# Management and Control of Receivers in a Satellite Distribution Network

**By Marty Stein**

*Managing and controlling a network of satellite-linked users presents a number of challenges not present in wired networks. In many cases receive sites are unattended or have no access to wired communications, so maintaining the integrity of the satellite link and implementing built-in recovery schemes is necessary. Over time, several techniques have been devised to control receivers via the broadcast signal and to allow receivers to automatically find their "home" frequency should some perturbation cause a temporary loss of signal. This paper describes the basic elements of satellite networks designed for program distribution and examines some of the techniques employed to maintain connection with receivers and to control the network.*

New satellite launches, advancements in digital compression technology, and cost reduction of both transmission and receiver equipment have made satellite networks more affordable for use in a variety of video/audio content distribution applications. For distributing large amounts of data (digital video/audio—in realtime or store-and-forward style) from a central point to an unlimited number of geographically dispersed targets, satellite networks can be extremely cost effective and easy to deploy and expand. Although the general concept of bouncing a signal off a satellite for reception at multiple downlink sites is straightforward, the successful implementation of a satellite-based network requires a number of considerations not normally encountered in wired networks.

## Point-to-Multipoint

One of the most common topologies for satellite distribution is the single signal origination site distributing content to multiple downlink sites. Examples are programmers-to-cable headends; private networks (corporations, distance learning, government agencies, financial institutions, etc.); and direct-to-home. A less common and more complex network is constructed when multiple signal origination sites communicate with multiple downlink sites. Some educational networks use this approach so that multiple institutions can create and distribute content to a unified network of downlink sites (Fig. 1).

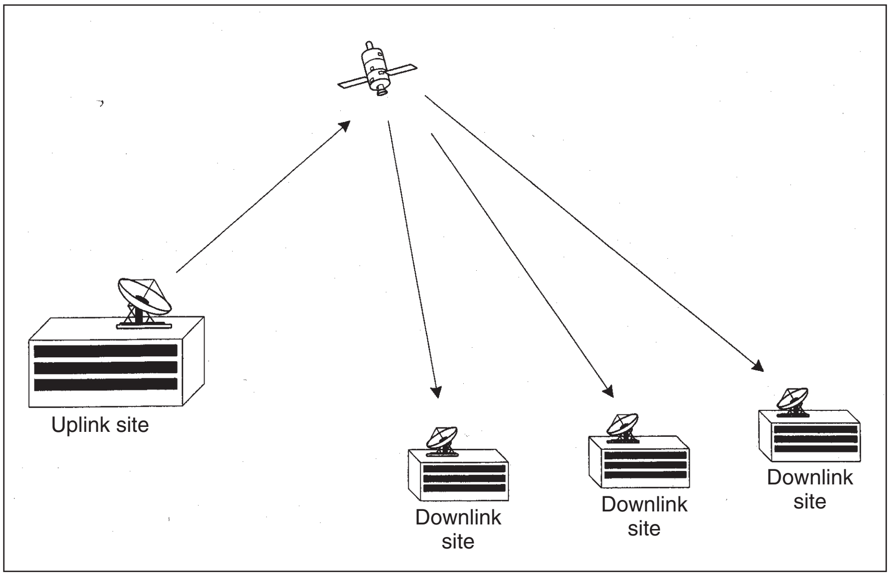

*Figure 1. Point-to-multipoint.*

## System Elements

A satellite communications network is comprised of three key elements: uplink transmission equipment; a network control system; and satellite reception equipment. A fourth element, satellite or telco return path, may also be implemented for certain applications but is not always reliable or available.

### *Uplink Transmission Systems*

The uplink site is where content is aggregated, formatted, and groomed for satellite delivery. There are four delivery methods: satellite signal; videotape; terrestrial network (fiber); emerging transport. Whatever the means, the content is converted to the appropriate digital format then multiplexed into a single stream for satellite transmission. Since satellite transmission throughput depends on the bandwidth and physical characteristics of the satellite transponder employed, the content must be

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groomed to fit the satellite transponder transmission envelope. Satellite programming intended only for authorized subscribers is protected using encryption and conditional access techniques applied at the uplink site (Fig. 2).

