WORKING "PACKET" ON OSCAR 10

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Abstract

This paper summarizes the technical and operational aspects of trying to communicate via packet radio on the AMICON channel of AMSAT's Oscar 10 satellite. A calculation of effective throughput is made which considers factors other than the traditional Eb/No parameter.

Background

In the summer of 1983 the Phase IIIB satellite of the Radio Amateur Satellite Corporation (AMSAT) was launched and became known as Oscar 10. After some early problems, the satellite achieved a stable, highly elliptical orbit of 26 degrees inclination. The orbit achieved provides outstanding communications coverage, and multi-hour path openings between points on the globe.

Within hours of the turn on of the transponder, several well equipped amateurs who were both packet radio & satellite enthusiasts attempted to transmit digital information on the special channel reserved for packet radio use. The opening of the transponder was also a challenge for the rest of us (primarily computer types) to take advantage of this new communications resource and to learn what the words "signal-to-noise ratio" really mean.

The author started assembling a satellite station in earnest in the Fall of 1983, and even though it would make a good story, this paper will concentrate on experiences of using the satellite, which has been the main activity since last December, when the last piece of the antenna system was put into place.

The plan is to describe as many of the technical and operational parameters involved in using the satellite for digital communications as is possible. These comments and observations are in the form of a calculation which attempts to compute the probability of getting a packet through the satellite at any given instant. Please don't take the figures too seriously, as most of the numbers are approximations and there are obvious holes in the logic used to compute probabilities. Nevertheless, the reader should gain an appreciation of the technical challenges involved in working packet on Oscar 10, and see how much room there is yet for innovation and improving our systems.

The sections which follow discuss the various factors involved in working packet, and in each case a number is derived which states the probability that the factor does not interfere with the successful transmission of that packet. At the end of the paper all the probabilities are multiplied (independence of factors is assumed) to determine the overall probability of success.

Satellite Visibility

The satellite is in a highly elliptical orbit, with an apogee of 35,000 km. and a perigee of 3500 km. The apogee sub-satellite point moves east about 9 degrees in longitude per day, and the apogee sub-satellite latitude remains constant at around 25 degrees. There are 2.06 orbits per day, but usually only one is visible for a given site, except at the transition where eastern passes change over into western passes, Antenna position during apogee is relatively stable, and only fine tuning is required. A printout or computer program is required to find out exactly where the satellite is during a pass, but the pattern is quite regular, and after a while one can almost sense where to point the antennas for the next orbit.

A complete pass lasts almost ten hours, but during perigee the transponder is turned off, and experience has shown that packet work is only good around apogee plus or minus 2 1/2 hours or so. So the channel is only usable for about 5 out of 24 hours, leading to a visibility probability of 5/24 or 0.21 .

Normally the satellite is in Mode B (435 MHz. up, 145 MHz. down), but for four hours around apogee on Wednesdays and Saturdays it is put into Mode L (1269 MHz. up, 436 MHz. down) which is currently unusable for packet work. So the Mode L time is 8 hours in a 168 hour week, and thus the Mode B probability is 160/168 or 0.95 .

A complete western horizon to eastern horizon series of orbits takes about twenty days, and the antennas point into a hill on the low western passes, and into an oak tree on the low eastern ones. So scratch about four days out of every twenty, and the probability of not irradiating the neighbors becomes 16/20 or 0.8 .

Every month the orbits for the next month are computed at work and printed for 30 days in advance, but usually only after getting ready to work the satellite and finding that the calendar has expired. So one day out of thirty is lost, and the probability of having the right printout is 29/30ths or 0.97 .

As the orbit apogee passes east over the 180 degree azimuth mark and works its way into Europe, the big boomers over there desense the receiver and make the power levels required to work packet more than the average ham can afford. So the probability of no Europeans is about fifty percent or 0.50 .

The earthstation ground terminal equipment room is also the OM's and XYL's bedroom, and this means that late night passes are unusable. So, the probability of daylight is 16/24 or 0.67 .

