WSR-88D Volume Coverage Pattern (VCP) Improvement Initiatives

Implement Common Elevation Clear-Air VCP
Implement Improved General Surveillance VCP
Reduce the Total Number of VCPs

1.0 INTRODUCTION

The WSR-88D was initially fielded with 4 Volume Coverage Patterns (VCPs). Two of the original VCPs (VCP 32 and VCP 31) were dedicated to Clear-Air observations and have exceedingly long dwell times, allowing a very low signal-to-noise ratio. These two VCPs have identical scanning angles (see Table 1) but employ different pulse lengths. The other 2 VCPs (VCP 21 and VCP 11) were designed for detecting, tracking and analyzing precipitation and severe weather signatures. The major differences between the precipitation VCPs are the scanning rates and the elevations scanned above 4.5° elevation (see Tables 2 and 3).

The initial suite of two precipitation VCPs has since been expanded to seven. First, responding to field request for faster updates, VCP 12 (see Table 4) was introduced with its overlapping low-level elevation angles and fast rotation rates as a significantly better severe weather interrogation alternative. Then SZ-2 processing was added to the three operational precipitation mode VCPs and VCPs 212, 211 and 221 were fielded. Finally, these VCPs were complimented by VCP 121 – a version of VCP 21 that was specifically designed for observing Hurricanes/Tropical Storms and widespread precipitation events.

2.0 CURRENT STATE OF OPERATIONS

Operational forecasters must be cognizant of the individual strengths and weaknesses of each VCP so they can invoke the proper precipitation pattern, from the suite of 7, to address the meteorological concerns of the moment. For example, for denser low-level coverage choose VCP 12 or 212, for better coverage aloft invoke VCP 11 or 211, if you need better data quality and coverage VCP 21 or 221 are in order, during severe weather when faster updates are required VCP 12 and 212 with SAILS should be used, etc.,. Since radar only entails a fraction of a forecaster's daily responsibilities keeping track of these details can be challenging and cumbersome. During routine weather situations, the selection of one VCP verses another may not make much of an impact on operations, but during inclement or severe weather situations,

the selection of the most appropriate VCP can be critical to the success of forecast and warning operations.

Polls and interviews about VCPs conducted over the years have all coalesced around a common theme summed up by the following core observations:

- There are too many (precipitation) VCPs – 7 now available
- Sometimes forecasters are unsure when to select one VCP over another
- Need more frequent low-level data updates, want faster VCP updates
- Forecasters do not want MORE precipitation mode VCPs

3.0 PROPOSED VCP IMPROVEMENTS

Addressing the concerns raised by field forecasters and the need for improved VCPs that have common scanning angles and employ modern processing techniques, the Innovative Techniques Working Group (ITWG), VCP Subcommittee has put into action the following three-part plan. First, design and implement a new Clear-Air VCP that incorporates SZ-2 processing and scans the same low-level elevations as the severe weather interrogation VCPs 12/212. Second, design and implement a new a General Surveillance VCP that incorporates the best attributes of VCP12/212, VCP 11/211 and VCP 21/221. And third, as part of the new VCP implementation, remove VCPs 11, 211, 21 and 221, which are now superfluous, from the operational software. Details concerning these three initiatives are provided below.

3.1 Design and Implement a Common Elevation Clear-Air VCP

There are two main reasons for developing a new Clear-Air VCP. First it is beneficial to share a common elevation set among the VCPs. The desire for common elevations is to support regional and national mosaics, improve algorithm performance and provide common product sets for looping and product distribution. Additionally, the lower elevations defined in VCP12/212 provide overlapping coverage for sampling all types of light to moderate precipitation events as well as non-precipitation returns. The second consideration is to utilize modern Doppler processing (SZ-2) to provide valid velocity data beyond the first trip of the active PRF. Refer to Figures 1 and 2 for VCP 35 definition and vertical coverage information.

