Appendix I
to Nextel Reply Comments
in WT Docket No. 02-55

Nextel's Available Spectrum in Top 320 Markets

Nextel's Available Spectrum in Top 320 Markets

Pop. Rank	Market	900 MHz Channels	900 MHz Running Average Channels	900 MHz Running Average MHz	800 MHz Channels	800 MHz Running Average Channels	800 MHz Running Average MHz	700 MHz MHz	Border Area
1	Los Angeles, CA	140	140	3.5	387	387	19.4	4	
2	New York, NY	160	150	3.8	365	376	18.8	4	
3	Chicago, IL	160	153	3.8	426	393	19.6	4	
4	Philadelphia, PA	150	153	3.8	387	391	19.6	4	
5	Detroit, MI	140	150	3.8	298	373	18.6	4	Canadian 3
6	Washington, DC	180	155	3.9	355	370	18.5	4	
7	Boston, MA	80	144	3.6	409	375	18.8	4	
8	Houston, TX	175	148	3.7	409	380	19.0	4	
9	Atlanta, GA	150	148	3.7	292	370	18.5	4	
10	Riverside, CA	130	147	3.7	320	365	18.2	4	
11	Dallas, TX	160	148	3.7	426	370	18.5	4	
12	Nassau, NY	160	149	3.7	352	369	18.4	4	
13	San Diego, CA	70	143	3.6	114	349	17.5	4	Mexican
14	Minneapolis, MN	170	145	3.6	370	351	17.5	4	
15	Anaheim, CA	140	144	3.6	332	349	17.5	4	
16	Saint Louis, MO	120	143	3.6	381	351	17.6	4	
17	Baltimore, MD	170	144	3.6	346	351	17.6	4	
18	Phoenix, AZ	120	143	3.6	418	355	17.7	4	
19	Oakland, CA	165	144	3.6	371	356	17.8	4	
20	Tampa, FL	120	143	3.6	399	358	17.9	4	
21	Pittsburgh, PA	170	144	3.6	438	362	18.1	4	
22	Seattle, WA	80	141	3.5	286	358	17.9	4	Canadian 5
23	Miami, FL	90	139	3.5	395	360	18.0	4	
24	Cleveland, OH	120	138	3.5	273	356	17.8	4	Canadian 3
25	Newark, NJ	160	139	3.5	368	357	17.8	4	
26	Denver, CO	90	137	3.4	390	358	17.9	4	
27	San Francisco, CA	165	138	3.5	371	358	17.9	4	
28	Kansas City, KS	100	137	3.4	426	361	18.0	4	
29	Sacramento, CA	165	138	3.4	371	361	18.1	4	
30	San Jose, CA	165	139	3.5	361	361	18.1	4	
31	Cincinnati, OH	170	140	3.5	376	362	18.1	4	
32	Norfolk, VA	170	141	3.5	388	363	18.1	4	
33	Milwaukee, WI	170	142	3.5	435	365	18.2	4	
34	Columbus, OH	160	142	3.6	395	366	18.3	4	
35	Fort Worth, TX	150	142	3.6	422	367	18.4	4	
36	San Antonio, TX	150	143	3.6	404	368	18.4	4	
37	Fort Lauderdale, FL	100	141	3.5	378	368	18.4	4	
38	Portland, OR	170	142	3.6	394	369	18.5	4	
39	Bergen, NJ	160	143	3.6	354	369	18.4	4	
40	Indianapolis, IN	170	143	3.6	372	369	18.4	4	
41	New Orleans, LA	160	144	3.6	321	368	18.4	0	
42	Charlotte, NC	150	144	3.6	358	367	18.4	4	
43	Orlando, FL	120	143	3.6	380	368	18.4	4	
44	Hartford, CT	120	143	3.6	407	369	18.4	4	

