

IOF Methodology



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Table of Contents

1.0 Introduction.....3

2.0 Scope.....3

3.0 Modeling Approach4

4.0 General Methodology4

 4.1 Stage 1 -Investment Element Calculation.....5

 4.2 Stage 2 – Basic Component Calculation.....8

5.0 IOF and HiCap Investment Development Process Details9

 5.1 IOF Service Designs10

 5.2 HiCap Network Architecture Assumptions11

1.0 Introduction

This document describes the methodology used within the VzCost system to estimate investments for interoffice transport facilities, commonly called Interoffice Facilities (IOF), and High Capacity (HiCap) customer access and carrier entrance facilities. These investments are used within the VzCost system to develop the unit costs of any service that uses capacity provided by these network infrastructures. Contained in this document is a description of the process, from the collection of basic investment and design information through the creation of Basic Cost (BC) elements within VzCost, that Verizon uses to determine investments that are specific to IOF and HiCap services. The general process of combining BCs to generate unit service costs is described in the general VzCost Manual.

2.0 Scope

The VzCost IOF investment development process addresses all network systems and functions employed to provide transport capacity between two or more Verizon Serving Wire Centers (SWC). This infrastructure supports all services that require interoffice transport capacity. The most important of these services are message trunking, signaling links, operator services trunking, dedicated transport, private line services, private networks, carrier interconnection facilities and data transport services. The IOF process develops costs for application-specific, terminal, and interface equipment at the edges of the IOF network, as well as backbone transport systems efficiently shared by all applications.

The VzCost HiCap investment development process addresses all network systems and functions employed to provide high capacity transport systems between Verizon SWCs on one end, and either end-user customer locations or carrier points of presence (POPs) on the other. The technical characteristics of these two systems are similar: systems between a SWC and retail customer locations and systems between a SWC and carrier POPs both typically support Entrance Facility services with bandwidths of DS3 or greater. These services are often classified in the broad category of “customer loops” since they use the same physical structures and routes as narrow-band fiber and copper subscriber loops. It is important to note, however, that the optical and electronic equipment and architectures used to provide these high capacity services are entirely distinct from that which supports ordinary voice-grade loops. In fact, the high capacity, customer access and entrance facilities use the same basic transport technologies and systems as the IOF network, and these facilities are best understood as local branches off the main transport infrastructure.

VzCost efficiently accounts for those elements of the IOF and loop networks that are shared. The forward-looking designs for all Verizon IOF and HiCap services employ fiber optic, physical transport. The fiber optic cables supporting these services also support the Digital Loop Carrier systems widely used to provide narrow-band loops. Furthermore, these fiber optic cables often share the physical support infrastructure (e.g.

poles, conduit, manholes) used by metallic copper loop cables. Within the VzCost system, all outside plant costs (OSP), including both cable and supporting structures, are developed with VzLoop, VzCost's loop investment calculator. The IOF and HiCap services fiber requirements are based on the fiber investments modeled by VzLoop. Only a user-specified fraction of the fiber investments modeled by VzLoop are included in the costs of narrow-band loop services. Because the IOF cost studies use a capacity-costing approach instead of a ground-up approach, VzCost does not assign the remaining portion of the fiber cable and structure investment to the IOF cost study. Rather, VzCost takes the average fiber and structure investment on a per-strand, per-foot basis from the forward-looking fiber investment modeled by VzLoop, and applies that average investment in the IOF and HiCap cost studies to determine the forward-looking fiber and associated structure investment for IOF and HiCap services.

3.0 Modeling Approach

The VzCost IOF and HiCap investment development processes use capacity-cost modeling. Capacity cost models identify the typical network configurations and associated investments used to support particular services. Appropriate units of capacity for each component of the configuration, such as ports, channels, pairs, and the like, are used to create investment estimates for units of capacity. These capacity investments are then allocated to specific services by using the capacity consumption parameters (such as bandwidth, length, number of ports, and utilization) that are appropriate for the service.

