A Total System Approach to Field Communications

North Texas NVIS Net

First Radios Back on the Air

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First, We Need to Get Back on The Air

This numerically referenced notebook is for initial NVIS planning in the field when there is no access to the internet. No one frequency will work for all contacts or band conditions. More importantly, for best NVIS reliability, ***all station must be configured for NVIS operation***. This notebook is to help you configure your station. Use the back of each page for your notes. Consider these tips when developing your NVIS radio plan:

1. First, we need to get you back on the air. Estimate distance and plot locations to receiving station from map options on Pg 3

2. You will need to start with an idea of ***average*** Solar Flux Indices (SFI) to establish a current Maximum Useable Frequency (MUF). SFI will yield different value between the Winter and Summer, Pg.4

3. If the internet is still functioning but not in your area, you can tune to WWV (2.5, 5, 10, 15 and 20 MHz) at 18 minutes past the hour or WWVH (5, 10, and 15 MHz). These broadcasts will give the current SFI and any special solar weather statements. Apply the given SFI to the charts on Pg. 4. This will get you started with an average MUF based on time of year. If one of your ***relay stations*** still has internet service, he can relay the broadcast from www.eham.net or the Critical Frequency chart from www.ngdc.noaa.gov/stp/IONO/rt-iono/realtime/AU930_foF2.png (MUF frequency will be 20% lower than Critical frequency)

4. Average hourly diurnal variations are on the chart on Pg 5. Choose an operating frequency nearest the solid line. The times across the bottom of the chart are local (not UTC) times.

5. Now pick a height for antenna based on that operational frequency Pg 6. Tune the antenna to your feedline and radio. The most important aspect of NVIS is a well-tuned and resonant antenna. Some tips on Pg 7.

6. Common Trouble Shooting tips are found on Pg. 8

You should be able to get back on the air. Refer to the appendices below to fine tune your operations and prepare for multiple operational periods.

Excerpts and charts in this manual taken from "NVIS Communications: Theory, Techniques, and Validation." Available from DX Engineering. #KMT-NEAR-VERT The articles are old but the theory is still good.

Mapping without the Internet

Maintain file of everyone you work with: Names, calls, towns, distance, organization, Lat Lon, antenna hiegth and type. Look it up on QRZ and keep it current. Prefer free standing ***laptop databases*** which doesn't rely on the internet!

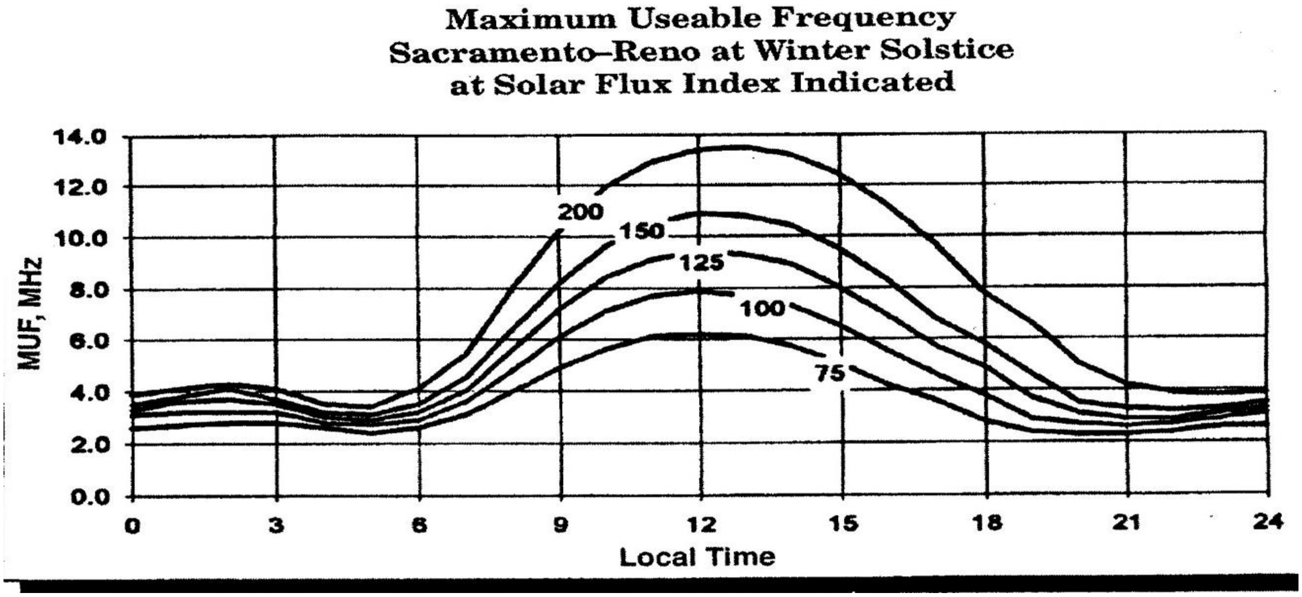
The VOACAP program has an excellent base map that can be used without the internet. You will not be able to search by placenames; must use Maidenhead grid or Lat Lon. It will give you distance and headings for the world. It's a good idea to turn it on in the morning or just leave it on. If you lose the internet service before you turn the program on, it will not be able to load.

