Instructions for using the CHANNEL LOADING CALCULATOR for 700 MHz Regional Planning Committee Guidance

National Regional Planning Council

NRPC

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Instructions for using the

TRUNKING SYSTEM CHANNEL LOADING CALCULATOR

<u>SECTION ONE:</u> Introduction

This Channel Loading Calculator is designed for 700/800MHz (RPC) Regional Planning Committees to offer guidance in determining how many frequencies are needed for a particular application. Especially useful in the case for new licensees, or new systems that do not have any prior traffic loading data available. Or for that matter, anybody interested in channel loading whether it be 700/800 MHz, VHF or UHF trunking.

The calculator itself is based on the standard Erlang C model. Erlang C assumes that all blocked calls stay in the busy queue until they can be handled. For example, in typical radio trunking system, a subscriber unit attempting to make a call will get a busy tone if all channels are busy and then be placed in the busy queue. As soon as there is an available channel, the subscriber unit will receive a talk permit tone indicating that a channel is open.

The Erlang is a unit of traffic loading or density in a telecommunications system. One Erlang is equal to 3600 seconds (60 minutes) of talk time in one hour in one voice path. For a multi-channel system it would represent the total traffic volume in one hour.

For example, if group of radio subscribers made 5400 calls in one hour and each call had PTT (Push-to-Talk) duration of 5 seconds, then the total Erlangs is worked out as follows:

- Seconds of traffic in the hour = number of calls x duration
- Seconds of traffic in the hour = 5400 x 5
- Seconds of traffic in the hour = 27,000
- Hours of traffic in the hour = 27,000/3600
- Hours of traffic in the hour = 7.5
- **Total traffic loading = 7.5 Erlangs**

Once the total traffic loading is determined than it is simply a matter of entering this loading number into the Erlang calculator, and then the calculator spits out the answer. The answer being the number of talk paths needed.

The challenge arises when no traffic loading data is available. For example, if a RPC receives an application from a particular agency that is requesting 20 channels based on the fact that this agency owns 2000 radios. The major unknown here is the lack of traffic loading data. Without knowing the number of radios that are actually making calls per hour, the number of calls per radio, and duration of each call is difficult, or near impossible, to determine traffic loading.

The next section will discuss some best practices on how to determine the number of Erlangs when no data is available.

SECTION 2: Discussion

An analysis of an existing trunking system was done to extract empirical data to be used when no data is available to use in the calculator.

This empirical data is based on the C800/WCCCA Motorola 800MHz simulcast trunking system that covers Clackamas County and Washington County. Approximately 2600 square miles and combined population of 946,000.

There are (4) four primary analog simulcast sub-systems (cells) and (2) two analog trunked repeater (IR) sites that provided the data.

1. WEST: Six channel four site simulcast.
2. WCCCA Central: Sixteen channel seven site simulcast.
3. MTN Road: Five channel IR site.
4. C800 Central: Ten channel six site simulcast.
5. East: Seven channel three site simulcast.
6. Goat: Seven channel IR site.

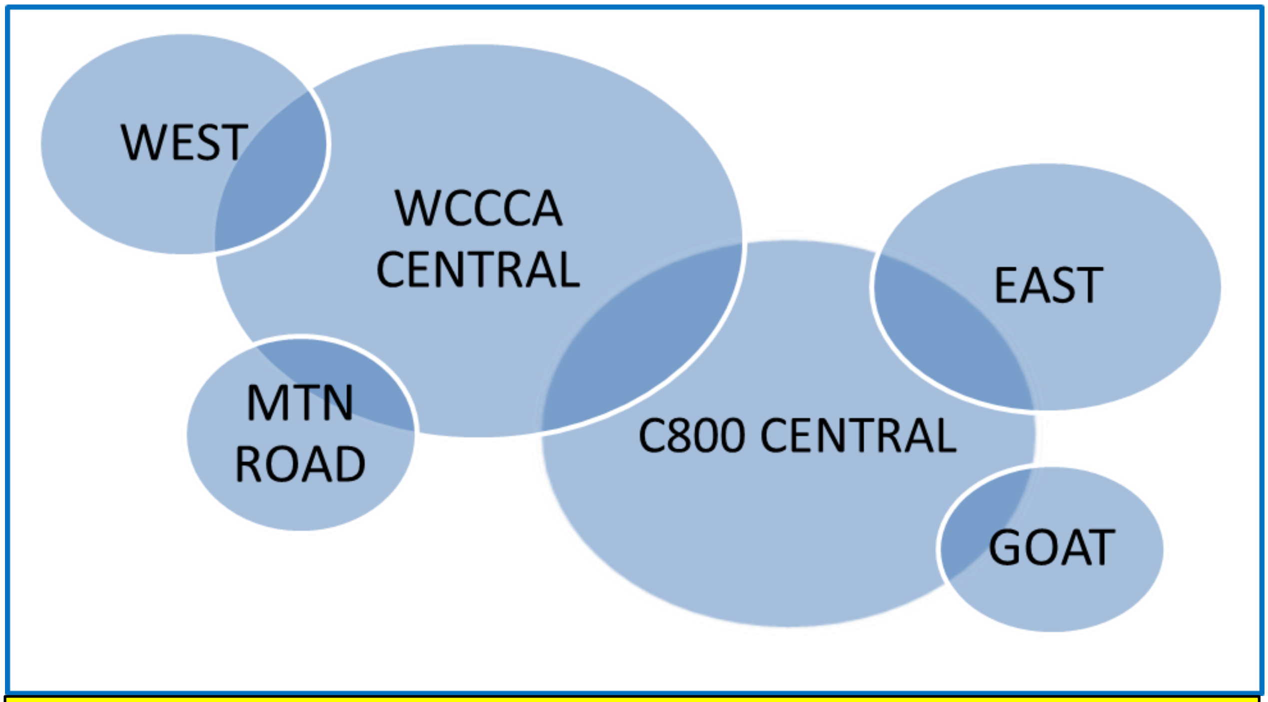

Figure 1: General configuration for the C800/WCCCA 800 MHz trunked radio system that covers Washington and Clackamas Counties in Oregon, USA

GenWatch3-ATIA was used to extract the data from the Master Site for the year of 2013.