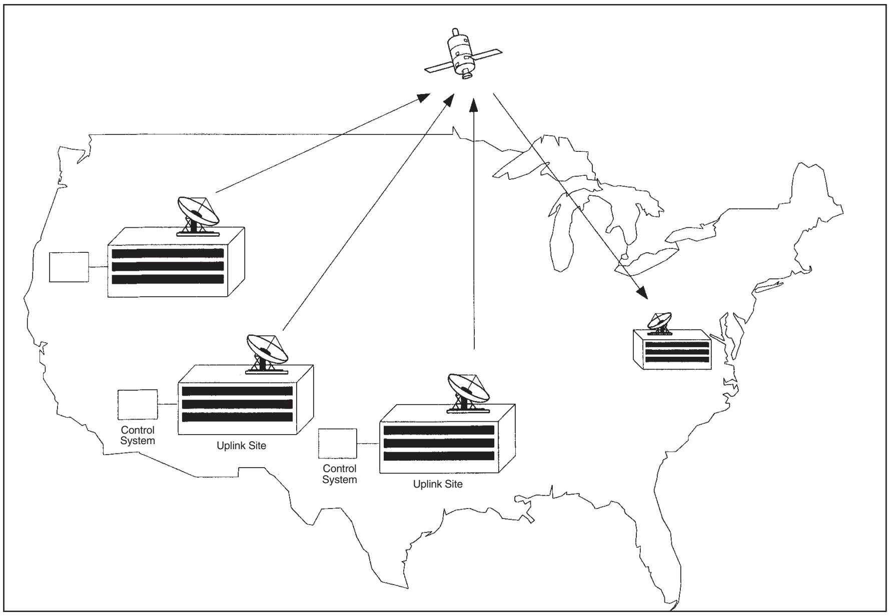
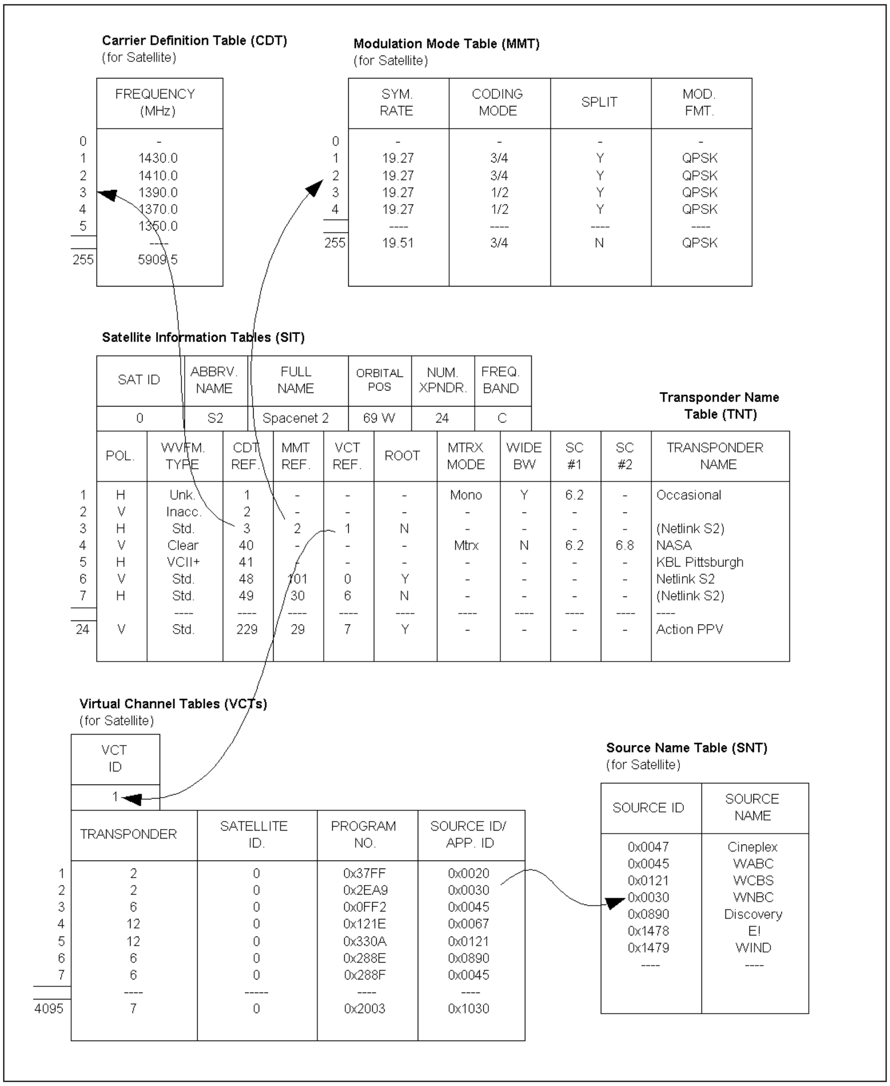