Car navigation system map may be useful for placenames or coordinates. All the different navagational manufactures have different features. Take your manual out and practice some senario's.

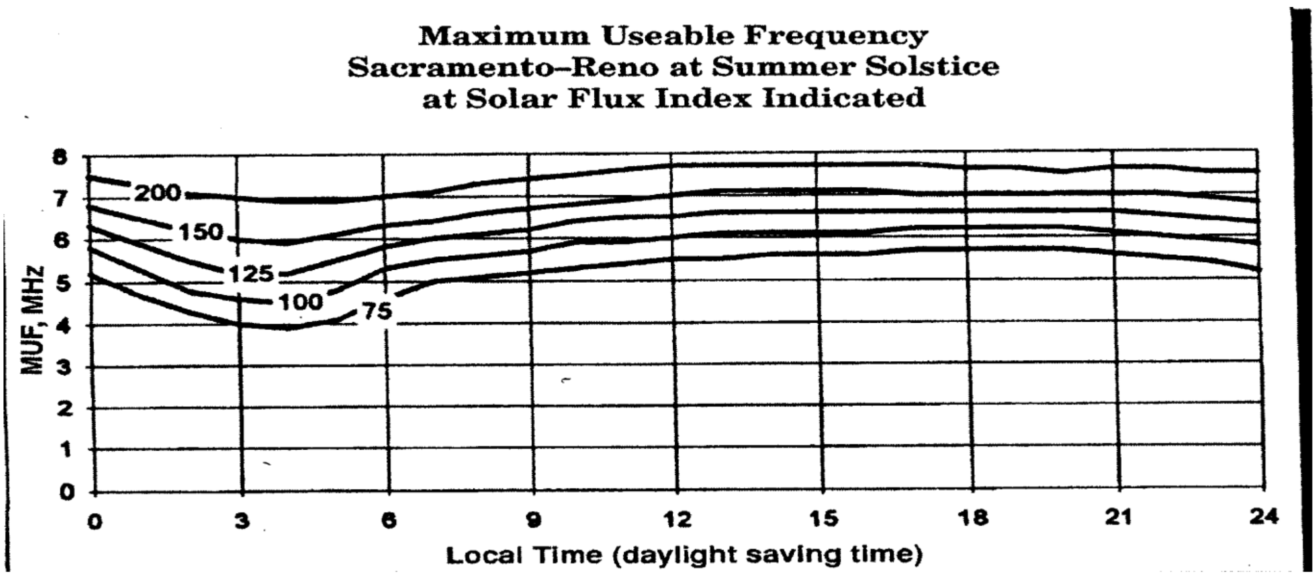
Check out satelite internet sevice for use during outages. www.starlink.com Not cheap

If nothing else maintain a couple of paper maps in this notebook folder.

The antenna system that is: the easiest to carry, deploy, has the best gain, is the ½ wave horizontal dipole at .1 to .25 wavelength above good ground.