Elev	Wave Form	Surv PRF	Dop PRF	Surv Pulses per Second	Surv Pulses per Radial	Dop Pulses per Second	Dop Pulses per Radial	RPM	Scan Time (Seconds)	Est SD	Rmax (km)	Rmax (nm)	Vmax (m/s)	Vmax (kts)	Beam Hgt at Rmax (ft)	Cumulative Scan Time
0.5	CS	1		321	64			0.83	72	0.33	467.29	252.16	8.03	15.60	59844	72
0.5	SZ		5			1013	64	2.60	23	0.57	148.08	79.90	25.33	49.23	8905	97
0.9	CS	1		321	64			0.83	72	0.33	467.29	252.16	8.03	15.60	70546	170
0.9	SZ		5			1013	64	2.60	23	0.57	148.08	79.90	25.33	49.23	12296	194
1.3	CS	1		321	64			0.83	72	0.46	467.29	252.16	8.03	15.60	81247	267
1.3	SZ		5			1013	64	2.60	23	0.65	148.08	79.90	25.33	49.23	15687	291
1.8	B	1	5	321	6	1013	48	2.52	24	0.77	467.29	252.16	25.33	49.23	94621	316
2.4	B	2	5	446	6	1013	48	2.74	22	0.77	336.32	181.48	25.33	49.23	70276	339
3.1	B	2	5	446	6	1013	48	2.74	22	0.77	336.32	181.48	25.33	49.23	83741	363
4	B	3	5	644	6	1013	46	3.05	20	0.76	232.92	125.69	25.33	49.23	64850	384
5.1	B	3	5	644	6	1013	46	3.05	20	0.76	232.92	125.69	25.33	49.23	79474	404
6.4	B	3	5	644	6	1013	46	3.05	20	0.79	232.92	125.69	25.33	49.23	96725	425