The underlying technology used in the IOF and HiCap networks is highly complicated, but a limited set of standard designs can be identified for the configurations used to deploy this technology on a forward-looking basis. Each of the many IOF and HiCap services has a unique set of terminal and interconnection configurations, and capacity cost models can be defined for each of these service configurations. Because the shared IOF backbone transport uses a highly consistent technology design and there are well-defined sets of parameters that characterize the cost of this design in different network environments.

In addition to the network and service design configuration, the IOF and HiCap capacity cost models require estimates of the many parameters that drive investment estimates within the configuration models. These parameters include the expected occurrence of the design options for each particular service, equipment utilization rates, and the mix of network architectures. Significant capacity additions, using the most efficient technology available, are made annually to the IOF and HiCap networks throughout Verizon operating areas. This current deployment experience provides a reliable basis for estimating the parameters used in the capacity cost models.

4.0 General Methodology

This section describes the general methodology used for both the IOF and HiCap investment calculations. Subsequent sections describe specific design and technology

assumptions. Section 4.1 describes the process of defining and calculating investment elements. Section 4.2 describes how those investment elements are used to develop basic components, which form the basis for various IOF and HiCap Unbundled Network Elements, retail transport services and transport access services.

Exhibit RP-18C presents the overall process flow for the IOF and HiCap Investment Development. The process is divided into two main stages: Investment Element Calculation and Basic Component Calculation.

4.1 Stage 1 -Investment Element Calculation

4.1.1 The Definition of Investment Elements

Within the IOF and HiCap processes, investment elements (IEs) constitute the investment for a unit of network capacity required to create a specific service within the IOF or HiCap infrastructure. Several IEs are usually required for a complete service, and IEs are also defined for miscellaneous services such as multiplexing.. Exhibit RP-19C presents one of the standard designs used to provide DS1 transport services within the Verizon network. This design, which is used to define all of the IEs used in the process, is divided into several logical sub-components, which represent the IEs for the design. There are similar standard design diagrams for every service provided by the Verizon IOF and HiCap infrastructure. Exhibit RP-20C contains the complete set of standard design diagrams.

The IEs are defined in such a way as to capture the variable aspects of the network investment. In the DS1 example, for instance, the termination element captures the investments that vary only by the type of service and volume of a service. The outside plant element varies by both the type of service and mileage. (Note: The OSP IE is generated in the Loop Investment Calculation Process.) The IEs vary by the type of service, mileage and the number of intermediate channel terminations (or “hops” between different SONET rings) in an average service. All IE calculations performed in the IOF and HiCap processes are conducted in units of DS0 capacity. This is accomplished by dividing the investments inputs by their transport capacity expressed in units of 64 Kbs. The choice of DS0 as a common, unitizing capacity is merely a convenience in the model that simplifies calculations. It is important to note that, because specific and appropriate designs are employed to calculate particular IEs, this does not create a “DS0 equivalent” investment as the term is usually applied, as the investments are calculated for a specific service and are valid only for that service. A unitized DS0 investment calculated for a DS1 service cannot be multiplied by 672 and converted into a DS3 investment. After all calculations and combinations of investments are done for a particular IE, the results are scaled up to the appropriate service bandwidth. For example, to create the DS1 service IE, the investment per DS0 that are specific to DS1 service are multiplied by 24.

The actual investment incurred to deploy a standard design is, in many cases, significantly influenced by factors specific to the particular geographic or market environment in which the service is provided. Because of the variation in the types of

geographic areas it serves, Verizon employs more than one standard design for each of the specific transport services, such as DS1, DS3, OC3, that it makes available to CLEC and end-user customers. The design options are designed to create the most economic deployment for a service in a particular area. By defining individual IEs that reflect each of these design variations, Verizon more accurately reflects these area- and market-specific factors in the IOF and HiCap process.

For each transport service provided, Verizon models the provisioning of that service by creating weighted averages of combinations of several layers of IEs. The layers of IEs reflect each of the design options that Verizon could use to provide that particular service:

Layer 1: Network Architecture – The Verizon IOF and HiCap networks employ economically efficient SONET ring designs consisting of two- to ten-node rings. Nodes are Verizon facilities that exist at SWCs along a SONET ring which facilitate the adding and dropping of transport services. The number of nodes deployed on any specific ring is a critical economic design choice, and is the major determinant of investment for the ring. Rings with different numbers of nodes are distributed throughout each geographic area, reflecting the particular topographical and demand characteristics of the area. The IOF and HiCap investment processes capture this variation by defining IEs that reflect each possible ring design choice for a service.

