MASTER'S THESIS

A Cost and Pricing Model for Direct Broadcast Satellite-
Video to the Home

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CSHCN M.S. 93-4
(ISR M.S. 93-7)

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ABSTRACT

Title of Thesis: A Cost and Pricing Model for Direct Broadcast Satellite-Video to the Home

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Degree and Year: Master of Science, 1993

Thesis directed by: Professor John S. Baras
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Direct Broadcast Satellite-Video (DBS-V) to the home is attracting substantial interest as a medium for providing a wide variety of services to individuals and organizations. Technically, DBS-V is feasible and offers several advantages with respect to competing technologies and media. However, the economic feasibility of DBS-V versus competing technologies has not been completely assessed.

In this thesis, we provide a detailed model, supported by an interactive decision aid for the financial analysis of DBS-V systems. The software developed is compatible with Microsoft Windows™ and requires modest computational resources.

The purpose of the model is to provide an economic analysis of the cost of providing DBS-V services and the cost of the DBS-V service to the customer. The user is required to enter a satellite network configuration consisting of broadcast satellite service network components. The model will estimate the cost of investing in, operating, maintaining and retiring the system using the given network configuration. Specific parameters of the model components may be

varied in order to observe the effects of varying the components on the system costs.

A Cost and Pricing Model for Direct Broadcast Satellite-Video to the Home

by

Sandra Learae Delancy

Thesis submitted to the Faculty of the Graduate School
of The University of Maryland in partial fulfillment
of the requirements for the degree of
Master of Science
1993

Advisory Committee:

Professor John S. Baras, Chairman/Advisor
Professor Guangming M. Zhang
Professor James Reggia

DEDICATION

To the memory of my mother, Mildred Josephine Delancy, who passed away on February 28, 1993. She did not make it to see the finished product, but I know that she was there in spirit.

ACKNOWLEDGMENT

I would like to acknowledge John S. Baras for allowing me the opportunity to explore the topic of satellite communications by assigning me this thesis subject area.

I would like to acknowledge Derek M. Hill for his encouragement while I spent long nights at the "lab."

I would also like to thank my family and friends for their moral support and particular key individuals for their technical support.

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LIST OF ABBREVIATIONS

BSB	Broadcast Satellite Business
DBS	Direct Broadcast Satellite
DBSCoMo	Direct Broadcast Satellite-Video Cost Model
DBS-V	Direct Broadcast Satellite-Video
CCDS	Center for the Commercial Development of Space
CER	Cost Estimating Relationship
CONUS	Continental United States
FCC	Federal Communications Commission
GEO	Geosynchronous earth orbit
GUI	Graphical User Interface
HDTV	High Definition Television
HPA	High Power Amplifier
HSD	Home Satellite Dish
IRD	Integrate/Receiver Decoder
ISR	Institute for Systems Research
LNA	Low Noise Amplifier
LNB	Low Noise Block
LV	Launch Vehicle
ELV	Expendable Launch Vehicle
SMATV	Satellite Master Antenna Television
SSPA	Solid State Power Amplifier
TDMA	Time Division Multiple Access
TVRO	Television Receive Only
TWTA	Travelling Wave Tube Amplifier
VSAT	Very Small Aperature terminal

Chapter 1
Introduction

"The National Association of Broadcasters estimates that about 20 to 30 million homes in the United States will never be wired for cable...The current backyard dish market is estimated at 3 million homes." (High Definition Television, Direct Broadcast Television, and Video Conferencing Services, 1990) These figures imply that Americans are willing to pay for the entertainment of direct to the home video and television services. The DBS service is defined by the Federal Communications Commission (FCC) as being "[The service] ... designed to provide many channels of video programming transmitted by a satellite direct to small parabolic ("dish") antennas located at the individual homes or other locations desiring the service." (Evolution of Broadcasting) Brought about by advances in technology, the means by which to provide direct broadcast satellite services to the home at an affordable cost is possible.

1.1 Purpose of This Thesis

Direct broadcast satellite services are no doubt a lucrative business to invest in; if the cost of providing the service is within range of the viewing public and if the inconvenience of owning this service is kept at a minimum.

In this regard there is a pressing need to develop, a cost and pricing model for DBS-V (DBSCoMo). The input to the model will be a DBS-V network configuration (i.e. the number of proposed satellites to be launched, number of uplink/downlink earth stations, number of programming channels, etc.). The output of the model will be bar graphs and charts representing the initial investment, operational, maintenance and retirement costs for the DBS-V system. Using these costs, the software can provide the price that consumers will be required to pay for monthly programming costs by using the costing equation

Cost = Price + Profit

Through the use of Microsoft Windows™, users will be able to export the charts to other software applications.

1.2 The Systems Analysis Approach

Since this thesis is being developed in the Systems Engineering department, the systems analysis approach will be taken complete the model. Before the systems analysis approach is discussed, the definition of a system will be stated. As proposed by Blanchard and Fabrycky (1981), a system is defined as "a set of interrelated components working together toward some common objective." Having said this it can be concluded that a Direct Broadcast Satellite System is a system because of its detailed makeup of interrelated parts working together to provide the DBS-V service.

The systems analysis approach as shown in figure 1.1 is a way of making decisions based on quantitative approaches and studies and incorporates risk and uncertainty. Throughout the development of this thesis, the steps shown in figure 1.1 will be merged into the paper to assure the systems approach is being taken. Every detail of the steps shown in figure 1.1 will not be used because every system is different and cannot be categorized by one process; however, the main techniques remain applicable in principle.

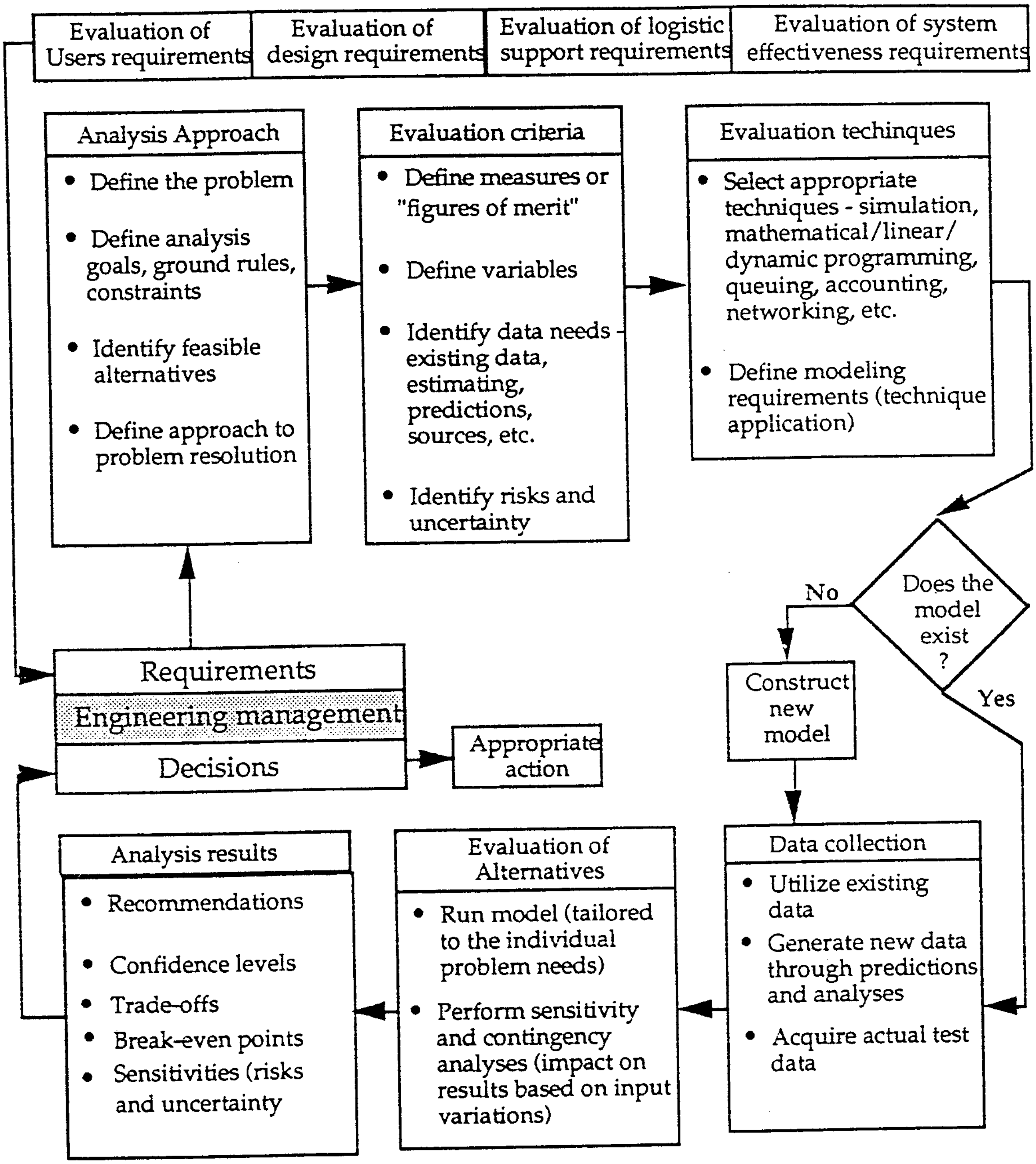


Figure 1.1 The system s analysis process (Source: Blanchard and Fabrycky, 1985)

1.3 Scope of the thesis

Chapter 2 of this thesis will provide an overall assessment of the risks of investing the Direct Broadcast Satellite-Video service.

Chapter 3 presents the subject of cost modeling in the Direct Broadcast Satellite service area. Methods that are used to accurately cost the service are given here.

Chapter 4 provides an analysis of the most valuable tool in the area of cost modeling, the Cost Breakdown Structure (CBS). The particular CBS used for costing the DBS-V service is developed here.

Chapter 5 describes methods and techniques used in the life cycle costing of the DBS-Video Cost Model (DBSCoMo).

In Chapter 6, the actual process of developing the DBSCoMo software is discussed. This chapter in conjunction with Chapter 7, which provides a sample use of the software, covers the design, implementation and coding of the DBSCoMo software.

Chapter 2
DBS-V Risk Assessment

The term Direct Broadcast Satellite can refer to two different broadcasting scenarios. The term can either refer to the satellite that is used to perform the service of direct broadcasting or it can refer to the actual process of performing the service. For the purpose of this thesis, "direct broadcasting satellite" will refer to the service and thus will be called the Direct Broadcast Satellite-Video (DBS-V) Service.

This chapter discusses some of the potential risks involved in the DBS-V market. Risk as defined by Riggs and West (1986) is simply "the chance that cash flow will fall short of, or exceed, expectation." Cash flow that exceeds expectations are not of primary interest here; however, the chance that cashflow will fal short of expectations is. There are many reasons that cash flow may fall short of expectations. The main one that will be discussed here is the risk that cash flow may fall short due to competition.

Another major risk associated with providing the DBS-V service is the cost of investing in the service. This cost has been estimated to be in the 100's of million dollar range. A discussion of this risk is beyond the scope of this thesis because this risk cannot be assessed until after the software has been developed and run by a potential service provider.

2.1 DBS Shortcomings

It is a well known fact that DBS-V requires a substantial amount of investment capital. This fact has caused it to have been previously put out of the running with terrestrial based cable television systems. These cable television systems did not require the launching of satellites, which is expensive. However, cable television systems were able to provide the same types of service as the proposed DBS system, excluding the remote broadcasting. The difference at this time between the two is that terrestrial-based services can be provided at a lower cost; because customers do not have to buy a "dish".

The purchasing of a large, expensive and in some cases unanesthetic satellite dish has been the main reason why consumers have been reluctant to buy into the idea of DBS-V. Rapidly emerging technological advances in communications such as "digital compression", HDTV and extremely powerful high power amplifiers (HPA) will probably allow DBS-V to hold its own in the future of direct-to-home satellite television.

By introducing these powerful amplifiers, DBS-V can be made available to every home with the purchase of a small (about one foot in diameter), easy to install and inexpensive dish antenna.

2.2 DBS Alternative Analysis

To assess more fully the potential of DBS systems other multichannel alternatives must be taken into account. Here the technical and economic characteristics of cable television, wireless cable, Home Satellite Dishes (HSD), and Satellite Master Antenna Television (SMATV) systems as potential alternatives to DBS-V are presented.

2.2.1 Cable Television

Cable television services in the US. are primarily the same services that are being proposed by DBS-V systems. The viability of DBS-V depends on its ability to compete with existing cable systems and still recover investment costs and cover operating costs. The capacity of broadcasting satellites to provide many channels of programming through the use of digital compression can also be achieved by cable television through the use of fiber optic cables. The differences in the two systems are the points to argue when considering whether DBS-V will be able to contend with cable.

Cable television is different from any of the other alternatives considered here because of its level of saturation. "The percentage of home being passed that subscribe to cable television has remained stable at 61 to 63 percent. (Johnson and Castleman, 1990) This implies that more than half of the homes in this country already have access to cable television services. To make the DBS-V service attractive enough to these customers to switch over or subscribe to DBS-V posses a complicated problem for DBS-V marketers.

One major advantage of DBS-V over cable is its ability to broadcast to the continental US (CONUS) from one uplink. This feat could also be accomplished by cable systems, but the coordination of the hundreds of cable system to transmit the same program simultaneously is not worth the effort. On the same line as CONUS coverage, transponder beams can also be shaped to provide regional coverage (i.e. Southern California, Washington, DC Metropolitan Area).

Although the idea of national or regional coverage is a strong advantage of DBS, the limited ability of DBS to carry local programming is a disadvantage. Cable television, however, easily handles this situation.

A small scenario will be used here to discuss the cost difference between cable and DBS-V. The costs to the subscriber for DBS-V services will be for a "dish" and programming costs. Other countries that have been successful in the DBS market are useful in studying because their DBS terminals will operate in much the same manner as those proposed in the U.S. "In the United Kingdom, the retail price for Sky Television's DBS terminal, which has a 60 cm diameter antenna, was $610 and BSB terminal costs $690." (Johnson and Castleman, 1990) These BSB terminals include the antenna, LNB, and FM receiver and integrate receiver-decoder/descrambler (IRD).

The expense of DBS terminals might be the major reason why a potential DBS subscriber would not either switch over to DBS-V or subscribe for the first time. To offset these costs from the subscriber, the DBS company may offer the DBS terminals as a package, much the say way as converter boxes are loaned to cable television subscribers. The costs of these terminals will drop significantly as the number of subscribers increase.

Another advantage of DBS-V services over cable systems is its ability to provide service to homes that are not presently passed by cable (due mainly to low housing density). It may be in this area that DBS-V can make its introduction.

High definition television (HDTV) is one of the primary impetus in the DBS services arena. When the a HDTV standard is selected by the FCC in 1993, all HDTV receivers will be designed to be compatible with this standard. In order to initiate this service, there has to exist at least one DBS uplink station that has the ability to transmit HDTV signals to CONUS. "In contrast, [cable network] broadcasting stations will require costly retrofitting ($5 million to $10 million)." (Johnson and Castleman, 1990) This figure would not make it worth the cost to offer HDTV services to low population density areas whose potential revenues would not justify the costs.

In addition to retrofitting broadcasting stations, fiber optic cables would have to be installed to the subscriber's premises to make the HDTV service available. According to Marek [1992], " a major downfall to any fiber transmission scheme is the last mile." The costs of providing this service to every subscriber's home, via cable, would definitely make the service not profitable.

2.2.2 Wireless Cable

DBS systems are not unique in their flexibility to serve selected households. Wireless cable systems, shown in figure 1.2, have similar characteristics. A program source transmits a signal to a satellite that retransmits the signal to a tower at a studio. Microwave signals are then transmitted from the tower of the studio. A user terminal is needed only for households that want service. The user terminals can be moved from one location to another. It would seem as if wireless cable would serve as a bigger competitor to DBS and existing cable systems. However there are some major disadvantages of wireless cable as well as advantages.

One major advantage is the low cost user terminals. The user terminals, consisting of small rectangular panel antennas and simple frequency downconverters, are even cheaper than the $600 quoted in the above section. However, this cost difference arises, mostly due to the digital compression techniques and access control for security are not incorporated in the wireless cable system as they are for the model DBS terminal presented in the section 2.2.1. If they were included, a complex IRD will also be required at each wireless cable user terminal and the costs would rise significantly.

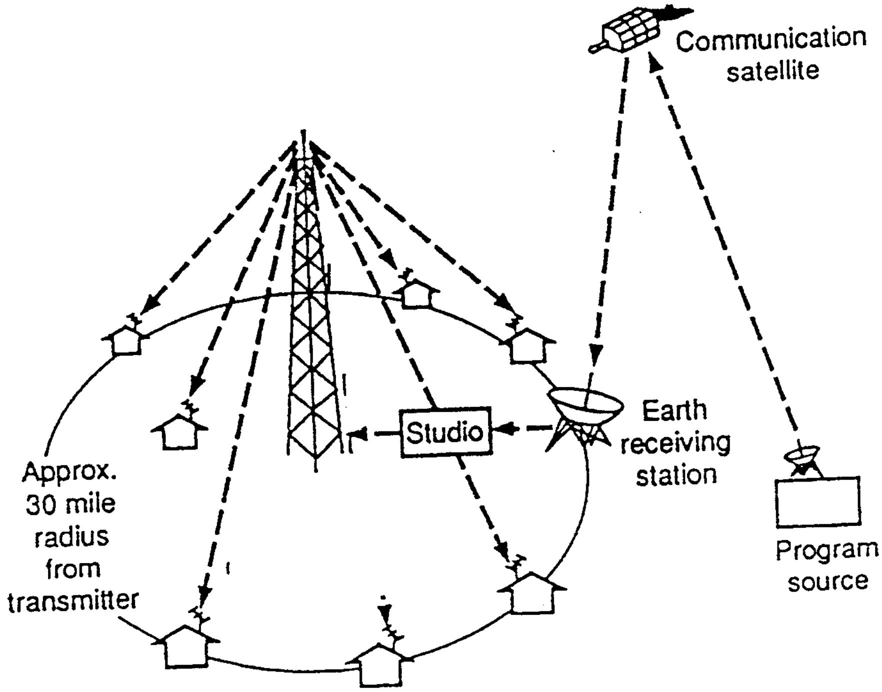


Figure 1.2 Wireless Cable System

Another advantage, of cable systems over DBS-V is the ability to transmit local signals. If channel capacity is available, wireless cable can easily carry local broadcasting signals. Local signals can be picked off the air with a master antenna, fed into the studio, and retransmitted over the wireless cable system.

However, the use of wireless terminals to receive local channels seems that a waste of an expensive broadcast medium. This is why the HSD terminal is usually sold as a package bundled with a VHF/UHF antenna to receive local broadcasts via microwave.

A major disadvantage of DBS is its receptiveness to signal loss caused by rain fade.

One disadvantage of wireless cable is its line of sight requirements. These requirements are difficult to meet because of the low angle of elevation between user antennas and the microwave tower. Therefore, hills, trees, buildings, and other objects in the line-of-sight are much more of a problem for wireless cable than for DBS.

2.2.3 Home Satellite Dishes (HSD)

When the DBS-V service becomes available, the market for HSD will probably decrease substantially enough to cause the HSD industry to not be profitable enough to maintain. This is because the HSD service, thus far, seems to be successful due to the special programming that is available to subscribers. However, when the DBS-V service becomes available with enough channel capacity to offer special programming, the provocative currently being offered may become less attractive.

An advantage of DBS-V over HSD is the use of the small dishes to provide the service. The present HSD subscribers that desire a change from the large, obstructive dishes may welcome the smaller dish and thus the service.

"One factor that will encourage retention of HSD terminals, however, is the multitude of channels to which the HSD user will continue to have access in the C-band." (Castleman and Johnson) Even though DBS-V will make its attractive stand in the Ku-band, at least a small base of the C-band user will probably still remain.

2.2.4 Satellite Master Antenna Television Systems

SMATV systems are essentially cable systems fed by HSD-type terminals to primarily serve apartment buildings. "Since 1987 the number of subscribers to SMATV has steadily dropped; due in part to the emergence of cable television service." (Castleman and Johnson) This facts probably reflects the fact that some SMATV systems were built in areas that at the time did not have cable service. Once cable service became available, the cable service became more attractive.

DBS-V service providers will probably seek to attract SMATV viewer by pricing access to their programming competitively.

Converting the SMATV large C-band terminal to the smaller DBS terminal would also have an aesthetic advantage. However, if the DBS-V system uses digital video compression, as discussed in section 2.3.2, this DBS terminal would likely be as expensive, if not more expensive, than an existing C-band unit.

2.2.5 Overall Assessment

The analysis in the previous sections suggest that DBS systems have a greater potential of widespread competition with existing cable than does other alternatives. The severe line-of-sight constraints on wireless cable systems, combined with their limited capacity prevents them from competing nationwide. However, these systems may do well in local markets. Unless C-band service offers programming that is attractive to some particular audience that is not accommodated by a DBS-V provider, the market for new HSD terminals will probably disappear in response to low-cost and more aesthetically appealing DBS systems. SMATV and HSD network will likely be assimilated into successful DBS networks.

However, it cannot be concluded from this analysis alone that DBS will offer widespread competition to cable. Outcomes will depend on several risk factors:

- The cost of earth terminals with satisfactory performance.
- The tradeoff between antenna size and marketability, given that the smaller the antenna size, the more attractive the terminal becomes—as well as manufacturing and other costs.
- The degree to which video compression reduces per-channel cost of the space segment.
- The amount of operating expenses including program investment costs.
- The extent to which market demands exist for channel capacity and services beyond those offered by cable systems.
- The extent to which DBS systems would be handicapped by carrying few, if any, signals of local broadcasting stations.

These factors can all be considered as risks that must be taken in order to invest in the notion of direct to the home television service.

Chapter 3
DBS-V Cost Model

"Models ... provide a convenient means of obtaining factual information about a system being designed or a system in being." (Blanchard and Fabrycky, 1981) The model developed in this thesis will provide cost and pricing information about the DBS-V systems. This particular cost model can be described as a decision model because it will be used by individuals to make decisions about the type of system that can be built, subject to cost requirements and constraints.

Development of this model requires that certain steps be followed to insure that a systems approach is being adhered to as discussed in Chapter 1. Section 3.1 will describe the process that will be taken in order to complete the cost estimating task. This process will be followed throughout the cost estimating portion of this thesis

3.1 The Cost Estimating Process

The actual process of developing the DBS-V cost model includes performing the activities listed in Figure 3.1. Once these steps are completed the Cost and Pricing Model for Direct Broadcast Satellite Video to the Home software (DBSCoMo) can be implemented. This software , when implemented, will act as the cost model itself.

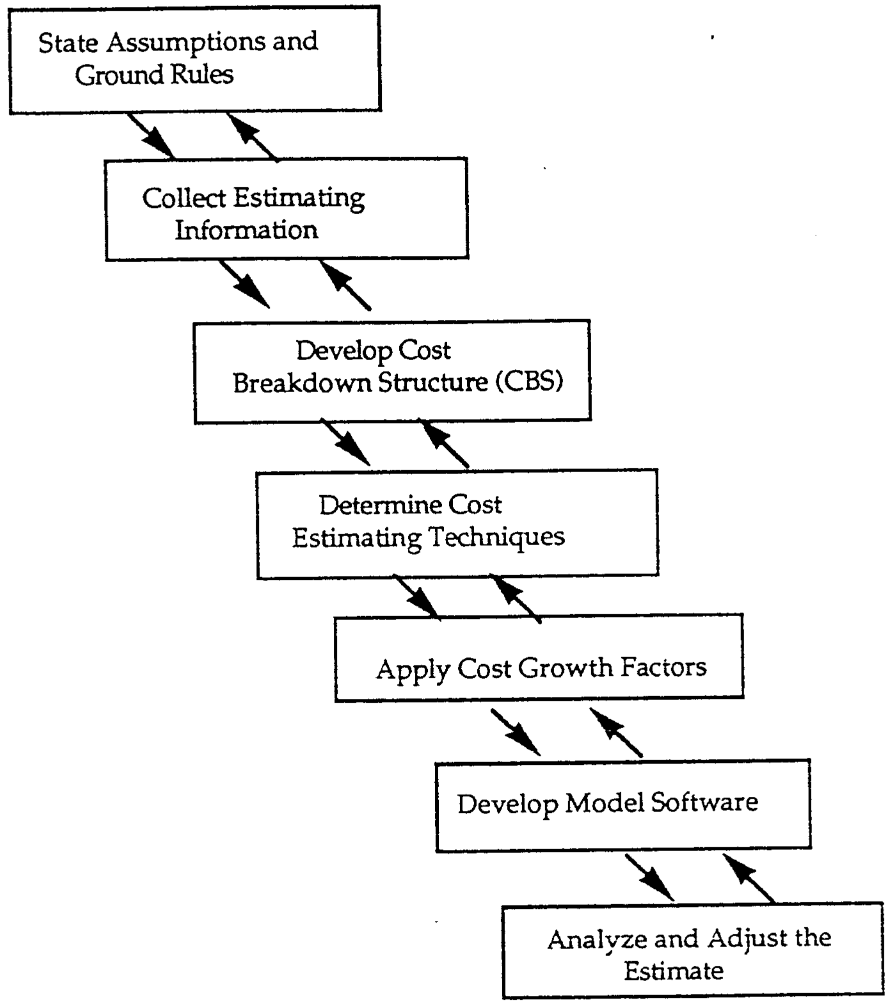


Figure 3.1 DBS-V Cost Estimating Process

Each of the steps in the process does not necessitate a complete subsection; however, they will be discussed in later chapters of this thesis as they become applicable.

The statement of assumptions and ground rules of the estimate are important to both the estimator and the service provider because it is these assumptions and rules that answer specific questions about the work element being performed. It is of utmost importance that any assumptions being made are clearly stated. An estimate that is missing an assumption could appear to be invalid.

The collection of estimating information is simply a gathering of historical data that will assist the estimator in the development of the estimate. This data may be in the form of handbooks, trade journals, newspapers, etc. In addition to printed information, historical data can be in the form of a database of information. Because the DBS-V service is a new one, there is not much historical data available for an estimate.

The cost breakdown structure(CBS)/cost element structure is by far the most important step in the cost estimating process. The CBS has been called "the fiber or refining cloth that holds a cost estimate together." (Stewart and Wyskida, 1987) The CBS for DBS-V is included in Appendix A.

The discount rates (cost growth factors) are extremely important in the development of a cost model that has a design life. Costs that are not properly discounted throughout the cost life cycle tend to make the cost estimate invalid.

