# FEED BACK

## GEORGIAN BAY AMATEUR RADIO CLUB NEWS

Editor Jack VE3DTS
SEPTEMBER 1977

Executive

| | | |
|---|---|---|
| President | Ian Trenholm | VE3HIP |
| Vice Pres. | Ian Sutherland | VE3HXX |
| Sec. Treas. | Cy Weaver | VE3DQA |

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The club meeting was held on Sept. 15th and was attended by about 20 people. A transmitter hunt was on the programme after the usual business meeting and even though the event had been publicised for the past month, only THREE mobiles took part. The transmitter was found by VE3CTQ and the scouts who were with him, afte going the wrong way initially.

We have now had three of these hunts with spectacular lack of participati on the part of the membership. The club executive puts in a lot of effort to try and maintain club activities, and it appears that the membership is only wanting to be entertained with minimum participation and effort.

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Jack, VE3DTS, who is the regular editor is in hospital in Toronto at this time and our best wishes for a speedy recovery go out to him. In the meantime you'll have to get by with me VE3EFX.

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A large part of this issue is devoted to AMSAT for a couple of reasons. The first being that I'm trying to interest as many of you as possible in supporting this project which is vitally important to amateur radio's future. The second reason is that I too will be spending a lot of time in Toronto this month so will not be able to get as much done as I'd have liked.

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The next meeting will be held on October 20th in the CIAG Computer Bldg at 8pm.

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Ian, VE3HXX now has 102 countries worked and 51 confirmed. A very good effort in such a short time

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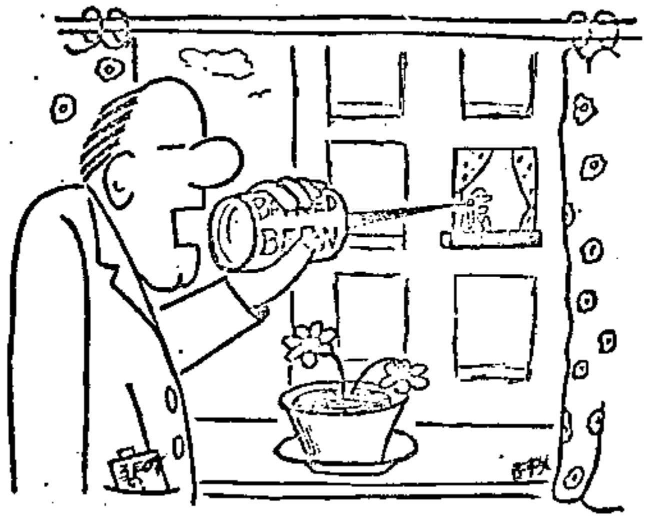
Bob, VE3FCW now has a TS700 in preparation for more OSCAR activity in the club.




VERY EFFECTIVE DICK ... BUT I DON'T THINK THE CLUB WILL BUY THEM

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The club operated stations at the Port Elgin Mardi Gras on Sept. 3rd and at a CB Coffee Break in Owen Sound on Sept. 11th. Both operations went off quite well with a good number of people expressing interest in becoming amateurs. Traffic was passed at both functions and information pamphlets were passed out along with club addresses and radio class dates.

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I'm not sure that our participation in CB Coffee Breaks is a good thing, and for the following reasons.

We are usually considered to be CBers by the general public, so if we are seen to be operating at their functions we can expect to be classed along with them.

The fact that amateur gear (FT101E, FL2100B) and other equipment that is illegal for CB operation (Linear Amplifiers and VFO's) were being sold right there in the hall.

The blatantly pornographic CB cards, signs and badges that abound where ever these people congregate have no place in Amateur Radio.

At our conventions (RSO, ARRL etc) you don't see CB operation being touted.

For these reasons Iwould like the club to consider NOT getting involved in future CB activities. We have enough things to do if we want to put out good public relations, such as the Split rail Festival and the winter rallys and marathons.

Your comments are invited for inclusion in the next issue of Feedback.

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We have been asked to provide communications for the Port Elgin Lions Club who are sponsoring a walkathon on October 16th. We need six mobiles at least and the start is planned for around noon.

In the July Issue of the club newsletter I suggested some contest activity should be indulged in by the club in order to sharpen up the operating ability of some of those who spend all their operating time on 2m and 80m.

Not one word has been heard as to whether anyone is interested and the idea of even a transmitter hunt provokes something less than an enthusiastic response. There are a number of very good contests coming up in the next few months and it would be a fine idea to get into them and see how your skills stack up when the going gets tough.

