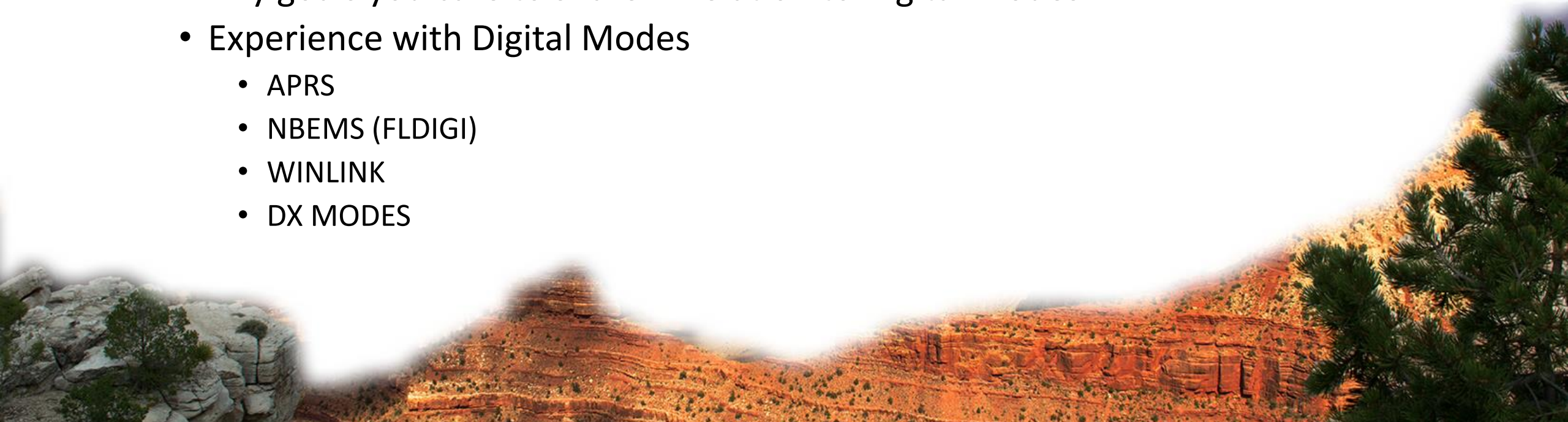

AG7GK
A Survey of
Digital Modes
9/22/2018

# Digital Mode Agenda

- Introductions
- Why Digital?
- Equipment requirements
- Tools of the Trade
  - Software
  - Propagation Websites (Wsprnet.com, pskreporter.info)
  - Logging (Logbook of the World, eQSL, QRZ.com)
- Type
  - Unstructured
  - Fuzzy
  - Structured
  - Networking
- Bandwidth
- Prevalence
- Examples of Modes
- NBEMS Discussion

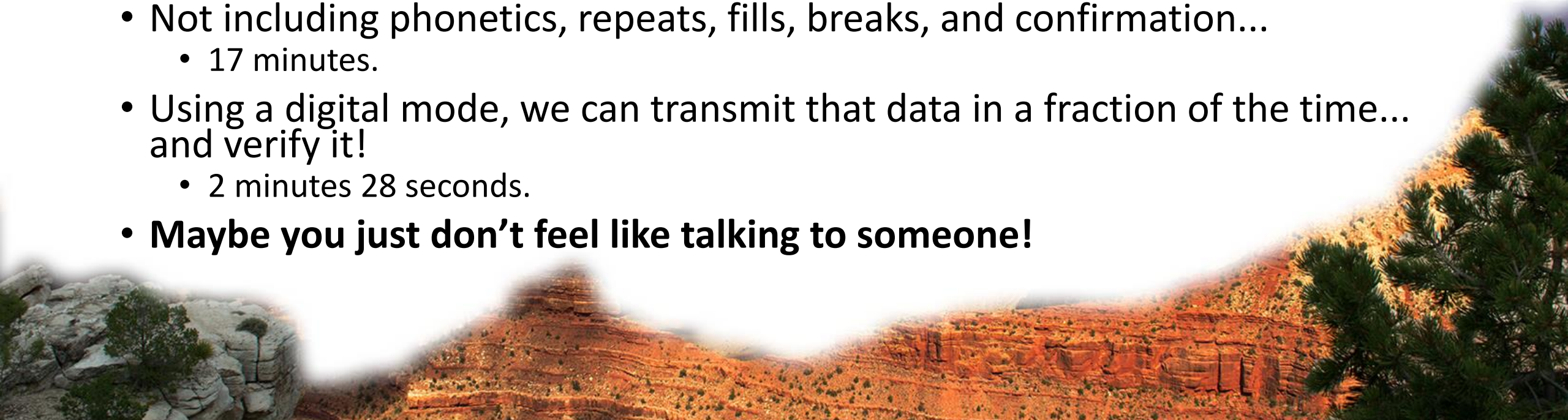
# Introductions

- Aaron Jones – AG7GK first licensed in 2016 as KI7DUK
- Go around the room:
  - Name and Callsign
  - License level
  - Any goals you care to share in relation to Digital Modes
  - Experience with Digital Modes
    - APRS
    - NBEMS (FLDIGI)
    - WINLINK
    - DX MODES



# Why Digital?

- CASE FOR DIGITAL EMCOMM
  - Voice example using NTS Traffic Protocols:
    - St. John's, prepare to copy.
    - Tag 176003, female, 20 - 30, transport helo, red.
- Now imagine having to transmit and verify that 20, 30, 50 times or more.
- How long would that take?
- Not including phonetics, repeats, fills, breaks, and confirmation...
  - 17 minutes.
- Using a digital mode, we can transmit that data in a fraction of the time... and verify it!
  - 2 minutes 28 seconds.
- **Maybe you just don’t feel like talking to someone!**



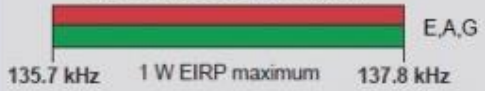
# US Amateur Radio Bands

**US AMATEUR POWER LIMITS — FCC 97.313** An amateur station must use the minimum transmitter power necessary to carry out the desired communications. (b) No station may transmit with a transmitter power exceeding 1.5 kW PEP.

ARRL The national association for AMATEUR RADIO®

Amateurs wishing to operate on either 2,200 or 630 meters must first register with the Utilities Technology Council online at **https://utc.org/plc-database-amateur-notification-process/.** You need only register once for each band.

## 2,200 Meters (135 kHz)




## 630 Meters (472 kHz)

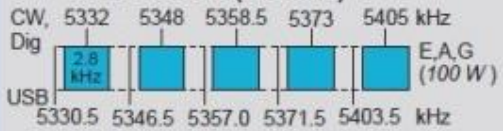
5 W EIRP maximum, except in Alaska within 496 miles of Russia where the power limit is 1 W EIRP.


## 160 Meters (1.8 MHz)

Avoid interference to radiolocation operations from 1.900 to 2.000 MHz

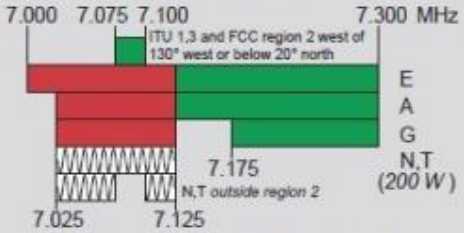

## 80 Meters (3.5 MHz)


## 60 Meters (5.3 MHz)




General, Advanced, and Amateur Extra licensees may operate on these five channels on a secondary basis with a maximum effective radiated power (ERP) of 100 W PEP relative to a half-wave dipole. Permitted operating modes include upper sideband voice (USB), CW, RTTY, PSK31 and other digital modes such as PACTOR III. Only one signal at a time is permitted on any channel.

## 40 Meters (7 MHz)

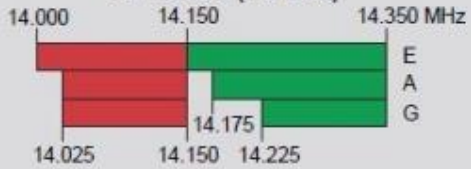



See Sections 97.305(c), 97.307(f)(11) and 97.301(e). These exemptions do not apply to stations in the continental US.

## 30 Meters (10.1 MHz)

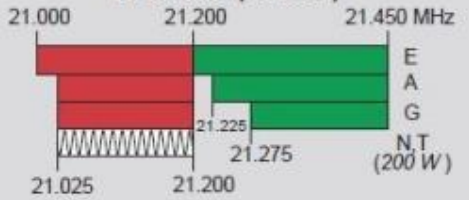
Avoid interference to fixed services outside the US.


## 20 Meters (14 MHz)



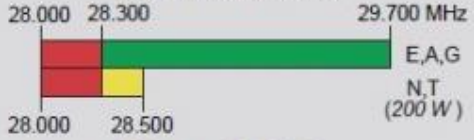

## 17 Meters (18 MHz)


## 15 Meters (21 MHz)




## 12 Meters (24 MHz)


## 10 Meters (28 MHz)



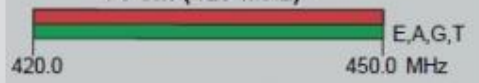

## 6 Meters (50 MHz)


## 2 Meters (144 MHz)

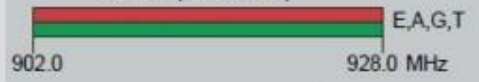

## 1.25 Meters (222 MHz)


*Geographical and power restrictions may apply to all bands above 420 MHz. See *The ARRL Operating Manual* for information about your area.

## 70 cm (420 MHz)*




## 33 cm (902 MHz)*




## 23 cm (1240 MHz)*


All licensees except Novices are authorized all modes on the following frequencies:

| | | |
|---|---|---|
| 2300-2310 MHz | 10.0-10.5 GHz ‡ | 122.25-123.0 GHz |
| 2390-2450 MHz | 24.0-24.25 GHz | 134-141 GHz |
| 3300-3500 MHz | 47.0-47.2 GHz | 241-250 GHz |
| 5650-5925 MHz | 76.0-81.0 GHz | All above 275 GHz |

‡ No pulse emissions

## KEY

***Note:***

**CW** operation is permitted throughout all amateur bands.

**MCW** is authorized above 50.1 MHz, except for 144.0-144.1 and 219-220 MHz.

Test transmissions are authorized above 51 MHz, except for 219-220 MHz

- = RTTY and data
- = phone and image
- = CW *only*
- = SSB phone
- = USB phone, CW, RTTY, and data
- = Fixed digital message forwarding systems *only*

E = Amateur Extra
A = Advanced
G = General
T = Technician
N = Novice

See *ARRLWeb at www.arrl.org* for detailed band plans.