Layer 2: SWC Complexity – For each type of transport service, there are individual IEs for Dense Urban, Urban, Suburban and Rural offices. The economic designs for any service are influenced by the complexity of the SWC in which it is provisioned. SWC complexity results from both the volume and range of services in the office. Large volumes and many services create complex cabling and interconnection requirements, and sophisticated network management devices like Digital Cross-Connection systems are employed in these complex offices to reduce operating costs and meet service quality requirements. By comparison, in smaller offices manual connection devices suffice. In general, large urban offices are the most complex and rural least, resulting in very different investments across the range of SWC complexity. The IOF and HiCap investment processes capture this variation by defining IEs reflecting different SWC complexity.

Layer 3: Multiple Suppliers - Verizon uses several suppliers for its SONET equipment, each with a specific price structure. In order to maximize efficiency, Verizon defines a different IE for each combination of supplier equipment, and produces a weighted average of these investments.

Verizon models a particular service, such as DS1, by creating combinations of these layers of IEs, and applying a weighted average that reflects the occurrence of those different IEs in the network. For example, for its DS1 service, Verizon first models 2-node SONET rings with different assumptions about the ring's SWC Complexity (Rural, Suburban, Urban, Dense Urban) and the equipment supplier for the ring (Nortel and Fujitsu). It then creates similar models for rings containing 3 through 10 nodes. After modeling all of these combinations, it then applies a weighted average to produce the average cost of providing the service (DS1).

In summary, a large set of IEs is defined for each type of transport service. Across IOF and HiCap, several thousand IEs are required to properly model all potential services and accurately capture the variation in economic design for a given geographic area or jurisdiction. These IEs capture the standard design options employed for the service and variations in investment for the designs resulting from multiple supplier options, network architecture options, and office complexity. These IEs are combined in the second stage of the process to produce the Basic Component investments for services.

4.1.2 The Investment Element Calculation Process

Input Data

The major input data sets used in the IOF and HiCap Investment Calculation processes are shown in the yellow boxes at the left side of Exhibit RP-18C. As the figure illustrates, all the input data is organized and managed in a single Master File. Two major data sets are used in the Investment Element Calculation: Component Investment Values and Component Fill Rates. Component investments are generated for each type of equipment by vendor. Individual investments are created for each component that is specified in the standard design sets for services. Multiple versions of component investments are produced as required to reflect architecture variations and accounting classifications; for example, there are specific SONET component investments for each ring containing two through ten nodes. The investments are based on the latest supplier contracts using standard configurations for the application. The Component Fill Rates are the estimated forward looking utilization rates for each component investment.

Container Program

IOF and HiCap IEs are calculated in the Container Program. Data are extracted from the master file and uploaded to the Container program via CSV files. Each element or "container" of this database contains a formula for a particular IE. The formula is created through a graphical interface that allows the user to select and assemble component investment names. The formula combines component investments of the standard designs for a service, weighting them together using the appropriate design occurrence rates. The formula also applies the appropriate fill factors for each component investment.

Output Data

The IEs for a particular IOF and HiCap services study are created by executing or “running” the container database. Each container of the database selects the appropriate component investment, design occurrence rate (HiCap only) and fill rate data from the master file, and calculates the investment for the specified IE. Investments are calculated by account class and are categorized as “direct” or “shared” as explained in the Cost Manual. The calculated values are output into a table that is subsequently input into the second stage of the process (the production of basic calculation investments for particular services). A second table is created and input to this second stage with the names of all the IEs.

