OFF-PREMISES BROADBAND ADDRESSABILITY: A CATV INDUSTRY CHALLENGE

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Abstract - A marketplace need for automating control of broadband CATV signal delivery is described. Past and current efforts to produce equipment meeting this need are outlined, and some concepts for future approaches are suggested. The economic forces at play in the implementation of such a system are described, along with an approach for modeling the operating cash flow needed to offset the required capital investment. The conclusion is drawn that a need for such a delivery technology does exist, and is likely to grow as competitive forces increase the cable industry's need to improve compatibility with consumer electronic equipment, deliver an increasing number of switched video (pay-per-view) services, and control operating expenses. Meeting this need is seen to involve meeting significant technical and economic challenges.

INTRODUCTION

Over the last several years the cable industry has been undergoing an agonizing reappraisal of the role which addressability should play in its operating systems. While there is not yet industry consensus, the outcome of this debate will be a major factor in determining cable's future. On the one hand, some operators are moving aggressively away from addressability, finding refuge in the simple negative and positive trap technology which initially built the pay TV business. Other operators are moving more aggressively into addressability because of their belief in the future of pay-per-view services.

The original dream of addressability encompassed automated delivery of multi-pay and pay-per-view, operating savings from reduced truck rolls, reduced converter losses, and the ability to market more flexibly. In retrospect, we see a number of unanticipated problems. Addressability introduced additional layers of complexity to virtually all operational aspects of our systems, and there were varying degrees of success in coping with this. Some vintage addressable converters were unreliable, wiping out potential operating savings and angering subscribers to boot. While most addressable set-top units being delivered today have achieved acceptable reliability, these problems will be with us for some years in our universe of older converters.

Additionally, the multi-pay environment did not require the number of channels once expected. Three or four services appear to meet the needs of most markets and trapping is often a viable delivery option. Problems with consumer friendliness, which resulted from the introduction of scrambled signals at the same time that "cable-ready" consumer equipment was being introduced in volume, were largely unforeseen, but have growing significance. According to research done by ATC over a large sample, over 52 percent of cable subscribers own cable-ready equipment and over 68 percent have VCR's. As an industry, we have not been particularly successful in addressing the resulting issues.

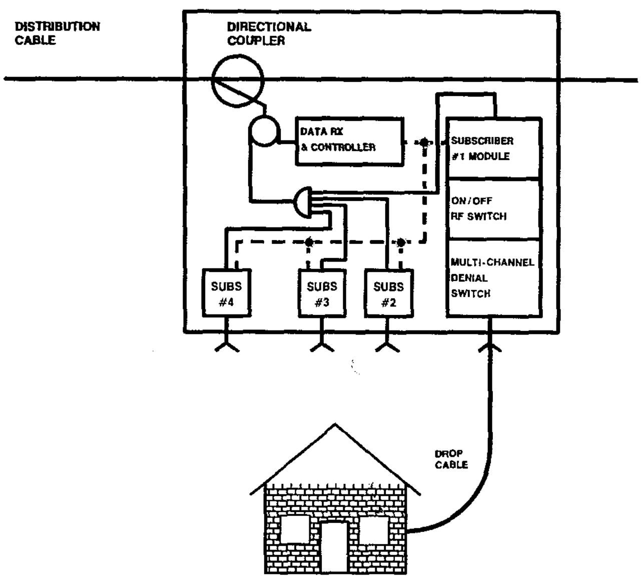
The experience of a number of operators indicates that there is additional revenue available from pay-per-view, although the magnitude remains unclear. In addition, our most likely long-term competitors, who will employ direct broadcast satellites and switched telco delivery systems, may well be capable of pay-per-view delivery to all of their subscribers. Thus, to the extent that pay-per-view offers things that consumers want, our moving away from addressable technology may put us at a competitive disadvantage.

The operating economies which are an unrealized part of addressability's potential are more important than ever. This is true in improving present-day margins, as well as in positioning for future price competition. In addition, skilled labor will continue to become more expensive and increasingly scarce in years to come.

We also need to capitalize on the proliferation of cable-ready equipment, with its potential to decrease the need for capital investment inside the home ATC's research indicates that 52% of cable subscribers have cable-ready TV sets currently. Further, the consumer expects us to be compatible with the equipment he purchases. While traps can satisfy the need for broadband, unscrambled delivery to the home, in the long term it is important that we explore ways to combine this feature with addressability.