Figure 1: Clear-Air VCP 35 Definition

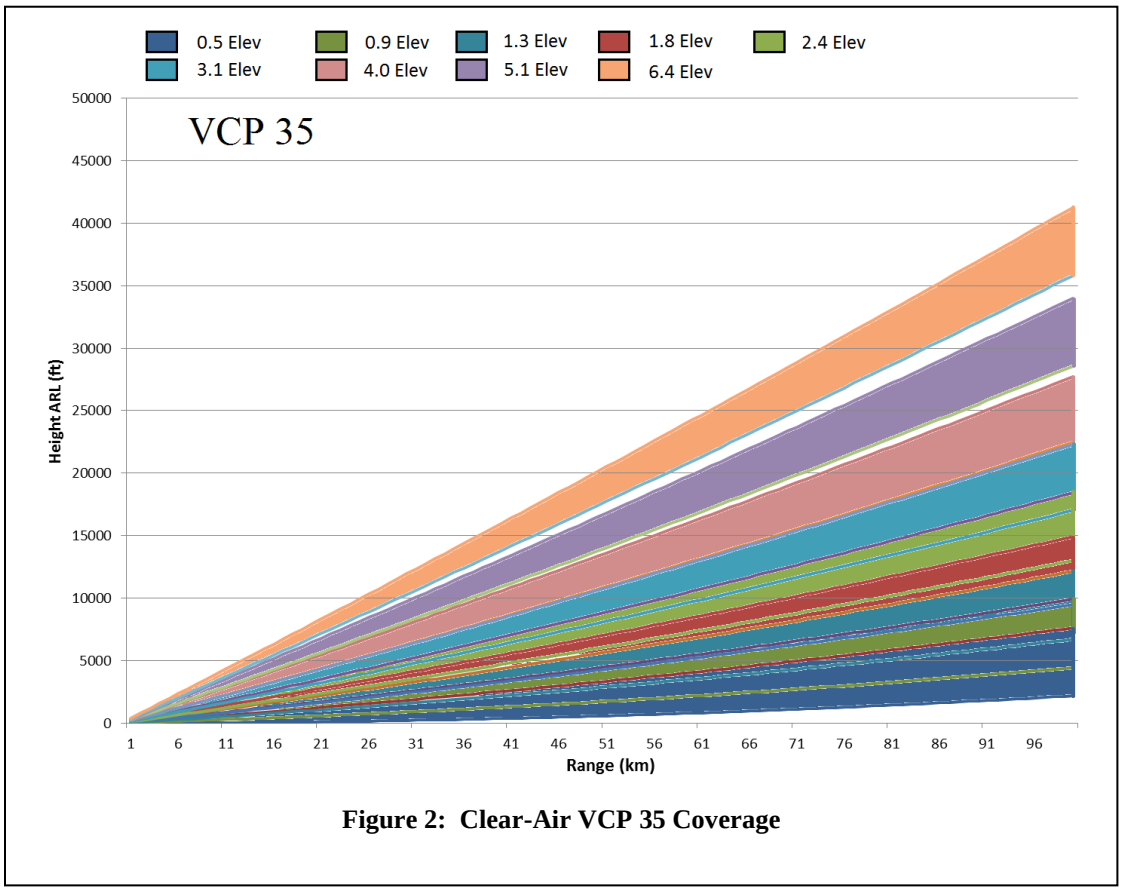

Figure 2: Clear-Air VCP 35 Coverage

3.2 Design and Implement a Common Elevation Improved General Surveillance VCP

With the over-arching goal of reducing the total number of VCPs in mind, the VCP Subcommittee developed the following "design guidance" to govern the new General Surveillance VCP definition:

- Base the low-level elevation definitions on VCP 12/212 elevations
- Provide better vertical sampling than VCP 11, 21, 211 and 221
- Maintain high data quality (standard deviation of estimates)
- Include modern processing techniques (SZ-2)

This design guidance resulted in the VCP definition provided in Figure 3.

General Surveillance VCP (Proposal - Includes Dense Coverage Aloft)

Elev	Wave Form	Surv PRF	Dop PRF	Surv Pulses per Second	Surv Pulses per Radial	Dop Pulses per Second	Dop Pulses per Radial	Rotation Rate (DPS)	RPM	Scan Time (Seconds)	Est Standard Deviation	Rmax (km)	Rmax (nm)	Vmax (m/s)	Vmax (kts)	Beam Hgt at Rmax (ft)	Cumulative Scan Time
0.5	CS	1		321	28			11.464	1.91	31	0.648	467.29	252.16	8.03	15.60	59844	31
0.5	SZ		6			1094	64	17.094	2.85	21	0.898	137.11	73.99	27.35	53.16	7926	54
0.9	CS	1		321	24			13.375	2.23	27	0.693	467.29	252.16	8.03	15.60	70546	81
0.9	SZ		6			1094	64	17.094	2.85	21	0.898	137.11	73.99	27.35	53.16	11066	103
1.3	CS	1		321	22			14.591	2.43	25	0.719	467.29	252.16	8.03	15.60	81247	128
1.3	SZ		6			1094	64	17.094	2.85	21	0.898	137.11	73.99	27.35	53.16	14206	151
1.8	B	1	5	321	10	1013	38	14.563	2.43	25	0.973	467.29	252.16	25.33	49.23	94621	177
2.4	B	2	5	446	8	1013	38	18.034	3.01	20	0.973	336.32	181.48	25.33	49.23	70276	198
3.1	B	2	5	446	8	1013	38	18.034	3.01	20	0.973	336.32	181.48	25.33	49.23	83741	219
4	B	3	5	644	6	1013	40	20.490	3.42	18	0.949	232.92	125.69	25.33	49.23	64850	237
5.1	B	3	5	644	6	1013	40	20.490	3.42	18	0.949	232.92	125.69	25.33	49.23	79474	256
6.4	B	3	5	644	6	1013	40	20.490	3.42	18	0.949	232.92	125.69	25.33	49.23	96725	275
8	CD		6			1094	44	24.864	4.14	14	0.905	137.11	73.99	27.35	53.16	66605	290
10	CD		8			1282	50	25.640	4.27	14	0.849	117.00	63.14	32.05	62.30	69571	305
12	CD		8			1282	50	25.640	4.27	14	0.849	117.00	63.14	32.05	62.30	82724	319
14	CD		8			1282	50	25.640	4.27	14	0.849	117.00	63.14	32.05	62.30	95779	334
16.7	CD		8			1282	50	25.640	4.27	14	0.849	117.00	63.14	32.05	62.30	113222	348
19.5	CD		8			1282	50	25.640	4.27	14	0.849	117.00	63.14	32.05	62.30	131051	363