Traffic handling is another weak area with many of you who have no idea what is going on when a piece of formal traffic is given over the air for either delivery or relay. The Amateur Service will need to justify its right to the bands it uses and if the majority of us can't even pass a short message without fouling up we all stand to lose. It is the responsibility of all amateurs to become familiar with traffic net operation, message format, and how to move a piece of traffic that is passed for delivery. Each piece of information in the preamble is there for a reason so make sure you have it all down and understand what it says. You should also have a pad of ARRL message forms handy.

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The Sunday morning net could use some more participation too as we are lucky to have a dozen members call in. The frequency is 3.785mhz at 09.30 local time.

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We are still running close to the borderline as far as maintaining our ARRL affiliation. The requirement is 51% of the licenced members to be in the ARRL and at the moment we are just making it. All the benefits that we get from the League are well worth holding on to so what about all the non-believers getting with it and joining. I've been hearing promises to join for a couple of years from some of you with no action yet. There is more to supporting Amateur Radio than sending in $13 to DOC and $5 to GBARC

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Those of you who are interested in finding out what is going on in the satellite business should listen in to the AMSAT net at 01.00z every Wednesday on 3.850mhz when all the latest news on both amateur and commercial space activities is put out by WA3NAN and W3UN.

Expectations of a Soviet OSCAR launch on October 4th are high. This will be the 20th anniversary of the launch of Sputnik 1 and it is believed that they will try for a launch at that time.

# the future of the amateur satellite service

During Phase III of the amateur satellite program AMSAT will place advanced communications satellites in high-altitude orbits which will allow long-range communications for up to 15 hours per day. This article discusses the capabilities of those satellites, and the financial support required from the amateur community

**Amateur radio stands** on the threshold of the most exciting and comprehensive change in its history, a change more revolutionary than that from spark to CW, or a-m to ssb, or the advent of vhf-fm repeaters. The Phase III Amateur Satellite Program, about which you'll be reading a great deal in the coming months, sounds more like science fiction than fact. However, in the past few years the *facts* have become increasingly clear: amateurs are already in command of the technology needed to produce a cost-effective satellite system — a *system*, not just a single satellite, capable of greatly enhancing the reliability of long-distance communications while simultaneously reducing the cost of the average amateur radio station.

One day, probably in late 1979, the first amateur Phase III satellite will be launched, and a new era in amateur communications will begin. It's possible that within ten years from today the majority of long-distance communications (over 50 miles or 80 km) by amateurs interested in DX, contests, traffic handling, and casual rag chewing will be by satellite. As a result, crowding of the high-frequency bands may be significantly reduced, even with a rapidly increasing amateur population.

Using satellite relays for global radio communications was first proposed by Arthur C. Clarke in the British journal *Wireless World* in 1945. Approximately 20 years later (March 9, 1965) the first active communications satellite, OSCAR 3, was launched. It may be hard to believe, but radio amateurs were communicating through OSCAR 3 months before the first commercial communications satellite, *Early Bird* (Intelsat I), was placed into orbit. Yet today, 12 years later, while satellites are carrying approximately two-thirds of all commercial transoceanic communications,[1] amateurs are still relying almost entirely on erratic high-frequency circuits for distant contacts.

Long-distance propagation on the high-frequency bands depends on signals being reflected by the ionosphere. A much more reliable communications system results when a satellite is substituted for the somewhat erratic ionosphere, and vhf or uhf bands are used for the radio links. You don't need to know much about the workings of the ionosphere to use the high-frequency bands; surprisingly, you don't need to know much about satellites to enjoy the advantages of this new mode of communications.

The satellite subsystem of primary interest to radio amateurs is the transponder, the electronic package which receives signals from stations on the ground and then retransmits them, on a different frequency with great amplification, back to earth. Although transponders are somewhat similar to 2-meter fm repeaters, there are significant differences: the linear transponders used on AMSAT satellites work equally well with ssb and CW signals, and they can simultaneously handle a large number of users.

To appreciate the communications capabilities which high-altitude spacecraft will provide we can

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compare communications links involving Phase III (high-altitude) satellites, Phase II (low-altitude) satellites such as OSCAR 6 and OSCAR 7 which are currently in orbit, and the 20-meter band. The comparison will consider a number of characteristics of specific interest to radio amateurs using these systems.

1. **Daily access time.** How many hours each day does the user have access to the satellite?

2. **Maximum communications range.** What is the maximum terrestial distance over which two stations can communicate?

3. **Communications performance.** How strong and intelligible are received signals? Can openings over specific paths be predicted reliably?

4. **Communications capacity.** How many stations can use the satellite at the same time?

5. **Frequencies.** What frequency bands will Phase III satellites use?