*Figure 2. Multiple uplink sites.*

### *Satellite Receivers*

The reception end of the network is charged with delivering the content in a useful format, appropriate to the end-user. Although many different programs or data streams may be present in the multiplex, a given user is usually only concerned with (or only entitled to) a small subset of the content. The typical digital satellite receiver is responsible for demodulating, demultiplexing, decrypting, and formatting the content for any number of physical output formats. Since digital satellite receivers both demodulate the signal and decode the MPEG-2 stream back to analog video and audio, they are commonly referred to as integrated receiver/decoders (IRDs).

The most challenging aspect of developing a sophisticated satellite network is that communication is essentially unidirectional, with no opportunity for the IRD to be controlled by any means other than the satellite link. Many techniques have been devised to ensure that the IRD will continue to operate if the satellite signal has been lost, temporarily or permanently.



**Carrier Definition Table (CDT)**
(for Satellite)

| | FREQUENCY (MHz) |
|---|---|
| 0 | - |
| 1 | 1430.0 |
| 2 | 1410.0 |
| 3 | 1390.0 |
| 4 | 1370.0 |
| 5 | 1350.0 |
| | ---- |
| 255 | 5909.5 |

**Modulation Mode Table (MMT)**
(for Satellite)

| | SYM. RATE | CODING MODE | SPLIT | MOD. FMT. |
|---|---|---|---|---|
| 0 | - | - | - | - |
| 1 | 19.27 | 3/4 | Y | QPSK |
| 2 | 19.27 | 3/4 | Y | QPSK |
| 3 | 19.27 | 1/2 | Y | QPSK |
| 4 | 19.27 | 1/2 | Y | QPSK |
| | ---- | ---- | ---- | ---- |
| 255 | 19.51 | 3/4 | N | QPSK |

**Satellite Information Tables (SIT)**

| SAT ID | ABBRV. NAME | FULL NAME | ORBITAL POS | NUM. XPNDR. | FREQ. BAND |
|---|---|---|---|---|---|
| 0 | S2 | Spacenet 2 | 69 W | 24 | C |

**Transponder Name Table (TNT)**

| | POL. | WVFM. TYPE | CDT REF. | MMT REF. | VCT REF. | ROOT | MTRX MODE | WIDE BW | SC #1 | SC #2 | TRANSPONDER NAME |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | H | Unk. | 1 | - | - | - | Mono | Y | 6.2 | - | Occasional |
| 2 | V | Inacc. | 2 | - | - | - | - | - | - | - | |
| 3 | H | Std. | 3 | 2 | 1 | N | - | - | - | - | (Netlink S2) |
| 4 | V | Clear | 40 | - | - | - | Mtrx | N | 6.2 | 6.8 | NASA |
| 5 | H | VCII+ | 41 | - | - | - | - | - | - | - | KBL Pittsburgh |
| 6 | V | Std. | 48 | 101 | 0 | Y | - | - | - | - | Netlink S2 |
| 7 | H | Std. | 49 | 30 | 6 | N | - | - | - | - | (Netlink S2) |
| | | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| 24 | V | Std. | 229 | 29 | 7 | Y | - | - | - | - | Action PPV |

