E9-1-1 Voice Circuit Requirements

Providing a P.01 Grade of Service

Technical Information Document (TID)

NENA E9-1-1 Voice Circuit Requirements, Providing a P.01 Grade of Service Technical Information Document (TID)
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Acknowledgments:

The National Emergency Number Association (NENA) Network Technical Committee developed this document.

NENA recognizes the following industry experts and their companies for their contributions in development of this document.

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1 Executive Overview

1.1 Purpose and Scope of Document

The purpose in determining voice circuit requirements for an E9-1-1 Trunk Group is to provide a transmission Grade of Service (GOS) for each 9-1-1 caller that is at least P.01 (probability that no more than one call out of 100 attempts made during the average busy hour will be blocked) and that, where available, physically diverse routing is being used between nodes. In no case is it ever recommended that voice circuits be designed at less than P.01 Grade of Service (GOS). Note that P.01 can also be described as P0.01 in the industry. In this document that are to be considered as synonymous.

1.2 Reason for Issue

This document is issued to serve as a technical reference guide or tool to size an E9-1-1 Trunk Group to provide a P.01 Grade of Service (GOS). If you choose to overflow your 9-1-1 calls to an alternate facility type you may need to seek traffic engineering assistance.

Note 1: The method described in this document does not apply to the IP side of the E9-1-1 gateway, nor does it apply to the VoIP i3 solution. All references moving forward to wireline also apply to the VoIP I2.0 Rev. 1 solution.

Note 2: The NENA Technical Committee takes no position on the use of separate trunk groups between wireline and wireless calls. If separate trunk groups are in operation, this tool should be applied individually to each trunk group. If wireless and wireline trunk groups are separate and one overflows to the other, the results of peg count studies at the PSAP will be skewed. In the case of a wireless trunk groups overflowing to a land-line trunk group one must keep in mind that a peg count of the land-line group could contain calls that are wireless depending on the busy condition of the wireless trunk group.

Note 3: Call blocking in the E9-1-1 network is a necessity as a result of congestion control, but will be minimized by use of a P.01 GOS[1].

1.3 Reason for Reissue

NENA reserves the right to modify this document. Upon revision, the reason(s) will be provided in the table below.

Version	Date	Reason For Changes
Original	4/13/2007	Initial Document

[1] See Nena Standard NENA 03-006, *E9-1-1 Call Congestion Management*.

1.4 Recommendation for Standards Development work

This Technical Information Document (TID) does not require Standards Development work. The document is not intended to be a standard but rather is intended to serve as a technical tool or reference guide to achieving a P.01 GOS in any given E9-1-1 trunk group.

1.5 Costs Factors

The implementation of a P.01 GOS on all 9-1-1 trunk groups may be impacted by cost. Consideration of network redundancy or the lack of redundancy, and network implementation may be associated with cost factors in achieving a P.01 GOS.

1.6 Acronyms/Abbreviations/Definitions

This is not a glossary! See NENA 00-001 - NENA Master Glossary of 9-1-1 Terminology located on the NENA web site for a complete listing of terms used in NENA documents.

The following Acronyms are used in this document:	
CCS	Hundred Call Seconds
GOS	Grade of Service
P.01	Probability of one (1) call in one (100) hundred calls being blocked