The heart of the challenge is the separation of scrambling from addressability, and the provision of unscrambled, broadband signal delivery under addressable control. A generalized approach which would meet these goals is shown in figure 1. This represents a device located outside a subscriber's premises which would allow broadband unscrambled delivery of all services ordered by that subscriber. The device would have the ability to turn "off" or "on", and to intercept premium services not ordered by the subscriber. This would allow a subscriber to use any cable-ready equipment he might own, and to receive all services to which he subscribed at all outlets within the home. Any TV or VCR not having the channel tuning capabilities necessary to receive this service would, of course, need an RF converter. However, subscribers with cable-ready equipment would not need any additional equipment inside their homes. The cable operator would have full control over each subscriber's reception remotely.

FIGURE 1



The system outlined would behave very much like a current CATV system with individual channel traps except that customer connection, disconnection, and changes in authorized services would be fully automated. This would have a number of implications. First, there would be an opportunity to substantially reduce operating costs through the elimination of physical visits to the subscriber's home in order to change to status of his service. This would be further enhanced by an expected increase in drop reliability due to a dramatically reduced need to physically handle drops. Drop cables, once installed, could be permanently secured and waterproofed, removing a major cause of future service calls.

The system would have the positive consumer equipment interface aspects outlined above, avoiding a significant cause of subscriber dissatisfaction in systems that currently use scrambling as a means of signal security. The cable company would reduce the amount of equipment necessary inside the home, which would result in a decrease in related capital and operating expenses as the universe of cable-ready equipment continues to increase.

In addition to reducing operating costs and improving customer satisfaction, the system outlined would also be capable of providing pay-per-view services to any subscriber. Marketing flexibility would be increased with the ability to demonstrate cable's products for any period of time desired.

Finally, such a system begins to set the stage for the future. The ability to authorize "slices" of spectrum leaves open the door to controlling potentially non-standard HDTV signals. In addition, this form of addressability would, in essence, provide distributed video switching, which could, if combined with switching elsewhere in the network, ultimately result in selective delivery of video to individual homes.

TECHNICAL CHALLENGES

While there are a number of conceptual approaches to realizing off-premises broadband addressability, implementing such technology in a practical way poses a number of challenges. Clearly,. an outdoor device can be built with the capability of turning a drop off and on under remote control. The control system would, in fact, be very much like that used for addressable descrambling systems today, and PIN diodes or relays could serve to disconnect an unauthorized drop with sufficient signal isolation. Additionally, there are a variety of approaches available to selective delivery of individual channels to the subscriber drop cable. These include fixed frequency and frequency-agile positive and negative traps, as well as various types of fixed and frequency-agile jamming signals to be summed with individual unauthorized channels.

The challenges in realizing a practical off-premises broadband addressable system arise from the need to deliver unimpaired signals on authorized channels, to remove or disrupt video information from unauthorized channels sufficiently to prevent practical use, and to prevent defeat scenarios which would involve signal processing inside the home. In addition, powering a large number of active devices in the CATV system is not a trivial matter. If they were to be powered from the CATV plant, it is likely that a substantial increase in system power supplies would be required, necessitating a significant capital investment in power supplies, in adding to increased on-going power expenses.

An additional concern is the maintenance and reliability implications of adding a large number of active devices to the network in a hostile physical and electrical environment. While this is partially true of addressable set-top converters as well, it should be remembered that a number of years passed before satisfactory reliability was achieved with those devices. Prior to that time, significant expense and subscriber disruption was caused by converter malfunction and failure. If off-premises broadband addressable devices cannot be produced with very high long-term reliability, it is clear that any operating cost reductions will be more than offset by maintenance costs, and subscriber satisfaction gains created by compatibility with cable-ready equipment will be destroyed by dissatisfaction due to service disruptions.

Thus, the goal of mass-producing an affordable, practical device for selective broadband signal delivery located outside the home, with a high degree of reliability, is a major challenge. This is further exacerbated by the hostile environment in which such a device must be placed, with the hazards of moisture, wide temperature variations, and electrical discontinuities caused by power utility fluctuations and surges. This challenge has, in fact, defeated several attempts in past years to produce such equipment.