Based on the following numbers:

1. Agencies = 40
2. Talk groups = 75
3. Subscribers = 7500
4. Push-to-talks = 14 million
5. Airtime = 48 million seconds.
6. Repeater hang time = 200mSec

Erlang C calculator default settings:

1. GoS (Grade of Service) = 1%
2. Busy Queue waiting time = 1 Second
3. All talk groups have the same priority level
4. 12.5KHz FDMA and 2-Slot TDMA voice only
5. No site preferences

The data used is the average of the daily peaks for each day for each talk group for the entire 365 days of 2013. The reporting software logs the number of PTT's for each hour in a 24 hour day. **(Refer to figure 2)** Than the peak PTT hour is extracted from each day per talkgroup. Than in turn, the 365 days of peak PTT's are averaged to give yearly average of 270 PTT's per hour.

Then, the same is done for the number radios that generate a PTT during each hour. **Figure 2** indicates that for Jan 1st 2013 from midnight to 0100 there were 44 radios that generated 320 PTT's which results in 7.27 PTT's per radios per hour. This results in yearly average of 41 radios per hour and 6.6 PTT's per radio. Drilling down the software will indicate each radio by trunking ID and number of PTT's for each particular radio. **(Refer to figure 3).** Just in case you were interested.

WCSO1	Jan 1st 2013		~	Jan 31st 2013		
Time	Radios	PTTs	~	Radios	PTTs	Ave for year
0:00	44	320	~	27	101	
1:00	41	205	~	17	75	
2:00	40	234	~	18	77	
3:00	40	239	~	7	59	
~	~	~	~	~	~	
20:00	18	90	~	20	133	
21:00	23	89	~	40	245	
22:00	24	138	~	46	308	
23:00	21	109	~	33	208	
Peak Radios/Hour	44		~	46		41
Peak PTT/Hour	320		~	308		270
Peak PTT per radio	7.27		~	6.70		6.6
Ave PTT duration	4.20		~	3.73		3.8

Figure 2: WCSO1 (Washington County Sheriff Office) TG: The peak value is taken from each of the 365 day's than the average of the peaks is taken.

Radio ID		PTT		Radio ID		PTT		Radio ID		PTT
33218		1		62333		2		64843		2
33244		6		62339		2		64850		2
33290		1		62345		6		64888		2
33291		20		62356		1		64936		1
33773		6		62367		1		64974		3
33778		2		62373		1		64997		5
33786		2		62375		2		65002		9
33811		3		62995		4		65049		8
33814		3		63204		2		65052		2
52849		152		63909		9		65055		8
60149		2		64292		2		65057		4
60169		3		64531		8		65063		2
60223		2		64542		6		65089		6
60256		8		64825		1		65109		2
62326		4		64840		2				
62333		2	**WCSO1 PTT's from midnight to 0100 on Jan 1st 2013 = 320**							

Figure 3: WCSO1 Talkgroup: Showing 1st hour from 1st day of year.
This data was generated with Genesis report entitled "Unit PTT's by Talkgroup". The 52849 radio ID represents the dispatch console. The console generated 47.5% of total 320 PTT's during that hour. This would represent fairly well balanced inbound and out traffic.

Now that the average of the peak PTT's per radio per hour is known and number of PTT's per radio per hour in known for this Talkgroup for entire year, all that is needed is PTT duration to calculate the channel loading. **Figure 2** illustrates that average PTT duration is 3.8 seconds per PTT.

1. Radios per hour = 41
2. Total PTT's per hour = 270 PTT's
3. PTT duration per PTT = 3.8 seconds
4. 270 X 3.8 = 1026 seconds
5. 1026/60 = 17.1 minutes or 0.285 Erlangs

The 17.1 Minutes represents the airtime per hour for the WCSO1 Talk Group. Not only does this represent the channel loading presented by this Talk Group, it also indicates the minimum time that the dispatcher would have to be involved in radio traffic.

Another key number from **Figure 3** is the 6.6 PTT's per radio. The 6.6 number is based on average of the daily peak. The importance of PTT's per radio will become apparent later in this discussion.

This empirical data collection was done for each Talk Group per agency. **(Refer to Figure 4)**. The data was collected from eight (8) talk groups belonging WCSO.

The key items to look for are:

1. Radios owned by the agency = 902
2. Actual radios in use per hour (line 2) = 121.36
3. Peak PPT per radio per hour (line 8) = 6.23
4. Average PTT duration (line 9) = 4.41

Radios Owned by Agency		902	WASHINGON COUNTY SHERIFF TALK GROUP BREAKDOWN for 2013							
		TOTAL	DISP1	DISP2	JAIL	TAC2	TAC1	CRTSEC	DET	REC
1	Daily (Avg Radios/Hour) averaged for the year	**61.16**	23.2382	11.6121	20.4032	1.5757	1.3324	2.5903	0.3256	0.0776
2	Daily (Peak Radios/Hour) averaged for the year	**121.36**	40.9781	23.0384	31.8575	6.9753	6.1813	8.7222	2.4776	1.1264
3	Daily (Ave PTT/Hour) averaged for the year	**339.36**	134.6153	101.4823	75.0057	7.4779	6.3674	10.9353	3.3308	0.1472
4	Daily (Peak PTT/Hour) averaged for the year	**818.15**	269.6466	226.9479	148.1205	44.5769	41.4643	54.3630	30.3806	2.6484
5	Total Airtime for the year secs	**11,342,881**	4,507,236	3,398,815	2,359,831	407,835	351,051	254,999	60,472	2,643
6	Total PTT for the year	**2,928,434**	1,179,230	888,985	657,050	65,327	55,626	70,861	10,712	643
7	Ave PTT per radio per hour(in 1 year period)	**4.71**	5.7748	8.7137	3.6617	4.6635	4.6765	3.9734	4.3851	1.8174
8	Peak PTT per radio per hour(in 1 year period)	**6.23**	6.5943	9.9676	4.6735	6.4922	6.6380	5.9298	7.4712	2.0888
9	Ave PTT duration(in 1 year period) secs	**4.41**	3.8225	3.8257	3.5877	6.3992	6.3462	3.6025	3.9019	3.8270
10	Peak PTT duration(in 1 year period) secs	**23.34**	32.9841	34.5707	17.1986	36.4299	34.1912	17.2485	8.9545	5.1808
11	Airtime minutes per hour		17.18	14.47	8.86	4.75	4.39	3.26	1.98	0.17