The next step in the cost model process is the development of the cost model software , Direct Broadcast Satellite-Video Cost Model (DSBCoMo). Chapter 5 is solely devoted to the discussion of this topic. It is in this step that the model is developed and used to generate a cost estimation for a user supplied satellite network configuration.

The analysis and adjustment of the estimate assumes that DBSCoMo has been used to generate an estimate. After the estimate has been analyzed and deemed unsuitable, the adjustment step comes into play. It may be that the estimated cost produced by the DBSCoMo software is over some preset budget. The model functions so that parameters that contribute to the major cost drivers may be varied in order to adjust the estimate to fit the cost constraints of the user.

3.2 Cost Estimation Techniques

A brief description of each of the methods used in the estimation of costs for the DBS-V system will be discussed in sections 3.2.1-3.2.6. Other methods of cost estimation do exist but a description of them are beyond the scope of this thesis.

3.2.1 Statistical and Parametric Cost Estimation

Statistical and parametric estimating involves collecting and organizing historical information through mathematical techniques and relating this information to the cost output being estimated. The format most commonly used for statistical and parametric estimating is the estimating relationship, which relates some physical characteristic of the work output (weight, power requirements, size, or volume) with the cost or labor-hours required to produce it. These relationships involving cost are known as cost estimating relationships (CERs).

The most effective means of developing a parametric cost estimate is to subdivide the costs into the smallest possible elements, as with the CBS, and then to use statistical or parametric methods to derive the resources required for these small elements. This point leads to the next method of cost estimating which dictates that cost should be subdivided in order for the method to work satisfactorily.

3.2.2 Detailed Resource Estimating

Detailed resource estimating involves the integration of a cost estimate from an estimate of the elements made at the lowest possible level in the cost element structure. Detailed estimating presumes that a detailed design of the product or project is available. The detailed design to be used is the CBS that is included in Appendix A. This type of estimating assumes that skills, man-hours, or materials can be identified for each work element through one or more of the methods that follow. A detailed estimate is usually developed through a synthesis of cost element estimates developed by various methods.

3.2.3 Direct Estimating

"A direct estimate is a judgmental estimate made in a "direct" method by an estimator who is familiar with the task being estimated." (Stewart, 1987) The estimator will study the element to be costed and then quote his or her estimate in terms of man-hours, materials, and/or dollars. For example, a direct estimate could be quoted as a dollar amount. If the direct estimate is quoted at "so many man-hours", then it is possible to estimate the associated cost by multiplying man-hours by dollars/man-hour.

3.2.4 Estimating by Analogy (Rules of Thumb)

This method is similar to the direct estimating method in that considerable judgment is required, but an additional feature is the comparison of the new cost element with some existing or past elements (reference elements). The estimator then collects resource information on a similar elements and compares the two. The estimator may then say that "this task should take about twice the time (man-hours, dollars, materials, etc.) as the one used as a reference." This factor (a factor of 2), would then be multiplied by the resources used for the reference element to develop the estimate for the new element.

3.2.5 Handbook Estimating

Handbooks, catalogs, and reference books containing information on virtually every type of product, part, supplies, equipment, raw material finished material are available in libraries and bookstores, and directly from publishers. These handbooks are referenced to find the applicable cost of a particular element that is being costed.

For the purpose of this thesis, handbooks may not be available for the DBS-V components.

3.3 The Cost Breakdown Structure (CBS)

The CBS is broken down into levels as shown in figure 3.2. Each level of the structure provides a parent-child type relationship between the components of the given level and the levels above and/or below it. For example , cost elements 1.1.1 and 1.1.2 make up the costs for cost element 1.1. The CBS is built from the top-down, but its hierarchical nature gives rise to costs being formulated from the bottom-up.

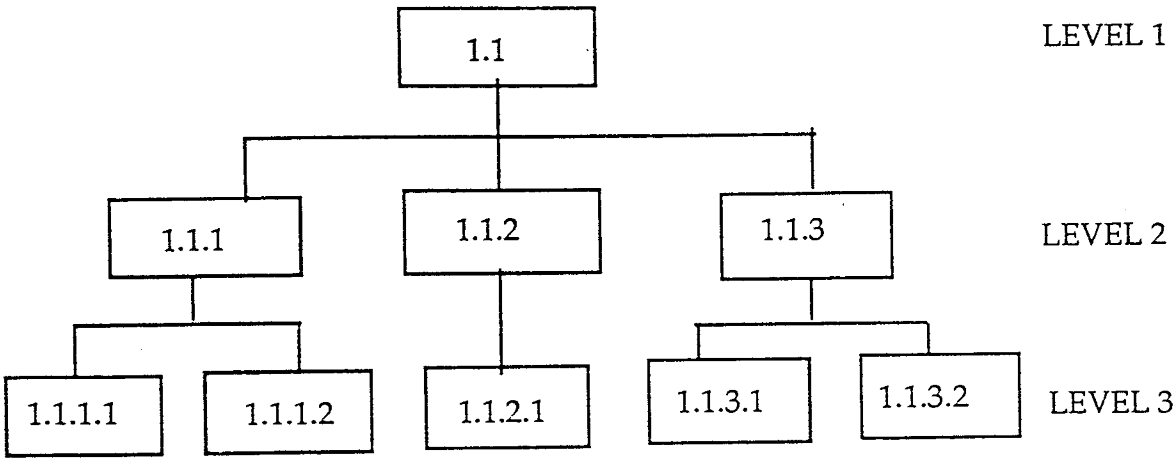


Figure 3.2 The Cost Breakdown Hierarchy

Determining the cost estimating techniques to be used for each work element entails the estimator determining which method(s) of cost estimation would be appropriate for each element. Elements may be costed from the bottom of the CBS, for instance, at the lowest level of the CBS, or the elements may be costed at higher levels.

Because of the nature of the cost model being developed, the estimating by analogy method is the most likely candidate for use. However, some components may be better suited for a different method. Therefore, the cost estimate will probably consist of a hybrid estimating scheme.

For example, the cost of the satellite depends primarily on its mass. This leads to the use of a parametric equation relating cost to weight. However, the cost of a Television Receive Only (TVRO) earth station may be more appropriately estimated by a direct quote.

Chapter 4
Cost Breakdown Structure Analysis

This chapter will analyze the Cost Breakdown Structure that was discussed at the end of the Chapter 3. As put forth by Stewart (1987), cost analysis is "a judgment or opinion of the cost of a process, product, project, or service." This task is difficult when it comes to "new technology" projects. This is because "new technology" activities or projects have never been developed before and therefore have no directly relatable historical data. In addition to this, "the disclosure of precise costs [by some companies] can be regarded as a breach of confidence [in some companies]." (Rainger, et. al., 1985) It is due to these circumstances that a detailed analysis of costs for DBS-V cannot be provided, however, the DBSCoMo software will be developed in a manner that allows the user the ability to enter this information at will.

The cost breakdown structure analysis is the process of analyzing the cost breakdown structure and predicting the costs associated with the components/elements through the use of one/some of the methods of estimating discussed in section 3.2. This section does not cover every component of the DBS-V systems as described in Appendix A, however the costs modeling techniques involved in costing the major components are covered. This chapter will serve to assist the user of DBSCoMo in determining the method of costing to use for some of the major components of the DBS-V system.

The Direct Broadcast Satellite-Video to the Home system is considered a new technology. Although many systems have been proposed and submitted to the FCC for approval, none have been implemented in the continental United States (CONUS); therefore, not much historical data exists. Because of this, it logically follows that the techniques used for estimating the cost of the system will be mainly estimating by analogy and detailed resource analysis combined with direct quotes.

A DBS -V system consists of two key elements: A ground segment and a space segment. The ground segment consists of any elements that are used on the earth and the space segment consists of the elements that are necessary to place a satellite in geosynchronous earth orbit (GEO).

4.1 Ground Segment Components

The ground segment of a DBS-V system consists of three types of elements: Earth stations, Tracking Telemetry and Control Center(s) and Satellite Control Center(s). The duties performed at each of these elements are discussed in the Cost Breakdown Structure dictionary in Appendix B.

Furthermore, earth stations can be further broken down into five classes: Major earth stations, Very Small Aperture Terminal (VSATs), Uplinks, Downlinks and Television Receive Only terminal (TVROs). The costs associated with building, operating and maintaining these earth stations are basically composed of the elements shown in figure 4.1. However, each earth station may not contain all of the elements shown in figure 4.1. For example, a TVRO will not contain an upconverter and a high power amplifier.

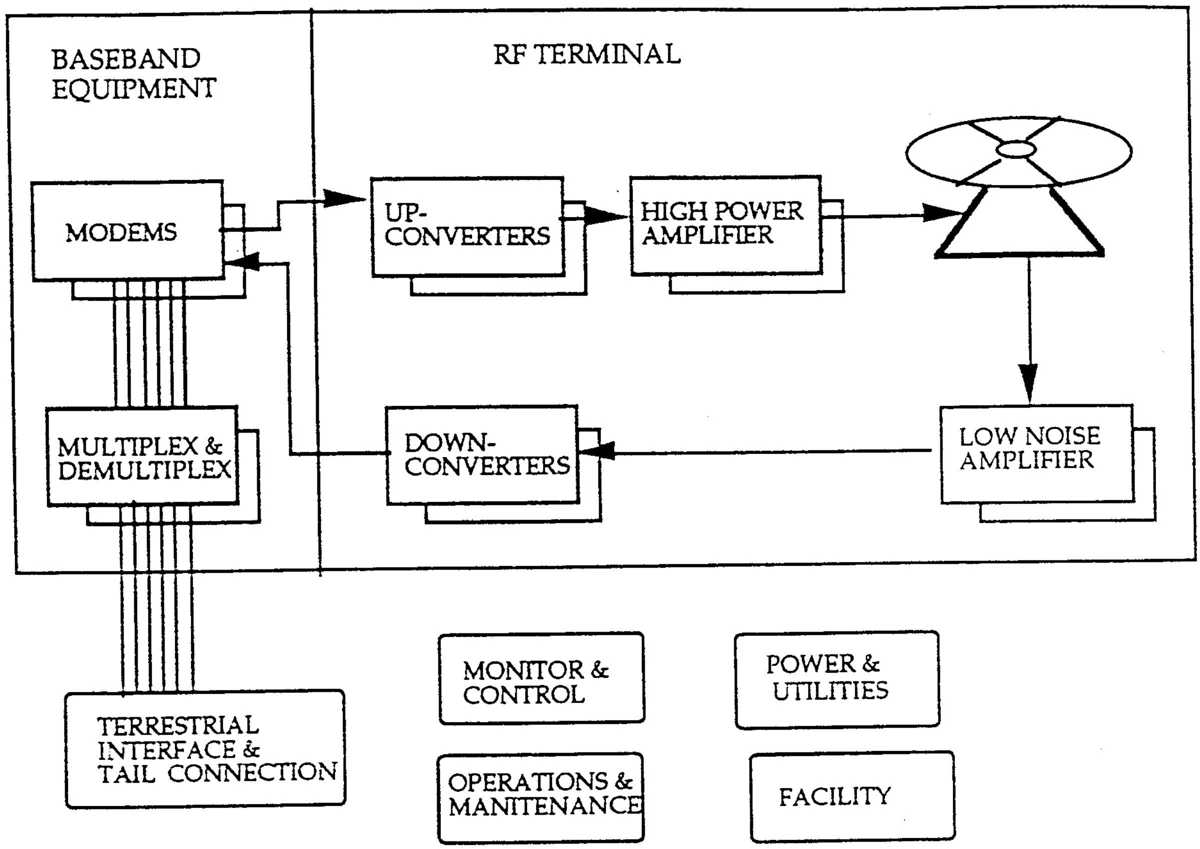


Figure 4.1 A Typical Earth Station Configuration

4.2 Space Segment Components

The space segment of a DBS-V system consists of the spacecraft that is used to launch the satellite, the satellite itself and the launch services required to put the satellite in geosynchronous earth orbit (GEO). These services are the same as for current lower powered C Band systems. The on major difference between the C-Band and the Ku-Band service is that the signals being transmitted from the satellite downlink are strong enough to be received by small TVRO dishes in the Ku-Band system.

The major components of a satellite can be divided into the spacecraft bus and the communications subsystem. Table 4.1 lists these major components of the spacecraft system along with their subsystems and state functions performed by each.

System	Function	Principle Quantitative Characteristics
Communications Subsystem:		
Transponders Antennas	Receive. amplify, process, and retransmit signals; capture and radiate signals	Transmitter power, bandwidth, *G/T*. beamwidth, orientation, gain, single-carrier saturated flux density
Spacecraft Bus:		
Structure	Support spacecraft under launch and orbital environment	Resonant frequencies, structural strengths
Attitude control	Keeps antennas pointed at correct earth locations and solar cells pointed at the sun	Role, pitch, and yaw tolerances
Primary power	Supply electrical power to spacecraft	Beginning of Life (BOI) power, End of Life (EOL) power; solstice and equinox powers, eclipse operation
Thermal control	Maintain suitable temperature ranges for all subsystems during life, operating and nonoperating in and out of eclipse	Spacecraft mean temperature range and temperature ranges for all critical components
Propulsion	Maintain orbital position, major attitude control corrections, orbital changes, and initial orbit, deployment	Specific impulse, thrust, propellant mass
Telemetry, tracking, and command (TT&C)	Monitor spacecraft status, orbital parameters, and control spacecraft operation	Position and velocity measuring accuracy, number of telemetered points, number of commands

Table 4.1 Spacecraft Subsystems

4.3 DBS-V System Costs.

The three major costs associated with the DBS-V System are investment, operations and maintenance. The retirement costs associated with the system as also of importance, however, the system provider may not wish to retire the system after its useful design life.

Investment costs are usually considered the most important of the cost classes because these costs are "sunk." This means that once money has been allocated for these costs, it cannot be recovered; unless, the system is made fully operational or sold. An organization may choose to either pursue the development of the system or to halt because of the magnitude of these investment costs. Operations and maintenance costs are discussed together because a system must not only be operated, but also maintained when it is brought into being and these costs are generally determined for the same components.

4.3.1 Investment Costs

The investment costs are all of the sunken costs of the DBS-V system that must be expended in order to make the system operational.

4.3.1.1 Pre-Launch Organization and Legal Costs

The costs associated with the pre-launch organization and legal components cover such expenses as studies to determine the feasibility of the system, market analysis, and FCC interactions. In the Cost Breakdown Structure given in Appendix A, these costs also include the Orbital Space costs.

Rees (1990) has estimated these costs to be a direct cost of $25 million.

4.3.1.2 Launch Services

The cost of placing a spacecraft in orbit is comparable to the cost of the spacecraft itself. A satellite operator does not purchase a launch vehicle itself, but rather purchases the services of a launching agency which is then responsible for the manufacturing and performance of the spacecraft system. Whether or not the transfer stage is part of the launch service depends on the particular LV.

The total cost of the launch mission, just like the spacecraft, is directly relatable to the spacecraft weight. It is easy to see why it is important to design the spacecraft for minimum weight.

Figure 4.2 shows the launch costs associated with using an expendable launch vehicle. As can shown, the launch cost decrease with time. This is due to technological improvements that allow for the use of less expensive launch methods.

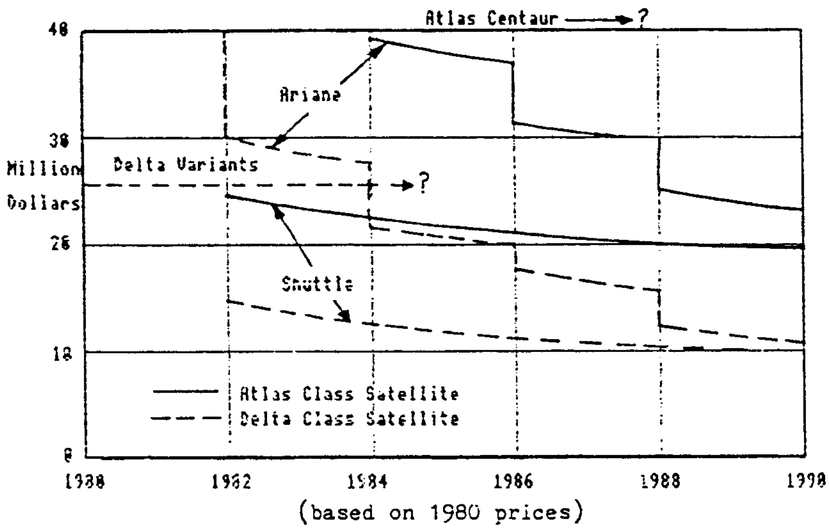


Figure 4.2 Launch Costs (Source Rainger, et. al, 1985)

Figure 4.3 shows another method for calculating the cost of launch services that is based on the weight of the spacecraft.

Some additional expenses associated with the launch mission involve the support services at the launch site and during the transfer and drift orbit phases. The spacecraft contractor can bundle the launch site (launch prep) expenses into the price of the spacecraft. Transfer orbit services are fixed and independent of the particular satellite design and can be purchased from another satellite operator. The cost of all of these services, while essential, is relatively low compared to the costs of the spacecraft and launch vehicle.

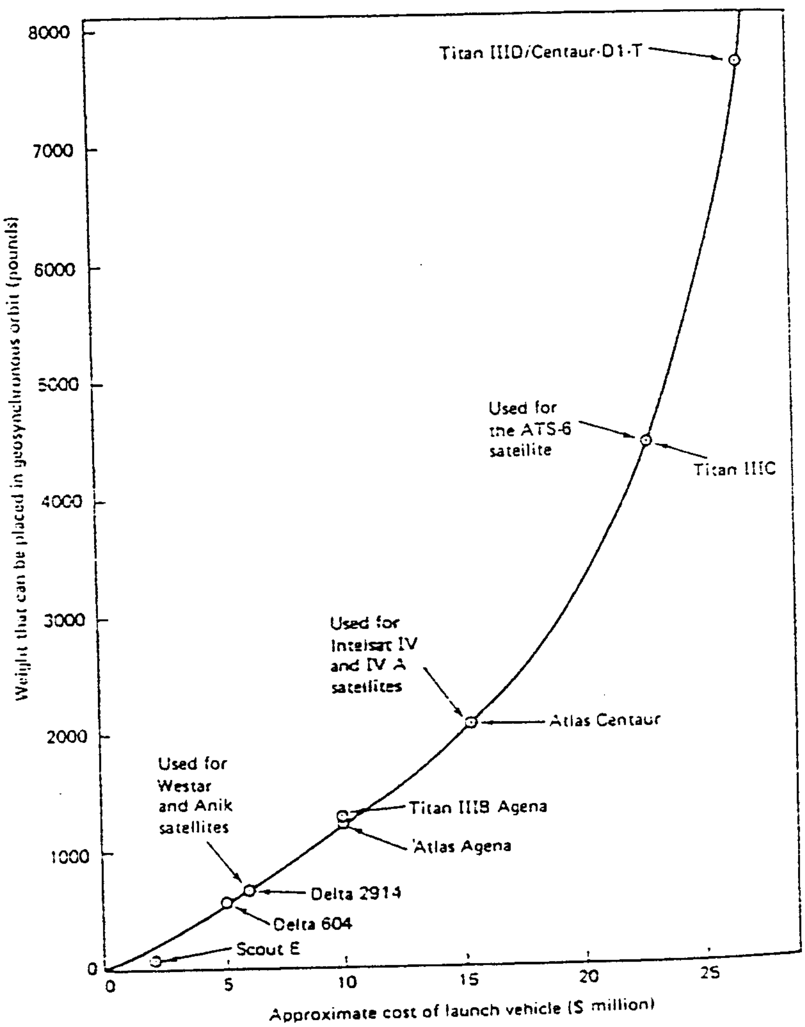


Figure 4.3 Launch Costs

4.3.1.3 Launch Insurance

Launch insurance is an important element of satellite system implementation, particularly when the system is operated as a commercial business and requires outside financing. "The risks associated with launch have always been very high but a nearly perfect commercial launch record between 1970 and 1980 made the risks appear to be diminishing". (Elbert, 1987) Consequently, launch insurance premiums costs during that decade were low enough to encourage satellite operators to insure all costs and revenues associated with the system.

The launch failures that occurred in the 1980s, however put an end to these low premium rates. They almost even lead to near elimination of launch insurance at any price. Premiums in the range of 20 to 30% of the insured value are however currently available. Higher rates have hastened satellite service providers to limit coverage to the cost of replacing the launch vehicle (LV) and spacecraft.

4.3.1.4 Spacecraft

Upon delivery of a spacecraft to the launch site, it is capable of being placed in orbit and operated for its useful life without direct servicing. Any repairs or adjustments must be made by ground command. Therefore, the cost of operating the satellite is included in the cost to operate the ground segment of the DBS-V system.

It should be evident that a communication spacecraft is a complex and therefore expensive item. Thus, a trend has been from small spacecraft with few transponders to larger spacecraft with many transponders and even multiple frequency bands of operation. The service provider is attempting to get more revenue out of the cost of launching less satellites.

Over the past years, the cost of a spacecraft has increased steadily in line with spacecraft weight and complexity. Communication payload weights have increased because the quantity of repeaters and size of the antenna have increased. Due to the nature of DBS-V, the power of the satellite has also increased. It follows that the weight of the spacecraft would also have to increase to provide the physical strength to support the expanded spacecraft and thus the cost.

It is possible to view the cost of a spacecraft as being directly related to its weight. Therefore, the heavier the spacecraft, the more it will cost. Figure 4.4 shows the relationship between the mass of a satellite (kg) and its primary power (W) according to the type of stabilization used.

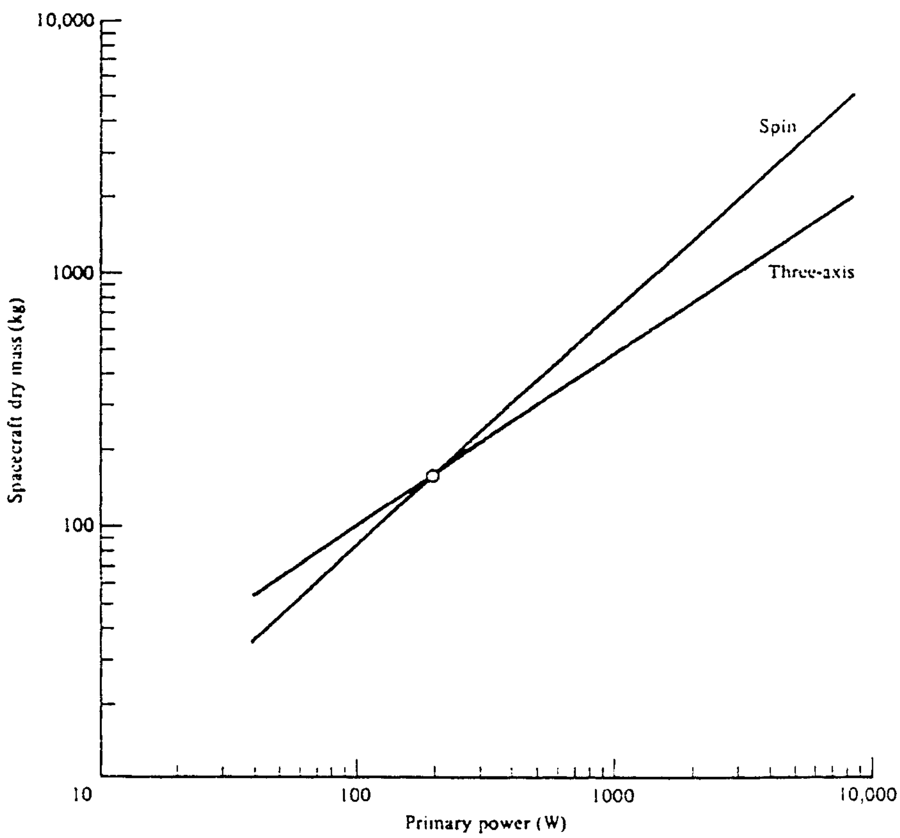


Figure 4.4 Primary Power relates to spacecraft mass (Source Rainger, 1985)

4.3.1.5 Earth Stations

The ideal way to cost an earth station is to identify each major element and relate its performance to the associated cost. This method of cost estimating was discussed in section 3.2. Such a detailed approach will give assure realism in determining total satellite cost. However, for the purpose of a cost model, this method would be difficult and virtually impossible,

The costs of a single earth station are reasonably simple to consider, once the elements and their costs have been identified. The investment costs and annual expenses of individual stations can be added together for each earth station in the satellite network and then analyzed as a system.

For the purpose of this discussion an earth stations will be divided into two subsections as shown in figure 4.1: the radio-frequency (RF) terminal and the baseband section. The RF terminal provides the actual uplink and downlink paths to the satellite, while the baseband equipment arranges the information (video, voice, and data channels) for efficient access. Interfacing with terrestrial users is by way of the terrestrial interface and tail (if required).

4.3.1.5.1 Radio Frequency (RF) Terminal

The two essential characteristics of the RF terminal are the transmit essential isotropic radiated power (EIRP) and the receive figure of merit (G/T). These two parameters have a direct impact on the investment cost of the earth station. The power output of the high-power amplifier and the gain of the transmitting antenna combine with each other to produce the specified value of EIRP. Using these two parameters to compute a parametric CER for the earth station would probably work better than any other method.

The relationship of performance to the costs of these elements is highly nonlinear and should be considered on a case by case basis. For example, the investment cost of an antenna increases at an increasing rate with diameter. Doubling the diameter from 5 to 10 meters increases cost not by a factor of two but by more like a factor of ten. A power increase from 10 to 20 watts (requiring a solid state power amplifier (SSPA)) may only increase cost by a factor of two, but increasing from 20 to 40 watts (requiring a traveling wave tube amplifier (TWTA) instead of an SSPA) could increase cost by a factor of four.

The use of a small antenna (with a relatively low figure of merit) requires that the high power amplifier (HPA) deliver a r high power output. On the other hand, increasing the size of the antenna permits the use of a lower powered HPA at reduced cost. There is typically a point where the sum of HPA cost and antenna cost is minimum.

The up converter and down converter are essentially fixed cost items not dependent upon the RF performance of the station.

4.3.1.5.2 Baseband Equipment

The modulators, demodulators, and multiplex equipment which make up the baseband section of an earth station often represent a significant portion of the investment and operation expense. Because of the assumption that digital processing will be employed (i.e. TDMA and packet data) and the fact that there are few standard digital stations, the cost of these stations is constantly changing. An earth station may be designed in such a way that the RF terminal can be retained, even if the baseband equipment is changed out. In VSATs or TVROs, on the other hand, the baseband portion may even be integrated into the RF terminal.

This technological improvement factor or changing of components due to new technology is integrated into the DBSCoMo.

