Introduction to Meteor Scatter

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Pacific NW VHF Society

This presentation was provided as a white paper for the PNWVHFS near Seattle in Washington state.
Barry K7BWH is an active member and officer in the Pacific Northwest VHF Society.
He maintains the Society website at http://www.pnwvhfs.org, the Issaquah ARC website at www.w7bi.com, and the Edmonds website at www.edwaynet.com

Why Are We Here?

Everything we do is to improve the probability of making contacts.

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Let me ask some rhetorical questions and suggest a practical answer.
Why are you in this hobby?
Why are you at this meeting?
Why are you looking at Meteor Scatter?

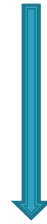A: Common factor is that everyone here is interested in ham radio.
You might reply "to improve yourself" or "learn something new".
But the underlying reason is to be able to make more contacts in more situations.

Outline

Why use meteor scatter
How does it work
How does it look
Demonstration
Best practices

Simple / Easy

Advanced

This presentation covers the basics by an appliance operator.
Barry K7BWH is not an expert; he only plays one during small presentations among friends.
This discussion covers Meteor Scatter and doesn't go into FT8 or other modes, although the same WSJTX software supports these and several more.
Show of hands:
- Who has a HF + 6m rig?
- Who has rig with built-in sound card?
- Who has tried any mode with WSJT?
- Who has tried FT8?

Why Use Meteor Scatter?

Improve the probability of making contacts.

"Meteor Scatter" is a fairly strange and exotic mode.

Messages are short, this is not a chat mode.

It is mainly used on 50 MHz, also 144 MHz, although some are exploring the possibilities on 222 and 432 MHz.

Although high-speed CW has been used awhile, the integration of computers with radios made it more popular.

Increased Range when Band is Dead

- When 6–meters is open, it's *really* open
- When 6–meters is NOT open, no amount of power and antennas will go far
- Popular ways to increase range are:
  ◦ Meteor Scatter: reflect signals from ionized trails
  ◦ Moonbounce: reflect signals from the moon
- But … Moonbounce is unreliable
  ◦ Subject to moon's position in sky
  ◦ Requires substantial power and equipment
  ◦ Meteor scatter works 24/7

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"Really open" means that a dipole and 10 watts can work across the country on 6 meters. When 6m is "not open" then, in truth, additional power and bigger antennas will help somewhat.

That is, when conditions are marginal, then more power and aluminum can help make contacts that others can't achieve.

But I operate as a portable station and I'm limited in how much I can carry.

Meteors enter atmosphere night and day, all 24 hours.

Other means to extend range include:

- Sporadic E
- Aurora
- Tropospheric ducting
- Ionoscatter
- Transequatorial propagation (TEP)
- Rain scatter
- Back scatter
- Airplane scatter
- Earth-Moon-Earth (EME)

My Contest Results 2013

- FSK441 for "2013 Winter Rally" contest during Geminids shower in December
- Won 1st Place in Pacific Time / Low Power!!!
  One entry
- Won 5th Place in Pacific Time!!!
  Five entries
- Won 17th Place in the world!!!
  Seventeen entries
- MSK144 Meteor Scatter is now mainstream

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Results posted at http://www.meteorscatter.org/2013contest.html (domain expired before 2019)

Good Fit for Portable Operation

- ▸ I visit grids in WA, OR, ID
- ▸ 6m (50 MHz) and 2m (144 MHz)
- ▸ Typical 200–300 miles SSB
- ▸ I want to make rare grids available
- ▸ Grid–chasers use 6 meters

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This slide describes why I personally want more range on VHF.
The 6 meter band uses frequencies near the traditional broadcast television band.
You may recall that TV signals work well for 10-20 miles from a transmitter.
However, ham radio operators routinely use a range out to 200 and sometimes 300 miles,
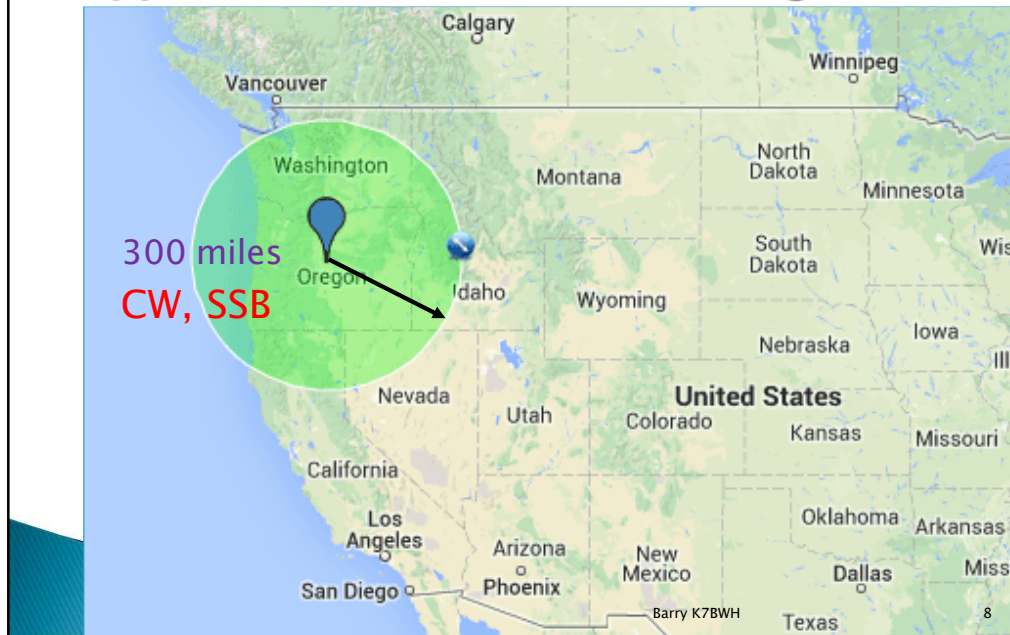typically by ground wave and tropo-scattering.