Figure 4: Summary of Genesis Empirical Data for the top busiest talkgroups for WCSO. This Talkgroup summary was done for every agency on the system. The most important number here is the number of radios in use per hour (line 2). For this agency they only use 13.5% of their radios in any given average peak hour. It's interesting to note that even though the agency owns 902 radios, only 121.36 radios are used per hour. **The 121.36 is the first number that is used to determine the actual traffic loading.**

	TRUNKING SYSTEM CHANNEL LOADING CALCULATOR										
	TALK GROUP NUMBER	1	2	3	4	5	6	7	8		
2	**WCSO TALKGROUPS**	**DISP1**	**DISP2**	**JAIL**	**TAC2**	**TAC1**	**CRTSEC**	**DET**	**REC**	**TOTAL**	**AVE**
3	Radios owned by Agency	902.00	902.00	902.00	902.00	902.00	902.00	902.00	902.00	902.00	
4	Percent used	0.05	0.03	0.04	0.01	0.01	0.01	0.00	0.00	0.13	
5	Radios in use per Hour	40.98	23.04	31.86	6.98	6.18	8.72	2.48	1.13	121.36	
6	PTT's per radio per hour	6.59	9.97	4.67	6.49	6.64	5.93	7.47	2.09		6.23
7	Total PTT per hour	269.65	226.95	148.12	44.58	41.46	54.36	30.38	2.65	818.15	
8	PTT Duration in Seconds	3.82	3.83	3.59	6.40	6.35	3.60	3.90	3.83		4.41
9	Erlangs	0.2863	0.2412	0.1476	0.0792	0.0731	0.0544	0.0329	0.0028	**0.92**	
10	Performance Objectives										
11	reference waiting time queue in sec (W0)	**1**	second(s)	Busies of 1 second or less are considered acceptable.							
12	GoS P(W>W0)	**1%**		1 busy over 1 second per 100 PTT's is considered acceptable.							
13	Offered Traffic Characteristics										
14	Call traffic (Erlangs)	**0.92**									
15	Average Holding Time	**4.41**	second(s)								
16	**System Type**	**FDMA**	**TDMA**	Assumming 12KHz channel bandwidth and 2-Slot TDMA in 12.5 KHz channel							
17	Number of Frequencies Needed	**4**	**3**	Frequencies include FDMA control channel							
18	Probability that a call has to wait	**1.53%**		Probability that call will not be handled immediately							
19	Probability that a call has to wait more than W0	**0.76%**		1 second or under is considered acceptable.							

Figure 5: This the basic format of the calculator. The Talk Group (TG) data from figure 4 was transferred into this calculator. It is shown that this agency uses 8 TG's to perform their necessary daily routine functions. Even though is for one agency it could also represent one-precinct of large multi-precinct city police department. Most law agencies or precincts usually have 2 dispatch, 2-5 tactical, detective, records, etc. Plus common law, gang, swat, drugs, etc. amongst several agencies. Fire may have only 1 dispatch plus 4-20 operational TG's

The value of this data to help the individual appreciate traffic load per TG and note the overall consistently of PTT's per radio per hour and PTT duration in seconds. **Also for DISP1; 41 radios generates 0.2863 Erlangs, that 17.2 minutes per hour of pure radio time not taking in account additional time for possible hang-time. Section 4 discusses this further that only about 41 radios per TG is possible for effective Public Safety communications.**

Section 3 will discuss in depth the actual operation and use of the Channel Loading Calculator.

Classically channel loading calculations are based on number of radios owned not the actual radios in use per hour. In this case WCSO is only using 13.5 % of their radios during the average busy hour. This may seem like a low number, but this agency has a large number of radios, most patrol units have both a mobile and portable radio and seasonal units such as snow cats are used only in the winter. Another example, CCSO takes their patrol cars home with them. The data has shown that smaller agencies use a higher percentage of their radios. **(Figure 6).**

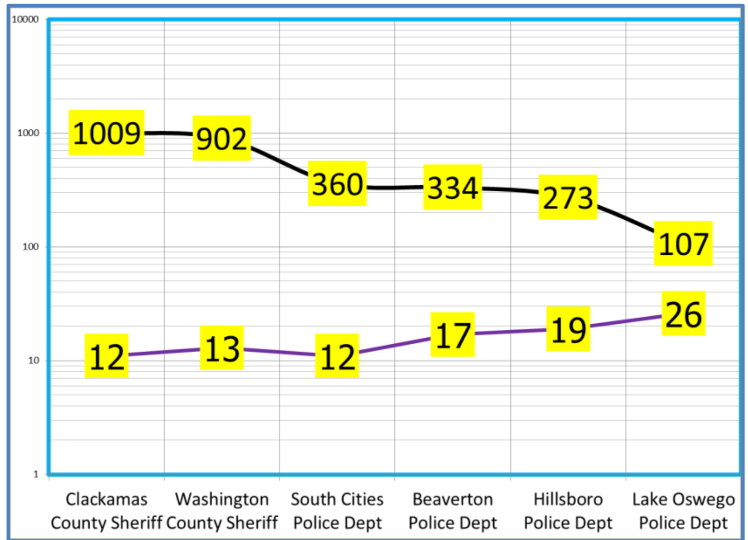

Figure 6: Showing percent radio's used per hour vs: radio's owned

Once it's been determined on how many radios are actually used per hour it now necessary to determine the amount of air time, or traffic loading, that each radio generates per hour.
The empire data revealed a unique correlation between PTT's and PTT duration of the various agencies regardless of the size of agency.