= finances required to buy all this satellite equipment required the author to maintain his job, and the remaining time is roughly split between playing with the kids and playing with the radios . So, the probability of having some free time and not arranging a PPRS meeting or talking to a local ham club is perhaps 4/16 or 0.25 .

Interference Conditions

One of the major disruptive elements to the success of working with the satellite today is man-made electrical noise. This is particularly troublesome on packet, where a stray impulse can kill a complete frame. The main sources are autos, line noise, and the neighbors' mixmasters, electric vibrators and buzzsaws . Two meters is very prone to interference of this type, and a move to higher frequencies would be warranted for this purpose alone. The subjective impression is that roughly twenty percent of the time some static is in the air, and thus the no-noise probability is 0.80 .

The packet downlink is 145.830, which happens to be the favorite watering hole of some crusty old simplex fm'ers in this area, who can't imagine why anybody would want to use their frequency, Most will move when asked, but others can't seem to comprehend that a five-way international qso could be in progress when the local channel sounds perfectly clear. The crusties seem to get their way about ten percent of the time, so the no crusty probability is 0.90 .

The receiving equipment has to be extremely sensitive, and unfortunately will pick up lots of stray radiation from unfiltered computer gear and unshielded, unboxed terminal node controllers, All the equipment purchased should be FCC Class B Certified, and all connecting cables should be shielded and grounds well maintained. One birdie from my modem on 145.760 serves as a nice test signal source, but the rest may cause trouble five percent of the time. Therefore, the non-birdie probability is 0.95 .

Station Equipment

In order to get anywhere on packet, a decent antenna system is required with a mast-mounted pre-amp. The commercially available gas-fets have • S dB noise figures, and are not too expensive, Most hams do not bother putting coax switches in their two-meter downlinks and setup their equipment so that the probability of transmitting into the gas-fet is near zero. Here are three creative excuses to tell friends after you've just smoked your high-priced gas-fet pre-amp: "My TAPR TNC did a cwid when I didn't expect it", "My two-year old was playing with the microphone", and the classic "My 726 was on RB-TA instead of RA-TB". So the probability of having a functioning gas-fet is about 0.98 .

Most packet stations are currently using the AX.25 protocol at 1200 bps with 202-style FSK modems. There are a few stations who may still be using older protocols or different modems or slower speeds. The compatibility probability is therefore 0.95 .

The use of 202 FSK modems is currently the biggest barrier to successful packet work, as their theoretical and practical performance is poor in relation to other potential designs, Tuning is difficult, and different designs of the 202 have different performance levels. If one has stable equipment, a tuning indicator such as an "eye" pattern, and reasonable receiving equipment , then about nine out of ten packets can be recorded successfully. So, the frame throughput probability is 0.90 .

Channel Contention

The packet community is relatively small at the time of this writing, only about a dozen or so stations have actually transmitted so far, So the probability of collisions with other traffic on the channel is quite small at the present time. However, the quarter second round trip delay permits two transmitters to start and collide without hearing each other's carrier, and this occasionally happens, Another source of collisions is TAPR boards left in full-duplex mode while running on a single frequency (not-split frequency) channel. So an estimate for the probability of no collisions is 0.95 .

Net Throughput

If the above factors are considered independent, then the probability of a successful transmission is the product of each of the above factors. Multiplying all the items above, we compute a net transmission probability of • 007059e This may not seem very high, but considering that twelve months ago the probability was zero, it is an infinite improvement!

If we also consider that in just one week there are 604800 seconds of potential transmission time on which we can place 72,576,000 bits of information, or 2,268,000 forty byte frames, then using the net number above implies that 16,009 forty byte frames will get through the channel in a week. That's 640,392 characters of information, more than an average person can consume in a week given reasonable assumptions,

Conclusion

Using the satellite for digital work has been one of the most interesting technical challenges the author has encountered for some time. It makes one appreciate the role satellites will play in the future, and opens up many new and interesting possibilities for information transfer,

Clearly, new designs in modems and automation of the ground station control systems will vastly improve the throughput available on this resource, These are interesting technical challenges which lie ahead, and others are encouraged to add their contributions.