September 2019

Final DRAFT Report
911 Dispatch Analysis

Peoria, Illinois

Prepared by:

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CONSULTANT REPORT

PEORIA FIRE DEPARTMENT
Executive Summary Report

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EXECUTIVE SUMMARY

In May 2019 Fitch & Associates (*FITCH*) delivered a final report to the City of Peoria which evaluated the operational performance of the Peoria Fire Department (PFD) and the overall performance in emergency medical services by also assessing the performance of Advanced Medical Transport (AMT) as the EMS transport provider.

During this initial assessment, *FITCH* made recommendations to adjust deployment within the Fire Department, the majority of which were adopted by the City Council. In addition, *FITCH* also recommended a full evaluation on the staffing and operations in the 911 center with the goal of improving performance and most closely aligning with best practices. This current report provides that full analysis of 911 dispatch operations and makes recommendation to enhance its effectiveness and efficiency – further strengthening the operational performance of public safety agencies which utilize the City's 911 dispatch services.

The analysis that follows employs various data sources which permit modeling of performance under various configurations. The major parameters to evaluate these models are Hours-OnTask and workload. Hours-OnTask is the sum of hours required in the dispatch center to be staffed over a single 24-hour period. Workload is characterized by the calculation of Erlangs (described later) and the ability of the 911 center to immediately answer a 911 call from the public (intake) or answer radio calls from first responders in the field (radio consoles). Increasing Hours-OnTask places more personnel in the 911 dispatch center, and results in an improvement in performance. The objective is to define an optimized state where effectiveness of 911 dispatch operations can be achieved in an efficient manner.

Major Findings

Current Operations with Dedicated Intake

Management's preferred configuration of personnel in Peoria's Emergency Communications Center was to have staffing at two telephone intake positions and six radio console positions. The conduct of operations in this configuration was predicated on having enough dispatch personnel available to fill all the seats. This model would require 192 dispatcher Hours-OnTask. The performance of this preferred configuration was modeled under both average incident counts and in the presence of surges in demand – the reported results were lopsided. The intake workstations are understaffed and do not meet FITCH's performance targets. The radio consoles are overstaffed and significantly exceed FITCH's performance targets.

Current Operations with Distributed Intake

When the number of dispatch personnel are restricted, the Peoria Emergency Communications Center functions with only the six radio consoles staffed. The Intake Workstations would not be staffed. As the "next" incident entered the system, the intake function was assigned to a dispatcher at one of the radio consoles. This model required 144 dispatcher hours-OnTask, and met FITCH's performance targets for intake answer delays and radio latencies even after a surge of incidents were used to challenge the model in all 24 hours-of-day.

While distributed intake is a very efficient utilization of dispatcher Hours-OnTask, FITCH is of the opinion that the proficiency of the intake function is degraded compared to the use of dedicated intake dispatchers. FITCH is also of the opinion that this degradation most seriously impacts medical incidents.

Recommendations

Implementation of a Medical Priority Dispatch System

FITCH recommends that intake functions be conducted by Emergency Medial Dispatch certified personnel using Medical Priority Dispatch System protocols, including Pre-Arrival instructions. The City should transition from the current 'paper card-system' to the electronic software version of MPDS which be integrated with CAD systems. It is estimated this transition will have a capital cost of $325,000 to $390,000.

Consolidation of Radio Talkgroups

FITCH recommends that radio talkgroups be consolidated onto as few radio consoles as possible, while still maintaining the FITCH performance target.

Proposed Model

A number of models were constructed and then evaluated against FITCH's performance criteria. These are reviewed in more detail elsewhere in this report. Most of these models were eliminated from consideration because of challenges in meeting performance criteria. An additional model embodying the above recommendations was constructed, and was given the moniker Model N. The intake functions in this model are more complex than those encountered during current operations. Not surprisingly, the Hours-OnTask required at the intake workstations increased compared to current operations. Fortunately, much of the increased Hours-OnTask at the intake workstations was compensated by decreases that were obtained by consolidating radio talkgroups onto three radio consoles. The performance characteristics of this model are summarized below.

Workstations	Dispatchers		Immed Answer %	Composite Answer Delay [sec] @ XXth %-tile
	N x Hr	Hours OnTask		
Model N Intake w MPDS & PreAr	3 x 24 1 x 12	84	95.58%	2.86sec @ 95th
Model N ECC_010203	1 x 24 1 x 12	36	84.24%	1.36 sec @ 97th
Model N ECC_0405	1 x 24	24	81.36%	2.14 sec @ 97th
Model N ECC_07	1 x 24	24	89.17%	0.85 sec @ 97th
Total Hours-OnTask Required		168		

This model requires 168 dispatcher Hours-OnTask and assumes the use of the electronic version of MPDS. The performance of this model conforms to FITCH's performance targets. The conversion of dispatcher Hours-OnTask to FTE's is discussed in the text of the report. Adoption of *FITCH's* recommendation will require an increase in the required minimum staffing from the current 6 positions plus 1 supervisor equivalent to the proposed 7 positions plus 1 supervisor equivalent. In total, it is recommended to fully staff the emergency communications center will require approximately 40 FTEs.

SOURCES OF DATA

The Consultants received the record of operations from the computer aided dispatch system (CAD) in the Peoria Communications Center for the period January 1, 2018 through December 31, 2018 as a Microsoft Excel file containing 366,666 records.

The Consultants received the record of operations on the Peoria radio channels for the period January 9, 2019 through March 5, 2019 as a Microsoft Excel file containing 525,566 records covering the 1,371 hours in this date interval. The Consultants received a Word document titled "Agency and Talkgroups by Radio Console" on March 18, 2019. Activity on 36 specific talkgroups was mapped to six radio consoles on the floor of the Emergency Communications Center based on this document.

The CAD records and the radio records do not cover exactly the same time periods. Since year-over-year changes in the Peoria system are modest, the Consultants believe that both the CAD records and the radio records remain valid representations of current operations in the Peoria system and can be used in the analyses that comprise this report.

METHODOLOGY

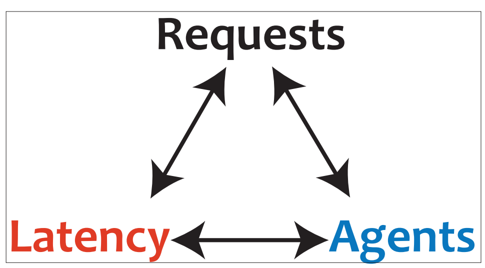
Modelling Dispatch Operations

The rationale for a model of dispatch operations is that it permits FITCH, as well as stakeholders, to pose questions that otherwise could not be addressed in the real world. Computer time is inexpensive compared to conducting the same experiments using the real stream of incoming calls, actual dispatchers and real PSAPs. The model becomes a cost-effective and timely tool for predicting the outcomes after changes have been imposed upon the real system. In turn, the model permits quantitative comparisons between these proposed operations and current operations.

FITCH's approach to the modelling and analyses of dispatch operations is to conduct exhaustive Erlang calculations by hour-of-day at each workstation. There were 30 configurations of workstations included in the models that were included in this report. Each workstation had to be evaluated at all 24 hours-of-day for a total of 720 Erlang C calculations. Such exhaustive applications of Erlang C calculations become feasible only through the use of FITCH's proprietary software.

The goal of Erlang queueing analysis is to calculate the number of agents required to satisfy demands for service impinging on the system without over-provisioning. Erlang's queueing theory makes it possible to quantify the three-cornered relationship between requests for service, number of agents, and latency as depicted in the Figure below.

Figure 1 Queueing Theory Triangle



Latency is the average delay between when a request for service is presented to an agent and when the agent is able to begin processing this next request for service. Latency at the Intake workstations has the special name, "Answer Delay". This is the interval between ring-in and dispatcher pick-up. Latency also occurs at the radio support workstations. In this case, latency is the interval between a field responder keying a transmit and the radio dispatcher acknowledging reception of the transmit. The mathematics and logical assumptions underlying Erlang queueing theory are presented in Appendix A, Erlang Mathematics and Assumptions.

Two measures of latency appear in this report. The first is the percentage of requests for service that are processed immediately, with no delay whatsoever. The larger this percentage, the more responsive the system is considered to be. The second is the maximum delay experienced when processing the first 95% of the incoming request for service. The smaller this number, the more responsive the system is considered to be.

The first step in applying Erlang queueing analyses is to identify the types of workstations used to execute the dispatch functions in the particular system. The second step is to quantitate all of the workloads that comprise the functions executed at each type of workstation in the Dispatch Center.

In queuing theory, workloads are measured in units of "Erlangs". An Erlang is simply the ratio of the summed durations of all the activities at a type of workstation per one hour on the clock. In the modelling that follows, both Erlangs and workloads will be expressed as decimal hours. For example, a workload that requires 15 minutes (00:15:00 hh:mm:ss) for execution will appear as 0.250 Erlang.

Documented Workloads

The first step in quantifying workloads was to import the data exported from the Peoria CAD into a data table in FITCH's proprietary database. A sample record from this data table is presented in the Figure 2, below. The next step was to import data exported from the Peoria Radio Records into a second a data table in the same database.

Figure 2 Sample Master Incident Record from the Peoria CAD

Peoria Emergemcy Communications Center
Master Incidents

Date	Time	Year	Mo	Day	Day Name	Day of Wk	Hr of Day	Hour of Yr
09/22/2018	21:36:27	2018	9	22	Sat	7	21	6,358

Incident_Date	Incident_Number	Incident_Type	KEY
09/22/2018	417	P	09/22/2018 417

Address_1	400 SW JEFFERSON AV
Address_2	PEORIA, IL
Agency_Juris	PA
Dispatch_Code	1032
Medical	
Dispatch_Descriptor	PERSON W/GUN
MPDS_Descriptor	
MPDS_Acuity	

TS_Rcvd	09/22/2018 21:36:27	Field_Init'd		0
TS_Init	09/22/2018 21:37:21	Intv_LDAP	1	00:00:54
TS_Assgn	09/22/2018 21:37:51	Intv_Assgn	2	00:00:30
TS_LastCleared	09/22/2018 21:41:49	Intv_Disp	3	00:01:24

1	00:00:54	elapsed	00:01:07

elapsed_avg

Vehicles Assgn & Arrived

	Agency	Unit ID	TS_Assgn	TS_Arrvd	TS_Clear
1	P	2A08	09/22/2018 21:37:51		09/22/2018 21:38:44
2	P	4F08	09/22/2018 21:37:51		09/22/2018 21:38:51
3	P	2A01	09/22/2018 21:38:44		09/22/2018 21:41:32
4	P	4F03	09/22/2018 21:38:51		09/22/2018 21:41:49
5	P	4F08	09/22/2018 21:39:31	09/22/2018 21:40:20	09/22/2018 21:41:25
6					
7					
8					
9					
10					

First Assigned

Agency	Unit ID	TS_Assgn
P	2A0	09/22/2018 21:37:51

Last Cleared

Agency	Unit ID	TS_Clear
P	4F0	09/22/2018 21:41:49

Sample records from the radio data table are presented in Figure 3, below. The records in this sample cover a one-minute interval on March 4, 2019 from 04:38:00 to 04:38:59.

Figure 3 Sample Records of Radio Traffic in the Peoria System

Radio PTT's Peoria ECC

Hr of Year	Hr of Day	Timestamp	Dur	Site	Target_Alias	Talk Group	Subscriber Alias	Subscriber_ID	ECC Console
1,493	4	03/04/2019 04:38:11	4.1	49	PREP_1	6651	pp_PoliE P	574241	ECC_0102
1,493	4	03/04/2019 04:38:15	0.1	1028	PREP_1	6651	Peoria OP02	579982	ECC_0102
1,493	4	03/04/2019 04:38:15	1.7	1028	PREP_1	6651	Peoria OP02	579982	ECC_0102
1,493	4	03/04/2019 04:38:16	0.1	1028	PREP_1	6651	Peoria OP01	579981	ECC_0102
1,493	4	03/04/2019 04:38:16	1.8	1028	PREP_1	6651	Peoria OP01	579981	ECC_0102
1,493	4	03/04/2019 04:38:28	6.9	1028	CMED_KIC	6737	Peoria OP05	579985	ECC_05
1,493	4	03/04/2019 04:38:40	3.6	49	PREP_1	6651	pp_RoseM	574238	ECC_0102
1,493	4	03/04/2019 04:38:43	0.1	1028	PREP_1	6651	Peoria OP01	579981	ECC_0102
1,493	4	03/04/2019 04:38:43	2.3	1028	PREP_1	6651	Peoria OP01	579981	ECC_0102
1,493	4	03/04/2019 04:38:46	3.2	49	PREP_1	6651	pp_GlorK	574196	ECC_0102
1,493	4	03/04/2019 04:38:49	2.2	1028	PREP_1	6651	Peoria OP02	579982	ECC_0102

Once these raw data for incidents and radio traffic were imported into the FITCH database, these records were then transformed into derived data tables, consolidated by hour-of-year and finally consolidated by hour-of day. Consolidation by hour-of-day is necessary because dispatch performance is to be evaluated by hour-of-day. A sample record of master incidents, consolidated by hour-of-day is presented in Figure 4, below. Seven parameters were extracted from the Master Incident records to produce this consolidation. There are 8,760 hours per year. Construction of the complete derived data table in Figure 4 required the execution of 61,320 queries into the underlying data table.