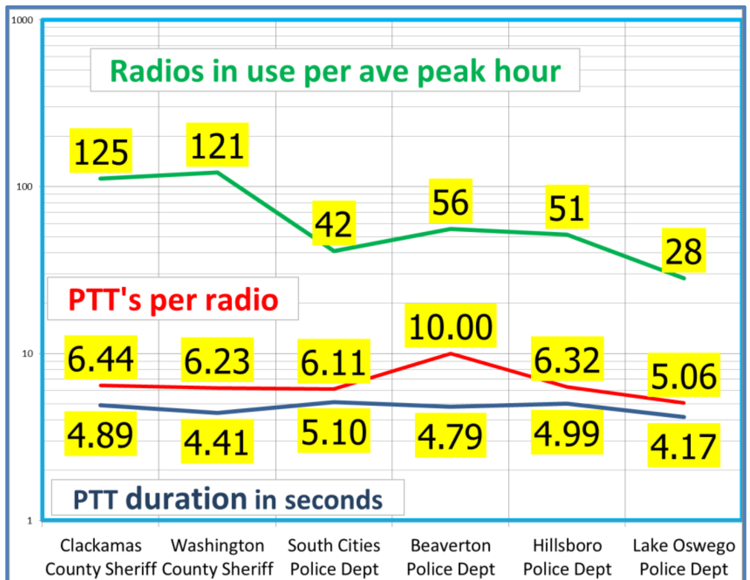

Figure 7: Correlation between numbers of radio's in use per average peak hour vs: PTT's and duration

As it turns out number of PTT's per radio averaged out to about 6 PTT's per radio and duration per radio averaged out to about 5 seconds per PTT.

Now back to the Erlang Traffic Loading Formula shown earlier.

The first number that is needed is the **number of calls**. Number of calls is equal to number of radios multiplied by the number of PTT's per radio.

For this example we will use CCSO (Clackamas County Sheriff Office). As shown in Figure 6 uses 12 percent of their 1009 radios per average peak hours or 125 radios. Number of calls per hour equals number of radio per hour multiplied by number of PTT's per radio, which in turn equals 805 PTT's,(125 x 6.44) or number of calls per hour.

- Seconds of traffic in the hour = number of calls x duration
- Seconds of traffic in the hour = 805 x 4.89
- Seconds of traffic in the hour = 3936
- Hours of traffic in the hour = 3936/3600
- Hours of traffic in the hour = 1.09
- **Total traffic loading = 1.09 Erlangs**

MULTI-AGENCY TRUNKING SYSTEM CHANNEL LOADING CALCULATOR REFERENCE SHEET Based on Erlang C due to queue														
1	**Description**	**WCF**	**CCSO**	**WCSO**	**SCPD**	**BPD**	**HPD**	**PW**	**NBF**	**LOPD**	**HSEC**	**BUS**	**TOTAL**	**AVE**
2	Talk Groups Used	9	10	8	7	7	6	2	3	4	2	2	**60**	
3	Radios owned by Agency	1112	1009	902	360	334	273	188	148	107	55	41	**4529**	
4	Percent used	8%	12%	13%	12%	17%	19%	8%	20%	26%	43%	38%		**20%**
5	Radios in use per Hour	92	125	121	42	56	51	14	30	28	24	15	**600**	
6	PTT's per radio per hour	4.32	6.44	6.88	6.11	10.00	6.32	3.88	4.01	5.06	7.47	6.54		**6.09**
7	Total PTT per hour	398	805	832	257	559	325	55	120	143	178	101	**3775**	
8	PTT Duration in Seconds	6.57	4.89	4.41	5.10	4.79	4.99	4.34	5.88	4.17	4.11	4.35		**4.87**
9	Erlangs	0.73	1.09	1.02	0.36	0.74	0.45	0.07	0.20	0.17	0.20	0.12	**5.15**	
10	Performance Objectives													
11	waiting time queue (W0)	1	sec	Busies of 1 second or less are considered acceptable.							Owned radio/FDMA freq			**377**
12	GoS P(W>W0)	1%		1 busy over 1 sec per 100 PTT's is considered acceptable.							Owned radio/TDMA freq			**647**
13	Traffic Characteristics													
14	Call traffic (Erlangs)	**5.15**		All talkgroups are at the same priority level										
15	PTT Duration in Seconds	**4.87**	sec											
16	**System Type**	FDMA	TDMA	Assuming 12KHz B/W and 2-Slot TDMA in 12.5 KHz channel										
17	Frequencies Needed	**12**	**7**	Frequencies include FDMA control channel										
18		1.85%		Probability that call will not be handled immediately										
19	Probability wait more than W0	0.56%		1 second or under is considered acceptable.										

Figure 8: Reference sheet empirical data base on 11 major agencies that consisted of 60 talkgroups. This calculates now uses the total traffic loading from each agency to determine loading for the entire system. Again indicating percent of radios used vs: radio in use. HSEC is Hospital Security that uses 43% of their 55 radios that only loads the system by 0.20 Erlangs. WCF (Washington County Fire) uses 8% of their 1112 radios, whereas NBF (Newberg Fire) uses 20% of their 148 radios.
Overall there are 3 significant bits of information gained from this data;

- **The percent of average radios used is equal to 20%.**
- **The average PTT's per radio per hour is equal to 6.**
- **The average PTT duration is equal to 5 seconds.**