**ARRL**
**We're At Your Service**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email: hq@arrl.org

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Toll-Free 1-888-277-5289 (860-594-0338)
email: membership@arrl.org

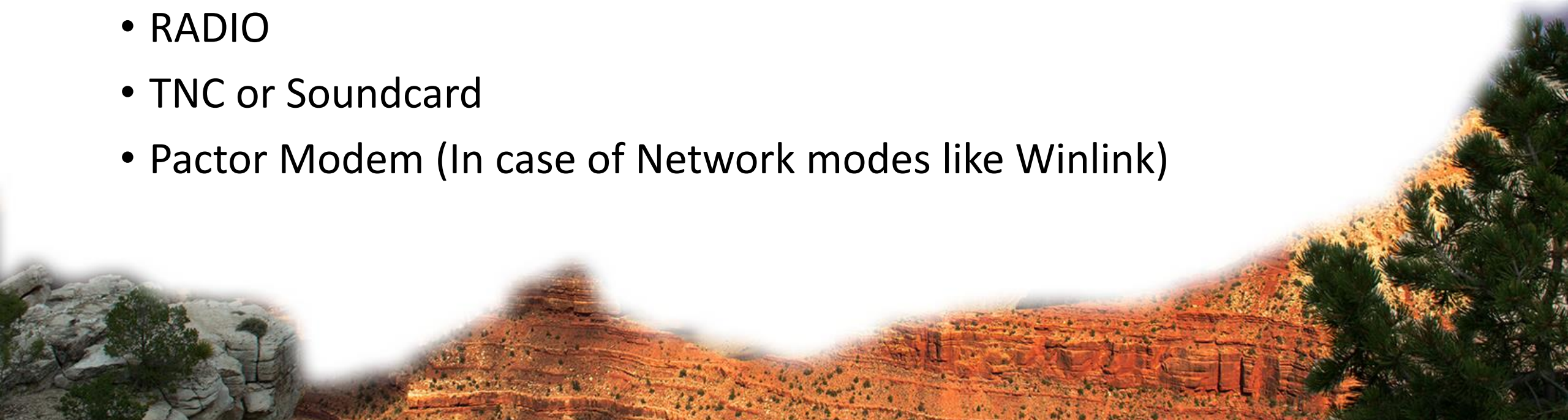
Getting Started in Amateur Radio:
Toll-Free 1-800-326-3942 (860-594-0355)
email: newham@arrl.org

Exams: 860-594-0300 email: vec@arrl.org


 rev. 9/22/2017

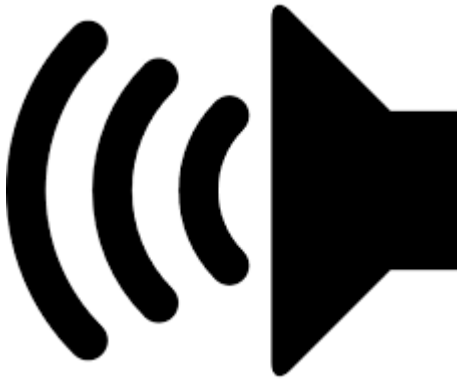
# Equipment

- Computer OR Tablet / Phone
- Cables
- Radio with APRS
- GPS
- RADIO
- TNC or Soundcard
- Pactor Modem (In case of Network modes like Winlink)



# HT Acoustical Coupling

- Tablet / Phone / Computer
- Apps:
  - Android SSTV
  - AndFLMSG
  - Droid PSK
- HT with HT specific cables
  - Baofeng HT
- APRS Specific Setup
  - HT
  - MOBILINK TNC and Cable
  - APRS Droid

# HT / Audio Cable

- Tablet / Phone / Computer
- Apps:
  - Android SSTV
  - AndFLMSG
  - Droid PSK
- HT with HT specific cables
  - Baofeng HT
  - Baofeng BT Tech APRS Cable using VOX PTT OR
  - Custom Audio interface cable to trigger PTT
- APRS Specific Setup
  - HT
  - MOBILINK TNC and Cable
  - APRS Droid

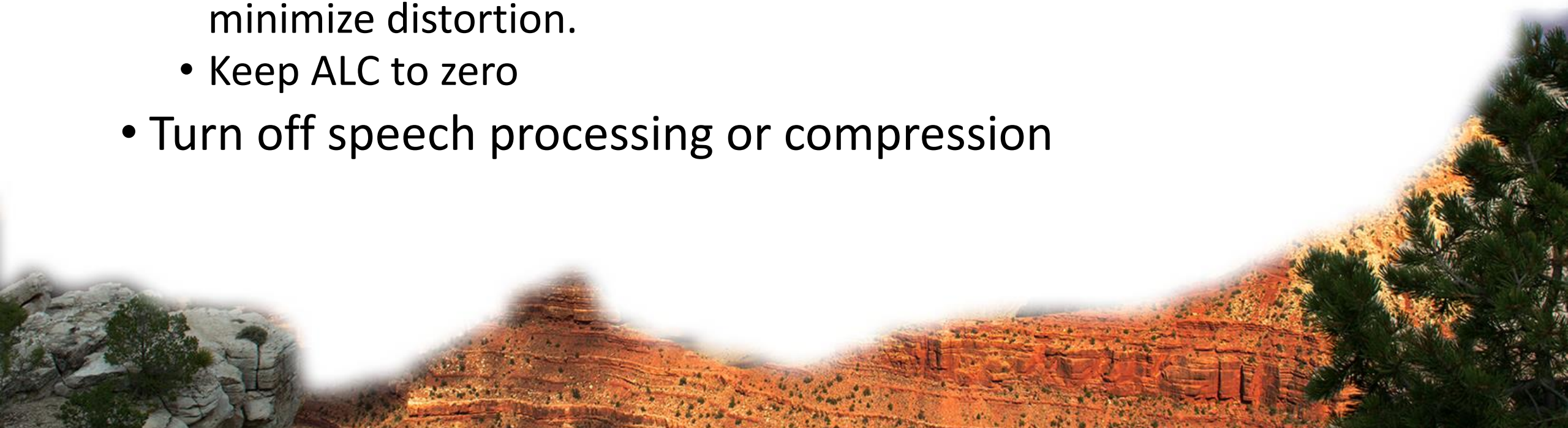

# Basestation

- Computer / Tablet
- Soundcard either built in or USB
- Apps:
  - MMSSTV
  - FLDIGI- FLMSG-FLRIG
  - WSJTX
  - WSJT-X JTalertX
- Bastation
- Any Antenna – Mag Loop, Dipole, Vertical, anything to get a signal in and out



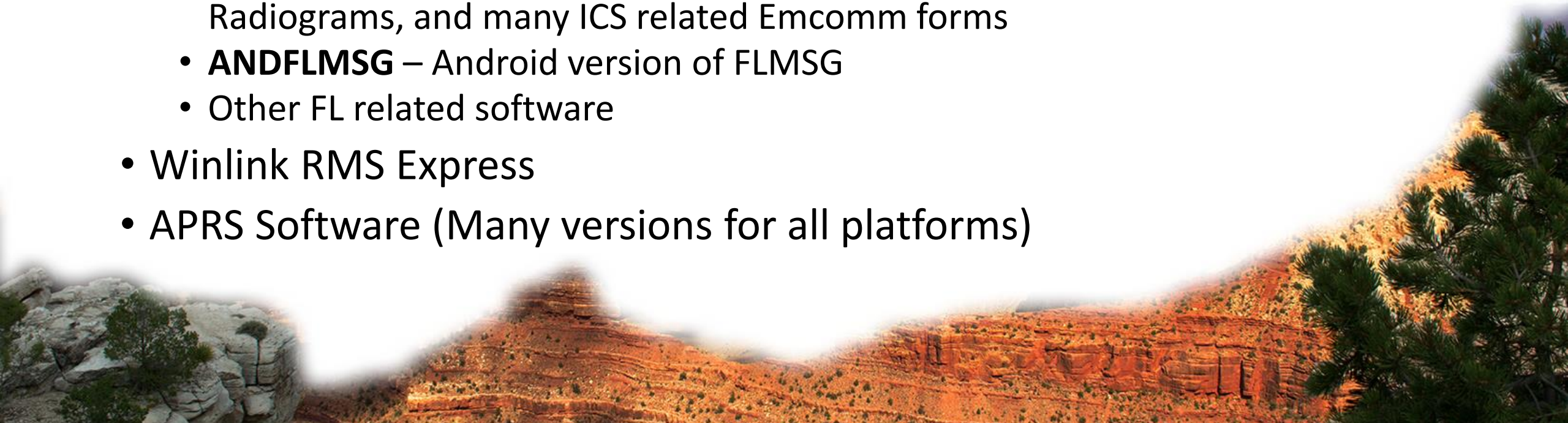
# Warning about Duty Cycle

- Reduce your power!
  - Unlike SSB, these modes either run at 100% duty cycle, or use multiple tones sensitive to intermodulation distortion!
  - Be kind to your finals!
  - Keep **peak** power out well below key-down CW maximum to minimize distortion.
  - Keep ALC to zero
- Turn off speech processing or compression



# Software

- WSJTX – used for FT8, JT Modes, WSPR, and Meteor Scatter
- MMSSTV – Used for Slow Scan TV
- FLDIGI – Many modes and options with companion software such as:
  - FLAMP - Amateur Multicast Protocol (One to Many Transmission of Files)
  - FLMSG – Message sending, one to many including CSV data, Text, Images, Radiograms, and many ICS related Emcomm forms
  - **ANDFLMSG** – Android version of FLMSG
  - Other FL related software
- Winlink RMS Express
- APRS Software (Many versions for all platforms)



