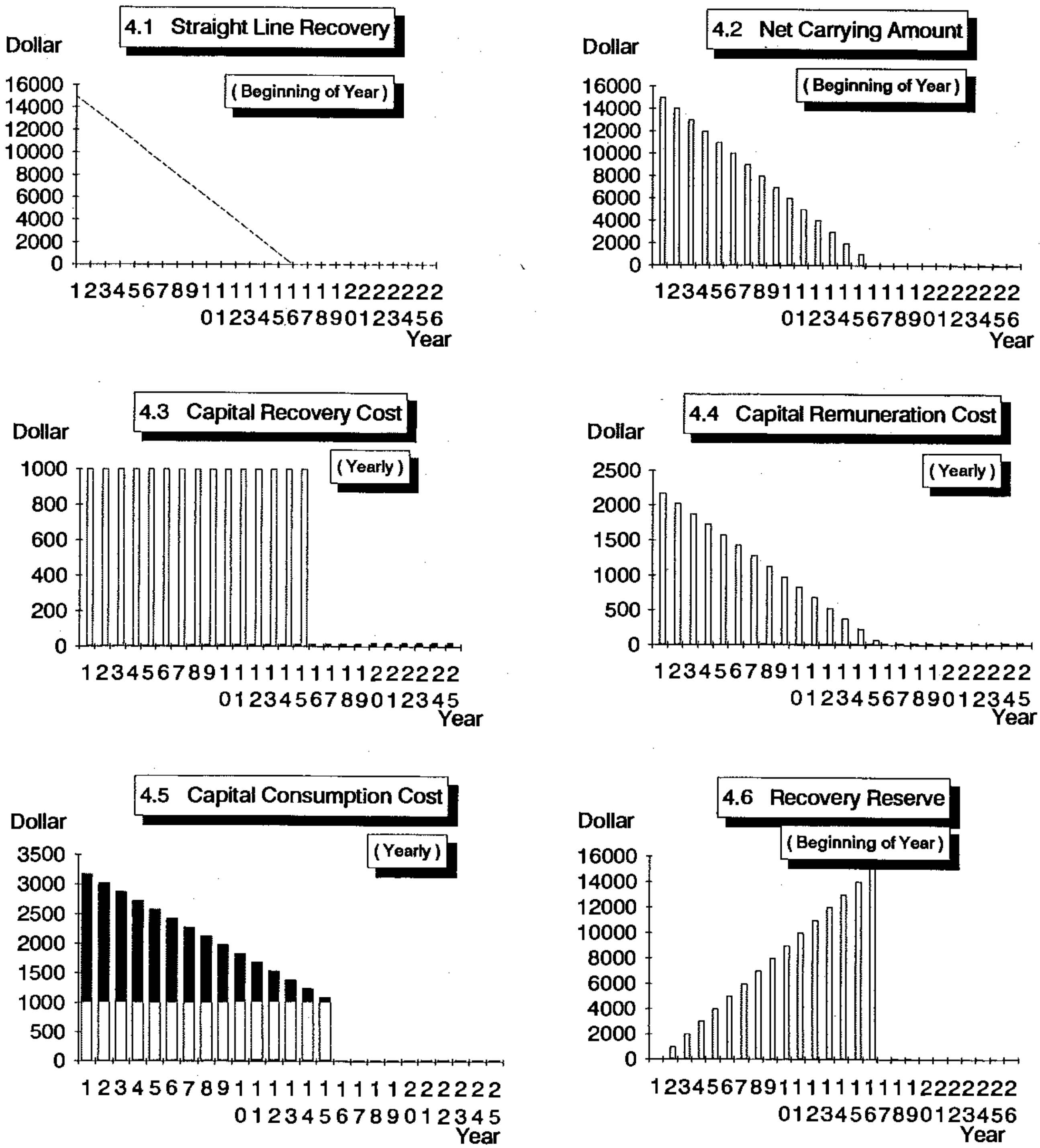


# Figure 4

## THE STRAIGHT LINE RECOVERY PATTERN

*( Excluding Deferred Tax Liability Impact )*

| ASSUMPTIONS | |
|---|---|
| Recovery Period | 15 Years |
| Capital Cost to Recover | 15,000 Dollars |
| Capital Remuneration Rate ( Cost of Financing ) | 15 % |

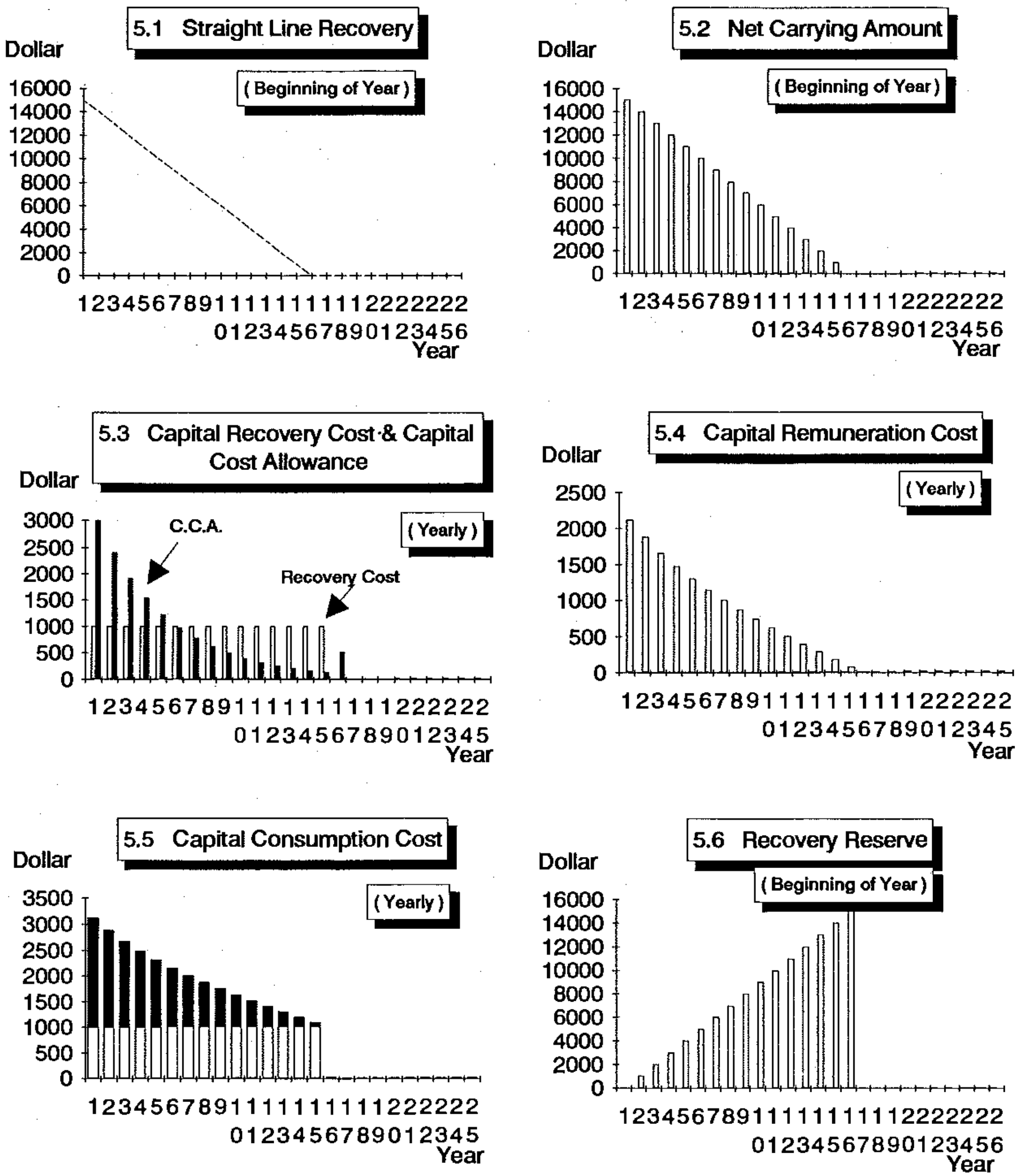


# Figure 5

## THE STRAIGHT LINE CAPITAL RECOVERY PATTERN

*( Including Deferred Tax Liability Impact )*

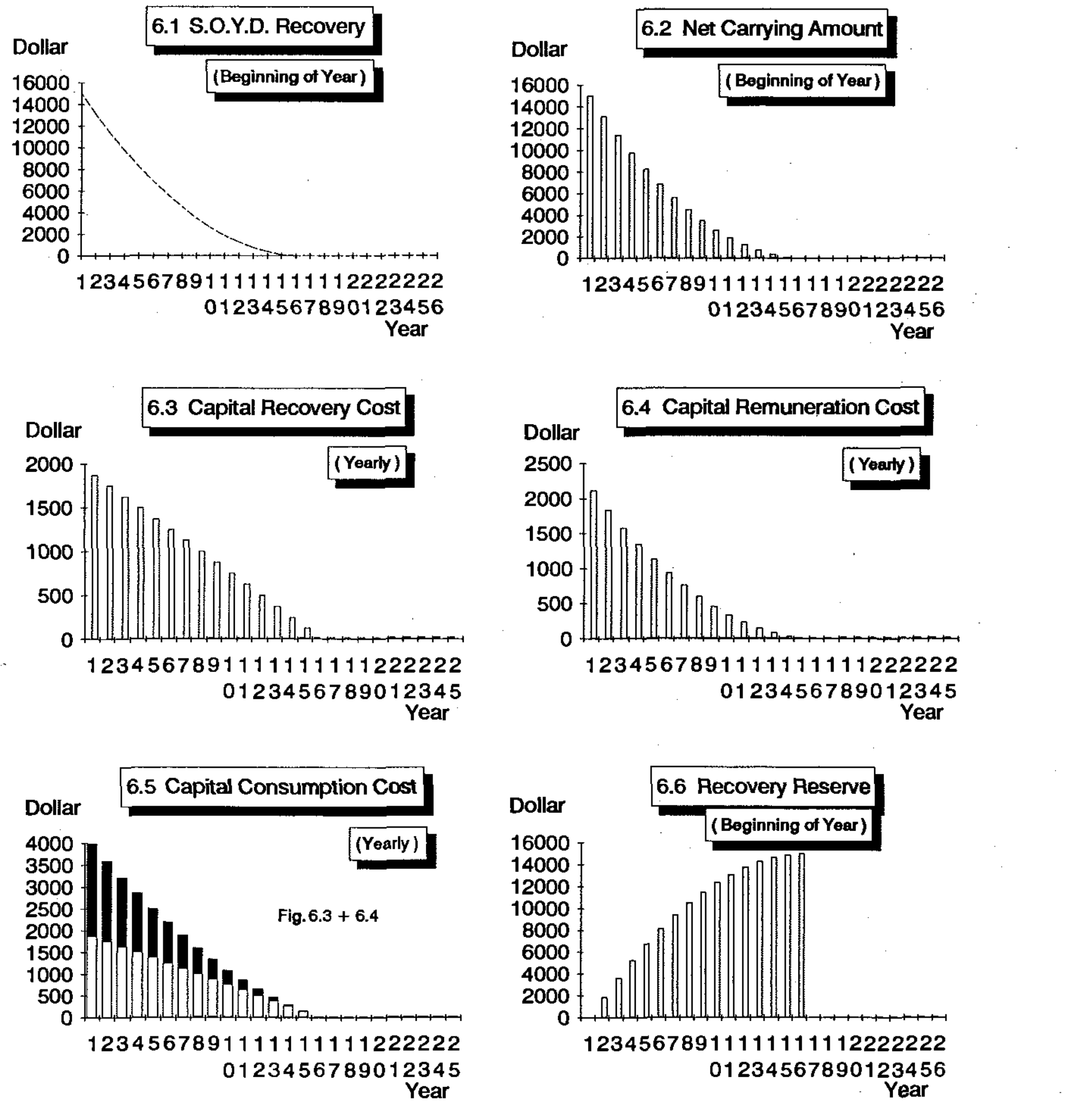
| ASSUMPTIONS | |
|---|---|
| Recovery Period | 15 Years |
| Capitalized Cost to Recover | 15,000 Dollars |
| Capital Remuneration Rate ( Cost of Financing ) | 15 % |
| Income Tax Rate | 36 % |
| Capital Cost Allowance Rate | 20 % |



# Figure 6

THE SOYD CAPITAL RECOVERY PATTERN
*( Excluding Deferred Tax Liability Impact )*

| ASSUMPTIONS | |
|---|---|
| Recovery Period | 15 Years |
| Capital Cost to Recover | 15,000 Dollars |
| Capital Remuneration Rate ( Cost of Financing ) | 15 % |

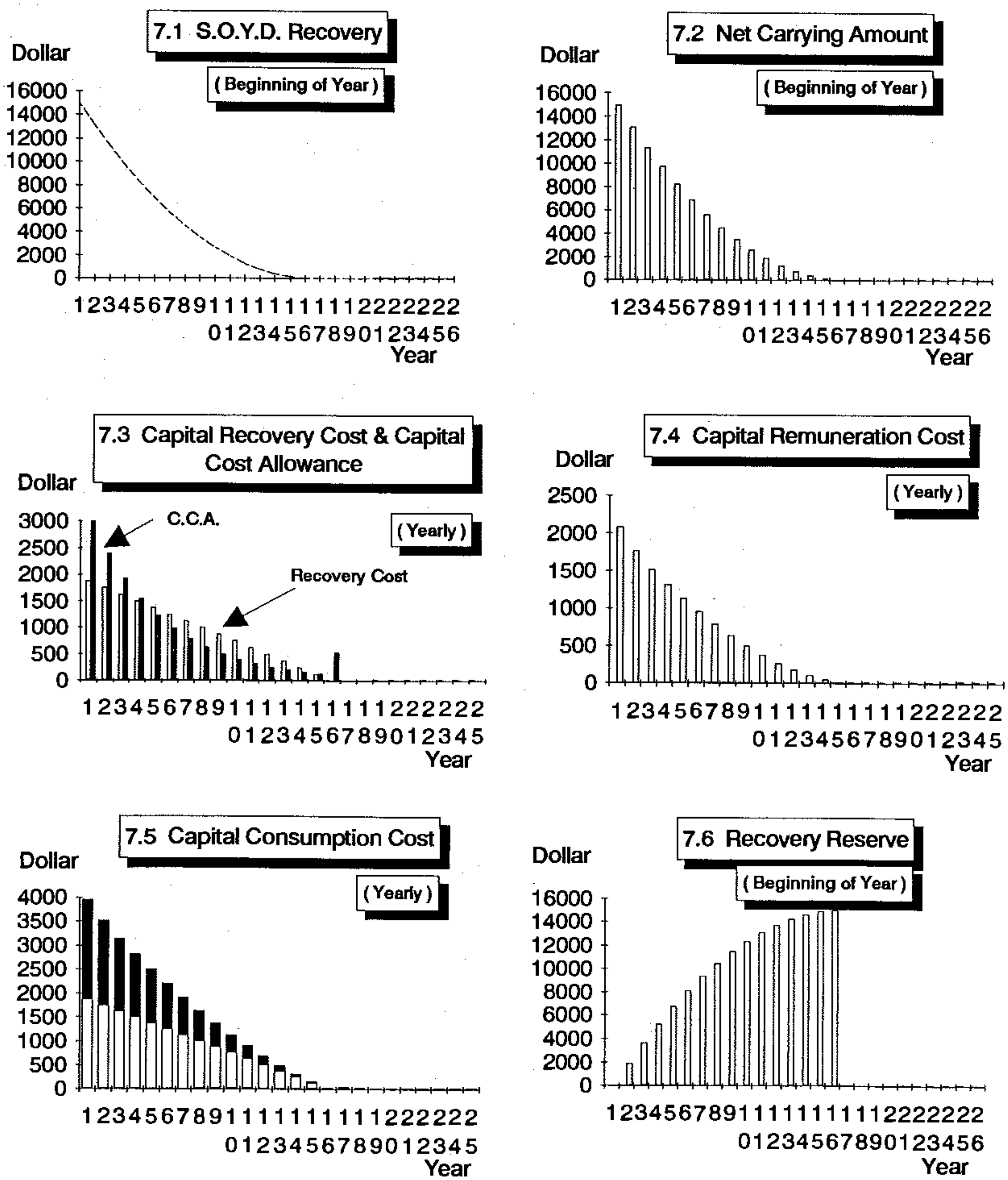


# Figure 7

## THE SOYD CAPITAL RECOVERY PATTERN

*( Including Deferred Tax Liability Impact )*

| ASSUMPTIONS | |
|---|---|
| Recovery Period | 15 Years |
| Capitalived Cost to Recover | 15,000 Dollars |
| Capital Remuneration Rate ( Cost of Financing ) | 15 % |
| Income Tax Rate | 36 % |
| Capital Cost Allowance Rate | 20 % |

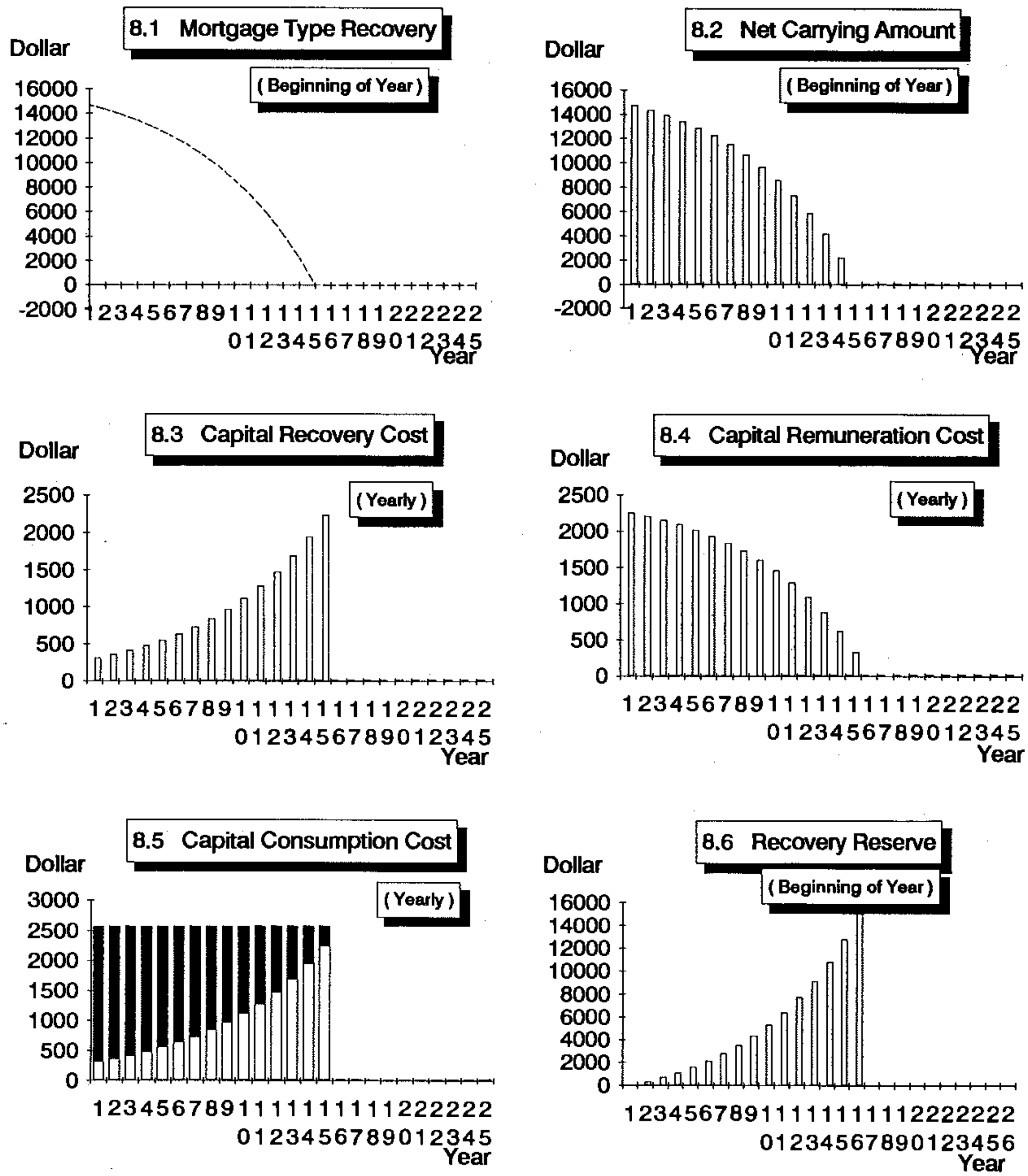


# Figure 8

MORTGAGE TYPE PROGRESSIVE CAPITAL RECOVERY PATTERN

*( Excluding Deferred Tax Liability Impact )*

| ASSUMPTIONS | |
|---|---|
| Recovery Period | 15 Years |
| Capitalized Cost to Recover | 15,000 Dollars |
| Capital Remuneration Rate ( Cost of Financing ) | 15 % |

