Catch a Falling Star

A beginner’s guide to meteor-scatter communication— just in time for “stormy” weather!

By Kirk Kleinschmidt, NT0Z

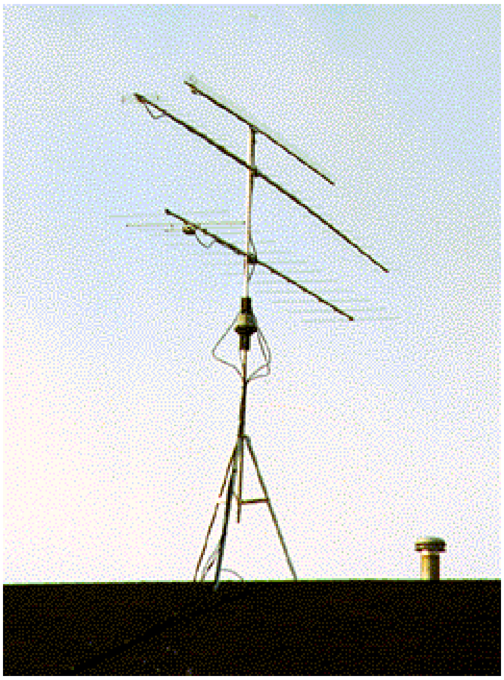
Newcomers to Amateur Radio usually have a few misconceptions about VHF propagation. The worst—which is often “propagated” by more experienced hams who should know better—suggests that VHF signals travel exclusively along line-of-sight paths and peter out after about 30 miles. That’s far from true, but if your VHF operation is limited to 2-meter FM it’s somehow practical, especially if you’re using a hand-held radio and a rubber ducky antenna.

Once you cross the “30-mile barrier,” however, there are many exciting and interesting ways to propagate your VHF signal hundreds or even thousands of kilometers. Articles in the *ARRL Operating Manual* and *QST* detail E- and F-layer skip, tropospheric ducting and transequatorial field-aligned irregularities, moon-bounce, auroral propagation and others.

These modes aren’t always casual. That is, many require robust stations, high power and more than a little patience. Meteor- scatter work—bouncing radio signals off the ionized trails produced by meteors burning through the ionosphere—doesn’t require an extraordinary station, but some patience is usually necessary unless you know exactly when conditions may be favorable!

That’s precisely the case with the November Leonids meteor showers for the next few years. (Meteor showers are named for the constellations from which they seem to appear. Meteors produced during the recurring November 17 shower seem to “pour” from the constellation Leo.) As an added bonus, on one or more of those November days the short-duration, high-intensity Leonids have the potential to produce the best meteor-scatter propagation since November 1966 (and a spectacular light show if you’re on the night side of the planet!).

The potential rain of meteors is so intense that, if the Leonids storm anywhere near 1966 levels, scientists are worried that satellites, space stations and spacecraft may be destroyed or damaged by meteoroid collisions! (See the sidebar, “Leonid Meteors Potential Satellite Killers?” for more information.) And even if every orbiting structure escapes unscathed, the combined effect of tens of thousands of meteors per hour burning through the ionosphere would provide a frenzy of VHF contacts in the 800 to 2000-km range. Six and 2 meters (SSB and CW) would sound like a 20-meter pileup!



Tom Hammond, WD8BKM, works meteor scatter and other forms of VHF/UHF DX from his condo with just 150 W. A

tripod on the roof supports 2 meter, 70 cm and 23 cm beam antennas. They're light enough for a small, inexpensive TV rotator to handle. See his article "Hooked on Meteors" in the May 1995 *QST*, page 74.

Meteors and Comets = Meteor Scatter = Radio Fun

Although the origin of meteors was once a mystery, scientists now know that meteor showers are produced when the Earth plows through the orbiting debris streams left by passing comets (known and otherwise). The debris, mostly dust and other small particles, burns up as it speeds through the atmosphere.

Although the Earth is continually running into "random debris" in its orbit of the Sun, meteor showers are recurring events, that is, the Earth encounters certain debris streams at about the same time each year. **Table 1** lists the major annual showers and their characteristics. There are dozens of minor showers that aren't listed.

