

## **Factual Report – Attachment 2**

National Weather Service information on KHGX WSR-88D operations.

# **METEOROLOGY**

DCA19MA086

*Submitted by: Mike Richards  
NTSB, AS-30*

## Richards Michael

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From: Steven Smith - NOAA Federal <[REDACTED]@noaa.gov>

Date: Mon, Apr 8, 2019 at 5:12 PM

Subject: Re: NTSB Request: Timing Questions Regarding 88D Volume Scans

To: Lora Wilson - NOAA Federal <[REDACTED]@noaa.gov>

Cc: Jessica Schultz - NOAA Federal <[REDACTED]@noaa.gov>, Christina Horvat <[REDACTED]@noaa.gov>

**- Request the following radial scan times on the attached sheet. All are for KHGX on 23 February 2019.**

See attached. I annotated the document you sent with the radial time. I have included both a PDF version and a DOCX version.

**- Request the start and end time table (as already provided for the 1835:02Z volume scan) for the following KHGX volume scans on 23 February 2019:**

**1814:24Z**

**1820:56Z**

**1828:14Z**

**1842:21Z**

SEQUENCE NUMBER: 1 VCP: 215 WEATHER MODE: A  
DOPPLER RESOLUTION: 0.5 m/s OVERLAY MARGIN: 0.0 dB  
CALIBRATION CONSTANT: -41.87 dB

| EL#                 | DATE     | START<br>TIME | END<br>TIME  | START<br>AZIMUTH | END<br>AZIMUTH | PSEUDO<br>RANGE | ELANG<br>RADS |     |
|---------------------|----------|---------------|--------------|------------------|----------------|-----------------|---------------|-----|
| 1<br>(Surveillance) | 02/23/19 | 18:14:24.212  | 18:14:55.455 | 279.26           | 278.76         | 0.00            | 0.5           | 720 |
| 2<br>(Doppler)      | 02/23/19 | 18:14:56.528  | 18:15:21.523 | 292.23           | 291.70         | 0.00            | 0.5           | 720 |
| 3<br>(Suveillance)  | 02/23/19 | 18:15:22.552  | 18:15:49.745 | 306.25           | 305.74         | 0.00            | 0.9           | 720 |

|                |          |              |              |        |        |      |      |     |
|----------------|----------|--------------|--------------|--------|--------|------|------|-----|
| 4              | 02/23/19 | 18:15:50.998 | 18:16:15.307 | 321.24 | 320.72 | 0.00 | 0.9  | 720 |
| (Doppler)      |          |              |              |        |        |      |      |     |
| 5              | 02/23/19 | 18:16:16.215 | 18:16:38.172 | 335.26 | 334.74 | 0.00 | 1.3  | 720 |
| (Surveillance) |          |              |              |        |        |      |      |     |
| 6              | 02/23/19 | 18:16:39.170 | 18:17:04.652 | 350.22 | 349.74 | 0.00 | 1.3  | 720 |
| (Doppler)      |          |              |              |        |        |      |      |     |
| 7              | 02/23/19 | 18:17:05.772 | 18:17:27.510 | 8.54   | 7.56   | 0.00 | 1.8  | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 8              | 02/23/19 | 18:17:28.508 | 18:17:45.774 | 25.55  | 24.56  | 0.00 | 2.4  | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 9              | 02/23/19 | 18:17:46.369 | 18:18:18.273 | 50.24  | 49.75  | 0.00 | 0.5  | 720 |
| (Surveillance) |          |              |              |        |        |      |      |     |
| 10             | 02/23/19 | 18:18:19.470 | 18:18:44.639 | 64.20  | 63.71  | 0.00 | 0.5  | 720 |
| (Doppler)      |          |              |              |        |        |      |      |     |
| 11             | 02/23/19 | 18:18:45.143 | 18:19:04.011 | 90.55  | 89.55  | 0.00 | 3.1  | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 12             | 02/23/19 | 18:19:05.204 | 18:19:22.927 | 112.56 | 111.55 | 0.00 | 4.0  | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 13             | 02/23/19 | 18:19:24.183 | 18:19:41.258 | 136.55 | 135.55 | 0.00 | 5.1  | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 14             | 02/23/19 | 18:19:43.642 | 18:20:00.889 | 163.54 | 162.55 | 0.00 | 6.4  | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 15             | 02/23/19 | 18:20:02.219 | 18:20:16.536 | 192.49 | 191.49 | 0.00 | 8.0  | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 16             | 02/23/19 | 18:20:18.023 | 18:20:31.378 | 228.51 | 227.50 | 0.00 | 10.0 | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 17             | 02/23/19 | 18:20:33.925 | 18:20:47.878 | 266.51 | 265.50 | 0.00 | 12.0 | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |