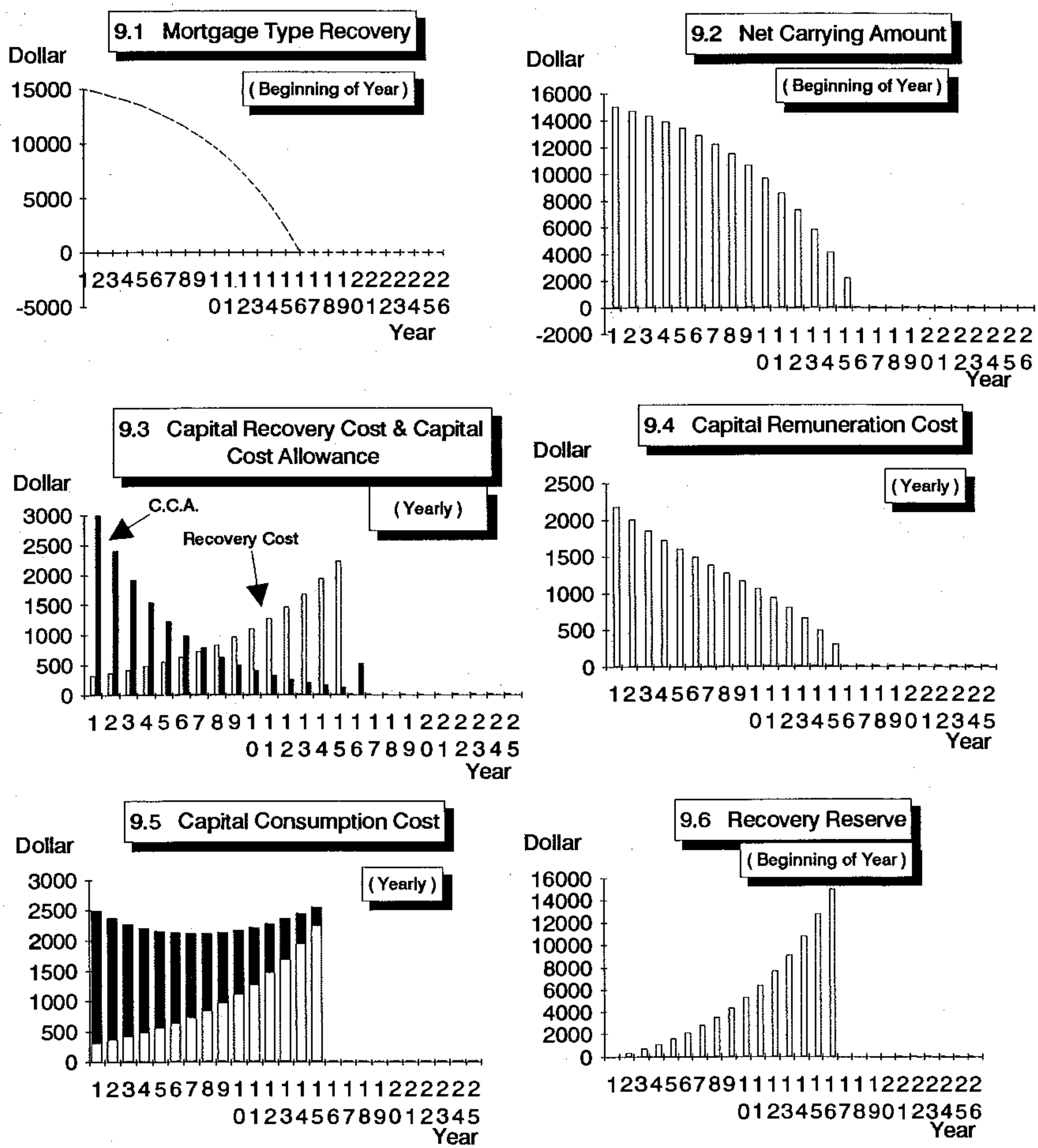


# Figure 9

MORTGAGE TYPE PROGRESSIVE CAPITAL RECOVERY PATTERN

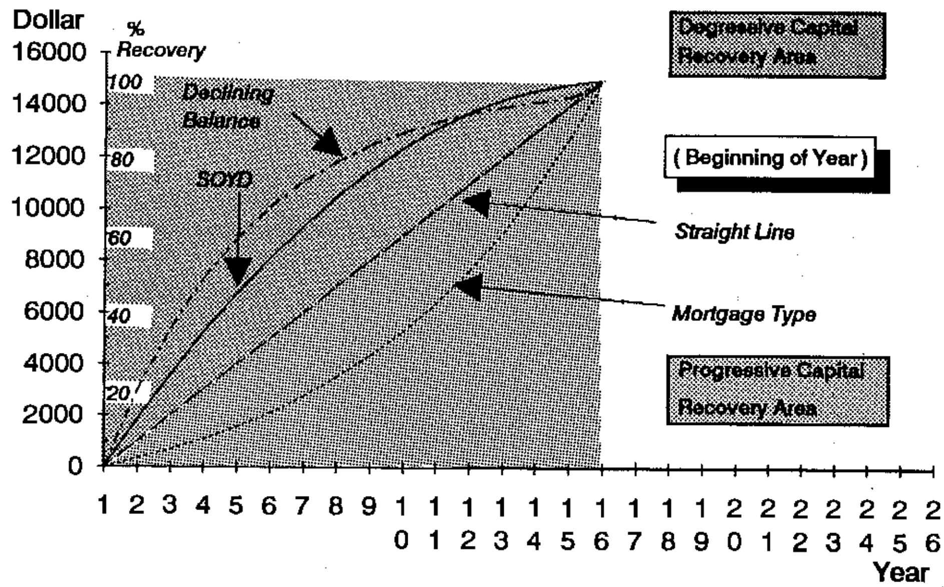
*( Including Deferred Tax Liability Impact )*

| ASSUMPTIONS | |
|---|---|
| Recovery Period | 15 Years |
| Capitalized Cost to Recover | 15,000 Dollars |
| Capital Remuneration Rate ( C.R.R.) | 15 % |
| Income Tax Rate ( I.T.R.) | 36 % |
| Capital Cost Allowance Rate | 20 % |



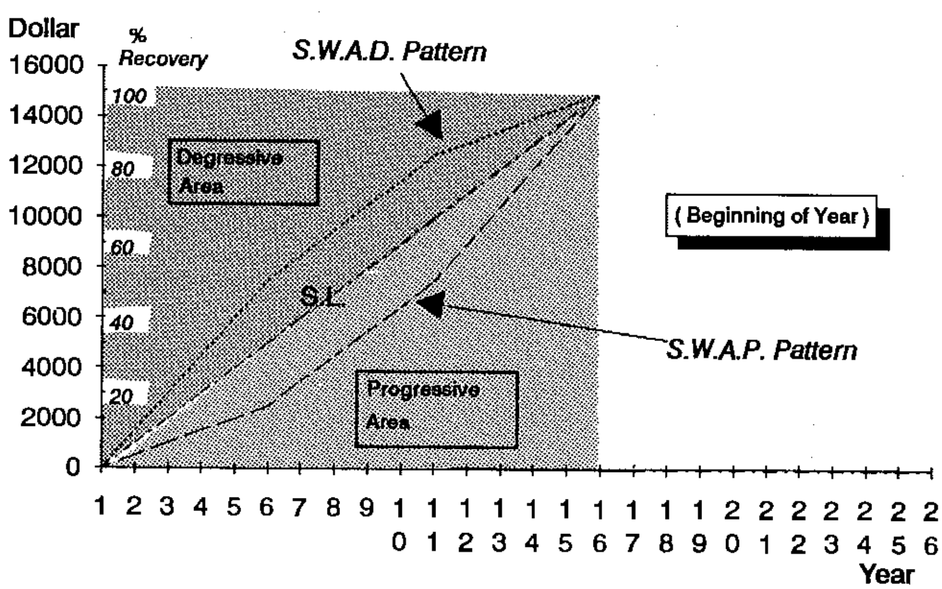
# Figure 10

CAPITAL RECOVERY RESERVE BUILD-UP PROFILES




# Figure 11

RECOVERY RESERVE BUILD-UP PROFILES
STEP-WISE ADJUSTED PATTERNS

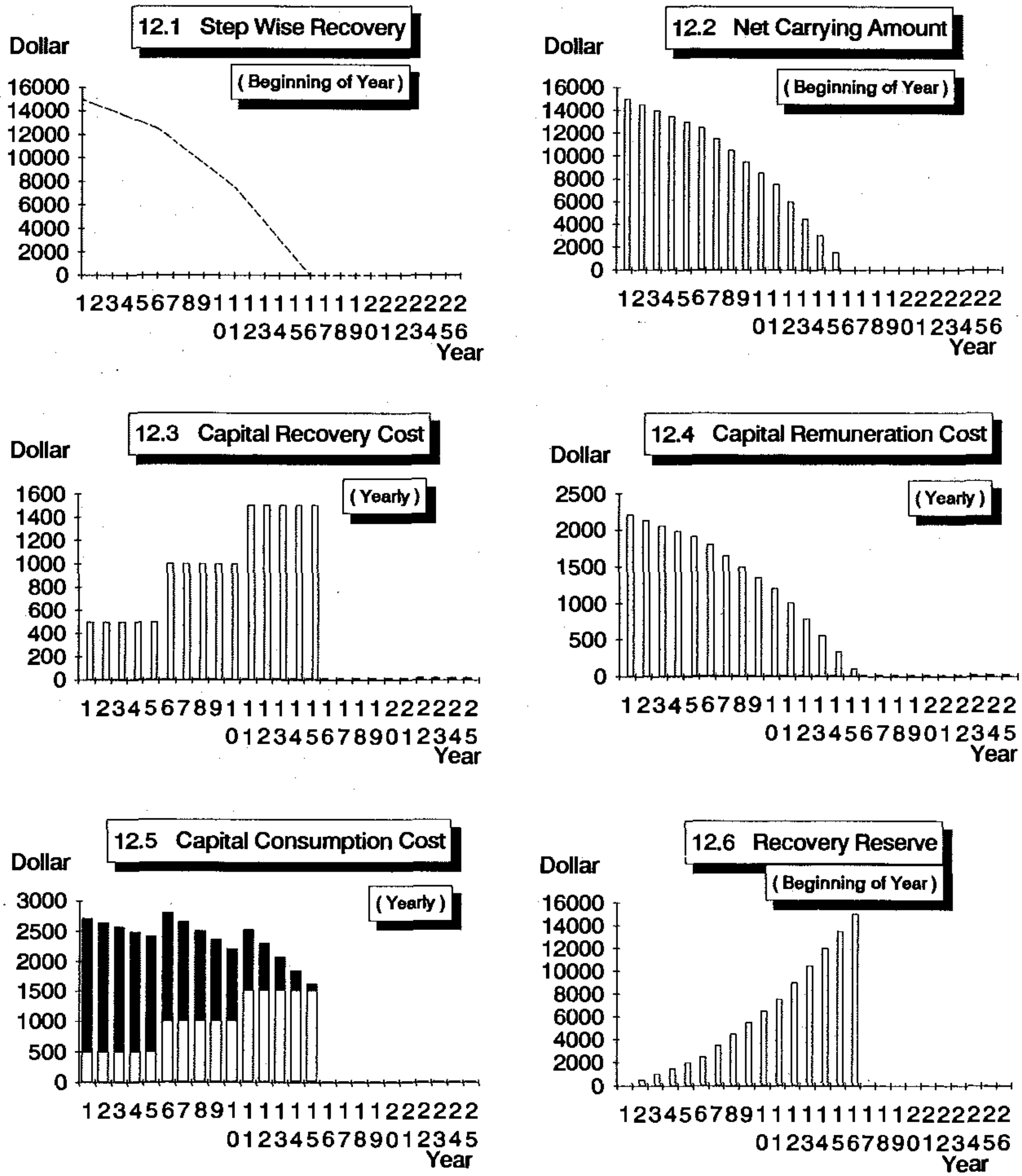


# Figure 12

STEP-WISE ADJUSTED PROGRESSIVE RECOVERY PATTERN ( SWAP )

*( Excluding Deferred Tax Liability Impact )*

| ASSUMPTIONS | |
|---|---|
| Recovery Period | 15 Years |
| Capitalized Cost to Recover | 15,000 Dollars |
| Capital Remuneration Rate ( Cost of Financing ) | 15 % |

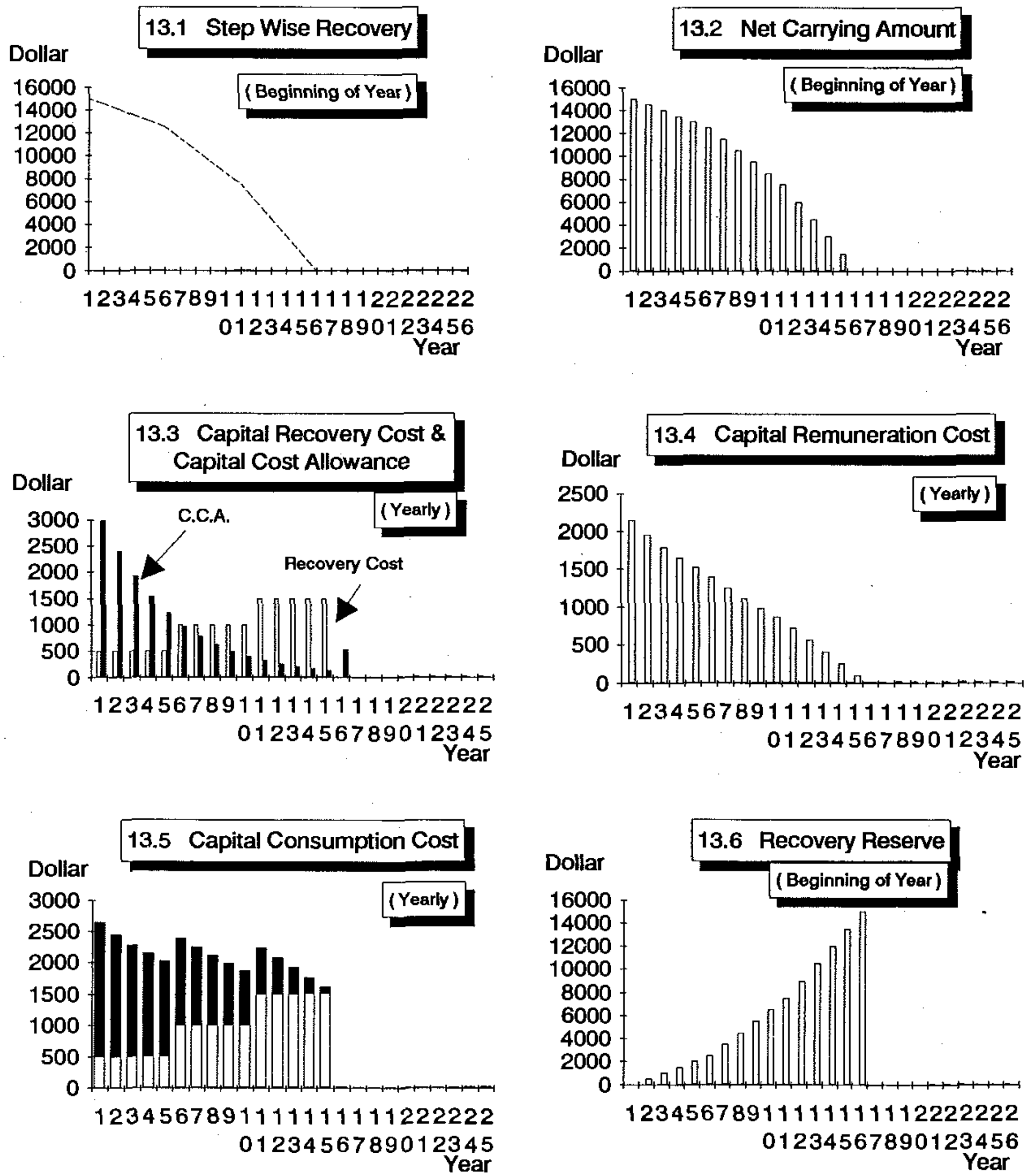


# Figure 13

STEP-WISE ADJUSTED PROGRESSIVE RECOVERY PATTERN ( SWAP )

*( Including Fiscal Impact - C.C.A. )*

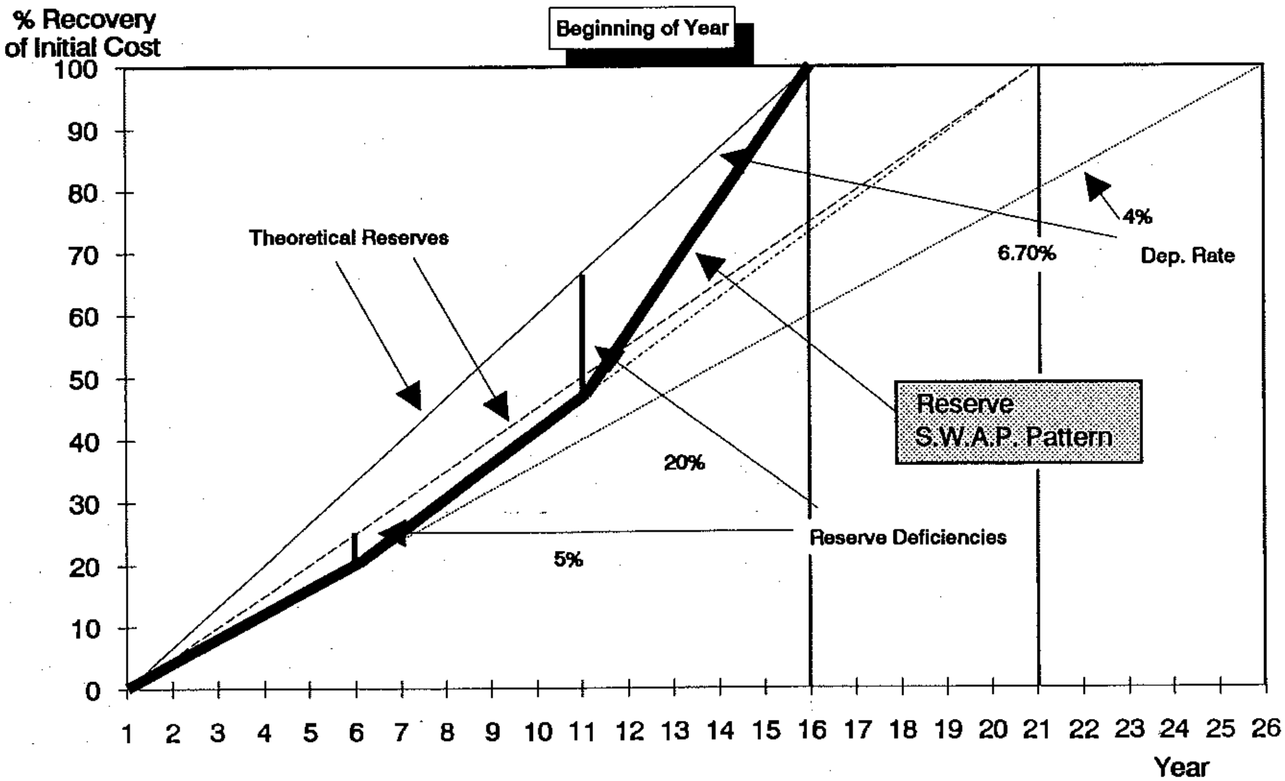
| ASSUMPTIONS | |
|---|---|
| Recovery Period | 15 Years |
| Capitalized Cost to Recover | 15,000 Dollars |
| Capital Remuneration Rate ( Cost of Financing ) | 15 % |
| Income Tax Rate | 36 % |
| Capital Cost Allowance Rate | 20 % |