4.3.1.6 TT&C and SCC Centers

The investment cost of implementing the ground facilities (shown in Figure 4.5) is small in comparison with that of any other single element as seen in figure 4.7. Designing and implementing a proper ground environment would therefore be a wise measure, even considering the extra cost of doing the job right.

The method used to cost the SCC and TT&C should be a direct quote or an estimation by analogy. The technology used at these centers is not much, if any, different than the equipment used by C-band systems.

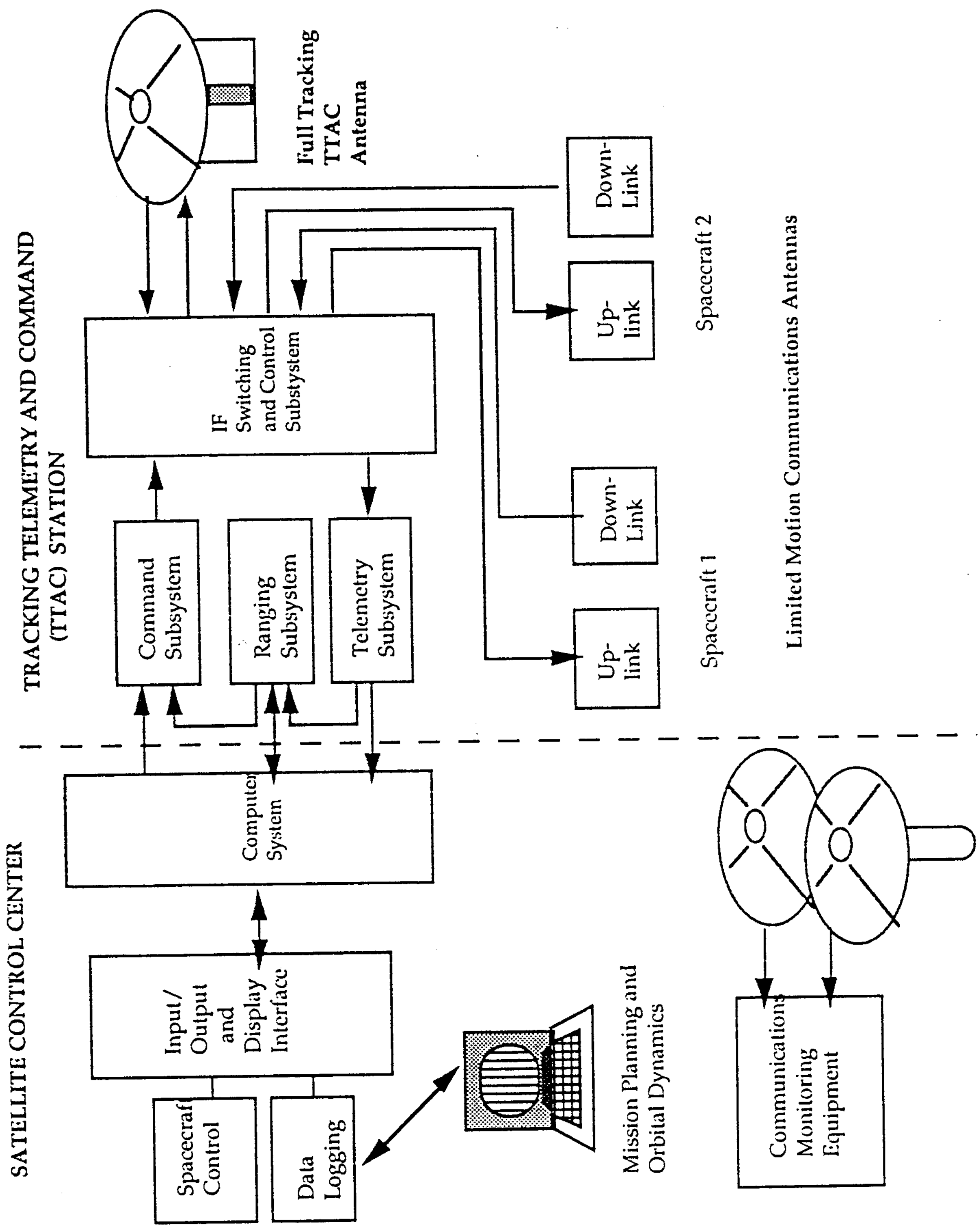


Figure 4.5 General Arrangement of TT&C Ground Facilities

4.3.1.7 Terrestrial Interface and Tail

The manner in which the user is connected to the earth station as well as the physical distances involved will have a large impact on station investment cost. Minimum cost goes along with tying the station directly to the user, which is the concept behind TVROs for direct-to-home service. However, a major earth station would serve several users or user locations; requiring that local access or terrestrial tail services be included. Figure 4.6 shows the costs of providing a microwave link versus running a fiber optic link terrestrial tail to a satellite network.

The costs of land and right-of-way are excluded.

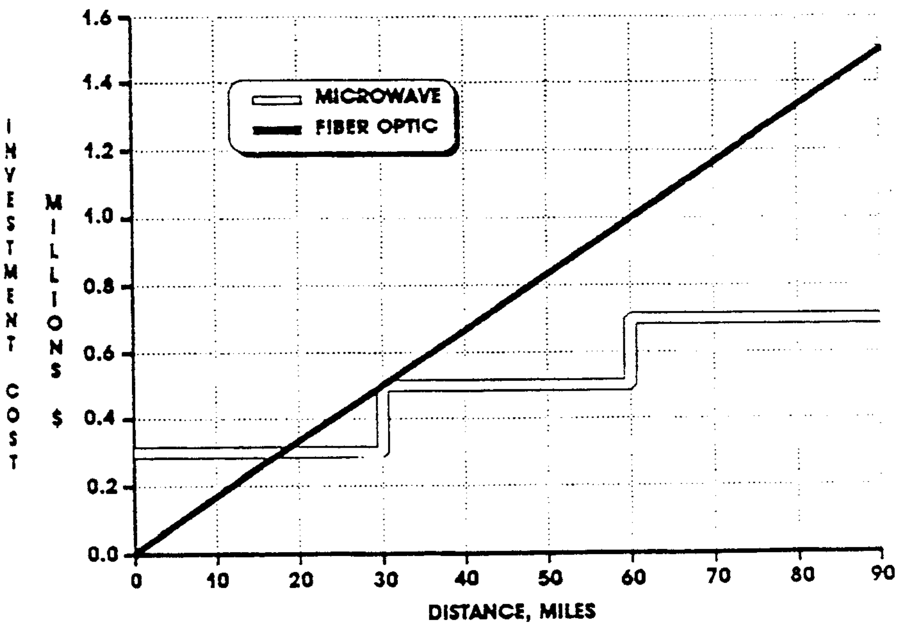


Figure 4.6 Terrestrial Interface Costs (Source: Blezard, 1985)

4.3.1.8 Monitor and Control

Having an automated system of monitor and control will reduce or eliminate the need for on-site maintenance or operations personnel. This is definitely preferred in a large network, where labor costs could be extremely high. Such a specialized network capability, however, will raise the initial investment in the network. If not installed in the beginning, an automated function will be extremely costly to add, since the electronic equipment at remote sites would not have been designed for remote control and monitoring.

4.3.2 Operations Costs

Operations cost for the system include all costs that are necessary in keeping the system operational once the DBS-V service has been initiated. The operations costs can be divided into the cost for operating the space segment and the space segment.

4.3.2.1 Space Segment

Once the satellite(s) is in orbit, the cost to insure the satellite and operate the SCC and TT&C center are the only costs that can be attributed solely to satellite operations. This is not to say that these are the only costs that are incurred in the DBS-V system. In addition to being space segment operations costs, the SCC and TT&C station can also be viewed as ground segment operations costs. However, one of the reasons for the use of the CBS is to ensure that costs are only accounted for once. Therefore, the SCC and the TT&C station are put into the ground segment component in the CBS in Appendix A.

4.3.2.2 SCC and TT&C

The performance of satellite control and network management is by the team at the TT&C station and satellite control center. These personnel include engineers, computer scientists, and technicians

The operations personnel who perform the ongoing tasks at the spacecraft and communication consoles need to be on duty 24 hours a day, seven days a week. Once these costs have been determined, is assumed that these personnel will be responsible for the operations of the ground segment and the space segment. As shown in Figure 4.7, the expense for this labor is substantial, amounting to approximately one-tenth of total system cost, assuming a five-year period.

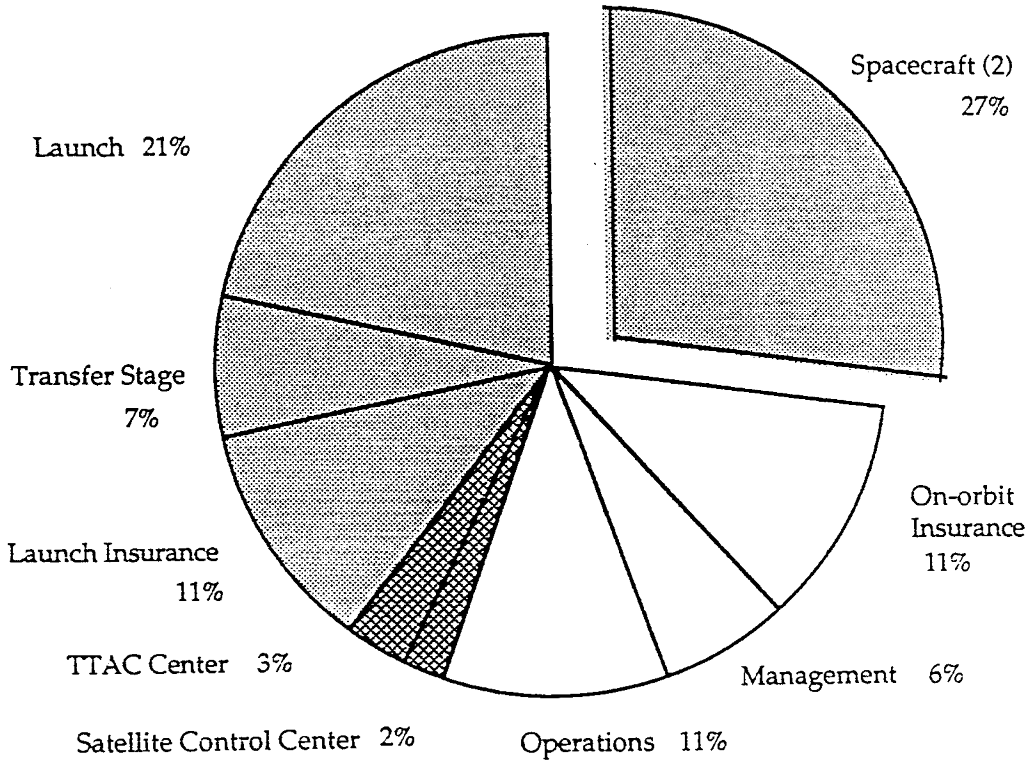


Figure 4.7 Allocation of the Cost of a Space Segment (5 years of operations support) (Source: Elbert, 1987)

4.3.2.3 On-Orbit Insurance

Insurance taken out on the performance of the satellite after it has been placed into service is called either in orbit insurance or life insurance. The need for this type of coverage depends very much on the circumstances of the particular satellite operator. For example, life insurance proceeds would compensate the satellite operator for lost revenues in the event of a loss of satellite capability. The significant amount shown in figure 4.7 is based on the assumption that the insurance is to cover the cost of replacing the satellites in orbit (i.e., including the cost of the LVs).

The method that can be used to estimated this cost is a rule of thumb estimate. Figure 4.6 estimates the cost of on-orbit insurance to be 11% of the total system cost. Therefore, to find the cost of the insurance, one must estimate the total system cost and then compute 11% of that cost.

4.3.2.4 Ground Segment Operations and Maintenance

Because SCC and TT&C centers operations and maintenance costs were discussed in the satellite operations costs, only typical earth station costs will be discussed here. Typical earth stations are of the following types: Major earth stations, VSATs, Uplinks, Downlinks and TVROs.

The ground equipment and facilities, which allow the operations personnel to perform their tasks, must be maintained properly during the useful lifetime. These expenses, while significant, are relatively small in comparison to the annual operations costs shown in figure 4.7. Exception is made for the utilities and maintenance on the buildings housing the SCC and TT&C stations. The electronic and computer equipment will usually be fairly costly to maintain, due to its complexity.

4.3.2.4.1.1 Management and Marketing

The non operations functions of management and marketing might be viewed as an unnecessary overhead. From an economic standpoint, however, a space segment cannot become self-supporting, unless these critical functions are provided for. Management organizes the various personnel resources of the system and arranges for hiring, training, and administrative support. In the case of a commercial system, management is responsible for operating the system at a profit in the face of internal technical and administrative problems and external difficulties with suppliers, customers, and competitors.

The role of marketing is to provide a continuing flow of new customers and revenues, without which the transponders on board the satellites will remain empty. In this context, the sales function (i.e., locating prospective customers and executing service agreements with them) is part of marketing. New applications for the space segment should continually be examined by the marketing staff so that services can be adapted to changing user needs. Marketing will usually be responsible for estimating the future loading of the current space segment and for the preparation of plans for replacement satellites.

4.3.2.4.2 Major Earth Station

Figure 4.7 shows the percentages of the costs involved in the investment operations and maintenance of a major earth station. A CER can be used to depict the costs of each of these components. For example, the HPA cost estimating relationship can be:

MajorESHPA=.11 * MajorESCost

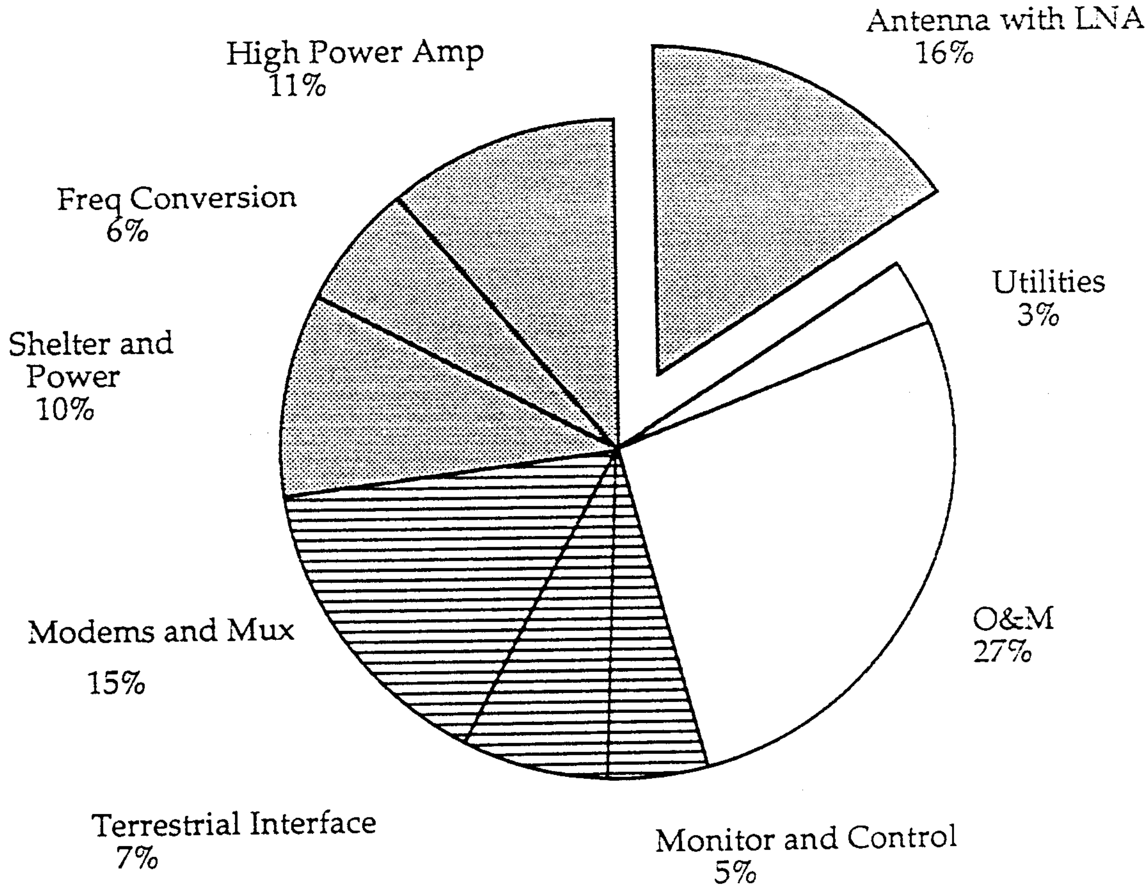


Figure 4.8 Allocation of Investment and Operating Expenses Among Elements of a Major Earth Station (Source: Elbert, 1987)

4.3.2.4.3 VSAT

The explanation of figures 4.9 and 4.10 are much the same as for figure 4.8 in the previous section. A CER can be used to represent the cost for each of the components shown in the figures.

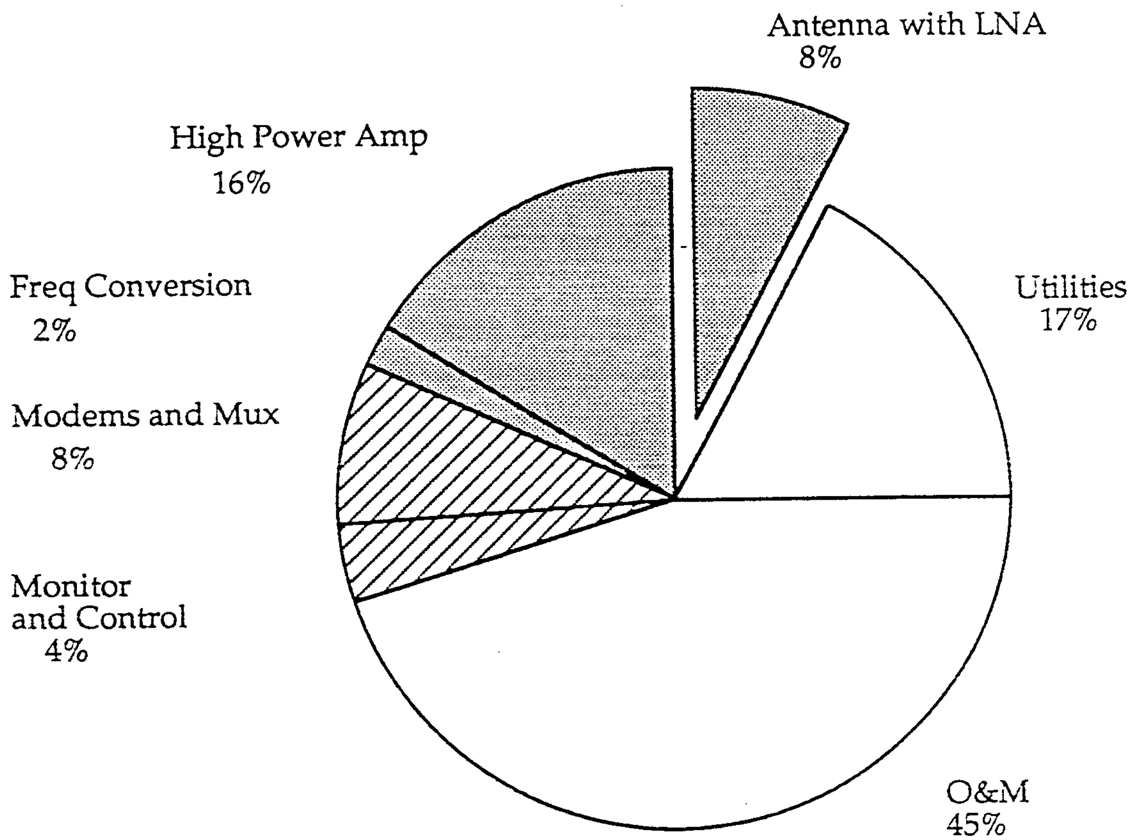


Figure 4.9 Allocation of Investment and Operating Expenses Among Elements of a VSAT (5 years) (Source: Elbert, 1987)

4.3.2.4.4 TVRO

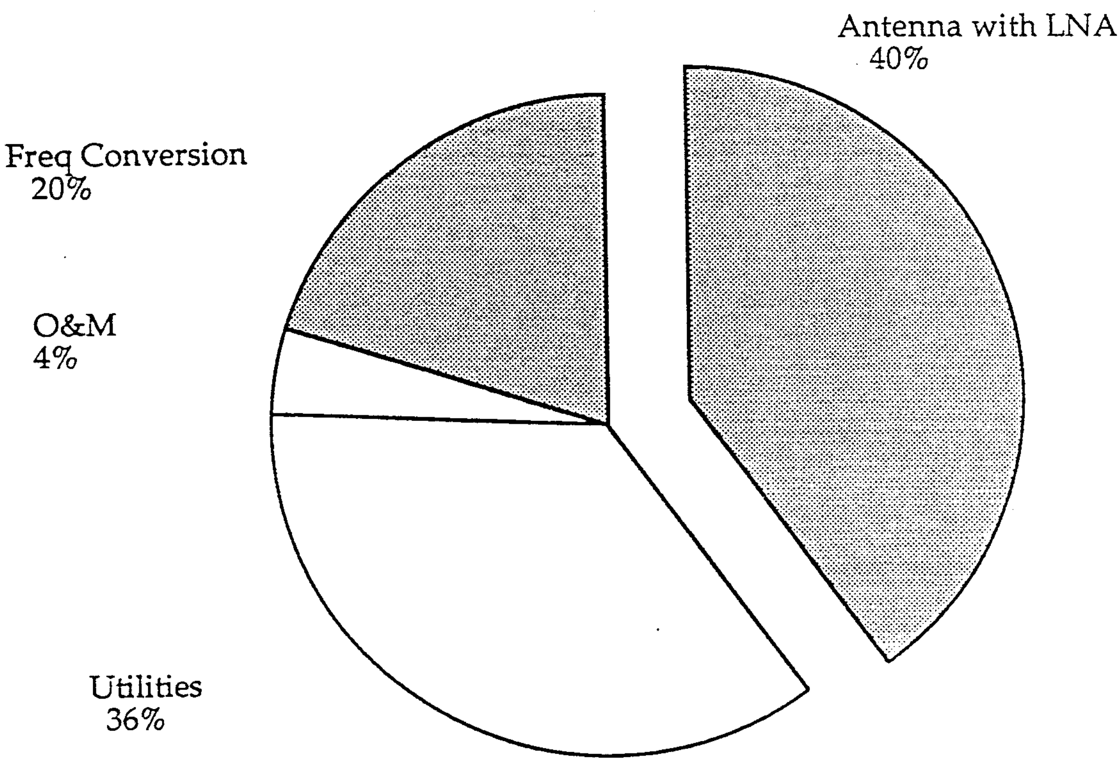


Figure 4.10 Allocation of Investment and Operating Expenses Among Elements of a TVRO terminal (5 years) (Source: Elbert, 1987)

4.3.2.5 Total System Cost

Figure 4.11 shows a graph of the satellite system costs as a function of the cost of the number of satellite launches. This is a unique CER for determining the cost of the system however, many trends may exist in historical data that determines the cost of a component.

Figure 4.2 also shows the breakdown of costs that makeup the total cost of a DBS-V system.

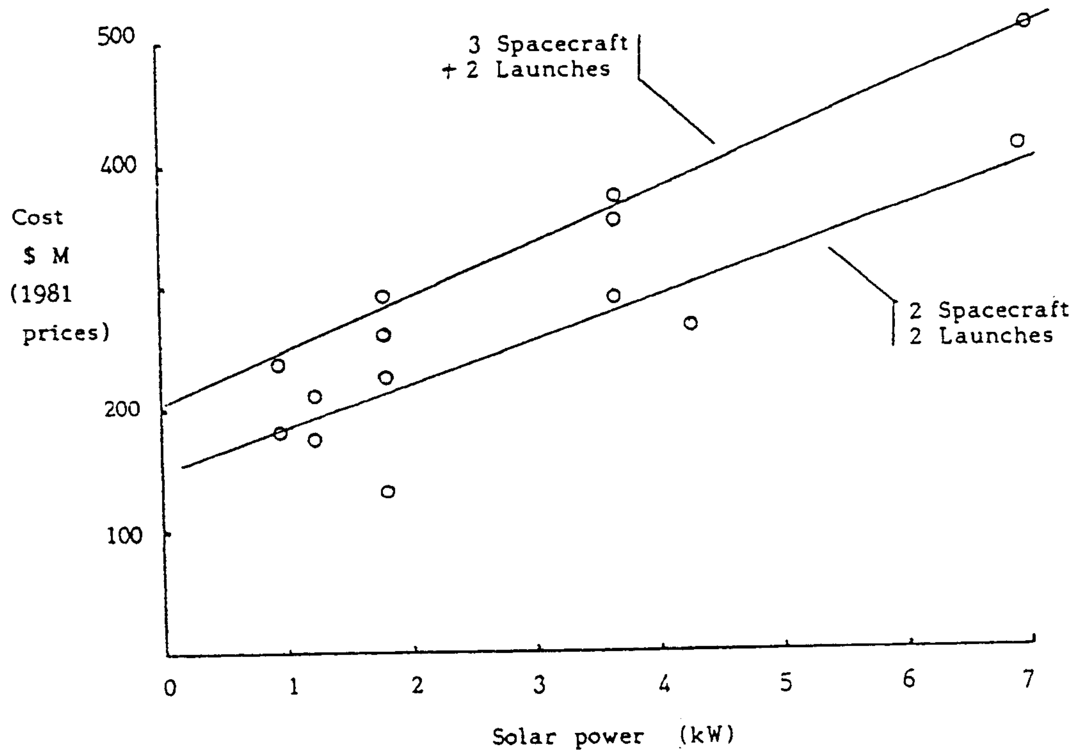


Figure 4.11 Satellite System Cost

Chapter 5
Life Cycle Cost Analysis (LCCA)

Up to this point, life cycle costing has not been discussed, even though it is an extremely important part of this thesis. Life cycle costing is the "method of calculating the total cost of ownership over the life span of an asset." (Brown and Yanuck, 1985). Life cycle costing is essential for the DBS-V system because it can assist the user in making decisions about :

- How to determine the most feasible cost of the DBS-V service that will make the service attractive/affordable to customers while still making a profit for the service provider, a break even analysis must be performed (break even analysis).
- How to determine when a return on investment can be expected (payback period).
- What the cash flow in and out of the system looks like.