4.2 Stage 2 – Basic Component Calculation

4.2.1 The Definition of Basic Components

Within the IOF and HiCap processes, a Basic Component (BC) contains the average investments required to create a specific service element in a defined geographic or market area. For example, the average investment required to provide a DS1 IOF transport service in a specific state is a typical BC. BCs are calculated by combining appropriate IEs using weightings and parameters that reflect the technical characteristics of the service and the economically significant characteristics of the area in which the service is studied. Those characteristics include, among other things, average circuit length, standard design occurrence rates, SONET ring characteristics, SWC complexity mix, and supplier mix. Several BCs can be defined for the same service by varying the weightings and parameters to reflect specific application assumptions.

4.2.2 The Basic Component Calculation Process

Input Data

Referring again to Exhibit RP-18C, the IOF and HiCap Basic Component Calculation Processes receive data from three sources: the IOF and HiCap Master Files, the IOF and HiCap Investment Element Calculation, and the Loop Investment Calculation Process.

The following data sets are input from the Master Files:

Standard Design Occurrence Rate – These data provide the expected relative frequency of use of each of the standard designs for a service. This data comes from engineering and reflects the most recent experience in deploying the service in the state. The process is a combination of looking at experience and adjusting for anticipated changes going forward. Standard design occurrence rates are defined for each SWC complexity category.

Ring Characteristics - These data provide the expected distribution of SONET rings by the number of connected nodes for the study area. It also provides

average values for key physical characteristics such as ring length, average circuit lengths, and loop lengths.

SWC Complexity – These data provide the weighing factors applied to the investments for each network design based on a distribution of SWCs in the study area by complexity category: Dense Urban, Urban, Suburban and Rural.

Supplier Mix – These data provide the expected mix of SONET equipment by supplier for the study area.

As already discussed, the names and values of the IEs are input from the first stage of the IOF and HiCap Investment Calculation process. Average per-mile, fiber cable and supporting structure investments are developed within the Loop Investment Calculation process, and delivered to the IOF and HiCap BC Calculation stage.

BC Families

Within VzCost, BCs are calculated in arrays of formulas called BC families. The IOF and HiCap BC families combine all the IE options available to create a particular BC and determine an average investment for that BC in the study area. The formulas that comprise a BC family apply the area-specific parameters from the master file to weight the IE options according to their expected occurrence. The formulas also incorporate the OSP investments received from the Loop Investment Calculation Process into BCs as required.

Outputs

The BCs for a particular IOF and HiCap study are created by executing or “running” the BC families. Each BC family selects the appropriate IEs, OSP investments, and area specific constants (parameters in the BC formula that weight the IEs, such as ring size distribution, complexity mix, vendor mix, and design mix), and calculates the average investment for the specified BC. BCs are calculated by account class and are categorized as “direct” or “shared,” as explained in the Cost Manual. The calculated values are output into a table that is input into the final service costing process. The BCs form a complete set of investments for IOF and HiCap service elements.

5.0 IOF and HiCap Investment Development Process Details

This section describes the specific details of the modeling assumptions used within the IOF and HiCap Investment Development Process. As already explained in previous sections, the general capacity costing methodology and process flow are the same for IOF and HiCap processes. However, different specific service designs, network architectures, and parameters are required within each process to accurately calculate service investments.

5.1 IOF Service Designs

The forward looking architecture employed in the Verizon network uses SONET ring technology for all IOF transport. A SONET ring provides transport services connecting two or more SWCs. Each SWC also houses an Add-Drop Multiplexer (ADM). The ADM provides three main functions. First, it provides low-speed electrical or optical interfaces that allow the adding and dropping of standard transport channels (DS3, STS1, OC3, etc.) from the high-speed interoffice optical system at the SWC. Second, it provides the multiplexing/demultiplexing functions that add and drop the low speed channels. Third, it provides the optical transmission and termination equipment that creates the high-speed optical systems connecting the ADMs.

At the physical optical layer, the SONET ring systems are provided either directly over a pair of optical fibers (2 fiber design) or over optical wavelengths on Dense Wave Division Multiplexing (DWDM) technology. DWDM allows many SONET systems to be carried over a single fiber optic pair. The forward looking SONET ring technology uses predominantly 2.5 GHz OC48 line optics with a specialized application of 10 GHz OC192 line optics for a small set of specialized services. An OC48 optical line rate allows a maximum load between the spans of a ring equivalent to 48 STS1 or DS3 channels, while an OC192 optical line allows the equivalent of 192 STS1 or DS3 channels.