Table 1—Major Meteor Showers

Name	*Peak Date*	*Approx Rate (per hour)*	*Best Path*	*Local Time*
Quandrantids	Jan 3-4	40-150	NE to SW	1300-1500, 0500-0700
Eta Aquarids	May 4-5	10-40	NE to SW	0500-1100
			E to W	
Arietids	Jun 7	60	N to S	0600-0700, 1300-1400
Perseids	Aug 12	50-100	NE to SW	0100-0300, 0900-1100
Orionids	Oct 22	10-70	NE to SW	0100-0300
			N to S	0700-0900
Geminids	Dec 13-14	50-80	N to S	0500-0700, 2200-2400

Nighttime observers see falling stars whiz across the sky. To the human eye, meteors speed by in an instant and disappear. To radio signals, however, the "corridor" left by the bullet-like passing is a long reflective trail of ionized particles. In the most basic sense, Earthbound stations that can "see" the ionized trail can communicate with each other by bouncing radio signals off the ionized corridor, which "scatters" them in many directions.

Frequencies, Physics and Geometry

Meteor-scatter contacts take place mostly on 10, 6 and 2 meters between stations 500 to 2300 km apart. Faster, larger meteors produce more intense, longer-lasting trails and better propagation paths. Slower, smaller particles produce little or no ionization/propagation.

For two stations to communicate via meteor scatter, a meteor(s) must pass through the ionosphere in a useful direction and at mutually visible elevations. The best directions are tangent to the straight-line path between the stations; the best elevations are 45 degrees or less (but still above the horizon!). See **Figure 1**.

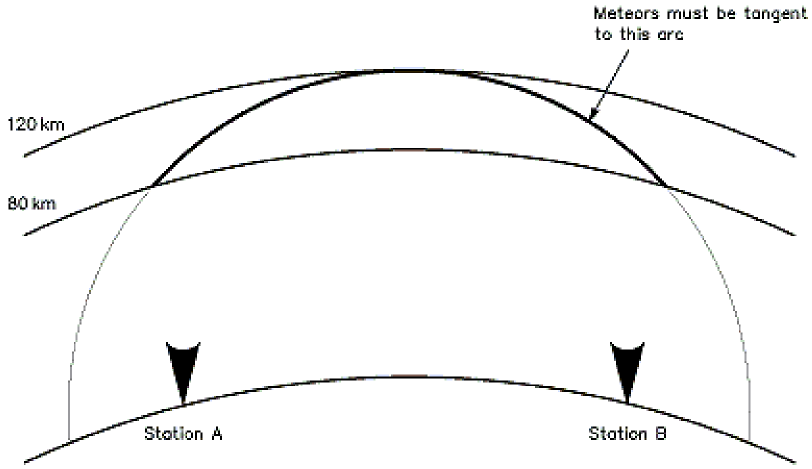


Figure 1—To support effective meteor-scatter communications, incoming meteors must produce ionized trails that are tangent to the straight-line path between the two stations and at useful elevations (altitudes).

The trail left by a typical meteor reflects radio waves from a few seconds to a few minutes, depending on the size and speed of the meteor itself, the frequency of the radio signal, and several other factors. At 28 and 50 MHz, an active meteor can sustain propagation for 30 seconds to several minutes. At 2 meters, the same meteor burst will allow communication for only a few seconds to a minute. (At UHF, where some meteor-scatter contacts are completed, a typical meteor reflects radio energy for less than a second!)

Meteor-scatter signals suddenly appear out of a dead band, persist for a short time, then disappear! The effect can be quite eerie! During a meteor shower, when several overlapping ionized trails may be reflecting radio waves at any one time, communications are possible for several minutes to several hours.

Armed with this new knowledge, it's easy to see why meteor-scatter ops are so excited about a potential Leonids storm. During a typical (good) meteor shower, 60 to 80 meteors blaze across the sky each hour. During the November 1966 Leonids storm, scientists put the *zenith hourly rate* (ZHR) at 150,000 meteors per hour—pileup central! (ZHR is the number of meteors an observer could count in a one hour period under optimal viewing conditions.) See **Table 2** for a list of expected Leonid peak times.