Figure 4 Consolidation of Master incidents Records by Hour-of-Day

Dispatch ct & dur HoD

Hour_of_Year	1,584	Hour_of_Day	23
RingIn_ct_avg	17.33	RingIn_ct_sd	8.42
Field_ct_avg	3.63	Field_ct_sd	3.43
EMS_ct_avg	2.75	EMS_ct_sd	1.91
LDAP_dur_avg	1,171.04	LDAP_dur_sd	597.94
emsLDAP_dur_avg	235.03	emsLDAP_dur_sd	175.98
elseLDAP_dur_avg	936.01	elseLDAP_dur_sd	521.49
ASSG_dur_avg	359.41	ASSG_dur_sd	184.58

Figure 5 Consolidation of Radio Traffic by Console and by Hour-of-Day

Console ct & dur x HoD

Hr-of-Day 23 **Hr-of-Year** 216

ECC0102_ct	233.00	ECC0102_ct_avg	247.36	ECC0102_ct_sd	49.61
ECC0102_dur	753.20	ECC0102_dur_avg	780.38	ECC0102_dur_sd	162.58
ECC0102PTT_avgdur	3.15	ECC0102_free	6,419.62		
		ECC0102_propor	0.318		
ECC03_ct	39.00	ECC03_ct_avg	62.05	ECC03_ct_sd	32.93
ECC03_dur	146.80	ECC03_dur_avg	225.51	ECC03_dur_sd	112.67
ECC03PTT_avgdur	3.63	ECC03_free	3,374.49		
		ECC03_propor	0.167		
ECC04_ct	34.00	ECC04_ct_avg	21.69	ECC04_ct_sd	17.95
ECC04_dur	154.20	ECC04_dur_avg	78.94	ECC04_dur_sd	72.75
ECC04PTT_avgdur	3.64	ECC04_free	3,521.06		
		ECC04_propor	0.174		
ECC05_ct	1.00	ECC05_ct_avg	27.60	ECC05_ct_sd	41.62
ECC05_dur	5.20	ECC05_dur_avg	152.63	ECC05_dur_sd	202.78
ECC05PTT_avgdur	5.53	ECC05_free	3,447.37		
		ECC05_propor	0.171		
ECC07_ct	39.00	ECC07_ct_avg	50.13	ECC07_ct_sd	30.13
ECC07_dur	142.90	ECC07_dur_avg	173.10	ECC07_dur_sd	109.75
ECC07PTT_avgdur	3.45	ECC07_free	3,426.90		
		ECC07_propor	0.170		
		Total_free	20,189.44		

Two parameters per each of the 36 talkgroups were extracted from the Radio records to produce this consolidation. Activity on each talkgroup was assigned to a specific console on the dispatch floor. There are 1,371 hours of records in the data dump made available to the Consultants. Construction of the complete derived data table in Figure 5, above, required the execution of 98,712 queries into the underlying data table.

The point of quoting the numbers of queries required for building the consolidated data tables in Figure 4 and Figure 5 is to highlight the prodigious amount of bookkeeping that must be executed in order to *prepare* to run dispatch models using Erlang analyses.

Undocumented Workloads

Many of the workloads that legitimately flow to a workstation in Peoria's Emergency Communications Center are not documented in the primary data dumps presented to FITCH. To ameliorate this deficiency, *FITCH* applied its experience with other dispatch systems to identify the absent workloads and fill them in, as best possible, in terms of an average value per incident. Most of these parameters come from FITCH's previous experience in the analyses of other dispatch systems. The goal is to most accurately represent the real levels of activity that occur on the dispatch floor in order to most accurately represent all the tasks that compete for the dispatcher's attention. The undocumented workloads and certain other parameters are presented in Figure 6, below.

Figure 6. Undocumented Workloads in the Peoria ECC

Peoria Emergency Communications Center Parameter Sets for Dispatch Models		
Component of Workloads	**Source of Information**	**Avg Value / Incident**
Temporal distribution of FIRE [f], Emergency Medical [e], and LAW [p & s] incidents	Data tables as taken from the Peoria 2018 CAD	Tabulated for each Hr-of-Day
Temporal distribution of FIRE [f], Emergency Medical [e], and LAW [p & s] radio traffic	Data tables as taken from the Subscriber Activity Report dated 01/09/19 thru 03/05/19	Tabulated for each Hr-of-Day
Location determination & Discipline req'd for response (L & D)	A component of NFPA 1221 Section 7.4.2 and FITCH experience in North American systems	18 sec
MPDS Acuity Assessment	MPDS protocols[1]	120 sec
Pre-arrival interval for Emergency Medical incidents	Data tables as taken from the Peoria 2018 CAD Patient contact: Assgn -> [Arrvd + Pt. Access]	357 sec
Open CAD record for field-initiated incident	FITCH experience in North American systems	15 sec
Wrap CAD record for field-initiated incident	FITCH experience in North American systems	10 sec
Null Ring-In: Proportion of incoming requests for service (Unintentional, misdials, redundant, & prank)	FITCH experience in North American systems	10%
Null Ring-In: Processing duration	FITCH experience in North American systems	36 sec
Proportion of Incidents requiring POTS communications	FITCH experience in North American systems	10%
POTS traffic In-Out (Admin & Info)	FITCH experience in North American systems	120 sec

[1] In a study of high-performing EMS systems, call prioritization time cumulatively reached 91% in 120 seconds or less. See Scott, G., Olola, C., Corike, T., Clawson, J., & Johnson, A. (2016). *Characterization of Call Prioritization Time in a Medical Priority Dispatch System*. Annals of Emergency Dispatch & Response, 4(1), 27-33.

Intake Workstations Performance Targets

Both the National Emergency Number Association, NENA, and the National Fire Protection Association, NFPA, make *recommendations* concerning the conduct of operations at the Intake workstations. As we will see later in this report, the Peoria Emergency Communications Center will need to use variable staffing by hour-of-day. The NENA recommendation only speaks to the busy hour of the day and is silent for the remaining 23-hours. This leaves NFPA as the applicable recommendation.

NFPA 1221, Section 7.4.1, recommends that the answer delay at the Intake workstations should not exceed 15 seconds at the 95th percentile. By defining an outcome, NFPA 1221 leaves open the possibility of variable staffing.

Radio Workstations Performance Targets

To define the base level of service for radio workstations, FITCH took note of a guidance document from the Office of the Canadian Minister of Industry (Industry Canada) titled "Spectrum Management and Telecommunications Policy Guidelines, Channel Loading Guidelines"[2]. This document is formally intended to assess the need for radio spectrum – essentially the determination of how many radio channels (talkgroups) can be accommodated with an allocation of "x" spectrum. However, this document is also insightful for framing the question asked herein – how much workload can a single radio operator handle?

The Ministry specifies that the channel loading analysis of a system that places blocked calls in queue will be based on a traffic theory model that uses a probability of delay and will be normally calculated using the Erlang C formula. Exactly this approach was used in the preparation of these analyses.

The Grade of Service (GOS) for systems with queues is the probability of a response to a call being delayed by busy radio dispatchers and is associated with a latency. The Grade of Service is expressed as a decimal multiple of the Holding Time (HT) on the channel. The Holding Time is the average duration that the radio dispatcher is busy on the call. In the context of radio channels, Holding Time is equivalent to the average duration of the Xmit/Rcv communication cycles on the channel in question. Overall, this is between 7 to 9 seconds in the Peoria system.

The Ministry of Industry recommends for public safety services using queued systems the grade of service should be:

GOS = 0.03 @ 1 HT

[2] Office of the Canadian Minister of Industry. (2003). Spectrum Management and Telecommunications Policy Guidelines, Channel Loading Guidelines. Author. Downloaded from https://www.ic.gc.ca/eic/site/smt-gst.nsf/vwapj/gl004e.pdf/$FILE/gl004e.pdf July 13, 2017

What the recommended GOS means in the context of the Peoria's radio consoles is that responses to 97% of field initiated transmits be responded to by the radio dispatcher in less than the duration of the average Xmit/Rcv duration on the channel, which fall into the range 7 to 9 seconds.

Operational Performance Targets

Intake Workstation

Answer delays are calculated for each hour-of-day at the 95th percentile.
Hourly answer delays are weighted by the event count in each hour.
The weighted average answer delay is calculated over the whole 24 hours.

First Performance Criteria

Weighted average answer delay over 24 hours < 10 seconds @ 95th percentile.

Second Performance Criteria

Answer delay in any single hour < 15 seconds @ 95th %-tile

Radio Workstation

The average duration of all PTT's at a workstation is calculated for the talkgroups being presented to that workstation.
Answer delays are calculated for each hour-of-day at the 97th percentile.
A single radio talkgroup, staffed with a single radio operator, should not exceed during any 4-hour block an Answer Delay of 2X the average PTT (approx. 7-9) seconds or greater at the 97th percentile.

Surges in Demand

As described above, *FITCH's* analyses of dispatch centers quantitates the level of staffing required to achieve a given level of performance. This facilitates making policy decisions based on cost-performance or cost-benefit ratios. A certain level of "overstaffing" in a dispatch center is required to absorb the random surges in demand that are expected in any system. A unique capability that *FITCH* brings to the analyses of dispatch centers is that these surges in demand are also quantitated and incorporated in the modelling. Thus, the policy decisions based on cost-performance or cost-benefit ratios may be extended to account for the effects of surges on performance.

The first step in the construction of dispatch models is to collect the averages of workloads flowing across each workstation. *FITCH* then incremented these average workloads in every hour of day by the surge in that particular hour that hits the system one day out of ten. Surges are measured in units of standard deviations represented by the symbol "σ". The methods used to treat surges in this report are presented in Attachment D, Calculation of Surges.

With the +1.28 σ surge added to every hour-of-day, the numbers of dispatchers OnDuty was empirically adjusted over the whole 24 hours until the calculated answer delays or latencies again conformed to the *FITCH* operational targets. The Erlang tables presented in this report reflect operations of the system under average conditions of workload and in the presence of +1.28 σ surges. This approach to surge capacity was a compromise; it is an attempt to design a robust dispatch system without excessive over-provisioning of dispatchers. It must be emphasized that a +1.28σ surge in every hour-of-day, back to back, is a very rare event. It was selected to be a substantive, yet reasonable, challenge to the system.

Sample Intake Workstation Analysis

The analysis of the intake workstations is presented in Figure 7, below. In this particular analysis, a surge of 1.28σ has been applied to workloads in all hours of the day. The conduct of operations at the intake workstation includes application of the Medical Priority Dispatch System protocols with meticulous assignment of medical incident descriptors. In addition, workloads for pre-arrival instructions on life-threatening incidents are also included.

Figure 7. Sample Analysis of Intake Workstation Performance

Year	Dispatch Model	Console	Surge
2018	Model N	Intake w MPDS & PreAr	+ 1.28 σ

Surge	Hour of Day	Avg per Hour-of-Day				Workstation Staffing & Performance		
			Ring-In	Field Init	Σ Erlangs	OnTask	Immediate Answer [%]	Ans Delay @ 95th %-tile
+	0000		25.56	14.75	0.821	3	94.52	3.65
+	0100		21.18	12.56	0.718	3	96.03	2.64
+	0200		17.72	9.15	0.589	3	97.61	1.55
+	0300		15.20	7.90	0.519	3	98.29	1.10
+	0400		12.81	5.89	0.463	3	98.74	0.87
+	0500		10.46	4.03	0.429	3	98.98	0.84
+	0600		11.61	5.59	0.494	3	98.50	1.22
+	0700		19.10	11.15	0.716	3	96.06	2.91
+	0800		25.26	19.34	0.892	3	93.35	4.50
+	0900		31.86	22.84	1.065	3	90.21	7.02
+	1000		34.88	25.90	1.156	4	96.35	1.74
+	1100		34.33	20.85	1.162	4	96.29	1.96
+	1200		32.28	19.59	1.140	4	96.50	1.92
+	1300		34.40	20.43	1.171	4	96.19	2.05
+	1400		34.99	15.18	1.222	4	95.66	2.72
+	1500		35.48	15.14	1.248	4	95.37	2.96
+	1600		36.32	17.88	1.288	4	94.92	3.17
+	1700		34.17	16.46	1.216	4	95.72	2.63
+	1800		33.78	15.56	1.206	4	95.83	2.60
+	1900		32.05	17.15	1.136	4	96.54	1.99
+	2000		31.53	17.94	1.111	4	96.77	1.79
+	2100		31.73	14.41	1.077	4	97.08	1.66
+	2200		26.81	8.99	0.954	3	92.26	7.19
+	2300		26.84	14.14	0.860	3	93.88	4.28
Avg Air-Time per PTT		Average per Hour			Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
			Ring-In	Field Init				
sec		0.00	27.10	14.70	0.944	84	95.58 %	2.86

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Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 95th %-tile
Contiguous	0800	1900	12	95.26 %	2.92
non-Contig			12	96.12 %	2.75

In Figure 7, above, there are nine columns as follows:

Column 1 flags which hours of the day are challenged with a surge, measured in units of σ.

Column 2 presents the hour-of day.

Column 3 is blank and is unused in this model.

Column 4 tallies the average count of FIRE, MEDICAL, & LAW ring-in's.

Column 5 tallies the average count of field-initiated incidents, these are almost exclusively LAW.
Column 6 tallies the Erlangs of workload in that hour-of-day.
Column 7 presents the number of dispatchers OnTask required to meet the performance targets of the model.
Column 8 presents the probability that the "next" request for service will be immediately answered by the dispatcher. This number is the result of an Erlang C calculation specific to this hour-of-day.
Column 9 presented the maximum answer delay at the 95th percentile experienced in that hour-of-day. This number is the result of an Erlang C calculation specific to this hour-of-day.