1.7 Intellectual Property Rights Policy

1.7.1 General Policy Statement

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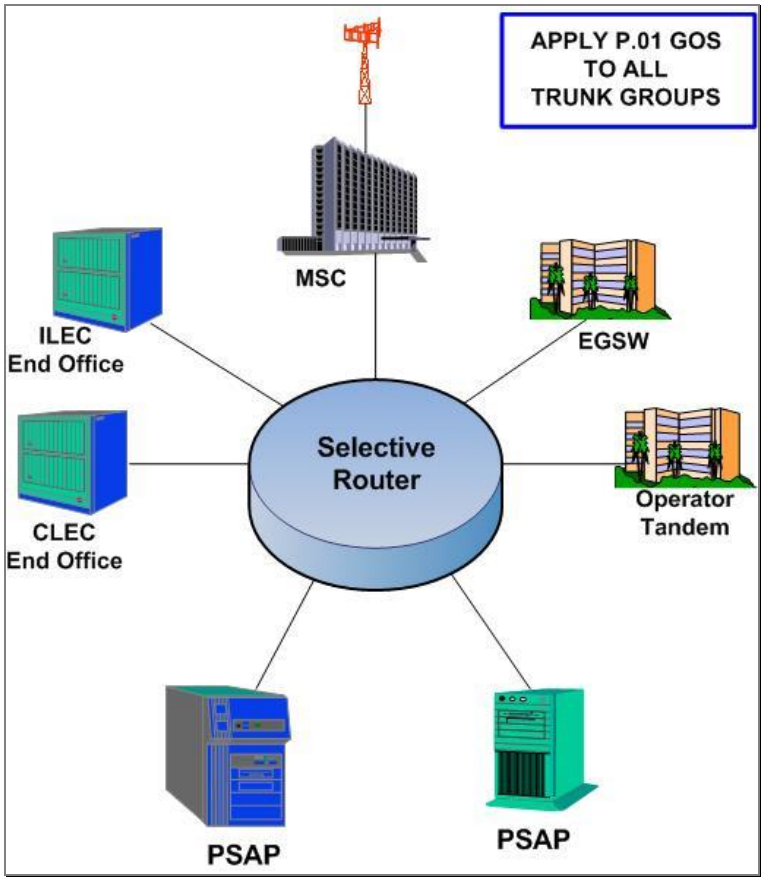
2 Technical Description

2.1 Introduction

This document is intended to provide information and straightforward instructions to determine the number of trunks required in a 9-1-1 trunk group to provide a P.01 Grade of Service (GOS). This method will apply between any of the following: End Office to Selective Router (SR); SR to PSAP; E9-1-1 gateway to the SR; Mobile Switching Center (MSC) to SR.

While this document is primarily targeted to the PSAP Manager community, the methodology described herein applies to all entities involved in the provision of 9-1-1 emergency service. Any network service provider (including but not limited to traditional wireline, wireless and VoIP) who claims compliance with NENA standards will engineer 9-1-1 trunk groups to not less than a P.01 Grade of Service (unless otherwise negotiated with the PSAP authority) using industry accepted methodologies like those described in this document, and detailed further in NENA 03-006 – NENA Standards for E9-1-1 Call Congestion Management.

A simple drawing intended to depict the various types of networks that should be engineered to provide a P.01 Grade of Service is provided on the following page.



This document is based on utilizing the Poisson Traffic Theory & associated Trunk Requirements Table, which is provided in this document (see appendix A). To utilize the Poisson Theory and the Trunk Requirements Table it will be necessary to understand the meaning of "providing a P.01 Grade of Service", and the method of determining CCS, or Hundred Call Seconds. NENA Standard **NENA 03-006,** *E9-1-1 Call Congestion Management* recommends that a 9-1-1 trunk group always be engineered to provide at least a P.01 Grade of service and have a minimum of two (2) trunks in every trunk group. Although this document uses the Poisson method to achieve a P.01 GOS it must be noted that Poisson is one of several methods that can be used to achieve this goal. 9-1-1 Trunk Groups should always be designed to a P.01 GOS as recommended in NENA Standard **NENA 03-006,** *E9-1-1 Call Congestion Management*.

2.2 P.01 Grade of service (GOS)

P.01 GOS, as it relates to 9-1-1 voice circuits, defines for the types of calling patterns characteristic of 9-1-1 calls, how many voice circuits are required to ensure that no more than one 9-1-1 call out of 100 attempts made during the average busy hour will exceeds the capacity of the trunk group and result in blockage. Providing a P.01 GOS is a NENA Standard[2].

2.3 Hundred Call Seconds (CCS)

The primary factor in the Poisson Trunk Tables is known as "CCS", or one hundred call seconds. The first "C" stands for Centum (the Roman numeral for 100) and the following "CS" stands for Call Seconds. Therefore, one CCS = 100 Call Seconds, or 100 busy seconds. The CCS is a unit of telecommunications call traffic density on a channel or trunk equivalent to 100 seconds.

To determine CCS for a 9-1-1 call center you first need to determine the number of 9-1-1 calls that occur during the PSAP's Average busy Hour. Then you must determine the average length of time it takes to complete these calls during that hour. Multiply the number of 9-1-1 calls that occur during the average busy hour by the average length of those calls, then divide by 100. For example: if you have 200 9-1-1 calls during the average busy hour with an average length of 60 seconds you would multiply 200 x 60 which = 12,000 seconds. Then, dividing 12,000 by 100 you get 120 CCS.