Table 2—Predicted Leonid Shower Peak Times

Year	*Center of Predicted Peak Periods*
1997	Nov 17, 1100 UTC
1998	Nov 17, 1702 UTC
1999	Nov 17, 2302 UTC
2000	Nov 17, 0517 UTC
2001	Nov 17, 1117 UTC
2002	Nov 17, 1731 UTC
2003	Nov 17, 2359 UTC

Note: These times assume that storms in the late 1990s will occur near the same solar longitude as the 1966 storm. The years 1998-2000 are most likely to show storm activity at some level, while 1997 and 2001-2003 are likely to show enhanced activity. Table courtesy of Peter Brown, University of Western Ontario.

Setting up Your Station

Although 2 meters is the workhorse band for many experienced meteor-scatter operators, the best bands for beginners are 10 and 6 meters. Station requirements are more modest and openings last longer and are more consistent.

Meteor-scatter contacts are made with dipole, vertical and even mobile antennas, especially on 10 and 6 meters, but some type of directional antenna is a practical necessity. On 10 and 6 meters, 50 to 100 W and a three-element Yagi produce solid results. On 2 meters, where the action is a bit more frantic, 150 W and a 10-element beam should do nicely.

If your station puts out less power, start on 10 and 6 meters before trying your hand at higher frequencies. A higher-gain directional antenna may offset reduced output power. Experimentation is the key!

In North America, most meteor-scatter work is done on SSB, although there is some activity on CW. In Europe, high-speed CW contacts are the norm (200 to 400 WPM). Ops on each end use tape recorders or computers to transmit high-speed messages during the short meteor bursts.

Working the Meteors

There are no special procedures for 10-meter meteor-scatter work. At this relatively low frequency, ionization trails usually persist long enough to allow conventional, brief contacts. Limit your transmissions to a few seconds. During meteor showers, Leonids and otherwise, try calling "CQ scatter" just above (and or below) 28.5 MHz. Aim your antenna in the direction you hope to make contacts.

On 6 meters, activity usually starts at 50.130 MHz and moves up, with many operators listening around 50.200 MHz. Contacts are fast, so stay awake! On 2 meters and above, most meteor-scatter work is accomplished via schedules, where each station transmits and receives in 15-second intervals. This technique is detailed in Chapter 12 of the *ARRL Operating Manual*. Most activity can be found between 144.175 and 144.225 MHz.

During peak shower periods on 6 and 2 meters, call CQ for a few seconds and then listen for a few seconds. “CQ CQ CQ scatter NT0Z NT0Z break”—spoken without pausing for syllables—is what’s needed to accommodate openings that may last only a few seconds! A quick reply might be “NT0Z W3EP W3EP break.”

Contacts are complete when call signs and one other piece of information (grid locator or state) is exchanged and acknowledged by “rogers.” Repeats are often required. Keep your transmissions short and stay with a station until a full exchange of information is made.

Get Started with the “Weekend Mornings” Gang

To get your feet wet, the “weekend meteor-scatter watering hole” offers excellent contact opportunities on a consistent basis. Every Saturday and Sunday morning from dawn to about 9 AM local time—prime time for meteors—scatter enthusiasts work 6 meters for fun. You should, too! There are plenty of contacts to be made year-round.

Although activity increases during shower periods, the Earth sweeps up thousands of meteors each day. The morning hours are usually the best for meteor-scatter work because the velocity of the Earth’s rotation increases the effective velocity of inbound meteors (conversely, the evening hours around 9 PM local time, when the Earth is rotating away from incoming meteors, are usually the worst). See **Figure 2**. As shown in **Figure 3**, June, July and August are the best months for Saturday and Sunday morning sessions (and meteor work in general).