The box at the upper right corner presents the size of the surge used to challenge performance.
The box at the bottom of column 7, presents the total of dispatcher hours OnDuty required.
The box at the bottom of column 8, presents the 24-hour weighted average Immediate Answer.
The box at the bottom of column 9 presents the 24-hour weighted average Answer Delay.

In examining this table, note that the answer delays at 0900 Hours and at 2200 Hours are both on the high side of strict acceptability. As it stands, this model has the fourth dispatcher OnDuty for 12 hours. To add the fourth dispatcher at 0900 Hours and at 2200 Hours would have this dispatcher OnDuty for 14 hours. This is an "odd" interval of time and might cause scheduling problems on the dispatch floor. FITCH made the decision to keep the scheduling simpler and to accept a small degradation in performance.

Sample Radio Workstation Analysis

Figure 8. Sample Analysis of Radio Workstation Performance

Year	Dispatch Model	Console	Surge
2018	Model N	ECC_123	+ 1.28 σ

Surge	Hour of Day	Avg per Hour-of-Day				Workstation Staffing & Performance		
				PTT's	Σ Erlangs	OnTask	Immediate Answer [%]	Ans Delay @ 97th %-tile
+	0000			333.19	0.304	1	69.57	3.00
+	0100			311.70	0.287	1	71.33	2.78
+	0200			250.15	0.229	1	77.13	2.04
+	0300			256.23	0.237	1	76.30	2.16
+	0400			213.69	0.195	1	80.48	1.66
+	0500			197.22	0.176	1	82.36	1.44
+	0600			188.40	0.170	1	83.02	1.38
+	0700			309.31	0.291	1	70.90	2.90
+	0800			360.78	0.345	2	95.17	0.21
+	0900			341.37	0.324	2	95.67	0.18
+	1000			377.00	0.357	2	94.88	0.22
+	1100			400.87	0.381	2	94.26	0.25
+	1200			422.48	0.401	2	93.72	0.28
+	1300			392.70	0.369	2	94.56	0.24
+	1400			391.55	0.368	2	94.58	0.23
+	1500			552.46	0.518	2	90.36	0.46
+	1600			479.31	0.452	2	92.30	0.35
+	1700			445.11	0.403	2	93.68	0.27
+	1800			455.75	0.417	2	93.28	0.29
+	1900			427.64	0.389	2	94.03	0.25
+	2000			409.01	0.368	1	63.15	3.95
+	2100			361.03	0.327	1	67.25	3.32
+	2200			373.73	0.340	1	65.98	3.52
+	2300			394.58	0.358	1	64.24	3.79

Avg Air-Time per PTT	Average per Hour			Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
			PTT's				
3.30 sec	0.00	0.00	360.22	0.334	36	84.24 %	1.36

index 18

Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 97th %-tile
Contiguous	0800	1900	12	93.70 %	0.28
non-Contig			12	70.98 %	2.88

In Figure 8, above, there are nine columns as follows:

Column 1 flags which hours of the day are challenged with a surge, measured in units of σ.

Column 2 presents the hour-of day.

Column 3 is blank and is unused in this model.

Column 4 is blank and is unused in this model.
Column 5 tallies the average count per hour of PTT events at this console.
Column 6 tallies the Erlangs of workload in this hour-of-day
Column 7 presents the number of dispatchers OnTask required to meet the performance targets of the model.
Column 8 presents the probability that the "next" request for service will be immediately answered by the dispatcher. This number is the result of an Erlang C calculation specific to this hour-of-day.
Column 9 presented the maximum answer delay at the 97^{th} percentile experienced in that hour-of-day. This number is the result of an Erlang C calculation specific to this hour-of-day.

The box at the upper right corner of the main table presents the size of the surge used to challenge performance.
The box at the bottom of column 7, presents the total of dispatcher hours OnDuty required.
The box at the bottom of column 8, presents the 24-hour weighted average Immediate Answer.
The box at the bottom of column 9 presents the 24-hour weighted average Answer Delay.
The box at the lower left corner of the main table presents the average duration of a PTT event on the talkgroups presented at this workstation. This number, times 2, becomes the operational target, not to be exceeded, at this console over any consecutive 4-hour block.

DISPATCH MODELS

Current Operations

Current Operations with Distributed Intake

The Peoria Emergency Communications Center often functions with six radio consoles staffed. The dispatchers were primarily tasked with providing radio support to the talkgroups allocated to the respective consoles. As incidents entered the system, the intake function was assigned to a dispatcher at one of the radio consoles.

No details of how the "next" incoming incident was assigned to the radio consoles was provided to the Consultants. The Consultants assumed that intake responsibilities were assigned to radio consoles in inverse proportion to the radio traffic appearing at the consoles. In this way, workloads for radio traffic and workloads for intake functions could be ascribed to each console. If some other distribution strategy was actually implemented, the performance of this model would not change materially.

Erlang calculations were then conducted for each hour-of-day for each of these consoles. The results of these Erlang calculations are summarized in Figure 9 and Figure 10, below. Figure 9 presents the summarized performances when average levels of incidents enter the system at each hour-of-day.

Figure 9. Current Operations with Distributed Intake (0.00σ Surges)

Workstations		Dispatchers		Immed Answer %	Composite Answer Delay [sec] @ XXth %-tile
		N x Hr	Hours OnTask		
ECC_0102	w Intake	2 x 24	48	93.96%	0.50 sec @ 95th
ECC_03	w Intake	1 x 24	24	81.65%	3.74 sec @ 95th
ECC_04	w Intake	1 x 24	24	85.41%	4.15 sec @ 95th
ECC_05	w Intake	1 x 24	24	83.22%	5.13 sec @ 95th
ECC_07	w Intake	1 x 24	24	93.11%	0.45 sec @ 95th
Total Hours-OnTask Required			144		

This Model, Current Operations with Distributed Intake, meets FITCH's performance targets when average counts of incidents enter the system.

The Erlang tables showing the hour-by-hour Erlang calculations at each workstation in the Model in Figure 9 above are presented in -APPENDIX C.

Figure 10, below, presents the summarized performances when this model is challenged with 1.28σ surges in each of the 24 hours of the day. A 1.28σ surge represents the increase in incident counts that will "hit" the system one day in ten. The numerical value of the surge is calculated for each hour-of-day based on historic data taken from the Peoria CAD for that hour-of-day. FITCH's treatment of surges insures that challenges to the dispatch models are grounded as solidly as possible to what actually occurred in the Peoria system.

Figure 10. Current Operations with Distributed Intake (1.28σ Surges)

Workstations		Dispatchers		Immed Answer %	Composite Answer Delay [sec] @ XXth %-tile
		N x Hr	Hours OnTask		
ECC_0102	w Intake	2 x 24	48	89.41%	0.99 sec @ 95th
ECC_03	w Intake	1 x 24	24	72.34%	6.13 sec @ 95th
ECC_04	w Intake	1 x 24	24	76.28%	6.19 sec @ 95th
ECC_05	w Intake	1 x 24	24	83.22%	5.13 sec @ 95th
ECC_07	w Intake	1 x 24	24	89.16%	0.76 sec @ 95th
Total Hours-OnTask Required			144		

This Model, Current Operations with Distributed Intake, meets FITCH's performance targets even after a 1.28σ surge of incidents is used to challenge the model in all 24 hours-of-day.

The Consultants note that this model of operations, Current Operations with Distributed Intake, uses personnel very efficiently. The model requires only 144 dispatcher Hours OnTask. The Consultants further note that this efficiency comes with a reduction in proficiency in executing Intake functions. In turn, execution of intake functions at the radio consoles almost certainly degrades the execution of radio support functions.

The Erlang tables showing the hour-by-hour Erlang calculations at each workstation in the Model in Figure 10, above, are presented in APPENDIX D.

Current Operations with Dedicated Intake

In the past, the preferred configuration Peoria Emergency Communications Center was to have staffing at six radio consoles and two intake consoles. In the following text, this model will be referred to as Model A.

Erlang calculations were conducted for each hour-of-day for each of these consoles. The results of these Erlang calculations are summarized in Figure 11 and Figure 12, below. Figure 11 presents the summarized performances when average levels of incidents enter the system at each hour-of-day.

Figure 11. Current Operations with Dedicated Intake (0.00σ Surges)

Workstations	Dispatchers		Immed Answer	Composite Answer Delay
	N x Hr	Hours OnTask	%	[sec] @ XXth %-tile
Model A Intake	2 x 24	48	86.21%	16.76 sec @ 95th
Model A ECC_0102	2 x 24	48	98.44%	0.06 sec @ 97th
Model A ECC_03	1 x 24	24	92.26%	0.65 sec @ 97th
Model A ECC_04	1 x 24	24	96.20%	0.28 sec @ 97th
Model A ECC_05	1 x 24	24	93.97%	0.67 sec @ 97th
Model A ECC_07	1 x 24	24	93.09%	0.51 sec @ 97th
Total Hours-OnTask Required		192		

Model A requires 192 dispatcher Hours OnTask. The answer delay at the Intake workstation does not meet FITCH's performance target. The latencies at the radio consoles are far shorter than FITCH's performance target. The conclusions from these performance parameters in Figure 11 are that the intake workstations are understaffed and that the radio consoles are overstaffed.

The Erlang tables showing the hour-by-hour Erlang calculations at each workstation in the Model in Figure 11, above, are presented in APPENDIX E.

Figure 12, below, presents the summarized performances when Model A is challenged with 1.28σ surges in each of the 24 hours of the day.

Figure 12. Current Operations with Dedicated Intake (1.28σ Surges)

Workstations	Dispatchers		Immed Answer	Composite Answer Delay
	N x Hr	Hours OnTask	%	[sec] @ XXth %-tile
Model A Intake	2 x 24	48	77.46%	32.81 sec @ 95th
Model A ECC_0102	2 x 24	48	97.17%	0.11sec @ 97th
Model A ECC_03	1 x 24	24	87.56%	1.13 sec @ 97th
Model A ECC_04	1 x 24	24	91.71%	0.70 sec @ 97th
Model A ECC_05	1 x 24	24	86.72%	1.60 sec @ 97th
Model A ECC_07	1 x 24	24	89.17%	0.85 sec @ 97th
Total Hours-OnTask Required		192		

The staffing for the model in Figure 12 is the same as in Figure 11. It is held constant at 192 dispatcher Hours OnDuty. The answer delay at the Intake workstation escalates to even longer durations compared to FITCH's performance target. About 5% of the intake callers will be on hold for more than 30 seconds. Even after the 1.28σ challenge, the latencies at the radio consoles remain far shorter than FITCH's performance target. The conclusions from the performance parameters in Figure 12 are that the intake workstations are understaffed and that the radio consoles are still.

The Erlang tables showing the hour-by-hour Erlang calculations at each workstation in the Model in Figure 12, above, are presented in APPENDIX F.

MPDS Intake and Consolidated Radio Support

At the request of Peoria personnel, FITCH constructed a model of dispatch operations with two requirements.

> The intake functions were to be conducted by Emergency Medial Dispatch certified personnel using Medical Priority Dispatch System protocols, including Pre-Arrival instructions.
>
> Radio talkgroups were to be consolidated onto fewer radio consoles, while still maintaining the FITCH performance target.

In the following text, this model will be referred to as Model N.

Erlang calculations were conducted for each hour-of-day for each of the consoles in Model N. The results of these Erlang calculations are summarized in Figure 13, Figure 14 and Figure 15, below. Figure 13 presents the summarized performances when average levels of incidents enter the system at each hour-of-day.

Figure 13. Intake with MPDS & Consolidated Radio Desks (0.00σ Surges)

Workstations	Dispatchers		Immed Answer %	Composite Answer Delay [sec] @ XXth %-tile
	N x Hr	Hours OnTask		
Model N Intake w MPDS & PreAr	3 x 24	72	96.25%	2.74sec @ 95th
Model N ECC_010203	1 x 24	24	74.40%	2.44 sec @ 97th
Model N ECC_0405	1 x 24	24	90.32%	0.95 sec @ 97th
Model N ECC_07	1 x 24	24	93.09%	0.51 sec @ 97th
Total Hours-OnTask Required		144		

Model N meets FITCH's performance targets when average numbers of incidents enter the system. In the absence of surges, Model N requires 144 dispatcher Hours OnTask. Not surprisingly, Model N requires more dispatcher hours-OnTask than Model A at the intake workstations; the intake functions have become more complex. The surprise in Model N is that the judicious consolidation of radio talkgroups permitted radio operations to be conducted using only three consoles. Radio operations in Model N meet FITCH's performance target.

The Erlang tables showing the hour-by-hour Erlang calculations at each workstation in the Model in Figure 13, above, are presented in APPENDIX G.

Figure 14, below, presents the summarized performances when Model N is challenged with 1.28σ surges in each of the 24 hours of the day. Staffing is the same as in Figure 13, above.

Figure 14. . Intake with MPDS & Consolidated Radio Desks (1.28σ Surges)

Workstations	Dispatchers		Immed Answer %	Composite Answer Delay [sec] @ XX^th %-tile
	N x Hr	Hours OnTask		
Model N Intake w MPDS & PreAr	3 x 24	72	90.58%	8.10 sec @ 95th
Model N ECC_010203	1 x 24	24	64.55%	3.99 sec @ 97th
Model N ECC_0405	1 x 24	24	81.36%	2.14 sec @ 97th
Model N ECC_07	1 x 24	24	89.17%	0.85 sec @ 97th
Total Hours-OnTask Required		144		

When Model N is challenged with 1.28σ surges in each of the 24 hours of the day, performance at the Intake workstations and on the ECC_010203 console no longer meet FITCH's performance targets.