6. **Tracking techniques and operating schedules.** Will the paper work involved in tracking and checking operating schedules be complicated and laborious?

7. **Ground-station equipment.** How much transmitter power and how large an antenna will be needed? Will commercial or surplus equipment be available for a moderate cost ground station?

8. **Antenna aiming.** Will the direction in which the antenna is pointed have to be continually adjusted while operating?

9. **Miscellaneous.** How will factors such as satellite lifetime, signal time delay, lack of skip zone, Doppler shift, and crowding affect users?

10. **Financing the Phase III program.** Can amateurs afford the Phase III program?

## daily access time

The average amount of time that a satellite will be within range of a specific ground station each day (daily access time) is determined solely by the ground station's latitude. The first Phase III satellite will be injected into an orbit that initially places it within range of ground stations at mid-northern latitudes (this includes most of the United States) for about 15 hours each day, and within range of ground stations at mid-southern latitudes for about 5 hours each day. The first Phase III satellite will therefore provide northern hemisphere amateurs with as much access time as ten optimally spaced OSCAR 7 satellites! Can you recall the last time that 20 meters was open 15 hours per day on a regular basis?

As the years pass, ground stations will find that their average daily access time will change. By 1985 the first Phase III satellite will only be within range of northern hemisphere stations about 5 hours each day while southern hemisphere stations will have about 15 hours of access time each day. But don't despair, AMSAT is capable of producing two additional Phase III spacecraft before 1985. If these spacecraft are inserted into orbits similar to that of the first Phase III spacecraft, ground stations anywhere on earth will have access to at least one Phase III satellite for about 20 hours each day.

This article focuses on the potential impact of the amateur satellite program on amateur radio over the next ten years. The author, Dr. Martin Davidoff, K2UBC, is an assistant professor of mathematics at a community college in Maryland where he directs a National Science Foundation project involving satellites and college level science instruction. In conjunction with the NSF project, he recently authored a textbook featuring the AMSAT-OSCAR series of satellites, *Using Satellites in the Classroom: A Guide for Science Educators*. K2UBC obtained his doctorate in Physics from Syracuse University in 1974 and has held an amateur license since 1956. **Editor.**

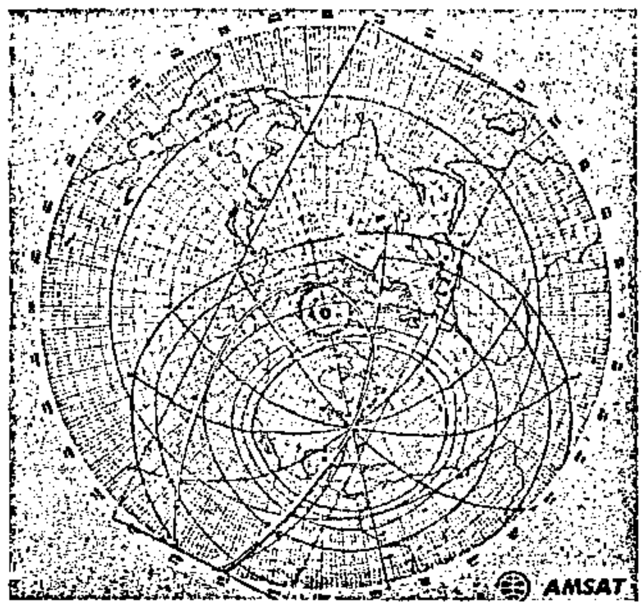


**fig. 1.** Photograph of *Satellable* style tracking nomograph for elliptical orbit of the type used by the Phase III-A spacecraft.

## maximum communications range

Phase II satellites provide a maximum communications range of about 5000 miles (8000km). While this is adequate for Worked All States and DXCC, it's not very satisfactory by high-frequency standards. Phase III satellites will enable amateurs to communicate over a much greater distance — up to about 11200 miles or 18000 km — leaving only a very small region at the opposite side of the earth out of range. The 20-meter band will continue to reward its followers with somewhat unpredictable openings to all parts of the globe.