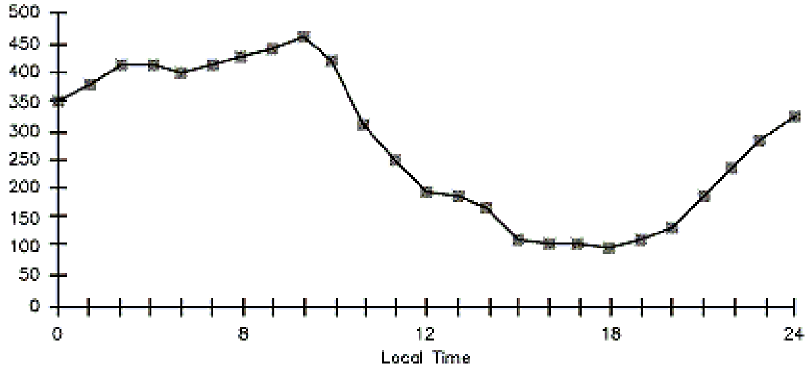


Figure 2—Average daily meteor rates (relative) by the hour.

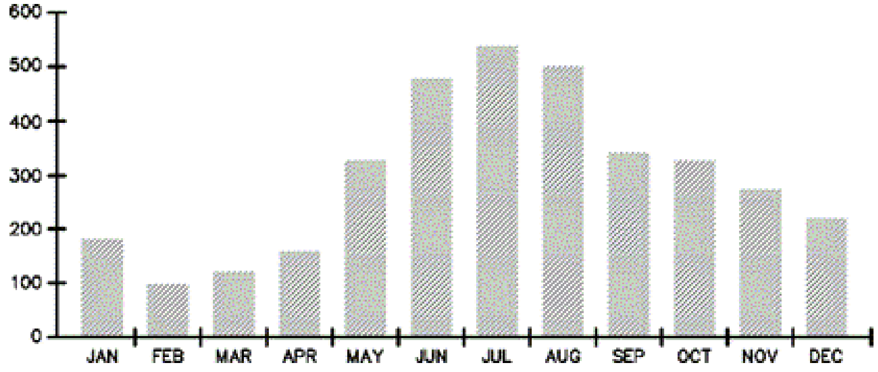


Figure 3—Sporadic meteor rates by season.

Awards, DX and Other Goodies

Because it’s sometimes impossible to discern meteor-scatter propagation from tropo or E-skip openings, there are no specific meteor-scatter awards per se. That said, meteor-scatter contacts work just fine for other awards or certificates you may be pursuing, including WAS and VUCC. Central US stations enjoy excellent “DX” potential. Several VHF operators have worked stations in all of the lower 48 states without using satellites or moonbounce.

The June VHF QSO Party overlaps the Arteids meteor shower which, unfortunately, tends to be a poor performer. Meteor-scatter propagation usually gives the best boost to the annual ARRL 10-Meter Contest, which intersects the December Geminids shower. Even during sunspot doldrums when 10 meters seems totally dead, morning meteor-scatter contacts will put at least a few stations in just about everyone’s log.

Resources

If you’re serious about pursuing meteor-scatter work there are many resources at your disposal. In addition to the operating procedures outlined in *The ARRL Operating Manual*, see Clarke Greene’s “Meteor-Scatter Communications” in January 1986 *QST*. *QST*’s monthly column “The World Above 50 MHz,” hosted by Emil Pocock, W3EP, periodically contains information of interest to meteor-scatter enthusiasts. Try the July 1994 column for starters.

If you have access to the Worldwide Web, point your browser to **http://www.qsl.net/dk3xt/ms.htm** for Bernie Gapinski, AB7IY’s excellent list of meteor-scatter links. Also interesting is the list of meteor/meteor-scatter experimenter’s links at **http://www.psnw.com/~n7stu/vhftools.html**.

Conclusion

If you’re itching to get involved in one of the more “esoteric” VHF modes, meteor-scatter communications is a perfect place to start. Station requirements are reasonable, and the gear you’ll accumulate will be useful for other VHF/UHF work. Besides, if a Leonids storm materializes on some November 17 between now and 2004, you won’t want to miss the best meteor-scatter event of your lifetime!

I’d like to thank Emil Pocock, W3EP, for his help with this article. (In my days as a *QST* editor, our nickname for Emil was “noted VHF authority W3EP”—and for good reason!) Thanks also go to the hams quoted in the “Soapbox,” whose speedy Internet replies were a big help!

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Leonid Meteors: Potential Satellite Killers?