VOLUME DURATION: 383

SEQUENCE NUMBER: 2 VCP: 215 WEATHER MODE: A  
DOPPLER RESOLUTION: 0.5 m/s OVERLAY MARGIN: 5.0 dB  
CALIBRATION CONSTANT: -42.27 dB

| EL# | DATE | START<br>TIME | END<br>TIME | START<br>AZIMUTH | END<br>AZIMUTH | PSEUDO<br>ELANG | RADS |
|-----|------|---------------|-------------|------------------|----------------|-----------------|------|
|-----|------|---------------|-------------|------------------|----------------|-----------------|------|

|    |                            |              |              |        |        |      |      |     |
|----|----------------------------|--------------|--------------|--------|--------|------|------|-----|
| 1  | 02/23/19<br>(Surveillance) | 18:20:56.479 | 18:21:28.466 | 134.28 | 133.76 | 0.00 | 0.5  | 720 |
| 2  | 02/23/19<br>(Doppler)      | 18:21:29.434 | 18:21:53.685 | 146.23 | 145.74 | 0.00 | 0.5  | 720 |
| 3  | 02/23/19<br>(Surveillance) | 18:21:54.648 | 18:22:21.684 | 159.25 | 158.76 | 0.00 | 0.9  | 720 |
| 4  | 02/23/19<br>(Doppler)      | 18:22:22.715 | 18:22:47.994 | 174.20 | 173.71 | 0.00 | 0.9  | 720 |
| 5  | 02/23/19<br>(Surveillance) | 18:22:48.029 | 18:23:11.161 | 189.25 | 188.76 | 0.00 | 1.3  | 720 |
| 6  | 02/23/19<br>(Doppler)      | 18:23:12.130 | 18:23:37.460 | 205.24 | 204.73 | 0.00 | 1.3  | 720 |
| 7  | 02/23/19<br>(Combined)     | 18:23:38.757 | 18:23:59.532 | 226.55 | 225.55 | 0.00 | 1.8  | 360 |
| 8  | 02/23/19<br>(Surveillance) | 18:24:00.995 | 18:24:32.745 | 244.25 | 243.75 | 0.00 | 0.5  | 720 |
| 9  | 02/23/19<br>(Doppler)      | 18:24:33.713 | 18:24:58.924 | 256.23 | 255.72 | 0.00 | 0.5  | 720 |
| 10 | 02/23/19<br>(Combined)     | 18:24:59.522 | 18:25:16.939 | 282.57 | 281.56 | 0.00 | 2.4  | 360 |
| 11 | 02/23/19<br>(Combined)     | 18:25:18.020 | 18:25:36.739 | 302.55 | 301.55 | 0.00 | 3.1  | 360 |
| 12 | 02/23/19<br>(Combined)     | 18:25:37.839 | 18:25:55.991 | 323.54 | 322.55 | 0.00 | 4.0  | 360 |
| 13 | 02/23/19<br>(Combined)     | 18:25:56.262 | 18:26:14.169 | 349.55 | 348.56 | 0.00 | 5.1  | 360 |
| 14 | 02/23/19<br>(Combined)     | 18:26:15.444 | 18:26:33.477 | 13.56  | 12.55  | 0.00 | 6.4  | 360 |
| 15 | 02/23/19<br>(Combined)     | 18:26:34.983 | 18:26:48.392 | 45.49  | 44.49  | 0.00 | 8.0  | 360 |
| 16 | 02/23/19<br>(Combined)     | 18:26:50.767 | 18:27:04.295 | 79.51  | 78.50  | 0.00 | 10.0 | 360 |
| 17 | 02/23/19<br>(Combined)     | 18:27:05.672 | 18:27:19.621 | 115.51 | 114.50 | 0.00 | 12.0 | 360 |
| 18 | 02/23/19<br>(Combined)     | 18:27:21.188 | 18:27:35.532 | 153.51 | 152.50 | 0.00 | 14.0 | 360 |