SECTION 3: Instructions

	B	C	D	E	F	G	H	I	J	K
2	MULTI-AGENCY TRUNKING SYSTEM CHANNEL LOADING CALCULATOR									
3	Description	Agency A	Agency B	Agency C	Agency D	Agency E	Agency	Total	Total with Growth	AVE
4	Radios owned by Agency	4000	1000					5000	6720	
5	Percent used	20%	20%							20.0%
6	Radios in use per Hour	800	200	0	0	0	0	1000	1344	
7	PTT's per radio per hour	6	6	6	6	6	6			6.0
8	Total PTT per hour	4800	1200	0	0	0	0	6000	8063	
9	PTT Duration in Seconds	5	5	5	5	5	5			5.0
10	Hang-Time in Seconds	0.2	0.2	0.2	0.2	0.2	0.2			
11	Erlangs	6.93						6.93	9.32	
12	Performance Objectives									
13	Queue Wait time (secs)	1								
14	GoS	1%								
15	Traffic Characteristics									
16	Erlangs	6.93		9.32						
17	PTT Duration (sec)	5.0		5.0						
18	System Type	FDMA	2 SLOT TDMA	FDMA	2 SLOT TDMA	4 SLOT TDMA				
19									radios/ frequency	radios/hr/ frequency
20	Frequencies	13	7	16	8	5				
21	Talk Paths	12	12	15	14	16		FDMA	385	77
22	Wait<1 sec	2.86%		3.30%				TDMA	714	143
23	wait>1 sec	0.85%		0.87%				With	3.0%	Growth
24		Growth percentage		3.0%				FDMA	420	84
25		Growth in years		10				TDMA	840	168

Figure 9: Channel Loading Calculator

Refer to figure 9 for the following discussion on using the calculator.
As stated earlier this is a standard Erlang channel loading calculator, simply enter in the Erlang value in cell C11 and cell C20 produces the answer. But first one needs to know how to get the Erlang value.

Following are steps to entering data into the calculator:

1. **Cells C4 – H4:** represent the **number of radios** that are owned by each agency.
    a. This number is **provided by the user**.
    b. Additional columns can be inserted to add more agencies.
    c. **I4:** represents the total number of radios that are **available to use** the system.
    d. **J4:** represents the growth factor that is entered in **Cell E24**.

2. **Cells C5 - H5:** represent the percent of the radios owned that are used per hour.
    a. This number is **provided by the user**.
    b. The value will vary depending on the type and size of the agency.
    c. The empirical data in Section 2 can be used as guide.

3. **Cells C6 – H6:** represent the actual number of radios in use per hour.
    a. This number is **auto-populated** when **Steps 1 and 2** are filled in.
    b. **I6:** represents the total number **of radios in use per hour** on the system.
    c. **J6:** represents the growth factor that is entered in **Cell E24**.

4. **Cells C7 – H7:** represent the number of PTT's per radio per hour.
    a. For this version of the calculator the number is fixed at 6 PTT's.
    b. Section 2 discussed that 6 PTT's turned out be common average.
    c. However, if necessary, it could be changed in later version.

5. **Cells C8 – H8:** represent the total number of PTT's per hour.
    a. This number is auto-populated when **Steps 1 and 2** are filled in.
    b. **I8**: represents the total number **PTT's per hour** on the system.
    c. **J8:** represents the growth factor that is entered in **Cell E24**.
    d. PTT's per hour can also be interpreted as the number of calls per hour.

6. **Cells C9 – H9:** represent PTT duration in seconds per call or PTT.
    a. For this version of the calculator the number is fixed at 5 seconds..
    b. Section 2 discussed that 5 seconds turned out be common average.
    c. However, if necessary, it could be changed in later version.

7. **Cells C10 – H10:** represent repeater hang-time and is user selectable.
    a. Depending on the system, typically hang-time can range for 0-2 seconds.
    b. Adding hang-time increases PTT duration.
    c. Increasing hang-time will increase channel loading and have add channels.

8. **Cells C11 – H11:** represent the traffic or channel loading in Erlangs.
    a. One Erlangs is equal to 3600 seconds of talk time in one hour.
    b. In this example of 6.93 Erlangs is equal to 24,948 seconds of talk time in one hour.
    c. Or equal to 415.8 minutes or 6.93 hours.
    d. This **6.93** number is equal to **C8*(C9+C10)/3600**
    e. **I11:** represents the total number Erlangs per hour on the system.
    f. **J11:** represents the growth factor that is entered in Cell E24.

9. **Cell C13:** Queue Wait time in seconds is one of two performance objectives.
    a. Public Safety systems typical set this time to 1 (one) second.
    b. This is the busy Queue time that is acceptable before it is logged as a busy.
    c. It is considered acceptable if a radio is held in the busy for 1 sec or less.

10. **Cell C14:** GoS (Grade of Service) is the second performance objective.
    a. Public Safety systems typical set this number to 1%.
    b. One busy per 100 PTT's for GoS of 1% is considered acceptable.
    c. Or another way: 99% of the calls are handled in 1 second or less.
    d. Increasing the GoS to 3% would allow 3 busies per 100 PTT's.
    e. Increasing the GoS lowers the channel (talk-path) requirement.

11. **Cell C16:** Brings down the total Erlangs from **I11**.

12. **Cell E16:** Brings down the total Erlangs due to growth from **J11**.

13. **Cell C17 and E18:** The given PTT duration in seconds.

14. **Cells C20 - G20:** Uses the Erlang Magic in the back ground to produce the number of channels.
    a. Assuming 12.5 KHz channel spacing for all calculations.
    b. **Cell C20: =** number frequencies needed for a FDMA system.
    c. **Cell D20: =** number frequencies needed for a 2-slot TDMA system.
    d. **Cell E20: =** number frequencies needed with growth factor for a FDMA system.
    e. **Cell F20: =** number frequencies needed with growth factor for a 2-slot TDMA system
    f. **Cell G20:** = number frequencies needed with growth factor for a 4-slot TDMA system

15. **Cells C21 – G21:** Displays available Talk Paths.

16. **Cells C22 and E22:** The probability that call will get busy **lasting one second for less.**
    a. In this example there is 1.82% probability that subscriber will get a busy of 1sec or less.
    b. A busy of one second or less is considered acceptable.
    c. A probability is the long-term chance that a subscriber will get a busy.