Countless numbers of techniques are available for the analysis of the life cycle costs of a system. Similarly, numerous topics of discussion may arise when dealing with the time value of money. Due to a time and manpower constraint, this thesis will only discuss the topics and techniques that required to perform the functions listed above

Section 5.1 serves to give a brief synopsis on the topic of the time value of money. Interest formulas that are used in the DBSCoMo are presented here. The remaining sections 5.2, 5.3 and 5.4 describe the three functions of life cycle costing analysis that are performed in DBSCoMo. The break-even analysis is performed so the user may find a point where the cost of the DBS-V service will make the revenues incurred from the system equal to the expenses incurred by system. Using this cost, the user can set a service cost that can be used to determine a payback period that suits their particular needs. In addition to the payback period, a cash flow diagram is provided by DBSCoMo to visually depict the flow of capital in and out of the DBS-V system.

5.1 Time Value of Money

To merely compute the cost of investing in, operating, maintaining and retiring the system does not constitute a life cycle cost analysis. In order to make the analysis realistic, the time value of the money must be taken into account.

Interest, the cost of using capital, is the major contributor to the time value of money. No LCCA would be complete without including the interest factor.

Another factor that contributes to the time value of money is time-equivalence. This concept asserts that "the effective interest rate computed for a nominally stated interest rate is an equivalent expression of the interest rate." (Riggs and West, 1986) Figure 5.1 shows the time-equivalence of money using an interest rate of 6%.

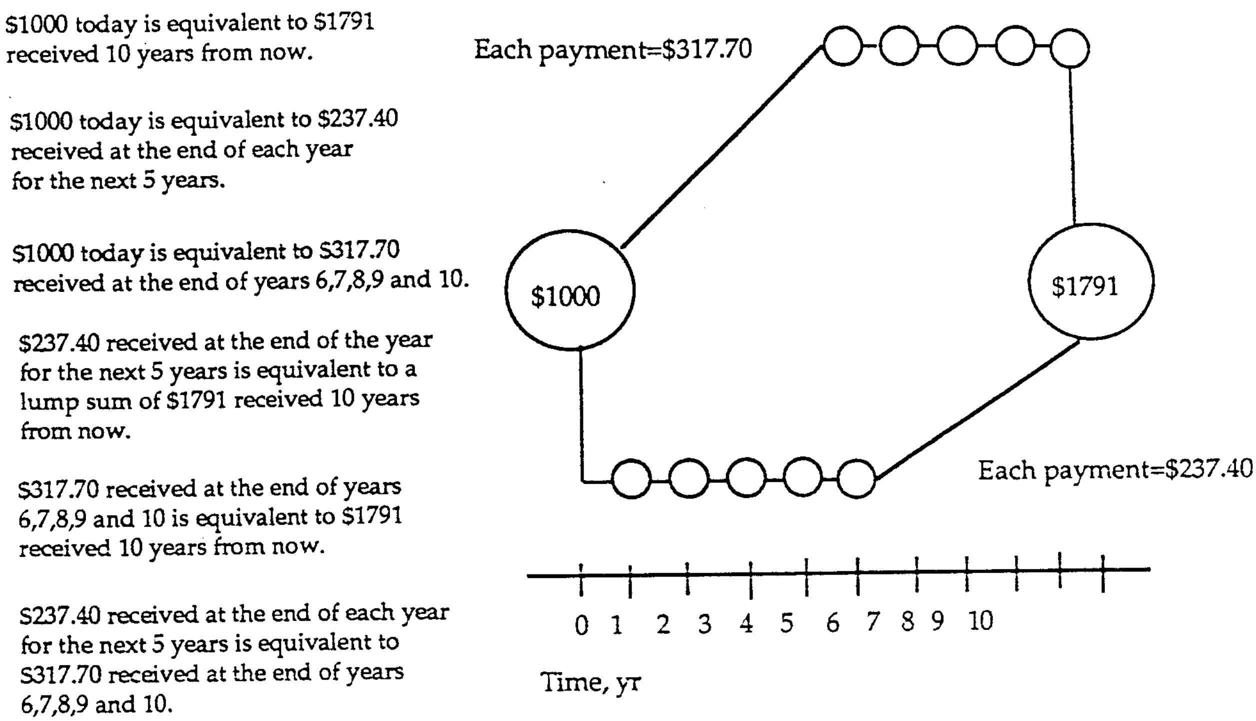


Figure 5.1 Time Equivalence of Money

The effect of using the compound interest formulas (shown in table 5.1) was demonstrated in figure 5.1. These formulas are also used in DBSCoMo for the life cycle cost analysis. A discussion on the development of interest formulas is beyond the scope of this paper.

The following list of abbreviations are used in table 5.1:

- Future worth, F
- Present worth , P
- Annuity amounts, A
- Uniform increase in amounts, G

Factor	To Find	Given	Formula
Compound Amount	F	P	$A = G\left[\frac{1}{i} - \frac{N}{(1+i)^N - 1}\right]$
Present Worth	P	F	$P = F\frac{1}{(1+i)^N}$
Sinking Fund	A	F	$A = F\frac{i}{(1+i)^N - 1}$
Series compound amount	F	A	$F = A\frac{(1+i)^N - 1}{i}$
Capital recovery	A	P	$A = P\frac{i(1+i)^N}{(1+i)^N - 1}$
Series present worth	P	A	$P = A\frac{(1+i)^N - 1}{i(1+i)^N}$
Arithmetic gradient conversion	A	G	$A = G\left[\frac{1}{i} - \frac{N}{(1+i)^N - 1}\right]$

Table 5.1. Interest Factors for discrete cash flow compounding

5.2 Break Even Analysis

Break-even analysis consists of finding the point where the value of a selected variable will produce equivalence in cost and/or revenue. Smith (1987) states that in order to apply the break even concept, "you must , (1) examine the parameters and their likely variability; (2) select the one parameter to whose variability the conclusion of the economy study appear most sensitive; and (3) treat that parameter as an unknown variable, solving for its value where the conclusion is a standoff (break-even) situation."

The parameters that may be used in the DBSCoMo can be the number of subscribers that will cause the model to break even, the cost of the service to the subscriber, the number of years before the system can break even or even the number of number of channels provided by the DBS-V service that will cause the model to break even. However, the most significant parameter to the sensitivity of the system if the price of the service to the customer.

One of the difficulties in developing the DBSCoMo break-even analysis module for the cost of the service is that the subscribers to the system must be projected. As discussed in Chapter 2 of this thesis, there are many other contenders to the direct-to-the-home television service. It is up to the DBSCoMo user to provide a feasible number of subscribers for the DBS-V system.

Once the subscriber amounts are entered, the break-even subscriber costs can be determined by using the interest formulas discussed in the previous section and solving for the unknown value of the subscriber cost. The equation used for the break-even subscriber cost was:

Annualized(Investment Costs + Operations Costs + Maintenance Costs + Retirement Costs) = X * Number of Subscribers

where X is the unknown variable Annual Subscriber Costs.

The annualized cost are computed using the formulas for discrete cash flows provided in table 5.1.

Figure 5.3 shows a diagram of the break-even analysis for the cost of a DBS-V service with recurring and non-recurring costs that have been annualized.

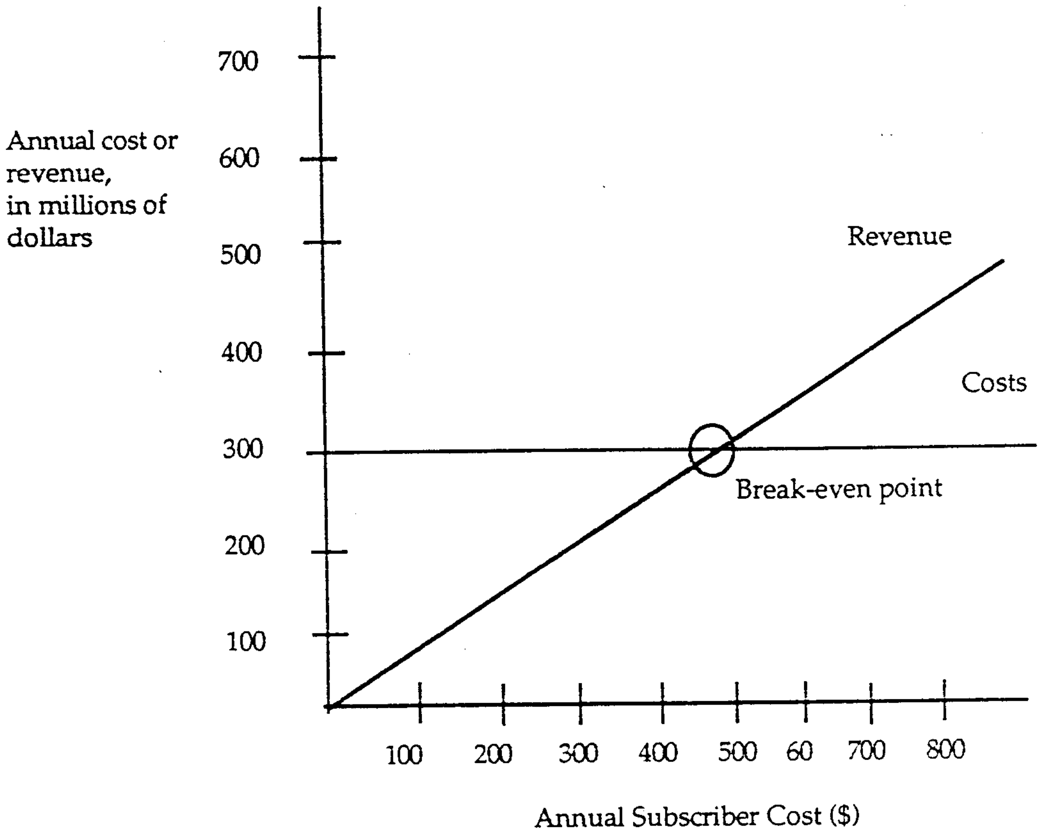


Figure 5.2 Break-Even Subscriber Service Cost

The break even point is the subscriber service cost where the revenues are equal to the costs. This amount is the minimal charge that can be used by the DBS-V service provider to break-even (recover investment, operations and maintenance costs). Any amount over this break-even subscriber charge can be attributed to profit.

5.3 PayBack Period

The payback period is a simple calculation that is used to determine the period of time that the investment costs of the system will be recovered in. The formula used is:

$$\text{Payback Period} = \frac{\text{Investment Costs}}{\text{Annual revenue} - \text{Annual costs}}$$

Since the break-even subscriber cost has been established by the user, the annual revenue can be calculated by multiplying the projected number of subscribers by the subscriber service cost.

This number may be important to investors in the system who want to know when they can expect some type of return on their investment.

5.4 Cash Flow Diagram

The cost/revenue cash flow diagram or simple the cash flow diagram provides a visual analysis of the capital that is being expended and earned for a given system.

Chapter 6
DBSCoMo Development

The actual process of developing the cost and pricing model goes far beyond cost estimating and cost analysis. The steps discussed thus far primarily make up the cost modeling step of the DBSCoMo development as shown in figure 6.1. The DBSCoMo design step consists of subtasks that must be completed before the design phase of the software is competed. These steps will be discussed in section 6.1. The majority of the work that was accomplished in the development of DBSCoMo was performed in the actual implementation of the software. The implementation phase will be discussed in section 6.2. Section 6.3 will discuss the testing phase of DBSCoMo.

The software will be functionally tested to ensure that it performs each of the tasks that are listed in the requirements for the software. If the software does not perform the function as specified, the corresponding component of code will be reviewed and redesigned as needed. A list of the software requirements is included in Appendix C.

6.1 DBSCoMo Design

The design phase of DBSCoMo consisted of all activities that were completed prior to the implementation phase of the software. Having said this, it can also be said that the development of the cost model (CER) should also be included in the design phase. Because the development model used here is so generic, certain activities were grouped together that in a more detailed development model would not have been.

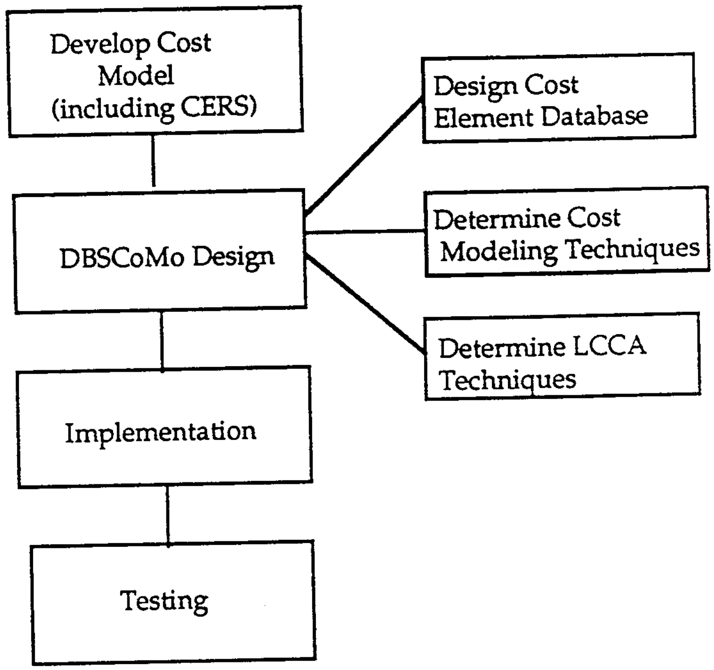


Figure 6.1 DBSCoMo Development Steps

6.1.1 Design Cost Element Database

The database used by DBSCoMo is not like the traditional database. The data is stored in one MS-DOS file, namely, the "Costdata.dat" file. Records in the database can be stored and accessed randomly through the use of the Cost Editor Window (discussed in Chapter 7) in DBSCoMo. The database contains one table whose purpose is twofold: to represent the relationship between the costs (as shown in the Cost Breakdown Structure in Appendix A) of the DBS-V components and to store the attributes of these cost elements. A diagram of the relationships between cost element entities is shown in figure 6.2.

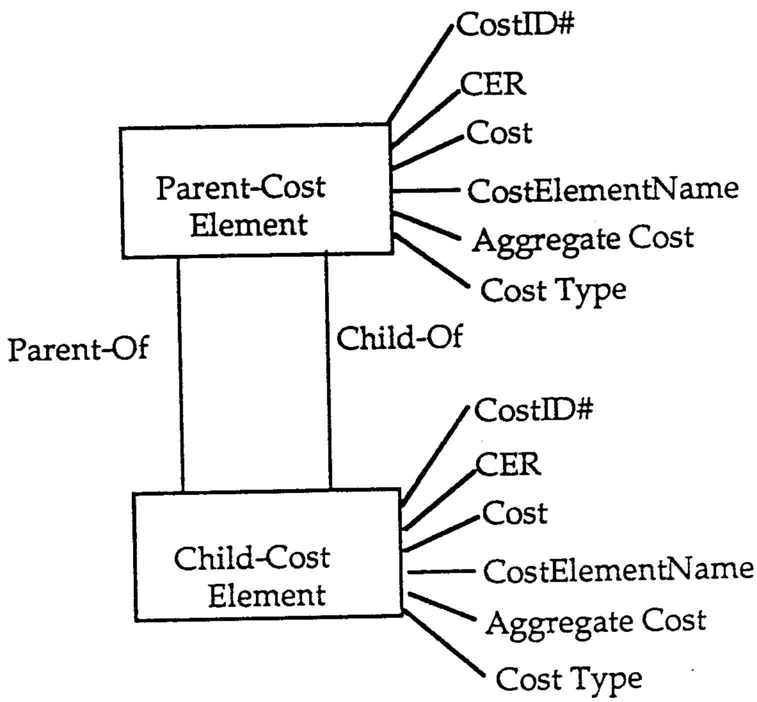


Figure 6.2 Parent-Child Cost Element Relationships

The parent-child relationship is used to breakdown the costs of each of the desired components of the system. The binary relationship (parent-of and child-of) is useful when implementing the cost model. In order to determine the cost of a parent cost element, a query of the database to determine the costs of the child elements is performed. This task could become complex when the cost hierarchy becomes deep.

Each of the attributes of the cost element serves a unique purpose in the determination of the final cost of the system. Each of the attributes will be discussed in sections 6.1.1.1 - 6.1.1.5.

6.1.1.1 CostID#

By using a prescribed numbering scheme (from a CBS), as discussed in section 3.3 , the relation between parent and child can be determined through the use of the CostID#. Each cost element must have a unique CostID#.

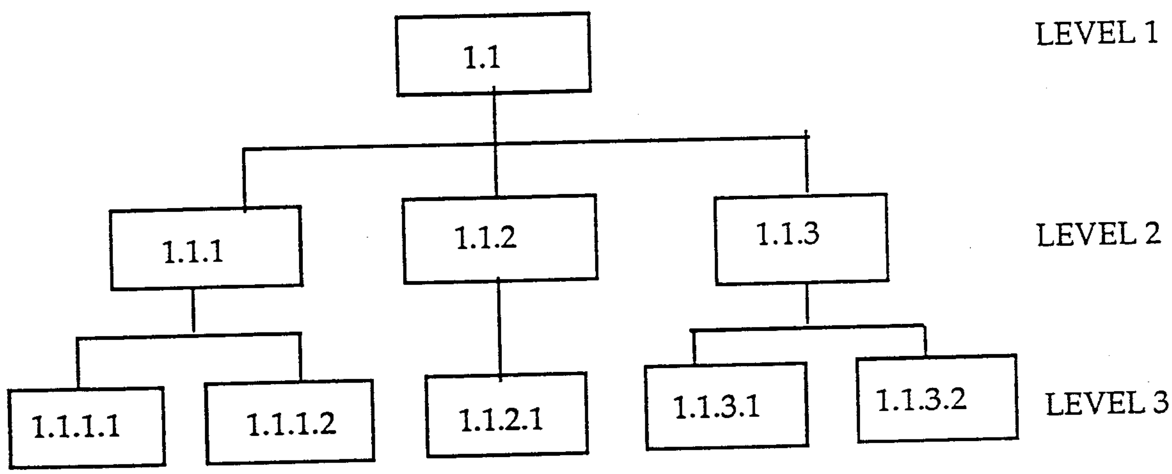


Figure 6.3 The Cost Breakdown Hierarchy

Figure 6.3 shows an example of the numbering scheme of a cost breakdown structure that could be used in the DBSCoMo. The CostID#s that can be used by DBSCoMo should not have the decimal points in order to peform correctly.

To determine the cost of the system shown in figure 6.3, the costs for all of the children will be added from the bottom up. This is the same methodology that will be used in DBSCoMo. An appropriate CBS for the DBS-V system is included in Appendix A.

6.1.1.2 Cost Element Name

The cost element name is not as important as the CostID# in keeping track of a component because two components could very well have the same name. For instance, a TVRO and a VSAT could both have a baseband section that could be named "Baseband." However, the CostID# for each of these components must be different.

The Cost Element Name is just a human way of referring to a component, instead of using a cost identification number.

6.1.1.3 CER

The Cost Estimating Relationship along with the Cost (section 5.1.1.3) are the attributes that are used to determine costs for each component. The CER was discussed in Chapter 5, therefore another discussion will not be presented here. The idea of this attribute is that if the component can be costed in terms of a CER, then the appropriate CER will be stored in this field.

6.1.1.4 Cost

This attribute is self-explanatory. If the component cannot be expressed in terms of a CER, then come directly quoted or handbook cost will be used to cost the component. A component will have either a CER or a cost associated with it, therefore, one of this fields must be filled in, unless, the component is an aggregate component.

6.1.1.5 Aggregate Cost

An aggregate component is one whose cost is determined by the cost of its children. In figure 6.3, the costs of components 1.1, 1.1.1, 1.1.2 and 1.1.3 will be determine by their children, therefore, their cost and CER fields will be left blank and their aggregate field will be populated.

6.1.1.6 Cost Type

The cost type can be one of three types and applies only to operational and maintenance costs (recurring costs). The cost types are: fixed, periodic and gradient.

- Fixed costs are costs that occur annually and are the same value each year. These costs start at year one and end at the design life of the system.
- Periodic costs are recurring, but the do not occur annually. They occur during some period of the design life of the system, for instance every three years. Periodic costs begin at year one and end at the design life of the system. This implies that the design life divided by the period must be an integer.
- The third type of cost, gradients, occur annually staring at year one and ending at the design life of the system. However, the gradient cost increases each year by some fixed amount, this type of cost may be useful for costs that grow as the system matures.

A particular cost may be one and only one of the three types.

6.1.2 Determine Modeling Techniques

The second subtask in the design step is the determination of the modeling techniques. This activity was discussed in detail in Chapters 3 and 4 of this thesis. Having discussed the techniques that are available to the user for cost estimating, the use of any of these techniques were synthesized into the design of the software.

The DBSCoMo Cost Element Database, discussed in section 6.1.1, describes a database that will be used to store the information needed to generate the final cost for the cost model. Once the user has decided on the method that will be used to determine the cost of a component, he or she must enter this information into software, where it will be stored in the Cost Element Database.

6.2 Implementation

Although it was not shown in figure 6.1, the implementation step of the DBSCoMo development process also consisted of subtasks. The development of a satisfactory user interface was of utmost concern when developing the software. Section 6.2.1 will discuss the issues concerning user interface development. A trade off analysis of software to be used to develop of the cost model was performed, although not formal. The software that was decided upon, Microsoft Visual Basic, is discussed in section 6.2.2. The hierarchy of form used in the design of DBSCoMo is described in section 6.2.3. Also included in this section is a brief overview of each of the forms.

6.2.1 Graphical User Interface Design

The design of graphical user interfaces (GUI) has become an important topic in the area of human computer interaction. The most well designed system can be ineffective due to a poorly designed user interface.

A graphical user interface did not have to be used in the development of DBSCoMo, a text based interface could have been easily and less laboriously implemented. However, the art of developing GUI has come to the forefront of computer science. An application software is only as good as it GUI. This statement is extremely true in certain cases and relatively true in others. An air traffic control system with an unusable GUI, could lead to fatalities, if released for commercial use. The DBSCoMo graphical user, if not implemented to strict user interface design rules, will no cause the death of any one, but the useless of the software could be jeopardized. Therefore, a list of rules for developing GUIs (adapted from SOURCES) was strictly adhered to.

The Open Software Foundation suggest guidelines to be used in designing human computer interfaces . They are:

- Adopt the user's perspective
- Give the user control
- Use real-world metaphors
- Keep interfaces natural
- Communicate application actions to the user.
- Avoid common design pitfalls.

6.2.2 Microsoft Visual Basic

DBSCoMo was developed using Microsoft Visual Basic Version 1.0. The software was decided upon because of its "object-oriented" nature and its ease of implementation. Visual Basic is an Application Generator software that can be used to create Microsoft Windows Applications. Visual Basic projects consist of two basic components: forms and controls. Forms are the actual generic windows and the controls are any elements that are used on the window to create the application (i.e. buttons, labels, text boxes, etc.) In addition to the forms and controls, Visual Basic requires that code be written in Quick BASIC to control the sequencing of windows and the flow of the code.

Further discussion of this software is beyond the scope of this paper.

6.2.3 DBSCoMo Forms Hierarchy

The forms that were used to develop DBSCoMo are shown in figure 6.4. The vertical flow of the forms determines that order that the forms will be viewed in is shown.

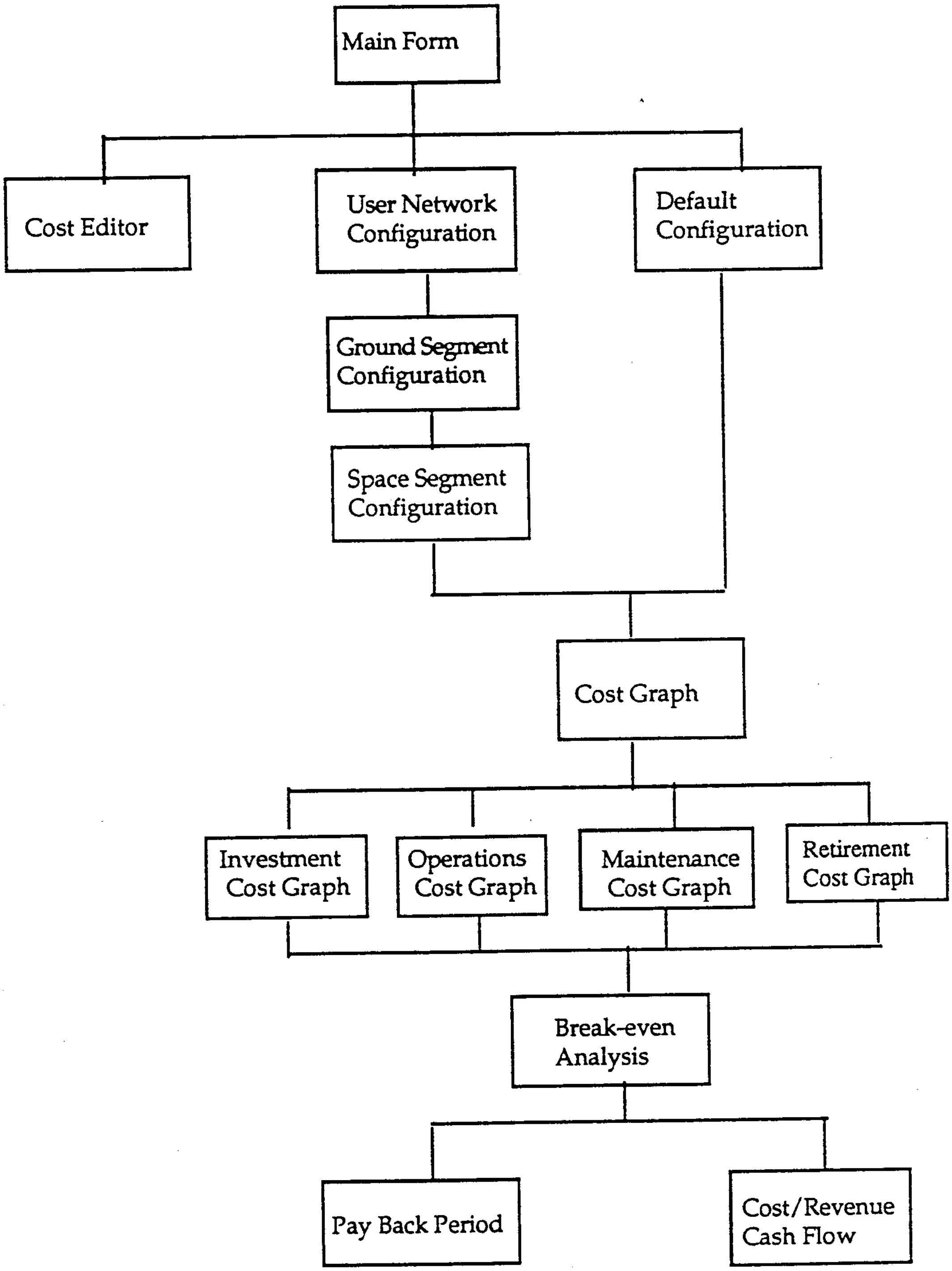


Figure 6.4 DBSCoMo Form Usage

- The main form provides a means by which the user can either enter a satellite network configuration, use the default network configuration or edit the cost element database.
- The Cost Editor Form allows the user to enter the CBS configuration using the format discussed in section 5.1.1. These components will the be used in determining the cost of the DBS-V system Components can be deleted, modified and added through this form. Before the software can be used, the cost element database must be populated through the use of this form.
- If the user chooses the Default Configuration Form, then a set DBS-V configuration will be used in the running of the software.
- The User Network Configuration Form allows the user to enter the desired network configuration from a list of available components. This configuration will then be used to run the software.
- The Cost Graph Form is the first place that the user gets to see what costs have been incurred through the use of the chosen configuration. The Investment, Operations, Maintenance and Retirement costs for the system are shown here in a graphical format. The components that make up the highest costs for these major components will be shown. Furthermore, the parameters that make up the costs for these highest cost components will be shown and the user has the opportunity to edit their values and recalculate the system costs.
- The Investment, Operations, Maintenance and Maintenance Cost Graphs further divide the costs of each of these major components into their highest cost subcomponents.
- Break-even Analysis Form allows the user to enter such information as applicable interest rates and projected number of subscribers for each year of operation. This projected number of subscribers information will be used by

the payback period and the cost/revenue forms. The software will be calculate the break-even number of subscribers.