2.4 General Overview of the Poisson Trunk Sizing Method

Siméon-Denis Poisson (1781-1840) was a French mathematician and physics scholar. In *Recherches sur la probabilité des jugements en matière criminelle et matière civile (Research on the Probability of Judgments in Criminal and Civil Matters)*, an important work on probability published in 1837, the Poisson distribution first appears. The Poisson distribution expresses the probability of a number of events occurring in a fixed time if these events occur with a known average rate, and are

[2] See Nena Standard **NENA 03-006**, *E9-1-1 Call Congestion Management*, section 2.3.2.

independent of the time since the last event.[3] Since inbound 9-1-1 calls are generated in a totally random manner, his theory is ideal for this application.

The primary factor in the Poisson Trunk Tables is known as "CCS", or Hundred Call Seconds, The math required to use the Trunk Requirements Table shown in Appendix "A" is also very straightforward. It is as follows:

(a) Determine the average length of time, in seconds, that a 9-1-1 call is in progress.

(b) Determine the total number of 9-1-1 calls that occur during the "average busy hour"

(c) Multiply the number of average busy hour calls by the number of seconds per call

(d) Divide your answer by 100.

(e) The answer equals the number of CCS of traffic occurring during the average busy hour

(f) Consult the Trunk Table under the P.01 Grade of Service to determine the number of circuits required to provide that grade of service. Hint, for good Public Safety Grade of Service, round up to the next trunk if the CCS falls between two different trunking levels.

2.5 Applying Poisson to the PSAP

Determine the number of 9-1-1 activities that occur during your average busy hour. How many 9-1-1 calls are received during your average busy hour? You should review peak times such as New Years Eve or some local event to reach this determination.[4] If you do not have detailed statistics available, you can use industry accepted assumptions[5] to estimate trunking needs for new service, or where extensive measurement is not possible. Generally:

- There are 1.5 to 3.0 people per telephone main station, say 3 people;
- An estimated 10 to15% of the total calls on the busy day of the average week will be placed during the busy hour of the day, say 12%;
- One 9-1-1 call per thousand people per day can be expected in a rural area;
- Two 9-1-1 calls per thousand people per day can be expected in an area with over 25,000 population or within five miles of such a suburban area; and
- Three 9-1-1 calls per thousand people per day can be expected in an urban area.

[3] http://en.wikipedia.org/wiki/Poisson_distribution

[4] Some jurisdictions have statutes or policy dictating specific parameters. For example, Minnesota's 9-1-1 law and rules require: "no more than one call out of 100 incoming calls will receive a busy signal on the first dialing attempt during the busy hour of an average week during the busy month."

[5] For more on sizing assumptions, see Nena Standard NENA 03-006, section 2.3.4.

If you do not have actual call volume statistics, you can also utilize the Call Taker Instructions in Appendix "B" and the call tally sheets in Appendix "C" & "D".. These are intended to assist you in making a manual count of calls-for-service in your PSAP.

Next, determine the average length of time for handling a 9-1-1 call. If you have an MIS System with your CPE, these average times can usually be derived from those reports. If not, you may need to sit and observe Call Takers and time a number of calls to determine the average length of a 9-1-1 call in your PSAP. Count time from call setup to completion (release) of the call when sizing trunk groups, or until completion of the CAD Dispatch Incident, including wrap-up time if you are determining staffing needs. It is better if you are able to differentiate between Land Line and Wireless calls since, typically, a Wireless call will require a different handling time. If you have no other data, a reasonable average is 60 seconds for a Land Line call and 90 seconds for a Wireless call.[6]Multiply the number of activities (9-1-1 calls) times the average length of the activity to determine total busy seconds during the average busy hour. For example, 120 Land Line calls X 60 seconds each = 7,200 Busy Seconds, plus 80 Wireless calls X 90 seconds = 7,200 Busy Seconds for a Total of 14,400 Busy Seconds during the Average Busy Hour.

Next, divide the total busy seconds by 100 to determine the CCS - 14,400 Busy Seconds ÷ 100 = 144 CCS of Traffic.

If you are only concerned with what you need for today, you can refer directly to the Poisson Traffic Table in Appendix "A".

If you plan to split your Land Line Trunks and your Wireless Trunks into two groups, do the math separately for each of the above scenarios. This would tell you that you have 72 CCS of traffic for each type of trunk group.