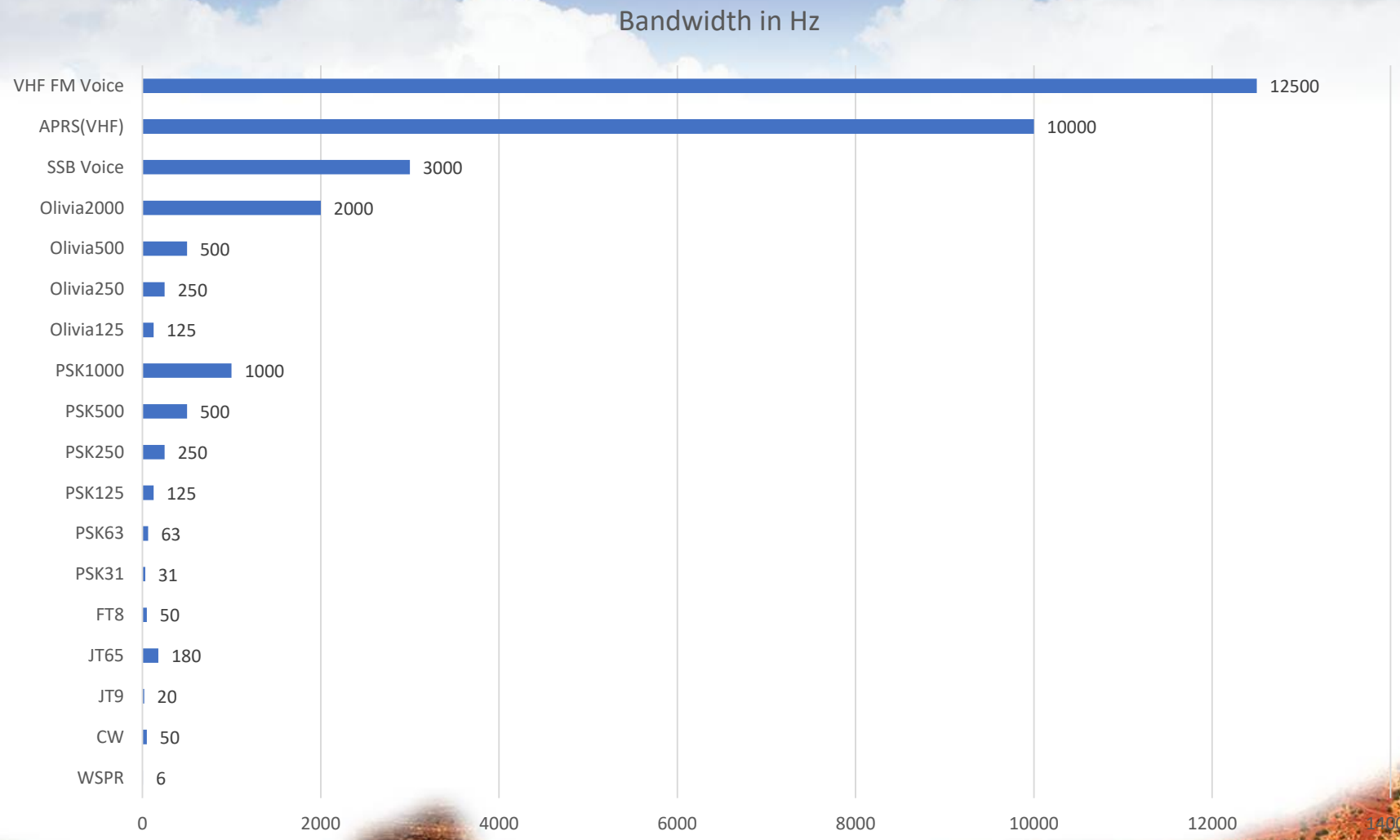
# Propagation Websites

- PSKreporter.info: https://pskreporter.info/pskmap.html
  - Use the stats page to see what modes are happening: https://pskreporter.info/cgi-bin/pskstats.pl
- Wsprnet for WSPR results; http://wsprnet.org/drupal/wsprnet/map OR alternative: http://wspr.aprsinfo.com/
- Hamspots.net: https://hamspots.net/
- APRS.fi: https://aprs.fi
- Online listing of hosted SDR receivers, great for verifying your signal on voice OR digital: http://websdr.org/

# Logging

- The reasons for logging your amateur activity fall into three categories: legal, operational and personal.
  - Legal – proof if someone complains of interference or similar issues(out of band operations)
  - Operational – DX'ing and QSL's
  - Personal – Who you've contacted, when, where, antenna, power, distance etc.  Next time you want to try that mode again, you can go back to the frequency you had success on as evidenced by your log
- Logging Programs: Online, or PC based
- DX Logging:
  - ARRL LOTW: https://lotw.arrl.org/lotwuser/default
  - eQSL.net
  - QRZ.com (also used for looking up hams, a must have if you are DX'ing)

# Bandwidth

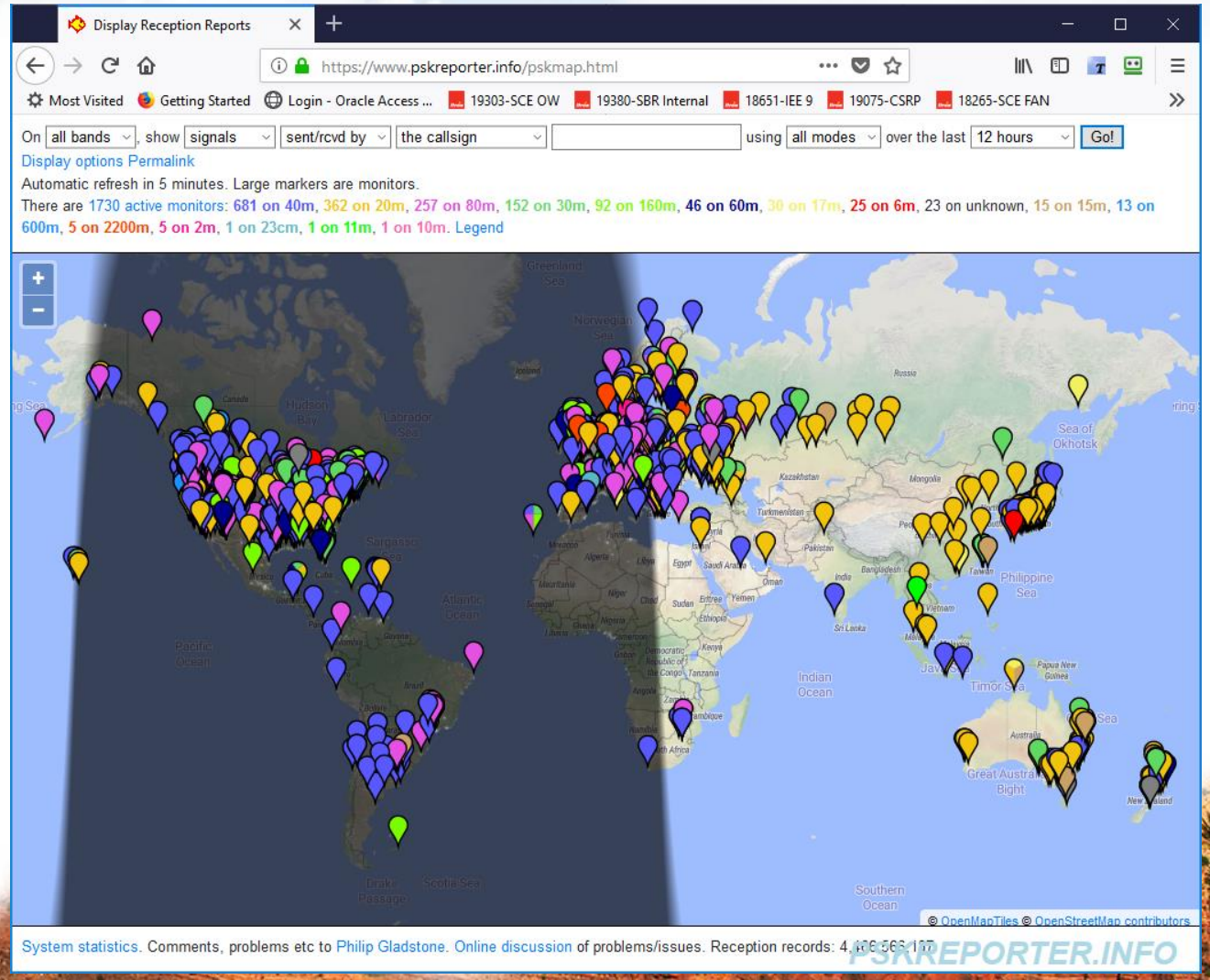



Note: Not “necessary bandwidth” as defined by ITU

# Digital DX Mode Prevalence

## Modes over last 2 hours

| Mode | Count |
|---|---|
| FT8 | 469570 |
| FT8CALL | 2651 |
| CW | 850 |
| JT9 | 166 |
| JT65 | 74 |
| PSK31 | 51 |
| MSK144 | 29 |
| OPERA | 20 |
| SIM31 | 11 |
| ROS | 5 |
| OLIVIA | 2 |
| PSK63 | 1 |
| DOMINO | 1 |
| RTTY | 1 |



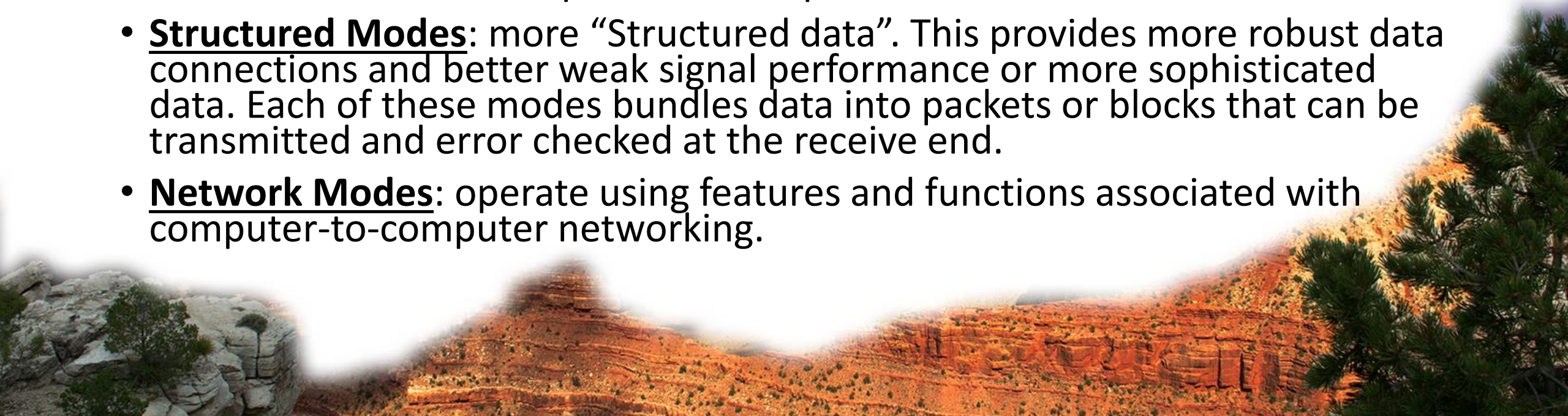

Note: APRS and Winlink are not reported here

# Digital Modes

- Unstructured:
  - CW
  - PSK AND VARIANTS
  - OLIVIA
  - MFSK
  - MT63
- Fuzzy Modes:
  - RTTY
  - HELLSCHREIBER
  - SSTV
- Structured Modes:
  - JTMODES (JT65, JT9, FT8, FT8CALL), WSPR
- Network Modes:
  - Winlink
  - APRS

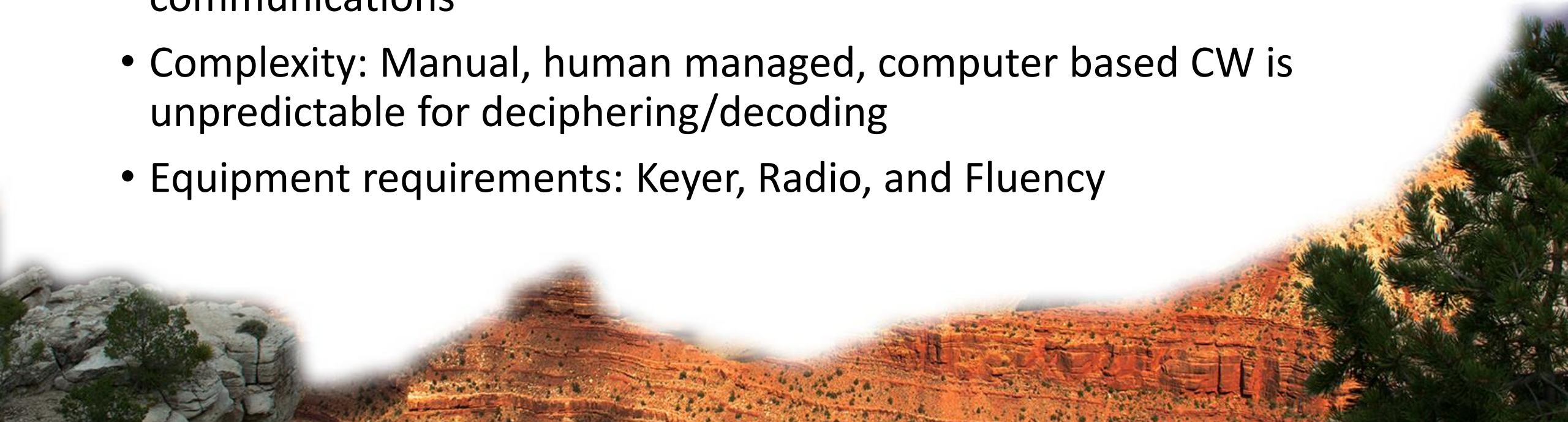
# Mode Definitions

- **Unstructured**: generally considered “sound card modes” for keyboard-to-keyboard communications. Because each of these modes is optimized for a specific purpose by blending multiple features, they often defy simple categorization. No specific timing sequences, though data is timed with specific frequency or audio shifts and durations.
- **Fuzzy Modes**: Machine generated and decoded, they are designed to be human-read. These output a visual representation of the data.
- **Structured Modes**: more “Structured data”. This provides more robust data connections and better weak signal performance or more sophisticated data. Each of these modes bundles data into packets or blocks that can be transmitted and error checked at the receive end.
- **Network Modes**: operate using features and functions associated with computer-to-computer networking.