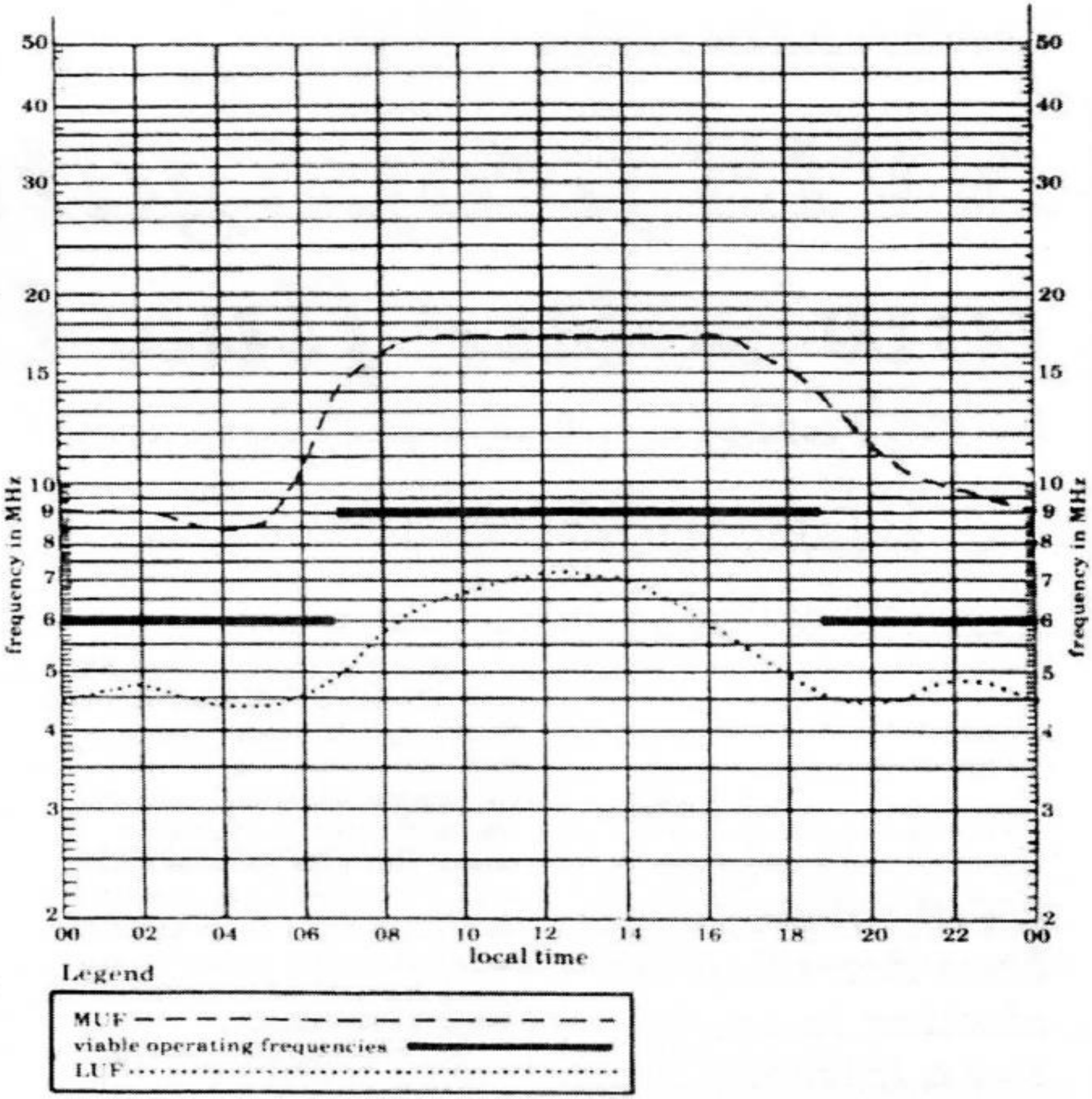


Average SFI, Pacific time zone, adjust to your local time. (Ed Farmer, NVIS Comm.)