# Figure 14

RECOVERY RESERVE PATTERN

*( Illustration of Reserve Deficiencies )*

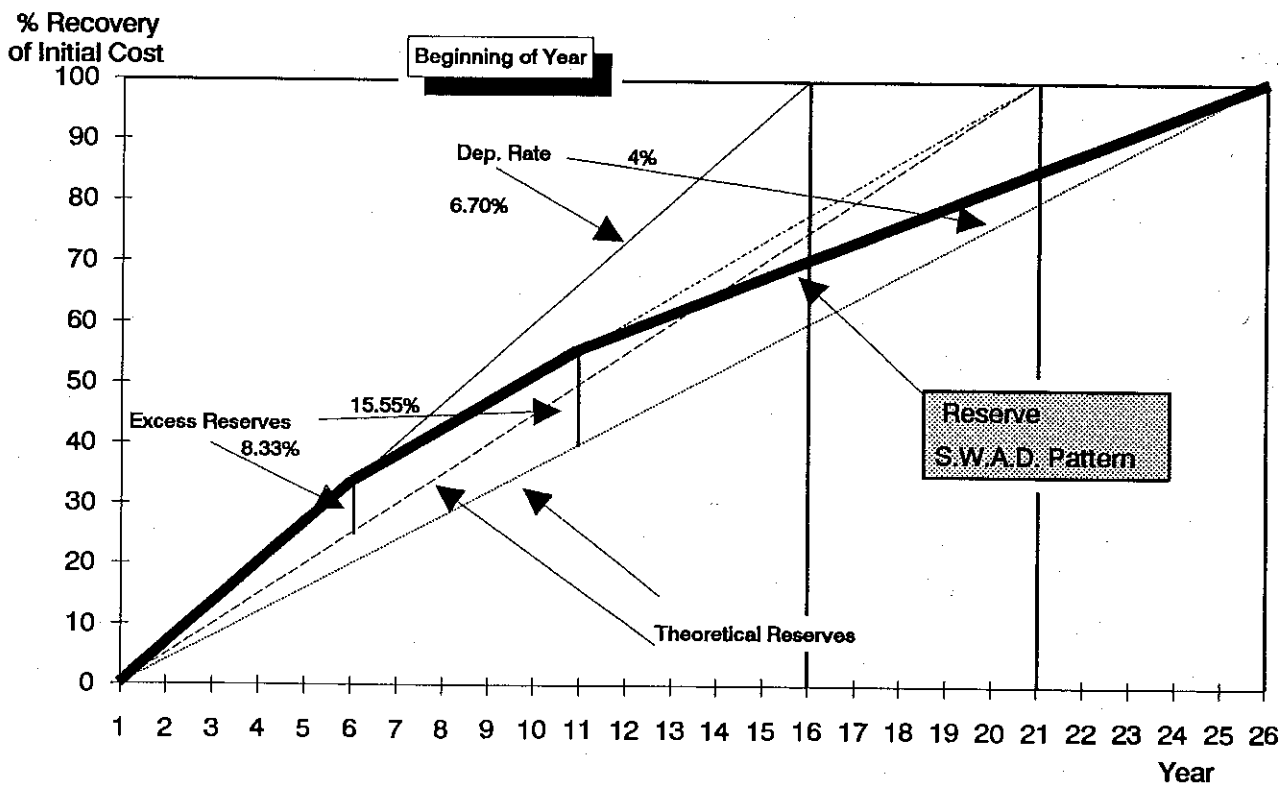



| % Recov. | Life Span | | Total Dep. Rate | | Theoretical Dep. Rate | | Deficiency Correction Dep. Rate | Theoretical Dep. Rates |
|---|---|---|---|---|---|---|---|---|
| 20 | 0 - 5 | : | 4.0 % | = | 4.0 % | + | 0.0 % | 25 Years - 4.0 % |
| 27 | 5 - 10 | : | 5.4 % | = | 5.0 % | + | 0.4 % | 20 Years - 5.0 % |
| 53 | 10 - 15 | : | 10.6 % | = | 6.7 % | + | 3.9 % | 15 Years - 6.7 % |
| 100 | | | | | | | | |

# Figure 15

RECOVERY RESERVE PATTERN

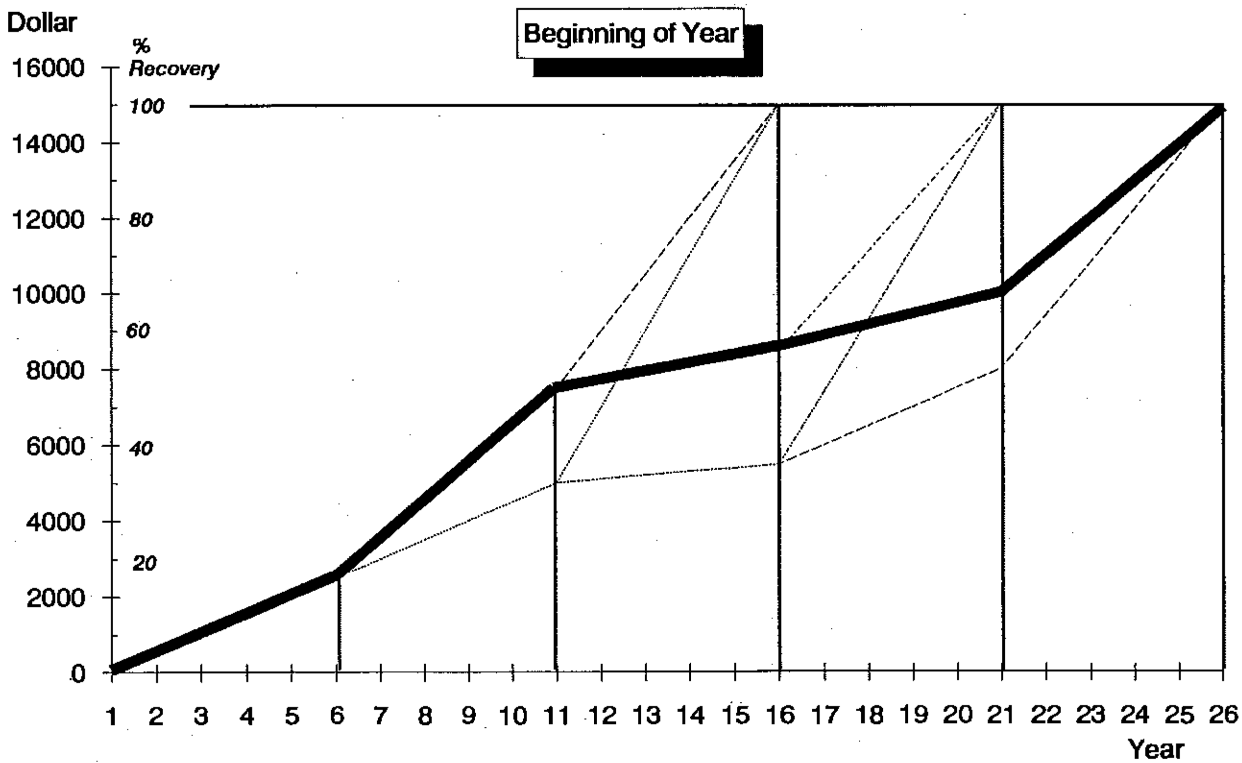
*(Illustration of Reserve Excesses )*




| % Recov. | Life Span | | Total Dep. Rate | | Theoretical Dep. Rate | | Excess Correction Dep. Rate | Theoretical Dep. Rates |
|---|---|---|---|---|---|---|---|---|
| 33.33 | 0 - 5 | : | 6.67 % | = | 6.67 % | - | 0.0 % | 15 Years - 6.7 % |
| 22.22 | 5 - 10 | : | 4.44 % | = | 5.00 % | - | 0.56 % | 20 Years - 5.0 % |
| 44.45 | 10 - 25 | : | 2.96 % | = | 4.00 % | - | 1.04 % | 25 Years - 4.0 % |
| 100.00 | | | | | | | | |

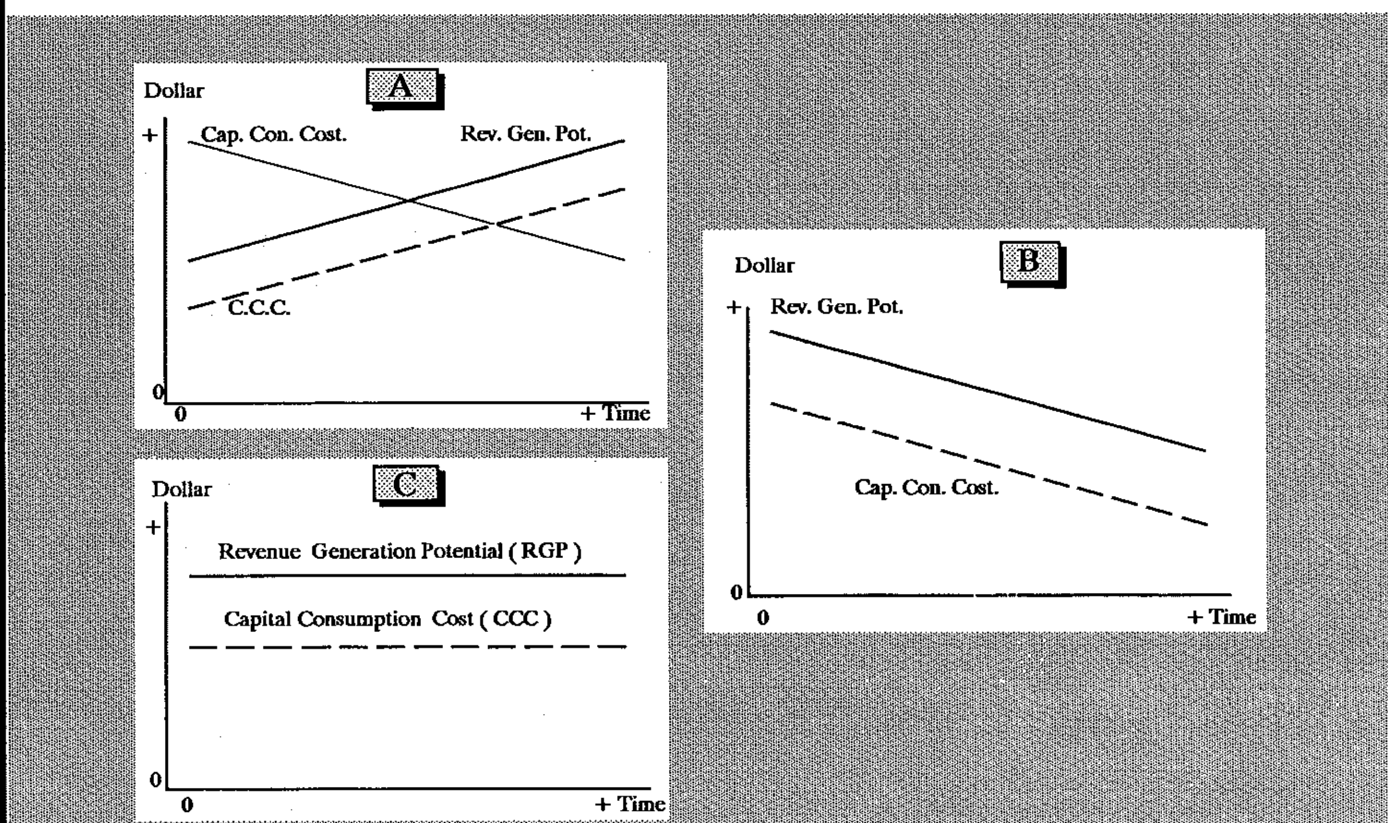
# Figure 16

## SWAP RECOVERY PATTERN EVOLUTION



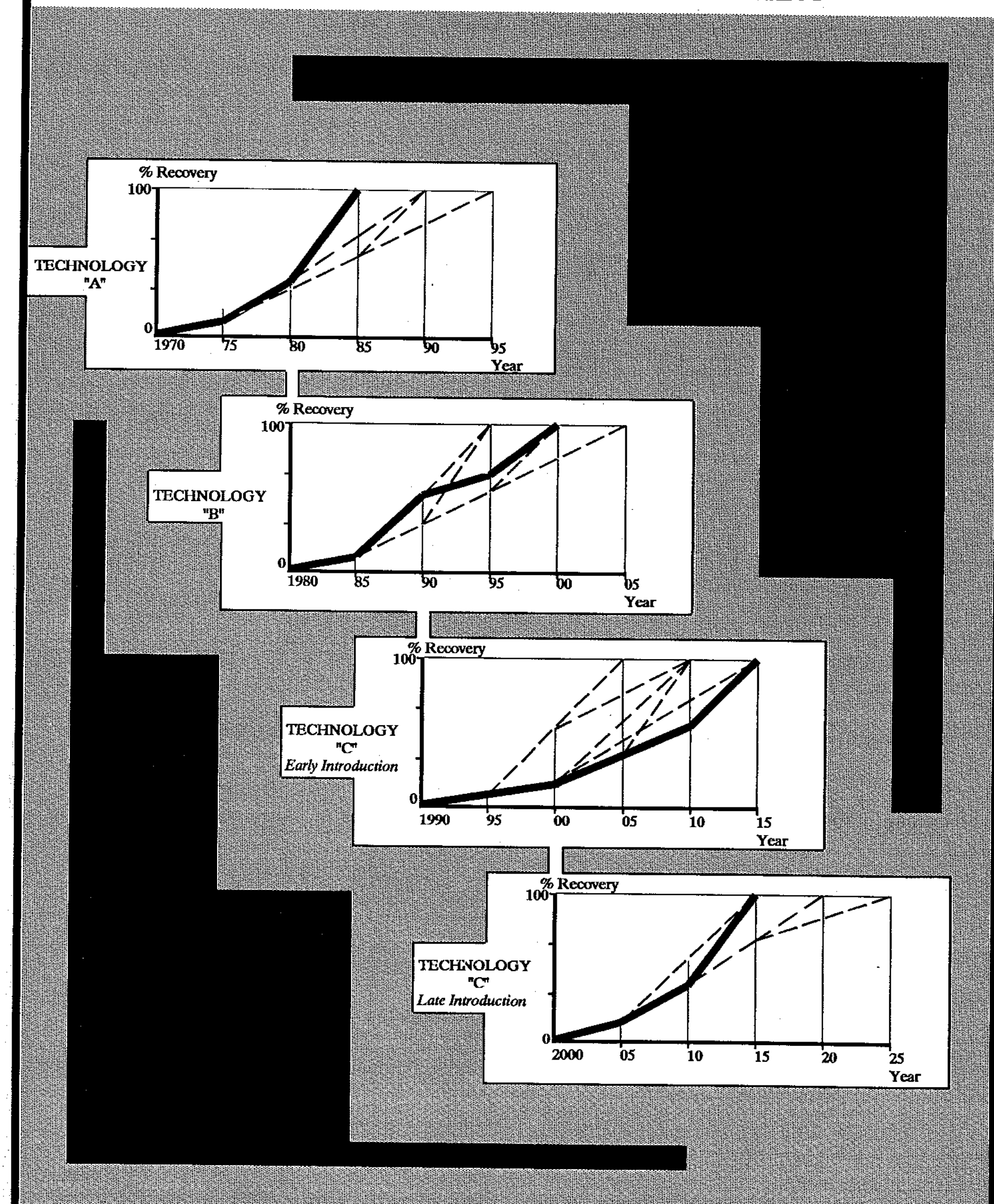

# Figure 17

## THE MATCHING CRITERIA



# Figure 18

## TECHNOLOGY TURNOVER MANAGEMENT STRATEGY

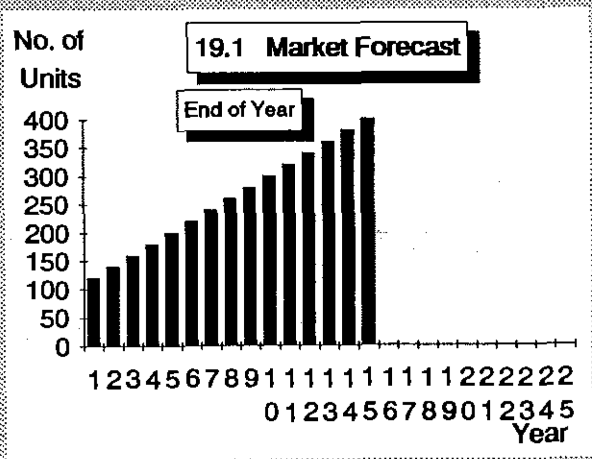


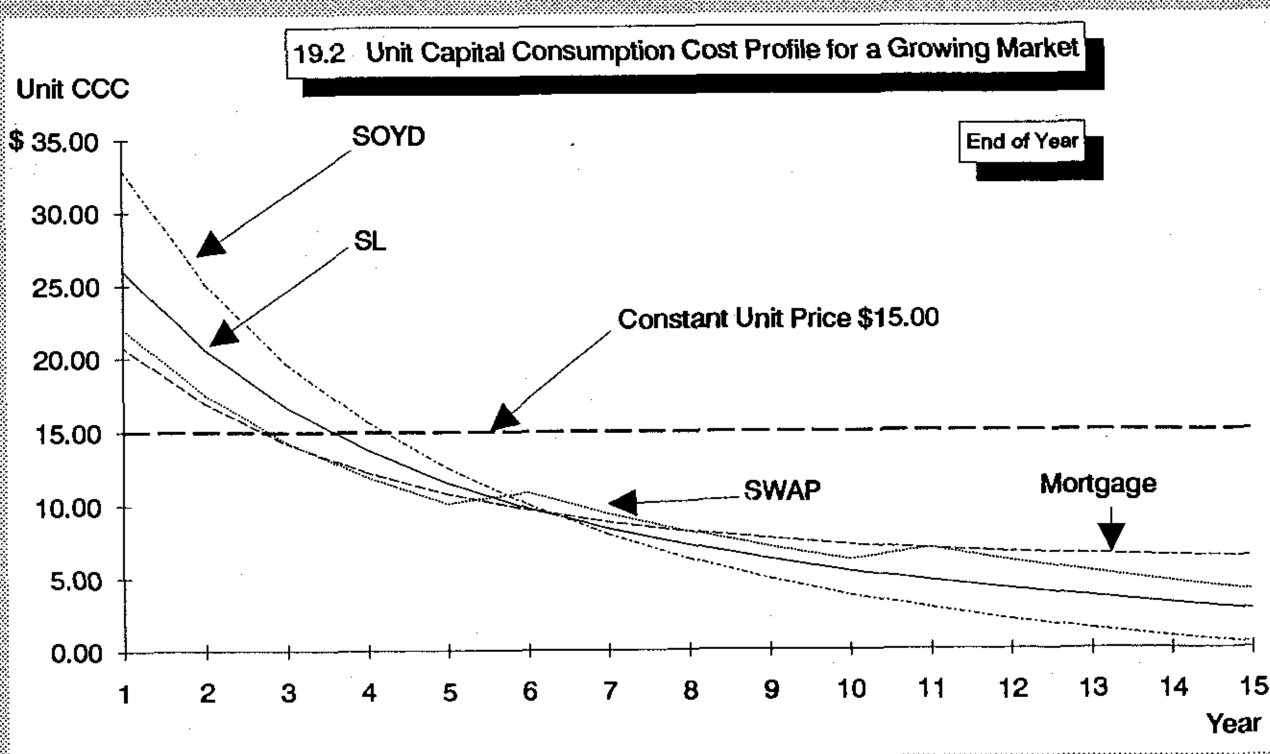
# Figure 19

UNIT CAPITAL CONSUMPTION COST PROFILES

*(Including Deferred Tax Liability Impact)*

| ASSUMPTIONS | |
|---|---|
| Recovery Period | 15 Years |
| Capital Cost to Recover | 15,000 Dollars |
| Capital Remuneration Rate (Cost of Financing) | 15 % |
| Income Tax Rate | 36 % |
| Capital Cost Allowance Rate | 20 % |
| Number of Units (End of Recovery Period) | 400 Units |
| Initial Market (Beginning of Recovery Period) | 100 Units |



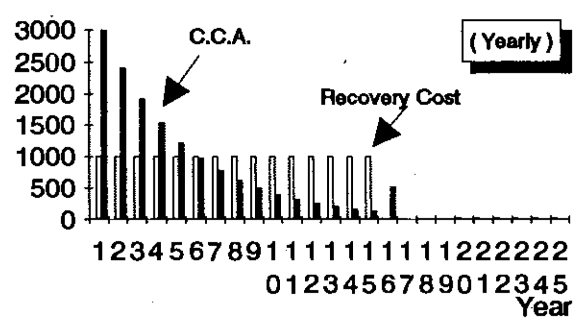
# Appendix A

## STRAIGHT LINE CAPITAL RECOVERY PATTERN

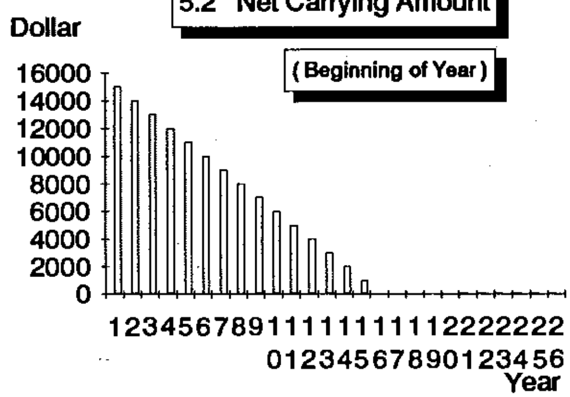
*( Illustration of the Capital Cost Allowance ( CCA ) fiscal impact on the Capital Remuneration Cost )*

| ASSUMPTIONS | |
|---|---|
| Recovery Period | 15 Years |
| Capitalized Cost to Recover | 15,000 Dollars |
| Capital Remuneration Rate (C.R.R.) | 15 % |
| Income Tax Rate ( I.T.R.) | 36 % |
| Capital Cost Allowance Rate | 20 % |

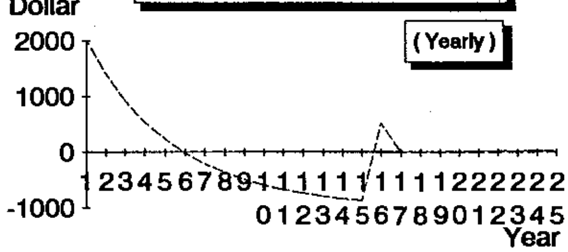
5.3 Capital Recovery Cost & Capital Cost Allowance