19 02/23/19 18:27:36.286 18:27:50.131 196.50 195.50 0.00 16.6 360  
(Combined)

20 02/23/19 18:27:52.365 18:28:06.502 241.51 240.49 0.00 19.4 360  
(Combined)

VOLUME DURATION: 429

SEQUENCE NUMBER: 3 VCP: 215 WEATHER MODE: A  
DOPPLER RESOLUTION: 0.5 m/s OVERLAY MARGIN: 5.0 dB  
CALIBRATION CONSTANT: -42.14 dB

| EL#                  | DATE     | START<br>TIME | END<br>TIME  | START<br>AZIMUTH | END<br>AZIMUTH | PSEUDO | ELANG | RADS |
|----------------------|----------|---------------|--------------|------------------|----------------|--------|-------|------|
| 1<br>(Surveillance)  | 02/23/19 | 18:28:14.855  | 18:28:46.631 | 83.25            | 82.77          | 0.00   | 0.5   | 720  |
| 2<br>(Doppler)       | 02/23/19 | 18:28:47.768  | 18:29:12.055 | 96.24            | 95.72          | 0.00   | 0.5   | 720  |
| 3<br>(Surveillance)  | 02/23/19 | 18:29:13.121  | 18:29:39.381 | 110.25           | 109.75         | 0.00   | 0.9   | 720  |
| 4<br>(Doppler)       | 02/23/19 | 18:29:41.483  | 18:30:05.892 | 124.21           | 123.72         | 0.00   | 0.9   | 720  |
| 5<br>(Surveillance)  | 02/23/19 | 18:30:06.821  | 18:30:29.796 | 139.26           | 138.76         | 0.00   | 1.3   | 720  |
| 6<br>(Doppler)       | 02/23/19 | 18:30:30.812  | 18:30:55.158 | 156.23           | 155.71         | 0.00   | 1.3   | 720  |
| 7<br>(Combined)      | 02/23/19 | 18:30:56.424  | 18:31:17.931 | 176.56           | 175.56         | 0.00   | 1.8   | 360  |
| 8<br>(Combined)      | 02/23/19 | 18:31:19.029  | 18:31:36.799 | 195.56           | 194.59         | 0.00   | 2.4   | 360  |
| 9<br>(Combined)      | 02/23/19 | 18:31:37.733  | 18:31:55.558 | 215.55           | 214.55         | 0.00   | 3.1   | 360  |
| 10<br>(Surveillance) | 02/23/19 | 18:31:57.162  | 18:32:28.177 | 240.24           | 239.76         | 0.00   | 0.5   | 720  |
| 11<br>(Doppler)      | 02/23/19 | 18:32:29.112  | 18:32:54.360 | 252.23           | 251.72         | 0.00   | 0.5   | 720  |
| 12<br>(Combined)     | 02/23/19 | 18:32:56.441  | 18:33:14.354 | 291.55           | 290.56         | 0.00   | 4.0   | 360  |