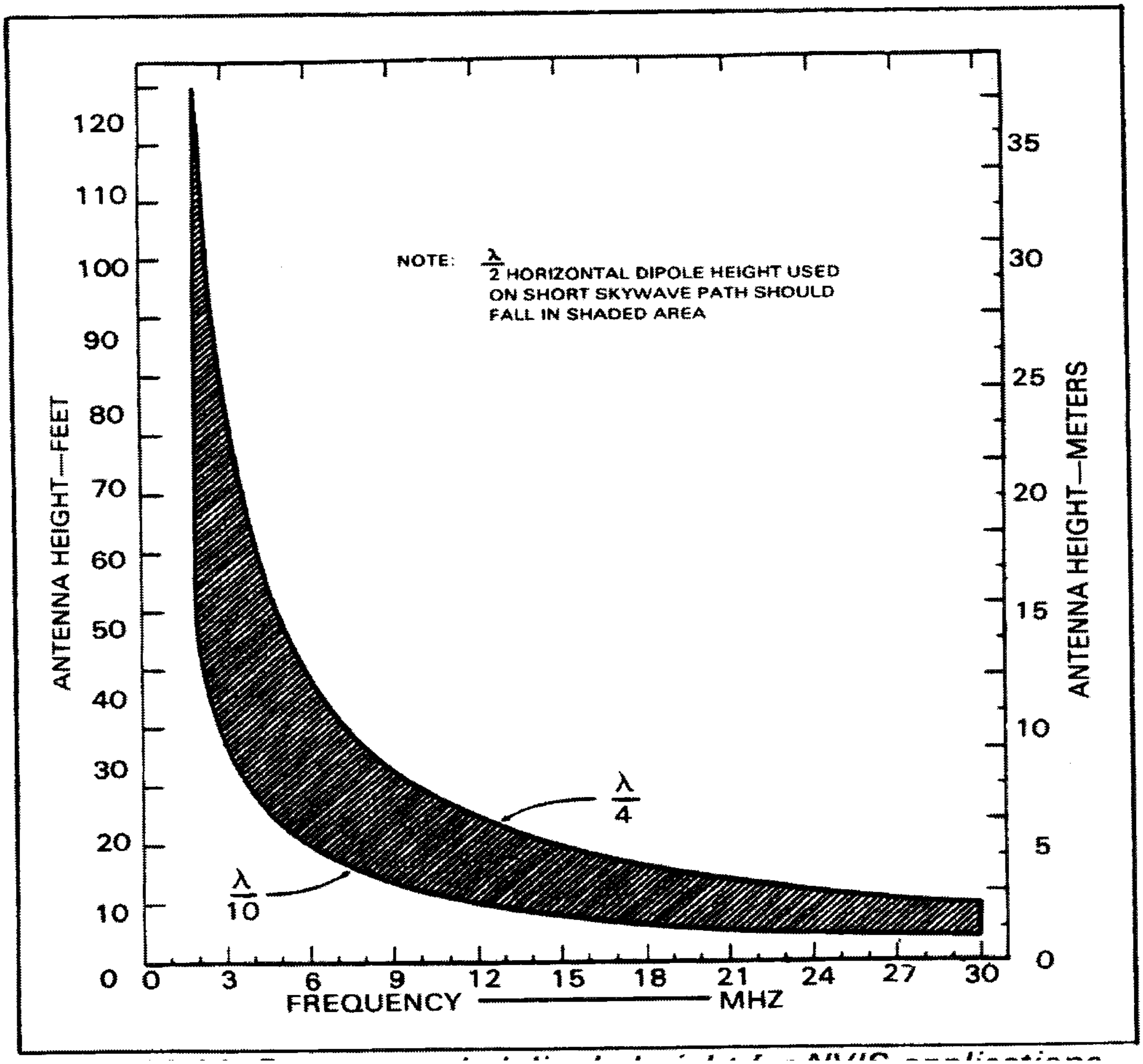
Average SFI, Pacific *daylight* time, adjust to your local time. (Ed Farmer, NVIS Comm.)

The antenna system that is: the easiest to carry, deploy, has the best gain, is the ½ wave horizontal dipole at .1 to .25 wavelength above <u>good</u> ground.



Typical Daily Frequency Variation: **Frequency** on sides. **Time of day** across bottom.