If you've had the opportunity of listening to ssb stations using the 432/146-MHz transponder on OSCAR 7, you know that satellites are capable of providing *telephone quality* links. The 20-meter band can provide similar performance, albeit in a some-

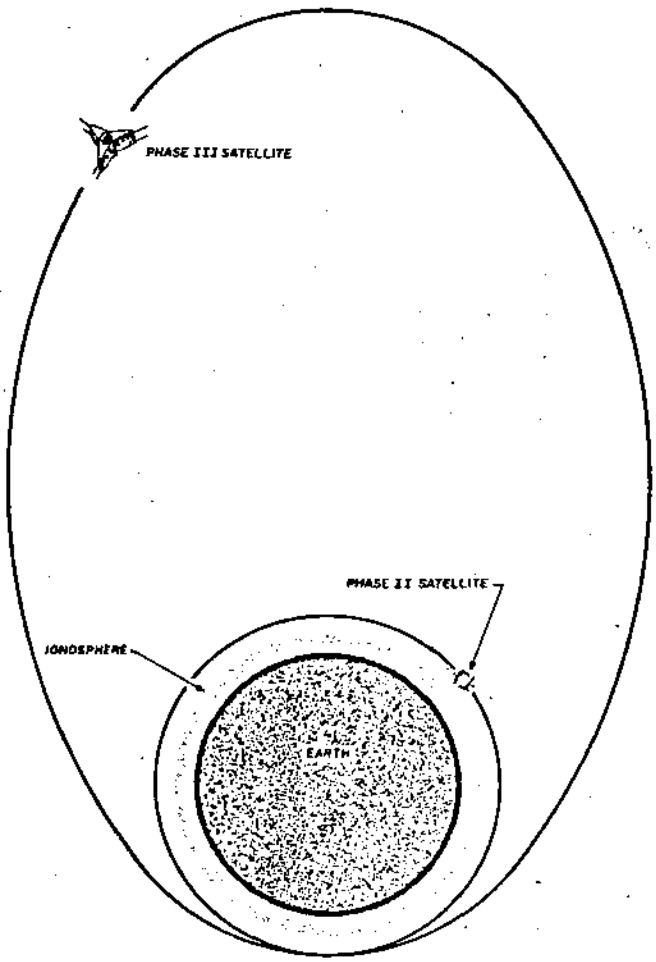



**fig. 2. Relative altitudes of Phase II satellites, Phase III satellites, and the ionosphere — shown approximately to scale. Drawing does not take inclination of orbits into account.**

what erratic manner. As an example, assume it's August, 1977, and you're interested in the Denver-Frankfurt path during January, 1978. The best prediction high frequency propagation experts can offer is that 20 meters will probably be open over the path of interest sometime between 1600 and 1800 UTC on about 15 days during January. If the first Phase III satellite was in orbit at this time, you could predict with better than 99% certainty, that the Denver-Frankfurt circuit would be open for several hours every day in January during time slots specified almost to the minute.

The advantages of a Phase III satellite for prearranged point-to-point schedules are even more impressive when you consider a three-way contact between, for example, New York, London and Tokyo. Satellites will make such contacts possible daily with clocklike regularity. What are the odds of being able to accomplish this on 20-meters?

The received signal strengths observed by stations communicating through a high-altitude satellite will be largely independent of the distance between the stations. This results from the fact that the earth-satellite-earth distance and path loss are, for all practical purposes, constant regardless of how far apart the two ground stations might be. Since distance doesn't count, a station across town and one nearly halfway around the globe will produce similar signals if they are using similar equipment. In fact, listening to your own signal being returned from the transponder will indicate quite accurately how you sound to any station within range of the satellite.

## communications capacity

The first Phase III satellite will provide a band of frequencies, nominally 150 kHz wide, capable of handling hundreds of simultaneous conversations. All users will be sharing the 50-watt satellite transmitter. Therefore, ssb and CW will be the preferred modes because they efficiently use the available satellite power. The satellite transponders will also be able to handle slow-scan TV, RTTY, and fm. But these modes should only be used in emergencies, or for special experiments coordinated with AMSAT, because they use a disproportionate amount of satellite transmitter power and, in the case of fm, excessive bandwidth.

A recent cost-effectiveness study suggests that crowding will not become a serious problem with the first Phase III spacecraft until 30,000 users are equipped to transmit on the uplink frequency.[2] To prevent crowding problems AMSAT plans an ongoing Phase III construction program which is designed to keep pace with a rapidly increasing user population. Placing an additional satellite in orbit every 24 months appears to be a realistic goal.

## frequencies

The first Phase III satellite will include two transponders. Therefore, even if one transponder fails, the satellite will still be available for communication on a full-time basis. If possible, the two transponders on the first Phase III spacecraft will use reciprocal frequency combinations: one transponder will receive on 435 MHz and transmit on 146 MHz, the other will receive on 146 MHz and transmit on 435 MHz. Users will be able to compare the performance of both transponders and express their preferences for scheduling and for future satellites.