A "grid square" is 1° latitude by 2° longitude – about 70 miles wide and 100 miles tall at our latitude.
Washington state has 18 grid squares.
Oregon state has 22 grid squares.
Idaho has 20 grid squares.
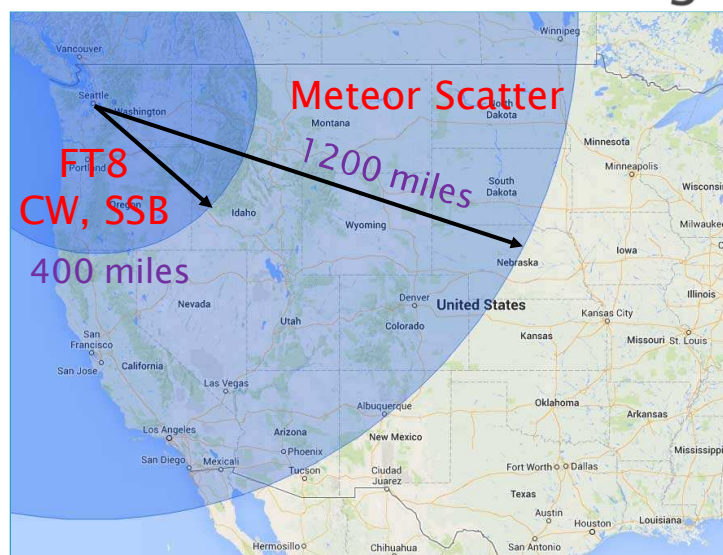
Typical Ground Wave Range

300 miles
CW, SSB

The circle is centered in Bend, approximately the middle of Oregon.
Circle radius 300 miles which is dependable on 2 meters.
Circle of 200 miles is dependable on 6 meters *from a good location.*

The circles are centered on Seattle, the home of K7BWH.
- Inner circle shows where meteor scatter will not work.
- Outer circle is the expected range of meteor scatter.
- Outside the circles is increasingly difficult to use meteor scatter.

At less than 400 miles, the meteor reflections are too weak to be useful. Besides, CW and SSB are quicker and easier.

You *could* try MSK144 but regular tropospheric propagation would probably allow the entire 15-second transmission to be received.

At 400 – 800 miles, a modest station of say 100 watts and 3-el Yagi can probably make contacts pretty easily.

At 800 – 1200 miles, more power and aluminum is an advantage.

Around 1400 miles is probably the maximum limit. The record distance is around 1600 miles.

How Does Meteor Scatter Work?

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This section introduces the characteristics of propagation, and briefly introduces WSJT software that was designed for this mode.

Meteor Scatter

- "meteor" = dust and sand swept up by Earth
- Altitude around 60 miles
- On entry, ionized trail for 0.1 to 2.0 sec
- If two hams can see the same piece of sky, they can use meteor scatter
- A short (1/10 sec) repeated message can get through

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A shared piece of high-altitude sky allows a chance of meteors to connect stations.
This is probabilistic, not a guaranteed contact.
Communications depend on velocity, frequency and particle size.
Suitable antennas and good power make 400 – 800 mile range relatively routine.