MUF - dashed lines, **LUF** - dotted lines, Optimal Frequency - solid line (Ed Farmer, NVIS)



Starting point for Antenna Height, based on frequency

If noisy, chose the lowest height. Some of the pre-engineered portable antenna's systems (BuddiPole) are designed for the easiest to work with height of 10' to 18'. In contrast, it's interesting to note, that the greatest antenna gain and widest band coverage, can be obtained for 80 through 40 meters with a ½ wavelength wire dipole with an ***apex angles or 120 to 140 degrees***, at 20 to 30 feet (no more than .25 wavelength) above average ground. (Lt. Col. David Fiedler Near Vertical Incidence Skywave Communications, Pg 64)

Tuning the NVIS System:

Those who are using Doublet antennas will likely find that its inherent narrow bandwidth (1 – 2 %) will lead to the need for retuning with every frequency change. Consider, the Buddipole with ***wire winders*** for quick adjustment of wire length as required frequencies change. It can be used for multi-bands with adapters and manual tuner. nvis2008.pdf (turbifycdn.com)

Use your tuner or antenna analyzer to check for antenna ***impedance***, may need a balum. Check forward and reflected power (SWR) against feedline and the radio at the desired frequency. Connections must be clean, secure and water tight!

Also, LUF is mostly determined by noise or atmospheric attenuation. Using higher power and/or better antennas can improve or at least lower the LUF. However, MUF is a function of the ionization and cannot be improved or increased by higher transmitter power. Change to higher ***contingency*** frequency.

For portable ops over ***poor ground***, use 2 – 8' pieces of counterpoise wire laid *on the ground* to form an X. Secure the X point with a clamp and ground rod and run a short piece of wire to the radio ground lug. These wires should be pre-cut and stored in your go-bag. Poor ground conductivity can be responsible for as much as a 50% loss of signal strength.

Troubling Shooting:

High Noise

- Add attenuation, adjust RF gain, adjust filters, then noise reduction.
- Lower Antenna
- Amplifier; make sure portable antenna wires are rated for higher power. Antenna gain is much more effective and easier to manage than adding heavy amplifier's for more power.
- Can't obtain low SWR or impedance match, try the inline TRSB switching balun. (Buddipole www.buddipole.com)
- Pre-designated ***relay operators*** to complete contact. Depending on both antenna configurations, you may be able to hear a station from 300 to 600 miles away but not 30 miles across town. Ask the relay station to call the station across town and deliver your message and then wait for a reply.
- See page 11 for ***Space Weather Contingency Planning***

Low audio:

- Both stations must be NVIS. Skywave & -ground wave arrive at different times making them out of phase
- Both stations must be ***horizontally*** polarized?
- Both antenna's at NVIS height, .1 to .25 wavelength
- Poor ground conductivity. You can lose as much as 50% of your signal strength; add grounded Radials
- ***Path loses*** from: vegetation, utilities, and buildings attenuate signals. Position antennas for a clear view of the sky.
- If nothing else, change locations

Appendix A: UTC Time Conversion Chart

UTC	AST EDT	EST CDT	CST MDT	MST PDT	PST
0000*	2000	1900	1800	1700	1600
0100	2100	2000	1900	1800	1700
0200	2200	2100	2000	1900	1800
0300	2300	2200	2100	2000	1900
0400	0000	2300	2200	2100	2000
0500	0100	0000	2300	2200	2100
0600	0200	0100	0000	2300	2200
0700	0300	0200	0100	0000	2300
0800	0400	0300	0200	0100	0000
0900	0500	0400	0300	0200	0100
1000	0600	0500	0400	0300	0200
1100	0700	0600	0500	0400	0300
1200	0800	0700	0600	0500	0400

UTC	AST EDT	EST CDT	CST MDT	MST PDT	PST
1300	0900	0800	0700	0600	0500
1400	1000	0900	0800	0700	0600
1500	1100	1000	0900	0800	0700
1600	1200	1100	1000	0900	0800
1700	1300	1200	1100	1000	0900
1800	1400	1300	1200	1100	1000
1900	1500	1400	1300	1200	1100
2000	1600	1500	1400	1300	1200
2100	1700	1600	1500	1400	1300
2200	1800	1700	1600	1500	1400
2300	1900	1800	1700	1600	1500
2400*	2000	1900	1800	1700	1600

Time 0000 and 2400 considered the same

AZ and HI do not observe Daylight Saving time

Appendix B: Voice of America Coverage Analysis Program and Space Weather

The first six steps in this manual got you back on the air but it's just a matter of time before you start wanting answers to more specific communication possibilities and how the space weather is going to affect your ability to stay connected with our neighboring communities and leaders. As darkness approaches or maybe the band you started out with just wasn't that good anyway; you are going to be looking for better options.