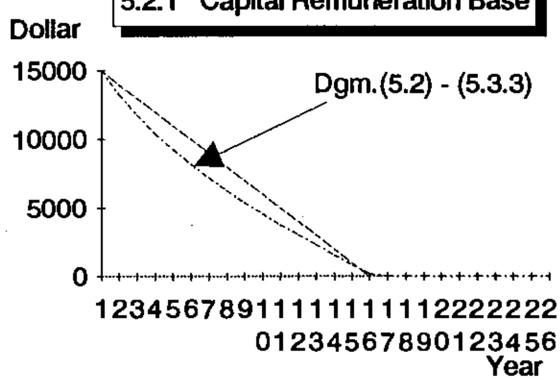

5.2 Net Carrying Amount



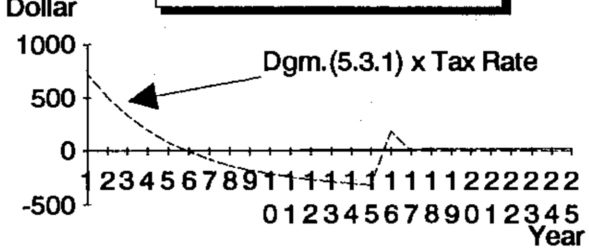

5.3.1 C.C.A. minus Recovery



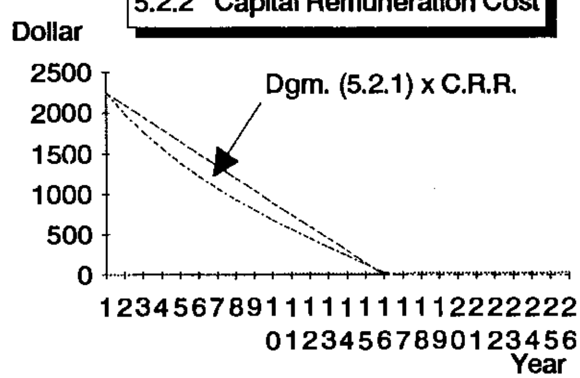

5.2.1 Capital Remuneration Base



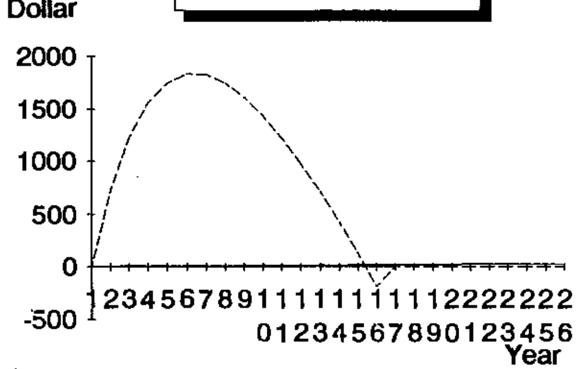

5.3.2 Deferred Tax Liability




5.2.2 Capital Remuneration Cost




5.3.3 Cumulative D.T.L.



# Appendix B

## STRAIGHT LINE CAPITAL RECOVERY FORMULAS

| Variables |
|---|
| A = Amortization Period |
| B = Capitalized Cost to Recover |
| C = Capital Remuneration Rate |
| D = Income Tax Rate |
| E = Capital Cost Allowance Rate |

| References |
|---|
| Figure 4 |
| Figure 5 |
| Appendix A |

EXCLUDING D.T.L. IMPACT

| Year Placed | Straight Line Recovery (DGM. 4.1) | Net Carrying Amount (DGM. 4.2) | Capital Recovery Cost (DGM. 4.3) | Capital Remuneration Cost (DGM. 4.4) | Capital Consumption Cost (DGM. 4.5) | Recovery Reserve (DGM. 4.6) |
|---|---|---|---|---|---|---|
| H | J | K | L | M | N | P |
| H{1} | J{1}=(B/A)(A-H{1}) | K{1}=(B/A)(A-H{1}) | L{1}= B-J{1}<br>L{2} = J{1}-J{2} | M{1} =((L{1}/2)+K{1})(C/100) | N{1} = L{1}+M{1} | P{1} = B-K{1} |
| H{n} | J{n}=(B/A)(A-H{n}) | K{n}=(B/A)(A-H{n}) | L{n} = J{n-1}-J{n} | M{n} =((L{n}/2)+K{n})(C/100) | N{n} = L{n}+M{n} | P{n} = B-K{n} |

INCLUDING D.T.L. IMPACT

| Year Placed | Straight Line Recovery (DGM. 5.1) | Net Carrying Amount (DGM. 5.2) | Capital Recovery Cost (DGM. 5.3) | Capital Remuneration Cost (DGM. 5.4 & 5.2.2) | Capital Consumption Cost (DGM. 5.5) | Recovery Reserve (DGM. 5.6) |
|---|---|---|---|---|---|---|
| H | J | K | L | M | N | P |
| H{1} | J{1}=(B/A)(A-H{1}) | K{1}=(B/A)(A-H{1}) | L{1}= B-J{1}<br>L{2} = J{1}-J{2} | M{1} =(((L{1}/2)-(0+T{1})/2)+K{1})(C/100)<br>M{2} =(((L{2}/2)-(T{1}+T{2})/2)+K{2})(C/100) | N{1} = L{1}+M{1} | P{1} = B-K{1} |
| H{n} | J{n}=(B/A)(A-H{n}) | K{n}=(B/A)(A-H{n}) | L{n} = J{n-1}-J{n} | M{n} =(((L{n}/2)-(T{n-1}+T{n})/2)+K{n})(C/100) | N{n} = L{n}+M{n} | P{n} = B-K{n} |

INCLUDING D.T.L. IMPACT

| Capital Cost Allowance (DGM. 5.3) | Net Fiscal Book Value | Deferred Tax Liability (D.T.L.) (DGM. 5.3.2) | Acc. D.T.L. (DGM. 5.3.3) |
|---|---|---|---|
| Q | R | S | T |
| Q{1} = B-R{1}<br>Q{2} = R{1}-R{2} | R{1} = B(100-E)/100<br>R{2} = R{1}(100-E)/100 | S{1} = (Q{1}-L{1})(D/100) | T{1} = S{1}<br>T{2} = S{1}+S{2} |
| Q{n} = R{n-1}-R{n} | R{n} = R{n-1}(100-E)/100 | S{n} = (Q{n}-L{n})(D/100) | T{n} = S{n-1}+S{n} |

# An Expansion of the Gompertz-Makeham Equation for the Life Analysis of Physical Property


Ted L. Leavitt †
Teresa T. Ninh ††


## ABSTRACT


This paper explores the idea of developing a formulation that will improve the current curve fitting process for the life analysis of telecommunications equipment.

Included is a review of the Gompertz-Makeham method in which the original terms accounting for retirements due to age and chance are used. We then introduce an additional term that takes competitive and technological activity into consideration. A new formulation is developed using a computer program for testing mathematical concepts. curve fitting processes, and analysis of results to determine the best general formulation. Sample exhibits of curve plots and best-fit statistics are included.

In conclusion, we show that this new method can produce a better curve fit based on standard statistical measurements. We further speculate how future observed data may reflect competitive and technological influences.


The original Gompertz-Makeham equation used for life calculations of telecommunications equipment was derived from the equation $U_x = Dc^x$. $\mathbf{U_x}$ is the retirement rate at age **x**, **A** is the term due to "chance" retirements, and $\mathbf{Dc^x}$ is the effect of retirements increasing geometrically with "age." If $\ell_x$ represents the proportion surviving at age **x**, then the rate of decrease in the proportion surviving is:

$d\ell_x/dx = (U_x)\ell_x$ where $d\ell_x/dx$ is the derivate of $\ell_x$ with respect to x

then:

$$d\ell_x/\ell_x = -(U_x)dx$$

or:

$$d\ell_x/\ell_x = -(A + Dc^x)dx$$

which leads to the solution:

$$\ln \ell_x = -)Ax + (Dc^x/\ln c) + K$$

which further reduces to:

$$\ell_x = e^{-Ax} e^{-(Dc^x/\ln c)} e^K$$

setting $s = e^{-A}$, $g = e^{-(D/\ln c)}$, and $k = e^K$

then:

$\ell_x = s^x g^{(c^x)} k$; when $x = 0$: $\ell_0 = kg = 1$, so $k = g^{-1}$

giving:

$$\ell_x = s^x g^{(c^x - 1)}$$

**s, g,** and **c** can be determined by "best-fitting" the observed proportions surviving. Thus we have the formulations (1) and (2).

$$U_x = A + Dc^x \quad (1)$$

$$\ell_x = s^x g^{(c^x - 1)} \quad (2)$$

For a more detailed background on the original Gompertz-Makeham (G-M) Equation and the development of the method above, see "A Modern Approach to the Application of the Gompertz-Makeham Equations for the Life Analysis of Telecommunication Property."

In the G-M Equation, the two terms **A** and $\mathbf{Dc^x}$ (chance and age) in (1) are factors contributing to the overall retirement rate. By adding a third term, $\mathbf{Bx^{(n-1)}}$, into (1), competitive activity and technological advances may be considered in some relationship to time or age. This term must be positive since these forces would increase the retirement rate with respect to time or age. Now the retirement rate could be formulated as:

$$U_x = A + Bx^{(n-1)} + Dc \quad (3)$$

Considering the rate of decrease in the proportion surviving, we can derive $\ell_x$ by the previous method:

$$d\ell_x/dx = (U_x)\ell_x$$

or:

$$d\ell_x/\ell_x = (U_x)dx$$

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†† Teresa T. Ninh is completing her final year of undergraduate studies at the University of Washington, majoring in Electrical Engineering. She contributed to this paper while serving a summer internship at U S WEST Communications.

Then:

$$d\ell_x/\ell_x = (A + Bx^{(n-1)} + Dc^x)dx$$

which gives the solution:

$$\ln \ell_x = -(Ax + Bx^n/n + (Dc^x/\ln c) + K$$

or:

$$\ell_x = e^{-Ax} e^{-(Bx^n/n)} e^{-(Dc^x/\ln c)} e^K$$

now setting $s = e^{-A}$, $h = e^{-(B/n)}$, $g = e^{-(D/\ln c)}$, and $k = e^K$

then:

$\ell_x = s^x h^{(x^n)} g^{(c^x)} k$; and at x=0: $\ell_0 = kg = 1$, and again $k = g^{-1}$

resulting in:

$$\ell_x = s^x h^{(x^n)} g^{(c^x - 1)} \quad (4)$$

where **s, h, g,** and **c** are determined from the observed proportions surviving.

The purpose for adding this third term is to more fully capture the influences of competitive and technological activity contributing to the overall retirement rate $\mathbf{U_x}$. As a result, this method will produce a better curve fit to the observed data values. A computer program that contains mathematical routines was developed for curve fitting and calculating life indications.

The most common measurement for comparing the best fit of a curve to a number of observed data values is the coefficient of determination, $\mathbf{R^2}$ (See Appendix A). $\mathbf{R^2}$ is unitless and ranges from 0 to 1. The nearer $\mathbf{R^2}$ is to 1, the better the fit of the equation to the observed data points. We compared the $\mathbf{R^2}$ values using the old method's routine versus that of the new method to determine which formulation best fit the data.

The program routines for both methods are similar in structure except for the addition of the new term $(\mathbf{h^{(x^n)}})$ in the new method. Data analyzed were the observed proportions surviving from bands of data for electronic switching equipment and circuit equipment accounts. The "least sum of squares" technique was used in both methods. The equation $\ell_x$ (4) is nonlinear in the constants **s, h, g,** and c. We use a logarithmic transformation to linearize (4) in ln **s**, ln **h**, and ln **g** (see Appendix B). "**c**" cannot be linearized so it must be determined by a "grid search." This is done by assigning successive values for **c** and searching for the minimum sum of squared differences. The nontransformed proportions surviving are used in determining the best fit.

In order to determine the proper exponent of the added term, $\mathbf{x\text{-}h^{(x^n)}}$, "**n**" is an input to the program. Most likely the effect on the retirement rate is governed by some relationship that can be determined by finding the appropriate exponent **n** in $\ell_x = s^x h^{(x^n)} g^{(c^x-1)}$ and consequently in the retirement rate $\mathbf{U_x}$ (3). "**h**" should be less than 1 since **B** must be positive in order for this new term to logically increase the overall retirement rate $\mathbf{U_x}$. That is, if **B** is positive, $\mathbf{h} = e^{-(B/n)} < 1$. Furthermore, if $\mathbf{n} < 1$, then $\mathbf{Bx^{(n-1)}}$ is a decreasing function in time. However, this term represents retirements due to technological advances in time and should be an increasing function. This eliminates values for $\mathbf{n} < 1$ as possible formulations.

For the older data bands prior to 1983, the best $\mathbf{R^2}$ values could not be improved with the new method. For more recent bands (83-87, 85-87), the best fit was improved with the new method using an exponent of 2 (See Exhibits I and II). These results were expected since only the most recent banded data would reflect the influences of competitive and technological activity. Thus, this additional effect is dependent on time. With $\mathbf{n} = 2$ in the proportion surviving equation (4), the new term in (3) is **Bx** which increases linearly with age. It is reasonable to expect that within five years, the effect of competitive and technological activity will be more defined in the data and may require an exponent of higher order. This was seen in some of the data in which the best fit was produced by an exponent of order 3. The banded data available currently is slightly premature in that we are just beginning to see the impact from these additional forces but in the next few years, we anticipate the data will reflect greater influences of technology and competition. The results thus far provide support to the concept that an additional term exists which captures the effects more fully and improves the current curve fitting process.

## CHARTS

### REFERENCES


Chou, Ya-Lun (1975). Statistical Analysis, 2nd Edition. Holt, Rinehart, and Winston, New York.

Draper, N.R. and Smith, H. (1981). Applied Regression Analysis. John Wiley and Sons, Inc., New York.

Gompertz, B. (1825). On the nature of the Function Expressive of the Law of Human Mortality, and on a New Mode of Determining the Value of Life Contingencies. Philosophical Transactions of the Royal Society of London, Vol. II, 513-529.

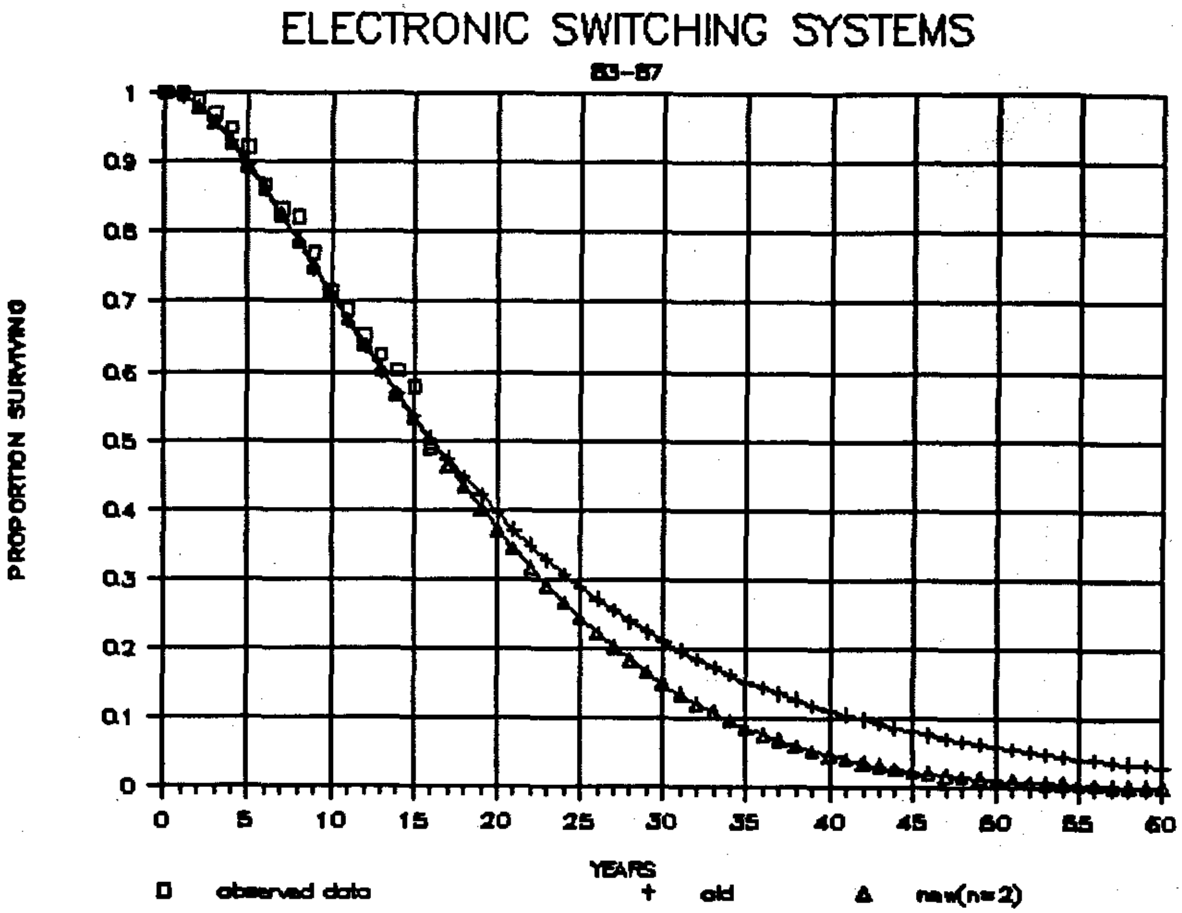
Leavitt, T.L. and Clopton, Jr., E.B. (1989). A Modern Approach to the Application of the Gompertz-Makeham Equations for the Life Analysis of Telecommunication Property. Journal of the Society of Depreciation Professionals. Vol. I, No. 1.

Makeham, W.M. (1860). On the Law of Mortality and the Construction of Annuity Tables. The Assurance Magazine, and Journal of the Institute of Actuaries. Vol. VIII, 301-310.

Pindyck, R.S. and Rubinfeld, D.L. (1976). Econometric Models and Economic Forecasts. McGraw-Hill, Inc., New York.

Thomas, Jr., G.B. (1962). Calculus and Analytic Geometry, 3rd Edition. Addison-Wesley, Inc., Reading, MA.

Washington, A.J. (1971). Technical Calculus with Analytic Geometry. Cummings Co., Menlo Park, CA.




old:

C= 0.83 G= .7085024 S= .9386844

R-SQR= .9930314
SSE= 2.785458E-03
VAR= 1.989613E-04
STD= 1.410536E-02

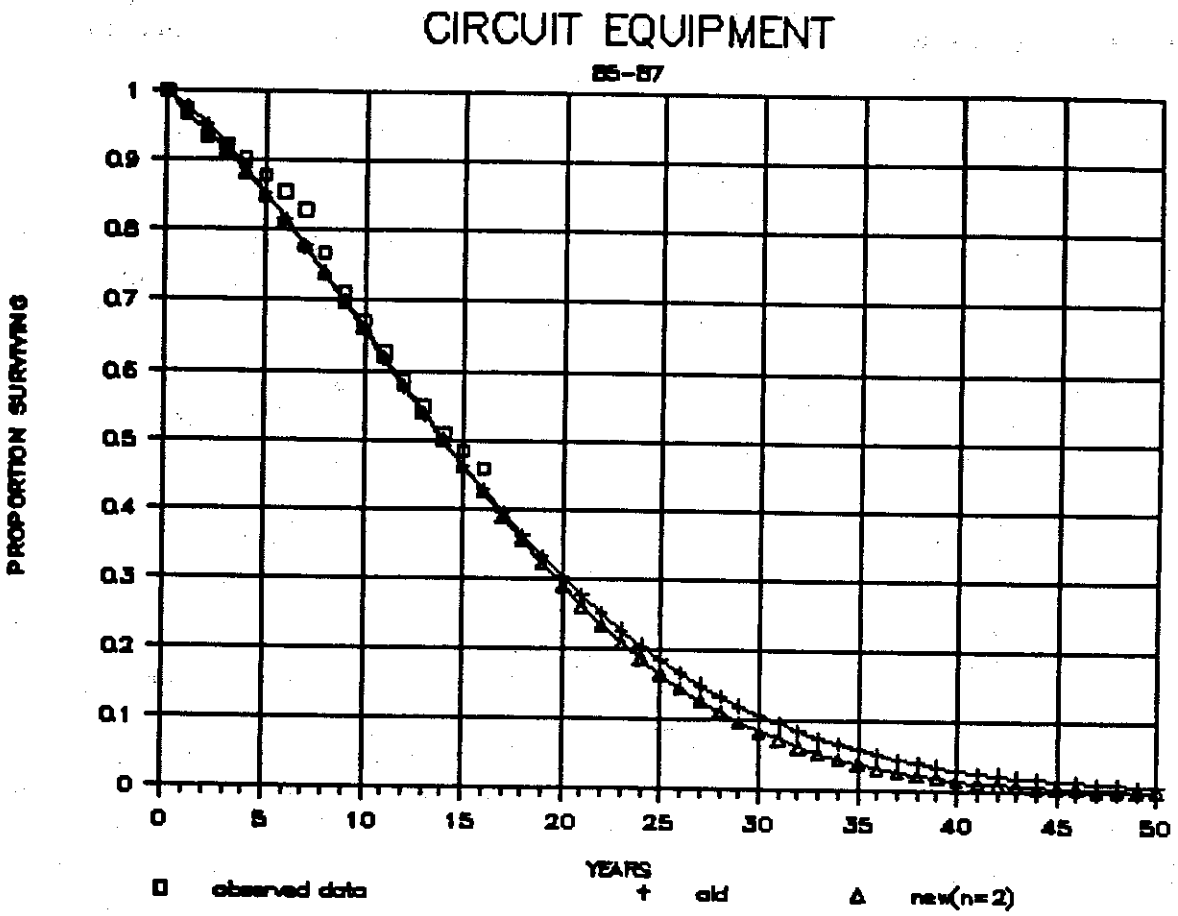
X-INTERCEPT= 90 CAL. LIFE = 20.4486

new(n=2):

C= 0.56 G= .9442194 S= .9736995 N= .9987194

R-SQR= .9932181
SSE= 2.710851E-03
VAR= 1.936322E-04
STD= 1.391518E-02

X-INTERCEPT= 56 CAL. LIFE = 17.90007




old:

C= 0.97 G= 5.646287E-03 S= .8370862

R-SQR= .9924674
SSE= 3.527932E-03
VAR= 2.519952E-04
STD= 1.587435E-02

X-INTERCEPT= 54 CAL. LIFE = 15.84056

new(n=2):

C= 0.02 G= 1.011455 S= .9806961 N= .9979177

R-SQR= .9932848
SSE= 3.14505E-03
VAR= 2.246464E-04
STD= 1.498821E-02

X-INTERCEPT= 47 CAL. LIFE = 15.29953

## APPENDIX A

Definitions of some common statistical measurements are given below. $Y_i$ is the "observed" data and $\hat{Y}_i$ is the "calculated" data for $i = 1,2,3,\ldots,t$.

| | |
|---|---|
| $\bar{Y} = \sum_i Y_i/t$ | the **mean** (average value) of t observations |
| $\sigma_s^2 = \sum_i (Y_i - \hat{Y}_i)^2/(t-2)$ | the sample **variance** of the regression (a measure of the closeness of the fit) |
| $\sigma_s = [\sum_i (Y_i - \hat{Y}_i)^2/(t-2)]^{1/2}$ | the **standard error** (sometimes called the Root Mean Square error (RMS)) |
| $SST = \sum_i (Y_i - \bar{Y})^2$ | total sum of squares (total error) |
| $SSR = \sum_i (\hat{Y}_i - \bar{Y})^2$ | sum of squares due to regression (explained error) |
| $SSE = \sum_i (Y_i - \hat{Y}_i)^2$ | sum of squares due to error (unexplained error) |

$$SST = SSR + SSE$$

$$1 = SSR/SST + SSE/SST$$

$R^2 = SSR/SST = 1 - SSE/SST$ coefficient of determination

$R^2$ can be used as a measure for comparison of curve fits by giving a relative change in the sum of squares due to error (SSE).