PAST APPROACHES

The attraction of off-premises addressability is not new. A system was developed by AMECO in the late 70's which utilized relays along with a data receiver in a line extender housing to produce an off-premises addressable tap. Latching reed relays were used to turn off and on individual subscriber drops, and to switch in and out a single negative trap on each output. The system was field tested, but was never implemented on a large scale, possibly due to the advent of multi-pay services at about that time as well as, it is surmised, concerns about cost-effectiveness.

In the early 80's, an addressable tap was marketed and was installed in a few cable systems by Delta-Benco-Cascade. The system was sold in both an outdoor, four-port addressable tap configuration, and an addressable wall-plate configuration for loop-wired multiple dwelling units. The DBC system used phase modulation of the AC powering waveform to transmit data from each power supply location to each tap or wall plate. This allowed the construction of an exceedingly simple data receiver within each tap, with a more complex RF data receiver located at each power supply receiving addressable instructions from a computer at the headend.

The DBC addressable taps could turn signals on and off, using PIN diode RF switching, as well as control two pay channels, using a negative and a positive trap. The product was ultimately discontinued and all known installations were dismantled, due to reliability problems with both the tap units and the data modulated power supplies. This is a clear illustration of the lack of reliability destroying any possible operating cost savings.

During the early to mid-80's, a variety of off-premises converter systems were developed and tested. These included the DST system developed by ATC and Toshiba, Texscan's TRACS converter system, C-COR's SCAT system, and Times Fiber's Mini-Hub I and II (Mini-Hub I used multi-mode optical fiber for the connection from the addressable converter to the home). While these approaches differed in specifics of powering, design and construction, the essentials of an addressable set-top converter were located outside the home, with only a control head at the television set. Up-stream signals from the control head instructed the external converter as to which channel to tune, and a single channel was delivered downstream to the television. Sometimes provision was made for several control heads and converters to share a single drop, using several channels. The external converter electronics contained a data receiver which received authorization information from the headend. All of these systems were field tested, and some were installed in some quantity in operating cable systems.

The introduction of these systems coincided with an increasing proliferation of cable-ready consumer equipment. These systems shared all the consumer interface drawbacks of addressable descrambling converters, and most lacked any ability to deliver broadband signals to the home for use by cable-ready TV sets and VCR's. In addition, the electronics moved outside the home were the inner-workings of a highly complex RF hetrodyne converter, and most systems had a variety of reliability problems. Consumer interface problems and the failure to realize operating economies proved fatal to these approaches, and all have been, or are being, discontinued from production and removed from service.

Thus, attempts, to date, to accomplish practical off-premises addressability have been defeated by failure to achieve cost-effective operation on a scale which justifies the capital expenditures involved, and, in the case of off-premises converters, to provide sufficient subscriber utility. The lessons which appear to have been learned are that broadband signal delivery from an off-premises device is important, both in terms of consumer interface issues and achieving a practical level of the simplicity, and that reliability is an absolutely critical factor in implementing this technology. Experiences with powering such devices from the cable system clearly involved high costs for additional power supplies, and for the substantial number of kilowatt-hours required. Approaches which used powering of the drop from the home avoided those problems but necessitated accessing the home, an additional source of trouble calls due to subscribers' inadvertently disconnecting power.

CURRENT APPROACHES

There are three basic approaches to off-premises broadband addressability currently available commercially. The first involves "signal interdiction" in an addressable tap at the pole. Variations of this are offered by AM Communications and Scientific Atlanta. In both cases, the pole mounted tap includes a data receiver and a jamming oscillator or oscillators which are frequency agile, and can be selectively switched onto a subscriber output port. In the case of the AM Communications product, a single oscillator can frequency hop to as many as sixteen channels, while Scientific Atlanta employees four frequency agile oscillators which can cover a larger number of channels. In both systems there is a clear tradeoff between the number of channels which share an oscillator, and the level of security and "signal masking" on unauthorized channels. Both allow a decrease in the number of channels sharing an oscillator to allow better masking of particularly controversial programming. While there are differences in features and costs of between the two systems, both are currently being installed, or will be installed in the near future, in working systems. This will hopefully result in the capture of meaningful data about their reliability and the actual operating savings realized.