Now, we can look at our chart and find that in order to provide a P.01 grade of service to answer our 200 calls, we would need for our 144 CCS of Traffic, today, ten (10) 9-1-1 Trunks. Actually 10 Trunks = the ability to handle an offered load of 149 CCS, but you should always round up to the next trunk for a Public Safety service level.

There is another factor that needs to be taken into account. If your call takers also answer 7-digit non-emergency calls, e.g. the listed number for Police and/or Fire, we need to do the same math to help determine the additional call load and the personnel required to handle those calls. In other words, add the total CCS for 9-1-1 traffic to the CCS of 7-digit call traffic to determine the real total call load and therefore, the number of personnel needed to handle the calls in a prompt and efficient manner.

Now that we know what today's requirements are, contact your local jurisdiction Planning Department (or what ever the department is named who can provide the information we need). Determine your jurisdiction's population during the most recent Census and ask; what is our population expected to be 15 and 20 years from now? Determine the percentage of growth

[6] Some jurisdictions have statutes or policy dictating specific parameters. For example, Minnesota's 9-1-1 law requires the use of an average call time of 70 seconds.

anticipated and multiply that percentage by the original total CCS of Traffic. The new total CCS will tell you how many trunks you should plan space for in your facility.

Lastly, be aware that this math also works to help answer the "How many dispatchers do I need?" question. The math is the same, but typically, the type of dispatch needs to be considered, especially if you do not have a CAD system that can provide the detailed information required to determine the average time it takes to handle Police, Fire and EMS dispatch incidents, along with other dispatcher activities such as Traffic Stops and NCIC Wants & Warrant checks. Generally, Fire Dispatch incidents, including the Dispatcher monitoring Fire Ground radio channels take longer than a Police Dispatch. If the Dispatcher tracks an EMS unit through the Hospital ER, this type of incident can require even more time than a Fire Dispatch.

The aforementioned formulas for 9-1-1 trunking calculations assumed that you are equipped with some type of 9-1-1 MIS that will allow you to gather information regarding number of activities and average call handling times, along with having a CAD System that provides any information you need to calculate dispatcher activities. If this is not the case in your jurisdiction, you can also contact your local telephone company, which can provide you with a traffic study that contains above-mentioned calls-for-service statistics. If for some reason this information is unavailable to you, this document provides some sample manual peg count forms to allow you to gather basic traffic information (see Appendix "C" & "D").

3 References

1. NENA 03-006 – NENA Standards for E9-1-1 Call Congestion Management
2. NENA 03-501 – Network Quality Assurance TID Issue 2
3. http://en.wikipedia.org/wiki/Poisson_distribution

4 Exhibits

Appendices begin on the next page.

4.1 APPENDIX "A" – Poisson Trunk Requirement Table

Poisson Trunk Requirement Table

QTY. REQ'd.	Total CCS Time					
	P0.001	P0.005	P0.01	P0.02	P0.03	P0.04
1	0.1	0.2	0.4	0.7	1.1	1.5
2	1.6	3.7	5.4	7.9	9.7	11.3
3	6.9	12.2	15.7	20.4	24.0	26.9
4	15.4	24.2	29.6	6.7	41.6	45.7
5	9.0	38.9	46.1	55.8	61.6	66.6
6	40.0	55.4	64.4	76.0	82.8	89.3
7	54.7	73.4	83.9	96.8	105	112
8	70.9	92.5	105	119	129	137
9	88.2	113	126	142	153	162
10	107	134	149	166	178	188
11	126	156	172	191	204	214
12	145	178	195	216	230	240
13	166	201	220	241	256	267
14	187	224	244	267	283	295
15	208	248	269	293	310	322
16	231	273	294	320	337	360
17	253	297	320	347	365	378
18	276	322	346	374	392	407
19	299	347	373	401	420	436
20	323	373	399	429	449	465
21	346	399	426	458	478	494
22	370	424	453	486	507	523
23	95	451	480	514	536	552
24	419	477	507	542	564	582
25	444	504	535	571	593	611
26	469	531	562	599	623	641
27	495	558	590	627	652	671
28	520	585	618	656	682	701
29	545	612	647	685	711	731
30	571	640	675	715	741	762
31	597	667	703	744	771	792
32	624	695	732	773	801	822
33	650	723	780	80	831	852
34	676	751	789	872	861	883
35	703	779	818	862	891	913
36	729	807	847	892	922	944
37	756	836	878	922	952	975
38	783	864	905	952	982	1006
39	810	892	935	982	1013	1037
40	837	921	964	1012	1043	1069
41	865	950	993	1042	1074	1099
42	892	979	1023	1072	1104	1130
43	919	1008	1052	1103	1136	1161
44	947	1036	1082	1133	1166	1192
45	975	1066	1112	1164	1197	1223
46	1003	1095	1142	1194	1228	1255
47	1030	1124	1171	1225	1259	1286
48	1058	1153	1201	1255	1291	1317
49	1086	1183	1231	1286	1322	1349
50	1115	1212	1261	1317	1353	1381