## APPENDIX B

Unless otherwise indicated, $\Sigma$ represents the summation from x=1 to x=t where t is the number of "observed" data values used in the process.

Since $l_x = s^x h^{(x^n)} g^{(c^x-1)}$ is nonlinear in **s**, **h**, **g**, and **c**, we use a logarithm transformation:

$$\ln l_x = x \ln s + x^n \ln h + (c^x-1) \ln g$$

or $L_x = Sx + Hx^n + G(c^x-1)$

where $L_x = \ln l_x$, $S = \ln s$, $H = \ln h$, and $G = \ln g$

If $y_x$ = "observed" proportion surviving and $Y_x = \ln y_x$, the sum of squares of the differences between $L_x$ and $Y_x$ can be written as:

$$F(S,H,G) = \Sigma (L_x - Y_x)^2$$

or

$$F(S,H,G) = \Sigma (Sx + Hx^n + G(c^x-1) - Y_x)^2$$

To obtain the minimum sum of squares, we take the partial derivatives of **F** with respect to S, H, and G and set each equal to zero.

$$\partial F/\partial S = 2\ \Sigma\ (Sx + Hx^n + G(c^x-1) - Y_x)x = 0$$

$$\partial F/\partial H = 2\ \Sigma\ (Sx + Hx^n + G(c^x-1) - Y_x)x^n = 0$$

$$\partial F/\partial G = 2\ \Sigma\ (Sx + Hx^n + G(c^x-1) - Y_x)(c^x-1) = 0$$

Rearranging the three expressions above we obtain the corresponding three equations containing the three unknowns S, H, and G.

$$S\ \Sigma\ x^2 + H\ \Sigma\ x^{(n+1)} + G\ \Sigma\ x(c^x-1) = \Sigma\ Y_x\ x \quad (1)$$

$$S\ \Sigma\ x^{(n+1)} + H\ \Sigma\ x^{(2n)} + G\ \Sigma\ x^n(c^x-1) = \Sigma\ Y_x\ x^n \quad (2)$$

$$S\ \Sigma\ x(c^x-1) + H\ \Sigma\ x^n(c^x-1) + G\ \Sigma\ (c^x-1)^2 = \Sigma\ Y_x(c^x-1) \quad (3)$$

Letting:

$M_1 = \Sigma\ x^2$, $M_2 = \Sigma\ x^{(n+1)}$, $M_3 = \Sigma\ x^{(2n)}$, $M_4 = \Sigma\ x(c^x-1)$

$M_5 = \Sigma\ x^n(c^x-1)$, $M_6 = \Sigma\ (c^x-1)^2$, $M_7 = \Sigma\ Y_x\ x$, $M_8 = \Sigma\ Y_x\ x^n$

$M_9 = \Sigma\ Y_x(c^x-1)$

and rewriting (1), (2), and (3), we get:

$SM_1 + HM_2 + GM_4 = M_7$

$SM_2 + HM_3 + GM_5 = M_8$

$SM_4 + HM_5 + GM_6 = M_9$

Using Cramer's Rule, where:

$\mathbf{D} = M_1M_3M_6 + 2M_2M_4M_5 - M_3(M_4)^2 - M_1(M_5)^2 - M_6(M_2)^2$

Then:

$\mathbf{S} = M_3M_6M_7 + M_2M_5M_9 + M_4M_5M_8 - M_3M_4M_9 - (M_5)^2M_7 - M_2M_6M_8\ /D$

$\mathbf{H} = M_1M_6M_8 + M_4M_5M_7 + M_2M_4M_9 - (M_4)^2M_8 - M_1M_5M_9 - M_2M_6M_7\ /D$

$\mathbf{G} = M_1M_3M_9 + M_2M_4M_8 + M_2M_5M_7 - M_3M_4M_7 - M_1M_5M_8 - (M_2)^2M_9\ /D$

and finally:

$\mathbf{s} = e^{\mathbf{S}}$, $\mathbf{h} = e^{\mathbf{H}}$, $\mathbf{g} = e^{\mathbf{G}}$

# Modified Retirement Experience Index For Life Span Life Analyses Using The Simulated Plant-Record Method

**Ronald G. Lucas †**

## ABSTRACT

When using the Simulated Plant-Record (SPR) method for life analysis of relatively new utility property, often a depreciation analyst will realize that according to a computed retirement experience index, the data lack sufficient history to produce a reliable life forecast. Studies involving life span calculations require a different computation of retirement experience because the property being observed will not live to a normal end, but will end suddenly and concurrently at a certain date. This paper focuses on the development of a modified retirement experience index for life span analysis.

### Introduction

The Stimulated Plant-Record (SPR) Method for life analysis of utility plant has been widely accepted and used in depreciation accounting. In 1947, before the National Conference of Electric and Gas Utility Accountants, AGE-EEI accounting group[1], Alex E. Bauhan presented a paper in which he describes two indices to be used with this method. They are the Conference Index, a measure of goodness of fit, and the Retirement Experience Index, a measure of the immensity of retirement data. This paper focuses on the modification of the retirement experience index when used in SPR life span studies.

### Why SPR?

For many utilties, SPR is the only way to perform a life analysis. Life analysis of utility plant involves the collection of historical data. While aged data is required for actuarial vintage (i.e., the placement or installation year of transactions) additions, retirements, transfers, and adjustments. At a minimum, actuarial studies require a year of installation and a year of booking for each transaction. Therefore, when a utility lists $1,000,000 in retirements for the year in its annual report, an actuarial study would require breaking the retirements down to their years of installation. For example, the $1,000,000 would be broken down to $500,000 of retirements from plant installed in 1950, $250,000 of retirements from the 1954 installation, and $250,000 of retirements from the 1957 installation.

Most utilities will record a year the transaction was booked but not the vintages that contribute to the transaction. In the above example, the utility recorded or booked $1,000,000 in retirements for the year in which the retirement occurred. The SPR Method involves using this type of unaged data in a life analysis. Therefore, data detailing the installation years for the $1,000,000 in retirements are not needed for an SPR study.

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### A Historial Look at SPR

The SPR Method was first known as the Indicated Survivors Method. In 1922, Cyrus Hill[2] applied this method to telephone data. He simulated current vintage survivors by applying percents surviving from a standard survivor curve to vintage additions. He varied the mean while holding the curve type constant or he varied the curved type while holding the mean constant, in order to determine the curve that resulted in the sum of the simulated vintage balances being within 1% of a given book balance. A weakness in this method was that a mean resulting in simulated vintage balances equalling a book balance could be determined for every survivor curve, and that mean could vary by curve. For this trial and error procedure, the analyst had to assume the shape of the curve.

In the 1943 Report of the Committee on Depreciation of the National Association of Railroad and Uiltity Commissioners[3], the Indicated Survivors Method was expanded to not just one year but to several simulated and book balance test years in order to determine curve type and mean. Also, the simulated and actual balances were graphed for visual comparisons.

By 1947, the Indicated Survivors Method had been renamed the Simulated Plant-Record Method and in that same year, Alex Bauhan presented his paper on the SPR method in which he replaced the visual comparison with a comparison based on the sum of squared differences between simulated and actual balances. He also presented indices to be used in curve selection to determine goodness of fit and maturity of an account.

Also in 1947, Henry R. Whiton presented a simulation method based on matching retirements instead of balances.[4] In the late 1960's, William D. Garland presented further work on simulation methods based on the comparison of simulated and actual retirements.[5]

While the SPR Method assumes that all vintages will follow one survivor curve, Computed Mortality (CM) allows variation of survivor curves to reflect different survivor characteristics for each vintage.[6] A property group may show distinct changes in survivor characteristics when technological improvements are made to later plant placements; therefore, one survivor curve may be appropriate for the early placements, but inappropriate for later plant additions.

### The SPR Method

The SPR Method compared actual plant history to simulated plant history. Using the historical additions, balances and the Iowa Survivor Curves[7], the SPR method generates a series of balances and retirements that could be compared to actual balances and retirements. There are two approaches to the SPR method. They are the balance method and the period retirements method. By trial and error, the SPR balance method tries different average service lives (ASL) for each Iowa Survivor Curve in order to determine the ASL that will give the minimum sum of squared differences between the simulated balances and the actual balances for that Iowa Survivor Curve. After determining the ASL that minimizes the sum of squared differences for each curve, all curves can be compared to determine the best Iowa curve to use for depreciation purposes. Also by trial and error, the period retirement SPR method tries different ASL's for each Iowa Survivor Curve in order to determine for a selected study period the ASL that will yield cumulative differences between simulated retirements and actual retirements equalling or closely approximating zero. The best curve is based on the curve with the minimum sum of the square differences between the annual simulated retirements and actual retirements for the study period.

**Stimulation Indices**

The conformance below, retirement experience index, and judgement are all used to select a best curve. As mentioned previously, the conformance index (CI) indicates the goodness of fit. It is calculated by first determining the mean square of the differences between the actual and simulated balance. The square root of the mean square differences is the standard error. The conformance index is the ratio of the average balances to the standard error and is expressed in the following equation:

$$CI = \text{ave. bal.} / \text{sqrt}(SSD/n)$$

where,

CI = Conformance Index
ave. bal. = (Sum of year-end balances) / n
sqrt = square root
SSD = Sum of squared differences between actual and simulated balances
n = number of balances observed

In his paper on life analysis using the SPR approach, Alex Bauhan arbitrarily chooses the following criteria to evaluate the conformance index:

| Rating | Conformance Index |
|---|---|
| Excellent | Over 75% |
| Good | 50 to 75% |
| Fair | 25 to 50% |
| Poor | Less than 25% |

The Retirement Experience Index (REI) is another tool to help the depreciation analyst determine the value that a selected curve might have in order to assist the analyst in forecasting future events. This index is based on the assumption that at a study date, retirements have followed a pattern of retirements for a selected survivor curve and the index equals the percent retired from the earliest vintage. When later additions are significantly larger than the first year's addition, the REI can be based on the percent retired from the earliest vintage with a significant addition. In equation form, the Retirement Experience Index can be expressed in either of the following forms:

$$REI = 100.0\% - X\%$$

where,

X% = The percentage of the earliest significant vintage addition simulated as surviving as of a study date

OR

$$REI = 100\% \times \text{Cum. rets.} / \text{Total rets.}$$

where,

Cum rets. = Cumulative retirement from the earliest significant addition to the study date
Total Rets. = Cumulative retirements from the earliest significant addition to maximum life

Generally, a long-lived property group will show little retirement experience after the first five or ten years, while a short-lived property group might show greater retirement experience at the same age.

In his paper on life analysis using the SPR method, Mr. Bauhan presents the following table to evaluate the retirement experience index:

| Rating | Retirement Experience Index |
|---|---|
| Excellent | Over 75% |
| Good | 50 to 75% |
| Fair | 33 to 50% |
| Poor | 17 to 33% |
| Valueless | Less than 17% |

With the Conformance and Retirement Experience Indices in hand, the analyst knows the value and completeness of the data to be used in the selection of a survivor curve. The analyst may reject a good fitting curve because of lack of retirement experience which would make forecasting unsupported. In any event judgement must be exercised in the final curve selection process.

**Property Groups and Retirement Analysis**

In using judgment, one should consider the type of property being analyzed. If one were to consider properties categorized into two general classifications, mass property groups and life span property groups, then the above tables could apply to both groups with modification of the retirement experience index for the life span property group.

A mass property group is a collection of like units having lives generally independent of one another. This group retires gradually over time with no distinction made between interim and final retirement. An interim retirement is a retirement that occurs prior to the expiration of all units in a group and a final retirement is the last retirement or entire retirement of a group. Mass property groups may contain a large number of small units. These units often retire according to a pattern which can be discovered by either SPR or actuarial methodology.

In contrast to a mass property group, a life span group contains units that will retire in a specific number of years after placement. For life span groups, there may be interim additions and retirements; however, all plant will be subject to a final retirement at a date that is known or can be estimated. Unlike mass property groups, life span groups often contain a small number of large units. The date of concurrent retirement for the entire group establishes the life span for the individual units. Actuarial or SPR methodologies can be used to develop a survivor pattern; however, for the life span property the survivor curve is truncated at the date of concurrent retirement of all property.

The truncated survivor curve is the basis for modifying the Retirement Experience Index. Because an event will cause all property to retire at a date independent of the retirement pattern, the retirement pattern after the truncation date is inconsequential. For this reason, the REI can be modified to be the ratio of the cumulative retirements of the first year's addition to the study date at the truncation date. Another way of looking at the REI Index is to observe it as the ratio of plant that has been retired to the plant that will be retired until the truncation date.

For example, quite often in the natural gas industry, property will retire because of exhaustion of gas supply, rather than the wearing out of equipment. To illustrate the point of the Modified Retirement Experience Index (MREI), a sample analysis based partly on actual plant data is presented below.

**The ABC Natural Gas Company**

The ABC Natural Gas Company has been producing natural gas in an Appalachian field in West Virginia since 1960. To aid production and deliverability, the company added compressor equipment and structures in 1970. The company's petroleum engineers have determined that the field will be depleted by the end of the year 2000 at which time all equipment will be retired. The depreciation analyst's job is to determine the adequate depreciation rate to recover the undepreciated investment by year-end 2000.

The depreciation analyst would collect historical data for all accounts. Account 333, Compressor Station Equipment, will be examined in detail.

Table 1 contains unaged data for Account 333. Note the large initial placement in 1970 and the 20-year history of moderate additions and retirements. Since this type of property is long-lived, the analyst might suspect that the retirement experience of this account might not be adequate for study purposes. From this table alone, the analyst can observe that over the history of this account, the sum of all the retirements is less than 30% of the sum of all the plant additions.

Using the data in Table 1, the best fitting curves by SPR study are shown in Table 2. While conformance indices for these curves are in the excellent range according to Mr. Bauhan's CI scale, the retirement experience indices are poor to fair. In his aforementioned paper, Mr. Bauhan states "In order for a life determination to be considered entirely satisfactory, it should be required that both the retirements experience index and the conformance index be 'Good' or better." Thus, the analyst might not feel well supported in using a curve based on this SPR study. However, further examination of the selected curves with respect to life span group adds foundation to the curve selection.

In Figure 1, the best fit curve has been selected for further study. The horizontal axis reads age in years; however, in order to observe the survivor characteristics of a particular vintage, calendar years can be substituted for age. For the first addition, the 1970 vintage plant, age 0 corresponds to midyear 1970, age 20 coincides to midyear 1990 and age 30 matches midyear 2000. The REI can be computed by first subtracting the number of units from the 1970 vintage plant surviving at the 1990 study date from the number placed in service in 1970, the first year, in order to determine the cumulative retirements of the 1970 vintage plant at the study date. The cumulative retirements are divided by the original units added in 1970. From Figure 1, 100% or all units (for simplicity, consider 100 units) are installed new at age 0 in 1970. Approximately 65% (65 units) of all units placed in service new survived at age 20 or year 1990. The cumulative retirements equal 35% (35 units). The equation is:

REI = (100 - 65/100 or 35% (34.53% according to a computer program that calculates the Iowa curves in fine increments).

The MREI can be calculated by noting the amount of plant expected to be surviving at the end point of the life span, the year 2000. Since all plant will be retired at the end of the year 2000, the analyst can focus on the plant that survives until the year 2000. For the first year's addition, the MREI relates the cumulative retirements at the study rate to the cumulative retirements at truncation. This relationship is based on the premise that retirement experience for a particular curve is measured against the retirements that will occur according to that curve. Without considering life span, the retirement experience is measured against the original addition which is the plant that will all retire according to a particular curve. For life span group, the retirement experience is measured against the plant that will retire according to a particular curve before the truncation date.

From Figure 1, approximately 35% or 36 units of the 1970 vintage survives at the year 2000 or age 30. The cumulative retirements at truncation amount to 64% or 64 units (100 - 36). The MREI equals the cumulative retirements at the study date divided by cumulative retirements at truncation. the equation for the MREI becomes:

MREI = (100/65)/(100-36) or 55% (54.05% by computer)

According to Mr. Bauhan's scale for retirement experience, the retirement experience for this curve selected by SPR analysis is "Good" when life span is considered. Because the property in this example was a life span group, the analyst could feel better supported in selecting a curve. Judgment, again, plays a major role in the final curve selection process. The analyst is not locked into selecting the best fit and highest REI or MREI survivor curve when informed judgment suggests a different choice. With life span analysis, the initial table of best curves for Account 333 of the ABC Natural Gas Company can be modified to reflect the MREI as shown in Table III.

**MREI for Actuarial Studies**

While this paper focused on life span analysis using the SPR Method, the modified retirement experience concept can also be applied to actuarial study. Because actuarial study involves the handling of aged data, the analyst can develop survivor profiles by vintage or vintages. A life table which relates plant surviving and age can be constructed for a property group. In many instances, data are not available to allow the life table to extend to a point where no plant survives, in which case the graph of the table would be a stub curve. A stub curve is one whose retirement experience is less than 100%. Since average service life is estimated from a curve that is complete, the stub curve must be extended to zero percent surviving. If an Iowa Survivor Curve is selected to represent a complete curve for the property group, the Iowa curve should coincide with the stub curve and be a logical extension of the stub. Ideally, one would want a close-fitting Iowa curve matched to a relatively long original stub curve.

The MREI relates a stub curve to a selected truncated survivor curve. In an actuarial analysis, the length of a stub curve depends on the placement and experience years used for analysis. According to the selected placement and experience years, data will be assembled to construct a life table. The maximum age of the life table determines the maximum length of the stub curve. The maximum age equals the time period from the earliest year to the latest experience year. If an analyst performed an actuarial analysis for the ABC Natural Gas Company, he or she would develop a stub curve using the original group method[8] or another exceptional method. If one were to choose to analyze the retirement experience of plant placed in service from 1970 to1990 as observed from 1970 to 1990, the maximum age is that of the 1990 retirement of plant installed in 1970. From Figure 2, the stub curve ends at age 20.5 years where 64.5% of the 1970 vintage plant survives. If the analysis of the property group does not involve life span, then the retirement experience extends 20.5 years out of a maximum life cycle of nearly 50 years. The REI equals approximately 35.5% (100-64.5/100) retirement of the 1970 original group. On the other hand, a life span analysis means truncating the curve at year-end 2000, age 30.5 where 38% of the 1970 original group will survive if the selected survivor curve is followed. The modified retirement experience with life span consideration extends 20.5 years out of a life span that only extends to age 30.5. The MREI equals approximately 56% (100-64.5)/(100-38) for the 1970 original group.

The MREI should be considered whenever a life span analysis is involved and inadequate retirement experience is suspected. By considering the truncated life of property in a life span group, an analyst can evaluate retirement experience as it relates to the cumulative retirement of that property at truncation. This evaluation should then determine the adequacy of data for life analysis and further depreciation work.

### References

[1] Bauhan, Alex E. Life Analysis of Utility Plant for Depreciation Accounting Purposes by the Simulated Plant-Record Method. National Conference of Electric and Gas Utility Accountants American Gas Association - Edison Electric Institute (AGA-EEI). Buffalo, New York. April 8, 1947.

[2] Hill, Cyrus G. Depreciation of Telephone Plants. Telephony. 82: No. 11: 12-18. 1922.

[3] National Association of Railroad and Utility Commissioners. Report of the Committee on Depreciation, 1943, pp. 104-105, 271, 274-277. Washington, D.C.