The Erlang tables showing the hour-by-hour Erlang calculations at each workstation in the Model in Figure 14, above, are presented in APPENDIX H.

Figure 15, below, presents the summarized performances when Model N is challenged with 1.28σ surges in each of the 24 hours of the day, and staffing is increased on the Intake workstation and on ECC_010203 in order to bring performance parameters into conformity with FITCH targets.

Figure 15. Intake with MPDS & Consolidated Radio Desks (1.28σ Surges)

Workstations	Dispatchers		Immed Answer %	Composite Answer Delay [sec] @ XX^th %-tile
	N x Hr	Hours OnTask		
Model N Intake w MPDS & PreAr	3 x 24 1 x 12	84	95.58%	2.86sec @ 95th
Model N ECC_010203	1 x 24 1 x 12	36	84.24%	1.36 sec @ 97th
Model N ECC_0405	1 x 24	24	81.36%	2.14 sec @ 97th
Model N ECC_07	1 x 24	24	89.17%	0.85 sec @ 97th
Total Hours-OnTask Required		168		

Dispatcher Hours-OnTask increase to 168 in Model N, in the presence of 1.28σ surges. A ½ dispatcher position needed to be added to the Intake workstations. A ½ dispatcher position will need to be added to ECC_010203, but only for a single hour during the interval 0800 – 1900. The ambiguity arises because the Consultant is unable to predict which hour will need the added dispatcher, as discussed below.

The Erlang tables showing the hour-by-hour Erlang calculations at each workstation in the Model in Figure 15, above, are presented in APPENDIX J.

Figure 16. Comparison of Operations on ECC_010203 over the Segment 0800-1900 Hours

Surge	Segment	Dispatchers OnDuty	Segment Statistics	
			Immediate Answer %	Composite Answer Delay [sec] @ XXth %-tile
0.00σ	0800-1900	1	70.97%	2.88 sec @ 97th
1.28σ	0800-1900	1	59.98%	4.79 sec @ 97th
1.28σ	0800-1900	2	93.70%	0.28 sec @ 97th

Operations on the combined radio workstation ECC_010203 requires special examination. Under average workloads, 0.00σ surge, the performance of this workstation with one dispatcher OnTask exceeds targets. When surges that occur one day in ten, 1.28σ, are applied to all hours in this segment, the performance of ECC-010203 approaches the targets at the 97th percentile. When surges that occur one day in ten are applied to all hours in this segment and a second dispatcher added, the performance of ECC-010203 jumps to far above target, 0.28 seconds actual versus the current 3.30 seconds.

In the presence of 1.28σ surges, the workloads in Model N appearing at ECC_010203 are at a cusp. Two dispatchers assigned to ECC_010203 for the full segment 0800-1900 hours is over-provisioning, while one dispatcher will be unable to respond to the next incident quickly enough. The question arises whether it is fiscally responsible to assign two dispatchers to the 0800 - 1900 segment.

A surge of 1.28σ occurs in a given hour one day in ten. There is a low probability that such a surge will hit in two hours back-to-back (probability = 1/10 X 1/10) at ECC_010203. The consequence of a 0.01 probability (1%) is when an overload condition occurs, it will resolve by the following hour and will not reappear in any of the subsequent hours that day during the segment 0800 – 1900.

A possible strategy to resolve the quandary at ECC_010203 over the segment 0800-1900 hours is to have a "spare" dispatcher shadow-in and provide ***temporary*** assistance until the surge in the offending ***single*** hour dissipates.

The probabilities are that this "spare" dispatcher would be called upon to provide assistance at ECC_010203 approximately once per day during the segment 0800 – 1900 Hours. A 1.28σ will hit in a given hour one day out of ten, however, there are 12 hours in the segment 0800-1900 hours. Twelve hours multiplied by a 10% probability per hour is a near certainty that the "spare" dispatcher will be called upon to provide assistance at least once per day, but only for a single hour.

The “spare” dispatcher in this discussion is very lightly utilized and could reasonably be tasked with other duties in the dispatch center.

RECOMMENDATIONS

FITCH recommends that:

- Dispatch operations be configured as outlined in Figure 15.
    - Employ dedicated call-intake positions.
    - Radio talkgroups be consolidated onto three radio consoles.
- Intake dispatchers be EMD certified.
- Emergency medical intake be conducted using Medical Priority Dispatch System protocols employing the electronic software.
- Pre-arrival instructions be provided on life-threatening medical emergencies.

DISPATCH COMMUNICATIONS SHIFT SCHEDULE STAFFING REQUIREMENTS & CONVERSION TO FTE'S

The Erlang calculations of workstation performance is framed in terms of dispatchers Hours-on-Task, that is, dispatchers actively on-duty at their workstations. Having modeled the required Hours-on-Task requirements for each workstation, a conversion to shift staffing requirements and then full-time equivalents (FTEs) is required. The Figure below presents the steps that must be executed in order to convert dispatchers Hours-on-Task to Full Time Equivalents (FTE's).

Figure 17. Conversion of Dispatchers on Task to Full Time Equivalents

Manpower Descriptor	Source
Dispatcher Hours-on-Task	Erlang modelling of the dispatch workstations provides the needed number of hours of dispatchers actively on duty at their workstations.
Dispatchers on Shift	Calculated from dispatchers on task by providing for local work rules, break time policies while on shift, and local contractual obligations.
Full Time Equivalents (FTE) (Dispatchers on Staff)	Calculated from dispatchers on shift by providing for local personnel policies, work rules, and contractual obligations.

As can be seen, a detailed knowledge of local work rules, break time policies while on shift, and local contractual obligations is necessary before dispatcher Hours-on-Task can be translated to FTE's. The conversion of dispatchers-on shift to dispatchers-on-staff, likewise depends on a myriad of details. Both of these conversions are best carried out by the local governing authority with an intimate knowledge of these details.

To determine staffing needs, many governing authorities utilize a staffing estimator and retention rate calculator known as RETAINS, a product of the Association of Public-Safety Communications Officials (APCO). The RETAINS title stands for Responsive Efforts to Assure Integral Needs in Staffing. The estimator is respected as a tool for estimating FTE needs, but ***only after*** the required level of frontline staffing on shift has been otherwise determined. This limitation of RETAINS is not widely understood.

A further limitation of the RETAINS estimator is that it is silent regarding the performance to be obtained from any level of staffing. The RETAINS estimator provides no guidance to policy makers regarding how specific changes in staffing will translate to changes in absolute performance, whether staffing is being under-provisioned or over-provisioned against performance targets.

Time-off used by Peoria dispatch personnel was obtained from the City and is reflected in the Figure below.

Figure 18: Average Time-Off Hours Annually per Employee

Time-Off Category	Average Hours
Vacation-3900	82
Personal-3231	25
Recognition Day-3240	4
Day off in Lieu of Holiday-3206	5
Bereavement-3424	2
Absent Without Pay-3121	2
Sick Without Pay-3122	52
Sick With Pay-3896	67
Worker Comp-3137	0
Total Time-Off	**239**

Figure 19: Staffing Multiplier

Hours in year	8760
Annual Hours Scheduled	2080
Reduce by Total Time-Off	239
Hours Actually Worked per FTE	1841
FTE's Needed per 'Seat'	4.76

Employing a methodology similar to APCO RETAINS, the above figure reflects the calculation of the staffing multiplier. In essence, the full-time equivalent (FTE) required to keep a single seat in the communications center filled 24 hours per day X 365 days in a year. However, specific needs can change depending on specific work rules and shift schedules. We therefore used an approximate multiplier of 4.76 and modeled staffing patterns under several conditions.

Derived from the analysis above, several alternative shift schedules and assumptions were considered. The above modeling reflected the need for 8 positions to be assigned to a 12-hour daytime shift from 0800 through 2000 hrs., and then a need for 6 positions to be staffed for the second 12-hour shift. In addition to these staffed positions, a single supervisor is also required across all hours. This is reflected below.

Figure 20: Staffing Requirements by Hour-of-Day

Hour-by-Hour Requirements	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Total
ETCs	6	6	6	6	6	6	6	6	8	8	8	8	8	8	8	8	8	8	8	8	6	6	6	6	168
Total w/o Supv	6	6	6	6	6	6	6	6	8	8	8	8	8	8	8	8	8	8	8	8	6	6	6	6	168
Supervisor	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	24
Total	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**7**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**9**	**7**	**7**	**7**	**7**	**192**

The alternatives between 8 and 12-hours shifts are reflected below, as is an additional alternative of a 12-hour shift schedule with some additional risk tolerated. While all alternatives are viable for consideration by the City, the primary alternative is to employ and 12-hour shift schedule which covers all risk. After 6-months or greater experience under the revised staffing pattern, managers should consider if other fine-tuning to the schedule can be made.

Full schedules consistent with these models are more fully detailed in Appendix XXX.

Estimated FTE Count		Personnel Hours/Wk	Personnel Hours /Yr	Annual Scheduled Hours	FTE's Required
12 hour shifts Covering all risk	Demand with Breaks	1512	78624.0	2080	37.8
	Demand	1344	69888.0	2080	33.6
	Suggested Staffing	1596	82992.0	2080	39.9
8 hour shifts	Demand with Breaks	1512	78624.0	2080	37.8
	Demand	1344	69888.0	2080	33.6
	Suggested Staffing	1568	81536.0	2080	39.2
12 hour shifts some risk	Demand with Breaks	1512	78624.0	2080	37.8
	Demand	1344	69888.0	2080	33.6
	Suggested Staffing	1512	78624.0	2080	37.8
			Est. FTE Count	Demand with Breaks	113.4
				Demand	100.8
				Suggested Staffing	116.9

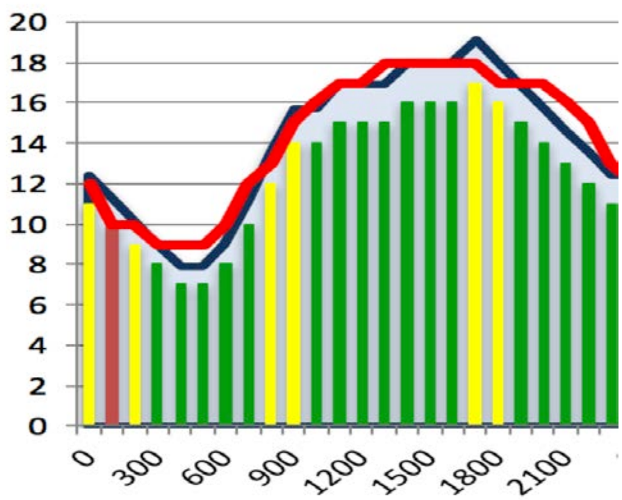
Applying the hour-by-hour analysis reflected above, a scheduling optimization program was utilized to develop alternate shift schedules, and thereafter determine FTEs requirements for each alternative. Alternative shifts were considered in this analysis, including the use 8-hour and 12-hour shifts. Because of the hour-by-hour requirements reflected above, 8-hour shifts were found to be generally inefficient. The modelling therefore focused on 12-hour shifts. The two alternative approaches were then applied, with a modified risk tolerance completed for the 12-hour shift.

The graphical representation reflects the required seats with 24 vertical bars, each representing an hour of the day and are color-coded. Green reflects good coverage, yellow reflecting minimally meets the coverage requirement, and red reflecting a deficit in coverage. The solid red line reflects the actual staffing level provided by the corresponding schedule, while the black line reflects the required staffing that includes both lunch and break periods allowed under contract.

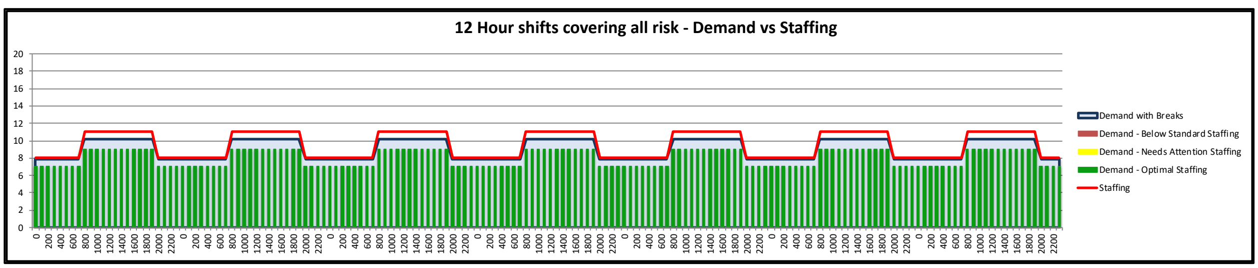
As will be seen for the recommended schedules, start times and / or shift length vary by the workstation type. For example, positions begin to ‘ramp up’ with start times beginning at 6:00AM. This practice more closely aligns resources to demand.