**Virtual Channel Tables (VCTs)**
(for Satellite)

| VCT ID |
|---|
| 1 |

| | TRANSPONDER | SATELLITE ID. | PROGRAM NO. | SOURCE ID/ APP. ID |
|---|---|---|---|---|
| 1 | 2 | 0 | 0x37FF | 0x0020 |
| 2 | 2 | 0 | 0x2EA9 | 0x0030 |
| 3 | 6 | 0 | 0x0FF2 | 0x0045 |
| 4 | 12 | 0 | 0x121E | 0x0067 |
| 5 | 12 | 0 | 0x330A | 0x0121 |
| 6 | 6 | 0 | 0x288E | 0x0890 |
| 7 | 6 | 0 | 0x288F | 0x0045 |
| | ---- | ----- | ---- | ---- |
| 4095 | 7 | 0 | 0x2003 | 0x1030 |

**Source Name Table (SNT)**
(for Satellite)

| SOURCE ID | SOURCE NAME |
|---|---|
| 0x0047 | Cineplex |
| 0x0045 | WABC |
| 0x0121 | WCBS |
| 0x0030 | WNBC |
| 0x0890 | Discovery |
| 0x1478 | E! |
| 0x1479 | WIND |
| ---- | ---- |

*Figure 3. Channel maps.*

## Channel Maps

Channel maps (Fig. 3) were devised to allow IRDs to have a roadmap to navigate different programs on different transponders and on different satellites. They are concise tables, stored in IRD memory that relate satellite location and transponder frequencies to individual programs located within a MPEG-2 transport stream. The key constructs within channel maps are tied together as virtual channels. A virtual channel number refers to an entire set of parameters that can be used to uniquely define a single program within a given channel map. For example, virtual channel #101 would call out a specific satellite location, transponder frequency, MPEG-2 transport stream, and the individual elements of the

MPEG-2 stream (video, audio, data) needed to comprise a single program. The channel map has a unique identifier and may contain many virtual channel definitions, outlining the full set of programs available to the network of downlink sites. Downloading a channel map from the uplink site "joins" the IRD to a specific network.

## Network Control

The process of building a satellite network includes configuring an uplink site, distributing IRDs to authorized receive sites, downloading the network's channel map to the IRDs, and authorizing each IRD for the specific programs to which it is entitled. All of these operations (except distributing the IRDs) are controlled by the system's network control system.

As mentioned earlier, the IRDs need to join the network by accepting the network channel map and receiving the proper authorization. To facilitate a commercial network rollout, the unit address (the unique numerical identifier for each IRD), the receive site's location, and the customer's program authorizations can be entered into the network control system's database prior to IRD deployment. Organized in this fashion, the IRD can be shipped directly to the receive site and pointed at the desired satellite. After selecting the transponder frequency, the IRD will accept the channel map and subsequently receive its authorization over the satellite link, without any communication or intervention from the uplink site.

The alternate (and more typical) process requires the operator to call a service provider after the IRD is installed and read the unit address from the IRD. After the service provider enters the unit address in the database, the authorization is broadcast over the satellite link so that the IRD can decrypt and decode its authorized program. To facilitate IRD installation, channel maps and authorizations are typically broadcast at regular, frequent intervals so that setup can be completed quickly.

When controlling a network of receivers via satellite—where the entire connection is based on an RF signal from a single point 22,000 miles above the earth—a number of techniques have been developed to maintain connections through a range of operational issues and physical disturbances:

### *Narrow Carriers and Occasional Use*

Satellite distribution for private networks and educational networks often do not require the use of an entire satellite transponder, which can lease for more than $1.5 million per year. In these cases, transponders are partitioned into a number of individual carriers with narrow frequency ranges. Where full transponders typically offer 27 MHz or 36 MHz of bandwidth, fractional transponder divisions can be as low as 3 or 4 MHz each. In these cases, with eight or nine adjacent carriers on a single transponder, care must be taken to keep an individual IRD from wandering to the adjacent carrier, since slight variances in power or atmos-