A second approach to broadband addressability which is currently being offered has been termed "on-premises addressability" This approach essentially automates positive and negative traps at a location outside each home, as opposed to being located at the pole or equipment pedestal. In these approaches, a data receiver controlling PIN diodes, turns the drop off and on and switches positive and negative traps in and out the circuit. They receive their power from inside the home, and can be located in an environment less hostile than that of pole-mounted equipment. Advantages of this approach include an incremental investment which can be selectively deployed against subscribers most likely to order pay-per-view services, or against some other rational. Drawbacks include the inability to share system costs across more than one subscriber and concerns about physical security.

A third category of addressable broadband addressability is being offered for the multiple dwelling unit environment. These generally are capable only of turning individual drops on and off remotely, and do not address the control of pay services. This technology is relatively simple, with the cost of the data receiver being shared by many subscribers. These units seem to be finding utility in multiple dwelling units with a high degree of subscriber turn-over, especially in resort and university environments.

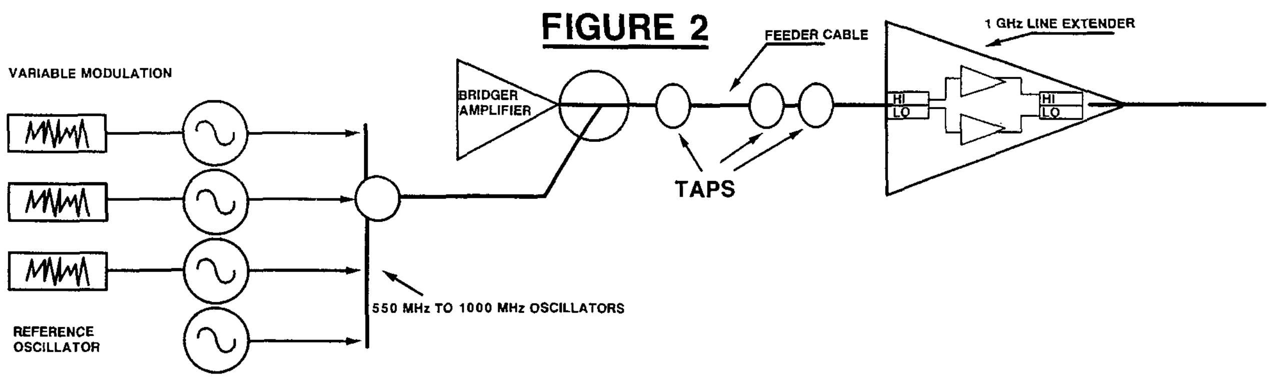
ALTERNATE APPROACHES

In examining other possible approaches to off-premises broadband addressability, the goals are to shed complexity and to share costs, while maintaining the ability to turn off and on individual subscriber drops and to control a reasonable number of individual channels. Figures 2 and 3 show such an approach. In this approach, a number of jamming oscillators, at frequencies well above those of the channels delivered by the CATV system, are located at the bridger amplifier. These are modulated to provide a high degree of video and audio masking to channels with which they are ultimately mixed. Also located at the bridger amplifier location is an unmodulated master oscillator, also well above the frequencies of interest in the system. These signals are combined with the bridger output, and are transported through distribution at high frequency. This requires tap electronics capable of passing frequencies perhaps as high as 1 GHz. It also requires that line extender amplifiers make provision for amplifying these frequencies. Because noise and distortion are not of great concern with regard to these signals, a separate amplifier stage for the high frequency jamming signals could be used within line extenders, in addition to a high-performance broadband amplifier for the CATV signal spectrum.

Figure 3 shows the inner workings of the tap. Switched notch filters are used to turn off and on individual jamming oscillators. The master oscillator frequency is recovered and applied to a mixer, hetrodyning the jamming oscillators down to their final frequencies within the CATV band. The summing of the switched jamming frequencies with the CATV spectrum results in a broadband signal to the subscriber with unauthorized channels obliterated. Notch filtering of jamming signals could also be performed after down conversion. This approach would allow one oscillator per channel, since the cost of oscillators would be shared across many subscribers.