- The Payback Period Form will be used to calculate the number of years (if any) that the system can be expected to bring in a return on the investment.
- The Cash Flow Form shows the cash flow for the system throughout the system design life.

Chapter 7
Sample Use of DBSCoMo

This chapter will show how DBSCoMo can be used to obtain cost and pricing information about a default satellite configuration or a network configuration that is submitted by the user. The flow of this chapter is configured in such as matter that this chapter may also serve as a user manual for DBSCoMo.

Before the sample use is presented, however, some assumptions have been made about the user of this software. The first assumption is that the user is familiar with the basics of using Microsoft Windows™. This means that the user is knowledgeable about the use of:

- pull-down menus
- single clicking
- double clicking
- check boxes
- option boxes
- The use of the "Alt" key to access pull down menu items and buttons shown with an underscored character "_".

There is also an assumption that the satellite network configuration that is being entered by the user is a viable configuration and the parameters values being entered can perform the DBS-V service.

The final assumption is that the user is knowledgeable in the parameters values and configuration of DBS-V satellite systems.

In the previous chapter, the flow of DBSCoMo was shown in the form of an hierarchical structure composed of forms. In this chapter, the forms that were previously presented will be referred to as windows (since the software flow is being discussed).

7.1 Main Window

When DBSCoMo is started up the screen shown in figure 7.1 is shown. At this screen, the user has five choices that are available from the four pull down menus shown.

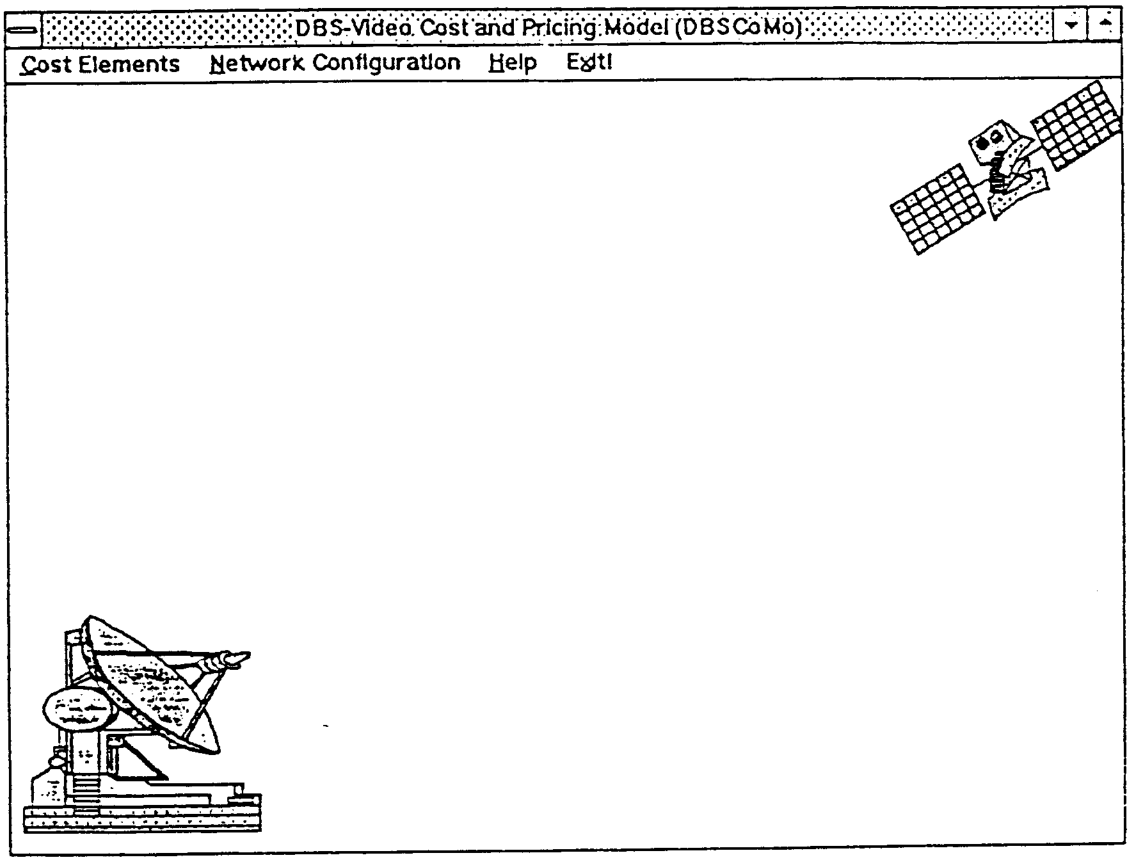


Figure 7.1 Main Window

If the user selects either of the following menus options, then the proceded action window is skipped:

- Edit Cost Elements ---> Cost Editor Window
- Network Configuration:

  Use Default Configuration --->Default Network Configuration Window

  Enter Configuration ---> User Network Configuration Window
- Help - provides a help screen about the use of the DBSCoMo software
- Exit - exits the system

7.2 Default Network Configuration Window

This window, shown in figure 7.2, allows the user to use a default configuration, that represents the minimal number of DBS-V broadcasting components needed to provide the service and to run the DBSCoMo software.

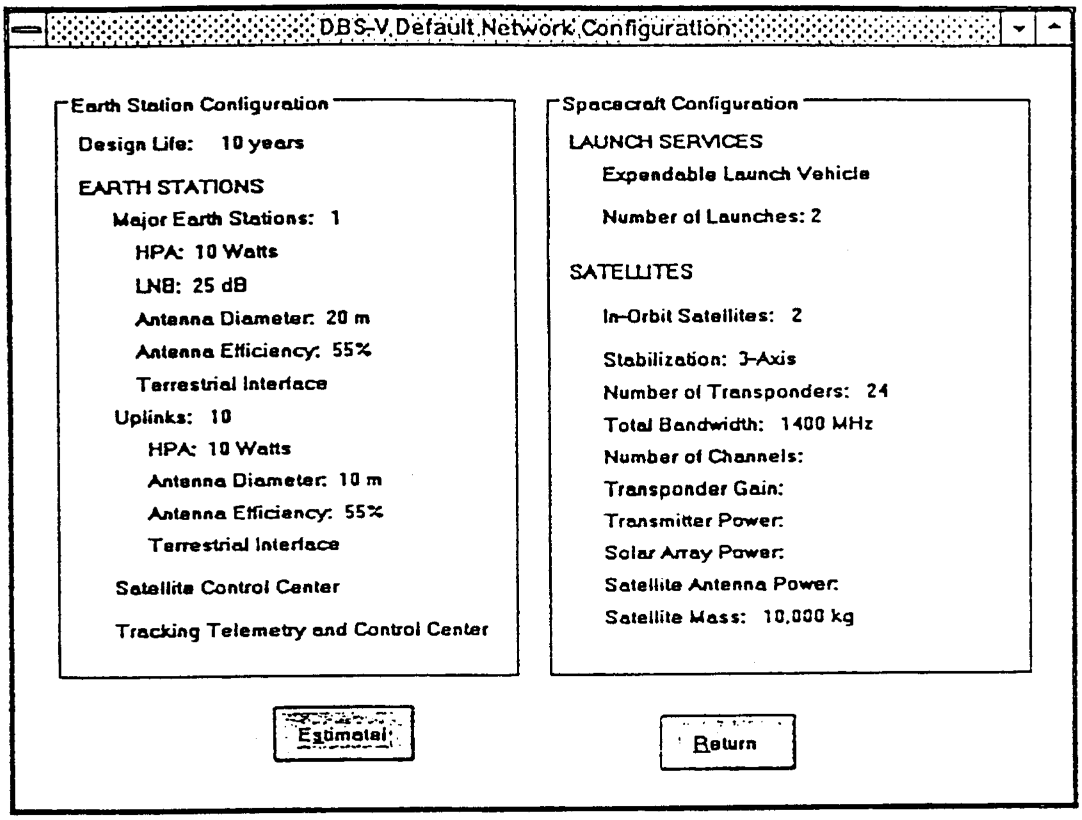


Figure 7.2 Default Network Configuration Window

The parameters that are shown for each major component (i.e. EARTH STATIONS and SATELLITES) represent the parameters that constitute the cost for each of these components.

If the user clicks on the Estimate Button, the Cost Breakdown Graph window is show.

If the user clicks on the Return button, the Main window is shown.

7.3 User Network Configuration Window

The function of this window is similar to that of the Default Network Configuration window in that the satellite network configuration is being set up here. In this window, however the user is allowed to enter the desired quantities and parameters that were pre-chosen in the "default" section.

The screen to appear when "user configuration" is chosen from the Main window is shown in figure 7.3.

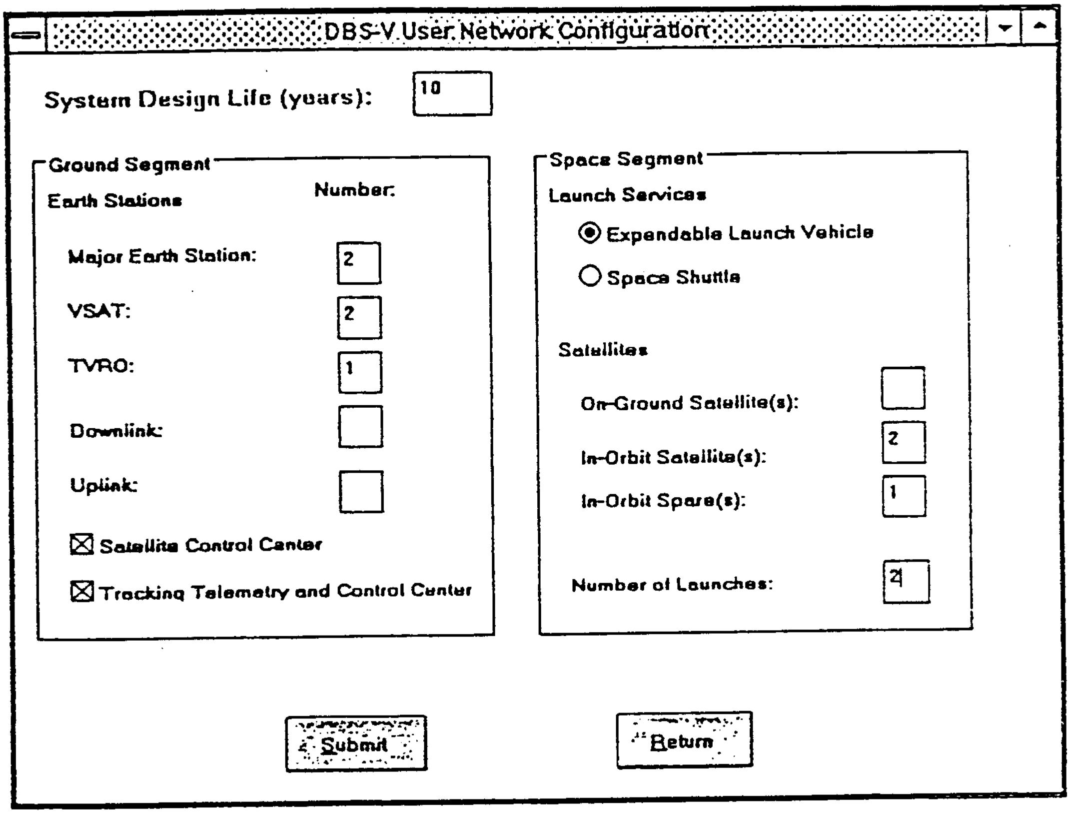


Figure 7.3 User Network Configuration Window

Here the user must supply general information about the type of network that is being set up. The system design life, number of each particular earth station, number of launches and number of satellites in orbit, on-ground or in-orbit spare require numerical values. The launch service type: expendable launch vehicle or space shuttle must be chosen. If the user desires to have a SCC or a TT&C station accounted for in the network, then these items must be checked.

If the user clicks on the submit button, the Earth Station Configuration window is shown.

If the user clicks on the Return Button, the Main window is shown.

7.4 Earth Station Configuration Window

For each type of earth station that the user choses on the User Network Configuration window, the Earth Station Configuration window (shown in figure 7.4) will be shown with the type of earth station being configured at the top of the window. The parameters for an earth station that need a value in order to run this software is shown in the Radio Frequency (RF) Box in this window.

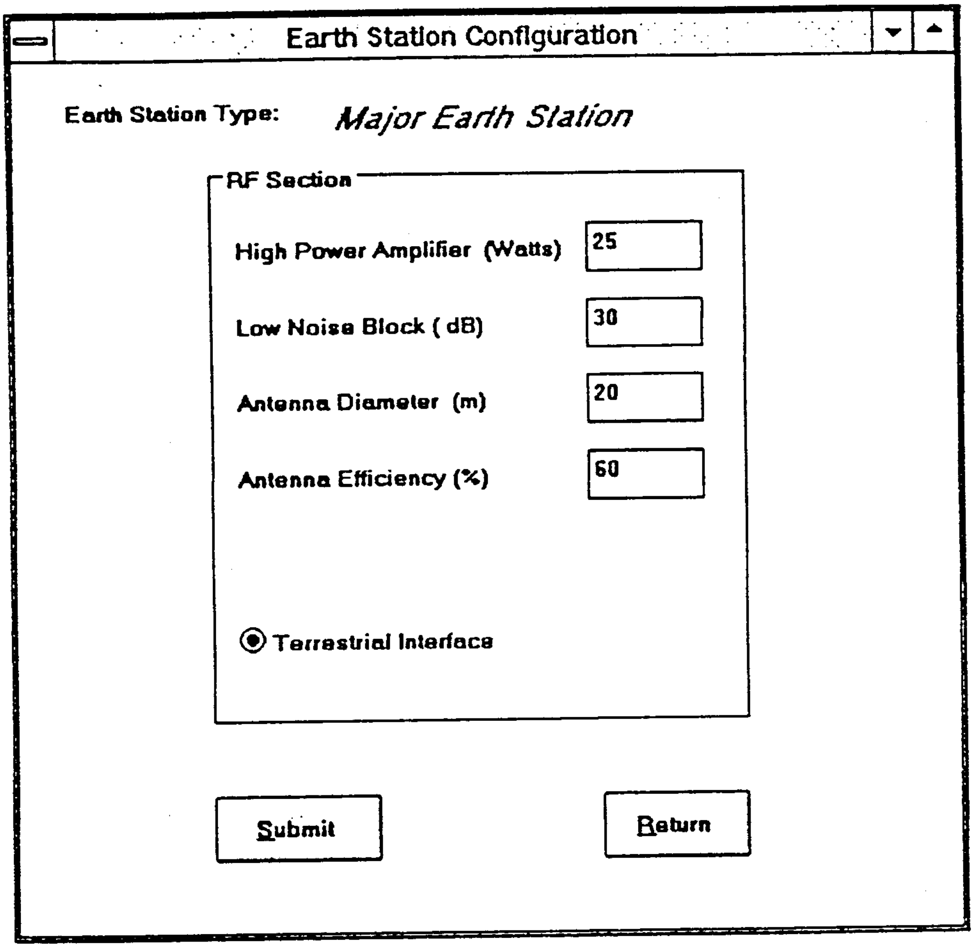


Figure 7.4 Earth Station Configuration Window

If the user requires that the particular earth station being configured have a terrestrial interface, then the terrestrial interface option must be selected.

Once the user has configured a particular earth station, the next earth station that needs to be configured will be shown. The same configuration is assumed for all earth station of a particular type.

If the user clicks on the Submit button, then the Satellite Configuration window will be shown, else if the user clicks the Return button, then the User Network Configuration window will be reshown.

7.5 Satellite Configuration Window

The satellite configuration window shown in figure 7.5 allows the user to configure the satellite(s) that were chosen in the User Network Configuration window.

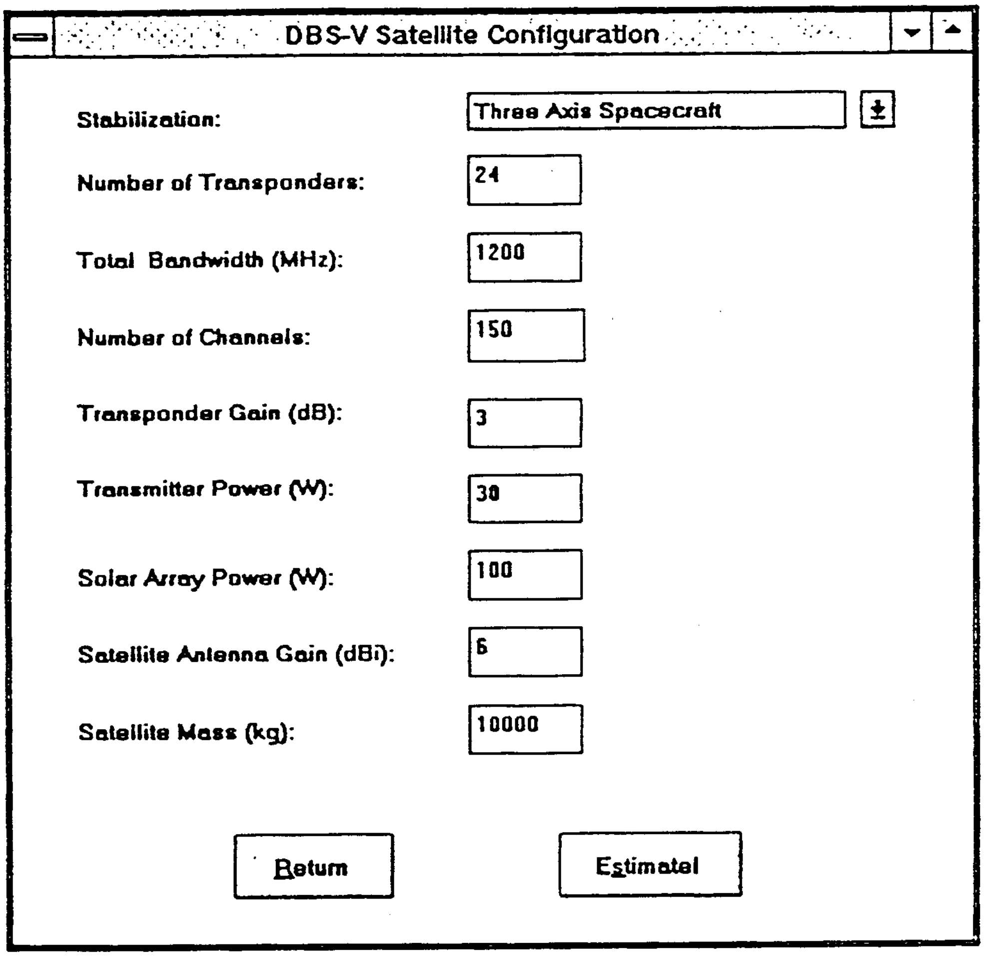


Figure 7.5 Satellite Configuration Window

If the user clicks on the Return button, the Earth Station Configuration window will be shown.

If the user clicks the Estimate button, the Cost Breakdown Graph window will be shown.

7.6 Cost Graph Breakdown Window

The Cost Graph window, in figure 7.6, shows the Investment, Maintenance, Operations and Maintenance cost of the chosen satellite network configuration.

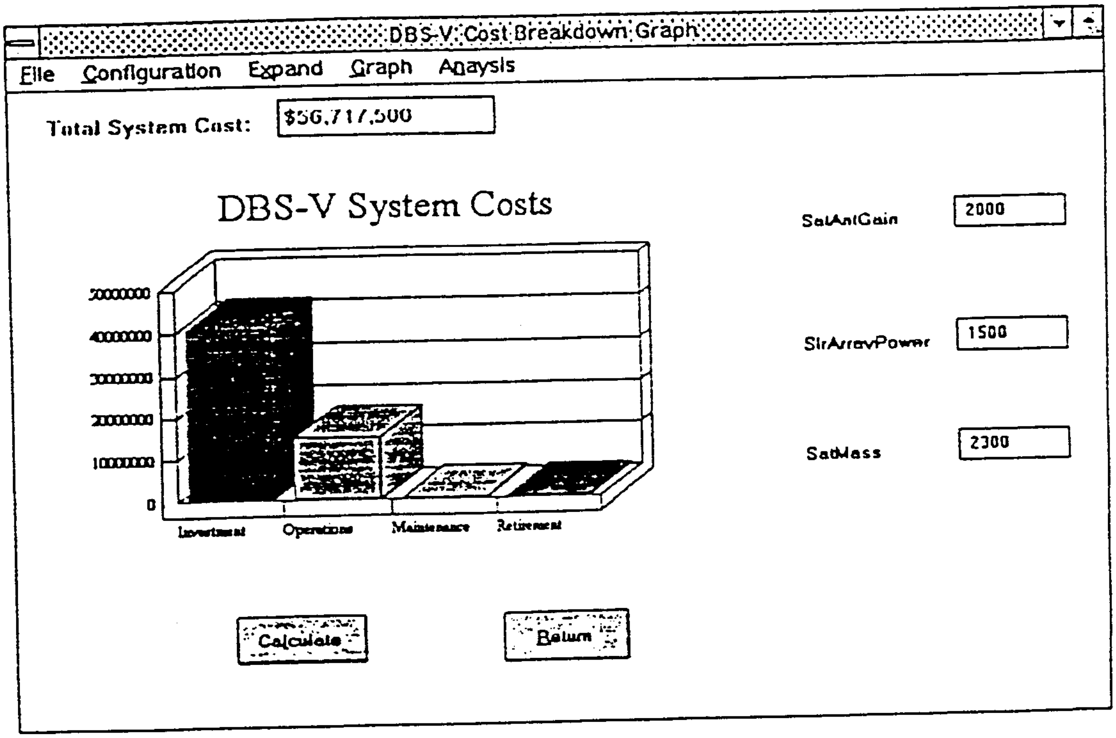


Figure 7.6 Cost Graph Breakdown Window

The total cost of the system is shown above the graph. The labels shown to the right of the graph indicate the parameters that contribute to costs that make up the highest costs of the system. For example, on the graph, the Satellite Antenna Gain (SatAntGain) parameter is contributing the most to the largest cost in the system, probably to the investment cost, but not necessarily. In order to lower the cost of this system and particularly the investment costs, this value should be the first to be lowered.

To lower the cost of the system, the number in the text box to the right of a label should be edited. Once the number has been changed, the Calculated button should be clicked. The new system cost graph will be shown along with the new total system cost. Up to the four highest cost-contributing parameters will be shown at a time.

The user also has eleven choices available from the five pull down menus shown.

- File

  Copy! - copies the graph shown to the clipboard

- Configuration

  Edit Configuration (if the user used the default configuration to obtain this graph, then a message will appear to ask the user if he/she would like to enter their own configuration, if so, the User Network Configuration window will appear, else the Cost Graph window will reappear. If the user had entered their own configuration, the User network Configuration window will be shown.)

- Expand - the cost shown in the given graph will be expanded to show costs for major sub-components such as:

  Investment Costs Graph window

  Operations Cost Graph window

  Maintenance Cost Graph window

  Retirement Costs Graph window

  (A figure for each of these windows will not be given.)

- Graph - here the user has the choice of redrawing the shown 3-D bar chart as:

  2-D Bar Chart

  3-D Bar Chart (default)

  2-D Pie Chart

3-D Pie Chart

- Break Even Analysis ---> Break Even Analysis window

If the user clicks on the Return button, the appropriate network configuration will be shown. This depends on the type of configuration that user entered previously.

7.7 Break Even Analysis Window

The Break Even Analysis window, shown in figure 7.7, calculates the price (to the customer) at which the configured DBS-V system can be provided and have the revenues and costs generated by the system break even. This calculation require that the user enter the number of projected subscribers for each year of the design life of the system and the interest rate at which the money should be discounted.

In order to calculate this number, the projected number of subscribers should be entered along with the interest rate and the Calculate button clicked. The resulting subscriber cost shown at the bottom of the left column in the window, is the lowest value that the service provider can offer the service at and break even. If the service provider decides to offer the service at a cost higher than that shown, then these moneys can be attributed to profit from the system.