Like the plot of a pulp science-fiction novel, an intense Leonids storm sometime during the next few years—which would easily be the most powerful of our modern electronic era—may destroy or damage satellites (ham satellites included), space stations and spacecraft.

In decades past, when comet Tempel-Tuttle passed near Earth’s orbit (every 33 years; the next perihelion will be in February 1998), awesome, apocalyptic meteor storms sometimes turned pre-dawn skies into terrifying, unforgettable displays. These fireworks, unfathomable and frightening to civilizations a thousand years ago, are sought-after events today.

The last big Leonids storm, in November 1966, with its amazing zenith hourly rate of 150,000 meteors per hour, was dazzling by even Leonids standards. It happened, however, before Earth’s space age began to pick up steam. Unlike today, citizens in 1966 didn’t rely on fleets of communication, weather, Amateur Radio and spy satellites. They didn’t launch space shuttles and build space stations, either!

If you think there’s no danger—you’re wrong. Satellites have recently been killed by micrometeoroids encountered during meteor showers far less active than those predicted for the 1997-2003 Leonids. And *Mir*, the Hubble Space Telescope and US space shuttles have been visibly damaged by debris and micrometeoroid collisions.

What might happen to the manmade satellites now in orbit during a meteor storm 10,000 times more intense than normal—with particle impact speeds exceeding 150,000 miles an hour?

What indeed! Those conditions were measured during the tremendous 1966 Leonids storm, and scientists are worried that we'll see a repeat performance (or one or *more* showers of lesser, yet potentially destructive intensity) during November Leonids showers over the next several years.

Physical collisions alone are cause for concern, but a second threat may be even more ominous. Because of the tremendous impact velocities involved (closing with the Earth at 71 km per second, the Leonids are the fastest-colliding cometary fragments known), the highly charged plasma clouds generated by the impacts of even extremely small Leonids particles may be powerful enough to kill satellites that would have been minimally affected by the physical collisions.

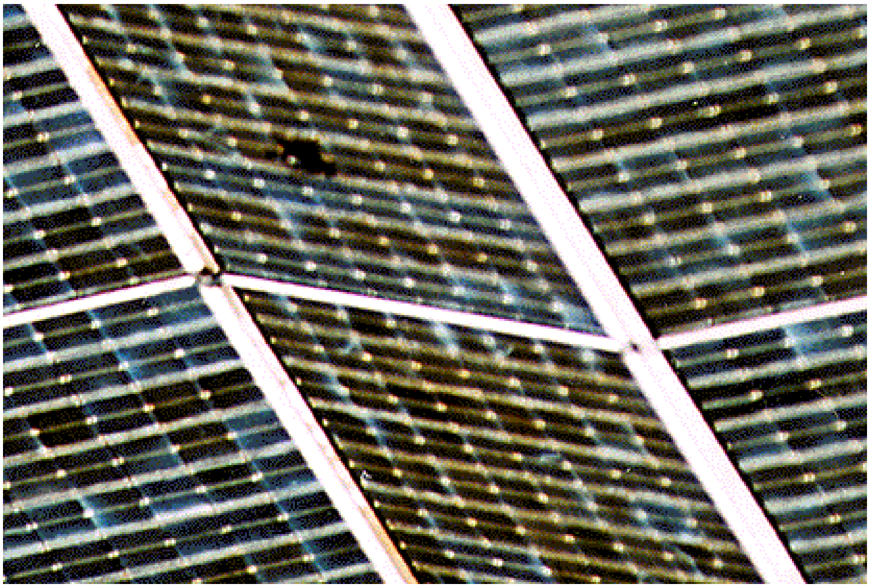
Death of a Satellite

Objects in orbit are constantly bombarded by very small particles. Space shuttle windows get "sandblasted" and pitted during missions and are routinely replaced before the craft is relaunched. Long-duration orbiters such as *Mir* have protective window covers to reduce cumulative micrometeoroid damage. The space station *Freedom* will even be armored to withstand the impact of a 1-cm aluminum sphere traveling at 10 km per second.

And while micrometeoroids don't usually kill satellites on the spot, a large satellite was killed in such an encounter in 1993. The incident spurred scientists to study micrometeoroid streams more closely.

