Ham Radio Activities at Marshall Space Flight Center during the 2017 Total Solar Eclipse: Transmitting Node

HamSCI Workshop
February 23-24, 2018 NJIT, Newark, NJ

- Jesse McTernan, USRA/MSFC (KN4EZR)
- Linda Krause, MSFC (K0DRK)
- Ghee Fry, MSFC (WL7C)
Ham Radio Activities at Marshall Space Flight Center

Part 2: Transmitting Node
Solar activity on Monday, 21 August 2017 was relatively quiet.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radio Flux</td>
<td>$F$</td>
<td>87.1</td>
<td>sfu</td>
</tr>
<tr>
<td>Sun spots</td>
<td>$R$</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>X-ray background flux</td>
<td>$A,B,C,M,X$</td>
<td>B2.6</td>
<td>(W/m^2)</td>
</tr>
<tr>
<td>K-index</td>
<td>$Kp$</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Space weather data from NOAA SWPC archives

X-ray activity plot from spaceweatherlive.com
Physical location and setup

Location

<table>
<thead>
<tr>
<th>lat</th>
<th>lon</th>
<th>Maidenhead</th>
</tr>
</thead>
<tbody>
<tr>
<td>37.035796</td>
<td>-87.304767</td>
<td>EM67ia</td>
</tr>
</tbody>
</table>

Local eclipse contact times (CDT = UTC – 5)

<table>
<thead>
<tr>
<th>C1</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Begin Partial)</td>
<td>(begin total)</td>
<td>(end totality)</td>
<td>(End Partial)</td>
</tr>
</tbody>
</table>

Very limited internet!
Physical location and setup

Christian Way Farm Near Hopkinsville, KY

Very limited internet!
**Physical location and setup: Antenna and Radio**

**Alpha Antenna**

6-80M complete multiband 500W portable antenna

Two mistakes: didn’t elevate antenna (5 feet)  
Installed matching network backwards

Icom 7300  
(80 Watts)
The antenna was designed to operate on multiple ham bands.

Note: the SWR for the 40-m band is around 1.5.

We measured SWR values less than 3.0 (MFJ-226), even with the matching network installed incorrectly.
## Relevant antenna characteristics

<table>
<thead>
<tr>
<th><strong>Electrical Characteristics</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Frequency range</td>
<td>3.5-29.7 MHz (54 MHz when mounted upon an optional tripod)</td>
</tr>
<tr>
<td>Polarization</td>
<td>Horizontal and Vertical polarization</td>
</tr>
<tr>
<td>RF power capacity (watts)</td>
<td>500 PEP SSB, 250 CW, or 100 digital</td>
</tr>
<tr>
<td>Input impedance</td>
<td>50 ohms</td>
</tr>
</tbody>
</table>

| **Radiation Pattern:**        |  |
| Azimuth                       | Omnidirectional/Semi-Directional |
| Elevation                     | NVIS & DX |

| **Physical Characteristics:** |  |
| Wind and ice                  | MilStick survives 70 MPH wind with no ice |
| Maximum Height erected        | 13 feet when mounted on the Jaw Mount and **19 feet** when mounted upon an optional tripod |
| Minimum foot-print required    | 3 foot by 3 foot + **25 foot NVIS-2.1** |
| Minimum Weight                | 2.00 pounds (MTCH-2.1 & MLSTK-2.1.XX) |
Data analysis (all contacts)

Dotted line
Asterisks
Magenta lines
Time independent

All Contacts made by K0DRK
Data analysis (all contacts)

Distances between DX (K0DRK) and All Contacted DE Nodes
(Calculated Using WGS 84 Reference Ellipsoid)

All Contacts made by K0DRK
Data analysis (contacts on 20-m only)

Distances between DX (K0DRK) and Contacted DE Nodes
(Calculated Using WGS 84 Reference Ellipsoid)

20m only

Contact Distance, km

UTC

Aug 21, 2017

16:30  17:00  17:30  18:00  18:30  19:00  19:30  20:00

Contact Distance, km

800  900  1000  1100  1200  1300  1400  1500  1600

Data analysis (contacts on 30-m only)