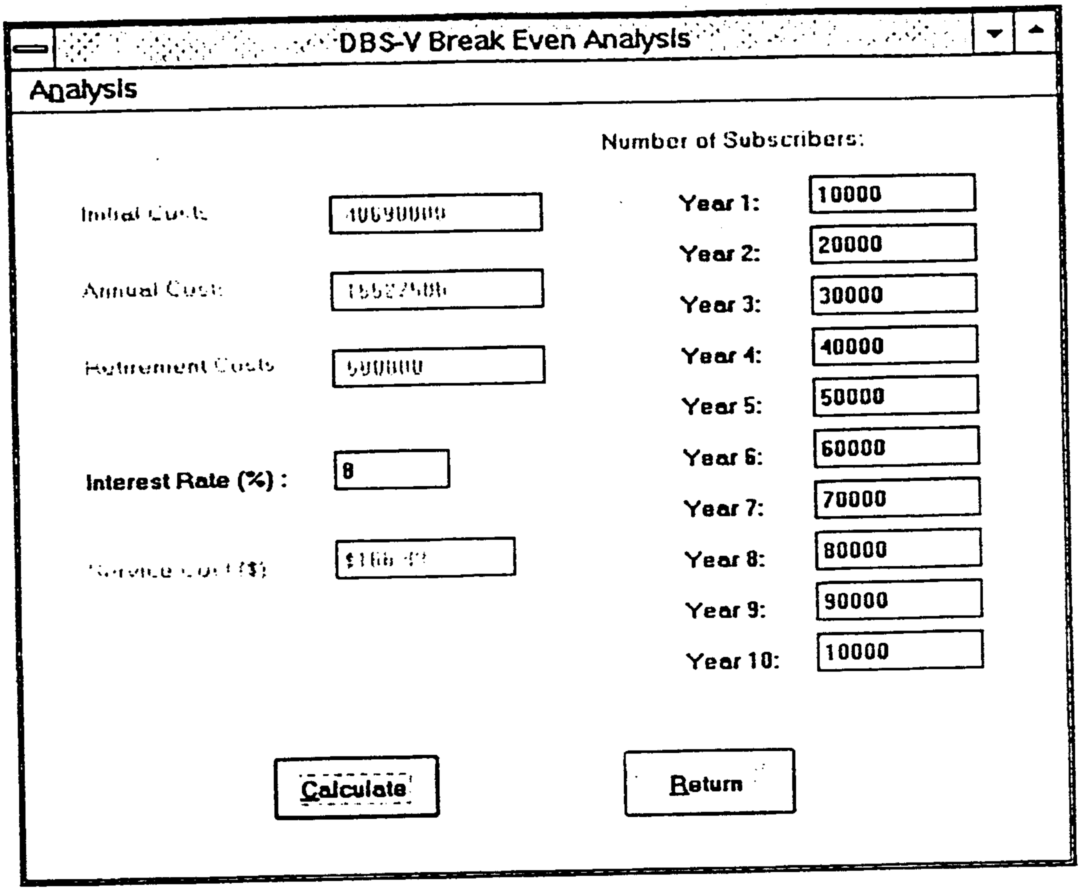


Figure 7.7 Break Even Analysis Window

Once this number is found, further analysis can be performed by selecting either Payback Period or Cash Flow from the Analysis pull down menu. If either of these functions are selected, the user will be prompted for the subscriber cost that he/she wishes to charge for the service for a years worth of service. This input window is shown in figure 7.8

If the Return button is clicked, the Cost Breakdown Graph is shown.

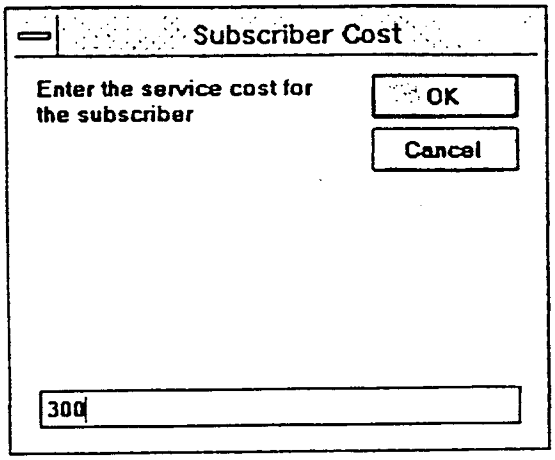


Figure 7.8 Subscriber Cost

If the user choses PayBack period from the "Analysis" pull-down menu, then the subscriber cost would be prompted for. The user will be shown the window shown in figure 7.9 that states the number of years (if any), that the given satellite network would be expected to recover , the cost of investing in the service.

Figure 7.9 shows that the particular system configured by the user, in this example, will expect a payback period of 4.07 years, given a subscriber cost of $300/year.

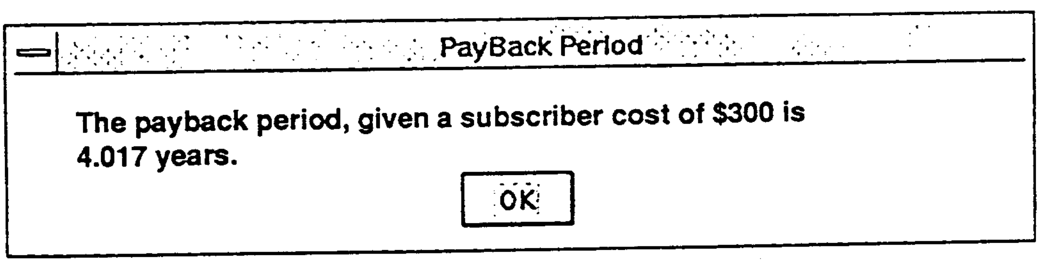


Figure 7.9 PayBack Period

7.8 Cash Flow Window

The cash flow window, shown in figure 7.10, does not provide any additional information about the cost of the system, however, it does show a time line of the cost and revenues that are in the system. In the diagram, the time value on money has not been take into account. This window serves to show the user in terms of today's dollars, the monies that are expected from the system throughout the system design life.

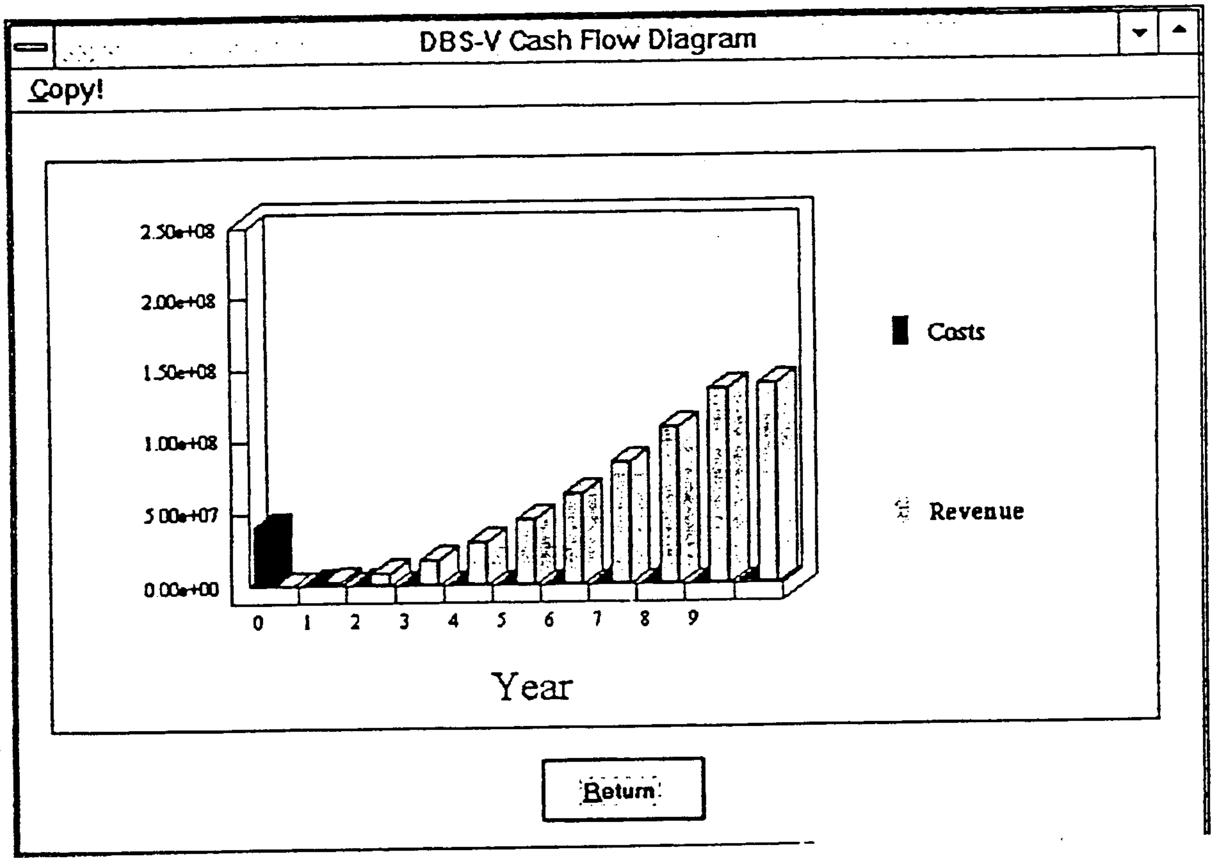


Figure 7.10 Cash Flow Diagram

7.9 Cost Element Editor Window

The Cost Element Editor window shown in figure 7.11, provides the most important function of the DBSCoMo software. The data stored for each component in the DBS-V system was discussed in chapter 6, so it will not be discussed again here.

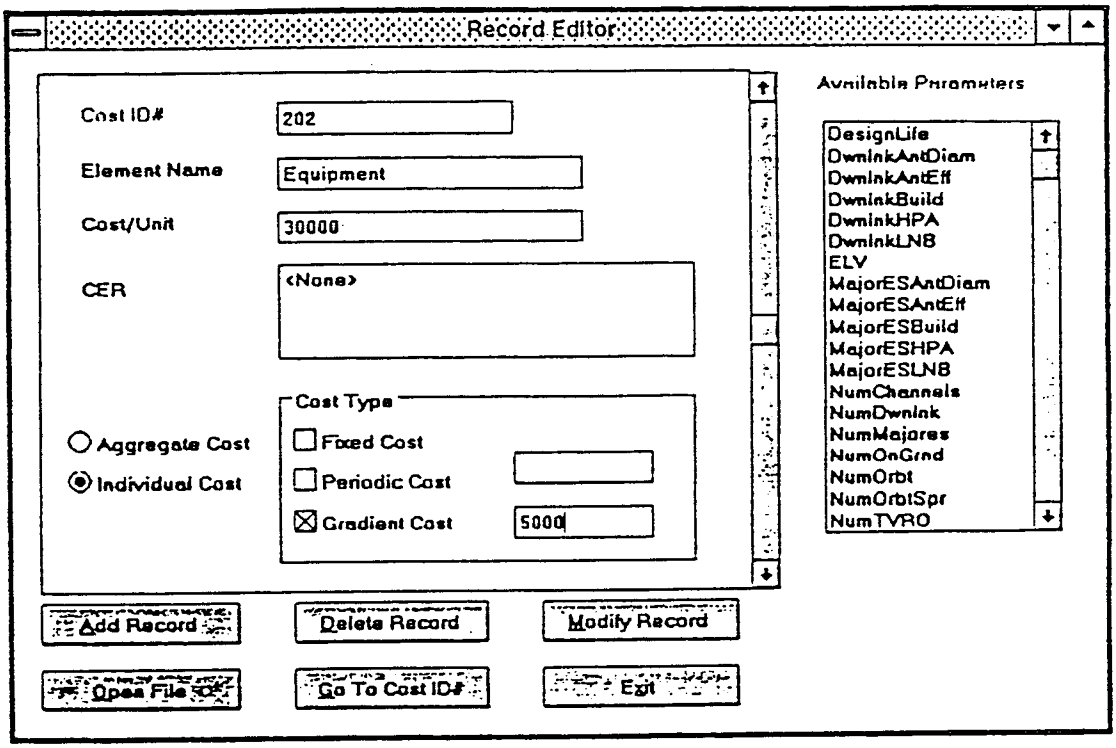


Figure 7.11 Cost Element Record Editor

The available parameter list, shown at the right of the window, contains all and the only system parameters that will be recognized by the software as valid parameters. It is up to the user to select the appropriate parameter, when entering a CER, in order to run the software. In order to choose a parameter from the list, simply click on the name of the parameter and it will be shown at the end of the currently shown text stream in the CER text box.

The buttons at the bottom of the window allow the user to perform various functions listed below:

- Add Record - adds a Cost Element Record to the database
- Delete Record - deletes the currently shown record from the database
- Modify Record-modifies the currently shown record to the specifications entered by the user.
- Open File - the default data file is "Costdata.dat", another file can be opened up to store the cost data in.
- GoTo Cost ID# - prompts the user for the CostID# and jumps to that record in the database.
- Exit - closes the Cost Element Editor window.

Chapter 8
Conclusion

Investing in the Direct Broadcast Satellite-Video service is risky business. One of the major risks involved in the DBS-V service is investment cost of the system. By using DBSCoMo, potential service providers can identify this risk and assess it.

With the help of DBSCoMo, this risk can be accessed through the use of a user-friendly decision aid that allows users to enter potentially any costing hierarchy and obtain costs such as a break even subscriber service charge and a payback period.

This decision support system (aid) should provide users with a robust means by which to determine the costs associated with the DBS-V service.

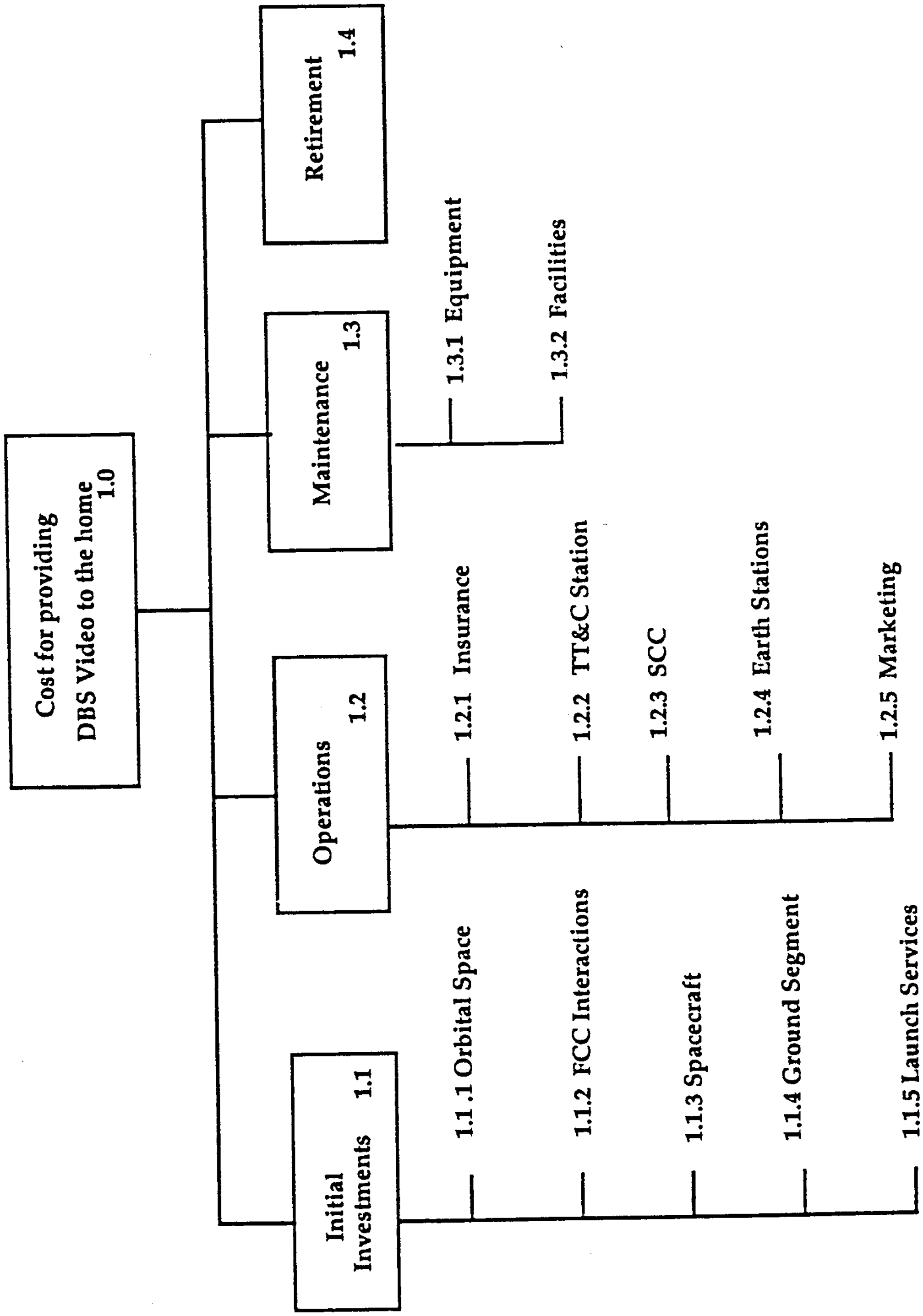
8.1 Future Research

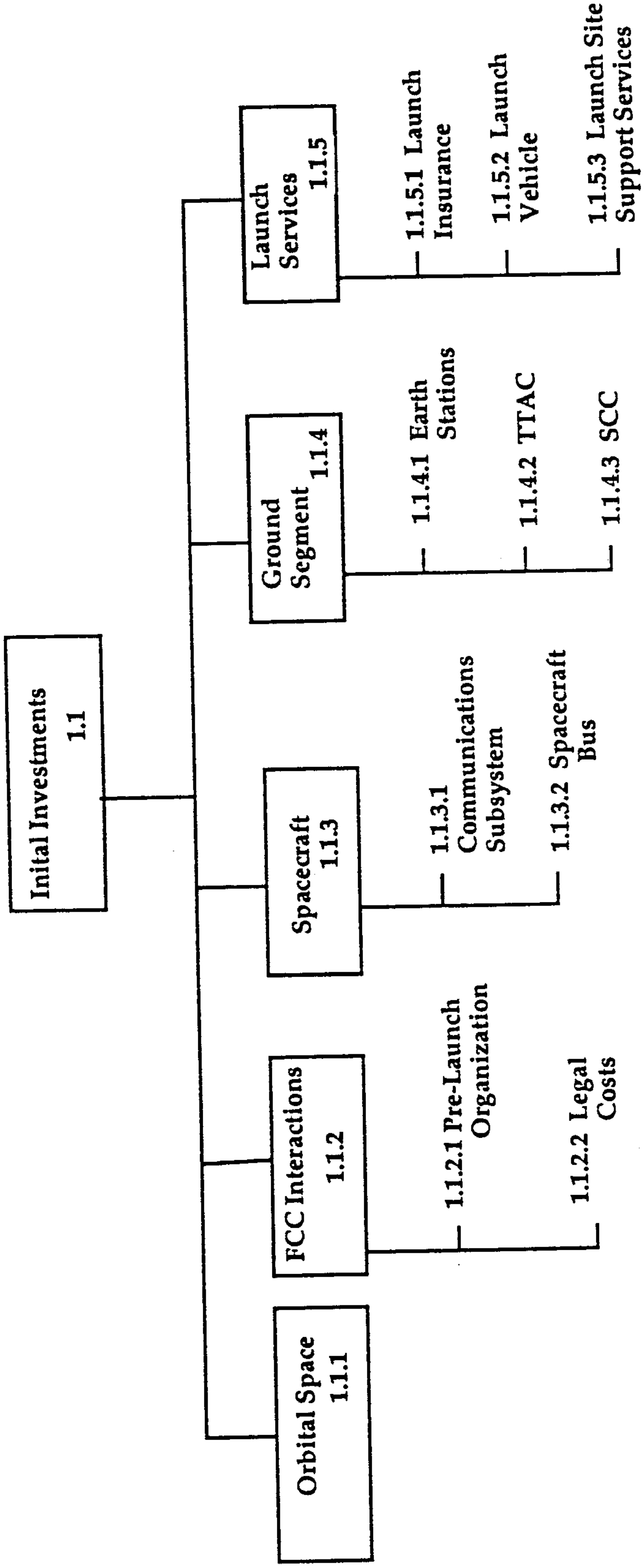
Future improvements to the system should include a larger database which can accommodate more detailed and richer cost models for the various components and subcomponents of a DBS-V system. In addition, an expert system should be further developed to assist in cost assessments and in particular with changing technologies and/or sizes of components.

The system should also be improved by including service and maintenance of the DBS-V system as part of the business life cycle. This will change, somewhat, the cost hierarchy and structure.

Finally, experimentation with the system and population with realistic data will lead to a more effective tool.

APPENDIX A
Cost Breakdown Structure

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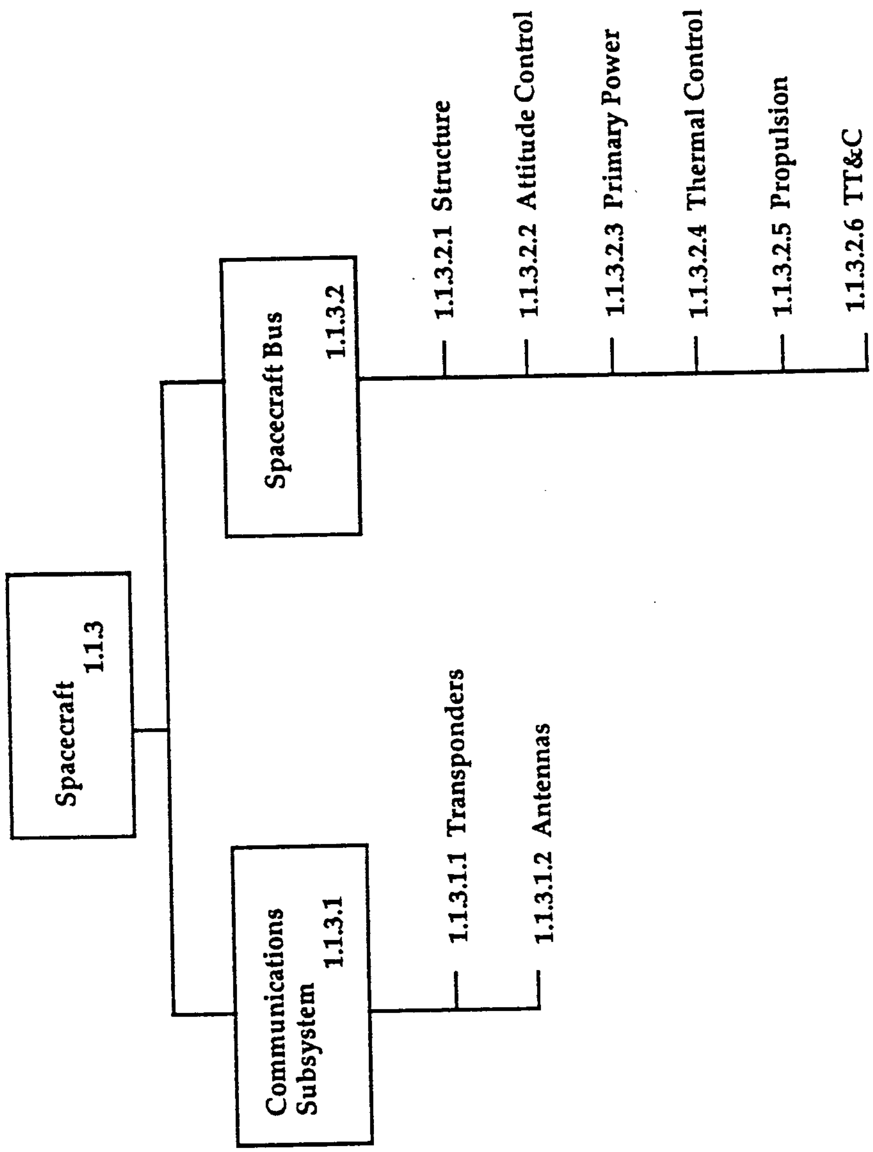
Orbital Space
1.1.1
FCC Interactions
1.1.2
1.1.2.1 Pre-Launch Organization
1.1.2.2 Legal Costs
Spacecraft
1.1.3
1.1.3.1 Communications Subsystem
1.1.3.2 Spacecraft Bus
Ground Segment
1.1.4
1.1.4.1 Earth Stations
1.1.4.2 TTAC
1.1.4.3 SCC
Launch Services
1.1.5
1.1.5.1 Launch Insurance
1.1.5.2 Launch Vehicle
1.1.5.3 Launch Site Support Services