The graphical software called **Voice of America Coverage Analysis Program (VOACAP)** can help you find a better band and give you an idea when things are going to change on the band you are on now. I know, we have been assuming that all facilities and services are down and that is why I have been repeatedly saying; ***relays at 300 miles***. Your relays may still have service and he will be running VOACAP for you. If you have to reach further out, you may have to go higher in frequency which will take you above the MUF. Designate an operator to monitor that ***Relay Only*** frequency. Give your relay what you need to know for frequency planning and he will get the answers back to you. Hear are some of the high points of the program:

- A graphical interface that is simple to use, rich in features, and has a short learning curve VOACAP Online for Ham Radio
- You will get a best percentage of ***probability*** for contact between two stations
- Easy to plot locations. Just drag a pin on the map to your location and another pin to the location of the receiving station; can plot up to five additional receiving locations at a time.
- I encourage you to review these two web links: the official "user's manual at https://www.voacap.com/2023/documents/VOACAP_Manual.pdf and the Army Signal Corp training video at https://www.youtube.com/watch?v=QEBho6Xvzdo . The Army version is only 18 minutes and to the point with everything we would need in the field. It's a little dated, so refer to the operator's manual (pdf above)
- This program can also give you the critical components of space weather that may or may not be affecting your ability to maintain traffic quality signals.
  - Receive signal strength on QSO tab
  - ***Current and future*** SFI and Kp on SWx tab
  - Percentage of probability for various power and antennas on Prop Wheel
  - Maidenhead grid, distance and ***True*** headings to locations

I consider VOACAP to be a major component of the Total System to Field Communications.

We are working on a Power Point presentation on using this software in conjunction with the space weather-indices and NOAA scales NOAA Space Weather Scales | NOAA / NWS Space Weather Prediction Center ***attaches in Appendix D of this notebook***. Note: the printed page used I this notebook is pretty small founts. It is much easier to read on the web site.

Some of these terms will need to be explained better than I can do so I have requested the guidance from a fellow amateur radio operator, Dr Tamitha Skov, The Space Weather Woman. For now, follow her at Space Weather Woman – Dr. Tamitha Skov – Dr. Tamitha Skov– The Space Weather Woman ***More to come…***

P.A.C.E. – Organize Your Radio Plan with Options

You have established a communication link with your team but you know the current situation won't last forever. Your relay's have provided you with options for current propagation and a 2- or 3-day indication of future space weather as defined on the NOAA scales. Now let's make a Radio Plan to get you through until an Incident Command Team arrives.

Organize your radio plan functionally using PACE. PACE is a military acronym for: Primary, Alternant, Contingent, and Emergency. Keep your plan only as complex as ***radio Span of Control*** dictates. Starting with the simplest planning model (typically less than 3 reporting assets) PACE will be divided into four parts:

Primary frequency – day time based on VOACAP

Alternate frequency – night or ***low*** SFI. Consider 60 meters to stay below MUF.

Contingency frequency – if the Primary or Secondary frequency is not usable due to adverse space weather (pre-plan Space Weather Contingency Plan below) or if additional frequencies become necessary on short notice.

Emergency – a guard net. If you are portable on a disaster, especially if more bad news is predicted; an emergency net should be predesignated and monitored 24 hours. 24-hour operations require frequency shifts and ***retuning*** of radio and antennas.

Complex incidents (greater than 3 reporting assets) will require more radio operators and should have a daylight and night time PACE Radio Plan. See Gray line simulator in VOACAP to determine time that sun exposure shifts to night.