Distances between DX (K0DRK) and Contacted DE Nodes
(Calculated Using WGS 84 Reference Ellipsoid)

- Contact Distance, km
- UTC
- Aug 21, 2017

Map showing contact locations across the United States.
Data analysis (contacts on 40-m only)

Distances between DX (K0DRK) and Contacted DE Nodes (Calculated Using WGS 84 Reference Ellipsoid)

40m only

Contact Distance, km

16:30 17:00 17:30 18:00 18:30 19:00 19:30 20:00 20:30

UTC

Aug 21, 2017

2 unique DE stations
Observations

- Very limited internet!
  - Made dynamic experimentation nearly impossible
- Apparent directionality of contacts (as expected with NVIS)
- Low number of data points
- Lack of confirmed DE/DX locations
- Did not contact MSFC’s receiving node (WL7C)
  - Lat: 36.50N, Lon: 87.34W, Distance: 60.61 km
  - Work remains to extract science from this dataset

Stats:
- 30 total contacts day of eclipse
- 12 contacts (40 meter)
- 10 contacts (30 meter)
- 8 contacts (20 meter)
- 10 unique DE stations
- 11 (most contacts with same DE)
- Wanted to use 80m (see lesson learned)

<table>
<thead>
<tr>
<th>Band (meters)</th>
<th>Frequency Range (MHz)</th>
<th>Range (kHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>14.00 – 14.35</td>
<td>350</td>
</tr>
<tr>
<td>30</td>
<td>10.10 – 10.15</td>
<td>50</td>
</tr>
<tr>
<td>40</td>
<td>7.00 – 7.30</td>
<td>300</td>
</tr>
</tbody>
</table>

Select ham-radio band plan, for reference
Future Plans include a long-term receiving node at NSSTC

Concrete roof (don’t think there is a metal layer)

Top View

5-foot PVC tube

15-foot radials
14-AWG stranded copper

Active Receive Antenna
The receiving node (RBN, WSPRnet, PSKReporter, etc.) is almost running in “phase 1”

Equipment List:
Active Receive Antenna (DXE-ARAV3)
Surge Protector (DXE-RLP75FF)
SDR Hardware (SDRplay RSP2pro)
SDR Software (SDRuno)
Virtual Audio Cables (VB-CABLE)
CW Decoder (CW Skimmer)
Future plans: ray tracing with AF-Geospace and PIM

**Preliminary Analysis**

- Frequency = 7 MHz (40m)
- Elevation span = 10 – 90 degrees

Relevant ionospheric parameters

Notice how NVIS signals penetrate the F layer. (70 and 90 degrees)

**Caveat:** no collisions
Future plans: ray tracing with IONOspheric Ray Tracing (IONORT)

Simulated 7-MHz ray pointed toward WL7C 60.6 km (37.7 miles) away at various elevations (electron density profiles created using IRI-2016)

Preliminary, not for reproduction
Future plans: ray tracing with IONOospheric Ray Tracing (IONORT)

Simulated ray pointed toward WL7C 60.6 km (37.7 miles) away at 80-degree elevation
(electron density profiles created using IRI-2016)
Conclusion

• Transmitted on 20m, 30m, and 40m from within totality using 80 watts and NVIS antenna
• We are establishing a receiving node at NSSTC (MSFC)
  • RBN, WSPRnet, PSKReporter, other?
• We will use ray tracing to investigate why our DX and DE stations did not make contact
• We are hoping to apply our lessons learned during future eclipses!
Please connect with us:
• Experience setting up receiving nodes?
• Plans for future solar eclipses (2019, 2020, 2024)?
• Ray tracing?

Thank you for your attention!
Sample output from IRI-2016 online
August 21, 2017
Hour = 16.42
Latitude = 30N
Longitude = -75W

IONORT
- D-region (collisions)
- Discrete electron density grids
  - Lat, lon, height