Figure 4 shows another possible arrangement, using a jamming oscillator at 74 MHz, between channel 4 and channel 5, located at the headend. Within the tap, this jamming frequency would be divided by two and applied to a comb generator which would generate multiples of 37 MHz. This would result in interfering carrier frequencies

FIGURE 2



at 111 MHZ, 148 MHz, 185 MHz, 222 MHz, etc. These jamming frequencies could then be selectively filtered before being combined with the CATV signals to each subscriber. Thus, a degree of system simplification could be achieved at the cost some inflexibility regarding the channels used for premium services.

FIGURE 3

TAP DIAGRAM

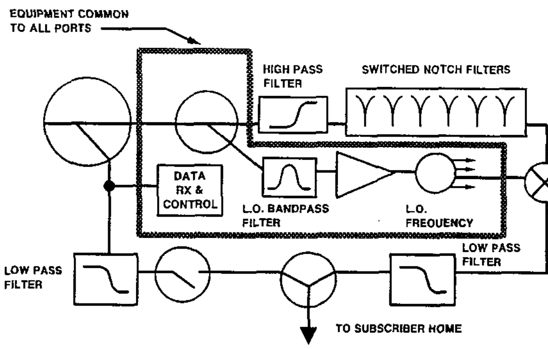
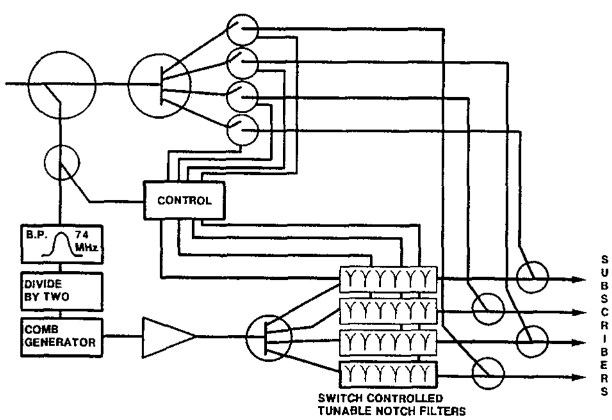


FIGURE 4



These are but a few of the possible architectures for use in an off-premises broadband addressable signal delivery system. Since such systems incur significant penalty for both initial capital expense and complexity, there is a premium to be obtained in simplifying the system and spreading the cost of expensive components or subsystems across a number of subscribers.

ECONOMICS

There are a number of positive and negative forces at work when we examine the cost-effectiveness of off-premises broadband addressability. Economic modeling of the equilibrium between these forces can become highly complex, as there are many variables. While only field experience will resolve some of these issues, it is worth examining key factors in building an economic model.

Reduction Of Subscriber Visits

This item has potential to be a major justification for the installation of off-premises addressability. It is assumed that an off-premises broadband addressable system would eliminate the need for most visits to the home. Once an installation had been performed, future disconnections, reconnections, and changes in level of service would be automated. The cost of rolling a truck to a subscriber's home is estimated to be between 20 and 30 dollars per visit. Basic churn in most cable systems is between 1 and 3 per cent of subscribers per month. It is may be assumed that installation of outlets in additional or different rooms in a subscriber's home would be billed at cost and would therefore, be cash flow neutral.

Universal Pay-Per-View

One obstacle to the growth of pay-per-view has been the limited number of homes in most systems which have addressable converter/descramblers. In systems which use set-top addressability, it can be argued that most potential pay-per-view subscribers also subscribe to scrambled pay services, but that hypothesis is untested. Additionally, it is clear that major pay-per-view events, such as boxing and wrestling matches, with their substantial revenue potential, could sell to a wider audience if a delivery mechanism were in place. When compared with a trapped system, off-premises broadband addressability has significant revenue potential in terms of pay-per-view.

There is no consensus in the cable industry about the size of this potential revenue, but it is an important factor to be examined in modeling off-premises addressability.

Consumer-Friendly Broadband Delivery

Systems which employ addressable scrambling, as opposed to trapping, in order to control selective delivery of pay television or pay-per-view product provide a fair degree of frustration to that majority of their subscribers which have cable-ready consumer electronics equipment. If there is any benefit to be gained from improved subscriber satisfaction, off-premises broadband addressability should capture it. Such a benefit should take two forms. First is an economic advantage, in the form of improved retention and, therefore, penetration. This is a difficult effect to isolate from other factors in subscriber penetration, and is a potentially large but difficult factor to use in economic modeling. The second advantage of improved utility of consumer electronics is strategic. With a variety of alternative video delivery systems on the horizon, cable's strategic ends are not well served by providing a source of subscriber frustration.