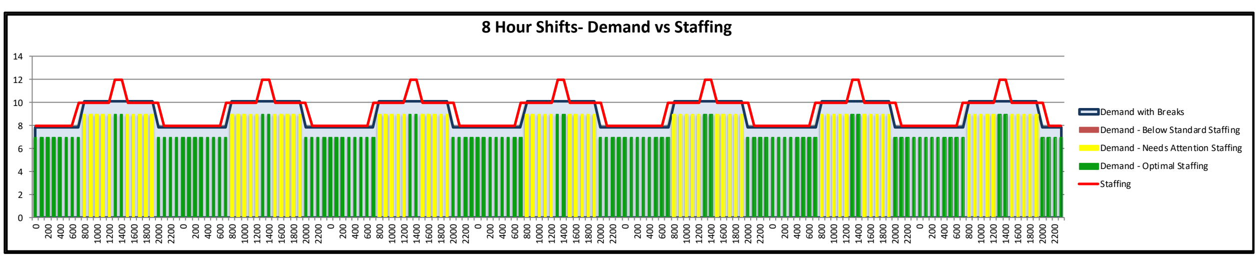
Call Intake Shift Staffing Requirements

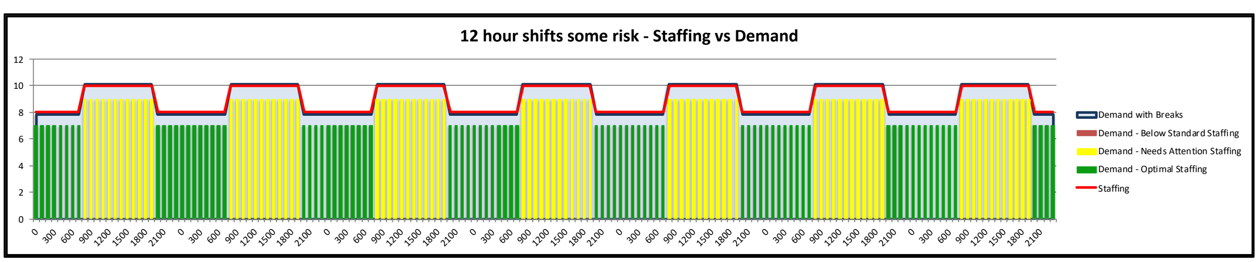
Figure 21: Call Intake - 8 Hour Shifts Only



The following figures reflect the alternative staffing schedules considered and their relative risk for 12-hour shifts.





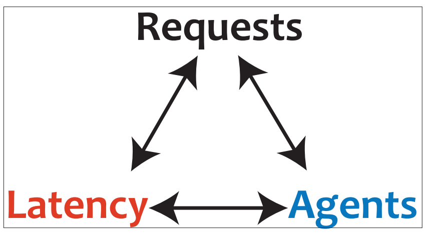


APPENDIX A. ERLANG MATHEMATICS AND ASSUMPTIONS

History

Agner Krarup Erlang was a Danish mathematician, statistician, and engineer who invented the field of telephone networks analysis while working for the Copenhagen Telephone Company from 1908 through 1929. The goal of Erlang's queuing analyses is to determine how many service providers should be made available to satisfy users, without over provisioning. Mr. Erlang quantified the three-cornered relationship between requests for service, number of agents, and latency (Figure 1).

Figure 1. Queueing Theory Triangle



The concepts and mathematics introduced by Mr. Erlang have stood the test of time. In the modern world, these methods are used to analyze queuing processes in systems as diverse as shoppers using grocery store checkout cashiers to data packet switching through Internet routers at megahertz frequencies.

The article authored by Chromy, Misuth, and Kavacky is a concise introduction to the application of the Erlang C formula to analyses of emergency services call centers.[3]

Mathematics

For Erlang's analyses to apply to a system, two conditions must be met:

- Users arrive more or less at random intervals;
- Users receive exclusive service from any one of a group of agents without prior reservations.

The flow of calls through the DFR Dispatch Center conforms to these requirements.

There are several versions of Erlang analyses depending on the exact model of the traffic flowing through the system. The specific model applicable to the DFR Dispatch Center has users either being served immediately or waiting in queue until a call taker becomes available. The specific mathematical embodiment of the analysis applicable to the DFR system is referred to as the Erlang-C equation.

Erlang analyses must be conducted over a selected interval of time. In the case of emergency service communications centers experiencing the number of calls seen at DFR, this interval is most appropriately one hour. Little insight would be gained by viewing each hour of the year as a special case. The need is for the analyst to consolidate individual hours into groups that present a valid picture of the way the system functions. The consolidation process appropriate to DFR has been described above in this Report.

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[3] E. Chromy, T. Misuth, and M. Kavacky, **2011**, *Advances in Electrical and Electronic Engineering*, **ISSN 1804-3119.**

The Erlang C formula calculates the probability that an arriving call will be diverted to the waiting queue rather than being served immediately. Three common sense parameters go into the Erlang C calculation:

- The average arrival rate of calls during the hours being considered.
- The average length of time the dispatcher spends processing each call.
- The number of dispatchers on duty.

For an Erlang analysis, the workload flowing through the DFR Dispatch Center must be expressed in units of erlangs, E.

$E = \eta\,\lambda$ **Equation 1**

E: Workload in units of erlangs

η: Average call arrival rate in calls per hour

λ: Average call processing time in decimal hours per call

The average call arrival rate and average call processing times that are required so that Equation 1 becomes specific to DFR are extracted from the historic Computer Aided Dispatch (CAD) system.

To avoid confusion, the reader should be advised that many of the time parameters appearing in the tabular data presented in this report will be formatted as decimal hours rather than as hours:minutes:seconds, hh:mm:ss. For example, 15 minutes, 00:15:00, will appear as 0.250 hr.

The probability that an arriving call will be diverted to the waiting queue, P_Q, rather than being answered immediately is calculated from the expansion of the Erlang-C equation.

$$P_Q = \frac{\left[\frac{E^N}{N!}\frac{N}{(N-E)}\right]}{\sum_{i=0}^{i=N-1}\left\{\frac{E^i}{i!} + \frac{E^N}{N!}\left[\frac{N}{(N-E)}\right]\right\}}$$ **Erlang-C Equation 2**

E: Workload in erlangs from **Eqn 1**

N: Dispatchers on duty at workstations

Discussions of queueing processes are often tabled in terms of three additional parameters:

P_A: Probability that an incoming call will be immediately answered.

W: Average answer delay. The time interval that a call in held in queue.

Q: Average number of calls waiting in queue for service.

Once the probability that an arriving call will be diverted to the waiting queue, P_Q, has been calculated using Equation 2, then these three additional parameters can be calculated using the algebraic transformations in Equations 3, 4, and 5.

$P_A = (1 - P_Q)$ **Equation 3**

$W = \frac{P_Q \lambda}{(N-E)}$ **Equation 4**

$Q = \frac{P_Q E}{(N-E)}$ **Equation 5**

Variables P_Q, N, and E are defined above.

Absolutely rigorous application of an Erlang-C analysis requires that three additional conditions be met:

- That callers never hang up while being held in queue.
- That all calls begin and end within a single time interval.
- That callers never call back after having hung up while in queue.

When these conditions are not met, as will be the case in the real world, then the Erlang-C formula predicts that slightly more call-takers should be used than are really needed to maintain a desired level of service. Thus, the Erlang-C analysis is generally viewed as providing an upper bound to the needed number of call-takers required to service a given flow of incoming traffic.

While this limitation of Erlang C analysis exists, in practice, it results in a negligible increase to the number of dispatchers predicted for Peoria Emergency Communication Center. The flow of offered traffic through the PECC system is modest and the number of dispatchers required is small. Dispatchers can be added to or subtracted from the system only in integer increments. Under these circumstances, incrementing the number of dispatchers by +1 will always result in such a large increase in answering probability that it overwhelms the propensity of a simple Erlang C analysis to slightly increase the required number of dispatchers.

Workloads, Staffing and Non-Linear Performance

A concise presentation of workload patterns and non-linear response of a queueing system is presented in the on-line PDF titled, "Call Center Basics".[4] The following is a paraphrase of portions of this article.

A naïve approach to calculating the number of agents needed in a call center is to divide the number of calls expected per hour divided by the average length of a call. For example, if 100 calls arrive per hour and the average time to service a call is 15 minutes, then it appears that 25 agents should be able to service the workload.

[4] www.easyerlang.com/pdfs/call-center-basics.pdf (July 15, 2015)

The flaw in this model is that calls do not arrive in an orderly fashion, one right after the other. Callers, seeking service, act independently of each other, and their calls arrive in a random pattern surrounding the average spacing between calls. Likewise, the interval required by the agents to service each call displays a random pattern surrounding its average value.

For call centers, the arrival rate is best described by a mathematical function called a Poisson distribution. The call processing interval is best described by a mathematical function called an Exponential distribution. Figures 2 and 3 illustrate the shapes of these distributions.

Figure 2. Poisson Distribution of Call Arrival Rates

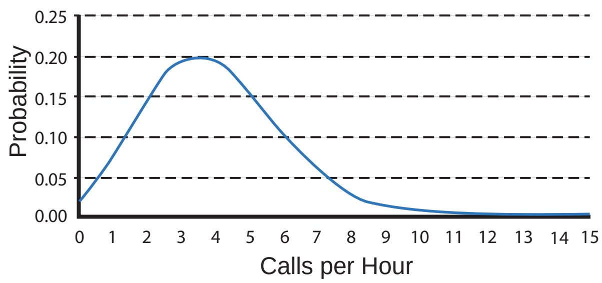
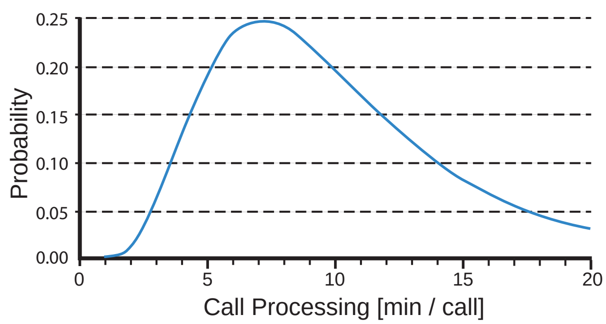


Figure 3. Exponential Distribution of Call Processing Intervals



The statistical behaviors of the call arrivals and call service intervals guarantees that changes in the number of agents will have a non-linear effect on performance of the system. In this hypothetical example, an increase of 10% in staffing will not result in a 10% decrease in the average answer delay. Rather, the average answer delay shows the behavior shown in Figure 4.

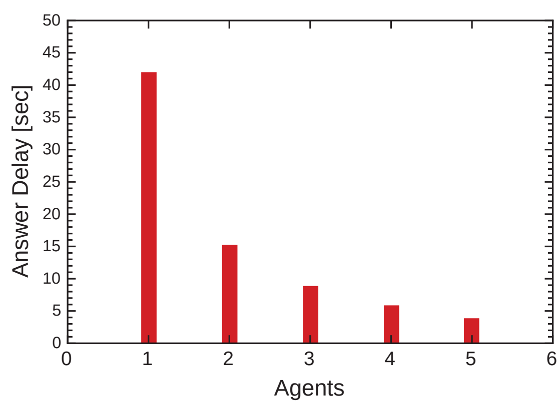
Figure 4. Average Answer Delay Versus Number of Agents

The purpose of this example is to emphasize that the performance of a queueing system changes in a very non-intuitive manner with respect to changes in both staffing and workload.

The dependence of average answer delay on the number of dispatchers is approximately hyperbolic. At constant workload, an increment or decrement of ± 1 dispatcher can result in very magnified or very compressed changes in average answer delays depending on which end of the curve in Figure 3 contains the operating point of the system. There is no substitute for running detailed calculations, using data specific to the system under consideration in order to accurately predict its queueing behavior.

In systems with large numbers of agents, the relationship between average answer delays and the number of agents on duty is approximately a continuous function. This relationship is very different for small systems (Figure 5).

Figure 5. Answer Delays and Agents in Small Systems



The relationship remains approximately hyperbolic, but the ***accessible*** answer delays become a step function. The number of agents on duty can only be changed in integer increments or decrements of ± 1.

Similar changes in average answer delays occur when the workload is varied using a constant number of dispatchers. Again, for a constant number of agents, small changes in workload result in very magnified or very compressed changes in average answer delays. There is no substitute for running detailed calculations, using data specific to the system under consideration, in order to accurately predict its queueing behavior.