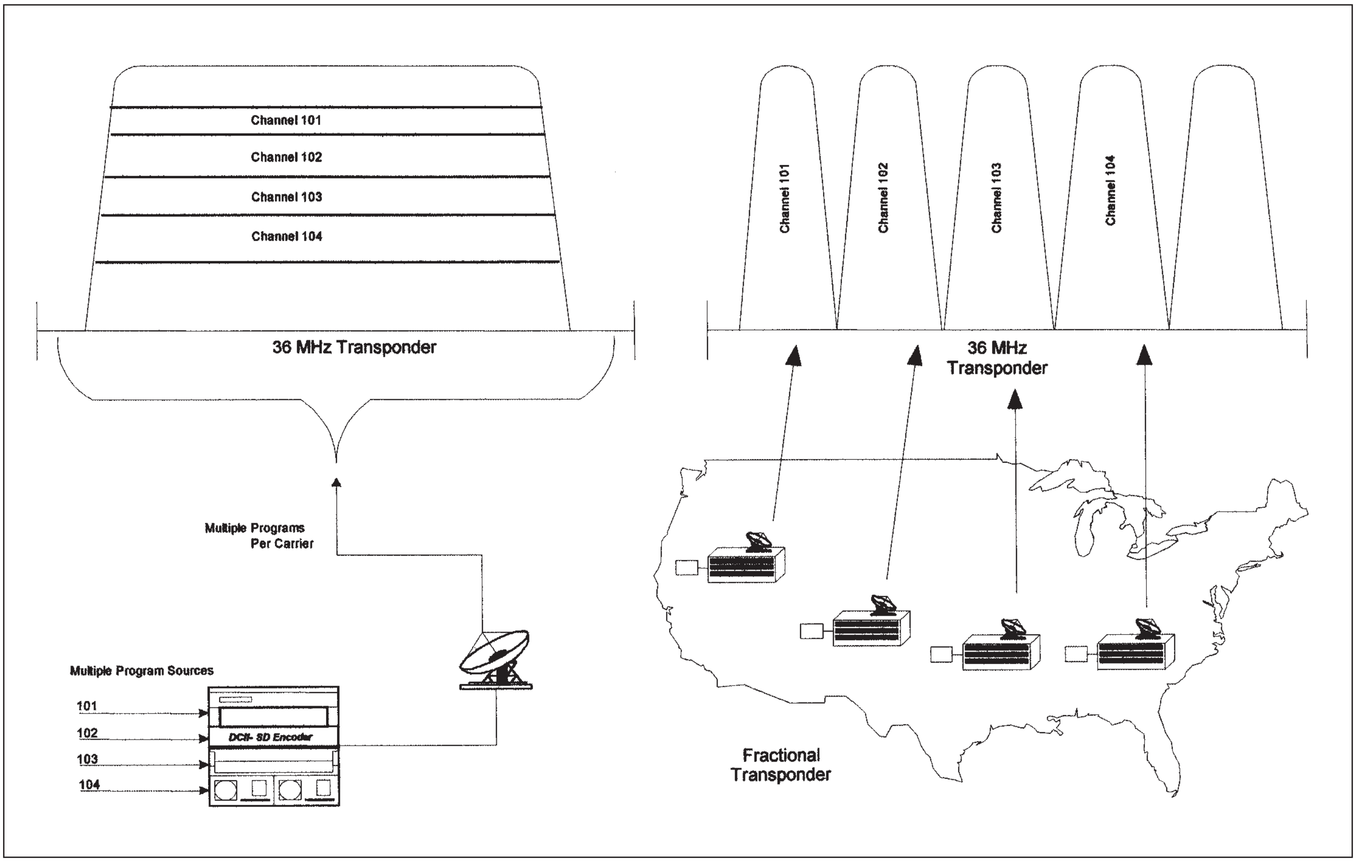


*Figure 4. Comparison of two systems: multiple channel per carrier (l); single channel per carrier (r).*