|            |          |              |              |        |        |      |      |     |
|------------|----------|--------------|--------------|--------|--------|------|------|-----|
| 13         | 02/23/19 | 18:33:15.571 | 18:33:33.694 | 314.56 | 313.55 | 0.00 | 5.1  | 360 |
| (Combined) |          |              |              |        |        |      |      |     |
| 14         | 02/23/19 | 18:33:34.864 | 18:33:52.937 | 338.55 | 337.55 | 0.00 | 6.4  | 360 |
| (Combined) |          |              |              |        |        |      |      |     |
| 15         | 02/23/19 | 18:33:53.316 | 18:34:07.805 | 8.49   | 7.50   | 0.00 | 8.0  | 360 |
| (Combined) |          |              |              |        |        |      |      |     |
| 16         | 02/23/19 | 18:34:09.279 | 18:34:23.264 | 42.50  | 41.50  | 0.00 | 10.0 | 360 |
| (Combined) |          |              |              |        |        |      |      |     |
| 17         | 02/23/19 | 18:34:24.632 | 18:34:38.033 | 79.51  | 78.51  | 0.00 | 12.0 | 360 |
| (Combined) |          |              |              |        |        |      |      |     |
| 18         | 02/23/19 | 18:34:40.555 | 18:34:54.954 | 117.50 | 116.50 | 0.00 | 14.0 | 360 |
| (Combined) |          |              |              |        |        |      |      |     |

VOLUME DURATION: 399

SEQUENCE NUMBER: 4 VCP: 215 WEATHER MODE: A  
 DOPPLER RESOLUTION: 0.5 m/s OVERLAY MARGIN: 5.0 dB  
 CALIBRATION CONSTANT: -41.91 dB

| EL#            | DATE     | START<br>TIME | END<br>TIME  | START<br>AZIMUTH | END<br>AZIMUTH | PSEUDO | ELANG | RADS |
|----------------|----------|---------------|--------------|------------------|----------------|--------|-------|------|
| 1              | 02/23/19 | 18:35:02.500  | 18:35:33.284 | 321.28           | 320.74         | 0.00   | 0.5   | 720  |
| (Surveillance) |          |               |              |                  |                |        |       |      |
| 2              | 02/23/19 | 18:35:34.303  | 18:35:59.564 | 334.23           | 333.71         | 0.00   | 0.5   | 720  |
| (Doppler)      |          |               |              |                  |                |        |       |      |
| 3              | 02/23/19 | 18:36:00.776  | 18:36:27.032 | 348.24           | 347.75         | 0.00   | 0.9   | 720  |
| (Surveillance) |          |               |              |                  |                |        |       |      |
| 4              | 02/23/19 | 18:36:28.061  | 18:36:53.202 | 1.23             | 0.72           | 0.00   | 0.9   | 720  |
| (Doppler)      |          |               |              |                  |                |        |       |      |
| 5              | 02/23/19 | 18:36:54.037  | 18:37:16.841 | 14.24            | 13.75          | 0.00   | 1.3   | 720  |
| (Surveillance) |          |               |              |                  |                |        |       |      |
| 6              | 02/23/19 | 18:37:18.081  | 18:37:42.272 | 32.24            | 31.73          | 0.00   | 1.3   | 720  |
| (Doppler)      |          |               |              |                  |                |        |       |      |
| 7              | 02/23/19 | 18:37:44.539  | 18:38:05.448 | 52.55            | 51.54          | 0.00   | 1.8   | 360  |
| (Combined)     |          |               |              |                  |                |        |       |      |
| 8              | 02/23/19 | 18:38:06.605  | 18:38:23.978 | 72.56            | 71.55          | 0.00   | 2.4   | 360  |
| (Combined)     |          |               |              |                  |                |        |       |      |