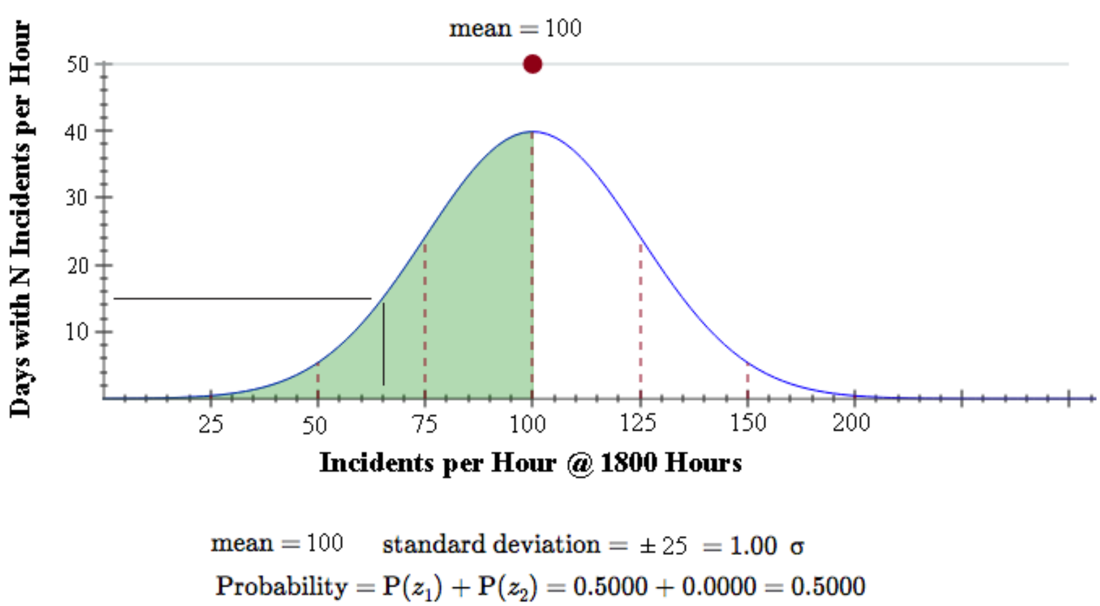
APPENDIX B. TREATMENT OF SURGES

Theoretical

Emergency services communications centers dispatch responses to defined geographic areas, the service jurisdiction. At a given hour of the day, and from day-to-day, the number of people in the service jurisdiction will be approximately the same. In turn, this condition leads to the historic observation that the number of requests for service will tend towards some daily average in that hour of the day. The next historic observation is that the number of requests in any particular day will vary above and below this long-term average. As it turns out, the excursions to higher or lower numbers of requests really are random. The randomness of the excursions is very important because it makes the analyses of the flow of requests much simpler.

Random processes are often characterized by statisticians using a “normal” distribution. A stylized example of a normal distribution is presented in Figure 1.

Figure 1. Normal Distribution of Requests per Hour

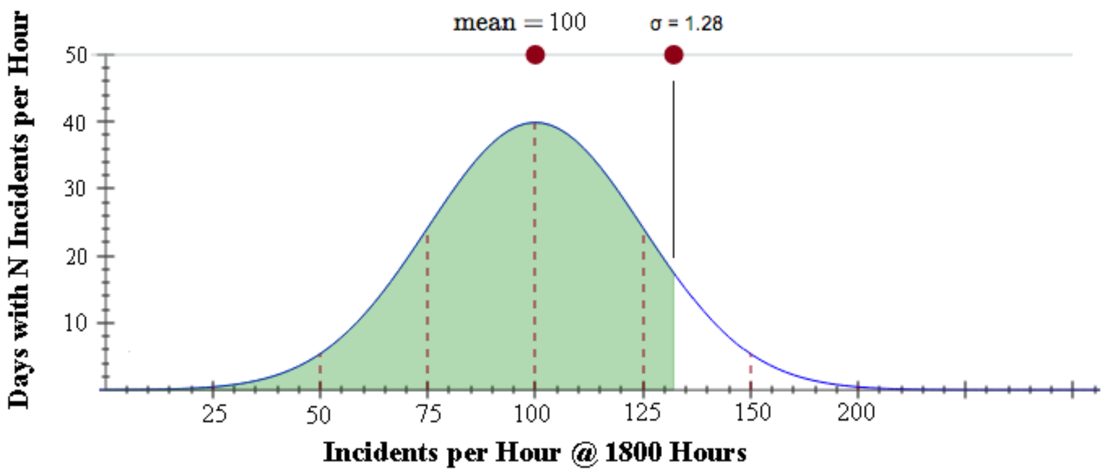


The interpretation of this figure starts with the x-axis, which is the number of incidents per hour (go to the vertical line at 65 incidents per hour, follow it up to the blue curve). The height of the curve at 65 incidents per hour gives the number of instances, the number of days in which exactly 65 incidents were experienced in the 1800 hour. The average number of incidents per hour is 100. There are exactly 40 days in which 100 incidents occurred in the 1800 hour. The distribution curve in Figure 1 has a width. The standard deviation, symbol σ, characterizes this width. In this example, the standard deviation is 25.

The area under the normal curve from zero to the average is shaded green. The green area is one half the area under the curve. In the context of a dispatch center, the green area means that one day out of two, there will be 100 incidents, or fewer, in the 1800 hour. Conversely, one day out of two, there will be 100 incidents, or more, in the 1800 hour.

The valuable property of the standard deviation, σ, is that it allows the extraction of the size and frequency of surges from the normal distribution. Consider Figure 2 where the green area has been extended to the right as far as [average + 1.28 σ] which happens to be 132 incidents per hour.

Figure 2. Normal Distribution Showing a One Day in Ten Surge.

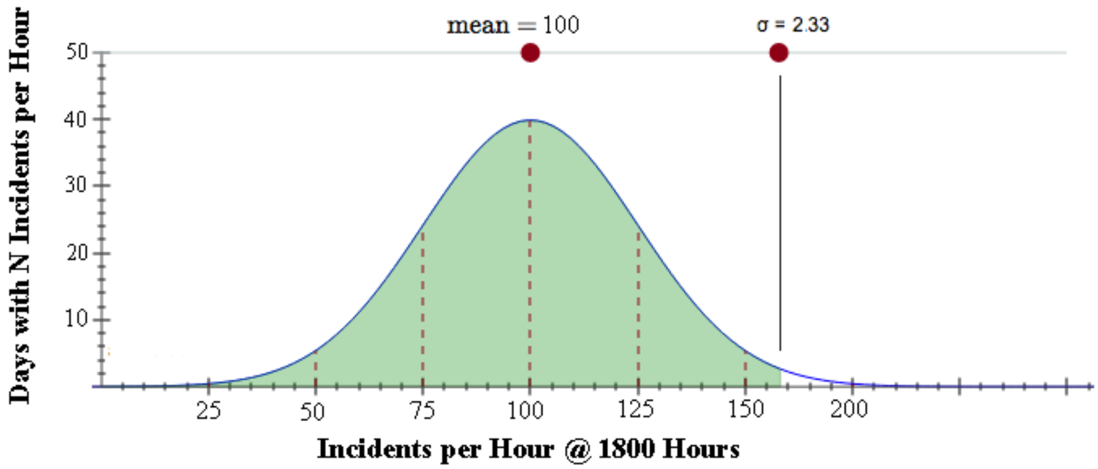


mean = 100 standard deviation = ± 25 = 1.00 σ
Probability = $P(z_1) + P(z_2) = 0.5000 + 0.4001 = 0.9001$

The green area now comprises 90% of the area under the normal curve. In the context of a dispatch center, the green area means that nine days in ten there will be 132 incidents, or fewer, in the 1800 hour. Conversely, one day in ten there will be 132 incidents, or more, in the 1800 hour.

In Figure 3, below, the green area has been extended further right to [average + 2.33 σ] or 158 incidents per hour. The green area now comprises 99% of the area under the normal curve. In the context of a dispatch center, the green area now means the ninety-nine days out.

Figure 3. Normal Distribution Showing a One Day in One Hundred Surge.



mean $= 100$ standard deviation $= \pm 25 = 1.00\ \sigma$

Probability $= \mathrm{P}(z_1) + \mathrm{P}(z_2) = 0.5000 + 0.4897 = 0.9897$

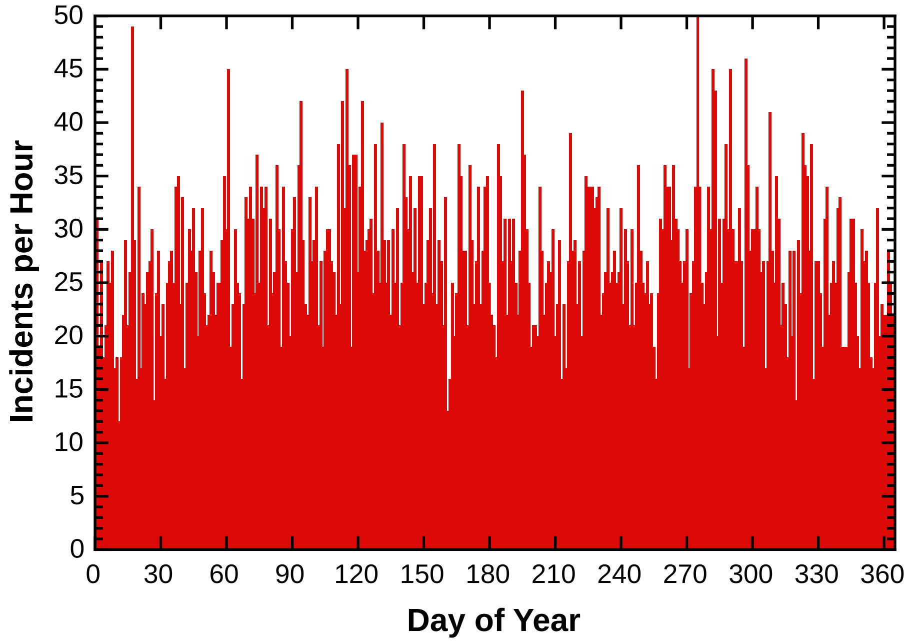
Of one hundred there will be 158 incidents, or fewer, in the 1800 hour. On one day out of one hundred, there will be 158 incidents, or more, in the 1800 hour.

The preceding discussion shows the usefulness of the standard deviation to answer questions of surges in dispatch systems. Once a collection of random incident counts has been converted to an average and a standard deviation, it becomes possible to conveniently extract the frequency and sizes of surges from the original set of data, at least in theory.

Real Example

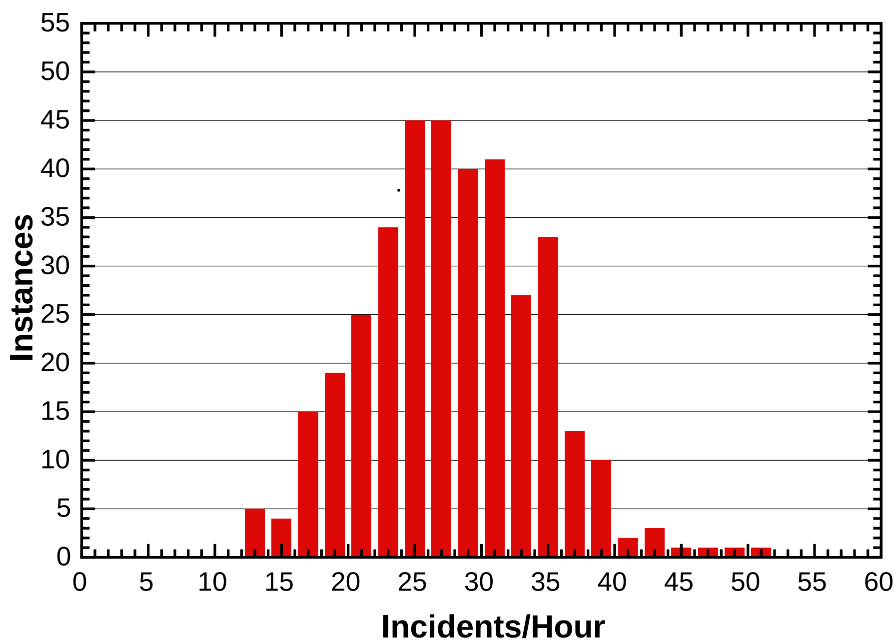
Figure 4, below, presents the number of incidents per hour experienced at a large metropolitan dispatch center at 1600 hours. One year's worth of data is included in the histogram. As can be seen, the day-to-day variability is substantial with a minimum of 12 incidents per hour to a maximum of 50 incidents per hour.

Figure 4. Incident per Hour at 1600 Hours



The data in Figure 4 was then consolidated into Figure 5. The process of this consolidation is referred to as "binning". All of the instances where 12 or 13 incidents per hour occurred were counted and the total placed in a "bin" labelled 12-13, and so forth. The outcome of this binning process results in the distribution presented in Figure 5, below. As can be seen, the envelope, or shape, of the distribution of incidents per hour derived from the real data is not as smooth as theoretical model.

Figure 5. Distribution of Incidents per Hour



Numerical methods were next used to calculate the normal distribution curve that most closely follows the contour of the real distribution. The calculated normal distribution is presented in Figure 6, below. Three specific surge limits are specified in Figure 6. The values of these surge limits are presented in Table 1, below. The surge limits may also be discussed in terms of the percentile contributions to the area under the normal curve.

Figure 6. Normal Distribution Most Closely Conforming Figure 5.