I know I have said this before but it is worth putting in your radio plan. Pre-positioned relays at 300 miles for two reasons. First, it's overlapping coverage to pick up those light stations. The secondly, and with a little luck, the power and communications may not be impacting the relay station location and they can pass your operational messages or obtain internet data, such as, VOACAP for you.

What If:
Sometimes NVIS, by itself, just won't provide traffic quality contacts. If you are experiencing very high noise levels or complete radio blackouts, you have no choice but to wait it out until dark or move to a higher frequency. Tune around the bands until you find a quitter frequency or check the NOAA ***Drap*** chart for frequency attenuation. You will have moved above the MUF and will therefore lose NVIS propagation so; antennas up above 1/4 wavelength. You will be able to contact the distant stations on the new HF frequency but you will not hear the local stations. Consider VHF simplex for local tactical coordination anytime solar flares render HF communications impossible. Yagi's (vertical for FM and horizontal for SSB) and tall mast or rooftop relays. Depending on terrain, it's not beyond the realm of possibilities. Try it.

This operational change should be listed under the Contingency plan and labeled ***Space Weather Contingency Plan.*** If it is listed in the radio plan, your people will know where to look for you after the band goes quiet. If nothing else, don't rule out messengers.

NOAA Space Weather Scales

Category: Scale	Category: Descriptor	Effect Duration of event will influence severity of effects	Physical measure	Average Frequency (1 cycle = 11 years)
Geomagnetic Storms			Kp values* determined every 3 hours	Number of storm events when Kp level was met; (number of storm days)
G 5	Extreme	Power systems: widespread voltage control problems and protective system problems can occur, some grid systems may experience complete collapse or blackouts. Transformers may experience damage. Spacecraft operations: may experience extensive surface charging, problems with orientation, uplink/downlink and tracking satellites. Other systems: pipeline currents can reach hundreds of amps, HF (high frequency) radio propagation may be impossible in many areas for one to two days, satellite navigation may be degraded for days, low-frequency radio navigation can be out for hours, and aurora has been seen as low as Florida and southern Texas (typically 40° geomagnetic lat.).**	Kp=9	4 per cycle (4 days per cycle)
G 4	Severe	Power systems: possible widespread voltage control problems and some protective systems will mistakenly trip out key assets from the grid. Spacecraft operations: may experience surface charging and tracking problems, corrections may be needed for orientation problems. Other systems: induced pipeline currents affect preventive measures, HF radio propagation sporadic, satellite navigation degraded for hours, low-frequency radio navigation disrupted, and aurora has been seen as low as Alabama and northern California (typically 45° geomagnetic lat.).**	Kp=8, including a 9-	100 per cycle (60 days per cycle)
G 3	Strong	Power systems: voltage corrections may be required, false alarms triggered on some protection devices. Spacecraft operations: surface charging may occur on satellite components, drag may increase on low-Earth-orbit satellites, and corrections may be needed for orientation problems. Other systems: intermittent satellite navigation and low-frequency radio navigation problems may occur, HF radio may be intermittent, and aurora has been seen as low as Illinois and Oregon (typically 50° geomagnetic lat.).**	Kp=7	200 per cycle (130 days per cycle)
G 2	Moderate	Power systems: high-latitude power systems may experience voltage alarms, long-duration storms may cause transformer damage. Spacecraft operations: corrective actions to orientation may be required by ground control; possible changes in drag affect orbit predictions. Other systems: HF radio propagation can fade at higher latitudes, and aurora has been seen as low as New York and Idaho (typically 55° geomagnetic lat.).**	Kp=6	600 per cycle (360 days per cycle)
G 1	Minor	Power systems: weak power grid fluctuations can occur. Spacecraft operations: minor impact on satellite operations possible. Other systems: migratory animals are affected at this and higher levels; aurora is commonly visible at high latitudes (northern Michigan and Maine).**	Kp=5	1700 per cycle (900 days per cycle)

* Based on this measure, but other physical measures are also considered.
** For specific locations around the globe, use geomagnetic latitude to determine likely sightings (see www.swpc.noaa.gov/Aurora)