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45	Salt Lake City, UT	110	142	3.6	419	370	18.5	4	
46	Middlesex, NJ	150	142	3.6	352	369	18.5	4	
47	Nashville, TN	140	142	3.6	399	370	18.5	4	
48	Monmouth, NJ	150	142	3.6	363	370	18.5	4	
49	Rochester, NY	40	140	3.5	135	365	18.3	4	Canadian 2
50	Memphis, TN	160	141	3.5	384	365	18.3	4	
51	Oklahoma City, OK	190	142	3.5	447	367	18.4	4	
52	Buffalo, NY	40	140	3.5	146	363	18.1	4	Canadian 2
53	Greensboro, NC	150	140	3.5	349	363	18.1	4	
54	Dayton, OH	170	140	3.5	367	363	18.1	4	
55	Louisville, KY	140	140	3.5	413	364	18.2	4	
56	Jacksonville, FL	130	140	3.5	417	364	18.2	4	
57	West Palm Beach, FL	80	139	3.5	391	365	18.2	4	
58	Providence, RI	80	138	3.5	406	366	18.3	4	
59	Birmingham, AL	170	139	3.5	311	365	18.2	4	
60	Richmond, VA	170	139	3.5	377	365	18.2	4	
61	Albany, NY	170	140	3.5	418	366	18.3	4	
62	Honolulu, HI	140	140	3.5	428	367	18.3	4	
63	Bridgeport, CT	160	140	3.5	337	366	18.3	4	
64	Austin, TX	150	140	3.5	413	367	18.4	4	
65	Las Vegas, NV	140	140	3.5	381	367	18.4	4	
66	New Haven, CT	170	141	3.5	378	367	18.4	4	
67	Raleigh, NC	150	141	3.5	386	368	18.4	4	
68	Scranton, PA	170	141	3.5	450	369	18.4	4	
69	Worcester, MA	80	140	3.5	399	369	18.5	4	
70	Tulsa, OK	190	141	3.5	412	370	18.5	4	
71	Fresno, CA	180	142	3.5	358	370	18.5	4	
72	Grand Rapids, MI	170	142	3.6	422	371	18.5	4	
73	Allentown, PA	160	142	3.6	393	371	18.5	4	
74	Tucson, AZ	70	141	3.5	134	368	18.4	4	Mexican
75	Oxnard, CA	140	141	3.5	384	368	18.4	4	
76	Syracuse, NY	40	140	3.5	122	365	18.2	4	Canadian 2
77	Akron, OH	120	140	3.5	244	363	18.2	4	Canadian 3
78	Greenville, SC	150	140	3.5	348	363	18.1	4	
79	Omaha, NE	110	139	3.5	330	362	18.1	0	
80	Toledo, OH	140	139	3.5	294	362	18.1	4	Canadian 3
81	El Paso, TX	90	139	3.5	176	359	18.0	0	Mexican
82	Knoxville, TN	140	139	3.5	324	359	17.9	4	
83	Springfield, MA	80	138	3.5	400	359	18.0	4	
84	Tacoma, WA	80	137	3.4	288	359	17.9	4	Canadian 5
85	Gary, IN	160	138	3.4	428	359	18.0	4	
86	Harrisburg, PA	160	138	3.4	389	360	18.0	4	
87	Wilmington, DE	150	138	3.5	394	360	18.0	4	
88	Bakersfield, CA	140	138	3.5	358	360	18.0	4	
89	Jersey City, NJ	160	138	3.5	369	360	18.0	4	
90	Lake County, IL	160	139	3.5	393	361	18.0	4	
91	Baton Rouge, LA	170	139	3.5	331	360	18.0	0	
92	Charleston, SC	150	139	3.5	389	361	18.0	4	

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93	Little Rock, AR	130	139	3.5	335	360	18.0	0	
94	New Bedford, MA	80	138	3.5	413	361	18.0	4	
95	Albuquerque, NM	170	139	3.5	399	361	18.1	0	
96	Stockton, CA	165	139	3.5	342	361	18.0	4	
97	Youngstown, OH	140	139	3.5	261	360	18.0	4	Canadian 7
98	Mobile, AL	170	139	3.5	292	359	18.0	0	
99	Vallejo, CA	165	140	3.5	369	359	18.0	4	
100	Wichita, KS	120	139	3.5	442	360	18.0	0	
101	Columbia, SC	150	139	3.5	361	360	18.0	4	
102	Chattanooga, TN	160	140	3.5	365	360	18.0	4	
103	Johnson City, TN	140	140	3.5	336	360	18.0	4	
104	Lancaster, PA	160	140	3.5	356	360	18.0	4	
105	Lansing, MI	170	140	3.5	289	359	18.0	4	Canadian 7
106	Flint, MI	140	140	3.5	253	358	17.9	4	Canadian 3
107	York, PA	160	140	3.5	363	358	17.9	4	
108	Melbourne, FL	130	140	3.5	449	359	18.0	4	
109	Lakeland, FL	100	140	3.5	356	359	18.0	4	
110	Colorado Springs, CO	90	139	3.5	435	360	18.0	4	
111	Santa Rosa, CA	165	140	3.5	389	360	18.0	4	
112	McAllen, TX	80	139	3.5	67	357	17.9	4	Mexican
113	Augusta, GA	160	139	3.5	374	358	17.9	4	
114	Des Moines, IA	90	139	3.5	322	357	17.9	0	
115	Jackson, MS	160	139	3.5	360	357	17.9	4	
116	Saginaw, MI	170	139	3.5	315	357	17.8	4	Canadian 7
117	Joliet, IL	160	139	3.5	397	357	17.9	4	
118	Canton, OH	140	139	3.5	274	357	17.8	4	Canadian 7
119	Modesto, CA	165	140	3.5	324	356	17.8	4	
120	Daytona Beach, FL	130	140	3.5	406	357	17.8	4	
121	Santa Barbara, CA	140	140	3.5	383	357	17.8	4	
122	Madison, WI	170	140	3.5	434	358	17.9	4	
123	Aurora, IL	160	140	3.5	407	358	17.9	4	
124	Fort Wayne, IN	170	140	3.5	395	358	17.9	4	
125	Salinas, CA	165	140	3.5	361	358	17.9	4	
126	Spokane, WA	120	140	3.5	386	359	17.9	4	
127	Portsmouth, NH	80	140	3.5	401	359	17.9	4	
128	Beaumont, TX	180	140	3.5	329	359	17.9	4	
129	Fort Myers, FL	70	140	3.5	436	359	18.0	4	
130	Lexington, KY	140	140	3.5	453	360	18.0	4	
131	Pensacola, FL	170	140	3.5	299	359	18.0	0	
132	Corpus Christi, TX	150	140	3.5	387	360	18.0	4	
133	Manchester, NH	80	139	3.5	415	360	18.0	4	
134	Davenport, IA	90	139	3.5	365	360	18.0	0	
135	Reading, PA	140	139	3.5	378	360	18.0	4	
136	Peoria, IL	170	139	3.5	350	360	18.0	4	
137	Shreveport, LA	150	139	3.5	360	360	18.0	4	
138	Trenton, NJ	140	139	3.5	362	360	18.0	4	
139	Visalia, CA	180	140	3.5	351	360	18.0	4	
140	Atlantic City, NJ	150	140	3.5	431	361	18.0	4	