4.2 APPENDIX "B" – Instructions for Peg Count Tally Forms

MEMORANDUM

TO: City of ABCDEF ***DATE:*** March 22, 2006

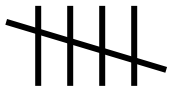
FROM: ***SUBJ:*** *(Peg Count Forms)*

The attached sheets are designed to allow you to easily determine both the number of Emergency calls-for-service received over your 9-1-1 trunks as well as the number of Dispatch Incidents. These numbers are important in the development of the quantity of positions that will be required to handle average busy hour loads. The information will be used for space planning in the new dispatch center.

Please be aware that this study IS NOT intended to determine how hard you are working at your position. Your position is necessary during your shift, irrespective of the call volume handled during any given hour. Please be accurate in counting calls.

We have found that the easiest method of completing these forms is as follows:

- First, at the beginning of your shift, get a blank sheet of paper, divide it into two columns by 9-1-1 Calls and Dispatch Incidents and have it handy to tally each call and dispatch incident, as they are answered and dispatched. To do the tally, by hour, on the blank page, keep what is commonly called a "Domino Score" – example below.

 = **5 CALLS**

- At the end of each hour of the shift, count the number of calls and dispatches, by type, for all positions, and enter into the appropriate hour on the form.

Thank you in advance for assisting in providing this critical information for our study.

4.3 APPENDIX "C" – 911 Call Tally

INCOMING CALL TALLY - EMERGENCY CALLS ONLY

TIME OF	MONDAY		TUESDAY		WEDNESDAY		THURSDAY		FRIDAY		SATURDAY		SUNDAY		HOURLY TOT.	
DAY	ANS.	DISP.	ANS.	DISP.	ANS.	DISP.	ANS.	DISP.	ANS.	DISP.	ANS.	DISP.	ANS.	DISP.	ANS.	DISP.
8:00 A.M.																
9:00 A.M.																
10:00 A.M.																
11:00 A.M.																
12:00 A.M.																
1:00 P.M.																
2:00 P.M.																
3:00 P.M.																
4:00 P. M.																
5:00 P.M.																
6:00 P.M.																
7:00 P.M.																
8:00 P.M.																
9:00 P.M.																
10:00 P.M.																
11:00 P.M.																
12:00 P.M.																
1:00 A.M.																
2:00 A.M.																
3:00 A.M.																
4:00 A.M.																
5:00 A.M.																
6:00 A.M.																
7:00 A.M.																
Total / Day																

GRAND TOTALS

DEPARTMENT NAME _____

NOTE: Tally ONLY Emergency (9-1-1) Type Calls for Service - Please DO NOT Count Administrative Type Calls

4.4 APPENDIX "D" – Administrative Call Tally

ADMINISTRATIVE CALL TALLY

TIME OF DAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY	SUNDAY	TOTAL HOUR
8:00 A.M.								
9:00 A.M.								
10:00 A.M.								
11:00 A.M.								
12:00 A.M.								
1:00 P.M.								
2:00 P.M.								
3:00 P.M.								
4:00 P.M.								
5:00 P.M.								
6:00 P.M.								
7:00 P.M.								
8:00 P.M.								
9:00 P.M.								
10:00 P.M.								
11:00 P.M.								
12:00 P.M.								
1:00 A.M.								
2:00 A.M.								
3:00 A.M.								
4:00 A.M.								
5:00 A.M.								
6:00 A.M.								
7:00 A.M.								
Total/Day								

Grand Total

DEPARTMENT NAME _____

NOTE: Please Tally ONLY Administrative Type Calls - DO NOT Include 9-1-1