Scale	Descriptor	Effect	Physical measure	Average Frequency
Solar Radiation Storms			Flux level of ≥ 10 MeV particles (ions)*	Number of events when flux level was met**
S 5	Extreme	Biological: unavoidable high radiation hazard to astronauts on EVA (extra-vehicular activity); passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk. *** Satellite operations: satellites may be rendered useless, memory impacts can cause loss of control, may cause serious noise in image data, star-trackers may be unable to locate sources; permanent damage to solar panels possible. Other systems: complete blackout of HF (high frequency) communications possible through the polar regions, and position errors make navigation operations extremely difficult.	10^5	Fewer than 1 per cycle
S 4	Severe	Biological: unavoidable radiation hazard to astronauts on EVA; passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk.*** Satellite operations: may experience memory device problems and noise on imaging systems; star-tracker problems may cause orientation problems, and solar panel efficiency can be degraded. Other systems: blackout of HF radio communications through the polar regions and increased navigation errors over several days are likely.	10^4	3 per cycle
S 3	Strong	Biological: radiation hazard avoidance recommended for astronauts on EVA; passengers and crew in high-flying aircraft at high latitudes may be exposed to radiation risk.*** Satellite operations: single-event upsets, noise in imaging systems, and slight reduction of efficiency in solar panel are likely. Other systems: degraded HF radio propagation through the polar regions and navigation position errors likely.	10^3	10 per cycle
S 2	Moderate	Biological: passengers and crew in high-flying aircraft at high latitudes may be exposed to elevated radiation risk.*** Satellite operations: infrequent single-event upsets possible. Other systems: effects on HF propagation through the polar regions, and navigation at polar cap locations possibly affected.	10^2	25 per cycle
S1	Minor	Biological: none. Satellite operations: none. Other systems: minor impacts on HF radio in the polar regions.	10	50 per cycle

* Flux levels are 5 minute averages. Flux in particles·s^{-1}·$ster^{-1}$·cm^{-2} Based on this measure, but other physical measures are also considered.
** These events can last more than one day.
*** High energy particle (>100 MeV) are a better indicator of radiation risk to passenger and crews. Pregnant women are particularly susceptible.

Scale	Descriptor	Effect	Physical measure	Average Frequency
Radio Blackouts			GOES X-ray peak brightness by class and by flux*	Number of events when flux level was met; (number of storm days)
R 5	Extreme	HF Radio: Complete HF (high frequency**) radio blackout on the entire sunlit side of the Earth lasting for a number of hours. This results in no HF radio contact with mariners and en route aviators in this sector. Navigation: Low-frequency navigation signals used by maritime and general aviation systems experience outages on the sunlit side of the Earth for many hours, causing loss in positioning. Increased satellite navigation errors in positioning for several hours on the sunlit side of Earth, which may spread into the night side.	X20 ($2x10^{-3}$)	Fewer than 1 per cycle
R 4	Severe	HF Radio: HF radio communication blackout on most of the sunlit side of Earth for one to two hours. HF radio contact lost during this time. Navigation: Outages of low-frequency navigation signals cause increased error in positioning for one to two hours. Minor disruptions of satellite navigation possible on the sunlit side of Earth.	X10 (10^{-3})	8 per cycle (8 days per cycle)
R 3	Strong	HF Radio: Wide area blackout of HF radio communication, loss of radio contact for about an hour on sunlit side of Earth. Navigation: Low-frequency navigation signals degraded for about an hour.	X1 (10^{-4})	175 per cycle (140 days per cycle)
R 2	Moderate	HF Radio: Limited blackout of HF radio communication on sunlit side of the Earth, loss of radio contact for tens of minutes. Navigation: Degradation of low-frequency navigation signals for tens of minutes.	M5 ($5x10^{-5}$)	350 per cycle (300 days per cycle)
R 1	Minor	HF Radio: Weak or minor degradation of HF radio communication on sunlit side of the Earth, occasional loss of radio contact. Navigation: Low-frequency navigation signals degraded for brief intervals.	M1 (10^{-5})	2000 per cycle (950 days per cycle)

* Flux, measured in the 0.1-0.8 nm range, in W·m^{-2}. Based on this measure, but other physical measures are also considered.
** Other frequencies may also be affected by these conditions.

URL: *https://www.spaceweather.gov/noaa-scales-explanation*

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