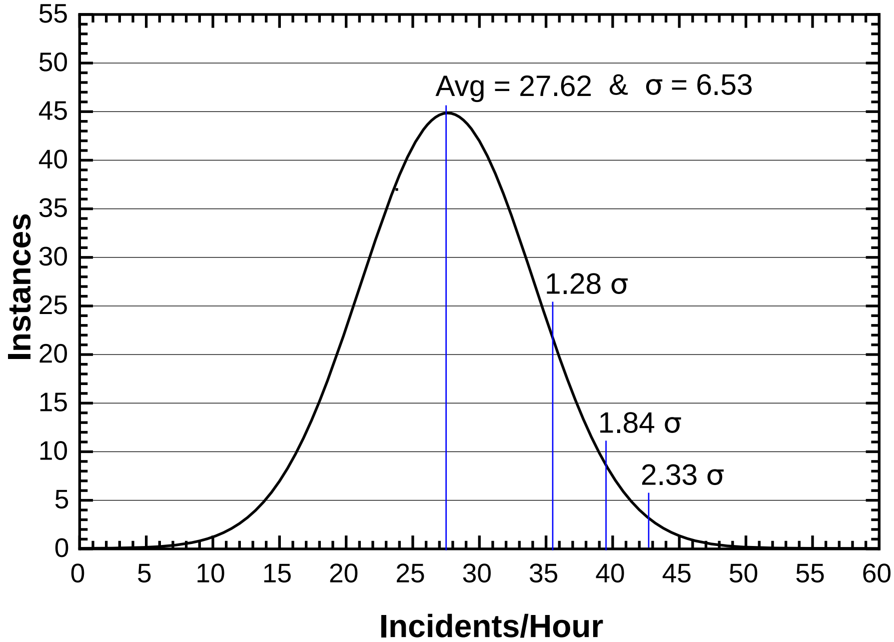
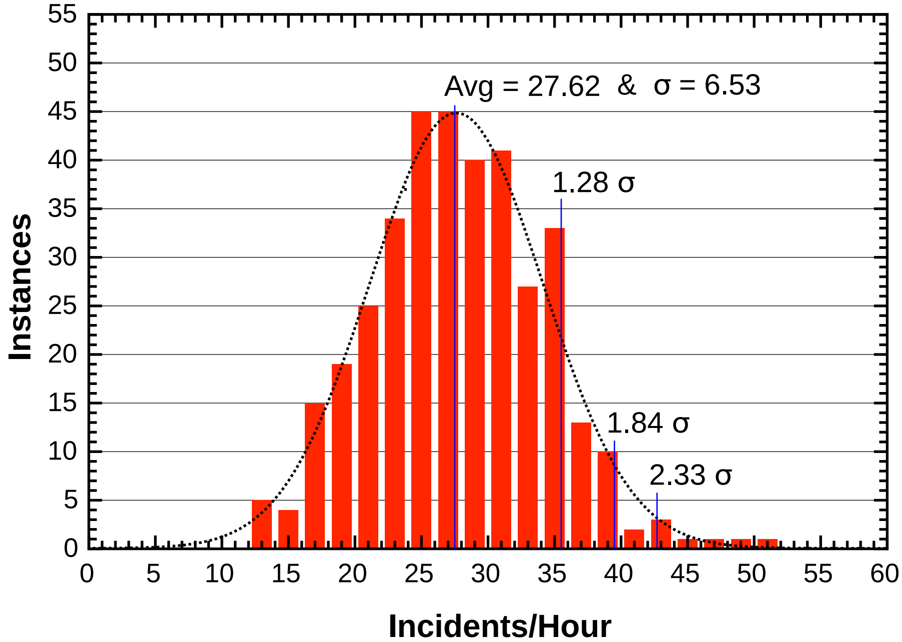


Table 1. Surge Limits Derived from Figure 6.

Frequency	Offset [σ]	Incidents per Hour			%-tile
		Average	Increment	Total	
One Day in 2	0.00 σ	27.62	0.00	27.62	50th
One Day in 10	+1.28 σ	27.62	8.36	35.98	90th
One Day in 30	+1.84 σ	27.62	12.02	39.64	97th
One Day in 100	+2.33 σ	27.62	15.21	42.83	99th

In Figure 7, the calculated normal distribution overlays the distribution of real data.

Figure 7. Comparison of the Real Distribution to a Normal Curve.



As 'lumpy" as the real distribution may appear, it is a respectable approximation of a precisely calculated normal curve. The frequency and size of surges calculated using the mathematical methods described in this section are a good approximation of reality.

APPENDIX C. CURRENT OPERATIONS, DISTRIBUTED INTAKE

The Erlang Tables in this Appendix are for workstations in the Model of Current Operations with Distributed Intake and 0.00σ surges. Staffing reflects current practices.

Figure 1. Operations at EEC_0102 with Distributed Intake, Average Workloads

Year	Dispatch Model	Console	Surge
2018	Current Ops	ECC_0102 w Intake	+ 0.00 σ

surge	Hour of Day	Avg per Hour-of-Day					Workstation Staffing & Performance		
			Intake	PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 95th %-tile
	0000		7.86	180.36	0.309		2	96.03	0.27
	0100		6.43	165.13	0.274		2	96.81	0.21
	0200		5.06	125.02	0.215		2	97.96	0.13
	0300		4.31	116.64	0.190		2	98.37	0.10
	0400		3.41	104.95	0.166		2	98.74	0.08
	0500		2.72	87.78	0.144		2	99.04	0.06
	0600		3.15	96.04	0.165		2	98.75	0.08
	0700		5.90	166.47	0.281		2	96.65	0.23
	0800		8.61	171.98	0.326		2	95.63	0.34
	0900		11.01	165.04	0.362		2	94.75	0.47
	1000		12.24	185.29	0.402		2	93.70	0.57
	1100		11.57	205.71	0.423		2	93.12	0.61
	1200		11.10	214.38	0.429		2	92.95	0.61
	1300		11.36	202.58	0.417		2	93.28	0.59
	1400		11.00	193.71	0.432		2	92.88	0.68
	1500		11.26	309.84	0.540		2	89.69	0.85
	1600		12.10	247.47	0.492		2	91.15	0.79
	1700		11.46	240.02	0.470		2	91.79	0.71
	1800		10.79	257.49	0.471		2	91.75	0.68
	1900		10.42	248.87	0.449		2	92.39	0.61
	2000		10.21	233.53	0.425		2	93.06	0.55
	2100		9.19	200.22	0.381		2	94.25	0.46
	2200		6.95	193.56	0.350		2	95.05	0.37
	2300		7.68	247.36	0.379		2	94.32	0.37

Avg Air-Time per PTT	Average per Hour			Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
		Intake	PTT's				
3.16 sec	0.00	8.57	189.98	0.354	48	93.96 %	0.50

index 1

Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 95th %-tile
Contiguous	0800	1900	12	92.51 %	0.64
non-Contig			12	95.97 %	0.29

Free time at each Radio Console was tallied from PTT durations. Intake workloads were assigned to each Radio Console in proportion to free time at that console.

Figure 2. Operations at EEC_03 with Distributed Intake, Average Workloads

Year	Dispatch Model	Console	Surge
2018	Current Ops	ECC_03 w Intake	+ 0.00 σ

Surge	Hour of Day	Avg per Hour-of-Day					Workstation Staffing & Performance		
			Intake	PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 95th %-tile
	0000		4.03	52.00	0.132		1	86.79	2.56
	0100		3.30	44.56	0.113		1	88.70	2.14
	0200		2.59	33.53	0.088		1	91.18	1.68
	0300		2.19	32.44	0.080		1	92.00	1.43
	0400		1.73	27.65	0.068		1	93.16	1.22
	0500		1.37	31.84	0.067		1	93.30	1.03
	0600		1.59	31.98	0.073		1	92.70	1.22
	0700		3.00	56.63	0.126		1	87.43	2.16
	0800		4.30	72.16	0.164		1	83.58	3.01
	0900		5.44	81.75	0.191		1	80.87	3.70
	1000		6.08	84.47	0.205		1	79.48	4.17
	1100		5.80	84.15	0.210		1	79.00	4.42
	1200		5.58	87.22	0.210		1	79.03	4.28
	1300		5.69	85.40	0.207		1	79.29	4.24
	1400		5.40	99.64	0.230		1	77.03	4.65
	1500		5.83	107.51	0.245		1	75.53	4.99
	1600		6.02	112.25	0.250		1	75.02	5.01
	1700		5.85	87.05	0.219		1	78.13	4.70
	1800		5.60	77.87	0.207		1	79.31	4.61
	1900		5.45	65.78	0.189		1	81.12	4.40
	2000		5.33	61.40	0.177		1	82.25	4.09
	2100		4.72	63.62	0.169		1	83.09	3.59
	2200		3.57	59.65	0.153		1	84.74	3.10
	2300		4.04	62.05	0.148		1	85.23	2.76

Avg Air-Time per PTT	Average per Hour	Intake	PTT's	Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
3.69 sec	0.00	4.35	66.78	0.163	24	81.65 %	3.74

index 2

Block Performance	Hours Included in Block: From First	Thru Last	Block Length	Parameters Weighted Over Block Lengths: % Immed Ans	Ans Delay @ 95th %-tile
Contiguous	0900	1900	11	78.29 %	4.50
non-Contig			13	86.84 %	2.57

Free time at each Radio Console was tallied from PTT durations. Intake workloads were assigned to each Radio Console in proportion to free time at that console.

Figure 3. Operations at EEC_04 with Distributed Intake, Average Workloads

Year	Dispatch Model	Console	Surge
2018	Current Ops	ECC_04 w Intake	+ 0.00 σ

Surge	Hour of Day	Avg per Hour-of-Day					Workstation Staffing & Performance		
			Intake	PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 95th %-tile
	0000		4.15	24.08	0.106		1	89.38	3.19
	0100		3.40	16.85	0.087		1	91.29	2.93
	0200		2.62	19.98	0.076		1	92.38	1.98
	0300		2.22	21.40	0.068		1	93.18	1.51
	0400		1.75	19.21	0.059		1	94.09	1.26
	0500		1.38	24.65	0.059		1	94.14	1.00
	0600		1.61	21.27	0.063		1	93.70	1.32
	0700		3.05	55.55	0.111		1	88.89	1.69
	0800		4.49	43.16	0.128		1	87.17	2.82
	0900		5.72	43.67	0.149		1	85.09	3.77
	1000		6.40	46.09	0.164		1	83.60	4.37
	1100		6.00	60.96	0.182		1	81.80	4.31
	1200		5.87	48.58	0.169		1	83.12	4.49
	1300		5.95	50.38	0.171		1	82.94	4.44
	1400		5.73	47.18	0.182		1	81.77	5.48
	1500		6.27	41.84	0.188		1	81.22	6.44
	1600		6.57	34.13	0.181		1	81.91	7.00
	1700		6.05	54.35	0.193		1	80.73	5.43
	1800		5.83	38.56	0.174		1	82.65	5.85
	1900		5.64	33.82	0.160		1	84.04	5.47
	2000		5.49	32.83	0.153		1	84.70	5.14
	2100		4.88	31.63	0.141		1	85.92	4.50
	2200		3.70	25.04	0.122		1	87.84	4.18
	2300		4.21	21.69	0.111		1	88.93	3.79

Avg Air-Time per PTT	Average per Hour			Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
		Intake	PTT's				
3.43 sec	0.00	4.54	35.70	0.133	24	85.41 %	4.15

index 3

Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 95th %-tile
Contiguous	0900	1900	11	82.56 %	5.10
non-Contig			13	89.44 %	2.81

Free time at each Radio Console was tallied from PTT durations. Intake workloads were assigned to each Radio Console in proportion to free time at that console.

Figure 4. Operations at EEC_05 with Distributed Intake, Average Workloads

Year	Dispatch Model	Console	Surge
2018	Current Ops	ECC_05 w Intake	+ 0.00 σ

Surge	Hour of Day	Avg per Hour-of-Day					Workstation Staffing & Performance		
			Intake	PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 95th %-tile
	0000		4.17	15.38	0.103		1	89.72	4.30
	0100		3.35	22.02	0.100		1	90.01	3.11
	0200		2.60	19.93	0.084		1	91.64	2.41
	0300		2.21	16.86	0.072		1	92.84	2.06
	0400		1.74	14.05	0.062		1	93.84	1.82
	0500		1.36	23.83	0.069		1	93.08	1.46
	0600		1.58	25.69	0.079		1	92.14	1.75
	0700		3.00	43.16	0.126		1	87.44	2.79
	0800		4.39	42.40	0.147		1	85.29	3.87
	0900		5.57	45.07	0.172		1	82.80	5.03
	1000		6.13	61.15	0.200		1	80.02	5.29
	1100		5.87	58.87	0.200		1	80.00	5.50
	1200		5.66	55.42	0.198		1	80.19	5.71
	1300		5.78	55.09	0.195		1	80.47	5.55
	1400		5.53	57.17	0.211		1	78.93	6.39
	1500		6.06	53.78	0.215		1	78.49	7.02
	1600		6.38	45.18	0.204		1	79.59	7.23
	1700		5.97	50.78	0.203		1	79.73	6.47
	1800		5.69	46.27	0.194		1	80.60	6.40
	1900		5.50	41.30	0.180		1	81.95	6.05
	2000		5.44	30.26	0.161		1	83.92	6.16
	2100		4.80	33.04	0.154		1	84.59	5.29
	2200		3.66	24.44	0.131		1	86.88	5.03
	2300		4.12	27.60	0.129		1	87.07	4.31

Avg Air-Time per PTT	Average per Hour			Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
		Intake	PTT's				
5.00 sec	0.00	4.44	37.86	0.149	24	83.22 %	5.13

index 4

Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 95th %-tile
Contiguous	0900	1900	11	80.18 %	6.04
non-Contig			13	88.27 %	3.61

Free time at each Radio Console was tallied from PTT durations. Intake workloads were assigned to each Radio Console in proportion to free time at that console.