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141	Appleton, WI	170	140	3.5	376	361	18.0	4	
142	Orange County, NY	160	140	3.5	347	361	18.0	4	
143	Utica, NY	170	140	3.5	262	360	18.0	4	Canadian 7
144	Huntington, WV	170	141	3.5	352	360	18.0	4	
145	Montgomery, AL	170	141	3.5	317	360	18.0	4	
146	Hamilton, OH	170	141	3.5	372	360	18.0	4	
147	Sarasota, FL	110	141	3.5	414	360	18.0	4	
148	Ann Arbor, MI	140	141	3.5	263	359	18.0	4	Canadian 3
149	Eugene, OR	170	141	3.5	429	360	18.0	4	
150	Macon, GA	160	141	3.5	352	360	18.0	4	
151	Salem, OR	170	141	3.5	382	360	18.0	4	
152	Rockford, IL	170	141	3.5	450	361	18.0	4	
153	Evansville, IN	140	141	3.5	433	361	18.1	4	
154	Fayetteville, NC	150	141	3.5	405	361	18.1	4	
155	Erie, PA	40	141	3.5	123	360	18.0	4	Canadian 2
156	Lorain, OH	120	141	3.5	275	359	18.0	4	Canadian 3
157	Provo, UT	110	141	3.5	402	360	18.0	4	
158	Fort Pierce, FL	79	140	3.5	435	360	18.0	4	
159	Brownsville, TX	80	140	3.5	72	358	17.9	4	Mexican
160	Reno, NV	180	140	3.5	383	358	17.9	4	
161	Poughkeepsie, NY	170	140	3.5	388	359	17.9	4	
162	Binghamton, NY	170	140	3.5	454	359	18.0	4	
163	Killeen, TX	150	140	3.5	380	359	18.0	4	
164	New London, CT	120	140	3.5	392	359	18.0	4	
165	Vancouver, WA	170	140	3.5	398	360	18.0	4	
166	Charleston, WV	170	141	3.5	364	360	18.0	4	
167	South Bend, IN	170	141	3.5	395	360	18.0	4	
168	Huntsville, AL	170	141	3.5	346	360	18.0	4	
169	Springfield, MO	120	141	3.5	352	360	18.0	4	
170	Savannah, GA	160	141	3.5	346	360	18.0	4	
171	Portland, ME	80	141	3.5	447	360	18.0	4	
172	Columbus, GA	160	141	3.5	366	360	18.0	4	
173	Tallahassee, FL	120	141	3.5	351	360	18.0	4	
174	Johnstown, PA	170	141	3.5	451	361	18.0	4	
175	Duluth, MN	170	141	3.5	347	361	18.0	4	
176	Santa Cruz, CA	165	141	3.5	365	361	18.0	4	
177	Anchorage, AK	190	141	3.5	48	359	17.9	0	
178	Boulder, CO	90	141	3.5	389	359	18.0	4	
179	Lubbock, TX	150	141	3.5	353	359	18.0	4	
180	Kalamazoo, MI	150	141	3.5	374	359	18.0	4	
181	Hickory, NC	150	141	3.5	363	359	18.0	4	
182	Roanoke, VA	170	141	3.5	358	359	18.0	4	
183	Niagara Falls, NY	40	141	3.5	148	358	17.9	4	Canadian 2
184	Bradenton, FL	110	141	3.5	397	358	17.9	4	
185	Galveston, TX	175	141	3.5	402	358	17.9	4	
186	Lincoln, NE	110	141	3.5	316	358	17.9	0	
187	Boise, ID	120	141	3.5	407	358	17.9	4	
188	Lafayette, LA	170	141	3.5	357	358	17.9	0	