Meteor Scatter Geometry
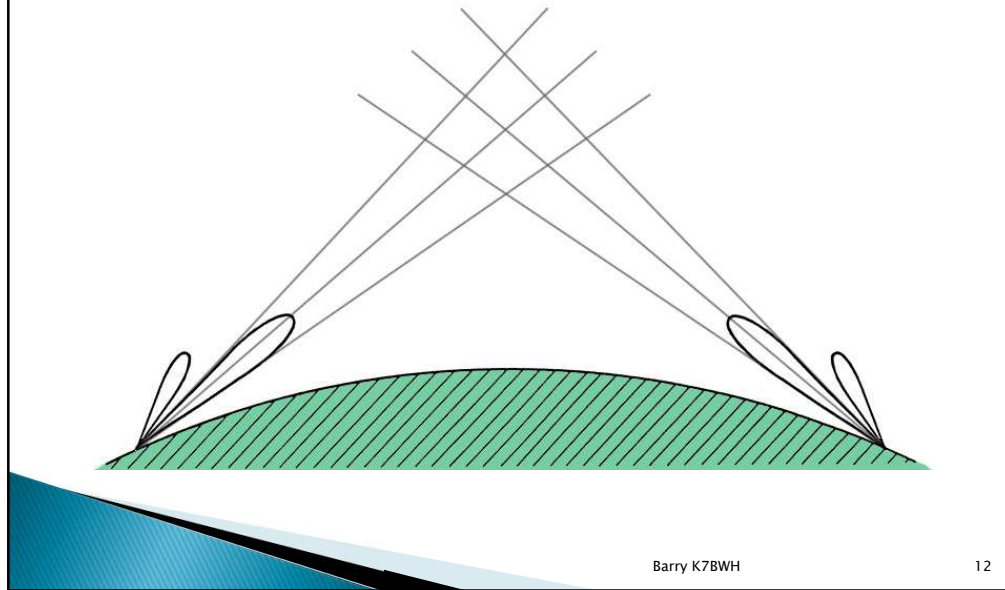
The distance achievable depends on the geometry that provides reflections from ionized trails in a shared space of sky.
The minimum distance, around 400 miles, corresponds to high angles.
The maximum distance, around 1200 miles, corresponds to low angles. Any lower and the amount of shared sky is diminished.
The goal is to illuminate the sky for the greatest chance of meteor trail reflections.
If the antenna is too focused, the small area reduces the chance of encountering a meteor.
If the antenna pattern is too broad, some power is wasted on the extra area.

Meteors by Time-of-Day

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

Source: QST Oct 1997
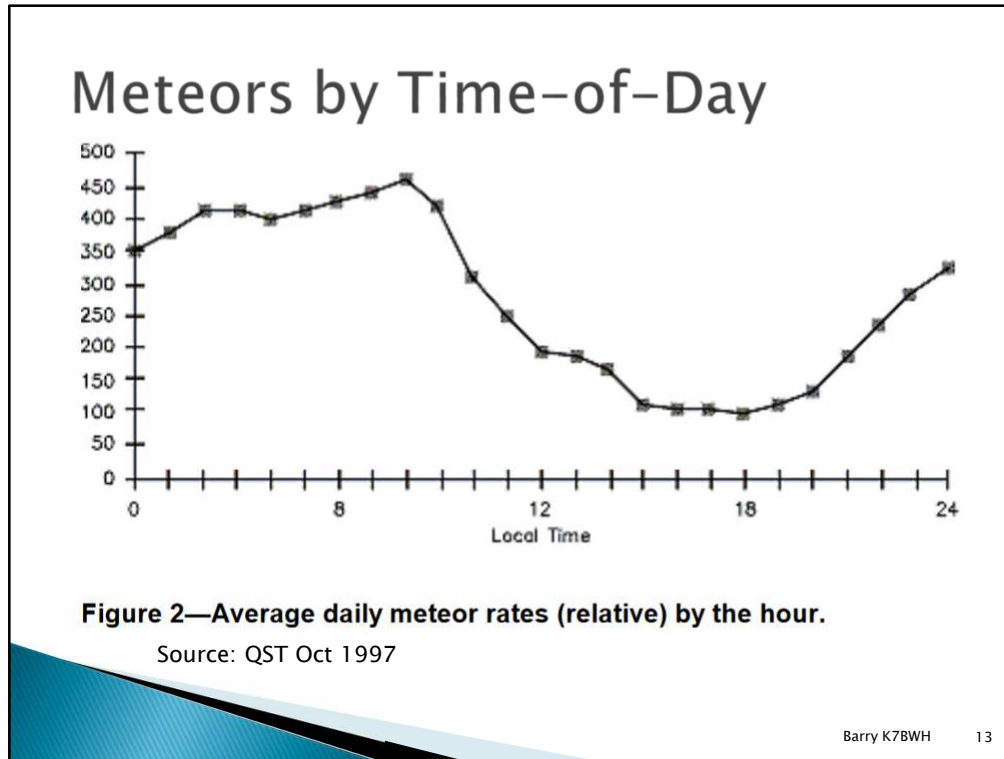
This is *arrival rate.*
In addition, there is *arrival velocity,* not shown.
Both characteristics are due to Earth's rotation and gravitational physics.
Best meteor activity is **6 am – 10 am local time**, due to favorable meteor rates and velocities.
You can use meteor scatter any time of day.