17. **Cells C23 and E22:** The probability that call will get busy **lasting more than one second.**
    a. In this example: 0.42% probability that subscriber will get a **busy lasting for more than 1 sec.**
    b. As long as this as this number is 1 or less the system is meeting GoS of 1 second.
    c. This number can be used as a great indicator as to how many radios can be added before another channel is needed.
    d. Refer to Figure 10 for graphical view of this feature.

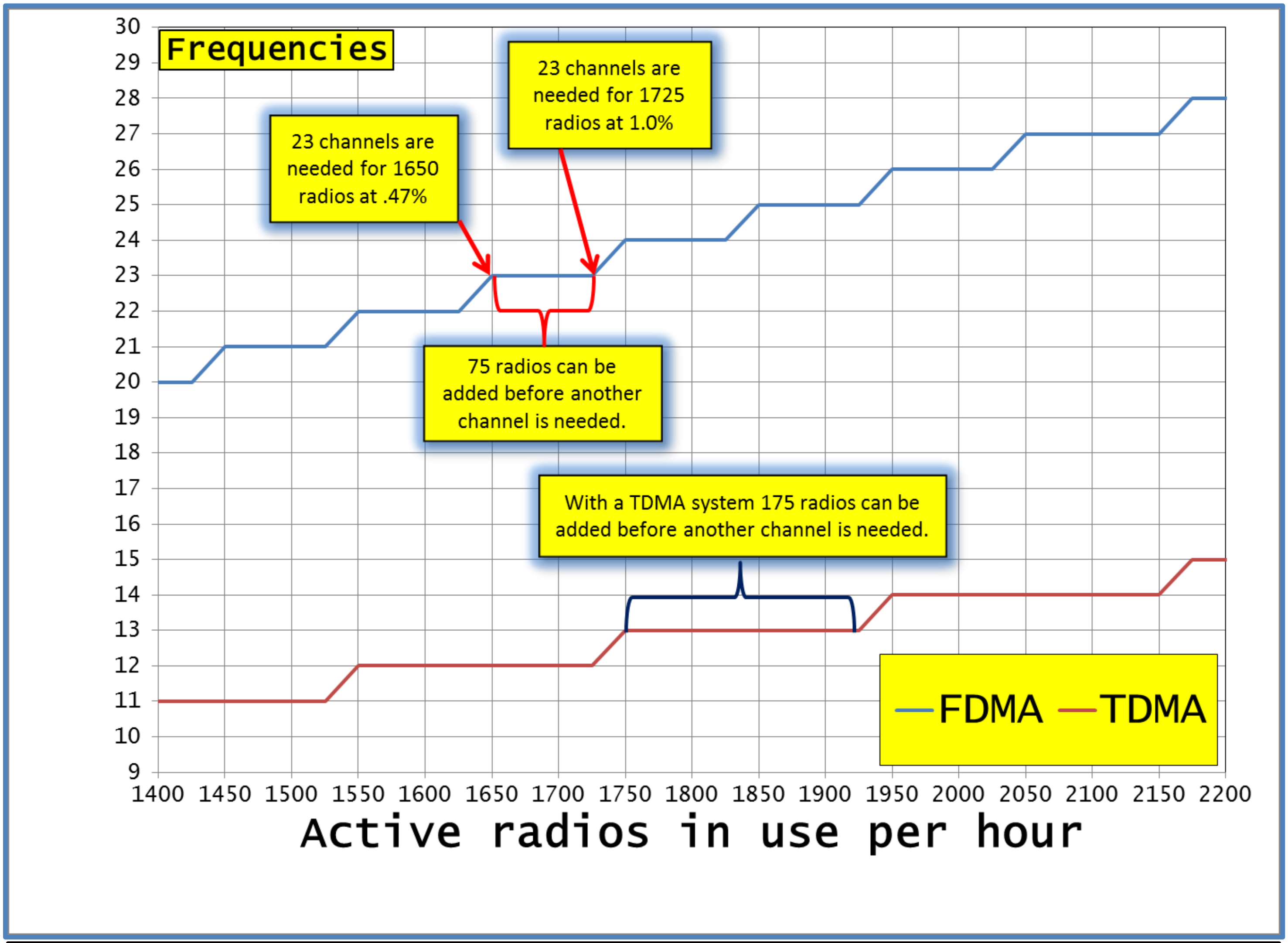

Figure 10: Correlation between number of radio and frequencies needed.
The probability percent in **Cell C23** can used as indicator to determine how close the system is loaded before another is needed. For example, if in the above system starts out with 1650 radios the calculator determine that 23 channels are needed with low probability of .47%. Than 75 more radios can be added before another channel is needed. Adding one more radio will jump the channel count up to 24 when the less than 1 second probability number reaches 1 %.

18. Cell E24 and E25: Can be used to calculate necessary channel capacity to handle system growth.

a. **E24:** Add percent growth.
b. **E25:** Numbers of years.

19. Cells J21 through K25 calculate radios per frequency and number of active radios per hour per freq.

SECTION 4: Reference

Affiliations on the trunked system

The empirical data used for this study only considered radios that generated PTT's. It **did not** consider affiliations directly but considered the impact of adjacent simulcast cells.
A separate program was run that analyzed the ATIA (Air Traffic Information Access) data from the master site to determine at which site the call was originated at or at which site the call was involved in.

There are (4) four primary analog simulcast sub-systems (cells) and (2) two analog trunked repeater (IR) sites that provided the data.

1. WEST: Six channel four site simulcast.
2. WCCCA Central: Sixteen channel seven site simulcast.
3. MTN Road: Five channel IR site.
4. C800 Central: Ten channel six site simulcast.
5. East: Seven channel three site simulcast.
6. Goat: Seven channel IR site.