Figure 3: General Surveillance VCP 215 Definition

A few important things to note regarding this new proposed General Surveillance VCP 215 definition:

- Same elevations as VCP 12/212 below 10° (see Figure 4)
    - Meets the goal of standard elevations for looping and central collection across VCPs
    - Retains the same overlapping elevation coverage below 4° as VCP 12/212
    - Seamless looping when transitioning from normal to severe weather (VCP) operations
    - Improved mosaics
    - Consistent algorithm performance with VCP 12/212
- Includes the same vertical coverage above 10° as VCP 11/211
    - More uniform vertical coverage than VCP 12/212
    - Improves vertical beam coverage aloft close to RDA
    - Limited vertical "No-Data" gaps (VCP 21 has significant "No-Data" gaps aloft)

- VCP duration is approximately 6 minutes
    - Meets maximum allowed VCP duration requirement
- Retains data quality consistent with VCP 21/221

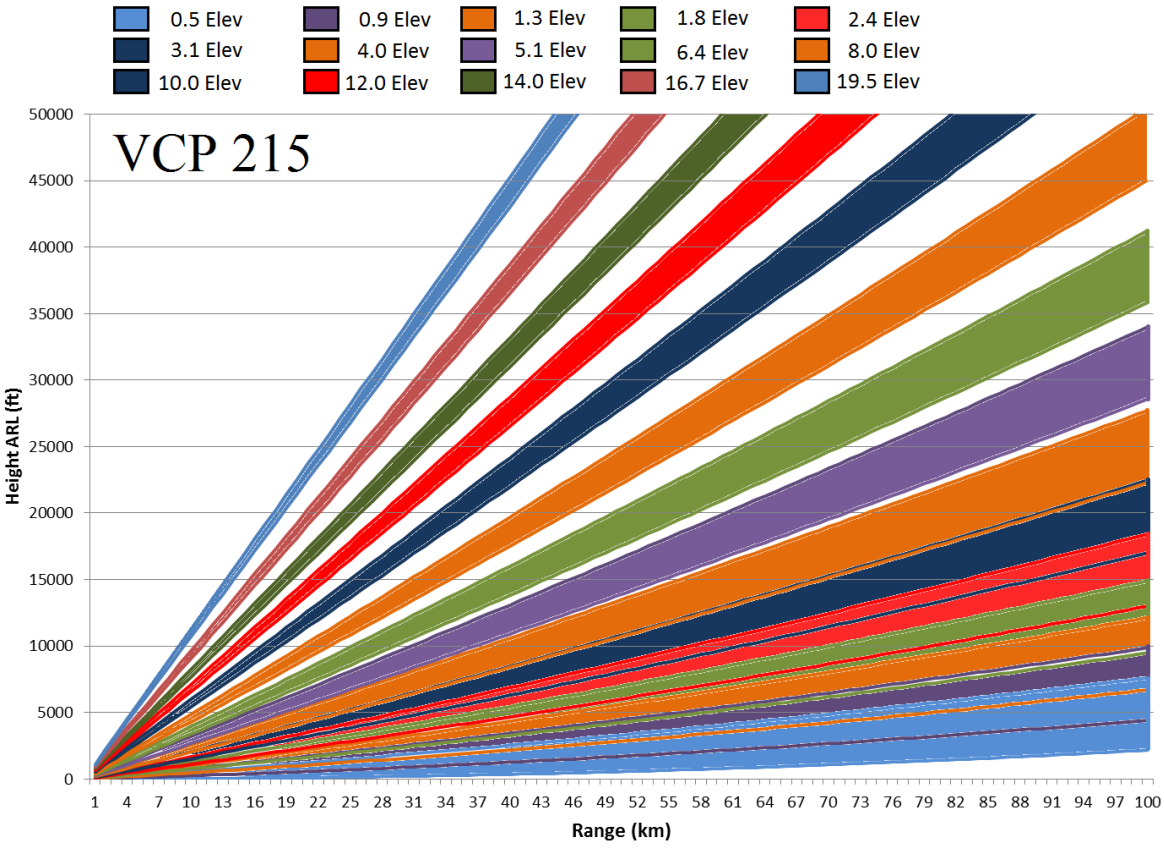

Figure 3: General Surveillance VCP 215 Coverage

The new General Surveillance VCP 215 incorporates the best attributes of VCPs 12/212, VCP 11/211 and VCP 21/212 into a single VCP. This new General Surveillance VCP 215 provides the forecaster with a better alternative than using VCPs 11, 21, 211 or 221.

3.3 Remove Superfluous VCPs

The new General Surveillance VCP definition provides:

- Data quality that exceeds the requirements
    - Virtually the same as VCP 21/221
    - Better than VCP 11/211
- Better low-level coverage than VCPs 11/211 and VCP 21/221
- Near uniform upper-level vertical sampling
    - Mimics the upper-level vertical coverage of VCP 11/211
    - Better coverage that VCP 21/221

- Meets the VCP update interval requirement (VCP duration of 6 minutes)

Given these facts, the new General Surveillance VCP is a viable solution as a general purpose VCP. The outdated VCPs 11, 21, 211 and 221, will be removed from the baseline.

Tables

The following tables provide vertical beam coverage examples for the current VCPs.