When I'm activating a grid, I work hard to be on the air by 6 am.
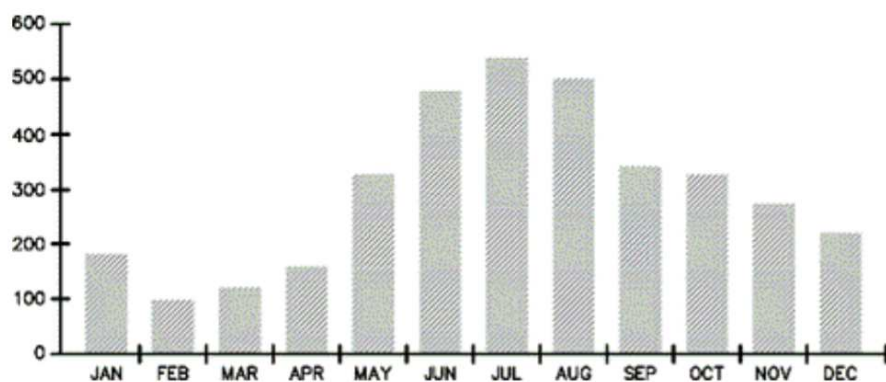
Figure 3—Sporadic meteor rates by season.

Source: QST Oct 1997

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This appears to include the regular predictable meteor showers.

Search for, and use, any of the many meteor shower calendars on the Internet.

E.g. American Meteor Society, https://www.amsmeteors.org/meteor-showers/meteor-shower-calendar/

For example in 2019:

- Southern Taurids – active Sept 10 – Nov 20, 2019
- Orionids – active Oct 2 – Nov 7, 2019

You can use meteor scatter any time of year.

Power and Antenna

Every dB counts in weak-signal VHF work.
- ▸ 100 watts works okay. Legal limit works better.
- ▸ Horizontal polarization.
- ▸ 2-element beam works okay. A 5-elt Yagi works better.
- ▸ But not too big: a narrow beam width does not illuminate much sky.

A modest antenna and 100 watts is fine.
I've had a lot of fun barefoot with a 3-element Yagi on 6 meters.

Verticals are poor. Low angle of radiation but wrong polarization and low gain.
Dipoles are poor. Low gain.
On two meters, 100 watts will work well and QSOs have been completed with 50 watts.
On six meters, as little as 10 watts are sufficient.

Moxon 6.1 dBi, three-element 8.1 dBi, five-element 11.5 dBi – every dB helps!

From a slot canyon on the Snake River below the Palisades Dam near Swan Valley, Idaho, DN43hk, I worked the PNW on meteor scatter.
You don't need to be on a hilltop.

WSJT Software

- WSJT = "Weak Signal by Joe Taylor"
- Started 2001, open sourced 2005
- Software supported by volunteers (and Joe)
- WSJT X supports dozens of protocols, hundreds of radio makes and models
- WSJT can be compiled for Windows, Linux, FreeBSD, Macintosh OS X, and most other UNIX-like systems.

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MSK144 is lately the only mode used for Meteor Scatter. See next slide.

FSK441 is obsolete; it is no longer shown in the list of available modes.

The "other modes" supported are unrelated to meteor scatter.

For example, ISCAT, ionospheric scattering is popular and useful but is not used for meteor scatter.

The version I'm using at time of writing is WSJT-X v2.0.1 7ddcb7, a free download.

Here's where I sidestep the tricky part: Configuring your radio-computer interface is left to the reader.

Strategy

- ▸ Send short message repeating continuously for 15 seconds
- ▸ Listen for 15 seconds while the other ham transmits
- ▸ Keep trying until a meteor trail provides enough reflection to decode the message
- ▸ Sporadic nature of pings makes it possible for many stations to share the frequency

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"Possible" to share the same frequency.
But a strong local station on the same frequency will wipe out your reception.

MSK144 Implementation

- **MSK** is "minimum phase shift keying"
  - Modulation at 1000 and 2000 Hz
  - Constant amplitude = 100% duty cycle
- **144** is number of bits in message frame:
  - 72 bits of user message
  - 8 bits CRC
  - 48 bits error-correcting redundancy
- 2000 baud = 72 msec message frame
- *Lots* of clever signal processing tricks

Joe Taylor's "hobby" is this playground of trying out new information theory algorithms for signal processing.

Message Exchange

▸ A "contact" requires:
1. Both stations copy both radio callsigns
2. Both stations exchange information (e.g. grid or signal report)
3. At least one acknowledgement ("Roger")

Most basic exchange requires five transmissions total.
Five transmissions * 15 seconds = 1 ½ minutes for shortest possible contact.

Example Contact

I receive: I send:

CQ K7MAC DN14

                     K7MAC K7BWH CN87

K7BWH K7MAC +06

                     K7MAC K7BWH R+09

K7BWH K7MAC R+03

                     K7MAC K7BWH RRR

K7BWH K7MAC 73

                     K7MAC K7BWH 73

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The example here was taken Thursday Oct 10th, 2019.
The process is called a "run".
We typically allow at least 10 minutes and frequently 20 minutes to complete a run.
This run took 8 minutes, from 1428z to 1436z.

How Does Meteor Scatter Look?