In order to meet service reliability and quality requirements, Verizon SONET rings employ Bi-directional Line Switch Ring (BLSR) protection. In a 2-fiber BLSR configuration, the ring is loaded to only half its line capacity on each segment to allow automatic protection of service in the event that a segment of the ring fails; for example, if clockwise transmission between two nodes on a ring is disrupted, the BLSR configuration allows the transmission to be resumed by sending the signal in a counter-clockwise fashion. The capacity of a BLSR is constrained by the optical line speed, that is, the maximum load on a segment between adjacent nodes. In practical application, Verizon attains an average maximum load on its BLSRs equal to the line rate. So for the predominant OC48 BLSR design, the maximum practical load achieved on average is the equivalent of 48 DS3s. This practical load is the same for rings of all node sizes. For this reason the average low speed load capacity installed at each ADM on a fully loaded ring is a direct function of the number of SWCs, or nodes, connected by the ring. For example, a two-node ring, when full, can support the full 48 DS3s of capacity between the nodes so the ADMs are equipped with the equivalent of 48 DS3s of low speed capacity. Three node rings have the equivalent of 32 DS3s capacity per ADM, four node rings 24, and so forth.

The IOF service designs used to create the IOF IEs often incorporate Digital Cross-connection System (DCS) functionality. DCS are software-driven electronics that provide advanced circuit aggregation and management functions, such as multiplexing and rearrangement, within the transport network. These DCS are integral and economically efficient components of the design. Many IOF IEs are composed of a

weighted average of designs, some using DCS and others not. Wideband Digital Cross-connection Systems (WDCS) and Broadband Digital Cross-connection Systems (BDCS) are deployed in large Verizon SWCs to automate the management and connection of transport services. The DCS also provide multiplexing functions: WDCS terminate DS1 and channelized DS3/STS1 providing complete interconnection of channels at the DS1 level, while WDCS inherently supply DS1-to-DS3 multiplexing functions for DS1 circuits that terminate in the SWC. BDCS also provide connections for DS3 and STS1 services.

Within the IOF investment calculation process, the ring interconnection configurations are called Intermediate Connection Terminations (ICT). ICT equipment allows circuits to be provisioned across multiple SONET rings that can be connected at intermediate wire centers to create a circuit between the desired wire center. ICTs are needed because the IOF SONET rings provide connections among hundreds of SWCs. Very often, a transport service between two particular offices cannot be connected over a single SONET ring. Any single office is only directly connected by rings to a small subset of the total offices in the area. In those instances, a ring interconnection configuration must be employed in an intermediate office to connect the service from one SONET ring to another. In long circuits, several of these interconnections maybe required. IEs are defined for each of these ICT configurations and reflect variations due to supplier mix, ring architecture, SWC complexity and expected occurrence rates.

The family of IOF services includes certain standalone transmission functions that can be purchased as part of a larger network. The most important of these are standalone multiplexing and DCS services. IEs are defined in the IOF investment calculation for these and similar service functionalities.

Exhibit RP-20C provides a complete set of diagrams for all the service designs used to define the IOF IEs in the Container program.

5.2 HiCap Network Architecture Assumptions

High Capacity Loop and Entrance Facility services are also deployed using SONET ring technologies. TheHiCap IEs reflect architecture options and parameters appropriate for these services.

The High Capacity Loop and Entrance Facilities are deployed using OC3, OC12, OC48 and OC192 ring designs. The mix and volume of service demand determine the economic choice of a particular ring speed. HiCap IEs are defined for each ring speed, for each of the High Capacity Loop and Entrance Facility services, such as DS1, DS3, and OC48. Separate IEs are defined for two- and three-node ring configurations. The HiCap Basic Component Investments for a specific study area are calculated by weighting the IEs with the expected occurrence rates of these ring design options.

Exhibit RP-21C provides a complete set of diagrams for all the service designs used to define the HiCap IEs in the Container program.