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189	Gainesville, FL	120	141	3.5	402	359	17.9	4	
190	Ocala, FL	130	141	3.5	427	359	18.0	4	
191	Bremerton, WA	80	140	3.5	199	358	17.9	4	Canadian 5
192	Biloxi, MI	170	140	3.5	310	358	17.9	0	
193	Green Bay, WI	170	141	3.5	413	358	17.9	4	
194	Fort Collins, CO	90	140	3.5	412	359	17.9	4	
195	Saint Cloud, MN	170	140	3.5	381	359	17.9	4	
196	Brazoria, TX	175	141	3.5	399	359	17.9	4	
197	Yakima, WA	170	141	3.5	319	359	17.9	4	
198	Springfield, IL	170	141	3.5	345	359	17.9	4	
199	Waco, TX	150	141	3.5	388	359	17.9	4	
200	Chico, CA	180	141	3.5	364	359	17.9	4	
201	Amarillo, TX	150	141	3.5	326	359	17.9	4	
202	Merced, CA	165	141	3.5	339	358	17.9	4	
203	Beaver County, PA	130	141	3.5	409	359	17.9	4	
204	Houma, LA	160	141	3.5	315	359	17.9	0	
205	Fort Smith, AR	130	141	3.5	380	359	17.9	0	
206	Asheville, NC	150	141	3.5	350	359	17.9	4	
207	Racine, WI	160	141	3.5	420	359	17.9	4	
208	Champaign, IL	170	142	3.5	384	359	18.0	4	
209	Clarksville, TN	140	142	3.5	415	359	18.0	4	
210	Cedar Rapids, IA	90	141	3.5	304	359	18.0	0	
211	Lake Charles, LA	180	142	3.5	304	359	17.9	4	
212	Olympia, WA	170	142	3.5	367	359	17.9	4	
213	Naples, FL	70	141	3.5	446	359	18.0	4	
214	Longview, TX	150	141	3.5	388	359	18.0	4	
215	Topeka, KS	100	141	3.5	480	360	18.0	4	
216	Benton Harbor, MI	170	141	3.5	409	360	18.0	4	
217	Muskegon, MI	170	141	3.5	413	360	18.0	4	
218	Athens, GA	160	142	3.5	300	360	18.0	4	
219	Elkhart, IN	170	142	3.5	391	360	18.0	4	
220	Wheeling, WV	170	142	3.5	411	360	18.0	4	
221	Redding, CA	180	142	3.5	357	360	18.0	4	
222	Fargo, ND	170	142	3.6	379	361	18.0	4	
223	Lima, OH	170	142	3.6	429	361	18.0	4	
224	Tyler, TX	150	142	3.6	393	361	18.0	4	
225	Jacksonville, NC	150	142	3.6	376	361	18.1	4	
226	Tuscaloosa, AL	170	142	3.6	342	361	18.0	4	
227	Richland, WA	120	142	3.6	334	361	18.0	4	
228	Jackson, MI	170	142	3.6	276	360	18.0	4	Canadian 7
229	Medford, OR	170	143	3.6	362	360	18.0	4	
230	Fort Walton Beach, FL	170	143	3.6	307	360	18.0	0	
231	Bangor, ME	90	142	3.6	196	360	18.0	4	Canadian 7
232	Parkersburg, WV	160	142	3.6	416	360	18.0	4	
233	Anderson, SC	150	143	3.6	318	360	18.0	4	
234	Waterloo, IA	90	142	3.6	283	359	18.0	0	
235	Monroe, LA	150	142	3.6	369	359	18.0	4	
236	Las Cruces, NM	90	142	3.6	158	358	17.9	0	Mexican

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237	Lynchburg, VA	170	142	3.6	351	358	17.9	4	
238	Jamestown, NY	40	142	3.5	127	357	17.9	4	Canadian 2
239	Steubenville, OH	170	142	3.5	398	358	17.9	4	
240	Burlington, VT	40	141	3.5	98	357	17.8	4	Canadian 2
241	Eau Claire, WI	170	142	3.5	379	357	17.8	4	
242	Janesville, WI	170	142	3.5	420	357	17.8	4	
243	Laredo, TX	80	141	3.5	139	356	17.8	4	Mexican
244	Vineland, NJ	150	142	3.5	398	356	17.8	4	
245	Pittsfield, MA	90	141	3.5	389	356	17.8	4	
246	Battle Creek, MI	170	141	3.5	366	356	17.8	4	
247	Joplin, MO	100	141	3.5	405	357	17.8	4	
248	Charlottesville, VA	180	141	3.5	362	357	17.8	4	
249	Greeley, CO	90	141	3.5	396	357	17.8	4	
250	Dothan, AL	170	141	3.5	357	357	17.8	4	
251	Bellingham, WA	80	141	3.5	186	356	17.8	4	Canadian 5
252	Lafayette, IN	150	141	3.5	305	356	17.8	4	
253	Alexandria, LA	170	141	3.5	353	356	17.8	4	
254	Panama City, FL	120	141	3.5	372	356	17.8	4	
255	Bloomington, IL	170	141	3.5	352	356	17.8	4	
256	Florence, AL	170	141	3.5	368	356	17.8	4	
257	Anderson, IN	170	141	3.5	276	356	17.8	4	
258	Kenosha, WI	150	142	3.5	402	356	17.8	4	
259	Altoona, PA	170	142	3.5	430	356	17.8	4	
260	Terre Haute, IN	150	142	3.5	306	356	17.8	4	
261	Yuba City, CA	175	142	3.5	349	356	17.8	4	
262	Sioux Falls, SD	170	142	3.5	360	356	17.8	4	
263	Mansfield, OH	140	142	3.5	203	355	17.8	4	Canadian 7
264	State College, PA	150	142	3.5	430	356	17.8	4	
265	Bryan, TX	180	142	3.6	408	356	17.8	4	
266	Pueblo, CO	90	142	3.5	464	356	17.8	4	
267	Wilmington, NC	150	142	3.5	414	356	17.8	4	
268	Hagerstown, MD	170	142	3.5	339	356	17.8	4	
269	Wichita Falls, TX	150	142	3.6	315	356	17.8	4	
270	Santa Fe, NM	170	142	3.6	344	356	17.8	0	
271	Texarkana, TX	150	142	3.6	354	356	17.8	4	
272	Glens Falls, NY	170	142	3.6	426	356	17.8	4	
273	Abilene, TX	150	142	3.6	344	356	17.8	4	
274	Williamsport, PA	170	142	3.6	461	357	17.8	4	
275	Sharon, PA	130	142	3.6	236	356	17.8	4	Canadian 7
276	Muncie, IN	170	142	3.6	296	356	17.8	4	
277	Odessa, TX	150	142	3.6	344	356	17.8	4	
278	Wausau, WI	170	143	3.6	468	356	17.8	4	
279	Anniston, AL	170	143	3.6	324	356	17.8	4	
280	Fayetteville, AR	130	143	3.6	339	356	17.8	0	
281	Florence, SC	150	143	3.6	397	356	17.8	4	
282	Sioux City, IA	90	142	3.6	335	356	17.8	0	
283	Pascagoula, MS	170	143	3.6	287	356	17.8	0	
284	Decatur, IL	170	143	3.6	344	356	17.8	4	