Table 1: VCPs 31 and 32

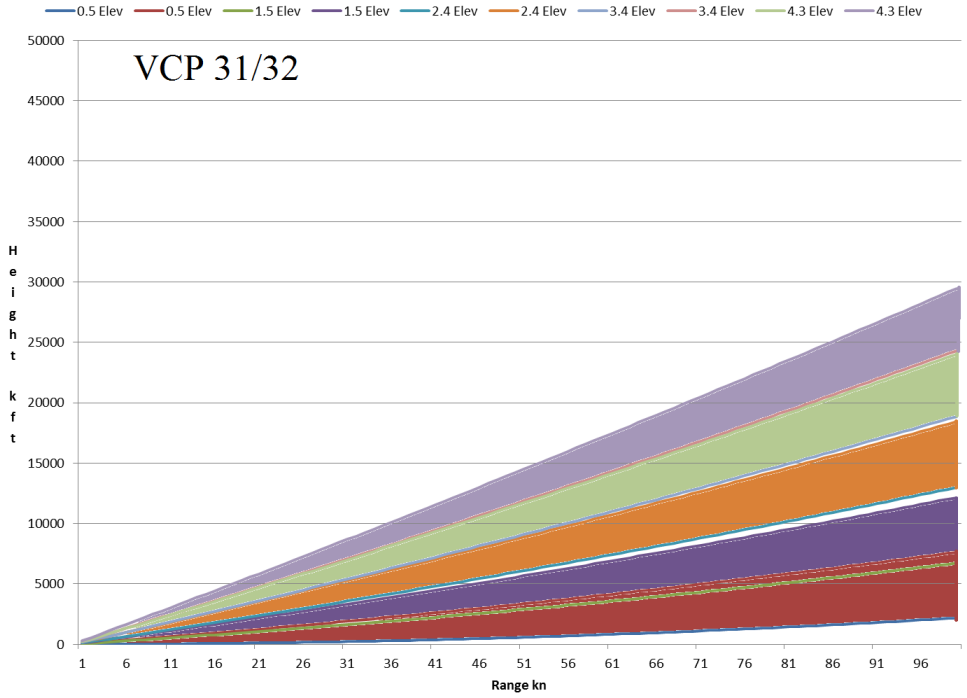

Table 2: VCPs 21, 121 and 221