[4] Whiton, Henry R. The Indicated Retirements Approach to the Simulated Plant-Record Method of Estimating Lives of Mass Accounts of Utility Property for Depreciation Accounting Purposes. National Conference of Electric and Gas Utility Accountants. American Gas Association-Edison Electric Institute (AGA-EEI). Buffalo, New York. April 1947.

[5] Garland, William D. Proposal of a Simulated Plant-Record Period Retirements Method for Plant Mortality Analysis. National Conference of Electric and Gas Utility Accountants. American Gas Association-Edison Electric Institute (AGA-EEI). Los Angeles, California. May 1967.

[6] Fitch, W.C., Jensen, S.D., Young, L.J. A Preliminary Study of Simulation Methods in Life Analysis, Prepared for Interstate Commerce Commission Depreciation Branch Bureau of Accounts. Kalamazoo, Michigan 1982.

[7] Iowa Survivor Curves are set of curves based on a summary of survivor characteristics of many types of industrial and utility property. Professor Edwin Kurtz began to assemble data in 1916 and in Bulletin 70 of the Iowa State College Engineering Station, published July 2, 1924, he announced some of his findings. Additional work has been presented in Bulletin 103, **Life Characteristics of Physical Property**, published in 1931 and Bulletin 125, **Statistical Analyses of Industrial Property Retirements**, published in 1935.

[8] The original group method involves observing at successive annual dates the units surviving from an original group placed in service at a given year. Fitch, W.C., Wolf, K.F., and Bissinger, B.H. The Estimation of Depreciation. Center for Depreciation Studies, Western Michigan University. Kalamazoo, Michigan. 1975.

### REFERENCES


Garland, William D. Simulated Plant-Record Period Retirements Method: Criteria for Mortality Pattern Evaluation. National Conference of Electric and Gas Utility Accountants. American Gas Association-Edison Electric Institute (AGA-EEI). Miami Beach, Florida. April, 1968.

Gilbert Associates, Inc. Depreciation Seminar Conducted for the Federal Power Commission, Washington, D.C. June 5-9, 1972.

National Association of Railroad and Utilities Commissioners, Public Utility Depreciation Practices, Washington, D.C. 1968.


**Table I Unaged data for SPR study.**

ABC Natural Gas Company
A History of Account 333

| Year | Additions | Retirements | Balance |
|---|---|---|---|
| 1970 | 1,000,000 | 0 | 1,000,000 |
| 1971 | 25,000 | 10,890 | 1,014,110 |
| 1972 | 100,000 | 11,747 | 1,102,363 |
| 1973 | 1,500 | 13,432 | 1,090,431 |
| 1974 | 500 | 14,098 | 1,076,833 |
| 1975 | 2,000 | 14,747 | 1,064,086 |
| 1976 | 25,000 | 15,404 | 1,073,682 |
| 1977 | 1,500 | 16,302 | 1,058,880 |
| 1978 | 500 | 16,956 | 1,042,424 |
| 1979 | 2,000 | 17,630 | 1,026,794 |
| 1980 | 250,000 | 18,369 | 1,258,425 |
| 1981 | 5,000 | 26,375 | 1,237,049 |
| 1982 | 2,000 | 22,881 | 1,216,168 |
| 1983 | 25,000 | 23,974 | 1,217,195 |
| 1984 | 8,000 | 25,386 | 1,199,808 |
| 1985 | 0 | 26,690 | 1,173,118 |
| 1986 | 8,000 | 27,965 | 1,153,153 |
| 1987 | 0 | 29,366 | 1,123,787 |
| 1988 | 500 | 30,715 | 1,093,571 |
| 1989 | 2,000 | 32,090 | 1,063,481 |
| 1990 | 7,500 | 33,491 | 1,037,490 |

**Table II SPR Study Summary**

ABC Natural Gas Company
Account No. 333
Simulated Plant-Record Analysis
Summary - Iowa Survivor Curve Selection

| Dispersion | ASL | CI | REI |
|---|---|---|---|
| R1 | 25.0 | 333 | 34.53 |
| L0 | 32.7 | 200 | 33.18 |
| S-.5 | 28.9 | 167 | 32.79 |
| L0.5 | 29.2 | 143 | 35.41 |
| R1.5 | 23.1 | 100 | 37.18 |
| S0 | 25.6 | 91 | 36.21 |
| R0.5 | 28.8 | 77 | 31.78 |

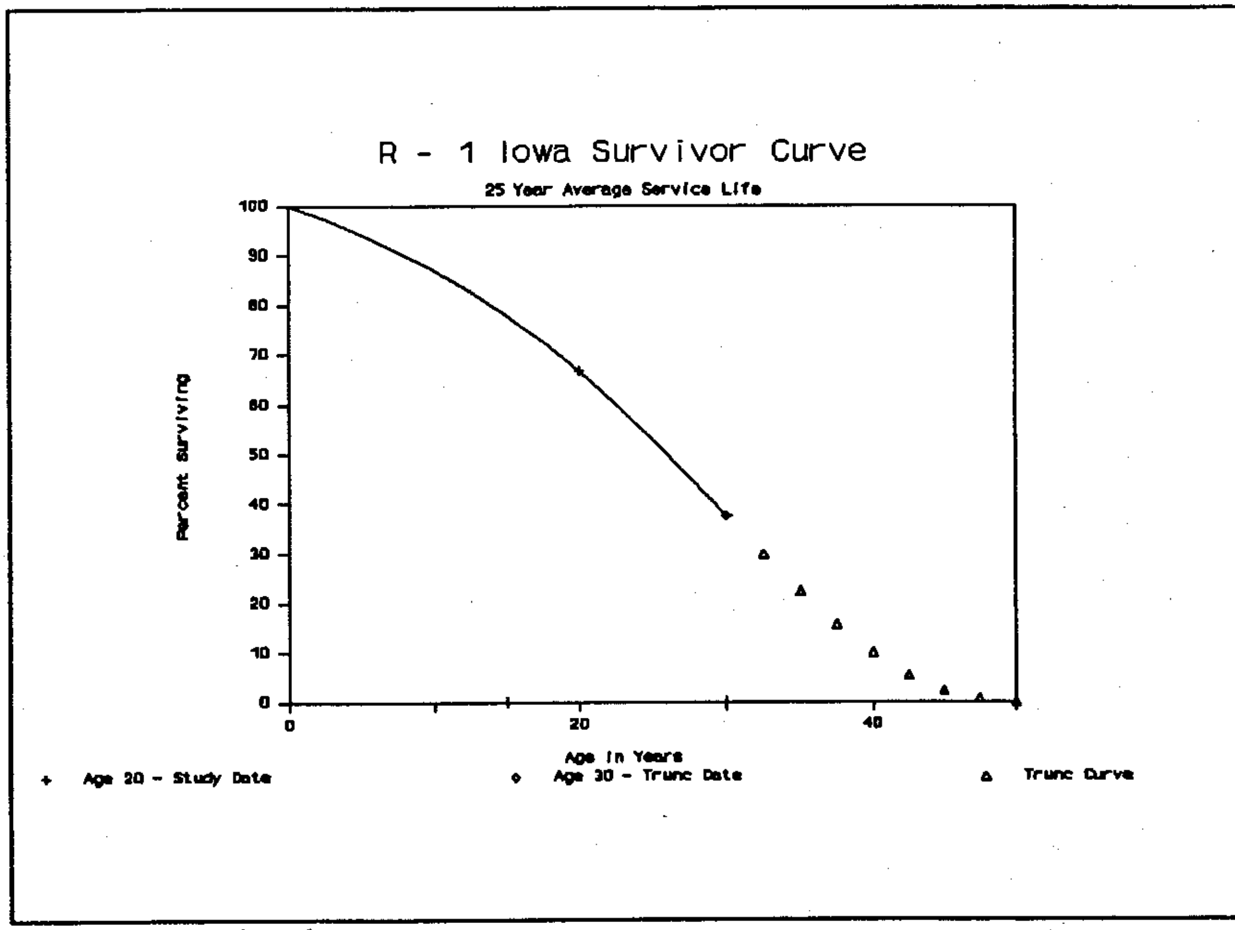


**Figure 1** A Truncated Survivor Curve

**Table III** SPR Study with Life Span Analysis

ABC Natural Gas Company
Account No. 333
Simulated Plant-Record Analysis
with Life Span Ending at the Year 2000
Summary - Iowa Survivor Curve Selections

| Dispersion | ASL | CI | REI | MREI |
|---|---|---|---|---|
| R1 | 25.0 | 333 | 34.53 | 54.05 |
| L0 | 32.7 | 200 | 33.18 | 64.89 |
| S-.5 | 28.9 | 167 | 32.79 | 61.47 |
| L0.5 | 29.2 | 143 | 35.41 | 62.02 |
| R1.5 | 23.1 | 100 | 37.18 | 49.19 |
| S0 | 25.6 | 91 | 36.21 | 57.14 |
| R0.5 | 28.8 | 77 | 31.78 | 61.19 |

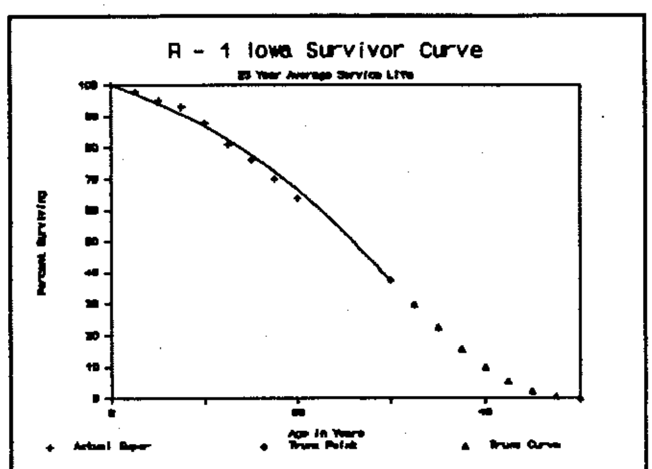


**Figure 2** A Truncated Survivor Curve - Actuarial Analysis

# Streamlined Depreciation Studies for Small Local Exchange Carriers

John H. Rudd †

Depreciation is becoming the most significant expense for many telecommunications companies and in today's environment determining appropriate depreciation rates can be a very complex task. Despite the complexities small companies are not exempt from the importance of using appropriate rates or from the need to perform periodic studies to determine what those rates should be. This paper describes the steps the staff of the Michigan Public Service Commission (MPSC) took to address that burden for the small local exchange carriers (LEC) — companies other than Michigan Bell or General Telephone.

## I. The Need To Streamline

The MPSC formally prescribes depreciation rates for each LEC under its jurisdiction whether it is exclusive or joint with the Federal Communications Commission (FCC). If the FCC is a fairly small company having little or no activity in its plant accounts, the orders are generally for a four-year period, but larger companies experiencing more activity are subject to three-year orders. Regardless of the period they are effective, the orders are generally for a three or four-year period and they include a requirement for each LEC to file a new depreciation study before the rates expire.

For quite some time the studies were filed late or were incomplete but the MPSC really had no "clout" to enforce its requirement short of excluding depreciation expense from revenue requirement calculations and reducing customer service rates accordingly. In 1987 this problem became significant when several LECs did not file their studies until such a threat was made. Recognizing a potential problem, the MPSC directed the Commission Staff to review the procedures used by the LECs and by the Staff in the depreciation rate-setting process.

The Staff found a considerable amount of resistance on the part of both the companies and their consultants toward performing the studies. They were not willing to commit their time and expense necessary when they saw little or nothing to be gained from performing complete life and salvage analyses that resulted in little change in the factors and, eventually, in annual depreciation expense. Consequently, the Staff developed proposed changes in study procedures that were intended to rectify this situation.

In 1988 the Staff's findings were discussed with the MPSC and then released as a report to the LECs and their consultants for comment. After a trial period of informal implementation, the Staff released its report in March 1990 in the form of guidelines to be used by the LECs other than Michigan Bell and General Telephone, due to joint regulation by both the MPSC and the FCC. The following sections of this paper explain how depreciation studies for LECs in Michigan have been streamlined to better target those areas that need periodic review while reducing the work load in the areas having little data, activity or likelihood of changes in the foreseeable future.

## II. Framework for Streamlined Studies

There are 36 small LECs in the state and it is for these 36 companies that the following guidelines are considered appropriate as an alternative to conventional depreciation rate setting. Thirty of the LECs have less than 10,000 access lines each and 24 are not subsidiaries of system companies. Generally, the depreciation rate prescription procedure begins with the LEC hiring a consultant to prepare the depreciation study which is then filed with an application for revised rates. The public is made aware of the proceeding when the Staff sends a Notice of Opportunity to Submit Comments to the LEC which has it published. Meanwhile, the Staff reviews the study, performs additional studies and/or field work and writes a preliminary report. This report supports the Staff's position in negotiations with the LEC and intervenors, if any. In almost all cases, a negotiated settlement is achieved and an ex parte order is then prepared for Commission action.

While the thirty-six LECs range in size from one to twenty-nine exchanges, all are similar enough in size and mode of operation that there have not been any major problems in the recent past with respect to review and monitoring of each company's depreciation practices. It is not unusual, however, for a significant amount of company and Staff resources to be spent on depreciation studies where the change in annual depreciation expense is not very large. In an effort to utilize company and Staff resources more efficiently without sacrificing responsibility for depreciation regulation, Michigan depreciation study procedures have been changed as outlined herein. The changes establish ranges of acceptable life and salvage factors for all the accounts except central office equipment and vehicles. Studies on these two accounts must be submitted with each application. Specific depreciation rates must still be prescribed and the LECs still have to apply for any changes, but the Staff will not require the LECs to prepare statistical studies as justification for proposals for the service life or net salvage factors falling within the acceptable ranges under these procedures. If any of the 36 LECs want to propose factors outside the ranges for one or all of their plant accounts, they have to submit a detailed study for Staff review. The Staff is aware of the effort put forth by telephone

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company management to be responsible and accountable in planning and budgeting their COE replacements. The changing technology and need for central office equipment varies with each LEC, so using ranges for this account fails to recognize each LEC's different plans. The expected documentation to be submitted with the depreciation study includes a description of the company's COE plans along with all justifying factors. Vehicle replacement policies are also very different from one LEC to the next, so they should be reviewed in each depreciation study. The depreciation rates are then established for these two plant categories on a case-by-case basis depending on the individual company plans.

Table 1 in this paper is a schedule of recommended ranges as set by the MPSC Staff for average service life (ASL) and average net salvage (ANS) for each of the major plant accounts. Average remaining life (ARL) must be calculated for each LEC based on its ASL and retirement history. Future net salvage (FNS) is usually the same as ANS for LECs using remaining-life depreciation rates. The recommended ranges were developed from the Staff's file of previously prescribed factors for the Michigan LECs, representing a reasonable basis for transition from required studies to optional ranges for life and salvage factors. Table 1 shows the total number of LECs which have assets in each account and how many of those companies have life or salvage factors falling within the ranges. A more detailed discussion of how the ranges were determined appears under the heading, **"Ranges of Life and Salvage Factors"** in Section III of this paper.

An exception to the use of the streamlined procedures occurs when the proposed total increase in depreciation exceeds 5% of the current annual depreciation expense on a whole life basis. It is one thing to have a bona fide need for increases in annual depreciation expense develop because a LEC is improving its facilities in ways that its customers will benefit from better service. It is quite another thing to propose a significant increase in annual depreciation expense resulting from the Staff and/or LEC wishing to reduce its workload and related expense by just reducing the service lives but still remaining within the recommended range. Consequently, the Staff expects that proposed life and salvage factors resulting in a significant change in annual depreciation expense would be supported by studies even if the factors are within the Staff's ranges. Specific limitations on the proposal for such purposes are outlined in the **"Five-Percent Rule"** part of Section III.

## III. Guidelines for Streamlined Study Procedures

Often the lack of data available makes more sophisticated, statistically based studies difficult to perform and of questionable reliability for small companies. In such instances a high degree of judgment must also be applied and the following guidelines are available as an option if a LEC desires to lessen the amount of work and documentation necessary to support its proposed life and salvage factors.

If something arises between periodic studies which causes the need for a new or revised depreciation rate, a LEC usually files an application to amend the existing order. These guidelines are also available for such amendatory filings, particularly in those instances where a LEC needs to establish a depreciation rate for a new category of plant.

The following sections describe the Staff's guidelines for performing streamlined depreciation studies.

### Streamlined Study Procedures

Each LEC, whether or not it is a subsidiary of a system company, will continue to file a formal application for revised rates to be effected upon expiration of its current rates. The current 3 or 4-year interval between revisions will be maintained. Under past procedures the proposed depreciation rates for all depreciable accounts had to be supported by a formal study of ASL and ANS. With streamlined procedures, requirements for these support studies are eliminated for most accounts or they are modified.

Whether or not a LEC uses the streamlined procedures for the other accounts, all applications must be accompanied by studies supporting the LEC's proposed life and salvage factors for the central office equipment and vehicle plant categories. If, however, the LEC wishes to retain its present ASL or ANS or if it wishes to propose something within the ranges shown on Table 1 for any of the other accounts, no study will be required. However, the Staff reserves the right, in its judgment, to require the LEC to submit additional support in the form of documents, studies and explanations for any proposed changes, particularly if a proposed change appears to be contrary to the company's plans or it is otherwise inconsistent. If the LEC wishes to propose a change in ASL or ANS different from that currently supporting a prescribed rate and it falls outside the range, the proposed factor must be supported by a complete life or salvage study.

The Commission will continue to issue formal orders prescribing depreciation rates for all plant accounts for each LEC. Each LEC will continue to file a formal application to amend the order if it wishes to change any ASL or ANS factor supporting the prescribed rates. The current practice of issuing a Notice of Opportunity to Submit Comments will be continued for these periodic studies whether or not the streamlined procedures are used.

### "Five-Precent Rule"

In the Staff's efforts to redirect the company and Staff resources to areas of greater concern, it is possible that the cumulative effects of changes in other areas, such as a change in depreciation technique, could become significant. Therefore, the streamlined study procedures may be used by the LEC only if the total increase or decrease in annual depreciation expense is less than 5% as compared to the existing expense level based on whole life rates for all accounts treated in this manner. The LEC will still be allowed to propose depreciation rates resulting in more than a 5% change in whole life expense, but it will have to file an application and studies supporting the proposals. This approach will allow both the LEC and the Staff to direct most of its time and resources to those areas most needing in-depth analysis.

### Ranges of Life and Salvage Factors

The Staff developed for each plant account what it considered to be reasonable ranges for ASL and ANS from an engineering standpoint, based on existing practices and available technologies. Once the preliminary ranges were determined, the staff reviewed these ranges for reasonableness with respect to the life and salvage factors supporting the rates prescribed by the MPSC. In a few cases the Staff modified the original ranges so that at least 50% of the LECs' factors fell within the range. The recommended ranges on Table 1, then, are the result of combining the Staff's experience and engineering judgment with the depreciation orders in effect at that time.

The Staff expects that the ranges will be reviewed on a periodic basis and revised when necessary. It is not expected that a contested proceeding will occur where these ranges would be questioned, although it is a possibility. Before going forward with a contested proceeding, it might be more efficient for the Staff, LECs and interested parties to reach a consensus or to negotiate a set of ranges.

## IV. Benefits of the Streamlined Study Procedures

As stated earlier in this paper, the Staff is concerned that both its resources and those of the 36 LECs could be used in a more efficient manner with regard to prescribing depreciation rates. While the Staff perceives areas where paperwork can be reduced for the LECs and the Staff, it is also aware of the need to continually monitor the changes taking place in the telecommunications field so it can be properly responsive to prescribing depreciation rates. That is why the Staff is relaxing its study requirements in some areas and increasing its work in other areas.

By reducing its reviews of the LEC depreciation filings, the Staff expects to better utilize the different kinds of available financial and operating information. Quality of Service reports can provide an overall impression of how well a LEC's central office equipment is working in each exchange and whether it might be in need of imminent repair or replacement. Trouble reports kept by the LEC and customer complaints to the LEC or the Staff can be of use in identifying future replacement needs. In Michigan the Staff contacted each LEC a few years ago to determine anticipated central office replacement dates, outside plant upgrade completion dates and the need, if any, for additional financing. If this information is kept up to date, it can be extremely helpful when used in conjunction with the LEC's most recent construction budgets in determining life and salvage factors that will result in proper depreciation rates.

The LECs can realize salvage under the streamlined study approach whether they perform the studies themselves or they hire consultants. Either way, fewer hours and a less costly report are the immediate benefits in a situation where these procedures are used and little change in depreciation expense is expected at the outset. In the longer run, the LEC can achieve improved credibility by not having to support proposed factors with little more than someone's conjecture about the future. With more time to devote to studying data for central office equipment, the LEC's depreciation analyst or consultant has the opportunity to demonstrate to the company's management the need and importance of coordinating depreciation studies with the company's construction plans.

The Staff believes these streamlined procedures should be made available to all the telephone companies over which the Commission exercises exclusive jurisdiction — that is, all LECs except Michigan Bell and General Telephone. The LECs benefit from a reduction in paperwork less cost to prepare their periodic studies and the preparation of more meaningful studies. The Staff benefits from being able to concentrate on those areas having significant changes and/or having a significant impact on depreciation expense while using less Staff resources. The system as a whole benefits from a better coordination of management planning, quality of service, targeted regulatory review and depreciation rate prescription.