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285	Columbia, MO	70	142	3.6	411	356	17.8	4	
286	Billings, MT	120	142	3.6	342	356	17.8	4	
287	Yuma, AZ	60	142	3.6	62	355	17.8	4	Mexican
288	Lawton, OK	190	142	3.6	272	355	17.7	4	
289	Albany, GA	160	142	3.6	381	355	17.7	4	
290	Bloomington, IN	170	142	3.6	297	355	17.7	4	
291	Burlington, NC	140	142	3.6	343	355	17.7	4	
292	Rochester, MN	170	142	3.6	367	355	17.7	4	
293	Midland, TX	150	142	3.6	342	355	17.7	4	
294	Danville, VA	140	142	3.6	363	355	17.7	4	
295	Lewiston, ME	80	142	3.6	306	355	17.7	4	Canadian 7
296	Sheboygan, WI	170	142	3.6	402	355	17.7	4	
297	Decatur, AL	170	142	3.6	351	355	17.7	4	
298	Cumberland, MD	160	142	3.6	435	355	17.7	4	
299	San Angelo, TX	150	143	3.6	396	355	17.8	4	
300	Gadsden, AL	170	143	3.6	317	355	17.7	4	
301	La Crosse, WI	170	143	3.6	369	355	17.8	4	
302	Iowa City, IA	90	143	3.6	298	355	17.7	0	
303	Kankakee, IL	160	143	3.6	382	355	17.7	4	
304	Kokomo, IN	170	143	3.6	273	355	17.7	4	
305	Elmira, NY	170	143	3.6	413	355	17.7	4	
306	Sherman, TX	150	143	3.6	408	355	17.8	4	
307	Owensboro, KY	140	143	3.6	430	355	17.8	4	
308	Dubuque, IA	90	143	3.6	351	355	17.8	4	
309	Pine Bluff, AR	130	143	3.6	332	355	17.8	0	
310	Lawrence, KS	100	142	3.6	427	355	17.8	4	
311	Rapid City, SC	90	142	3.6	312	355	17.8	4	
312	Bismarck, ND	170	142	3.6	378	355	17.8	4	
313	Saint Joseph, MO	100	142	3.6	403	356	17.8	4	
314	Jackson, TN	160	142	3.6	408	356	17.8	4	
315	Great Falls, MT	120	142	3.6	325	356	17.8	4	
316	Victoria, TX	180	142	3.6	440	356	17.8	4	
317	Cheyenne, WY	90	142	3.6	434	356	17.8	4	
318	Grand Forks, ND	170	142	3.6	129	355	17.8	4	Canadian 7
319	Casper, WY	90	142	3.6	422	356	17.8	4	
320	Enid, OK	190	142	3.6	374	356	17.8	4	
	Median	150		3.8	369		18.5	4.0	26.2
	Mean	142		3.6	356		17.8	3.7	25.0

360 - 800 MHz Channels = 16.0 MHz

Appendix II
to Nextel Reply Comments
in WT Docket No. 02-55

Technical Statement of Leonard Cascioli

TECHNICAL STATEMENT OF LEONARD M. CASCIOLI
Vice President RF Engineering and Operations
Nextel Communications, Inc.

The Consensus Plan for Realigning the 800 MHz Land Mobile Radio Band Will Effectively Mitigate CMRS – Public Safety Interference

Introduction

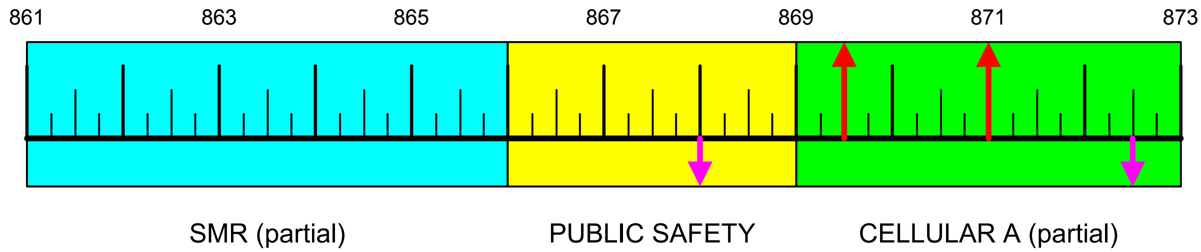
This document is designed to (a) show why the Consensus Plan for realigning the 800 MHz Land Mobile Radio Band provides significant reduction in IM-based interference; (b) review the principles behind intermodulation (IM) interference; and (c) discuss how the Consensus Plan also deals effectively with out-of-band emissions and sets the stage for further minimizing CMRS – public safety interference in the future.

The Consensus Plan will reduce the probability of IM interference to 800 MHz public safety licensees by relocating public safety operations out of the 821-824/866-869 MHz current NPSPAC spectrum allocation to a new replacement NPSPAC channel allocation at 806-809/851-854 MHz. It will also relocate low-power cellular operations from channels interleaved between public safety and B/ILT channels in the lower part of the 800 MHz band. Taken together, these actions will substantially mitigate the 800 MHz CMRS – public safety interference problem, as detailed below. For even greater levels of interference elimination, improvements in public safety handsets must occur.