The amateur satellite program will continue to rely heavily on the 146-MHz and 435-MHz bands throughout the 1980s. In the mid or late 1980s Phase III satellites are likely to include links at even higher frequencies such as the 920 MHz (32cm) and 2.3 GHz (13cm) bands; specific plans must await the outcome of the 1979 World Administrative Radio Conference.

Low-altitude (Phase II) satellites may continue to use 10 meter downlinks, a band which is not suitable for Phase III. Readers interested in the factors involved in selecting frequencies for amateur satellite systems are referred to the excellent paper by Ray Soifer, W2RS.[3]

## tracking techniques and operating schedules

You may be pleasantly surprised to learn that you won't need to know anything about tracking to use a Phase III satellite. After the first Phase III spacecraft is in orbit, you'll be able to turn on your receiver (with an omni-directional antenna connected) and check to see whether or not the band is open (satellite within range) by simply tuning for signals. About 65% of the time stations in mid-northern latitudes (most of the United States) will find that they're in luck — signals will be present. If a second Phase III spacecraft is launched into a similar orbit, the probability of finding the band open will be about 90%. When the band is open, you'll switch to a beam antenna and home in on the satellite by peaking your S-meter on a beacon signal. The same antenna setting will work for all stations received via the satellite. Peaking the antenna every 15 minutes should be more than sufficient.

While the casual user can get away without any knowledge of tracking, some tracking skill (like a little insight into 20-meter propagation) will pay big dividends by enabling you to predict specific openings, to rare countries.

Many radio amateurs think that satellite tracking is very difficult and requires a strong mathematical aptitude. This just isn't true. Tracking is a simple, mechanical skill that takes only a few minutes to learn, and the only math needed is basic arithmetic. The ability to predict 20-meter propagation stands in sharp contrast; it's an impressive skill which requires a great deal of knowledge and experience.

Most tracking methods use some sort of nomograph which usually consists of a map and transparent overlay. Until recently everyone had to build their own tracking nomograph from scratch — a straightforward but tedious job which is no longer necessary since excellent commercial tracking aids are now available.[4] With minor modifications the basic tracking techniques and nomographs used with OSCAR 6 and 7 will also work for the radically different orbits which early Phase III spacecraft will introduce. In fact, these same nomographs were actually used to evaluate the communications capabilities provided by the various orbits considered for Phase III. Construction details for Phase III tracking nomographs will be published in the near future.

In the past, OSCAR 6 and 7 users have sometimes complained about the bookkeeping involved in determining which OSCAR 6 orbits are available for general use and which OSCAR 7 transponder is scheduled to operate. The latest W6PAJ orbit calendar[5] eliminates most of the bookkeeping drudgery by clearly listing the times and operating status for every OSCAR 6 and OSCAR 7 orbit during 1977. AMSAT will have a great deal of flexibility in scheduling future Phase III satellites because they will be controlled by onboard microcomputers that can be programmed by suitably equipped ground stations. User convenience will be the primary consideration when satellite schedules are chosen so bookkeeping requirements should be minimal. Tracking nomographs and orbit calendars will be made available for Phase III satellites soon after they're in orbit.

## ground station equipment

**Receiving.** Ground stations working with Phase III satellites will need a good ssb/CW receiver capable of tuning a few hundred kHz around 146 MHz and/or 435 MHz.

**Transmitting.** A CW or ssb transmitter with about 50 watts output at 146 or 435 MHz will be required for the uplink.

**Antennas.** Ground station communication via the Phase III satellite will usually require moderate gain (10-15 dBi) beam antennas for receiving and transmitting. A typical antenna array may consist of two or more Yagis mounted on a common mast using a single set of azimuth and elevation rotators. The entire structure can be smaller and lighter than the average three-element beam used on 20 meters.

The selected antenna site should place the antenna clear of surrounding objects and relatively close to the operating position since feedline losses are an important consideration at 146 and 435 MHz. As a result, a chimney mount will often be as effective as a large tower. Neighbors (and zoning committees) will probably be unable to distinguish between a roof-mounted Yagi array for satellite work and a large television antenna!

Although beam antennas will usually be required for reliable communications, simple omnidirectional antennas will also be useful at times. For example, an omnidirectional receiving antenna can be used during the entire orbit to determine whether the satellite is within range. In addition, omnidirectional transmitting and receiving antennas will sometimes be convenient for communication when the satellite altitude is relatively low (less than 15% of each orbit).

**General**. The satellite ground station that you put together will no doubt depend on the size of your pocketbook, the equipment you already own, the amount of time you have to devote to the project, and the transponder frequency.