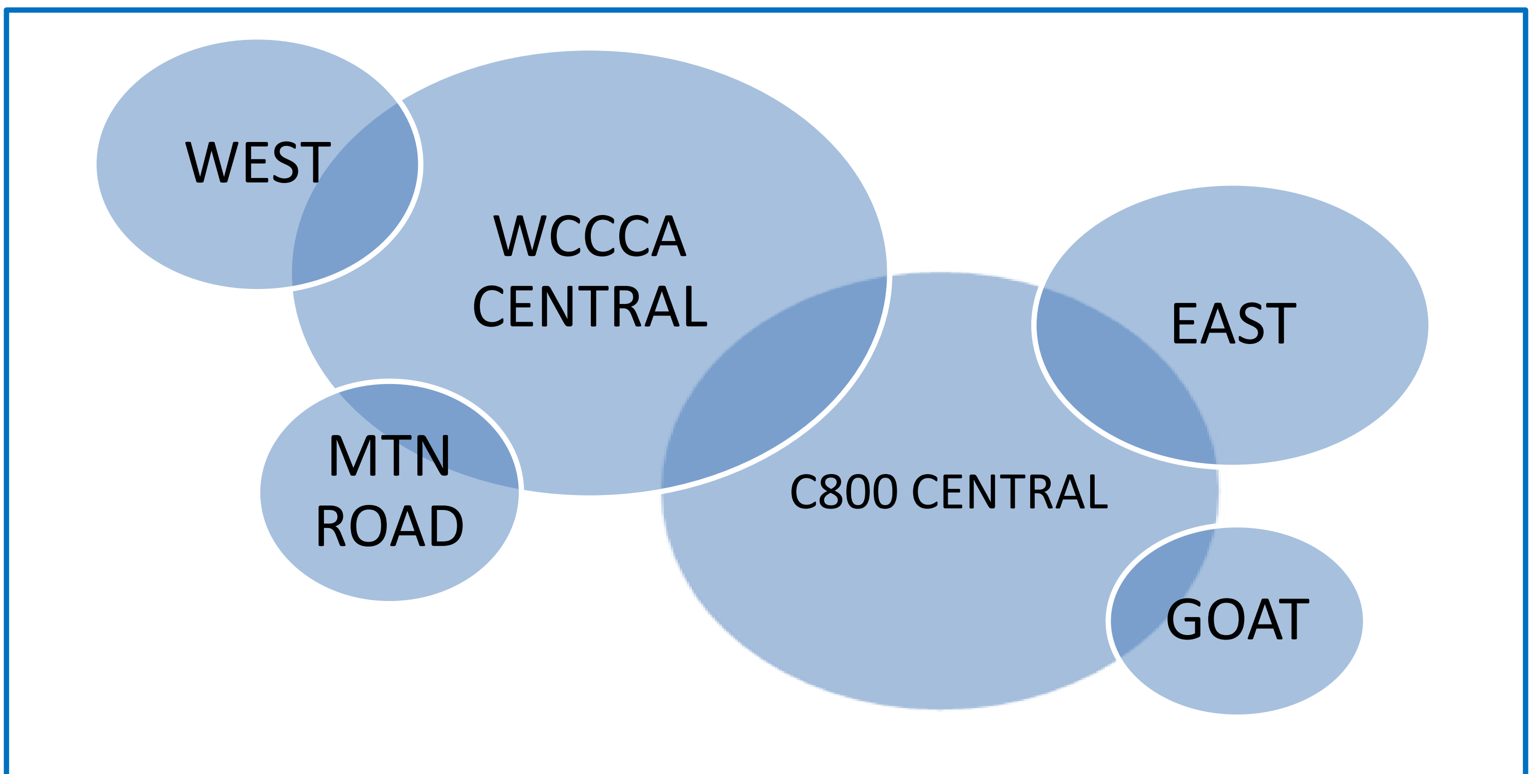

Figure 11: General configuration or the C800/WCCCA 800 MHz trunked radio system that covers Washington and Clackamas Counties in Oregon, USA

The Genesis program extracted empirical data from all six sites that was used in the study.

Site Originations vs: Site Involvement

The WCCCA Central simulcast provides the majority of the coverage for the WCSO (Washington County Sherriff's Office) subscribers and home of the WCCCA dispatch center. The C800 Central simulcast provides the majority of the coverage for the CCSO (Clackamas County Sherriff's Office) subscribers and home of C800 dispatch center.

The ATIA data discovered that about 95% of the WCSO radios originated their calls on the WCCCA Central simulcast system and that about 97% of the CCSO radios originate their calls on the C800 Central Simulcast system. This data is what was used to provide PTT count for this study.

Now the ATIA data revealed that about 81% of the WCSO calls were involved on the C800 system and that about 95% of the CCSO calls were in involved on the WCCCA system.

This is where radio affiliations come into play. One definition of affiliation:

The process in which a subscriber unit signals to the system which talkgroup or site it is currently associated with.

As seen in **Figure 11** there is considerable overlap between the WCCCA central and C800 central systems, plus there considerable amount of varying terrain that can affect signal levels. What this indicates is that about 81% of the time that when the WCCCA dispatch generates a WCSO call there is a WCSO unit affiliated on the C800 central system. For all practical purposes what this means is that every time the WCCCA dispatch calls a WCSO unit it needs a channel on both the WCCCA central and C800 central simulcast systems.

Since the C800/WCCCA system has no site restrictions, it allows all units/talkgroups to access all sites. Digging deeper into the data reveals that there is the small amount of involvement on all the calls for a majority of originated calls.

The calculator as portrayed in back in **Figure 9** is assuming that 100% of the CCSO traffic is on the WCCCA central system. A different result would be calculated if the CCSO units were not allowed in the WCCCA central system. If this were the case, than the channel requirement would drop from 12 channels to 10 channels.

The flexibility of this calculator allow one to simulate various table top scenario's to study channel loading impacts different system programming configurations.

Considering Data

If heavy use of P25 enhanced data is considered than it would be recommend that dedicated additional channel(s) could be added.

Talk Groups vs: Radios

The number of radios doesn't necessarily determine channel loading. One thousand radios on (1) one talkgroup would only need (1) one channel. Of course that is not practical, however, as **Figure 12** even with 75 Talk Groups only the top 16 significantly impact the system traffic load.