|                |          |              |              |        |        |      |      |     |
|----------------|----------|--------------|--------------|--------|--------|------|------|-----|
| 9              | 02/23/19 | 18:38:25.490 | 18:38:56.577 | 96.24  | 95.75  | 0.00 | 0.5  | 720 |
| (Surveillance) |          |              |              |        |        |      |      |     |
| 10             | 02/23/19 | 18:38:57.607 | 18:39:22.503 | 108.23 | 107.74 | 0.00 | 0.5  | 720 |
| (Doppler)      |          |              |              |        |        |      |      |     |
| 11             | 02/23/19 | 18:39:24.208 | 18:39:42.975 | 136.55 | 135.55 | 0.00 | 3.1  | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 12             | 02/23/19 | 18:39:43.068 | 18:40:01.365 | 158.56 | 157.54 | 0.00 | 4.0  | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 13             | 02/23/19 | 18:40:02.544 | 18:40:20.213 | 181.54 | 180.56 | 0.00 | 5.1  | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 14             | 02/23/19 | 18:40:21.637 | 18:40:39.702 | 208.55 | 207.55 | 0.00 | 6.4  | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 15             | 02/23/19 | 18:40:40.082 | 18:40:55.898 | 238.50 | 237.50 | 0.00 | 8.0  | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 16             | 02/23/19 | 18:40:56.323 | 18:41:10.454 | 275.51 | 274.50 | 0.00 | 10.0 | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 17             | 02/23/19 | 18:41:12.075 | 18:41:25.360 | 313.49 | 312.50 | 0.00 | 12.0 | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 18             | 02/23/19 | 18:41:27.876 | 18:41:41.879 | 351.50 | 350.51 | 0.00 | 14.0 | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 19             | 02/23/19 | 18:41:43.412 | 18:41:57.806 | 32.49  | 31.50  | 0.00 | 16.6 | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 20             | 02/23/19 | 18:41:58.696 | 18:42:12.738 | 77.49  | 76.50  | 0.00 | 19.4 | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |

VOLUME DURATION: 430

SEQUENCE NUMBER: 5 VCP: 215 WEATHER MODE: A  
 DOPPLER RESOLUTION: 0.5 m/s OVERLAY MARGIN: 5.0 dB  
 CALIBRATION CONSTANT: -41.91 dB

| EL#            | DATE     | START<br>TIME | END<br>TIME  | START<br>AZIMUTH | END<br>AZIMUTH | PSEUDO | ELANG | RADS |
|----------------|----------|---------------|--------------|------------------|----------------|--------|-------|------|
| 1              | 02/23/19 | 18:42:21.575  | 18:42:52.724 | 286.27           | 285.75         | 0.00   | 0.5   | 720  |
| (Surveillance) |          |               |              |                  |                |        |       |      |
| 2              | 02/23/19 | 18:42:53.793  | 18:43:18.796 | 298.22           | 297.72         | 0.00   | 0.5   | 720  |
| (Doppler)      |          |               |              |                  |                |        |       |      |

|                |          |              |              |        |        |      |      |     |
|----------------|----------|--------------|--------------|--------|--------|------|------|-----|
| 3              | 02/23/19 | 18:43:19.680 | 18:43:46.880 | 310.26 | 309.75 | 0.00 | 0.9  | 720 |
| (Surveillance) |          |              |              |        |        |      |      |     |
| 4              | 02/23/19 | 18:43:47.882 | 18:44:12.293 | 323.21 | 322.71 | 0.00 | 0.9  | 720 |
| (Doppler)      |          |              |              |        |        |      |      |     |
| 5              | 02/23/19 | 18:44:13.267 | 18:44:35.197 | 338.24 | 337.75 | 0.00 | 1.3  | 720 |
| (Surveillance) |          |              |              |        |        |      |      |     |
| 6              | 02/23/19 | 18:44:36.253 | 18:45:01.739 | 355.24 | 354.72 | 0.00 | 1.3  | 720 |
| (Doppler)      |          |              |              |        |        |      |      |     |
| 7              | 02/23/19 | 18:45:02.926 | 18:45:24.369 | 14.56  | 13.56  | 0.00 | 1.8  | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 8              | 02/23/19 | 18:45:25.421 | 18:45:42.100 | 34.55  | 33.56  | 0.00 | 2.4  | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 9              | 02/23/19 | 18:45:43.287 | 18:46:02.139 | 54.55  | 53.55  | 0.00 | 3.1  | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 10             | 02/23/19 | 18:46:04.112 | 18:46:35.927 | 82.25  | 81.75  | 0.00 | 0.5  | 720 |
| (Surveillance) |          |              |              |        |        |      |      |     |
| 11             | 02/23/19 | 18:46:36.092 | 18:47:01.393 | 95.23  | 94.73  | 0.00 | 0.5  | 720 |
| (Doppler)      |          |              |              |        |        |      |      |     |
| 12             | 02/23/19 | 18:47:03.561 | 18:47:21.232 | 134.55 | 133.55 | 0.00 | 4.0  | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 13             | 02/23/19 | 18:47:22.371 | 18:47:40.445 | 156.55 | 155.56 | 0.00 | 5.1  | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 14             | 02/23/19 | 18:47:41.702 | 18:47:59.877 | 182.56 | 181.55 | 0.00 | 6.4  | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 15             | 02/23/19 | 18:48:00.485 | 18:48:14.856 | 213.50 | 212.49 | 0.00 | 8.0  | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 16             | 02/23/19 | 18:48:16.340 | 18:48:30.690 | 249.50 | 248.50 | 0.00 | 10.0 | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 17             | 02/23/19 | 18:48:31.116 | 18:48:45.061 | 286.50 | 285.49 | 0.00 | 12.0 | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |
| 18             | 02/23/19 | 18:48:47.620 | 18:49:01.166 | 324.50 | 323.50 | 0.00 | 14.0 | 360 |
| (Combined)     |          |              |              |        |        |      |      |     |