Here are some options that you may want to consider. If you presently own a good high-frequency receiver, a top-line vhf or uhf converter will provide you with a state-of-the-art receiving setup. For transmitting, the 10-watt multimode or ssb/CW transceivers currently available for 2 meters and 70 cm look like a good choice. A linear amplifier with 6-10 dB of gain will keep the transmitting antenna requirements within modest limits.

Numerous pieces of commercial equipment suitable for satellite work (converters, transmitters, antennas) are currently available off the shelf; I'm not speculating as to what the future may offer. If you have some time and a little technical knowhow, you'll be able to put together a relatively inexpensive station using a surplus fm strip as a CW transmitter and homebrew helix antennas. In any event, if you're currently thinking of investing in a vhf or uhf fm transceiver or amplifier, consider paying a little extra to obtain a rig with ssb/CW capabilities and purchasing an amplifier that can be run in the linear mode for ssb.

Let's look at the equipment procurement problem from a different perspective by putting ourselves in the shoes of a newcomer to amateur radio five years from now (1982). If the newcomer intends to stick with the hobby for quite a few years and wants to set up a first-class station for local and DX work with new, off-the-shelf equipment what are the options?

**Option A**

- Synthesized 2-meter fm transceiver
- Separate transmitter and receiver for high-frequency bands
- Kilowatt high-frequency amplifier
- 50-foot (80m) tower and triband Yagi

**Option B**

- 10-watt multimode 2-meter transceiver
- 10-watt multimode 70-cm transceiver
- 50-watt, 2-meter and 70-cm linear amplifiers
- Modest roof-mounted antenna array

While each of these options will provide roughly equivalent capabilities, **Option B**, which depends on satellites for long-distance work, costs approximately half as much as **Option A**. Since prices for vhf and uhf ssb/CW gear are likely to decrease when a big new market opens up, the financial advantage of **Option B** is likely to increase.

The first Phase III satellite will be a moving target. The question that concerns radio amateurs is: How difficult will it be to track this satellite with a moderate gain beam? In other words, how frequently will the ground station operator be required to adjust the azimuth and elevation controls? The answer depends on a number of factors including: satellite orbit characteristics, location of the ground station with respect to the satellite, and the beamwidth of the antenna.

An analysis of the problem, taking these factors into account, shows that a ground station using a moderate gain beam will, on the average, need to adjust azimuth and elevation controls about once every 15 minutes during most of the orbit. However, there will be times while the satellite is near the low point on its orbit (perigee) when almost continual adjustment of beam elevation and azimuth will be required. Since signals will be very strong near perigee, ground stations will find it convenient to switch from beams to simple fixed omnidirectional antennas during this relatively short period of time.

Let's compare the dynamic antenna aiming requirements for Phase III, as just outlined, to requirements for Phase II satellites and the 20-meter band. Radio amateurs who have been using low or moderate gain beams to access OSCAR 6 and OSCAR 7 will find that they'll be able to pay far less attention to azimuth and elevation controls when they communicate via a Phase III satellite. Operators familiar with 20 meters will probably also be pleased to observe how a single antenna setting will work for all stations using the satellite; there's no need to repeatedly adjust the antenna for each weak DX signal.

AMSAT hopes that some future Phase III satellites may be placed in geostationary (or nearly geostationary) orbits.[6] A satellite in a geostationary orbit will appear to remain fixed directly above a spot on the earth's equator; a satellite in a nearly geostationary orbit will appear to drift slowly in longitude while remaining directly above the equator. Ground stations using these satellites will only need to adjust azimuth and elevation controls when switching from one satellite to another or when turning on the ground station after it's been off for a day or longer.

## miscellaneous

**Lifetime**. Satellite lifetime concerns radio amateurs for several reasons. First, lifetime affects the yearly cost of the satellite. This subject will be covered in detail in the next section. Second, lifetime affects the long-term reliability of a satellite communications system. If a system depends on a single satellite, satellite failure shuts down the system. Potential users of a system based on a single satellite are naturally hesitant about investing time, energy, and money in a ground station that might suddenly have no function. Although the long lifetimes of OSCAR 6 and OSCAR 7 have alleviated this concern to some extent, the real solution is to produce a multiple satellite system so that the failure of a single satellite causes users only minor inconvenience. The term Phase III connotes just such a system. For this reason amateurs building ground stations for Phase III need not worry about their station suddenly becoming useless.

Let's look briefly at some of the plans for implementing the Phase III system. Experience with Phase II has shown that it's reasonable to expect operational lifetimes of five years for Phase III satellites. During the five year period following the launch of the first Phase III satellite, additional spacecraft will be placed into orbit; a new satellite every two years is a realistic goal for the 1977-1985 time frame. By 1984 the system should average three or more Phase III spacecraft in orbit and operating at any given time.