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Communications Subsystem 1.1.3.1
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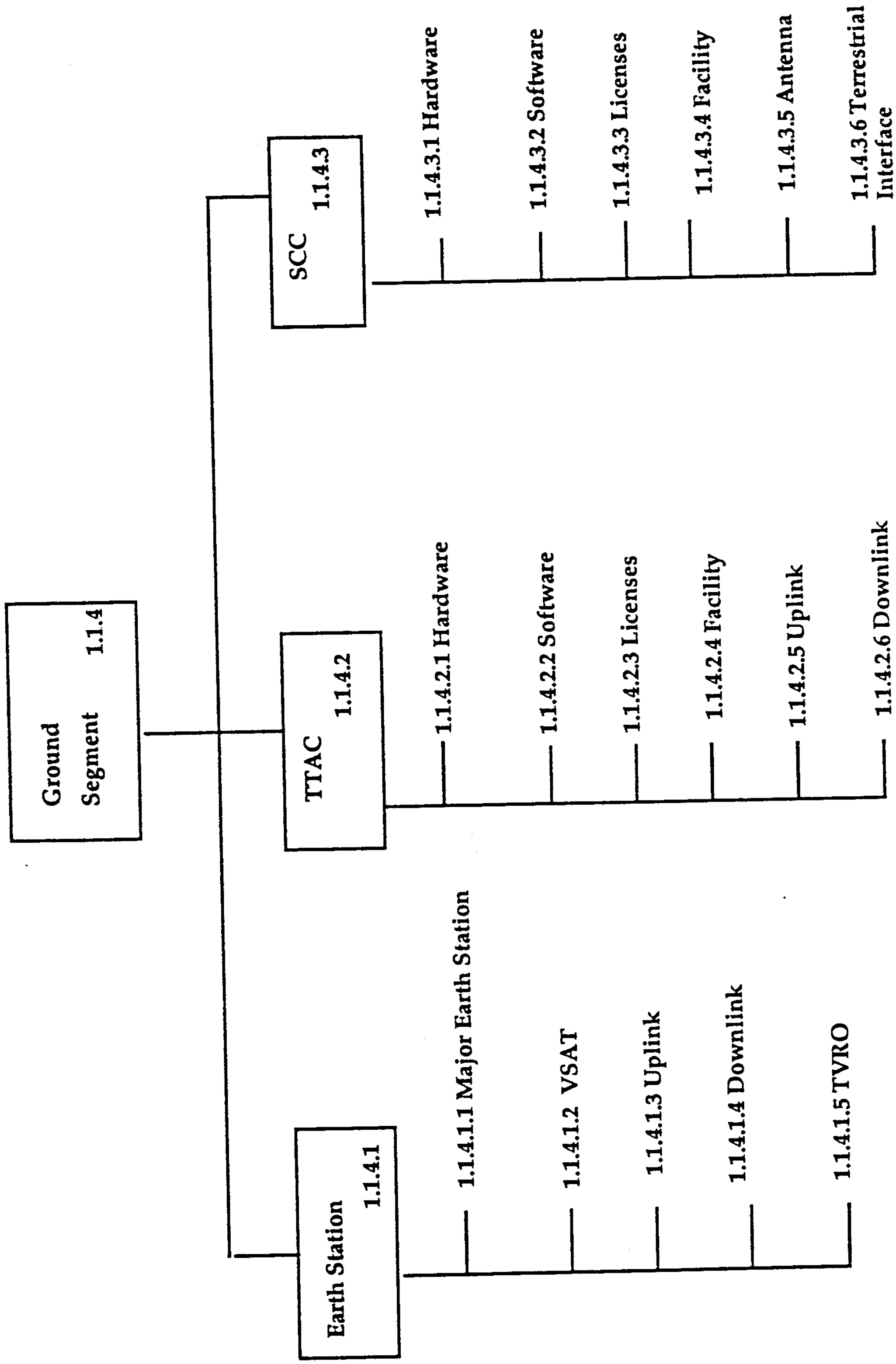
1.1.3.1.2 Antennas
Spacecraft Bus 1.1.3.2
1.1.3.2.1 Structure
1.1.3.2.2 Attitude Control
1.1.3.2.3 Primary Power
1.1.3.2.4 Thermal Control
1.1.3.2.5 Propulsion
1.1.3.2.6 TT&C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TTAC 1.1.4.2
SCC 1.1.4.3
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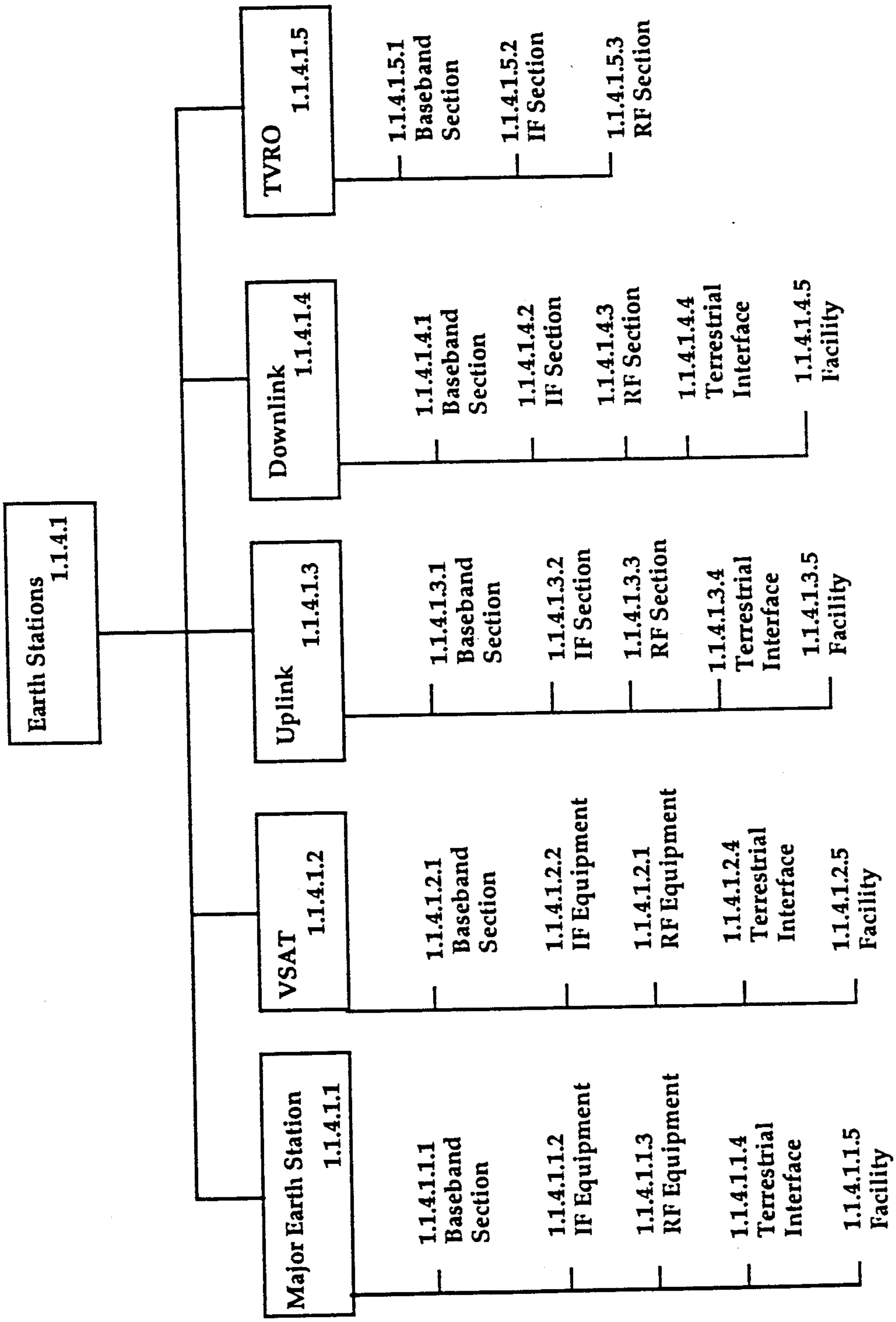
1.1.4.1.2 VSAT
1.1.4.1.3 Uplink
1.1.4.1.4 Downlink
1.1.4.1.5 TVRO
1.1.4.2.1 Hardware
1.1.4.2.2 Software
1.1.4.2.3 Licenses
1.1.4.2.4 Facility
1.1.4.2.5 Uplink
1.1.4.2.6 Downlink
1.1.4.3.1 Hardware
1.1.4.3.2 Software
1.1.4.3.3 Licenses
1.1.4.3.4 Facility
1.1.4.3.5 Antenna
1.1.4.3.6 Terrestrial Interface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1.1.4.1.1.3 RF Equipment
1.1.4.1.1.4 Terrestrial Interface
1.1.4.1.1.5 Facility
VSAT 1.1.4.1.2
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1.1.4.1.2.2 IF Equipment
1.1.4.1.2.1 RF Equipment
1.1.4.1.2.4 Terrestrial Interface
1.1.4.1.2.5 Facility
Uplink 1.1.4.1.3
1.1.4.1.3.1 Baseband Section
1.1.4.1.3.2 IF Section
1.1.4.1.3.3 RF Section
1.1.4.1.3.4 Terrestrial Interface
1.1.4.1.3.5 Facility
Downlink 1.1.4.1.4
1.1.4.1.4.1 Baseband Section
1.1.4.1.4.2 IF Section
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1.1.4.1.4.5 Facility
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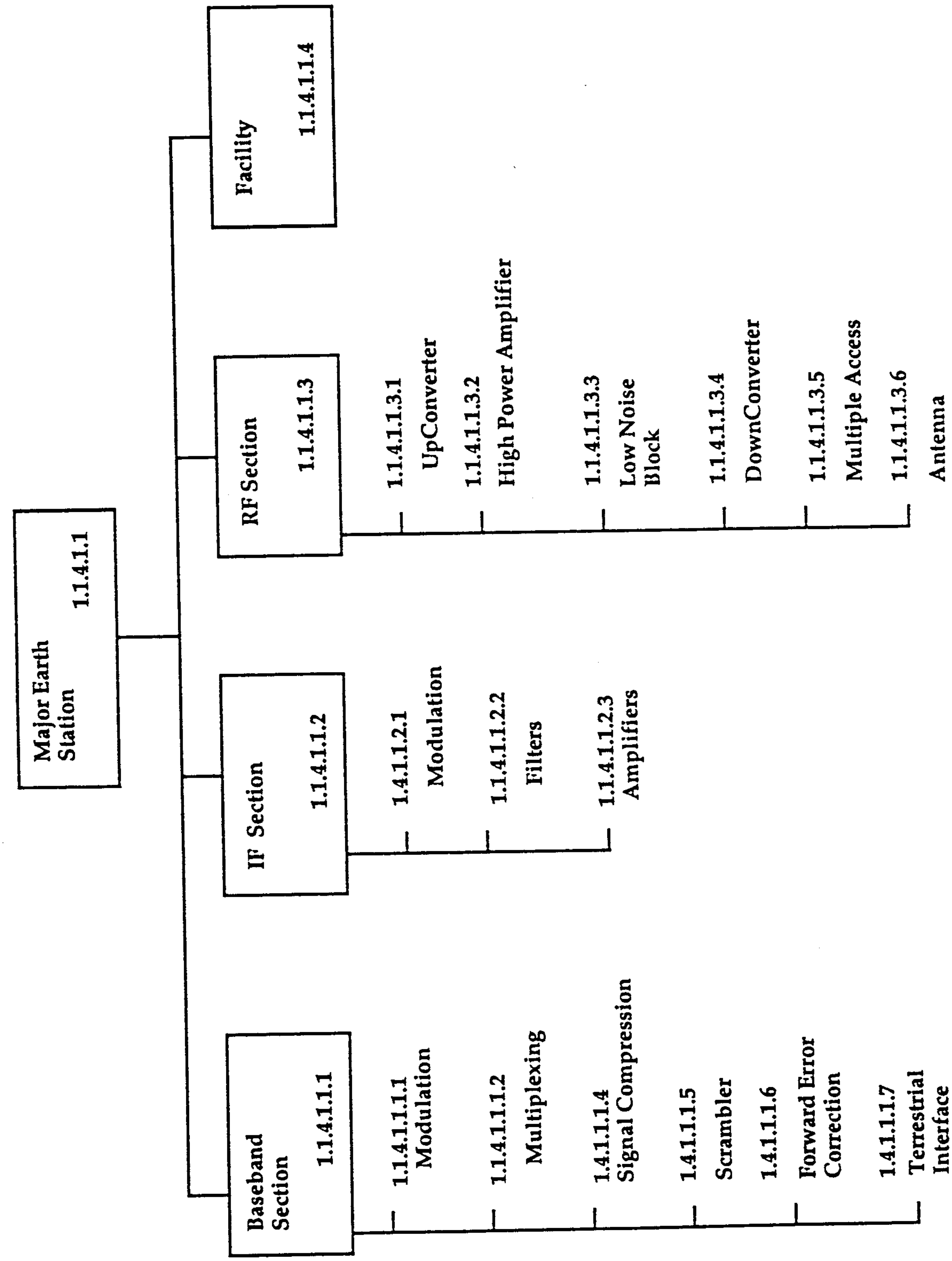
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RF Section 1.1.4.1.1.3
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1.1.4.1.1.1.2 Multiplexing
1.4.1.1.1.4 Signal Compression
1.4.1.1.1.5 Scrambler
1.4.1.1.1.6 Forward Error Correction
1.4.1.1.1.7 Terrestrial Interface
1.4.1.1.2.1 Modulation
1.1.4.1.1.2.2 Filters
1.1.4.1.1.2.3 Amplifiers
1.1.4.1.1.3.1 UpConverter
1.1.4.1.1.3.2 High Power Amplifier
1.1.4.1.1.3.3 Low Noise Block
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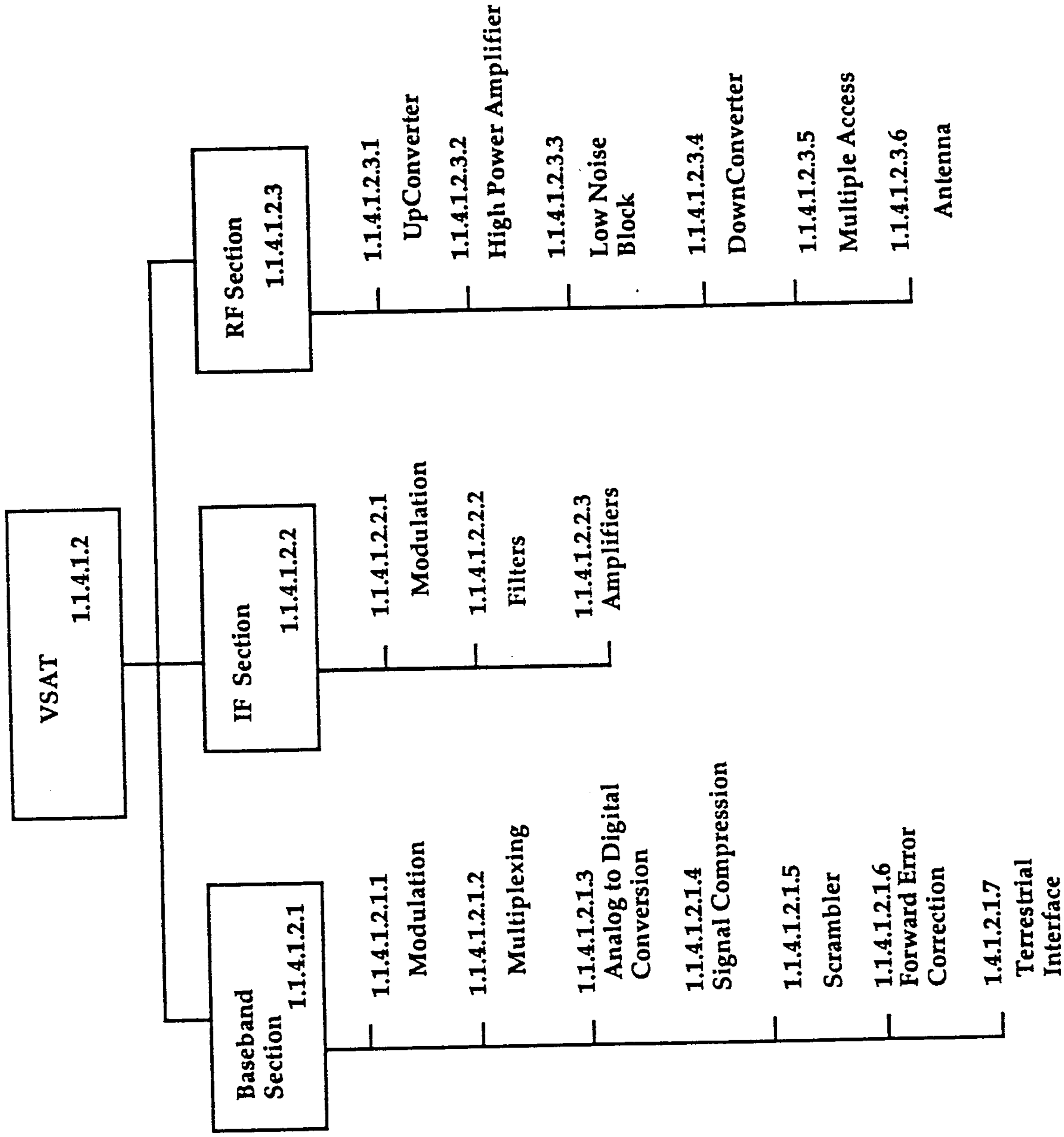
1.1.4.1.1.3.5 Multiple Access
1.1.4.1.1.3.6 Antenna



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RF Section
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Modulation
1.1.4.1.2.1.2
Multiplexing
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Signal Compression
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Scrambler
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Forward Error Correction
1.4.1.2.1.7
Terrestrial Interface
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Modulation
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Filters
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Amplifiers
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UpConverter
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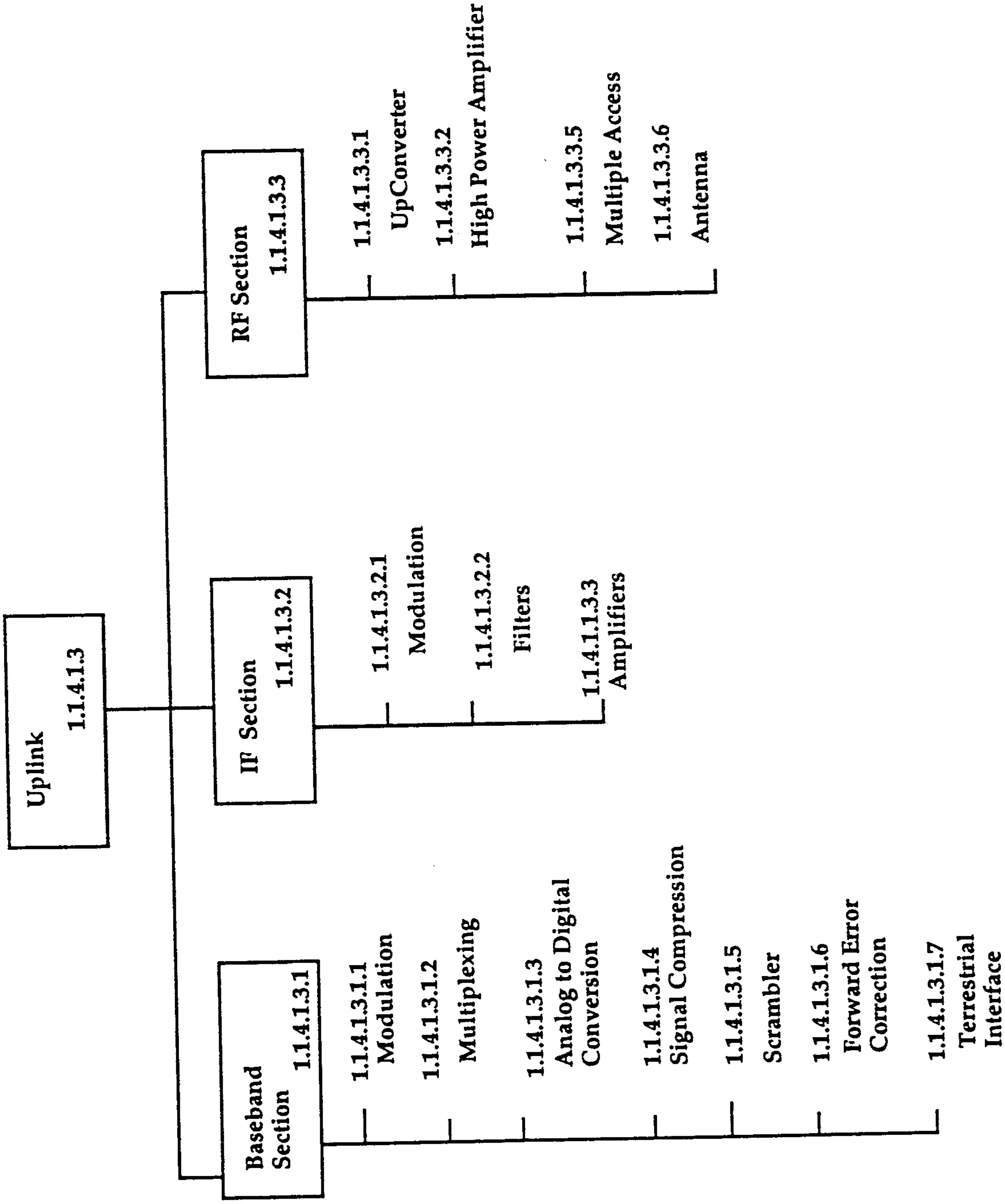
Antenna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UpConverter
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High Power Amplifier
1.1.4.1.3.3.5
Multiple Access
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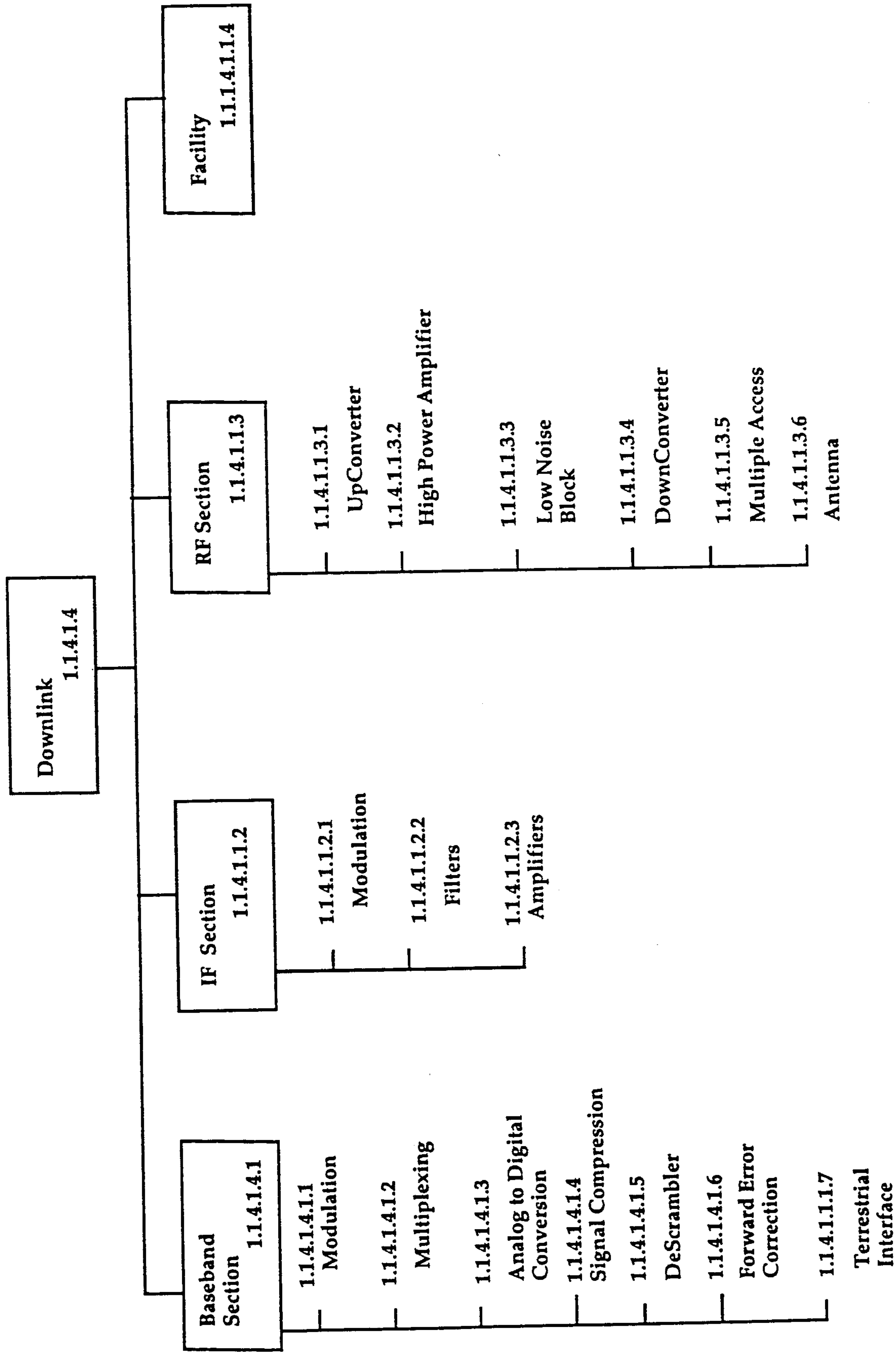
Antenna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Multiple Access
1.1.4.1.1.3.6
Antenna
Facility
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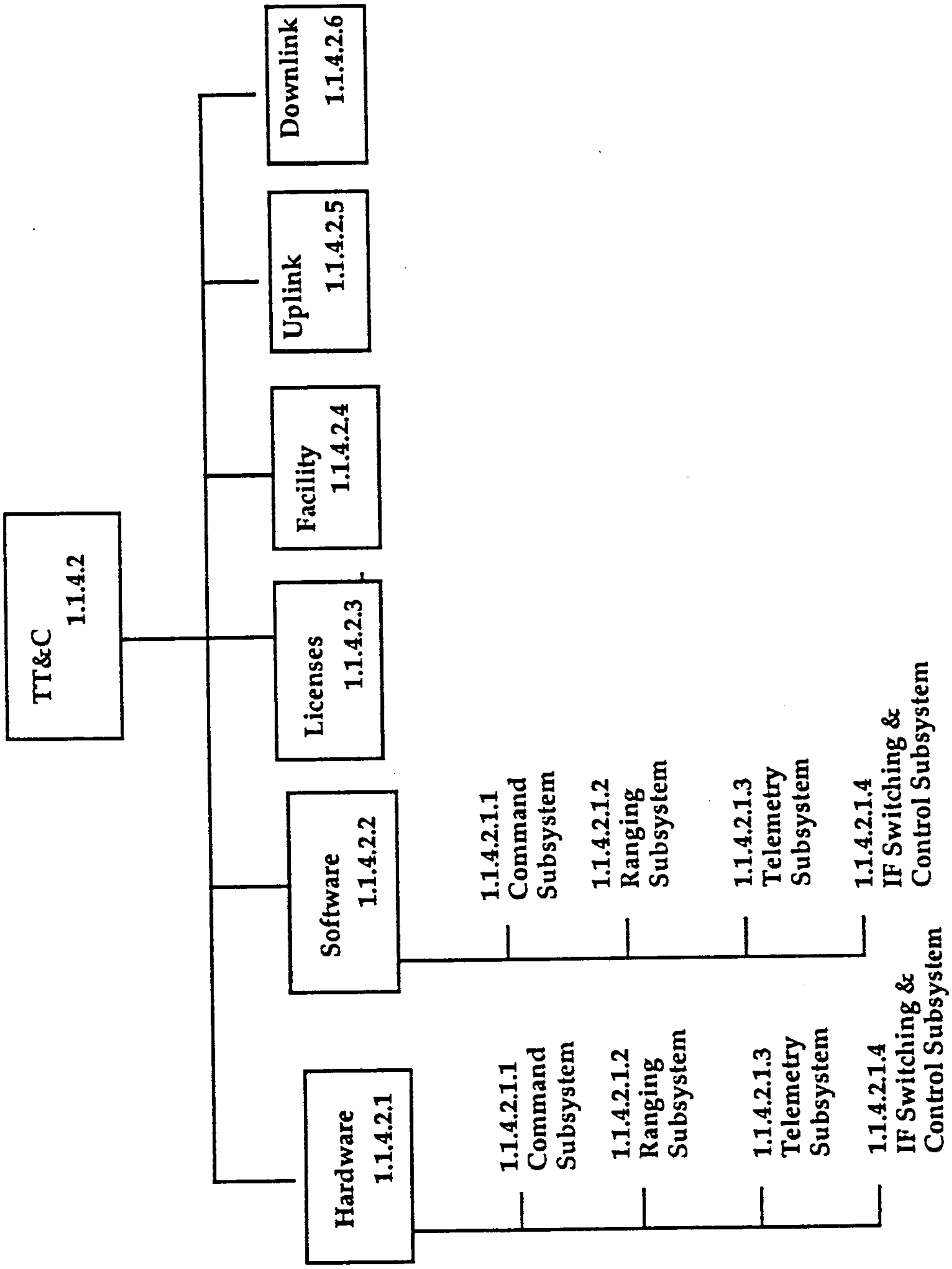
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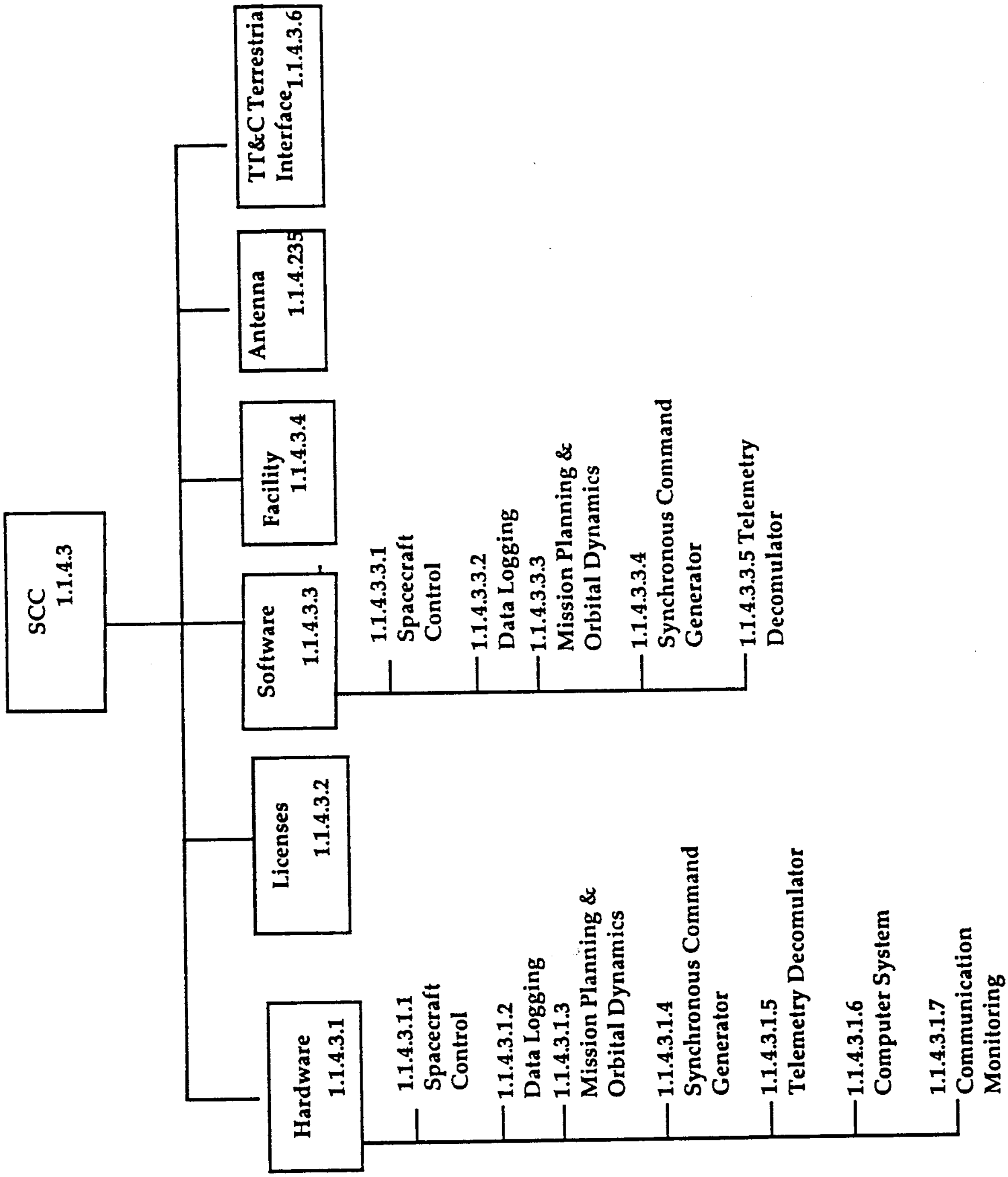
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1.1.4.3.3.1 Spacecraft Control
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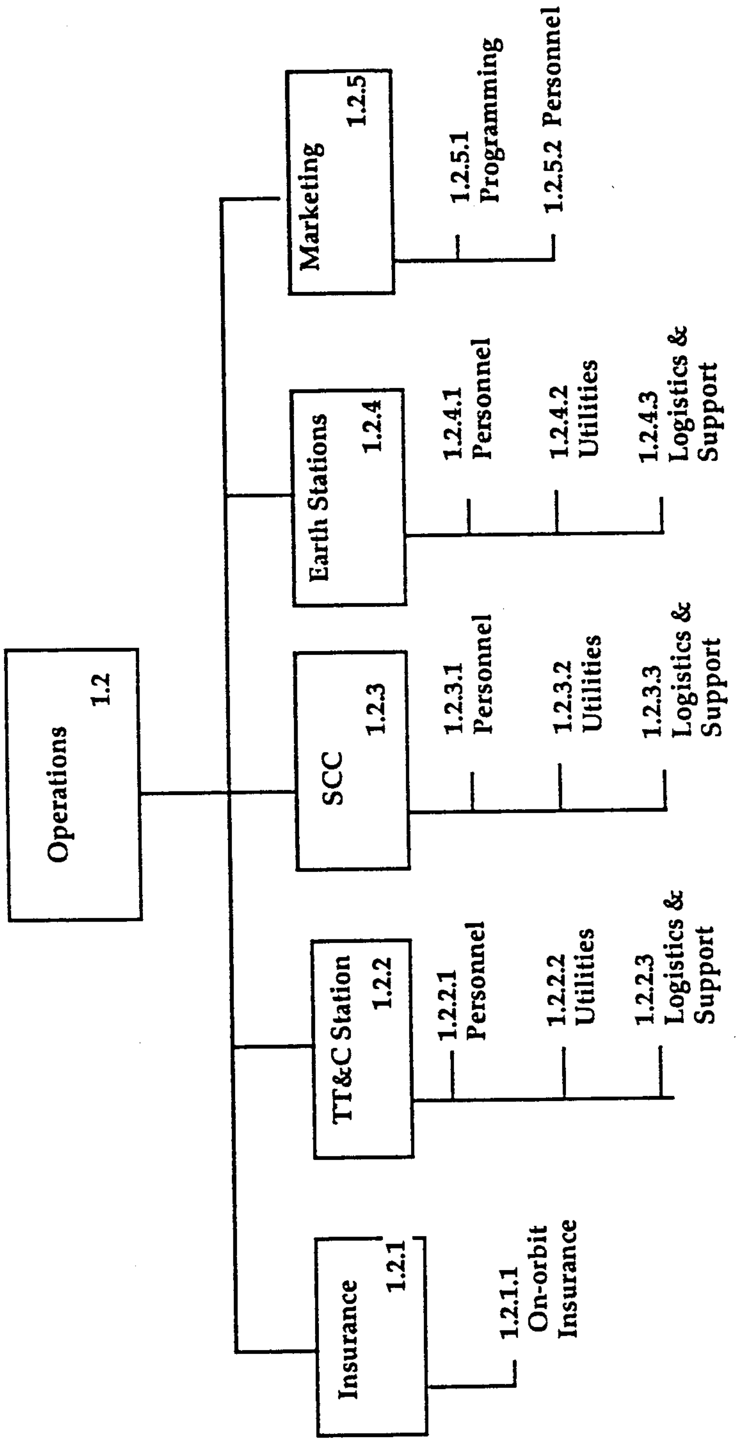
1.1.4.3.3.3 Mission Planning & Orbital Dynamics
1.1.4.3.3.4 Synchronous Command Generator
1.1.4.3.3.5 Telemetry Decomulator