VOLUME DURATION: 399

**- Question: Do the radial scans for “combined” tilts match up exactly between BR and BV? i.e., would the (for example) 44.4° azimuth for reflectivity be sensed at the same time as the 44.4° azimuth for velocity?**

YES ... for the radials on tilts which contain both reflectivity and velocity (i.e., the "combined" tilts), the data are collected at the same time.

**- Question: Is there a way to determine individual times an azimuth was sensed for a particular tilt and volume scan without having to ask someone at the ROC to do it? In other words, when these questions come up again, can we do this ourselves with available data? And if so, how/where/what?**

The data I included is provided by non-operational tools on the Radar Product Generator (RPG). You can download the RPG code from the following URL: <https://www.weather.gov/code88d/>  
This website has all the instruction you need install an RPG. You will need a computer running Linux.

If you decide to go this route, I can point you to the tools that you can use to play back data and also the tools you can use to produce the information you seek.

I do not know what might be available in the commercial world.

Having said that, the ROC is always available to assist in these matters.

## Richards Michael

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From: Steven Smith - NOAA Federal [REDACTED]@noaa.gov>

Date: Mon, Apr 8, 2019 at 5:18 PM

Subject: Re: NTSB Request: Timing Questions Regarding 88D Volume Scans

To: Lora Wilson - NOAA Federal [REDACTED]@noaa.gov>

Cc: Jessica Schultz - NOAA Federal <[REDACTED]@noaa.gov>, Christina Horvat <[REDACTED]@noaa.gov>

**Question: in the table sent previously, the “RADS” column gives 720 for non-combined scans. I don’t know what this means, but it maybe is something like two full rotations for each scan? Anyway, could this column be explained, and if there are two sweeps for each of these scans, how would that compromise getting a particular time for the azimuths requested for the non-combined scans?**

For the non-combined scans (i.e., the Surveillance and Doppler), the radar outputs a radial every 0.5 deg ( $0.5 \text{ deg} * 720 = 360 \text{ deg}$ ). The radials are centered (approximately) on the 0.25 and 0.75 deg azimuths ... i.e., 0.25, 0.75, 1.25, 1.75, 2.25, 2.75, etc. For the combined scans, the radar outputs a radial every 1.0 deg ( $1.0 \text{ deg} * 360 = 360 \text{ deg}$ ).