Reduced Set-Top Converter Capital Investment

When an off-premises broadband addressable system is compared with a set-top addressable descrambling system, the off-premises system has a clear advantage in its ability to benefit from cable-ready consumer equipment in the reduction of the set-top converters needed in the system. Since set-top addressability requires a device in the home regardless of the kind of television set the subscriber owns, and since the number of cable-ready TV's and VCR's is steadily increasing, a system using off-premises addressability should show a decreased need in future years for set-top converters. In addition to gradually reduced set-top capital requirements, elimination of converters from an increasing number of homes decreases the need for service call, and converter delivery and pick up. Additionally, this would result in fewer unretrieved converters.

High Capital Cost

Off-premises broadband addressable signal delivery systems currently available have an installed capital cost between $75 and $125 per subscriber. This represents a very significant incremental investment, and we can reasonably expect to make it only if offset by sufficient benefit.

Powering

Powering from the home involves no incremental additional power cost, but does involve accessing in the home for the installation and maintenance of a low voltage power supply and power inserter. This is somewhat at odds with the goal of using off-premises addressability to reduce operating costs and subscriber contact. Such a scheme also increases the capitalized investment necessary to implement an addressable system. Powering from the plant has the potential of requiring many additional power supplies. This item is highly dependent upon power consumption of the addressable devices, and provides a powerful incentive for developers to minimize power requirements.

Maintenance

Even though off-premises broadband addressable taps are conceptually quite simple, the fact that they would be deployed in very large numbers has potential to have enormous impact on system maintenance economics. In a sample design of a 3,000 mile plant, 105,000 active addressable taps were found to be required. Thus, there is substantial economic impact from anything but exceedingly high device reliability. In addition, any lack of reliability will result in a loss of subscriber satisfaction.

Economic Modeling - An Approach

A practical means of developing a feel for the economic trade offs involved in installing an off-premises broadband addressable system can be derived from examining the annual incremental cash flow requirements necessary to provide a reasonable internal rate of return (IRR) against incremental capital required for the installation of the system. In the following example, the assumption was made that the existing system used traps for signal security, and was in need of a major plant upgrade, involving splicing in new system taps throughout. Thus, no incremental labor was included for the installation of addressable taps. Figure 5 shows basic statistics regarding the system sampled.

FIGURE 5

SAMPLE CATV SYSTEM
($ X 1000)

280 MILES OF PLANT (TRAPPED FOR SECURITY)
21,550 PASSINGS
16,500 BASIC SUBSCRIBERS
10,500 PAY UNITS

REVENUE	
TOTAL BASIC	**$3,183**
TOTAL PAY	**1,197**
MISCELLANEOUS REVENUE	**227**
TOTAL REVENUE	**4,607**
COST OF SALES (PROGRAM COST)	**735**
OPERATING EXPENSES	**1,615**
TOTAL CABLE CASH FLOW	**2,257**

The following assumptions were used for the modeled off-premises addressable system:

The subscriber unit would be made up of two pieces. The housing and back plane would have the potential to serve for subscribers, and would cost $150. Additionally, one subscriber module would need to be added for each active customer served. These modules would cost $50 each. It was also assumed that the unit could be driven by standard tap input levels, so a system would require the same number of active as a non-addressable system. It is further assumed that this system would be powered from the home, at an installed cost of $10 per home.

It is also assumed that the increased maintenance cost from the installation of over 7,000 additional, but highly reliable, active devices is offset by the service call savings resulting from decreased drop handling and the ability to permanently weatherproof drops.

Over time, with churn, it is assumed that 88% of homes passed would be installed, requiring capital investment in off-premises modules.

Although each tap is capable of serving four homes, it is assumed that the design is 70% efficient; that is that 30% of the tap outputs (4 per device) will be unused, on average. This means that the 21,550 passings will require 7,395 devices to be installed.