## V. The Michigan Experience

While the streamlined procedures have been available for two years, their effects are just beginning to be realized by the LECs and the Staff. Most new or revised procedures initially meet with a lack of understanding and these streamlined procedures are no exception.

For a while, consultants were still performing studies using limited data in accounts having little activity just to see if the study results were close to the recommended ranges. This defeated, of course, one of the main purposes for having streamlined procedures. Fortunately, the consultants now appear to have realized that factors resulting from full studies and factors arrived at using the recommended ranges result in such a small difference in annual depreciation expense that the time and effort expended on those studies was indeed not justified.

Perhaps the Staff has realized the most benefits to this point. A two-year backlog of depreciation filings has been eliminated and the few cases remaining open from the 1989 filings only need final resolution through the negotiation process. It is a credit to the streamlined procedures that once review of the LEC studies began in earnest, the Staff reports for all ten cases were completed in about three months. By comparison, three months used to be an average amount of time spent reviewing the study and writing a Staff report for one large or two small LEC filings.

Certainly as the LECs and their consultants become more adept at using the streamlined procedures and the Staff's workload becomes better targeted, these reductions should continue. As more time and resources become available, a better interrelationship can be developed between depreciation studies and deployment of new plant facilities.

As an outgrowth of the implementation of streamlined study procedures, Michigan Bell and General Telephone have each apprised the Staff with streamling proposals of their own, involving their smaller plant accounts. Because of joint jurisdiction with the FCC and an extensive data base maintained by these companies, the Staff is not likely to implement ranges of life and salvage factors. However, due to the early success of streamlined study procedures for Michigan's small LECs, there will likely be some form of streamlined studies used by Michigan Bell and General Telephone in their next filings with both the FCC and the MPSC.

## V. Conclusion

The MPSC Staff identified the cause of a serious problem — late or incomplete depreciation studies filed by the small LECs. The solution — streamlined study procedures — allows the LECs to propose life and salvage factors within certain ranges for most of their depreciable plant accounts without having to perform studies in support of those proposed factors as long as the aggregate change in annual depreciation expense on a whole life basis for such accounts is less than 5%. Since the procedures are optional, the LECs are free to propose whatever factors they believe are appropriate as long as they can be supported by studies if they are outside the Staff's recommended ranges. The 5% limit does not apply to the change in depreciation expense resulting from proposals outside the life and salvage ranges, from proposed factors for COE and vehicle plant categories and from a change in depreciation methodology such as whole life to remaining-life conversion. Early indications are that the procedures will be even more successful when they are fully understood and implemented and that they likely have already lead to similar streamlining for large companies.

**TABLE I**
**MICHIGAN LOCAL EXCHANGE CARRIERS**

**STAFF RECOMMENDED RANGES FOR LIFE AND SALVAGE FACTORS**

| Account Number | Description | Average Service Life Minimum (Yrs.) | Average Service Life Maximum (Yrs.) | Averget Net Salvage Minimum (%) | Averget Net Salvage Maximum (%) | Number of LECs Within Range (1) Total | ASL | ANS |
|---|---|---|---|---|---|---|---|---|
| 2116 | Other Work Equipment | 10 | 15 | 5 | 20 | 38 | 22 | 19 |
| 2121 | Buildings | 25 | 35 | 0 | 10 | 38 | 30 | 34 |
| — | Furniture & Office Equipment | 12 | 20 | 0 | 10 | 36 | 25 | 32 |
| 2122 | Furniture | 17 | 22 | 0 | 10 | 4 | 3 | 4 |
| 2123.1 | Office Support Equipment | 8 | 12 | 0 | 10 | 3 | 2 | 2 |
| 2123.2 | Co. Communications Equip. | 7 | 15 | 0 | 10 | 23 | 13 | 21 |
| 2124 | General Purposes Computers | 6 | 10 | 5 | 10 | 10 | 8 | 5 |
| 2351 | Public Tel. Terminal Equip. | 7 | 15 | 0 | 10 | 24 | 16 | 23 |
| 2411 | Poles | 17 | 25 | (15) | 0 | 31 | 21 | 24 |
| 2421 | Aerial Cable | 21 | 30 | (10) | 0 | 31 | 18 | 22 |
| 2422 | Underground Cable | 28 | 35 | ( 5) | 0 | 13 | 11 | 12 |
| 2423 | Buried Cable | 25 | 31 | ( 2) | 2 | 37 | 37 | 35 |
| 2423 | Buried Wire | 14 | 18 | ( 2) | 2 | 20 | 11 | 20 |
| 2424 | Submarine Cable | 25 | 30 | ( 2) | 2 | 5 | 4 | 5 |
| 2431 | Aerial Wire | 10 | 15 | (15) | 0 | 26 | 13 | 18 |
| 2431 | Rural Distribution Wire | 10 | 19 | (15) | 0 | 11 | 8 | 10 |
| 2441 | Conduit Systems | 35 | 45 | ( 5) | 0 | 12 | 8 | 12 |

(1) Study conducted when there were 38 local exchange carriers under exclusive MPSC jurisdiction.

*Discussion Paper:*

# Incentive Regulation: Hidden Disallowance Through Slow Depreciation

**Thomas A. Nousaine †**
**Jay M. Blomquist ††**

Abstract: Regulated Local Exchange Carriers (LECs) face a two-pronged risk under incentive regulation schemes such as Price Caps because the depreciation rate setting process remains unchanged. Most forms of alternative regulation follow a similar pattern: prices will be fixed for certain market segments, but no reforms are incorporated for the depreciation process. Prices established at the beginning of the alternative regulation period do not adequately recognize the true rate at which capital was consumed in prior periods, nor the rate at which it will be consumed in the future. The net result is a hidden disallowance of prudently invested embedded capital and a major risk to investors.

**Depreciation And Capital Recovery**

When a firm buys expensive and long lived (capital) productive capacity, it must estimate how long the equipment will produce goods. This estimate is used to determine depreciation expense, or the amount of capacity "used up" producing goods in the current year. In turn, prices are set that will ultimately recover all variable costs plus the original investment (depreciation) and any return required by shareowners or creditors over the life of the assets used to provide the product or service.

The cash used to buy plant is completely spent before any products are made. Therefore, depreciation has characteristics of "prepaid expense." In an ongoing business, investors may not require return of principle each year allowing the firm to use cash from sales that represents depreciation as internally generated funds to buy more capacity or improve efficiency. That money, of course, still belongs to the investors and must be used to increase the value of the business.

**Investment Decisions: Process and Criteria**

A firm will invest capital in productive capacity when the expected net present value of revenue streams and cost savings exceeds the costs of acquiring the new equipment.

An unregulated business is free to price its products at any level in any accounting period with the risk of either losing market share if the price is too high, or not maximizing revenues, if too low. If total revenues do not recover costs during multiple accounting periods, the firm will eventually fail.

A regulated company, however, has its prices set by regulators. A hidden assumption of the regulatory process is that capital costs (e.g. depreciation expense) are recoverable with equal risk in future accounting periods and can be recovered along with additional associated carrying charges (i.e., return and taxes). To the extent that the market is a true monopoly, with an essential product, the assumption is appropriate.

However, when regulatory practice factors lower prices today at the expense of higher prices tomorrow, the regulated firm faces increased risk. When competitive forces develop or customer willingness to pay becomes limited, the regulated firm may not be able to recover deferred costs.

**Depreciation Practices: Deferral and Incentives**

Depreciation practices at both the state and federal levels have historically deferred recovery of investor capital. Because the telephone industry was reasonably monopolistic with an expanding customer base over which to spread cost, firms providing regulated telephone services fared well in the decades between 1950 and 1980 even though it was acknowledged that depreciation rates were too low.

Small customers, in particular, received great benefit during this era. Technology advances reduced cost and helped ensure high quality. The expanding market base enabled common costs to be spread over a wide audience, and depreciation rates deferred recognition of some costs several decades into the future. The utility of telephone service became so strong, subsidy pricing schemes were successfully employed for residence, small businesses and hard to serve areas.

The overall cost of providing telephone service was generally under-estimated through the use of long depreciation lives and the constant political pressure for moderation in near-term rate increases. The situation was exacerbated by regulatory lag. Rate cases frequently lasted a year or more from application to award.

Faced with these pressures, telephone companies needed to reduce operating costs quickly. Technology innovations offered large opportunity for labor content reduction. Therefore, tremendous operating cost reductions were seen in the telephone industry between 1950 and 1980 as local exchange companies moved from manual switching into the digital age. (Graph #1)

Today, these technological advances, pioneered for the most part by the industry itself, have lowered the cost of production equipment to the point where new entrants are entering the market both as common carriers and through private networks. Many regulatory and legal barriers to market entry have been removed as well. This leaves local

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telephone carriers faced with a large investment base of partially recovered analog and copper technology quickly becoming obsolete due to competitive market conditions. The United States Telephone Association (USTA) estimated the shortfall for Local Exchange Carriers was $25 Billion at the end of 1988.[1]

Further, competition is now even being encouraged in local transport. Competitors such as Metropolitan Fiber Systems are serving high-volume areas with digital and fiber technology, causing regulated local Exchange Carriers' analog equipment to become obsolete even faster. The considerable unrecovered investment, if loaded onto tariffs for the remaining customers, will make some of them more likely to leave regulated networks. The resulting cost-recognition spiral may rapidly drive away customers having a choice of carriers.

**Depreciation and Incentives: Changes in the '80s**

Since the early 1980s, regulatory conditions have tended to discourage rapid deployment of technology by regulated firms. First, even though it became obvious that regulation had not provided timely recovery of investor capital for the prior decades, regulatory reform efforts developed slowly. The FCC reform plan was initiated by AT&T in 1973 and ordered in 1980. This plan, which included methods reform as well as amortizations of inside wire account investments and reserve deficiencies in many other accounts, will not be officially complete until 1991.[2] This two-decade span demonstrates the tendency of the current process to defer recovery. Furthermore, USTA estimated the FCC Reserve Imbalance Amortization plan only recognized about half the existing deficiency when implemented in 1985.[3]

Telephone company depreciation rates did not approximate rates used by typical American firms until the mid-1980s. (Graphs #2 and #3). Even so, LEC rates include a large catch-up for the previous decades of under-recovery and the amoritzation of embedded Station Connections Inside Wire. Underlying depreciation rates representing estimated consumption in the current accounting period ("stripped of catch-ups") remain below 6.5%. (Graph #2)

On the state level some jurisdictions have moved far ahead of the FCC in establishing realistic rates and some have lagged behind. On the whole, most states' rates are very similar to those set by the FCC.

Competitive forces in the interexchange market caused AT&T to write off massive amounts of capital investment in 1983 and 1988.[4] FASB 71 presently assumes the "regulatory promise" allows recovery of similar LEC investments in future accounting periods. However, the investment represented analog equipment which for the most part had been placed in service prior to divestiture to serve "monopoly" customers.

LECs have much of this kind of equipment still in place, which represents a major liability to them as competition spreads into interLATA toll and high density metropolitan local loops.

**Price Caps: No Depreciation Incentives**

Interestingly, Price Caps and other forms of incentive regulation do not address this problem. The FCC will continue to prescribe depreciation rates exactly the same way under price caps as they do now. Increases in depreciation rates from represcriptions will not be allowed to drive price changes; in other words, they will be written off directly at shareowner expense. In contrast, planned decreases in depreciation expense, such as amortization expiration, will directly reduce prices.

USTA estimates show amortizations which will reduce the aggregate Price Caps Base for the Bell Operating Companies and GTE by $1.8 Billion when they expire over the next three years.[5] This disparate treatment of expected future increases and known future reductions in depreciation expense provides no positive incentives to make capital expenditures.

Interestingly, these reductions will occur at precisely the same time large Infrastructure investments will be required.

Depreciation rates are inadequate today. Reform measures undertaken thus far, while useful, have taken nearly 20 years to enact and implement and have not changed the basic process. Depreciation policy today does not provide strong incentives for LEC investment in modern telecommunications equipment.

Even Cable TV companies are attempting to forestall LEC fiber-to-the-home by intervening in rate cases to hold down depreciation rates on copper cable. They argue that better recovery of existing facilities allows LECs to unfairly leverage investment in fiber through customer rates. Local loop competitors such as Metropolitan Fiber Systems have argued against competitive pricing by LECs using similar logic.[6]

**Summary:**

Depreciation practices at both the Federal and Local levels tend to produce results which discourage modernization and defer recovery of investor capital. Depreciation policy reform is the key to providing positive investment incentives to LECs under new regulatory formats. While it may be politically impractical to quickly rectify existing deficiencies, the process for establishing depreciation rates needs to be altered to allow more rational treatment of new assets as they are placed, reduced regulatory oversight, and streamlined study and represcription procedures.

This presents an interesting dilemma. LECs have proposed shorter lives and higher depreciation rates for the past decade. If they get better rates under Price Caps or other alternative regulation plans, it will be at shareowner expense. Increases in depreciation rates with no commensurate opportunity to increase prices is a form of disallowance unless computed earnings are above authorized levels. Even then the FCC and PSCs hold the ability to manipulate computed earnings by adjusting depreciation, which is the single largest LEC expense component.

Incentive regulation is supposed to offer incentives for LECs to modernize and increase efficiency. The way most plans are structured today, LECs will have to remain much more productive than the economy, as a whole, just to break even. Given this, their investors will not be granted a reasonable opportunity to recover the $25 Billion of prudently invested, but underaccured, embedded capital.

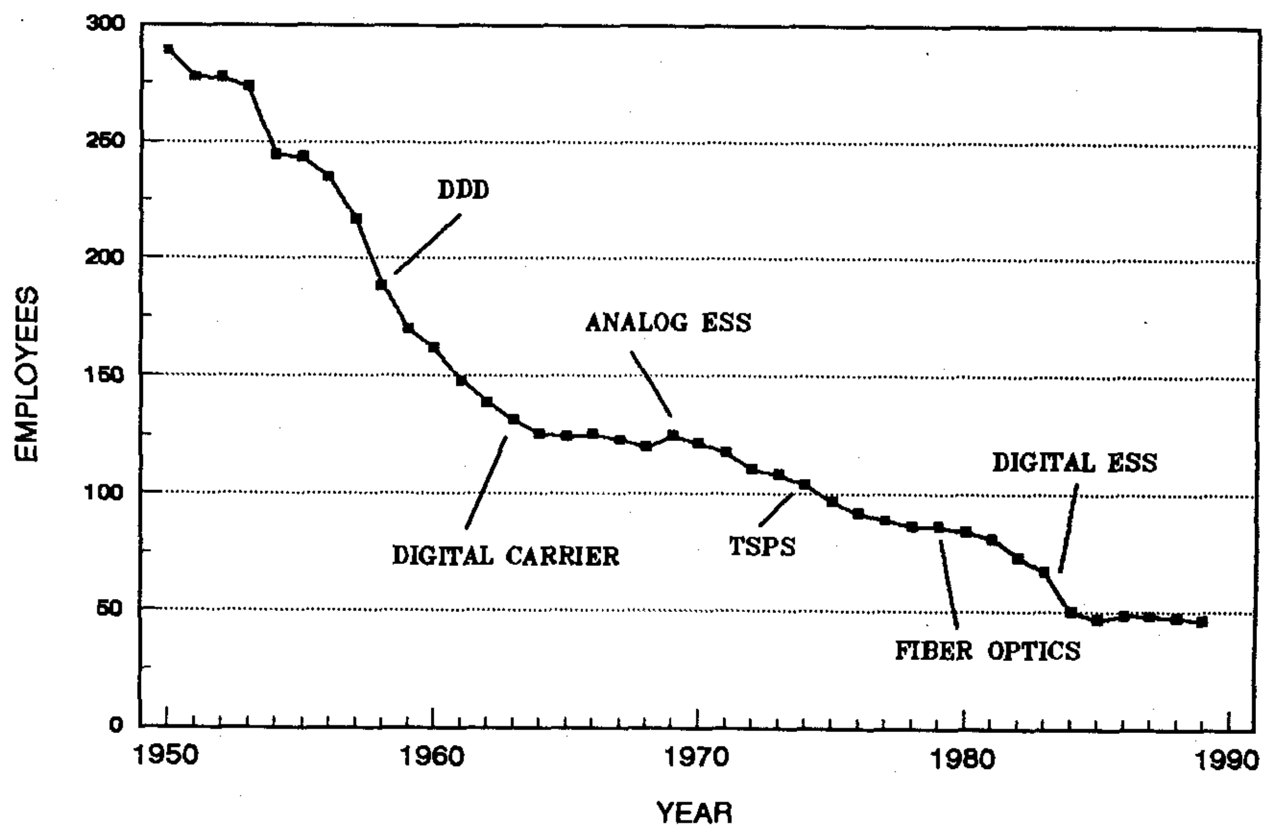
There is a logical alternative:

Depreciation rates for embedded plant should be frozen at present levels and a separate proceeding established to address existing reserve deficiencies. This prohibits either regulators or LECs from manipulating calculated earnings by adjusting depreciation expense. Represcriptions should be reserved for adopting new service lives for **new** investments which would be part of the **new** Infrastructure.

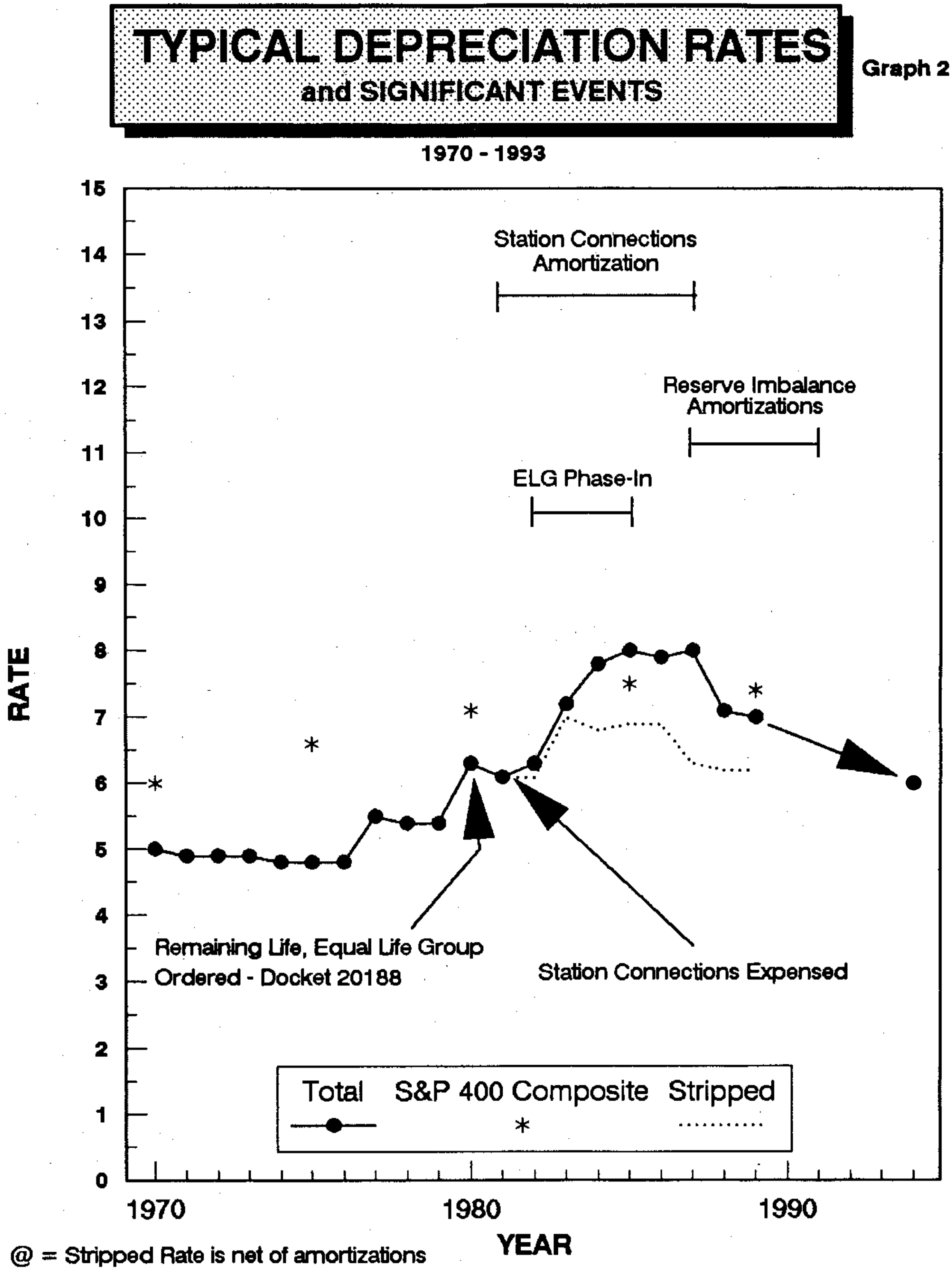
What better incentive would there be to move away from an under-recovered obsolete rate base than to offer incentives on new investment. Short-term price increases will be minimized by applying rates to new investments only.