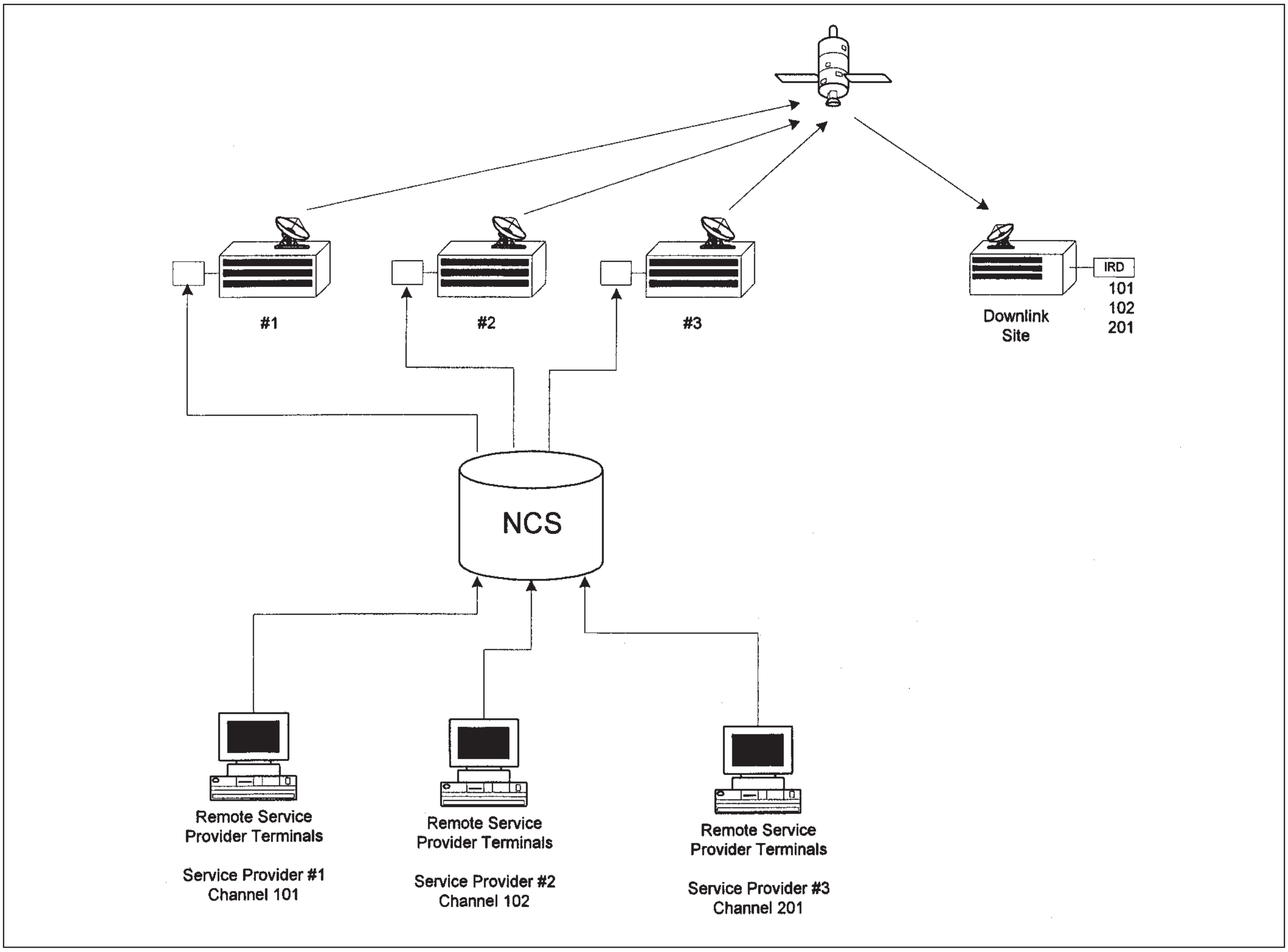


*Figure 5. Centralized control of multiple uplinks.*

pheric disturbances can actually cause an IRD to lock onto the adjacent carrier.

A technique employed to minimize this problem is the establishment of a "transport stream identifier." Using this approach, each separate uplink site is assigned a unique identifier for its own MPEG-2 transport stream, which is communicated to the IRDs that are part of that specific network. Once the transport stream ID feature is enabled in a given IRD, it will "refuse" to lock onto a carrier that contains a nonmatching ID and continue to automatically search frequencies to the "right" and "left" (higher and lower in the frequency range) until the matching transport stream ID is found.

Transport stream ID is also helpful when the same frequency is used at different times by different service providers (time-sharing a transponder frequency). In this case, IRDs from different networks may be tuned to the exact same frequency, but may only be authorized to receive the programming from one of the service providers (Fig. 4).

When the program from one of the uplinks ends and the carrier is "taken down," the IRD may just assume that it has lost signal lock due to an atmospheric disturbance and begin to search slightly up or down the frequency range to find its home frequency. When the carrier from the other uplink is "brought up" the IRD will naturally attempt to lock, but will be unable to due to a nonmatching transport stream ID. The IRD will continually search for the matching transport stream ID/frequency combination, which may not actually occur for several days. When the matching service provider is on the air again, the IRD will find and lock to the signal without the need for operator intervention.