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This section shows how WSJT software looks on your computer screen.
WSJT is high-tech software written by high-tech developers *for* high-tech users.
Using this software is, in part, training your eye where to look.
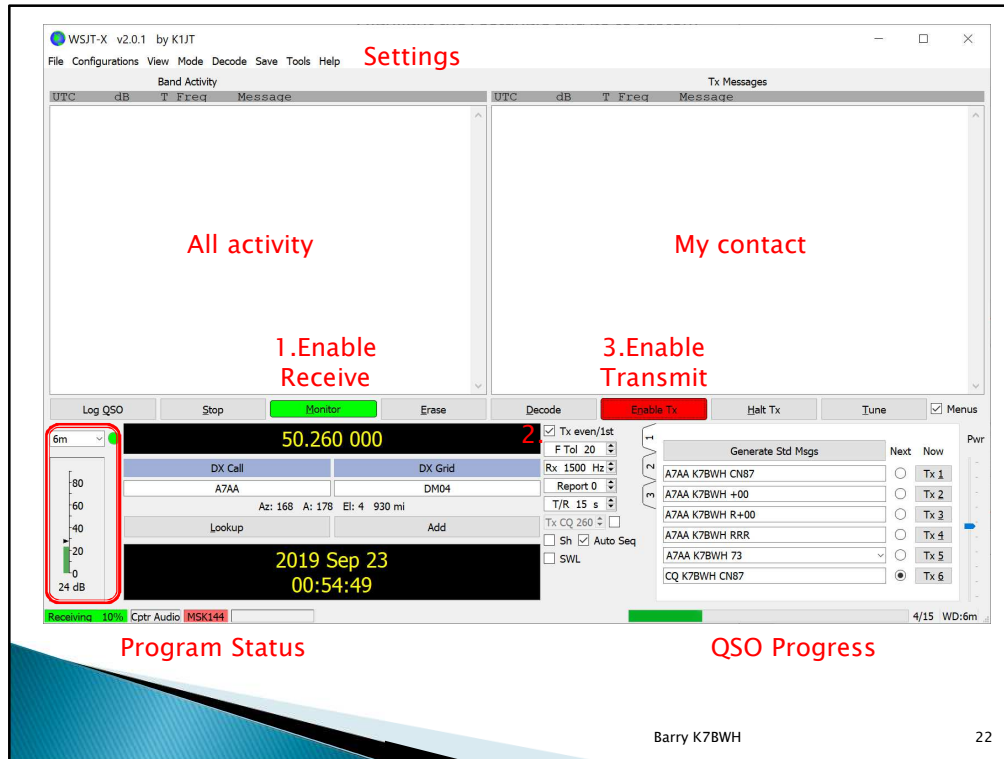
This is like driving a car.
1. Get in the car: Turn on MONITOR
2. Where are we going?
   • Point east: TX EVEN/1ST ON
   • Point west: TX EVEN/1st OFF
3. Start going there: Turn on ENABLE TX
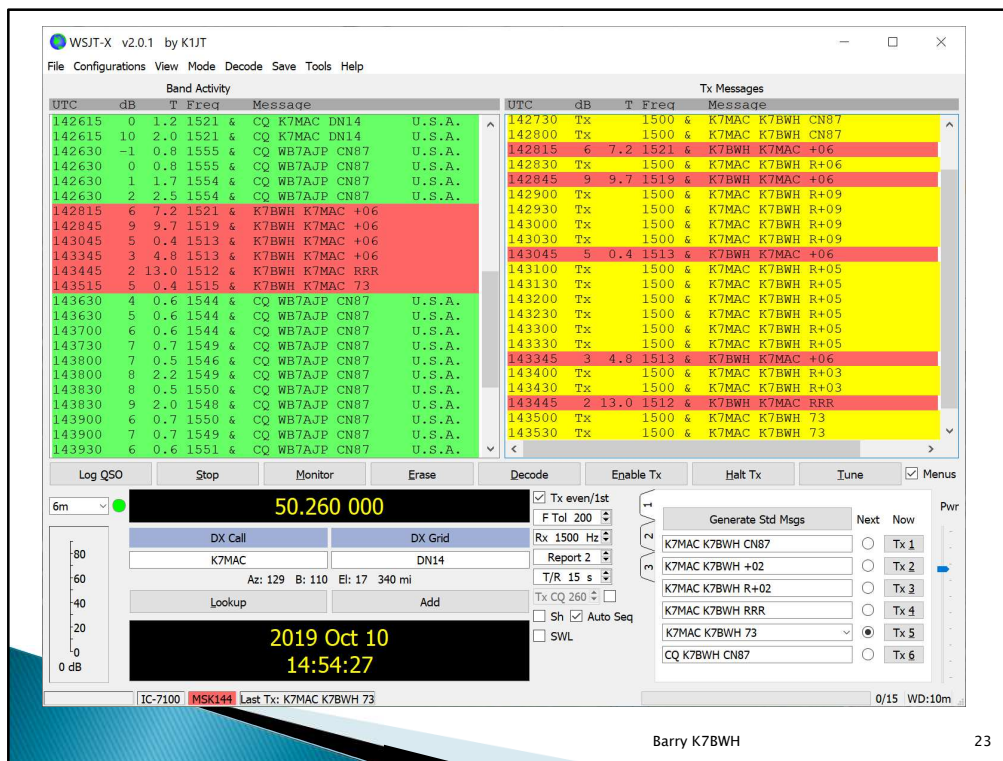
K7MAC is Roland "Mac" McGaha in Cascade, ID
WSJT helpfully suggests: Azimuth 129°, Elevation 17°, 340 miles
Suggestion is based on 4-digit grids.
The suggestion is pretty close to 6-digit result for DN14xn –to– CN87us of 124° and 371 miles.