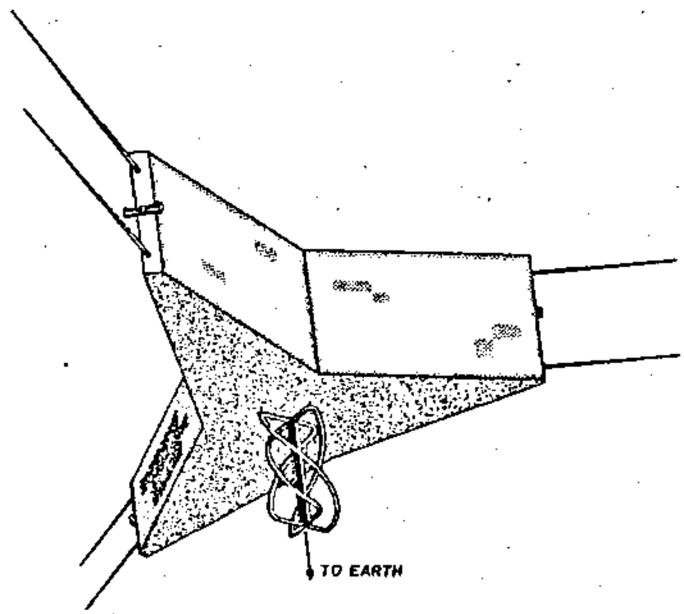
In the past amateurs thought that a satellite's useful life ended when it ceased to function. In the future AMSAT might decide to retire an old operating spacecraft from service in order to replace it with a new, more powerful model before total failure occurs

**Time delay.** Time delays from 10 to 300 milliseconds on the earth-satellite-earth path will make continuous monitoring of your own downlink distracting — to say the least. This is just one illustration of the many subtle differences between terrestial and satellite communications systems which amateurs will encounter in the future.

Each time amateurs have introduced new communications systems (ssb in the 1950s, for example, or fm repeaters in the 1960s), they've had to develop new operating procedures. Satellite systems will also require such innovations. One way to compensate for the time delays encountered while using high-altitude satellites might be to set the hang time on the vox or CW break-in system to 300 milliseconds and pause periodically for a second or two to enable the other party to break in.

**No skip zone.** Satellite communication systems do not exhibit skip zones. Consequently, it's easy to tell if a frequency is being used and a lot of unintentional interference can be avoided. In addition, round-table and net operation will be greatly facilitated since all users will hear each other. No problems to cure here — just a big bonus for satellite operators.

**Doppler shift.** Anyone who has listened to signals from a low-altitude satellite such as OSCAR 6 or 7 has probably noticed the pronounced downward shift in frequency that signals exhibit during nearby passes. A similar downward shift in frequency can be observed when a train passes with its whistle blowing. In both cases the frequency shift (called Doppler shift) is observed even though the source frequency is constant. The magnitude of the Doppler shift which amateurs encounter during satellite com-




Sketch of AMSAT-Phase III-A spacecraft.

munications depends on the relative velocity between satellite and ground station and the frequency being used — higher relative velocities and higher frequencies produce greater shifts.

Single-sideband communication is especially sensitive to Doppler shift since frequency changes of a few hundred cycles can make an ssb signal unintelligible. The largest Doppler shift that amateur radio operators have so far encountered during two-way communications occurs when OSCAR 7 passes directly overhead with the 432/146 MHz transponder in use. Under these conditions the Doppler shift is annoying, but ssb stations are able to compensate by frequent receiver tuning.

The first Phase III satellite will be moving slowly (relative to the surface of the earth) most of the time. During this portion of the orbit, Doppler shift will be smaller than observed with Phase II spacecraft which use the same transponder frequency combinations. However, there will be a small segment of each orbit, amounting to less than 10% of the period, when Doppler shift may be annoying, although ssb communications should still be possible.

Later Phase III satellites may be placed in geostationary orbits. Since these satellites will appear to remain fixed in space (no relative motion between satellite and ground station), no Doppler shift will be observed. In sum, Doppler shift will be of minor concern only with early Phase III satellites and of no concern with geostationary Phase III satellites.

**Crowding.** It has been estimated that the first Phase III satellite can accommodate 30,000 users equipped to transmit on the uplink bands. The estimate is based on ssb stations using 100 kHz and CW stations using 50 kHz of the transponder. If crowding becomes a problem before the follow-on Phase III spacecraft is launched, users have several options. Many may shift from ssb to CW to accommodate more stations in a given bandwidth. However, the opposite strategy, switching from CW to ssb, may actually be more effective in reducing crowding problems because a station can pass a given amount of information in a much shorter time period with ssb than with CW, while using less total spacecraft energy. This strategy would work only if amateurs limit themselves to essential information — a questionable objective.