# CW

- Origin: Samuel Morse, 1830’s-1840’s, sending electrical pulses over wire
- Bandwidth: 50-100 hz
- Prevalence: Used extensively for contesting, worldwide communications
- Complexity: Manual, human managed, computer based CW is unpredictable for deciphering/decoding
- Equipment requirements: Keyer, Radio, and Fluency



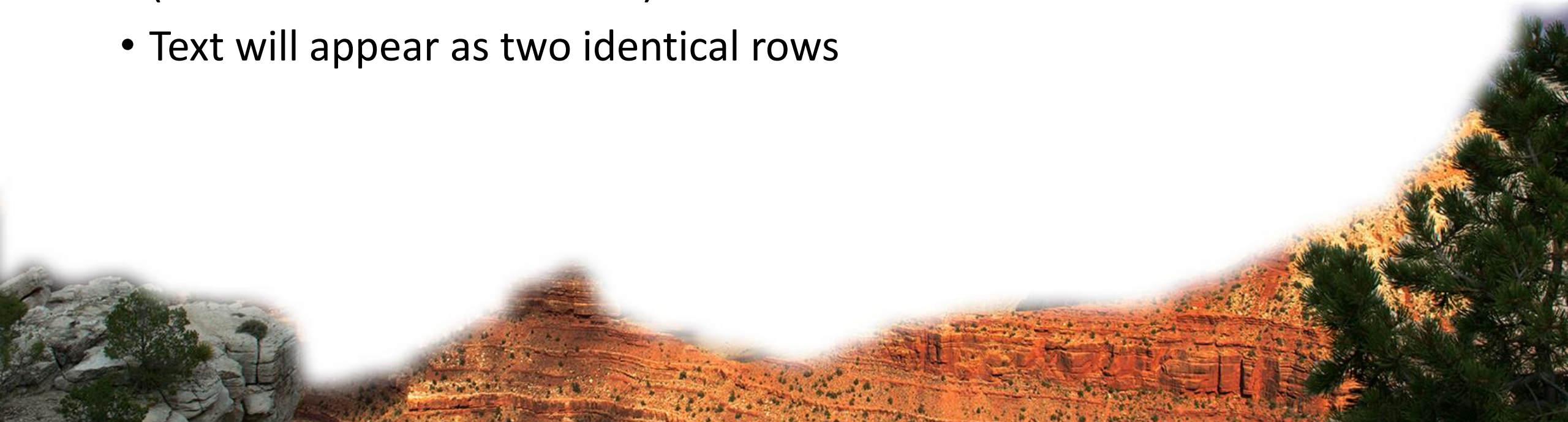
# RTTY

- Origin: 1910 Electrical impulses for each key on a typewriter, shifted to wireless
- Bandwidth: 250 hz
- Prevalence: For contests lately
- Complexity: Computer based FLDIGI software or similar
- Equipment requirements: Computer, Soundcard, Radio

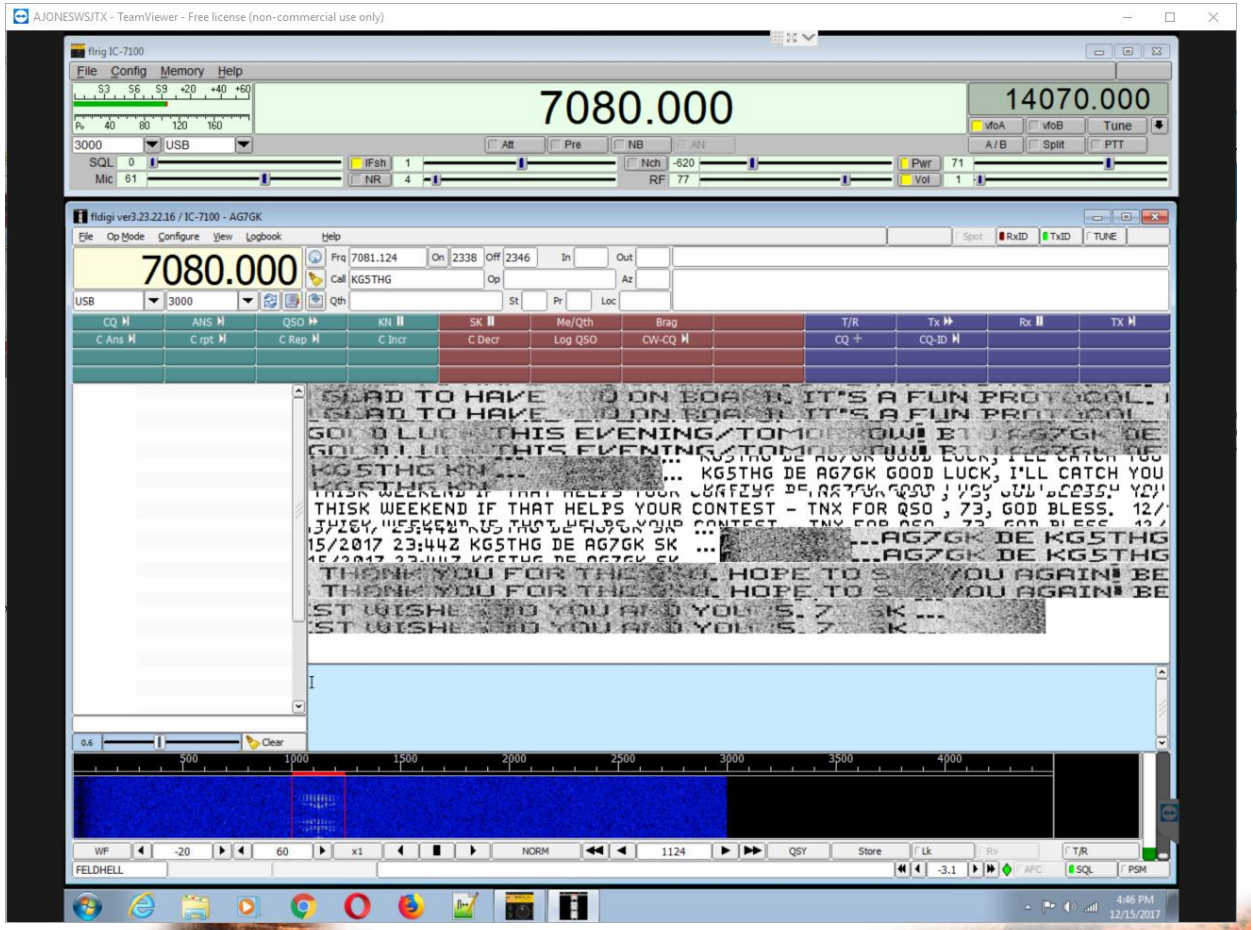
- To send teletype signals on the air, the transmitter generates a continuous carrier that is shifted slightly between two different frequencies that correspond to the mark or space states. This technique is known as "frequency shift keying" or FSK

# HELLSCHREIBER

- Facsimile-based mode developed by Rudolph Hell in 1929
- Text is transmitted by dividing each column into seven pixels and transmitting them sequentially starting at the lowest pixel. Black pixels are transmitted as a signal and white as silence at 122.5 bit/s (about a 35 WPM text rate). Pixels sent TWICE
- Text will appear as two identical rows