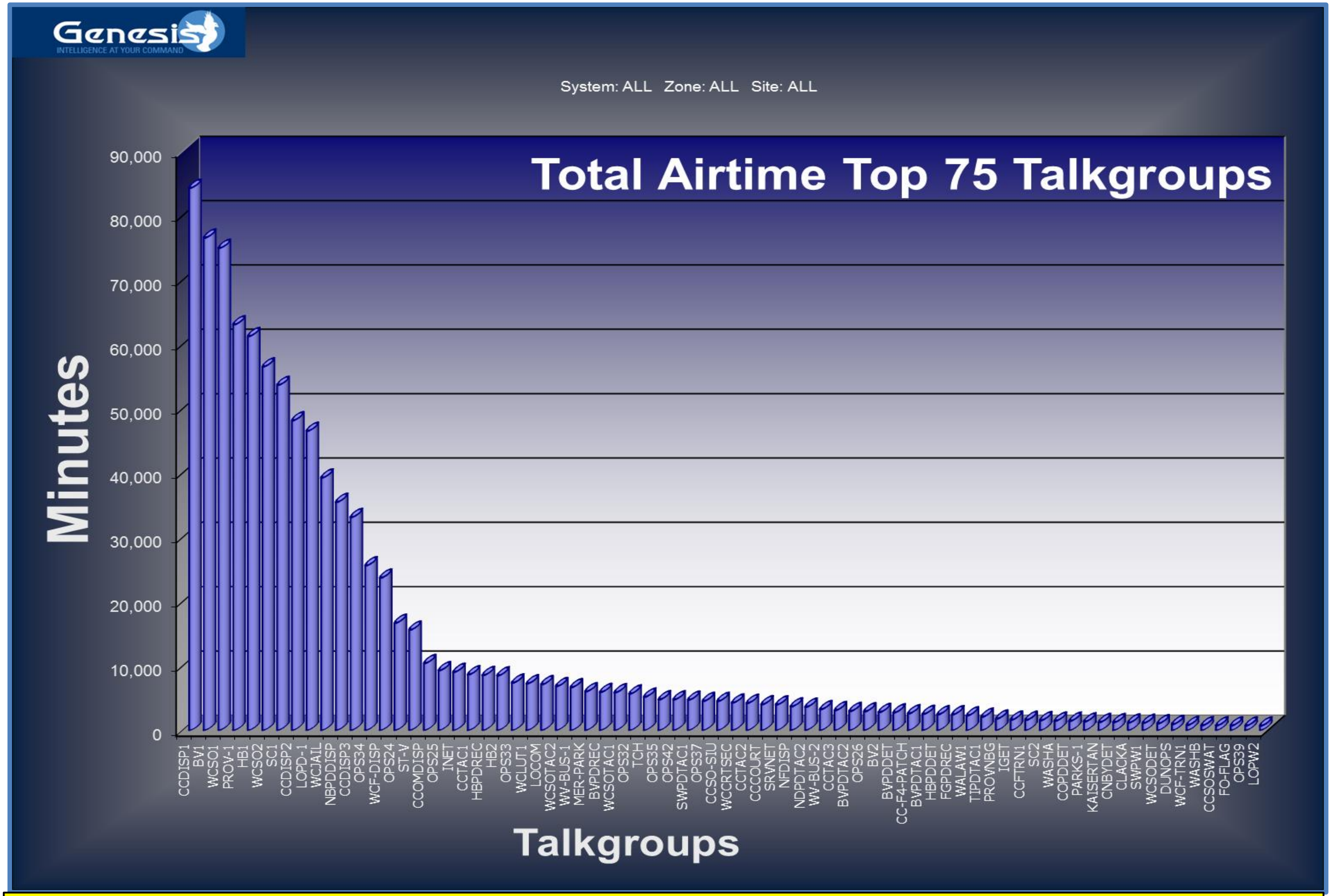

Figure 12: Graph showing Total Airtime for the 75 Talk Groups. However, only the top 16 actually contribute a fair of amount channel loading to the system.

Some might find the following data useful for analyzing radio dispatcher time of evolvement with radio traffic during a one hour period. Another important that can be extracted from this data is the number of active radios per Dispatch position per Talk Group. **This data indicated that around 41 radios max per hour per Talk Group per Dispatch position.**

WCSO1 Dispatcher Radio Involvement time

- **41** Radios Per Hour
- **7** PTT's per radio per hour
- **4** seconds duration per PTT
- 41 times 7 = 287 PTT's per hour
- 287 times 4 seconds = 1,148 seconds = 19 minutes of airtime per hour
- Assume 3 PTT's per conversation = 287/3 = 96 conversations per hour
- Each conversation = 4 seconds times 3 PTT's = 12 seconds airtime per conversation Add 1 seconds per PTT to pick up mic,etc = 12 + 3 = 15 seconds per conversation.
- Add 10 sec for dispatcher to update CAD entries. 15 + 10 = 25 sec per conversation **Dispatcher involvement** = 96 conversations x 25sec = **40 minutes per hour**

References

Final report of the PSWAC (Public Safety Wireless Advisory Committee) 1996
Page 702 has some calculations that predicted future busy hour airtime.
It states that each officer would generate 3.7 minutes of airtime per hour.
And that one message is comprised of (3) three (5) five second transmissions.
Interesting that data in this document refers to the book by Garry G. Hess.

Land-Mobile Radio System Engineering by Garry G. Hess 1993
Chapter 13 in this book addresses engineering aspects of a radio system's capacity to carry messages, or radio traffic.

The message times per call were based on early 90's data. This was before the wide spread use mobile data and cell phones and telephone interconnect on the trunking system. The author believes that today's call lengths are much shorter and therefore more users per channel is possible.

This basic layout would not have been possible without all the help from **Guy Jouannelle** at Televate LLC.

Many thanks to EF Johnson. http://go.efjohnson.com/systemdesign