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1.2.2.1 Personnel
1.2.2.2 Utilities
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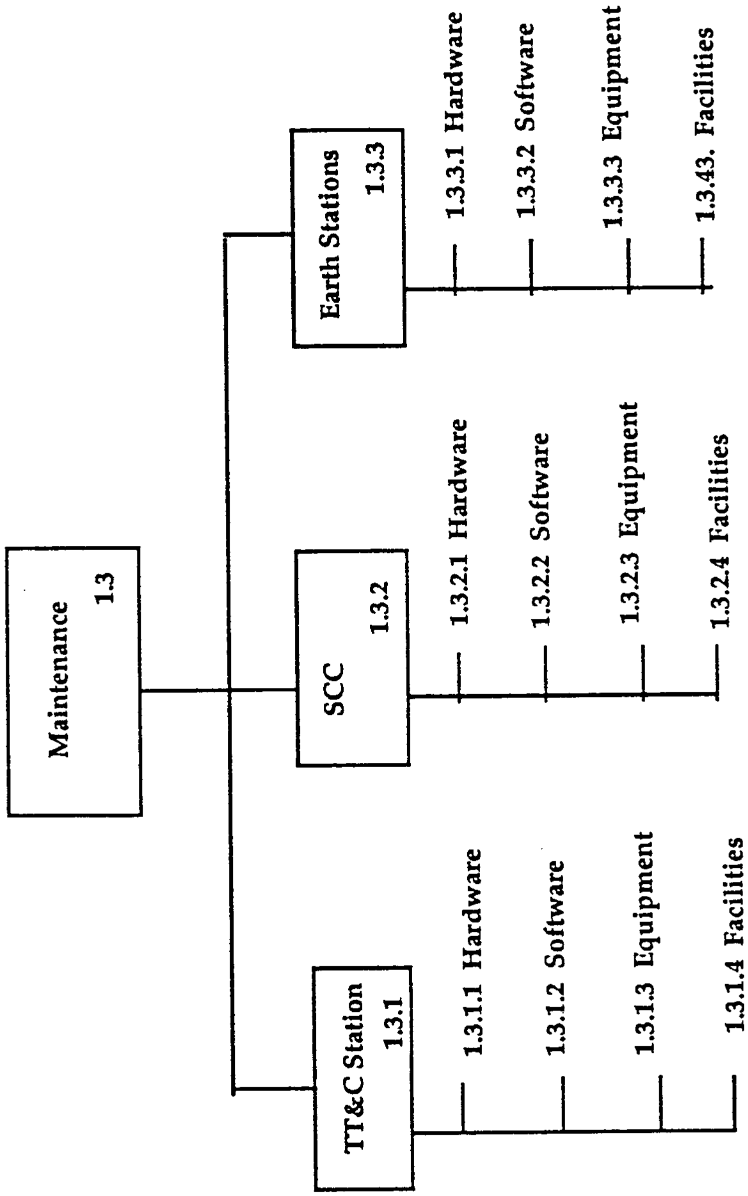

Maintenance
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1.3.43. Facilities

APPENDIX B
Cost Breakdown Dictionary

1.0 Cost for Providing DBS Video to the Home

This cost breakdown structure represents the total costs necessary to provide a direct broadcast satellite service to the Continental United States (CONUS) by a number of satellite in geosynchronus orbit. Some of the components that will be discussed below may not come into play in every configuration of a DBS system, but they are used in some type of configuration.

The configuration for the DBS service should be known prior to using this model to estimate the cost of bringing the system into being.

The major costs that have been identified are:

Initial Investment Costs
Operating Costs
Maintenance Costs
Retirement Costs

Each of these costs will be discussed in the sections that follows.

The initial investment costs section identifies the one time only costs that are incurred by bringing the system into being.

Once the system is operational, the expenses incurred due to daily operation of the system. These costs are covered under Operations in Section 1.2

Maintenance costs that are incurred in keeping the system operational are covered in Section 1.3. These costs are similar to the operational costs in that they may occur on a day-to-day basis, however, they differ in that they are specifically incurred because components need to be maintained.

Section 1.4 covers cost to retire the system at the end of the life cycle period, if desired. These costs may not come into play if the system is not retired after the life of the satellites. Replacement satellites may be launched to keep the system operational.

1.1 Initial Investments

The initial investment costs that have been identified here are one time expenses and are necessary to make the DBS system operational. These items identified in this component must be purchased prior to the initiation of operation of the DBS system are and expected to last through the design life of the satellite.

1.1.1 Orbital Slot Assignment

Orbital Slot assignment refers to the costs that are incurred in order to obtain the slot for the satellite(s) in orbit.

1.1.2 FCC Interactions

FCC Interactions covers the licenses and application costs for bringing a DBS service into being.

1.1.2.1 "Application for Authority to Construct and Operate an Earth Station"

1.1.2.2 "Application for Radio Station License or Modification Thereof under Parts 23 or 25"

1.1.3 Spacecraft

The spacecraft costs are the cost that are incurred by purchasing/making a satellite(s) for the purpose of providing direct broadcast satellite communication services. If the satellite is being made the cost for building each of the major components must be considered.

1.1.3.1 Structure

This element focuses on the components that support the spacecraft under launch and the orbital environment.

1.1.3.2 Attitude Control

These components keep the antennas pointed at the earth and the solar cells pointed at the sun.

1.1.3.2.1 Spin Stabilized

1.1.3.2.2 Three-Axis Stabilized

1.1.3.3 Primary Power

Supply electrical power to the spacecraft

1.1.3.4 Thermal Control

Maintains suitable temperature ranges for all subsystems during their lives whether they are operational or non-operational.

1.1.3.5 Propulsion

Maintains orbital position, major attitude control corrections orbital changes and initial orbit deployment

1.1.3.6 Telemetry Tracking and Control (TT&C)

Monitor spacecraft status, orbital parameters and control spacecraft operations.

1.1.3.7 Antenna

1.1.3.8 Repeaters

1.1.3.9 Transponders

Shift the frequency of an uplink signal and amplifies it for retransmission to an earth station.

1.1.4 Ground Segment

The ground segment of the DBS system consist of the facilities and equipment that are used to transmit/receive signals between the earth and a satellite. Earth stations constitute the major portion of the ground segment costs.

The ground segment costs also include the Tracking Telemetry and Control (TT&C) Center and the Satellite Control Center (SCC). These two facilities may be collocated or the may housed at different sites.

1.1.4.1 Earth Station

The types of earth stations that are being considered for this analysis are major earth stations, uplinks, downlinks, VSATs and TVROs. Also included for some of the earth stations are terrestrial links

1.1.4.1.1 Major Earth Station

Major Earth stations function as both an up- and downlinks, provide a terrestrial interface and usually have access to two or more antennas (movable and fixed).

1.1.4.1.1.1 Baseband Equipment

This is the equipment that is used to manipulate the signal before it is modulated onto the carrier.

Since the signal can be either digital or analog, both types are taken into consideration.

1.1.4.1.1.1.1 Modulation

Signal is converted into a form suitable for transmission

1.1.4.1.1.1.2 Multiplexing

Several channels are combined to form a single composite high speed signal.

1.1.4.1.1.1.3 Analog to Digital Conversion

1.1.4.1.1.1.4 Signal Compression

1.1.4.1.1.1.4.1 Digital Speech Compression

1.1.4.1.1.1.4.2 Video Compression

1.1.4.1.1.1.5 Scrambling

1.1.4.1.1.1.6 Forward Error Correction (FEC)

Technique used for detecting and correcting transmission errors by the transmission link.

1.1.4.1.1.1.7 Terrestrial Interface

The terrestrial interface is a way to allow information from the terrestrial world to be connected to the DBS system. This information includes voice via telephone lines and television via microwave.

Methods to do this include fiber optic cables, coaxial cables, etc.

1.1.4.1.1.2 Intermediate Frequency (IF) Equipment

The frequency that a signal is modulated onto before being translated to it final RF.

1.1.4.1.1.2.1 Modulation

A baseband signal containing one or more channels are is modulated on a carrier in a matter suitable for transmission over a radio-frequency (RF) link.

1.1.4.1.1.2.1.1 FDM

1.1.4.1.1.2.2 Filters

1.1.4.1.1.2.3 Amplifiers

1.1.4.1.1.3 Radio Frequency (RF) Equipment

1.1.4.1.1.3.1 Up Converter

A component of a uplink earth station that translates IF signal channels to their final carrier frequency (RF).

1.1.4.1.1.3.2 High Power Amplifier (HPA)

The final amplifier in an uplink circuit.

1.1.4.1.1.3.3 Low Noise Block (LNB)

A cross between a low noise amplifier that is designed to produce very little noise and a down converter.

1.1.4.1.1.3.4 Down Converter

A component of a downlink earth station that translates RF channels downward to their intermediate frequency (IF).

1.1.4.1.1.3.5 Multiple Access

1.1.4.1.1.3.5.1 Frequency Division Multiple Access (FDMA)

1.1.4.1.1.3.5.2 Time Division Multiple Access (TDMA)

1.1.4.1.1.3.5.3 Code Division Multiple Access (CDMA)

1.1.4.1.1.3.6 Antenna

The medium by which a signal is transmitted from the earth to a satellite.

1.1.4.1.1.3.6.1 Limited Motion Communication Antenna

1.1.4.1.1.3.6.1.1 Primary Focus Feed Parabola

An antenna consisting of a parabolic reflector that is illuminated directly with a feed horn located at its focus.

1.1.4.1.1.3.6.1.2 Cassegrain

A dual reflector antenna in which the reflector is convex toward the main reflector.

1.1.4.1.1.3.6.1.3 Multibeam Torus

1.1.4.1.1.3.6.1.4 Offset Reflector

1.1.4.1.1.3.6.2 Full Tracking Antenna

An antenna with the ability to be pointed in any direction without having to physically move it.

1.1.4.1.1.3.6.3 Fixed Antenna

An antenna that can only be pointed at a single location unless it is physically moved.

1.1.4.1.1.3.6.4 Limited Motion Antenna

An antenna that can be pointed without being physically moved, however, the directions are limited.

1.1.4.1.1.3.6.5 Wave Guide

1.1.4.1.1.3.6.6 Antenna Feed

1.1.4.1.1.4 Facility

<u>1.1.4.1.2 VSAT</u>

VSATs are basically the same as a major earth station in that they both serve as uplinks and downlinks, however the VSAT is smaller than the major earth station and there is no terrestrial interface.

<u>1.1.4.1.3 Uplink</u>

Uplinks are earth stations that are used to transmit a medium (voice, data, video) from the ground to a satellite

1.1.4.1.4 Downlink

Downlinks are earth stations that are used to transmit a medium (voice, data, video) from a satellite to the ground.

1.1.4.1.5 TVRO

An earth station that can only receive signals from a satellite.

1.1.4.2 Tracking Telemetry and Control (TT&C) Earth Station

Communicates with the TTAC subsystem of the spacecraft bus by way of the satellite's command uplink and telemetry downlink.

1.1.4.2.1 Hardware

Each of these subsystems of the TTAC requires hardware to operate.

1.1.4.2.1.1 Command Subsystem

Takes digital commands from an incoming data stream and modulates them on the IF carrier.

1.1.4.2.1.2 Ranging Subsystem

Generates a baseband ranging signal which the command system modulates

1.1.4.2.1.3 Telemetry Subsystem

Receives the telemetry carrier at the IF from the downlink and demodulates the stream of data.

1.1.4.2.1.4 IF Switching and Control Subsystem

Interconnecting and switching command telemetry and ranging links between each other and among different satellites

1.1.4.2.2 Software

Each of these subsystems of the TTAC also requires software to operate.

1.1.4.2.1.1 Command Subsystem

Takes digital commands from an incoming data stream and modulates them on the IF carrier.

1.1.4.2.1.2 Ranging Subsystem

Generates a baseband ranging signal which the command system modulates

1.1.4.2.1.3 Telemetry Subsystem

Receives the telemetry carrier at the IF from the downlink and demodulates the stream of data.

1.1.4.2.1.4 IF Switching and Control Subsystem

Interconnecting and switching command telemetry and ranging links between each other and among different satellites

1.1.4.2.3 Licenses

These component covers any licenses that need to be filed in order to operate a TTAC station.

1.1.4.2.4 Facility

The TTAC station and the SCC may be collocated therefore not making this element a valid one.

1.1.4.2.5 Uplink

An uplink to transmit data to the satellite. One uplink per satellite.

1.1.4.2.6 Downlink

A downlink to receive data from the satellite. One downlink per satellite

1.1.4.3 Satellite Control Center (SCC)

Provides the computing power and human intelligence necessary to operate and control a system of several satellites and TTAC earth stations.

1.1.4.3.1 Hardware

1.1.4.3.1.1 Spacecraft Control

This is the hardware that is used to control the spacecraft. Control activities include attitude control.

1.1.4.3.1.2 Data Logging

This equipment produces a print out of all of the data that is being transmitted and received to and from the satellite(s).

1.1.4.3.1.3 Mission Planning and Orbital Dynamics

1.1.4.3.1.4 Synchronous Command Generator

Used with spinning satellites, this device synchronizes itself with the satellite spin rate

1.1.4.3.1.5 Telemetry decomutator

Accepts the telemetry TDM data stream and demultiplexes the telemetry channels.

1.1.4.3.1.6 Computer System

Provides sufficient computing power to support all functions of the SCC. Performs real time functions of command generation, telemetry reception and processing and ranging.

1.1.4.3.1.7 Communication Monitoring

Monitors the transmission of information to and from the satellites

1.1.4.3.2 Software

1.1.4.3.2.1 Spacecraft Control

This is the hardware that is used to control the spacecraft. Control activities include attitude control.

1.1.4.3.2.2 Data Logging

This equipment produces a print out of all of the data that is being transmitted and received to and from the satellite(s).

1.1.4.3.2.3 Mission Planning and Orbital Dynamics Terminal

1.1.4.3.2.4 Synchronous Command Generator

Used with spinning satellites, this device synchronizes itself with the satellite spin rate

1.1.4.3.2.5 Telemetry decomutator

Accepts the telemetry TDM data stream and demultiplexes the telemetry channels.

1.1.4.3.3 Licenses

These component covers any licenses that need to be filed in order to operate a TTAC station.

1.1.4.3.4 Facility

May be collocated at the same site as the TTAC earth station, therefore the facility cost may be shared between the TTAC and the SCC.

1.1.4.3.5 Antennas

A fixed antenna for each satellite in operation.

1.1.4.3.6 TTAC Terrestrial Interface

This element encompasses the cost of providing an interface between the TTAC and the SCC. Since a large amount of data needs to pass between the two facilities, this is an extremely important investment.

1.1.5 Launch and Transfer Stage Services

Launch services are the cost incurred due to the launching of the satellite(s) into GEO so that the satellite may be used by the DBS system. These costs include insurance for the launch and the to make or lease the services of the launch vehicle to put the satellite(s) into orbit. Additional expenses associated with the launch mission involve the support services of the launch site and during the transfer and drift orbit phases. Preparation of the launch site are also included here.

1.1.5.1 Launch Insurance

This is the insurance costs associated with the delivery of the satellite and launch vehicle into GEO. Once the satellite is placed into GEO, the insurance services are picked up by the in-orbit insurance costs.

1.1.5.2 Launch Vehicle

1.1.5.2.1 Space Shuttle

1.1.5.2.2 Expendable Launch Vehicle (ELV)

Launch vehicles that are destroyed in the atmosphere when the spacecraft is launched.

1.1.5.3 Launch Site Support Services

1.2 Operations

This section covers the operation of the Tracking Telemetry & Control Subsystem, the Satellite Control Center and all of the earth stations that make up the DBS system. Operations includes payroll for Personnel and any other costs that come into effect due to the daily operation of the above subsystems.

The cost for bring these components are covered in section 1.0 Initial Investments and the costs for maintaining these components are covered in section 3.0 Maintenance.

1.2.1 Insurance

1.2.1.2 In-Orbit Insurance

In orbit insurance covers the cost of insuring the satellite(s) once it is in orbit.

1.2.2 TTAC Station

1.2.2.1 Personnel

1.2.2.1.1 Operations Personnel

This component covers the cost for all of the personnel involved in the actual operation of the satellite. These personnel include engineers, scientists and technicians.

1.2.2.1.2 Equipment Operations Personnel

Equipment operations included personnel whose primary responsibility is to keep the equipment at each of the stations listed below operational. These personnel members allow the satellite operations personnel the means by which to perform their job duties.

1.2.2.1.3 Management Personnel

Although management is a part of the satellite operations personnel, the group was purposely separated so that special services that are provided her can be identified.

Management personnel includes individuals that provide services that are not directly related to the operations of satellites in orbit. These individuals include marketing personnel, managers, lawyers, etc.

1.2.2.2 Utilities

These elements represent the costs for utilities for the TTAC. They include electricity, water, etc.

1.2.2.3 Logistics & Support

This component is a catch all for all operations type expenses that can be categorized as logistics or support.

Included in this category are cost to perhaps hire temporary help or costs for providing travel.

Costs here may also include supplies for the facility.

1.2.3 SCC

1.2.3.1 Personnel

1.2.3.1.1 Operations Personnel

1.2.3.1.2 Equipment Operations Personnel

1.2.3.1.3 Management Personnel

1.2.3.2 Utilities

1.2.3.3 Logistics & Support

1.2.4 Earth Stations

1.2.4.1 Personnel

1.2.4.1.1 Operations Personnel

1.2.4.1.2 Equipment Operations Personnel

1.2.4.1.3 Management Personnel

1.2.4.2 Utilities

1.2.4.3 Logistics & Support

1.2.5 Marketing

Because the service that is being provided is so dependent on its use by the public, the marketing subsystem play a major part in the operations of the system. Marketing entails selling DBS services to the public and it desired selling satellite services to the public.

The individuals that make up the marketing organization are included in sections 1.2.2.3, 1.2.3.3 and 1.2.4.3.

1.3 Maintenance

Maintenance costs are those costs that are incurred because the equipment and facilities that make up the DBS need to be maintained. The equipment consists of all of the earth stations that are the property of the DBS, as well as hardware located in the Tracking Telemetry & Control Subsystem, the Satellite Control Center.

1.4 Retirement

Retirement Cost are those costs that are necessary to dispose of the equipment from the DBS service. In most cases there are no disposal costs. As a matter of fact there are usually salvage value left in the equipment that can be converted to revenue.

APPENDIX C
DBSCoMo Requirements

The functional requirements for the systems are as follows:

- The software should produce a break even analysis for the DBS-V system once the system costs are determined.
- The software should be interactive.
- The software should allow the user to enter a satellite network configuration.
- The software should calculate the total system cost for DBS-V.
- The software should interface with a database used to store costing data
- The software should allow the user to edit the database (add, delete and modify records).
- The software should allow the user the ability to enter projected subscriber numbers for each year of the system design life.
- The software should calculate the payback period.
- The software should be able to identify the major parameters that contribute to the cost of the system.
- The software should show the users the cash flow expected for the system throughout its design life
- The software should allow the user the ability to view the costs of investing in, operating, maintaining and retiring the system in a graphical form.
- The system should users the ability to change parameters contributing to the most cost and view the net change in the system costs.

GLOSSARY

User - the individual that is operating the DBSCoMo software

Estimator - the individual who provides the costing methods for determining costs

Service provider - an individual or organization that is offering the DBS-V service to the public.

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