Q: What was WB7AJP doing during this time?
A: He noticed that we began a contact and stopped sending CQ while we ran.
He picked up his CQ again after he saw both of our 73's.
Great operator!

Demonstration

▶ Initial setup
- ◦ Enter station information
- ◦ Select computer mic and speakers

▶ Essential settings
- ◦ Set mode to MSK144
- ◦ Set band to 6-meters
- ◦ Set sequence "Tx even" at westmost station

▶ Call CQ

Improve the probability of making contacts.

Wait… What About Hardware?

Improve the probability of making contacts.   Barry K7BWH   25

The next few slides describe the necessary equipment in rather general terms.

Any Digital Station on HF / VHF

- ▸ "Meteor Scatter" is just another WSJT mode that happens to be on VHF.

- ▸ Any VHF station that works on digital modes can use meteor scatter and other WSJT modes.

- ▸ Pretty much any Windows, Mac or Linux computer will work.

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There isn't really any special requirement imposed by WSJT above regular digital mode operation.
WSJT was first developed for Windows XP machines.
It is not very demanding and continues to run well on almost any Windows computer.
The next few slides will review what equipment is needed by digital modes in general.

Station Hardware

Computer needs radio connections for:
- Toggling transmit/receive mode
- Received audio
- Transmitted audio

- *Bonus* if computer can read radio's frequency and mode for logging
- *Big Bonus* if computer has Internet access

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Station Hardware

Transceiver — Interface — Computer

Audio Out
Audio In
PTT

WSJT
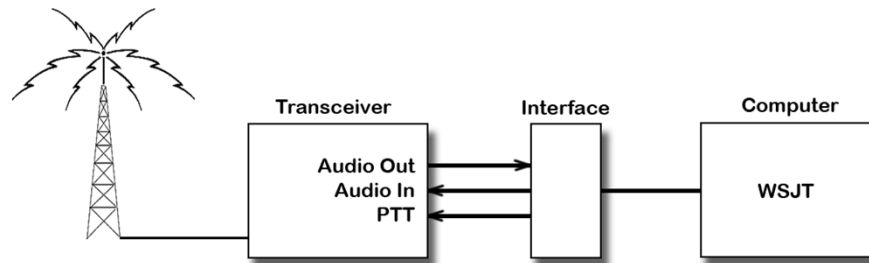
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This slide is provided because, when I began, I was pretty hazy about the required connections.
Every digital station needs to provide some kind of solution for these three connections:
1. Received audio
2. Transmitted audio
3. Toggling transmit/receive mode

Meteor Scatter Best Practices

Everything we do is to improve the probability of making contacts.

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This section suggests some tools and practices.
This is all helpful but optional.

Computer Clock Set

- "Nice to have" accurate time
  - Not critical
  - Same message repeats every 72 msec

- Dimension 4
- Meinberg NTP
- GPS Dongle
- Time Fudge
- Many more

TimeFudge v1.1
Fudge Seconds -0.2
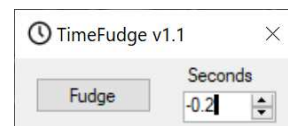
Improve the probability of making contacts.   Barry K7BWH   30

How do you know when to send?

If your clock is off by many seconds the MSK144 message will still decode.
This is different than FT8 – if your clock is off by 1 second then you risk decode failure.
For meteor scatter, it's an advantage to be accurate within one second.
Why? Because you only lose 7% of the available time (1 sec divided by 15 seconds).

Western station sends on even sequence. Put checkmark in "Tx even/1st".

VHF-Chat Slack

- http://vhf-chat.slack.com
- Pacific NW chat for VHF
  ◦ Rovers, grid-chasers
  ◦ MS and Iono-scatter and EME

- Slack easy to use on smartphones and tablets
  ◦ Supports images and videos
  ◦ Very chatty
  ◦ History limited to 10,000 messages (about 10 days)

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How do you know where to point?
How do you know when to quit running?

"Slack" is a *very* widely used team collaboration software.
Acronym for "Searchable Log of All Conversation and Knowledge."
Runs on, and has clients for, and is optimized for a very wide variety of devices.
N5TM opened a (free) Slack channel for VHF users.