The casualty was *Olympus*, a large communications platform operated by the European Space Agency. During the 1993 Perseids meteor shower, an outboard solar panel was hit by a meteoroid. The kinetic energy transferred during the hit spun the satellite off axis and a highly charged plasma cloud "bathed" the satellite and entered its internal structure, causing gyro errors. Ground-control operators eventually stabilized the satellite, but with no remaining station-keeping fuel the satellite was effectively dead.

During the same 1993 shower a space shuttle launch was delayed and the Hubble Space Telescope was positioned so that its powerful optics were aimed directly away from any incoming meteors. Later shuttle missions would reveal that the Hubble's high-gain dish antenna was cleanly punctured by a meteoroid (or orbiting debris), as were several *Mir* solar modules. Whether the hits took place during the Perseids shower isn't known.



This photo, taken by shuttle astronauts, shows the large "cookie-cutter" hole punched through a *Mir* solar panel. It was caused by a collision with a passing meteoroid or other orbiting space debris. Photo courtesy of NASA.

Kinetic Encounters or Plasma Attack?

When most of us think about particles hitting satellites we tend to imagine *ballistic* damage. Much like shooting a bullet at a target, we visualize meteoroids punching into satellites at tremendous speeds. We might even picture the satellite breaking up or even exploding—like a scene from a Clint Eastwood movie.

Ballistic damage is a pressing concern, especially when even a tiny, speck-like particle moving at incredible velocity can pack as much punch as a missile. A particle's kinetic energy increases with the square of its velocity, and Leonids particles, with closing velocities much faster than those of typical meteoroids, can pack a tremendous punch.

(Unlike most comets, Tempel-Tuttle orbits the Sun in nearly the same plane as Earth—but in the *opposite direction*. When Earth moves through the comet's very narrow debris field, this head-on collision results in a closing velocity of 71 km per second.)

Simple ballistic models make sense, especially when particles hit thick, solid objects such as the main bodies of spacecraft or satellites. This allows the tremendous kinetic energy stored in the fast-moving particle to be transferred to the "target."

Kinetic damage is bad enough, but scientists are more concerned about the plasma clouds produced when superfast particles hit just about anything (such as those that were likely produced in the *Olympus* incident). As scientists are discovering, slower, bigger micrometeoroids cause more kinetic damage and produce less "plasma effect" than faster, smaller particles.

When particles collide at Leonids velocities, the physical matter simply "falls apart" and disintegrates into a charged plasma cloud before the bulk of its kinetic energy can be transferred to the target.

Imagine an Iowa Farm-League pitcher who could throw a baseball so fast that when the hitter smacked it dead to rights with his bat, instead of the cover being knocked off the ball, as in the old movies, the ball literally "poofed" into nothing (a plasma cloud) while the batter corkscrewed around as if he missed the pitch entirely!

The intensity of the plasma field generated on impact varies with the particle's velocity *to the fourth power*. It's amazing to think that a Leonids particle weighing a thousandth of a gram might strike the main structure of a satellite at 155,000 miles an hour and leave only a microscopic pit in the paint—micro- seconds before consuming the satellite's electronic systems in a powerful plasma cloud, shocking it as though it had been struck by lightning!

A second effect of plasma clouds may be just as deadly. If the affected satellite survives the direct plasma pulse, it may still be destroyed or damaged by electrostatic discharges between its own components.

In orbit, the vacuum of space is an excellent electrical insulator. Insulated spacecraft components such as antennas and solar panels gradually accumulate static charges picked up by "brushing against" the continuous stream of solar emissions, much like an airplane that becomes charged by flying ("frictioning") through the air.

Under normal conditions these charges can safely accumulate. But when a satellite is enveloped by a highly conductive plasma cloud, the charged components can "flash over," potentially damaging or knocking out electronic circuits.

At Leonid speeds, meteoroid hits don't have to cause *any* mechanical damage to kill or damage a satellite. In fact, at 71 km per second, scientists think plasma damage may be much more of a problem than mechanical damage.

What's NASA Doing?