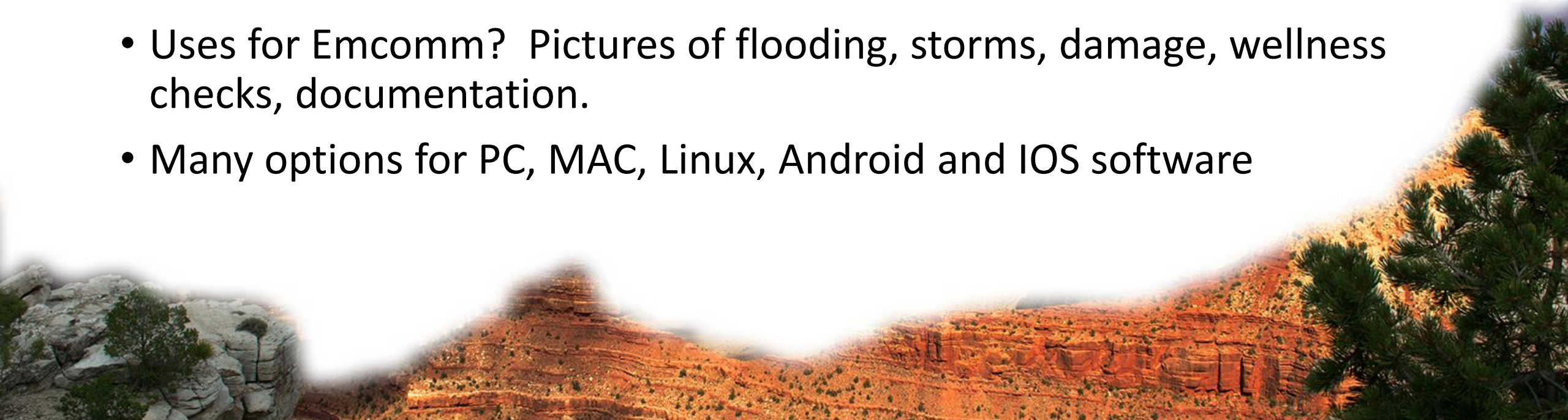


# HELLSCHREIBER



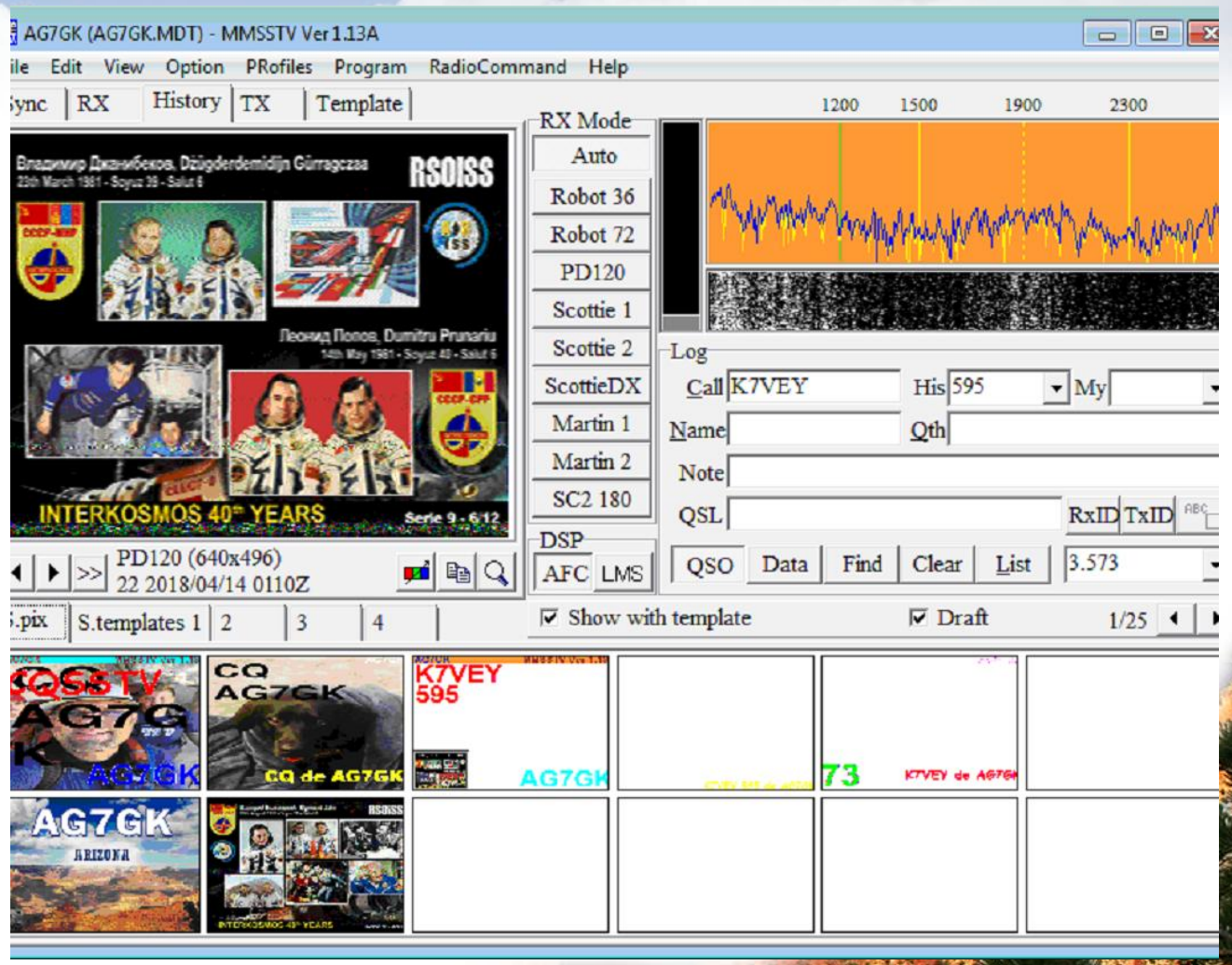
# SSTV

- A single image is converted to individual scanned lines and those lines sent as variable tones between 1500 and 2300 Hz
- A color image takes about 2 minutes to transmit, depending on mode. Some black and white modes can transmit an image in under 10 seconds
- Uses for Emcomm?  Pictures of flooding, storms, damage, wellness checks, documentation.
- Many options for PC, MAC, Linux, Android and IOS software



# SSTV

- SSTV Software “MMSSTV”
- Captured on 145.500 Mhz VHF from International Space Station from Russian Cosmonauts celebrating 40 years in space
- Fun mode for sending pictures and various software options for computer, Android, and IOS

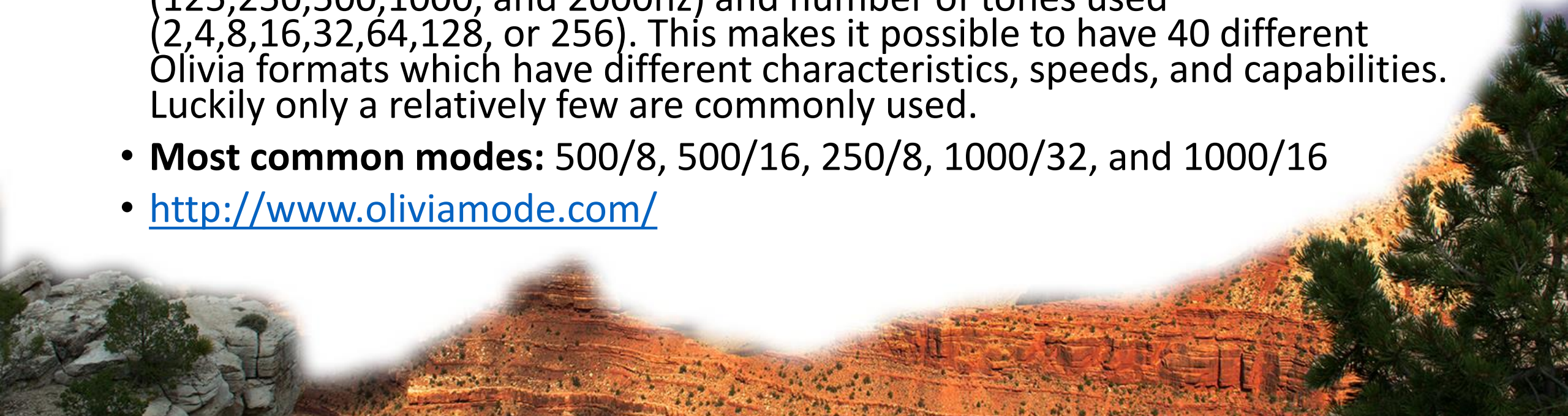


# PSK AND VARIANTS - Demo

- Developed in 1990's as computers became ubiquitous and digital signal processing improved
- PSK stands for Phase Shift Keying. In the context of amateur radio, it describes a family of operating modes (each of which has a slight variation in the signaling parameters) that are used for on-the-air keyboard-to-keyboard contacts.
- Peter Martinez (G3PLX) established signaling parameters (bit rates, coding schemes, etc.) and called his product PSK31
- DEMO FLDIGI Single and Multi-PSK

# OLIVIA

- **Developed in 2003**
- **Olivia** is a ham radio digital mode designed to work in difficult (low s/n ratios plus multipath propagation) conditions on HF bands (though it also works as well on VHF/UHF).
- **Olivia has many formats** some of which are considered *standard* and they all have different characteristics. The formats vary in bandwidth (125,250,500,1000, and 2000hz) and number of tones used (2,4,8,16,32,64,128, or 256). This makes it possible to have 40 different Olivia formats which have different characteristics, speeds, and capabilities. Luckily only a relatively few are commonly used.
- **Most common modes:** 500/8, 500/16, 250/8, 1000/32, and 1000/16
- http://www.oliviamode.com/

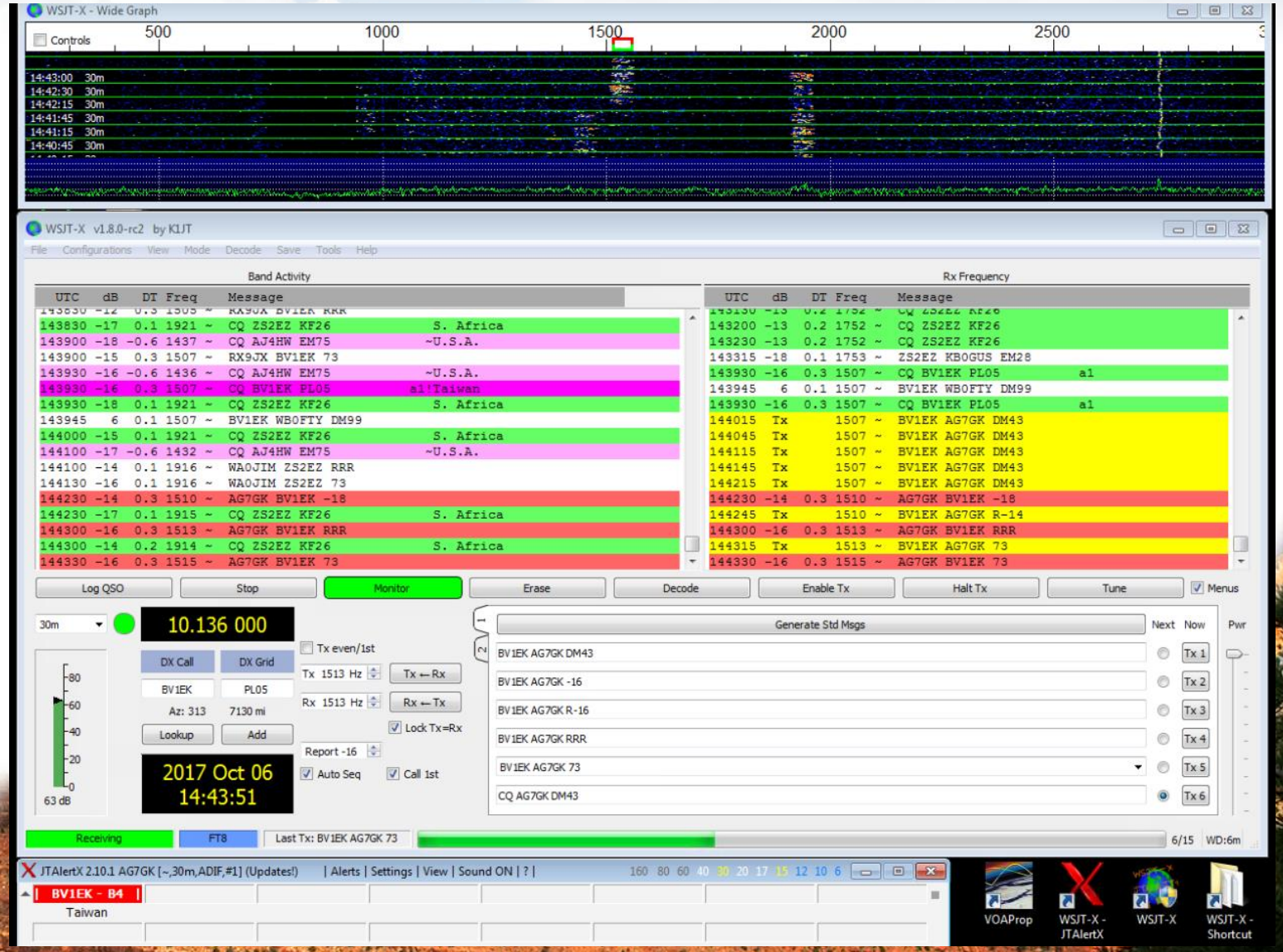


# JT Modes (JT65, JT9, FT8)

- Origin: Created by Joe Taylor W1JT in 2003 for EME work
  - A way to have a QSO using a computer
  - A weak signal digital communications mode for Amateur Radio
  - A Multi-Frequency Shift Keying scheme employing Forward Error Correction with 65 tones
- Bandwidth: 50-180 hz
- Prevalence: Predominant modes for DX contacts
- Equipment requirements: HF Radio, Soundcard(ext/int), Computer, Rpi can work, WS-JTX software, other options exist
- Pros: Widespread, with FT8 very fast QSO's, SNR resilience
- Cons: Not conversational