Be careful not to disqualify a contact by giving out what is heard before receiving either the standard "RRR" or "73".
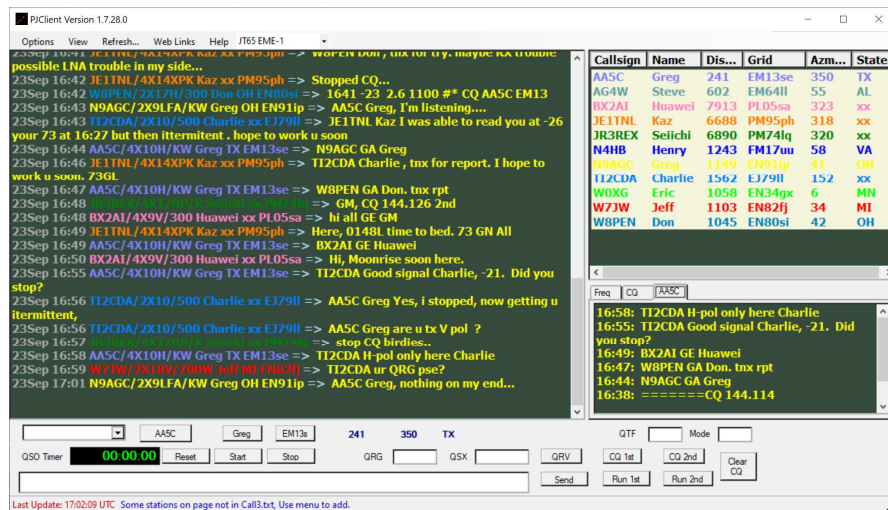
Ping Jockey Chat Room

PJClient Version 1.7.28.0

Options   View   Refresh...   Web Links   Help   JT65 EME-1

Callsign	Name	Dis...	Grid	Azm...	State
AA5C	Greg	241	EM13se	350	TX
AG4W	Steve	602	EM64ll	55	AL
BX2AI	Huawei	7913	PL05sa	323	xx
JE1TNL	Kaz	6688	PM95ph	318	xx
JR3REX	Seiichi	6890	PM74lq	320	xx
N4HB	Henry	1243	FM17uu	58	VA
N9AGC	Greg	1149	EN91ip	41	OH
TI2CDA	Charlie	1562	EJ79ll	152	xx
W0XG	Eric	1058	EN34gx	6	MN
W7JW	Jeff	1103	EN82fj	34	MI
W8PEN	Don	1045	EN80si	42	OH

23Sep 16:41 JE1TNL/4X14XPK Kaz xx PM95ph => W8PEN Don , tnx for try. maybe RX trouble possible LNA trouble in my side...
23Sep 16:42 JE1TNL/4X14XPK Kaz xx PM95ph => Stopped CQ...
23Sep 16:42 W8PEN/2X17H/300 Don OH EN80si => 1641 -23 2.6 1100 #* CQ AA5C EM13
23Sep 16:43 N9AGC/2X9LFA/KW Greg OH EN91ip => AA5C Greg, I'm listening....
23Sep 16:43 TI2CDA/2X10/500 Charlie xx EJ79ll => JE1TNL Kaz I was able to read you at -26 your 73 at 16:27 but then ittermitent . hope to work u soon
23Sep 16:44 AA5C/4X10H/KW Greg TX EM13se => N9AGC GA Greg
23Sep 16:46 JE1TNL/4X14XPK Kaz xx PM95ph => TI2CDA Charlie , tnx for report. I hope to work u soon. 73GL
23Sep 16:47 AA5C/4X10H/KW Greg TX EM13se => W8PEN GA Don. tnx rpt
23Sep 16:48 JR3REX/4X17H/7K Seiichi xx PM74lq => GM, CQ 144.126 2nd
23Sep 16:48 BX2AI/4X9V/300 Huawei xx PL05sa => hi all GE GM
23Sep 16:49 JE1TNL/4X14XPK Kaz xx PM95ph => Here, 0148L time to bed. 73 GN All
23Sep 16:49 AA5C/4X10H/KW Greg TX EM13se => BX2AI GE Huawei
23Sep 16:50 BX2AI/4X9V/300 Huawei xx PL05sa => Hi, Moonrise soon here.
23Sep 16:55 AA5C/4X10H/KW Greg TX EM13se => TI2CDA Good signal Charlie, -21. Did you stop?
23Sep 16:56 TI2CDA/2X10/500 Charlie xx EJ79ll => AA5C Greg Yes, i stopped, now getting u itermittent,
23Sep 16:56 TI2CDA/2X10/500 Charlie xx EJ79ll => AA5C Greg are u tx V pol ?
23Sep 16:57 JR3REX/4X17H/7K Seiichi xx PM74lq => stop CQ birdies..
23Sep 16:58 AA5C/4X10H/KW Greg TX EM13se => TI2CDA H-pol only here Charlie
23Sep 16:59 W7JW/2X10V/700W Jeff MI EN82fj => TI2CDA ur QRG pse?
23Sep 17:01 N9AGC/2X9LFA/KW Greg OH EN91ip => AA5C Greg, nothing on my end...