1 **Telephone Industry Depreciation Reserve Deficiency**, United States Telephone Association, Washington, D.C., (October, 1989)
2 Docket No. 20188, (December, 1980) and CC Docket No. 87-447, (January, 1988), Federal Communications Commission, Washington, D.C.
3 **Telephone Industry Depreciation Reserve Deficiency**, United States Telephone Association, Washington, D.C., (November, 1986)
4 **Annual Report**, American Telephone & Telegraph, New York, NY (1984 and 1989)
5 **Telephone Industry Depreciation Reserve Deficiency**, United States Telephone Association, Washington, D.C. (October, 1989)
6 "Who Pays for Fiber?", **Communication Week** (July 2, 1990); "Should BOCs give CO Access to Alternative Local Carriers?"; **Network World** (July 2, 1990); ex parte presentation, CC Docket Nos. 87-313 and 89-614 (June 25, 1990)

**EMPLOYEES PER 10,000 ACCESS LINES** **Graph 1**




During the decades prior to Divestiture, labor reduction opportunities provided strong incentives to modernize the network.

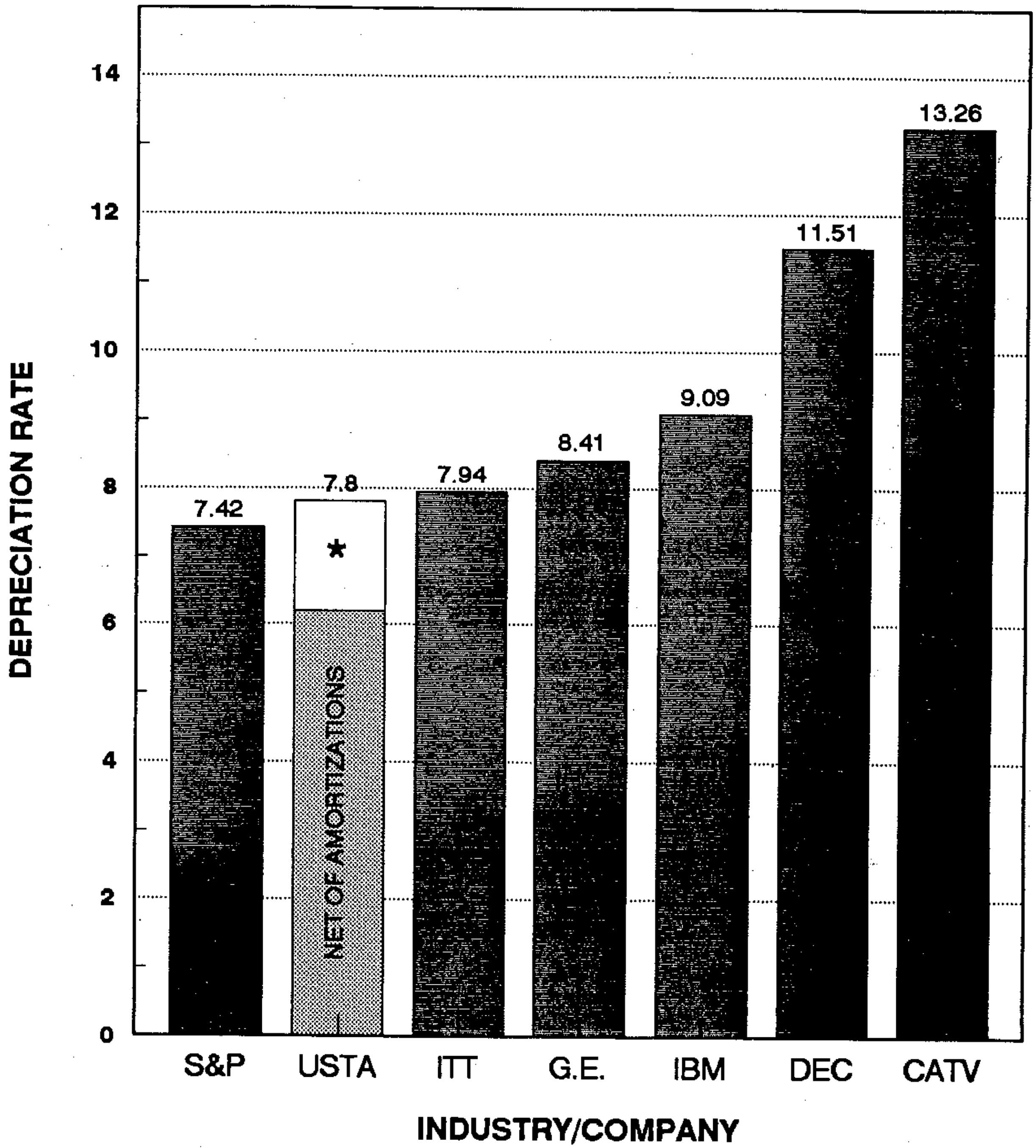



Real (stripped) depreciation rates rose only modestly during the 1980s.

## INDUSTRY
### DEPRECIATION RATE COMPARISON

**Graph 3**

AS OF 12/31/89




* = Amortizations

LEC depreciation rates trail the economy.

*Discussion Paper:*

# Managing Depreciation Expense Under Incentive Regulation

Carl R. Lanterman †

## ABSTRACT

The determination of depreciation rates in a regulated utility has historically been a labor intensive task, compared with non-regulated companies, for both the industry and the regulators, and more recently for consumer advocates. The thesis to be developed herein is that management of depreciation expense under incentive regulation lies with the management of the company, the same as if the company were not regulated. Beginning with the major issues of the past two decades and a description of the price cap formula, the role of depreciation is discussed in terms of depreciation accounting objectives and financial reporting objectives. The correlation between depreciation expense and pricing is developed under both regulated and competitive concepts. Finally, the changing role of the regulator is discussed briefly, as emphasis is moved from setting of depreciation rates to monitoring the correlation of annual depreciation expense to long term capital programs.

**Introduction**

It's time for a change. Achievement of competition in the telecommunications market is dependent upon flexibility for the companies to price services and control costs. Alternatives to the historical rate of return regulation (e.g., price caps, rate stabilization and price banding plans) come under the umbrella of incentive regulation. The degree of incentive to achieve pricing flexibility and cost containment varies depending on the structure of the plan. However, the underlying intent of most incentive plans is to enable the company to set prices according to market conditions (pricing flexibility) and achieve greater operating efficiencies (cost control). One of the major costs of a capital intensive industry is depreciation expense. The telecommunications industry has, for many years, set the pace towards improved forecasting of depreciable lives in order to better manage this major expense.

Statistical research related to depreciable lives of property, which was performed at Iowa State University, culminated in the early 1940s with a method of plotting trends in physical life characteristics, and comparing those trends with documented survivor curves to estimate the average life of capital assets. The documented results of this research cultivated the seed of data analysis within regulated utiltizes which touched off myriad new applications. The application of the resulting analytical techniques, in turn, ushered in an era of statistical and financial analysis, negotiations, legal confrontations and political arguments rivalled by few, if any other regulatory issues of the century. A vast amount of labor and other resources have been expended by utility companies, regulatory bodies and consumer advocates across the country, not including political, legislative and other resources outside the industry.

Under full monopolistic regulation, the long term depreciation accounting objective of full recovery over the life of the asset is guaranteed, with funds provided by current and future customers. Utility service rates are determined by revenue requirement, of which depreciation expense is a substantial share. This is accomplished at the federal leveral (FCC) for interstate rates and at the state level (PUC, PSC, etc.) for intrastate rates. A limit is additionally placed on total intrastate rate of return (ROR). With ROR regulation, depreciation rates have been established with emphasis on recovery over the physical life of plant, with the shorter term accounting objective of matching revenues with expenses at only the highest level of aggregation.

In the 1970s, competition and technological advancements began to impact the telecommunications market at a rate never before experienced by the industry. A greater concern was expressed relative to recovery of capital investment prior to technological obsolescence and subsequent retirement of the asset. The impact of technology on competition, and vice versa, further complicated the task of forecasting the life of plant. The development of better analytical tools introduced more precise forecasting of remaining lives. With the use of theoretical reserve studies, indications of imbalance conditions between consumption of assets and reserve accumulation came to the forefront. In the mid-1980s, the debate was whether the depreciation reserve in the telecommunications industry was under-accrued by $15 billion or $25 billion.

Over the past decade, companies and regulators have agreed on shortened lives, introduced new techniques within the straight line method and addressed the reserve imbalance. They have begun to utilize plant life estimates which more closely reflect actual life cycles, and are continually reviewing lives and techniques. The easing of regulatory controls over depreciation rates would facilitate the movement towards competitive markets within the industry.

**Introduction of Incentive Regulation**

At the beginning of 1984, the AT&T divestiture was the "big bang" that was to open the doors of competition within the telecommunications industry. About six years later, the FCC initiated a price cap plan for AT&T related to long distance rates, and similar proceedings related to the Local Exchange Carriers (LECs). The California Public Utilities Commission (CPUC) completed phase two of its three-phase investigation into a New Regulatory Framework (NRF), with the new price-cap plan effective beginning in 1990. The NRF replaces traditional cost of service rate making with a system which utilizes price caps based on a national price index and industry productivity measurements. The order specified a sharing threshold for

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earnings, above which the company and the customer would share in these earnings. Other states are investigating and implementing variations of incentive regulations. For example, Michigan's state plan is to share earnings not only with the customer, but also to reinvest in modernization of plant.

It is intended that this movement from traditional rate of return (ROR) regulation encourage competition in the local telecommunications market through pricing flexibility. Under ROR regulation, the company's capital and expense costs as approved by the regulators were included in the revenue requirement. The rate structure was developed within the parameters of total revenue requirement. The price cap concept begins with base rates which are periodically adjusted according to a national price index and industry productivity. Product and service pricing can be adjusted within the price caps. The incentive is for the company to improve its competitive position through competitive pricing and internal cost controls. If the company is to exercise flexibility in pricing, and also meet the accounting objective of matching expenses to revenues, then it also must have flexibility in managing depreciation expense. If ROR is continued as a barometer for company performance, such as with sharing of earnings above a fixed ROR, then the regulator may monitor operations which impact depreciable lives, with the determination of depreciation rates left as a business decision. Without full control over this major component of financial reporting, the ability of the company to manage costs associated with revenues while generating a satisfactory rate of return for stockholders would be seriously impaired.

Price cap regulation is based primarily on a national inflation rate which is at least partially offset by expected productivity improvements on the part of the company (X factor), and adjusted upward or downward by factors outside the direct control of the company (Z factor).

The basic price cap formula consists of the rate of change for a given year equal to a national price index netted with an industry productivity change (endogenous factors) and exogenous factors. Endogenous factors are those elements within the normal operations of the company, such as depreciation expense. Exogenous factors would be those which are outside the company's control, e.g., accounting changes, tax changes, or other regulatory and legislative changes which have a major impact on the company's costs or revenues.

Assuming that the GNP-PI is used as the inflation factor and that a national productivity factor were available for the industry, one formulation of price cap determination would read:

$$\text{Rate}(t) = \text{Rate}(t\text{-}1) * (1 + I - X \pm Z/R);$$

where, Rate(t) = the rate effective for the coming year.

Rate (t-1) = the rate effective in the current year.

I = the percentage change in the GNP-PI for the most recent complete year, at a given time.
X = national industry productivity factor for a given year.
Z = dollar impact of authorized exogenous factors
R = appropriate revenues associated with the authorized exogenous factors.

Administration of price caps will be on an annual basis. The productivity factor may be established for a longer period, such as the current FCC three-year review cycle for depreciation. Primarily for the lack of a standard national measurement, the X factor has been adopted through review processes by each state and federal telecommunications regulating agency. When a national industry productivity measure is produced annually, this may be used as a standard X factor by all agencies on an annual or triennial basis. The GNP-PI appears to be the most popular measure of inflation to be used in the formula.

Assuming that the change in the GNP-PI is 5%, the productivity has improved by 3% and there are no exogenous factors, the company's rates to the customer would increase by 2% for the next year. Within this price cap, including the 2% composite price increase, the competitive pricing of individual services is also reviewed. The regulator may stipulate a maximum price change for any one service, e.g., plus or minus 10%. This fixes a limit to pricing changes within the company's price structure, beyond which the company would seek approval on an exception basis. For example, if the cost of a given service were dramatically reduced through the economic depreciation cycle of the assets, and the current prices were no longer economically justified, the company could petition the commission to dramatically reduce rates for that service and offset that reduction in revenues within an increase in prices for newer and more expensive services, all within the price cap.

### Role Of Depreciation In Price Cap Regulation

Book depreciation expense plays a role, with varying degrees of influence, in three aspects of the price cap process. The first aspect is regarding price cap development and the other two are related to financial reporting. None has a direct effect on cash flow.

1. In determining the X factor, depreciation expense in capital intensive industries is a substantial portion of the annual operating expenses. However, the annual expense tends to remain relatively stable from year to year. Therefore, the impact on total factor productivity change is relatively insignificant.

2. After the total factor levels of the rate cap elements have been established for a given year, depreciation levels contribute to earnings in the same way as do other operating expenses. The ROR formula in Table 1 displays that effect. The depreciable lives used to determine rates, and the impact of those rates on financial indicators such as net income, is reviewed by corporate bond rating agencies. Imprudent selection of plant lives would be viewed negatively in the rating reports.

**Note**: The term rate base is derived from using ROR either for rate determination or for benchmarking.

3. In measuring rate of return, depreciation reserve reduces the rate base. A change to depreciation affects net income in a given period, thus changing the numerator in the ROR formula on Table I. This current period change affects depreciation reserve in later periods, which impacts the rate base in the denominator.

These three financial elements require controls by company management to balance long term capital recovery objectives with short term financial reporting. Therefore, depreciation becomes a business decision and, having no direct impact on prices, does not require regulatory constraints.

### Depreciation And Pricing

Depreciation techniques used by telephone utilities are based on the straight line method, with depreciable lives adjusted periodically. Estimated lives have typically been longer than the plant actually remained in service. The estimated lives were adjusted downward from time to time until the class of plant was fully recovered and retired. For example, electromechnical switching in most companies was originally estimated to have a life of 40 years. This estimate was continually adjusted downward to approximately 12 to 15 years, until the surviving plant at a point in time was amortized to ensure full recovery. Each time the life was adjusted, the change in the pattern of depreciation created an imbalance between the consumption of plant to date and the net value of the plant. In many cases, the annual depreciation expense had to be dramatically increased to assure full recovery prior to final retirement.

It has been common practice under ROR regulation to utilize approved book depreciation lives in calculating depreciation expense as part of the basis for pricing of services. The capital expenditure decisions to install the plant supporting those services are made largely on the basis of economic analysis. Some of these economic factors are cost of new, maintenance of old, and expected life of the plant. These same considerations should be carried over to depreciation analysis, whereas in the past, depreciation analysis was treated as a separate function. This segregation of plant analyses hinders the business process within the company. Price cap regulation provides the opportunity to change price levels. It does not dictate any change to the pattern of depreciation, without which there can be no matching of asset consumption to revenues generated by the asset.

The market price of a service will be reduced over time once a new service is available. The net book value of assets, when using straight line depreciation, will be reduced at a linear rate, whereas their economic value is determined by the net present value of future revenues. With this discontinuity between net book values and economic value, a price developed from revenue requirement will not equal the market price. The result is ultimately a defeat of the achievement of free competition.

Economic value depreciation can be used to estimate the economic life of the asset and the depreciation pattern which will maintain a net book value equal to the economic value. This method has not been readily accepted by practitioners. The reluctance may be partially due to the cumbersome techniques employed and to the accounting classification of plant which does not relate directly to products and services sold. The approach does, however, have some merit in estimating plant lives and depreciation expense which would maintain the economic value of plant.

Another pricing issue which deserves attention is that of the sale of embedded plant by utilities. It has been a popular practice to utilize net book value of plant as a price base for sale or transfer of utility property to subsidiaries, other utility companies or outside interests. For example, with the deregulation of customer premises equipment (CPE), some telcos were directed to sell their embedded CPE at net book value plus administrative costs. At the time of the sale, the price was based on the past history of regulatory decisions, and may have had no resemblance to market price. In a deregulated environment, the telco would have the responsibility to maintain an economic value of the plant, so that net book value plus other internal expenses would closely simulate market price. If price cap regulation is a step towards deregulation of the local telecommunications market, the practice of pricing embedded plant on the basis of net book value deserves some review. In fact the FCC has established rules which define how transactions between regulated and non-regulated affiliates will be priced. These rules, while protecting against cross-subsidization, may be detrimental to the achievement of free competition.

### Company's Role

The pattern of depreciation expense which keeps pace with the economic value is the economically correct pattern for booking annual depreciation expense. By calculating the net present value of future net revenues, the economic value of the asset can be determined at a given age. This value compared with the book value of assets can be used as an indicator of the adequacy of managing depreciation expense. Modified techniques may be developed to simplify the calculation of expense for a given year, while economic depreciation models can be used for developing long-term capital recovery strategies.

Effective management of depreciation expense involves a balancing of long term depreciation accounting objectives and short term financial reporting. In order to determine the long term reserve objectives, the depreciation analyst utilizes economic value, technology forecasting, historical trends, theoretical reserve and long term impacts of capital program scenarios. Within the parameters of the long term objectives, the analyst periodically reviews the primary indicators for each class of plant relative to its current status. New evidence may cause a change to life estimation, or new accounting guidelines may cause changes to depreciation rates or schedules. The impact of these changes would be subject to executive review to determine the impact on financial reporting.

For administration of the models used, capital cost trends for economic value forecasting may be developed from the capital costs used in economic selection studies. The maintenance costs used in economic value forecasting may be trended from the same economic selection models. This will ensure a depreciation pattern which is consistent with the economic choice for installation of new plant. The plant life determined by the analyst may in turn be used in economic selection studies which determine viable capital projects. When these projects are optimized within the capital budget structure, the capital decisions drive plant additions and replacements, which in turn drive the depreciable lives. The same considerations used in capital expenditure decisions should be used in depreciable plant life estimation. This link should be recognized by both the company and the regulators.

Management of depreciation expense is an integral part of managing the capital assets of the company. Changes to capital management have a direct and sometimes considerable impact on depreciation expense. This integration of capital planning and depreciation, absent the monopolistic ROR regulation, necessitates a shift in the determination of depreciation rates from regulatory approval to a business decision.

**Regulator's Role**

With the introduction of price cap regulation, which may include sharing mechanism, the role of the regulator shifts from approval of costs to monitoring the change to the company's capital assets. The regulator's primary concern is that the company maintain satisfactory service levels at a reasonable cost.

In a capital intensive industry, rapid technological changes create a unique challenge in balancing costs while providing the latest in technological advancements. The regulator, in this case, would monitor the rate of modernization and the impact of that modernization on service levels and costs. The role of the regulator in approving capital expenditures and associated depreciation is modified to monitoring the change in capital assets to ensure that the customer receives modern services at competitive prices.

Price cap regulation with some form of incentive such as sharing of earnings above a fixed rate of return, still allows the company to determine the appropriate level of depreciation expense. Managing depreciation under price cap regulation will allow rational pricing while meeting long term depreciation accounting objectives. Aside from development of revenue requirement in ROR regulation, depreciation expense has no effect on cash flow, so that its primary function is financial reporting. Adherence to generally accepted accounting principles is ensured by major auditing firms. Therefore, the primary concern with depreciation expense aside from accounting objectives is its impact on earnings, with the management of the company answerable to the stockholders.

**Summary**

The pioneers in development of depreciation techniques deserve a great deal of credit for their accomplishments, curve fitting, technology forecasting and economic value have all made their contributions to the study of depreciation. The transition from regulation to competition carries an even greater challenge. The counterbalancing of monopolistic regulation with a more flexible method of setting depreciation through easing of regulatory controls is achievable through incentive regulation. The primary concern with depreciation in this environment is matching the asset consumption with revenues and the financial reporting of the results.

If incentive regulation through competitive pricing is to be truly successful, the pattern of depreciation should reflect the economic consumption of assets. The correct pattern of depreciation is that which reflects the net present value of future net revenues generated by the assets. The effects of adjusting annual depreciation must be carefully analyzed relative to long term recovery objectives and short term financial reporting. As with any other analysis, the tools of the trade should be utilized to yield optimal results, which may require some reassessment of techniques, organizational communication and regulatory policies.

Flexibility for company management in setting the appropriate pattern of depreciation will be enhanced by the changing role of the regulator, from one of approving rates to monitoring capital expenditures which impact rates. In a fully competitive mode, this monitoring would not be necessary. The transition from monopolistic regulation to free competition is enhanced by incentive regulation.

The advantages of this new framework should not be compromised by unnecessary regulation of expenses. The latitude afforded the companies in setting depreciation rates will partially dictate their ability to take advantage of the incentives of flexible pricing. Good management of the transition from regulation to competition is dependent upon management of each of the elements of flexible pricing, including depreciation.

**TABLE 1 -**
**COMPONENTS OF NET INCOME AND RATE BASE**

$$\text{Rate of Return} = \frac{\textbf{Net Operating Income}}{\text{Rate Base}}$$

$$= \frac{\textbf{Revenues - Operating Expenses - Taxes}}{\text{Rate Base}}$$

**Net Operating Income**

**Revenues** =
Local + Access + Toll + Miscellaneous

**Operating Expenses** =
Plant Operations + Customer Operations + Corporate Operations + Operating Taxes + Depreciation Expense

**Taxes** =
State Franchise Tax + Federal Income Tax

**Rate Base***
Telephone Plant In Service + Property for Future Use - Depreciation Reserve + Material & Supplies - Deferred Taxes + Working Cash

*Rate base components may vary in some jurisdictions.