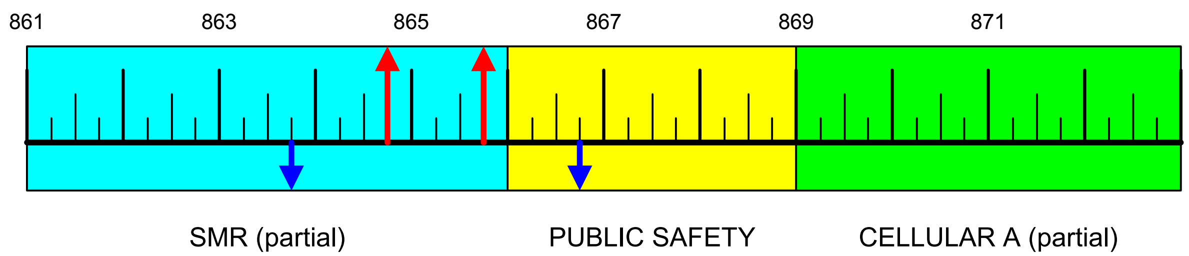
The Consensus Plan Substantially Mitigates IM Interference

The NPSPAC public safety allocation between 866 and 869 MHz is subject to IM-related interference from licensees on both of the adjacent channel blocks acting either independently or jointly. The base-to-mobile transmissions from cellular A-band licensees above 869 MHz, Nextel (or other low-site, cellular architecture operators) below 866 MHz, and collocated or near-collocated operations in both allocations can combine in a public safety mobile or portable receiver to produce IM products on the NPSPAC channels.

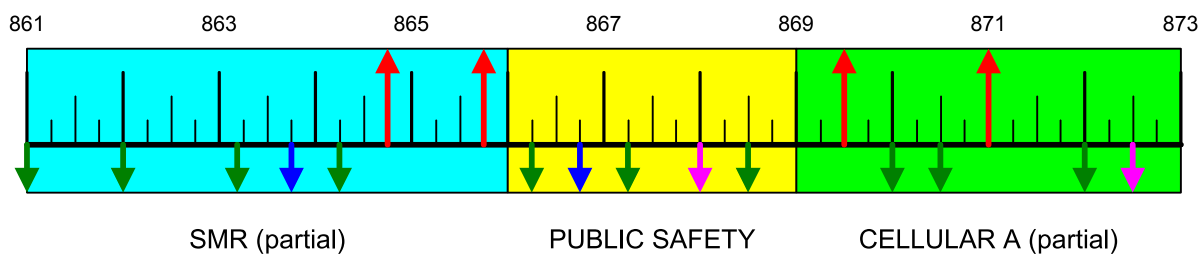
For example, consider a co-location site with two transmitters in the cellular A band and two in the SMR band. For this example, we will use the cellular-A frequencies of 869.5 and 871.0 MHz, and two SMR frequencies of 865.75 and 864.75 MHz. In the graph below, the two cellular frequencies are shown (upward-pointing red arrows) along with the two 3rd-order IM products they produce (downward-pointing purple arrows). Note that one cellular-A IM product falls in the public safety band at 868 MHz. The other IM product falls in the cellular A block and therefore causes no interference to public safety communications.



In the next graph, the two SMR frequencies are shown (upward-pointing red arrows) along with the two 3rd-order IM products they produce (downward-pointing blue arrows). Again, one product falls in the NPSPAC channel block.



Now, consider the IM products from all 4 co-located transmitters described above operating at the same time:



In addition to the IM products generated solely by the SMR transmitters, and the IM products generated solely by the cellular-A band operator, there are now numerous additional IM products generated by the combination of SMR and cellular-A base-to mobile transmissions. In this example, the combined cellular A and SMR operations produce three additional IM products on the NPSPAC channels. Note that this graph does not depict the total number of IM products created by this combination of transmissions; there are 3 additional products below 861 MHz, the lowest being 858.25 MHz. Public safety communications on the NPSPAC channels cannot be protected from IM interference so long as the channels remain “sandwiched” between spectrum blocks used by cellular architecture, low-site operations, while NPSPAC public safety systems use high-site, non-cellular, noise-limited technology.

The Consensus Plan will virtually eliminate IM interference to public safety communications on the NPSPAC channels by relocating them to the 806 – 809/851-854 channel block at the bottom of the 800 MHz band. First, since the greatest preponderance of Nextel-controlled spectrum is currently in the range 861-866 MHz, the preponderance of Nextel transmitters at a given site will normally be in that range. IM products produced solely by Nextel transmitters are therefore more likely to involve transmitters in the 861-866 MHz range than Nextel transmitters operating below 861 MHz. After realignment, of course, Nextel will completely vacate the band below 861 MHz, and inhabit the 861 – 869 channels including the then-former NPSPAC spectrum.

It can be shown mathematically that significant IM products from Nextel transmitters in the 861-866 MHz range will not fall below 856 MHz and will not fall above 871 MHz. Therefore, relocating the NPSPAC channel block below 856 MHz *virtually eliminates* Nextel-only IM products on the relocated channels. ***For locations where public safety users are currently experiencing Nextel-only IM-related interference on the NPSPAC channels, relocating the NPSPAC channels as described herein will reduce the probability of Nextel-only IM interference on the relocated channels by 98 percent to 100 percent.***

Additionally, it can be shown mathematically that by limiting the span between the highest and lowest frequencies in use at a site, the spectral spread of IM products can be controlled as well. By removing the interleaving below 861 MHz, and creating a contiguous spectrum block for cellular, low-power operations from 861 – 869, the probability that a Nextel-only product will fall on a public safety frequency will be reduced by enabling Nextel to reduce the span of frequencies it deploys at a specific site from as much as 15 MHz today to no more than 8 MHz post-realignment.