1814:24z volume start

0.5° reflectivity – azimuth 38.8° **18:14:34**  
0.5° velocity – azimuth 37.3° **18:15:04**  
0.9° reflectivity – azimuth 38.4° **18:15:29**  
0.9° velocity – azimuth 38.3° **18:15:55**  
1.3° reflectivity – azimuth 36.9° **18:16:20**  
1.3° velocity – azimuth 37.3° **18:16:43**  
1.8° combined – azimuth 36.7° **18:17:07**  
2.4° combined – azimuth 35.7° **18:17:28**  
SAILS 0.5° reflectivity – azimuth 42.0° **18:18:17**  
SAILS 0.5° velocity – azimuth 38.9° **18:18:42**

1820:56z volume start

0.5° reflectivity – azimuth 40.9° **18:21:19**  
0.5° velocity – azimuth 41.3° **18:21:46**  
1.8° combined – azimuth 39.7° **18:23:48**  
2.4° combined – azimuth 39.6° **18:25:05**  
SAILS 0.5° reflectivity – azimuth 45.0° **18:24:15**  
SAILS 0.5° velocity – azimuth 45.4° **18:24:43**

1828:14z volume start

0.5° reflectivity – azimuth 45.9° **18:28:42**  
0.5° velocity – azimuth 44.9° **18:29:08**  
1.8° combined – azimuth 43.7° **18:31:10**  
2.4° combined – azimuth 44.7° **18:31:29**  
SAILS 0.5° reflectivity – azimuth 51.1° **18:32:12**  
SAILS 0.5° velocity – azimuth 48.8° **18:32:40**

1835:02z volume start

0.5° reflectivity – azimuth 48.9° **18:35:10**  
0.5° velocity – azimuth 48.4° **18:35:40**  
0.9° reflectivity – azimuth 48.0° **18:36:05**  
0.9° velocity – azimuth 48.0° **18:36:31**  
1.3° reflectivity – azimuth 47.4° **18:36:56**  
1.3° velocity – azimuth 47.8° **18:37:19**  
1.8° combined – azimuth 48.7° **18:38:05**  
2.4° combined – azimuth 47.8° **18:38:22**  
SAILS 0.5° reflectivity – azimuth 54.5° **18:38:53**  
SAILS 0.5° velocity – azimuth 54.6° **18:39:18**

1842:21z volume start

0.5° reflectivity – azimuth 56.4° **18:42:32**  
0.5° velocity – azimuth 56.5° **18:43:02**  
0.9° reflectivity – azimuth 56.9° **18:43:27**  
0.9° velocity – azimuth 56.8° **18:43:53**  
1.3° reflectivity – azimuth 55.4° **18:44:18**  
1.3° velocity – azimuth 55.5° **18:44:41**  
1.8° combined – azimuth 55.9° **18:45:05**

2.4° combined – azimuth 56.7° **18:45:26**

3.1° combined – azimuth 54.6° **18:45:43**

SAILS 0.5° reflectivity – azimuth 60.0° **18:46:33**

SAILS 0.5° velocity – azimuth 59.5° **18:46:58**

## Richards Michael

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**From:** Lora Wilson - NOAA Federal [REDACTED]@noaa.gov>  
**Sent:** Tuesday, April 23, 2019 12:57 PM  
**To:** Richards Michael [REDACTED]@ntsb.gov>  
**Subject:** Re: NTSB Request: Timing Questions Regarding 88D Volume Scans

See if this helps...

The RDA uses the NTP protocol to synchronize time to the a local NTP server, in the UTC time zone. This NTP server is a COTS device manufactured by MicroSemi (Symmetricom) that uses GPS signals as its synchronization source. The model of the NTP server at KHGX was likely an S100 on 2/29/2019, with a small chance the model was an older NT150. Either unit will make the RDA system time accurate to around 10 milliseconds UTC. (So the radial time stamp, which is from the end of the radial, is also accurate to around 10milliseconds.)

If the GPS server happens to malfunction at KHGX, the RDA ntp configuration provides two backup NTP servers that are made available via NOAANet. The backup servers will provide accurate time as well, but I don't know how many milliseconds of accuracy would be lost if the backup servers happen to be used, but I expect it to only be a small loss of accuracy.

The name of the RDA NTP client software is 'chrony'. This software is RedHat Linux's default NTP software, in RHEL7, which is the OS used by the RDA.

Lora