## *Directed Channel Changes*

Another interesting control feature required in certain types of satellite networks involves the network control system "reaching out" over the satellite link to literally change the channel on a set of IRDs. An example of this is sports networks, where games in certain areas are blacked out and local viewers are switched to a different event—all without the need to physically touch the IRD. This technique is called either "retune" or "virtual channel override." In the case of virtual channel override (VCO), the target IRDs remain tuned to a given virtual channel number, but the uplink redefines the parameters of the virtual channel by downloading this new information to the channel map in the IRD.

So, virtual channel 101 may have previously been defined as satellite N, transponder M, frequency X may have its definition changed to a new transponder Q, frequency Y (but most likely remain on the same satellite). With the IRD still set on channel 101, but the definition of "101" now changed, the IRD will search for the right frequency and then lock to it. To ensure that the IRD returns to its home channel after the override is complete, a start-time and end-time for the override is broadcast to the group of affected IRDs. If the sporting event runs long or short, new end times are continuously broadcast to guarantee that the IRD returns.

### *Disaster Recovery*

One phenomena that has received attention recently is the possibility of the failure of a portion of a satellite or the complete loss of a satellite. In many instances, the uplink provider has made prior arrangements for backup satellite space if the primary satellite/transponder becomes unavailable. The process of changing the uplink parameters to broadcast to a new frequency and even repoint the antenna to a new satellite location is fairly straightforward, but processes also have to be implemented within the IRDs so that the network "knows" how to respond to a loss of signal. It's important that normal or even extreme atmospheric disturbances (for example, sunspot-induced outages that may last for up to ten minutes) are not confused with satellite failure. To accommodate the variety of conditions that can upset the integrity of a satellite network, a number of preset "rules" need to be built into the IRD. These rules primarily consist of a list of instructions to execute in the case of signal loss. Based on the length of time that the signal is not present, the IRD is preprogrammed to search for different frequencies, transponders, or satellites (IRDs with multiple RF inputs can be instructed to select between different satellite signals) in a priority order. There are always intervals (if an authorized signal is not found) for the IRDs to return to the home channel frequency in hopes that the original signal has been re-established. According to satellite availability and business strategy, the owner of the network can always download a new list of instructions to the IRD network.

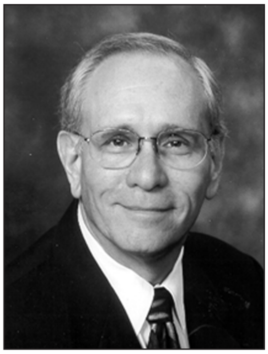
## Complex Networks

Some networks grow to utilize multiple uplink sites and consolidate multiple service providers. An example of this is an educational network, where different uplink sites contribute content to a single network of users (students or classrooms). In this type of network each service provider might like to view the group of IRDs that receive his signal as his own private network. In addition, some service providers may share a common uplink, yet continue to maintain their own network view. In this case, a common network control system with remote clients can be employed to both tie the network together yet allow each service provider to maintain control of his own subset of the network. A simple example of the benefit of a unified network is the distribution of a common channel map. Rather than have two independent service providers assign the same virtual channel number, or force all of the service providers to coordinate channel map changes, a central channel map is created and distributed from a central control system. In addition, it's easy for one site to serve as the backup for another site when everyone is communicating to the IRDs via the same centralized resource. As depicted in Fig. 5, it's convenient to deploy client terminals to each service provider so that, regardless of their physical location, they can easily control their portion of the network. Today's powerful database management tools allow each service provider a view of only his "customers" while ensuring privacy from other network members.

## Conclusion

Satellite networks can be effectively deployed for a variety of applications provided there is enough intelligence and flexibility in the network control system and enough forethought has gone into the design and functionality of IRDs. While the network is typically easy to operate, it can be very costly to restore it to operating order if the satellite link between the uplink center and the IRDs is lost or if IRDs wander and lock onto stray or neighboring signals.

## THE AUTHOR



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