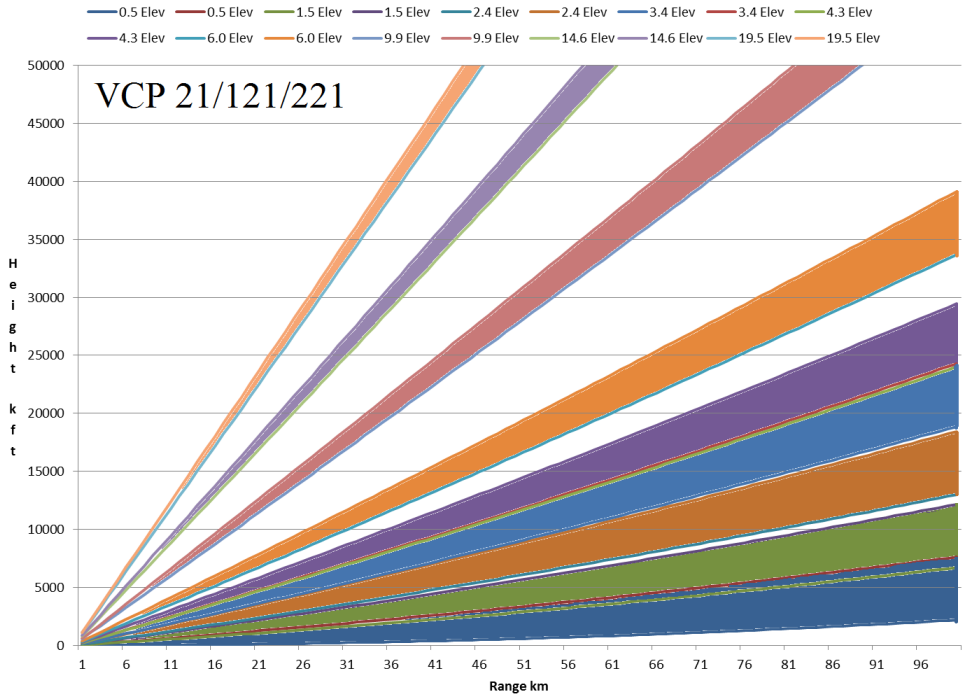

Table 3: VCPs 11 and 211

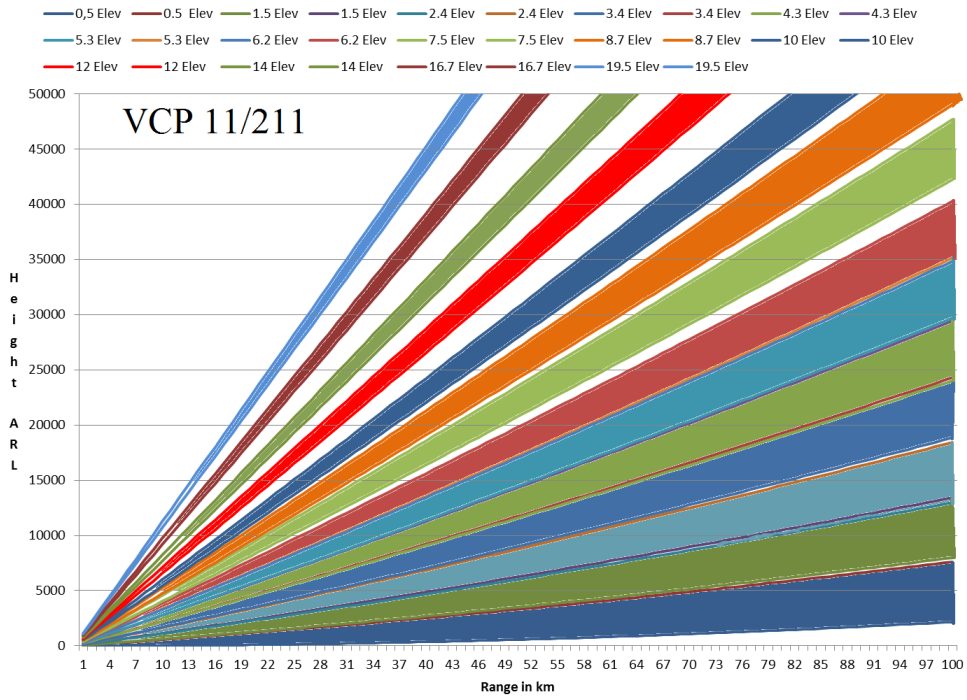

Table 4: VCPs 12 and 212