Crowding effects can also be minimized by increasing the amount of roundtable and net operation. Phase III satellites are especially suitable for such use since there will not be any skip zone, and Doppler shift will be minimal. In any event, it should be evident that a number of viable options exist in response to any crowding problems that may temporarily occur. I have no doubt that amateurs who were raised on the 40- and 80-meter Novice bands will be able to devise satisfactory solutions.

## financing

Phase III will become a reality only if the international amateur community is willing and able to financially support the program. While large donations from individuals, corporations, and foundations are needed to produce the first Phase III spacecraft, a long-term Phase III program depends on small donations from a very wide base of support in the amateur community.

An educated guess places the procurement cost for a commercially built Phase III satellite in excess of five million dollars. An early AMSAT estimate pegs the cost of the first Phase III satellite at two-hundred thousand dollars, a considerably smaller but still imposing figure. A much more meaningful number is the cost per year of service. Experience has shown that it's reasonable to expect an operational lifetime of five years for a Phase III spacecraft, so the cost per year of service for the first Phase III satellite is expected to be less than $45,000.

Let's look at this figure more closely. When the number of amateur radio operators equipped for the uplink reaches 15,000 (half the estimated spacecraft capacity), the yearly cost per user will be less than three dollars! This means that when AMSAT membership reaches 50% of user capacity, the current $10 AMSAT membership fee* should be able to support an expanding program of satellite construction and provide for membership services, educational programs, and the *AMSAT Newsletter*. However, AMSAT satellites will always be free access and available to anyone licensed to operate on the uplink frequencies. Readers interested in cost breakdowns for the first Phase III satellite should read the current series in *QST* by Jan King, spacecraft project manager.

## general comments

Phase III satellites have been compared to Phase II satellites and 20 meters throughout this article. The points of comparison were chosen to illustrate Phase III satellite capabilities in familiar terms. As a result many of the unique and desirable characteristics of Phase II satellites and 20 meters have been ignored. I will now briefly discuss some of these features.

The 20-meter band will certainly remain a favorite of amateurs for a number of reasons. It's probabilistic nature is actually a very appealing characteristic — a skilled, knowledgeable, patient operator with a simple low-power 20-meter station will eventually be rewarded with exciting openings to the entire world. In addition, RTTY and sstv buffs can use 20 meters for hour after hour without ever worrying about using an unfair amount of satellite power.

Low-altitude satellites can be used by very simple ground stations. Contacts through Phase II satellites have been made with as little as 100 milliwatts, and numerous amateurs have had contacts using less than 1 watt of transmitter power; it is therefore possible to communicate through low-altitude satellites using small hand-held portable units. Low-altitude satellites can also be used in a broadcast mode, for example, to carry a single bulletin to the entire United States via 2-meter fm. Because of these features AMSAT will launch another Phase II satellite in late 1977 and continue the Phase II program through the 1980s. If you haven't already done so, try your hand at using the low-altitude satellites currently in orbit; they can provide a great deal of fun and excitement.

I think it's clear that Phase III will add a new dimension to amateur radio by augmenting the existing long-distance communication modes, not by replacing them.

*Regular AMSAT membership is $10 per year; life membership is $100. Write to AMSAT, Post Office Box 27, Washington, DC, 20044.

With the uncertain outcome of amateur frequency allocations at the World Administrative Radio Conference in 1979, and the rapidly increasing amateur population in the United States and abroad, the question is no longer "Can we afford to go ahead with the Phase III project?" The question is, "Can we afford not to go ahead with the Phase III project?"

The European Space Agency has selected the first AMSAT Phase III satellite for a late 1979 launch. The selection was a significant honor for the AMSAT team, but satellite construction can proceed on schedule only if AMSAT can obtain adequate funds. The money needed can be raised if amateurs are willing to demonstrate their commitment to the Phase III satellite program by joining AMSAT now, before the first Phase III satellite is launched.

Individuals who would like to make a more substantial contribution are encouraged to do so by donating money — contributions are tax deductible under section 170 of the IRS codes and/or donating time — volunteers are needed for a myriad of Phase III related activities (and you don't have to live in the greater Washington, D.C. area to participate).

Ten years from today amateurs will probably look back at the years 1977-1981, bracketing the launch of the first Phase III satellite, as one of the most exciting periods in the histoory of amateur radio. Take part in making history and enjoy it as it happens; *invest yourself in the future of amateur radio.*

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