It can be seen in the highly simplified example in Figure 6 that the installation of off-premises broadband addressable taps in this previously trapped system, during its normally scheduled upgrade, results in a reasonably favorable economic scenario driven primarily by operating economies and contributed to by pay-per-view revenues. If such an installation were contrasted with addressable set-top converter/descramblers, subscriber satisfaction and converter capital reduction elements would be introduced, but the pay-per-view benefit would be reduced, since that capability exists with set-top addressables as well.

FIGURE 6

SAMPLE SYSTEM ECONOMICS

CAPITAL INVESTMENT REQUIRED

HOUSINGS & BACK PLANES	
7,395 LOCATIONS X $150	$1,109,000
SUBSCRIBER MODULES	
88% X 21,550 PASSINGS X $50	948,000
POWER SUPPLYS	
88% X 21,550 X $10	190,000
TOTAL	$2,247,000

ANNUAL INCREMENTAL

CASH FLOW REQUIRED FOR 10YR IRR OF 10%

$365,000/YR

CASH FLOW GENERATORS

TRUCK ROLLS SAVED FOR DISCON & RECON	
30% CHURN X 16,500 SUBS	
X $20/TK. ROLL X 2 TK. ROLLS	
(DISCON & RECON)	= $198,000/YR
TRUCK ROLLS SAVED FOR SPIN	
10,500 PAY SUBS X	
20% SPIN X $20/TK. ROLL	= $42,000/YR
20% PPV REVENUE/MONTH X 12 MO X 16,500	
SUBS X $2 NET/TAKE	= $79,200/YR
	$319,200/YR
ACTUAL IRR =	7 %

The example illustrates the difficulty of viewing off-premises broadband addressability as a highly attractive investment in terms of direct pay back. However, when viewed in the context of a more competitive environment the argument for its installation becomes far more compelling. Clearly, reduction in the hardware cost, or a more aggressive view of Pay-Per-View revenue potential would have a major favorable impact.

SUMMARY

We've seen that the quest for an improved cable television signal delivery system leads us to seriously examine off-premises broadband addressable delivery of our services. We have also seen that there are significant technical and economic challenges in our path as we seek to realize hardware which would meet these goals. There is clearly a substantial reward to the cable industry in finding such a solution. It is hoped that in working with potential manufacturers of such hardware, the industry as a whole can realize the goal of reduced operating costs, increased subscriber satisfaction with our service, enhanced pay-per-view revenues, and a network which is better positioned for a more competitive future.

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Jim Chiddix - Senior Vice President, Engineering and Technology, for American Television and Communications Corporation, the country's second largest cable television operator, headquartered in Stamford, Connecticut. Mr. Chiddix is responsible for corporate engineering activities as well as research and development. ATC serves 3.9 million subscribers in 32 states and is 82% owned by Time, Inc. Upon completion of its pending merger with Warner Communications, which also owns cable TV operations, the combined companies will serve 5.6 million homes.

ATC leads the cable industry in exploring the use of optical fiber technology in cable television systems. Their "fiber backbone" concept for optical trunking has gained wide acceptance as an evolutionary approach, offering the prospect of improved performance and increased channel capacity from existing cable systems. In recognition of his pioneering role in exploring this use of fiber, Mr. Chiddix was named Man Of The Year by Communication Engineering and Design Magazine in January, 1989.

Mr. Chiddix, 43, has been in the cable television business for 17 years. He spent seven years as General Manager at Cablevision, Inc. in Waianae, Hawaii, and eight years as Engineering Vice President at Oceanic Cablevision in Honolulu, an ATC division. In September, 1986, he joined ATC's corporate office.

Mr. Chiddix is a Senior Member and former Director of the Society of Cable Television Engineers (SCTE). In 1983 he received the National Cable Television Association's Engineering Award for Outstanding Achievement in Operations, reflecting, in part, his role in introducing addressable converter technology.

Dave Pangrac is the director of engineering and technology for American Television and Communications Corporation (ATC), the country's second-largest cable television operator.

Pangrac has been in the cable television business for 22 years. He joined ATC in 1982 as Vice President and chief engineer for American Television of Kansas City and in 1987 joined the ATC corporate staff as director of engineering and technology.

Pangrac is a member of the Society of Cable Television Engineering and past president of the Hart of America Chapter.

Pangrac is currently involved in ATC's effort to develop the use of fiber optic technology in cable television plants.