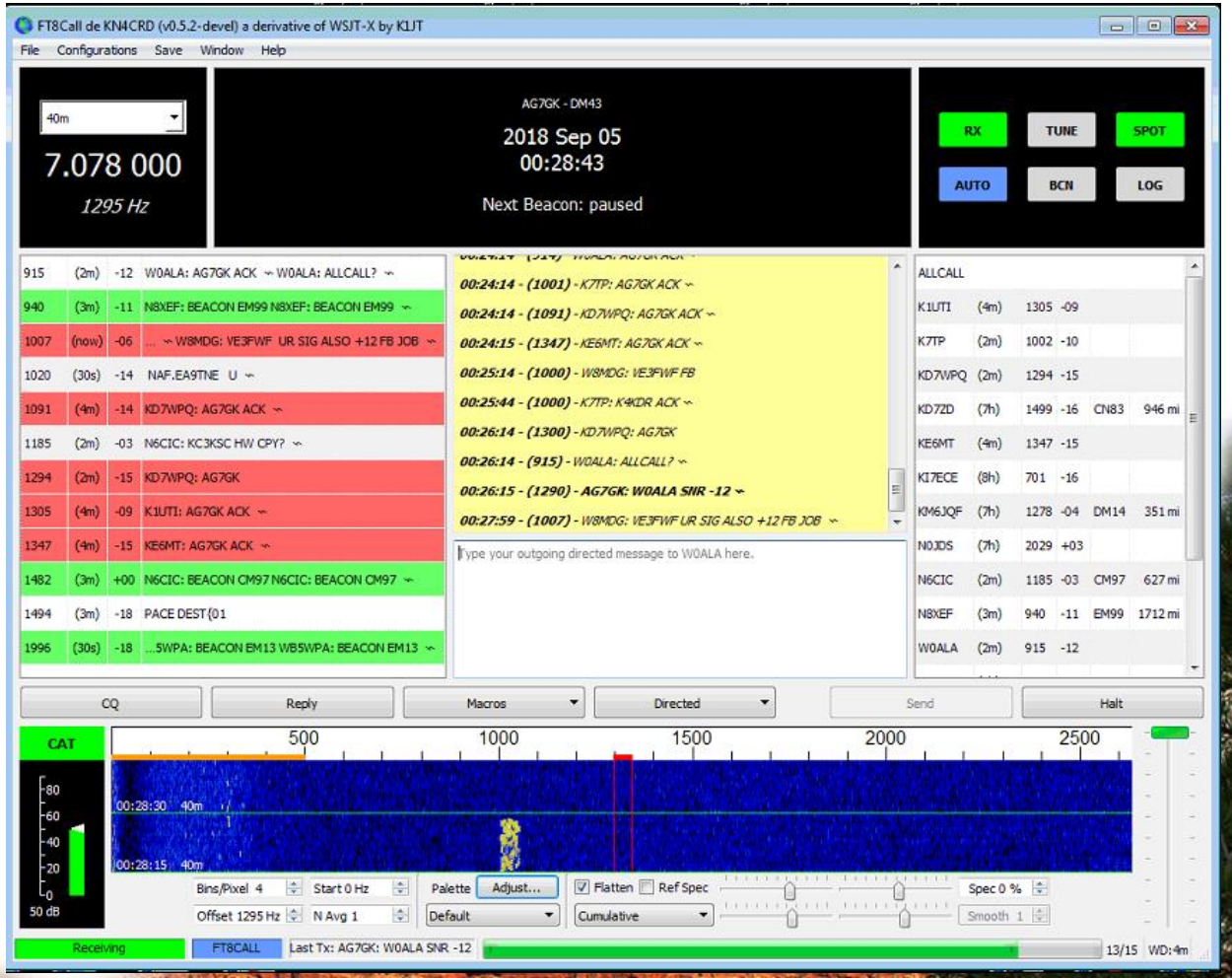
# JT Modes (JT65, JT9, FT8)

- Exchange with TAIWAN
- 30 Meters
- Very weak signal, BV1EK reported my signal at -18 SNR and I reported his at -14



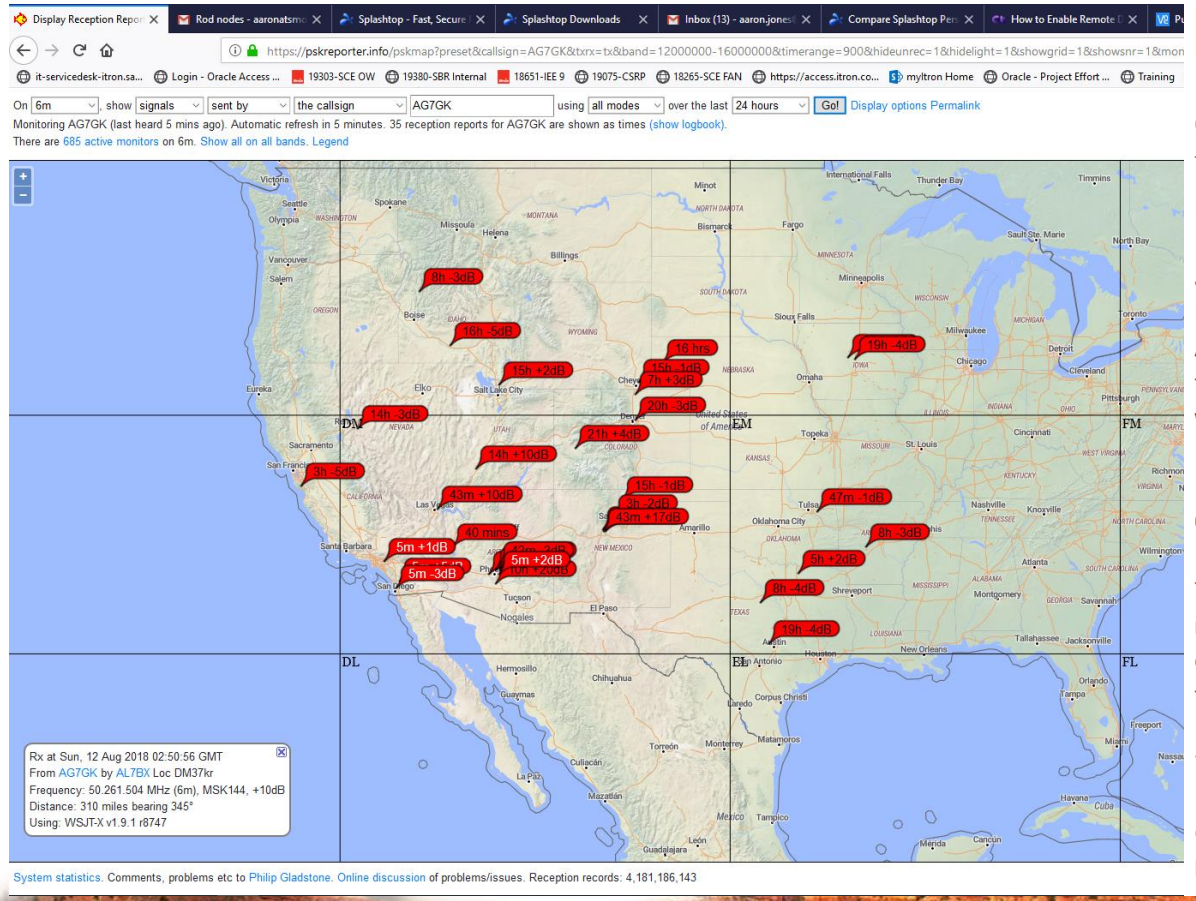
# FT8CALL New Software

- New software being built TODAY
- Uses FT8 Protocol but allows keyboard to Keyboard Conversational Style
- Integrated with APRS to allow location updates and EMAIL-2 directed messages
- Getting Popular but get ready to WAIT, very slow.



# 6M HVF MSK144 Meteor Scatter

- As meteors are vaporized in the upper atmosphere, they leave behind ionized trails at heights of 60 – 70 miles that are sufficiently dense to reflect  radio waves in the HF and VHF range.
- A long trail lasts only 15 seconds – most trails are less than 1 second long




Meteor scatter HAM ×

**Gary Smith** <Gary@ka1j.com>
to AARON

Hi Aaron,

Just wanted to say our 6M contact with MSK144 is my farthest MS contact to date. According to WSJT-X it was 2188 miles, I think that's approaching the edge of what's possible.

I'm at FN31xi, was using 1500W into a M2 6M7JHV at 20'-25' on a roof mount antenna.

Thanks for the new personal distance record. I'm still hoping for a California contact but Connecticut to CA, I think that's impossible on 6M MS.

73,

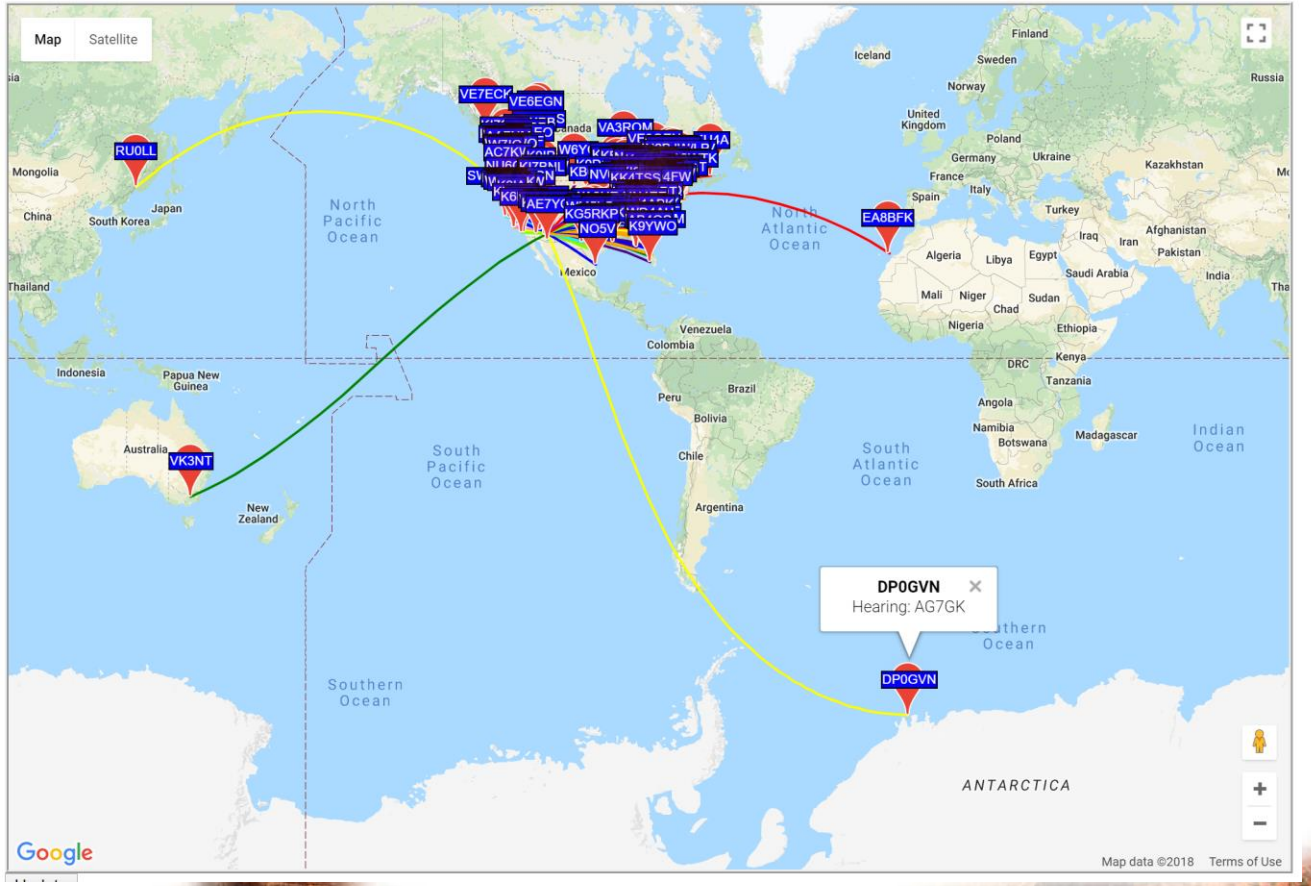
Gary
KA1J

# WSPR (Demo)

- Origin: 2008 by Joe Taylor
  - The Weak Signal Propagation Reporter
  - An automated system designed for sending and receiving low-power transmissions to test propagation paths on the MF and HF bands.
  - The program can decode signals with S/N as low as -28 dB
- Bandwidth: 6 hz
- Antenna propagation at: http://wsprnet.org/drupal/wsprnet/map OR http://wspr.aprsinfo.com/
- Equipment requirements: HF Radio, Soundcard(ext/int), Computer, Rpi can work, WS-JTX software, other options exist
- Pros: Great for seeing where your signal is going
  - “WSPR is about 11 dB better than ear-and-brain CW.
  - “For most operators, the difference is more like 15 dB."