Relocating the NPSPAC channels as described above will be even more effective in eliminating IM products from cellular A band-only operations (as well as cellular B band operations). Nextel's internal tests have shown that the bandpass filter in the first stage of the typical public safety receiver provides little attenuation to RF energy at frequencies immediately above 869 MHz. Nextel's tests indicate that the typical first-stage filter attenuates RF signals 3 dB at approximately 873.5 MHz, approximately 8 dB at 880 MHz, and approximately 12 dB at 884 MHz. <u>This aligns closely with results provided to Nextel by Motorola of 3 dB at 873 MHz and approximately 20-25 dB at 894 MHz</u>. The relatively small amount of attenuation from 869 to 873 MHz means that strong signals from cellular-A transmitters in this frequency range can by themselves cause IM-related interference in a public safety radio operating in the current 866-869 NPSPAC channels at levels almost as intense as those generated by transmitters operating in the 861-866 MHz range. Transmissions above 873 MHz will not produce comparably strong IM products, however, because the receiver front-end filter more effectively attenuates the contributing signals.

If public safety operations on the current NPSPAC channels are relocated below 861 MHz, it can be shown mathematically that for cellular A or cellular B-band base-to-mobile transmissions to directly produce IM-related interference to a public safety receiver, at least one of the cellular transmitters involved must be above 877 MHz. As discussed above, the attenuation characteristics of the typical public safety front-end receiver filter will so reduce the strength of an IM product created from a frequency greater then 877 MHz that the probability of the IM product causing real-world interference is minimal. ***At locations where public safety users are today experiencing cellular-only based IM interference on NPSPAC channels, the Consensus Plan NPSPAC relocation will reduce the probability of IM interference on the relocated channels by 100 percent.***

The Consensus Plan would include a guard band at 814 – 816/859 – 861 MHz between the proposed non-cellular spectrum block and the cellular, low-site system channel block at 816 – 824/861 – 869 MHz. Operations in the cellular channel block will produce IM products in the guard band; therefore, the guard band should be used by communications systems that can best tolerate some interference such as campus systems, or systems used for non-life safety, non-mission critical communications services.

The Consensus Plan will also reduce the probability of co-located (or near co-located) Nextel and cellular base-to-mobile transmission producing IM products on the realigned public safety channels. The Consensus Plan reduces the spectrum range over which **full-strength** IM products will fall. It accomplishes this by leveraging the public safety receiver front-end filter roll-off specifications referenced above; *i.e.,* IM products generated by various combinations of Nextel and cellular transmission will be weaker the farther the cellular contributor moves above 869 MHz. In addition, relocating Nextel's operations above 861 MHz and into the 866 – 869 MHz channels, reduces the probability of a combined Nextel-cellular IM product falling on the new public safety channels spectrum because it is less likely that the Nextel contributor will be sufficiently low in frequency to cause the resultant IM product to fall in the public safety spectrum.

In other words, although the Consensus Plan does not completely eliminate the possibility of CMRS – public safety IM interference, even under the worst-case assumptions, it reduces the likelihood of IM interference to a level manageable through coordination among the affected operators. ***For locations where public safety users are currently experiencing combined Nextel – cellular A band IM interference on NPSPAC channels, relocating these channels as provided in the Consensus Plan will reduce the probability of post-realignment IM interference by at least 78 percent to as much as 94 percent, depending on the specific channels being used.***

Motorola has recently stated publicly that the front-end filter specifications for its public safety receivers are actually far broader than the figures it previously provided Nextel, as referenced above. Nextel's own tests, Motorola's earlier e-mailed comments, and Nextel's field experience all indicated that the filter specifications set forth above are in fact correct. This is corroborated by the complete absence of any significant indication of B-band cellular carrier involvement in CMRS – public safety interference to date, and the preponderance of A-band carrier involved interference using channels in the lower part of the cellular A band allocation. If the public safety receiver filter specifications were as broad as Motorola is now asserting, *i.e.,* (down only 3 dB at 885 MHz), there would be empirical evidence of B-band IM involvement because B-band signals would pass into the public safety receiver with little or no attenuation. On-off testing with B-band carriers around the country, however, has provided no indication of B-band involvement to date.

If Motorola's current assertions were correct, there should also be more extensive IM interference by cellular A-band carriers because A-band signals would pass into a public safety receiver attenuated by only a fraction of a dB in most cases. Cellular A band contributions to CMRS – public safety interference are substantial -- as much as 35 percent of the total CMRS – public safety interference incidents in at least one market and a contributor in at least 15 percent of the individual occurrences nationwide – but should be even more extensive under Motorola's current filter performance assertions.

The Consensus Plan will also eliminate wideband noise as a component of CMRS – public safety interference at 800 MHz. This is primarily facilitated by removing the interleaved spectrum between Nextel's operations and those of high-site, noise-limited systems in the lower part of the band. This makes it possible to replace duplexers which currently must pass 851-866 MHz. These new duplexers, with suitable roll-off immediately below 861 MHz and below 869 MHz, allow Nextel to extract maximum capacity out of the 8 MHz block of base-to-mobile spectrum it will operate within post-realignment while ensuring that wideband noise is effectively and thoroughly attenuated below the guard band.