NASA is sifting through Leonids data on several fronts and is taking the potential threat seriously enough to delay shuttle missions and critical launches during the November 17 shower periods. And if astronauts are aboard the yet-to-be-launched space station, they will likely be moved into *Freedom*'s protected internal areas or emergency crew-recovery modules during the relatively short-duration peak periods.

The Bottom Line

Determining the *precise* odds of a spacecraft colliding with a Leonids meteoroid is difficult at best because orbiting structures vary in size, and objects over different parts of the globe see widely varying particle rates.

Using 1966 storm data, scientists calculate an impact probability of approximately 0.1% per hour for satellites of "standard area" (10 square meters) exposed to peak-rate particle streams. Many satellites are much larger, especially when their solar arrays are exposed to the stream.

An impact probability of 0.1% per hour doesn't sound all that risky, but when you consider that a satellite of standard area normally has a 0.07% impact probability *per year*, the meteor storm figure stands out. The space station *Freedom*, with an exposed area of almost 500 square meters, should experience an impact probability of about 0.5%, with a maximum risk of 1%.

This figure assumes the station's heavy shielding, however, and estimates the risk associated with a *critical* impact. Its chances of being hit by smaller particles may be greater. And how the station may be affected by potential plasma discharges is unknown.

Even with impact probabilities that seem mathematically insignificant, there are hundreds of objects in orbit, each one a potential target for the fast-moving Leonids.

More Information

Information on the Leonids threat is emerging daily, so the best place to get the latest scoop is on the Internet. Point your browser to **http://medinfo.wustl.edu/~kronkg/** to get started. Meteorologist and Leonids expert Joe Rao's excellent article, "Leonids: King of the Meteor Showers," can be found in the November 1995 issue of *Sky & Telescope.* It's provides a must-have Leonids education. Much of this sidebar was excerpted from my article, "Bracing for the Leonids Firestorm," which appeared in the March/April issue of *Satellite Times*.*—NT0Z*

Meteor Scatter Soapbox

If you think meteor-scatter hamming is too tricky, requires too much hardware or massive antennas, think again. We asked several meteor-scatter aficionados to share their thoughts and experiences with potential newcomers.

"I've had two meteor-scatter contacts from my car while running 150 W to a Comet CA-HV antenna!"*—Earl Needham, KD5XB*

"I have worked many 2-meter meteor-scatter stations with 150-W brick and single Yagi. What is more interesting is the 2-meter SSB meteor-scatter QSOs we make in the Midwest with 25 W and 20-element OSCAR antennas (crossed 10-element Yagis). That adds a little more challenge to working random meteor-scatter QSOs. The same setup is also very effective for 2-meter aurora contacts."*—Ed Fitch, W0OHU*

"150 W and a small/medium Yagi (14- to 21-foot boom) is more than adequate for meteor-scatter work. In fact, I worked 37 states on 2 meters and much more than VUCC with just such a station. Mark, KM0A, has worked hundreds of stations with 150 W at his end. I worked him when I was portable from South Carolina in early June without the benefit of a meteor shower. I was running 150 W to a portable 14-foot Yagi antenna from the top of a condo."*—Gene Zimmerman, W3ZZ*

"I started out with a converted Midland CB [converted to 6 meters—*Ed.*], giving me 10 W output to a five-element Yagi that I built from plans in an old *ARRL Antenna Book.* I worked stations in ZS2, ZS4, ZS5 and ZS6 via meteor scatter with no problems. You *can* do it with a low-budget station, I did!"*—Johan le Roux, ZR1AEZ*

"I lived in an apartment in Wichita, Kansas, during th mid '80s and ran 80 W on 2 meters to a four-element quad. I was able to work the following in the 1983 Perseids shower: N8AXA, OH; W9IP, IL; K6PVS, CA; W5FF, NM; WA7JUO, NV; and W5RCI, MS. Last year I went on a grid expedition during the Perseids meteor shower to DM98 in western Kansas. I used a TR-751A and a 100-W amp to a medium-size Yagi operating from a rest stop near Kalvesta, Kansas, on 2 meters. On August 12 I worked 16 stations!"*—Jon Jones, N0JK*