# WSPR (Demo)

Map



# Digital "Systems"

APRS

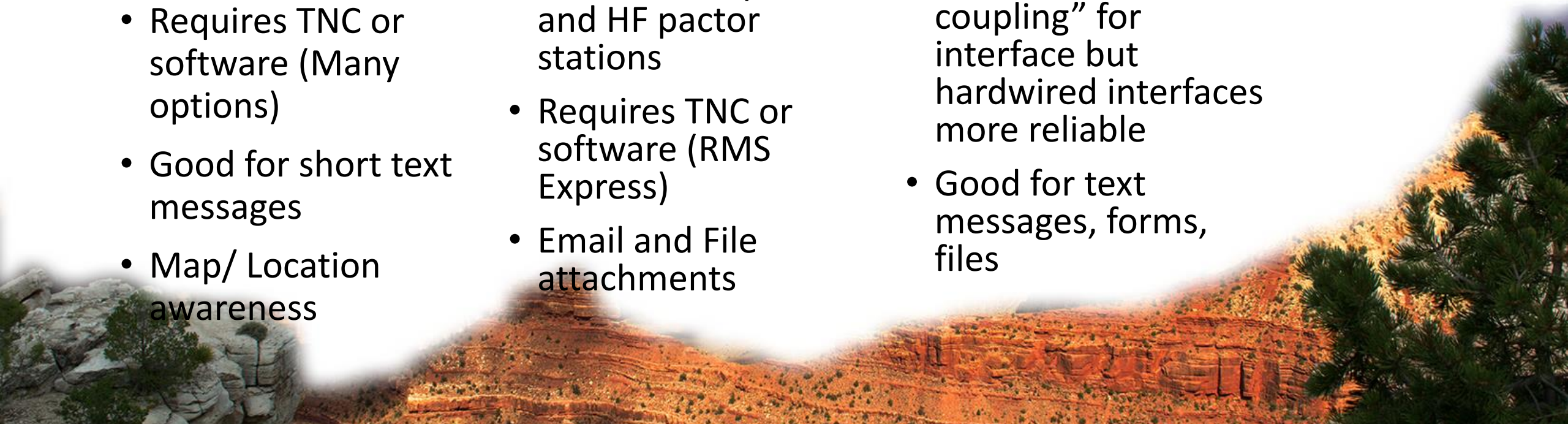
- VHF 144.39 MHz simplex
- Utilizes "Digipeaters"
- Requires TNC or software (Many options)
- Good for short text messages
- Map/ Location awareness

Winlink

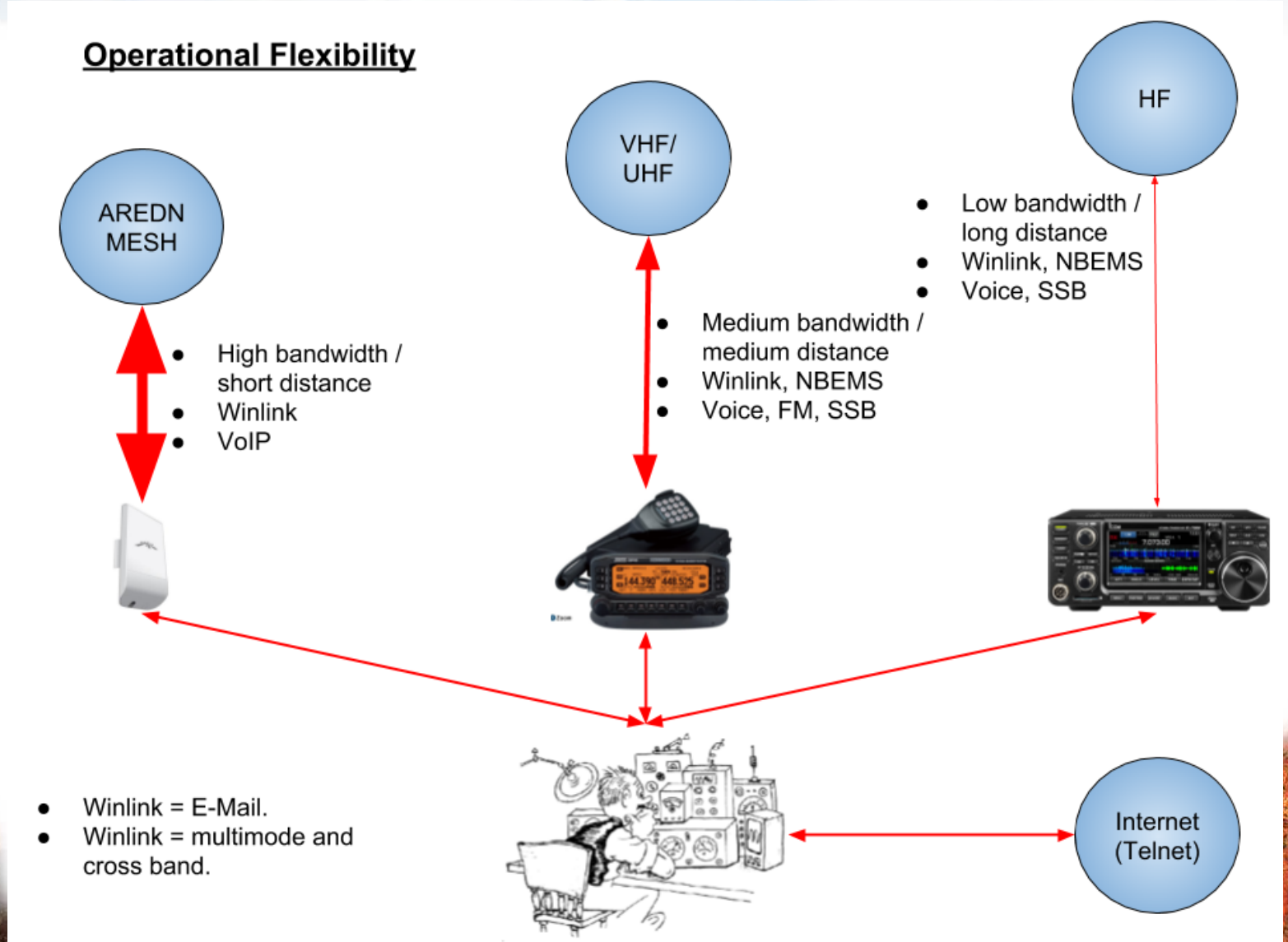
- VHF 145.01 MHz simplex and certain HF
- Utilizes RMS packet and HF pactor stations
- Requires TNC or software (RMS Express)
- Email and File attachments

NBEMS/FLDIGI

- Can utilize any VHF/UHF simplex freq, repeaters, HF
- Can use "acoustic coupling" for interface but hardwired interfaces more reliable
- Good for text messages, forms, files