Freq   CQ   AA5C

16:58: TI2CDA H-pol only here Charlie
16:55: TI2CDA Good signal Charlie, -21. Did you stop?
16:49: BX2AI GE Huawei
16:47: W8PEN GA Don. tnx rpt
16:44: N9AGC GA Greg
16:38: =======CQ 144.114

| | AA5C | Greg | EM13s | 241 | 350 | TX | QTF | Mode |
QSO Timer 00:00:00   Reset   Start   Stop   QRG   QSX   QRV   CQ 1st   CQ 2nd   Clear CQ
Send   Run 1st   Run 2nd

Last Update: 17:02:09 UTC   Some stations on page not in Call3.txt, Use menu to add.

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"Ping Jockey" has nothing to do with submarines or sonar.
So called because we call meteor trails "pings".
This chat room has been around for many years.
There is both a web page chat room and a Windows client (shown here).
Another complicated UI written by programmers *for* programmers.
Let's try to make sense of it:
- Upper left: main window
- Upper right: callsign window
- Lower right: "Freq" to see what frequencies are in use, "Callsign" to isolate a single user.
- Bottom: Type your message and press Enter.
- Several buttons are offered for common meteor scatter activities.

Personally, I don't use PingJockey on my portable ops.
PJ is too difficult to see/use on my laptop and works best on a big screen.
I prefer vhf-chat.slack.com.

You, yes you, can run install and run this Right Now to watch the chatter.
Two ways to participate:
1. Install "Ping Jockey Client" for standalone program at www.meteorscatter.org
2. Visit web view of same chat room at www.pingjockey.net/cgi-bin/pingtalk
Main window is real-time conversations, colorized by user.
Callsign window displays users logged in, and can be sorted by grid or distance or state or other ways.

Freq window tab displays users that have notified Ping Jockey that they're using a certain frequency.

CQ window tab displays users that have notified Ping Jockey that they're calling CQ.

The lower input fields allow users to notify the chat room where they're operating. This helps reduce interference.

The chat room is NOT the contact; the operators only arrange schedules.

Ping Jockey Central lets you agree on a schedule and settings:

- What Frequency will we use?
- Who will go first? (savvy operators already know, based on standard operating procedures)
- When will we start / stop?
- Do you want to use ST (short tones)?

Ping Jockey does not replace the contact.

Exchanging any contact details on PJ before it's complete will invalidate the contact.

Examples of what NOT to say on PJ:

- "Have you gotten both calls yet?"
- "Sorry I skipped a message, going back to Calls and Reports"
- "Sending RRR now"
- "I just got your report"
- "What message are you sending?"
- "Have R 26, I am sending RRR now"

Grid Tracker

- ▶ Listens to your WSJT decodes
  - ◦ Draws map of stations heard and your contacts
- ▶ Monitors PSK-Reporter band activity
  - ◦ Draws map of other contacts
- ▶ Monitors other Grid Tracker users
  - ◦ Draws map of other people online
  - ◦ https://tagloomis.com/grid-tracker/

JT Alert

- Monitors your WSJT
- Audio and visual alerts for chasing awards
- Wakes you for:
  - Wanted callsigns, wanted prefix, wanted grid, wanted states, wanted DXCC, wanted zone, wanted continent, and more
- Identifies "worked before" stations
- https://hamapps.com/

Logging

- Lots of choices for logging
- WSJT has built-in logger
  - Log file is directly compatible with LotW
  - Also keeps all contacts, successful or not
  - Also can store/playback audio files
- WSJT has published API used by:
  - N1MM
  - Ham Radio Deluxe
  - Grid Tracker
  - Several others

Conclusion

- MSK144 is a great tool in the 6-meter toolkit
- Great 24 hours/day
- Great for 400-1200 miles
- Great for modest stations
- Great in valleys
- Easy to operate
- But contacts are very slow

- MSK144 will keep making contacts after everything else dries up

Meteor Scatter Web Sites

- Joe Taylor K1JT
  www.physics.princeton.edu/pulsar/K1JT/
- Ping Jockey   www.pingjockey.net/cgi-bin/pingtalk
- VHF Real-time Spots   www.dxmaps.com
- Grid Tracker   tagloomis.com
- International Meteor Organization   imo.net
- American Meteor Society   www.amsmeteors.org/
- WSJT Ops by Wes WA5TKU
  www.ntms.org/files/WSJTOPS_WA5TKU.pdf
- Typical QSO Experience
  preview.tinyurl.com/ka6refx
- Barry K7BWH   www.coilgun.info/hamradio/

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And many more great resources on the web.

Discussion Groups

- WSJT group   (Yahoo)
  - PNWVHFS group   (Google group)
  - VHF FFMA group   (Yahoo)
  - VHF Contesting group   (List group)
  - VHF Contesting Rovers group   (Yahoo)

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WSJT - https://groups.yahoo.com/neo/groups/wsjtgroup/info
PNWVHFS - https://groups.google.com/forum/?fromgroups#!forum/PNWVHFS
VHF FFMA - https://groups.yahoo.com/neo/groups/FFMA/info
VHF Contesting - http://lists.contesting.com/mailman/listinfo/VHFcontesting
VHF Rovers - https://groups.yahoo.com/neo/groups/vhfrovers/info

Image is from large meteor in Russia on Feb 13, 2013.