Intermodulation Principles

The following paragraphs provide a basic discussion of intermodulation principles as they relate to the CMRS – public safety interference problem at 800 MHz. We provide this discussion to assist the reader in understanding the above analysis, and thereby better appreciating why the Consensus Plan will substantially mitigate CMRS – public safety interference.

IM occurs whenever two or more RF signals interact with an item that is electrically nonlinear. The exact mathematical derivation of IM is done through trigonometric manipulation of the contributor signals (with each contributor expressed in the form $A_n \cos \omega_n t$, where A is the amplitude of the contributor and ω_n represents the frequency of the contributor), with the combined result E_i applied to the transfer function of the nonlinear item (which can be expressed in general terms as $E_o = A_1E_i + A_2(E_i)^2 + A_3(E_i)^3 + A_4(E_i)^4 + \ldots + A_n(E_i)^n$).

Although a complete study of IM is well beyond the scope of this document, basic principles as they apply to current interference problems are summarized below.

a. IM occurs whenever two or more RF signals interact with an item that is electrically nonlinear. Examples of such nonlinear elements are:

1. An amplifier in a transmitter or receiver. All amplifiers are nonlinear to some extent regardless of the signal levels that they are delivering.

2. A passive component in a transmitter or a receiver.

3. Connectors in the antenna plant of a transmitter or receiver

4. Nearby rusty bolts, fences, and other objects containing poorly-joined or accidentally-joined dissimilar metals.

In the current interference environment IM generated in the first stage or stages of a public safety receiver is the most significant form of IM.

b. When two or more RF signals interact with the nonlinear item, new RF signals are produced. These new signals are called **IM products**. These new signals have a **frequency** and a **strength** just like other RF signals have. The frequencies of these new RF signals are mathematically related to the frequencies of the original contributors. The strengths of these new RF signals are mathematically related to the strengths of the original contributors and the electrical characteristics of the nonlinear item.

c. The **order** of an IM product is derived mathematically from the combination of the contributor signals with the nonlinear item. The IM products that are significant in dealing with interference issues are the odd-order products, with 3rd-order products being the most significant because they occur for lower levels of contributor signals than the higher-order products. Nextel's experience, based on dealing with a large number of interference complaints, is that 3rd-order IM is almost always going to be the only IM issue in play. 5th-order, 7th-order, and higher order products have not been an issue in the field experiences to date.

Since 3rd-order IM products are the most commonly dealt with in solving interference complaints, it is useful to know the formulas by which the IM product frequencies can be calculated. The two general forms are:

$f_{im} = 2 * f1 - f2$ (two-carrier)

$f_{im} = f1 + f2 - f3$ (three-carrier)

Since the total number of products formed in a given situation is based on every possible combination of the available contributors according to the formulas above, it is easy to see that for any more than a handful of contributors the number of discrete products grows quite large.

In the example used above with 4 transmitters at 864.75, 865.75, 869.5, and 871 MHz, 3rd-order IM products were produced on the following frequencies:

858.50	862.00	866.75	870.50	874.75
859.50	863.25	867.25	872.00	875.75
860.00	863.75	868.00	872.50	876.25
860.50	864.25	868.50	873.25	
861.00	866.25	870.00	874.25	

Note that some of the frequencies listed have multiple IM products on them.

d. In order to know the strength of a given IM product, it is necessary to know both the strength of the contributors and at least enough details about the transfer function of the nonlinear item to calculate the resultant strength of the product in question. Because each nonlinear item is different, there is no generalized formula that can be presented to deal with this.

The manufacturers of public safety radio products generally classify their hardware according to TIA-603 or later standards. TIA-603 identifies the IM rejection of a particular receiver only for a single 3rd-order, 2-contributor product. No higher-order products or 3-carrier 3rd-order products are classified as part of TIA-603.

e. It can be shown mathematically that for a collection of transmitters that has a lower frequency L, an upper frequency H, a span S = (H-L), and an individual bandwidth per transmitter of BW, 3rd-order IM products will not fall below $(L - S - \Sigma(BW))$ and will not fall above $(H + S + \Sigma(BW))$.

Thus, in order for an IM product or products formed in a public safety receiver from the presence of strong CMRS signals to interfere with the desired public-safety transmission, two conditions must be satisfied:

a. Energy from the IM product(s) must fall within the receiver passband (i.e. the IM product must either fall on the desired frequency or very close to it).

b. The strength of the product(s) must be sufficient to lower the ratio of the desired signal strength to the composite interference and noise (the C/I+N ratio) below an acceptable level (e.g. 17 dB for a typical FM radio system).

Future Improvements

As noted above, the Consensus Plan sets the stage for further reducing the likelihood of CMRS – public safety interference at 800 MHz in the future by allowing equipment manufacturers to design front end filters that cover a smaller range of spectrum. By beginning to roll off public safety receiver response even faster than the current filters perform (which should be possible due to the smaller band that must be passed), involvement by cellular-A carriers and Nextel transmitters in the upper part of the SMR band should be virtually eliminated. This improvement is only possible, however, upon completion of the 800 MHz realignment described herein, including the consolidation of non-cellular systems and cellular, low-site systems into separate contiguous channel blocks.