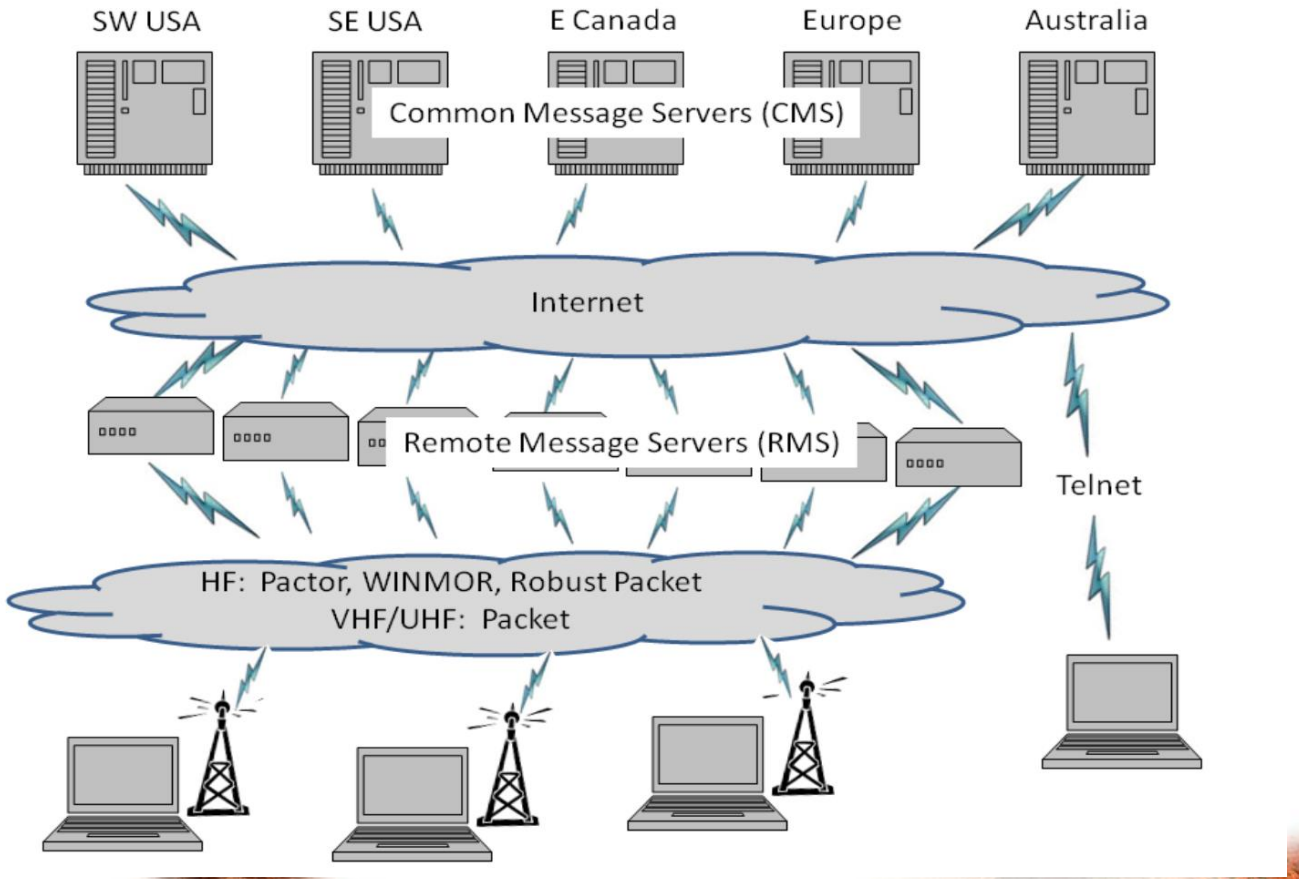
# Operational Flexibility



# Winlink

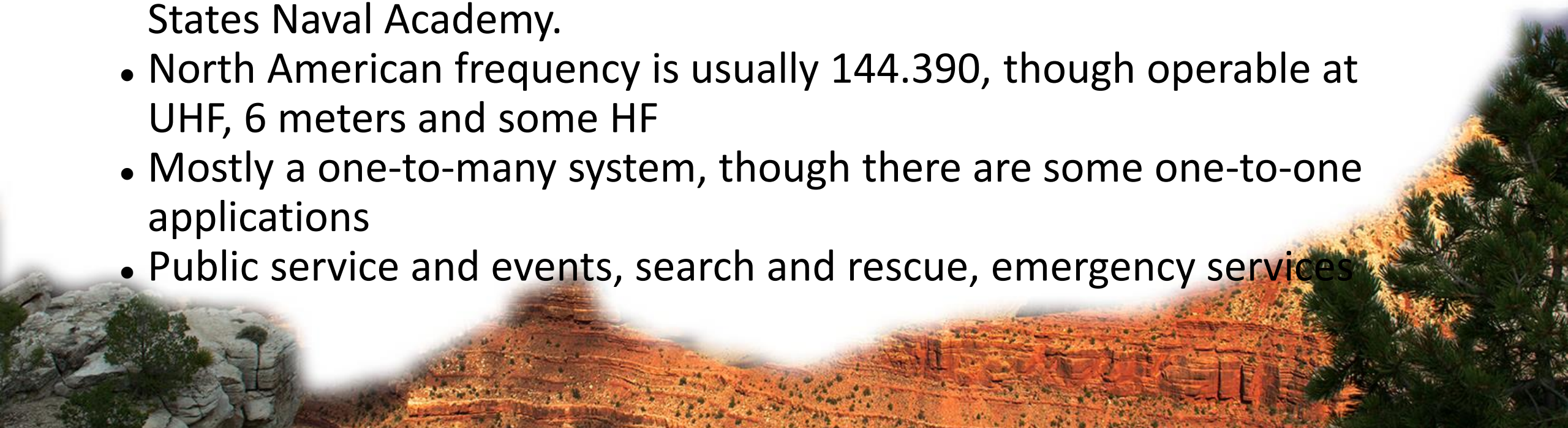
- Worldwide  system for sending e-mail via radio
- Provides e-mail from almost anywhere in the world.
- Adopted for contingency communication by many government agencies
- Used by infrastructure-critical NGOs such as International & American Red Cross, Southern Baptist Disaster Relief, DHS Tiered AT&T Disaster Response & Recovery, FedEx, Bridgestone Emergency Response Team, etc.
- VHF and HF options
- Hardware: Computer, TNC or Pactor Modem, RMS Express Software, Radio
- Pros: Pactor is very fast for HF, reliable, has peer-to-peer options
- Cons: Reliant on internet in normal operation, complexity

# Winlink


SW USA
SE USA
E Canada
Europe
Australia
Common Message Servers (CMS)
Internet
Remote Message Servers (RMS)
Telnet
HF: Pactor, WINMOR, Robust Packet
VHF/UHF: Packet

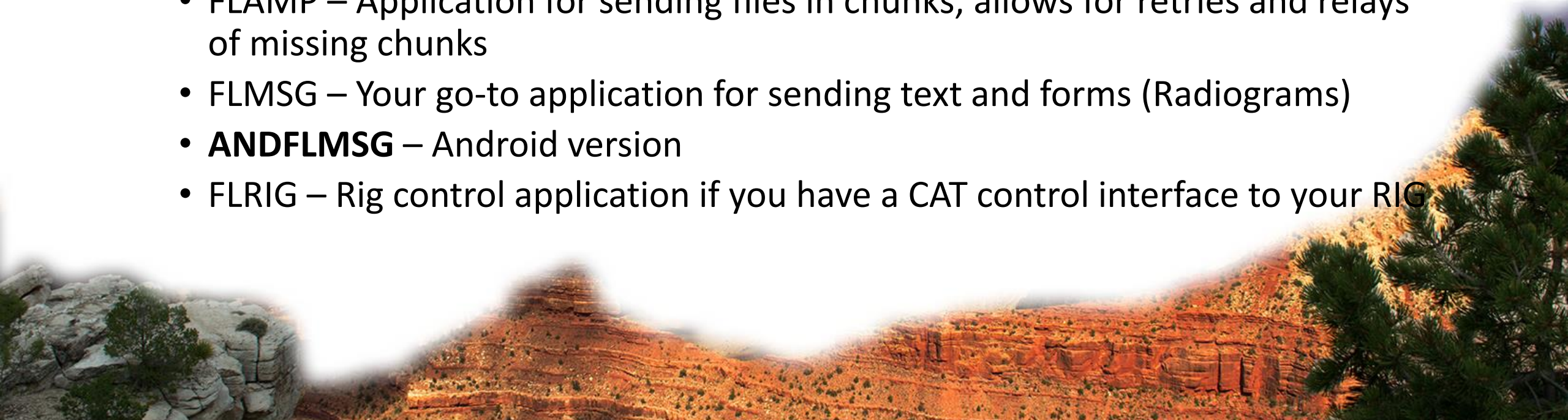
# APRS (Demo)

- **A**utomatic **P**acket **R**eporting **S**ystem
- Original Developed in 1984 to Map Navy Positions, with availability of GIS in the 90's became feasible for GPS integration
- The system is based on the AX25  Packet protocol, and was developed by Bob Bruninga WB4APR, a senior research engineer at the United States Naval Academy.
- North American frequency is usually 144.390, though operable at UHF, 6 meters and some HF
- Mostly a one-to-many system, though there are some one-to-one applications
- Public service and events, search and rescue, emergency services



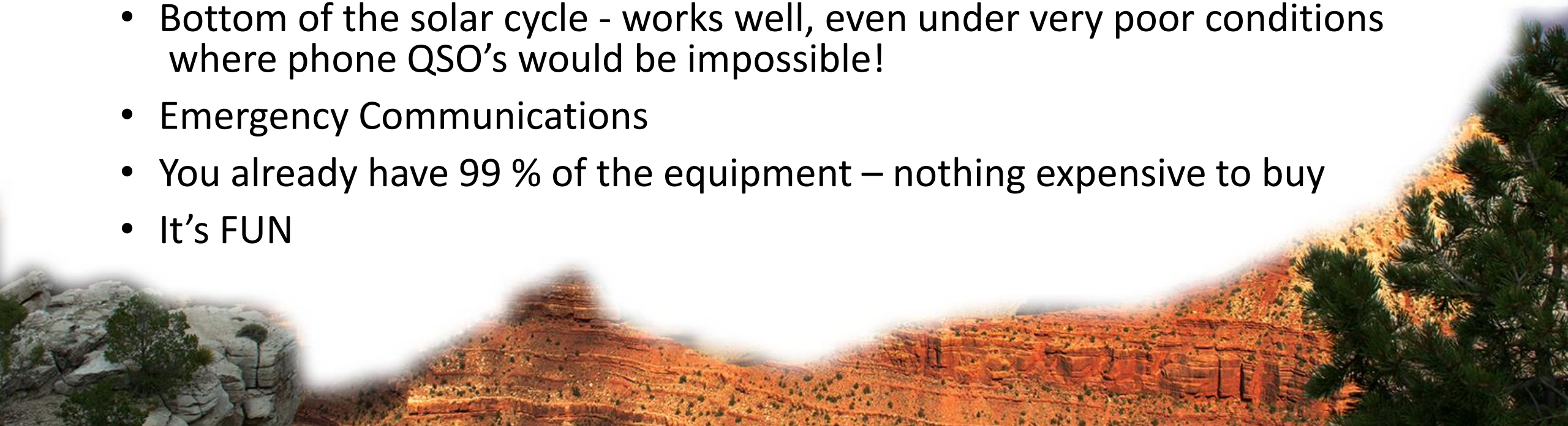
# NBEMS / FL "Suite"

- Narrow Band Emergency Messaging System
- *http://www.w1hkj.com/NBEMS/NBEMS.ppt*
- Software (All free):
  - FLDIGI – Main application for mode selection, rig control, QSO's
  - FLAMP – Application for sending files in chunks, allows for retries and relays of missing chunks
  - FLMSG – Your go-to application for sending text and forms (Radiograms)
  - **ANDFLMSG** – Android version
  - FLRIG – Rig control application if you have a CAT control interface to your RIG



# NBEMS - Demo

- Low Power - never need to run over 50 watts,
  5 -30 watts is almost always sufficient
- Reliable communications – succeeds even when CW fails
  some modes work below -8 dB s/n
- Many modes - choose your mode depending on conditions
- Bottom of the solar cycle - works well, even under very poor conditions
  where phone QSO's would be impossible!
- Emergency Communications
- You already have 99 % of the equipment – nothing expensive to buy
- It's FUN



# Useful Websites

- Comprehensive Guide to NBEMS / FLDIGI, equipment setup, instructions, etc: http://gblakesl.net/ARES/Basic-NBEMS-Workshop.pdf
- Presentation on Winlink: http://www.philsherrod.com/Winlink/Winlink_RMS_Express.pdf
- Excellent Presentation on NBEMS and FLDIGI: https://www.jeffreykopcak.com/drive/ham_radio/digital_modes/vhf_uhf_nbems_an_introduction_using_fldigi_and_flmsg_presentations/vhf_uhf_nbems.pdf
- Presentation on JT Modes: http://www.informationtechnologies.com.au/files/JT65%20Presentation.pdf
- WSPR Presentation: https://www.powershow.com/viewht/1a4552-ZDc1Z/What_is_WSPR_powerpoint_ppt_presentation
- Meteor Scatter Introduction: Link

# More Useful Websites

- APRS: http://www.aprs.org/APRS-mobile.ppt
- A PRACTICAL EVALUATION AND COMPARISON OF SOME MODERN DATA MODES: http://www.qsl.net/zl1bpu/MFSK/datmodes2.pdf
- ARRL presentations on NBEMS (Narrow Band Emergency Message System) with FLDIGI
  - http://www.arrl.org/files/file/On%20the%20Air/Tutorials/Introduction_to_NBEMS_ARRL.pdf
  - http://www.arrl.org/files/file/On%20the%20Air/Tutorials/Advanced_NBEMS_3_0.pdf
  - *http://www.w1hkj.com/NBEMS/NBEMS.ppt*
- Digital Mode Comparisons from FLDIGI Help files: http://w1hkj.com/FldigiHelp-3.21/Modes/Compare.htm
- Signal ID Wiki – listing of all digital signals, explanations, samples:
- https://www.sigidwiki.com/wiki

# Nerd Reading