Figure 5. Operations at EEC_07 with Distributed Intake, Average Workloads

Year	Dispatch Model	Console	Surge
2018	Current Ops	ECC_07 w Intake	+ 0.00 σ

Surge	Hour of Day	Avg per Hour-of-Day					Workstation Staffing & Performance		
			Intake	PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 95th %-tile
	0000		4.07	49.73	0.046		1	95.39	0.30
	0100		3.32	44.83	0.042		1	95.82	0.27
	0200		2.59	35.45	0.033		1	96.71	0.21
	0300		2.20	32.43	0.031		1	96.89	0.21
	0400		1.75	19.23	0.019		1	98.15	0.12
	0500		1.37	29.24	0.027		1	97.28	0.18
	0600		1.53	80.89	0.069		1	93.13	0.44
	0700		2.97	76.61	0.068		1	93.24	0.44
	0800		4.37	67.04	0.062		1	93.81	0.41
	0900		5.56	71.31	0.065		1	93.53	0.42
	1000		6.18	80.05	0.073		1	92.67	0.48
	1100		5.89	82.29	0.075		1	92.51	0.49
	1200		5.66	84.96	0.077		1	92.28	0.51
	1300		5.76	86.13	0.076		1	92.44	0.48
	1400		5.30	133.67	0.119		1	88.15	0.82
	1500		5.97	97.05	0.087		1	91.30	0.57
	1600		6.25	89.71	0.080		1	91.96	0.52
	1700		5.94	80.89	0.073		1	92.65	0.48
	1800		5.67	71.64	0.067		1	93.32	0.44
	1900		5.49	64.44	0.060		1	94.04	0.38
	2000		5.39	54.00	0.051		1	94.89	0.33
	2100		4.81	49.44	0.044		1	95.58	0.27
	2200		3.52	78.11	0.072		1	92.83	0.48
	2300		4.10	50.13	0.048		1	95.19	0.32

Avg Air-Time per PTT	Average per Hour			Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
		Intake	PTT's				
3.27 sec	0.00	4.40	67.05	0.061	24	93.11 %	0.45

index 5

Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 95th %-tile
Contiguous	0900	1900	11	91.98 %	0.53
non-Contig			13	94.73 %	0.34

Free time at each Radio Console was tallied from PTT durations. Intake workloads were assigned to each Radio Console in proportion to free time at that console.

APPENDIX D. CURRENT OPERATIONS, DISTRIBUTED INTAKE

The Erlang Tables in this Appendix are for workstations in the Model Current Operations with Distributed Intake and 1.28σ surges. Staffing reflects current practices.

Figure 1. Operations at EEC_0102 with Distributed Intake, Challenged with 1.28σ Surges

Year	Dispatch Model	Console	Surge
2018	Current Ops	ECC_0102 w Intake	+ 1.28 σ

Surge	Hour of Day	Avg per Hour-of-Day	Intake	PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 95th %-tile
+	0000		13.05	272.00	0.484		2	91.37	0.69
+	0100		10.95	256.12	0.437		2	92.73	0.54
+	0200		8.80	200.26	0.352		2	95.00	0.36
+	0300		7.58	206.17	0.329		2	95.57	0.29
+	0400		6.13	177.61	0.288		2	96.50	0.23
+	0500		4.80	154.13	0.249		2	97.31	0.17
+	0600		5.73	143.70	0.263		2	97.03	0.21
+	0700		9.96	224.84	0.408		2	93.53	0.50
+	0800		14.69	257.60	0.494		2	91.10	0.76
+	0900		18.10	230.04	0.523		2	90.21	1.00
+	1000		20.09	259.45	0.575		2	88.64	1.17
+	1100		18.18	283.42	0.597		2	87.93	1.21
+	1200		16.99	304.48	0.607		2	87.62	1.20
+	1300		18.03	273.28	0.584		2	88.35	1.17
+	1400		16.74	261.83	0.599		2	87.88	1.33
+	1500		16.11	405.07	0.726		2	83.81	1.56
+	1600		17.57	327.53	0.673		2	85.51	1.52
+	1700		16.45	331.39	0.644		2	86.43	1.32
+	1800		15.85	345.37	0.650		2	86.24	1.31
+	1900		15.76	338.37	0.623		2	87.10	1.18
+	2000		15.85	330.99	0.616		2	87.33	1.16
+	2100		14.93	280.33	0.564		2	88.97	1.05
+	2200		11.63	293.17	0.543		2	89.60	0.91
+	2300		13.03	310.86	0.527		2	90.11	0.78

Workstation Staffing & Performance applies to the OnTask, Immediate Answer and Ans Delay columns.

Avg Air-Time per PTT	Average per Hour	Intake	PTT's	Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
3.16 sec	0.00	13.63	269.50	0.515	48	89.41 %	0.99

index 1

Block Performance	Hours Included in Block: From First	Thru Last	Block Length	Parameters Weighted Over Block Lengths: % Immed Ans	Ans Delay @ 95th %-tile
Contiguous	0800	1900	12	87.31 %	1.25
non-Contig			12	92.11 %	0.65

Free time at each Radio Console was tallied from PTT durations. Intake workloads were assigned to each Radio Console in proportion to free time at that console.

Figure 2. Operations at EEC_03 with Distributed Intake, Challenged with 1.28σ Surges

Year	Dispatch Model	Console	Surge
2018	Current Ops	ECC_03 w Intake	+ 1.28 σ

Surge	Hour of Day	Avg per Hour-of-Day					Workstation Staffing & Performance		
			Intake	PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 95th %-tile
+	0000		6.70	85.48	0.215		1	78.48	4.56
+	0100		5.63	72.87	0.185		1	81.47	3.83
+	0200		4.49	63.02	0.154		1	84.56	2.98
+	0300		3.86	65.22	0.149		1	85.06	2.71
+	0400		3.12	51.22	0.124		1	87.60	2.31
+	0500		2.41	55.17	0.118		1	88.23	1.94
+	0600		2.89	53.26	0.123		1	87.66	2.20
+	0700		5.06	102.18	0.207		1	79.31	3.59
+	0800		7.33	116.03	0.258		1	74.18	5.20
+	0900		8.93	124.43	0.288		1	71.18	6.24
+	1000		9.99	131.36	0.310		1	68.96	7.05
+	1100		9.11	134.52	0.317		1	68.26	7.33
+	1200		8.55	132.38	0.306		1	69.41	6.82
+	1300		9.03	133.96	0.314		1	68.58	7.18
+	1400		8.22	151.45	0.340		1	66.02	7.81
+	1500		8.34	166.90	0.355		1	64.50	7.95
+	1600		8.74	173.31	0.366		1	63.44	8.25
+	1700		8.40	137.55	0.319		1	68.15	7.27
+	1800		8.22	132.42	0.316		1	68.40	7.40
+	1900		8.25	113.06	0.289		1	71.13	6.89
+	2000		8.28	100.38	0.276		1	72.42	6.89
+	2100		7.66	103.15	0.269		1	73.12	6.36
+	2200		5.97	93.19	0.239		1	76.08	5.41
+	2300		6.85	104.20	0.235		1	76.48	4.64

Avg Air-Time per PTT	Average per Hour			Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
		Intake	PTT's				
3.69 sec	0.00	6.92	108.20	0.253	24	72.34 %	6.13

index 2

Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 95th %-tile
Contiguous	0800	1900	12	68.19 %	7.19
non-Contig			12	79.52 %	4.31

Free time at each Radio Console was tallied from PTT durations. Intake workloads were assigned to each Radio Console in proportion to free time at that console.

Figure 3. Operations at EEC_04 with Distributed Intake, Challenged with 1.28σ Surges

Year	Dispatch Model	Console	Surge
2018	Current Ops	ECC_03 w Intake	+ 1.28 σ

surge	Hour of Day	Avg per Hour-of-Day					Workstation Staffing & Performance		
			Intake	PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 95th %-tile
+	0000		6.70	85.48	0.215		1	78.48	4.56
+	0100		5.63	72.87	0.185		1	81.47	3.83
+	0200		4.49	63.02	0.154		1	84.56	2.98
+	0300		3.86	65.22	0.149		1	85.06	2.71
+	0400		3.12	51.22	0.124		1	87.60	2.31
+	0500		2.41	55.17	0.118		1	88.23	1.94
+	0600		2.89	53.26	0.123		1	87.66	2.20
+	0700		5.06	102.18	0.207		1	79.31	3.59
+	0800		7.33	116.03	0.258		1	74.18	5.20
+	0900		8.93	124.43	0.288		1	71.18	6.24
+	1000		9.99	131.36	0.310		1	68.96	7.05
+	1100		9.11	134.52	0.317		1	68.26	7.33
+	1200		8.55	132.38	0.306		1	69.41	6.82
+	1300		9.03	133.96	0.314		1	68.58	7.18
+	1400		8.22	151.45	0.340		1	66.02	7.81
+	1500		8.34	166.90	0.355		1	64.50	7.95
+	1600		8.74	173.31	0.366		1	63.44	8.25
+	1700		8.40	137.55	0.319		1	68.15	7.27
+	1800		8.22	132.42	0.316		1	68.40	7.40
+	1900		8.25	113.06	0.289		1	71.13	6.89
+	2000		8.28	100.38	0.276		1	72.42	6.89
+	2100		7.66	103.15	0.269		1	73.12	6.36
+	2200		5.97	93.19	0.239		1	76.08	5.41
+	2300		6.85	104.20	0.235		1	76.48	4.64

Avg Air-Time per PTT	Average per Hour			Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
		Intake	PTT's				
3.69 sec	0.00	6.92	108.20	0.253	24	72.34 %	6.13

index 2

Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 95th %-tile
Contiguous	0800	1900	12	68.19 %	7.19
non-Contig			12	79.52 %	4.31

Free time at each Radio Console was tallied from PTT durations. Intake workloads were assigned to each Radio Console in proportion to free time at that console.

Figure 4. Operations at EEC_05 with Distributed Intake, Challenged with 1.28σ Surges

Year	Dispatch Model	Console	Surge
2018	Current Ops	ECC_04 w Intake	+ 1.28 σ

Surge	Hour of Day	Avg per Hour-of-Day					Workstation Staffing & Performance		
			Intake	PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 95th %-tile
+	0000		6.90	62.67	0.200		1	80.02	5.11
+	0100		5.79	48.01	0.168		1	83.16	4.52
+	0200		4.55	51.69	0.153		1	84.71	3.50
+	0300		3.90	59.12	0.142		1	85.82	2.65
+	0400		3.15	55.81	0.128		1	87.15	2.29
+	0500		2.44	56.15	0.118		1	88.16	1.94
+	0600		2.93	49.32	0.120		1	88.00	2.23
+	0700		5.15	94.50	0.180		1	82.01	2.82
+	0800		7.65	72.82	0.207		1	79.28	4.80
+	0900		9.40	75.50	0.235		1	76.54	6.04
+	1000		10.51	80.79	0.252		1	74.78	6.64
+	1100		9.43	120.94	0.300		1	69.99	7.03
+	1200		8.99	98.22	0.261		1	73.87	6.15
+	1300		9.45	109.29	0.284		1	71.58	6.77
+	1400		8.73	97.07	0.290		1	71.00	7.98
+	1500		8.97	79.06	0.284		1	71.57	9.15
+	1600		9.54	68.00	0.276		1	72.35	9.71
+	1700		8.68	112.93	0.310		1	69.02	8.15
+	1800		8.57	83.93	0.281		1	71.85	8.50
+	1900		8.54	72.19	0.254		1	74.57	7.66
+	2000		8.52	71.92	0.256		1	74.38	7.82
+	2100		7.93	88.44	0.262		1	73.83	6.86
+	2200		6.19	66.64	0.222		1	77.84	6.17
+	2300		7.15	44.67	0.186		1	81.39	5.85

Avg Air-Time per PTT	Average per Hour			Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
		Intake	PTT's				
3.43 sec	0.00	7.21	75.82	0.224	24	76.28 %	6.19

index 3

Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 95th %-tile
Contiguous	0800	1900	12	72.70 %	7.36
non-Contig			12	81.46 %	4.49

Free time at each Radio Console was tallied from PTT durations. Intake workloads were assigned to each Radio Console in proportion to free time at that console.

Figure 5. Operations at EEC_07 with Distributed Intake, Challenged with 1.28σ Surges

Year	Dispatch Model	Console	Surge
2018	Current Ops	ECC_05 w Intake	+ 1.28 σ

Surge	Hour of Day	Avg per Hour-of-Day	Intake	PTT's	Σ Erlangs	Workstation Staffing & Performance: OnTask	Immediate Answer [%]	Ans Delay @ 95th %-tile
+	0000		6.92	39.34	0.184	1	81.63	6.37
+	0100		5.71	54.77	0.184	1	81.64	4.87
+	0200		4.52	49.43	0.161	1	83.87	4.10
+	0300		3.89	38.56	0.136	1	86.36	3.62
+	0400		3.14	32.21	0.121	1	87.94	3.34
+	0500		2.41	74.41	0.166	1	83.38	3.08
+	0600		2.88	61.19	0.156	1	84.40	3.21
+	0700		5.07	89.07	0.223	1	77.72	4.84
+	0800		7.48	80.94	0.248	1	75.23	6.57
+	0900		9.15	93.00	0.288	1	71.20	8.13
+	1000		10.06	132.48	0.348	1	65.17	9.31
+	1100		9.22	119.46	0.334	1	66.62	9.27
+	1200		8.67	133.64	0.356	1	64.44	9.83
+	1300		9.17	116.98	0.327	1	67.28	8.99
+	1400		8.42	145.20	0.382	1	61.76	10.99
+	1500		8.66	101.82	0.330	1	66.98	10.51
+	1600		9.27	92.72	0.324	1	67.64	10.82
+	1700		8.57	125.00	0.353	1	64.68	10.30
+	1800		8.36	97.22	0.316	1	68.38	9.87
+	1900		8.33	83.58	0.287	1	71.26	8.99
+	2000		8.45	60.97	0.262	1	73.78	9.57
+	2100		7.80	81.08	0.286	1	71.43	9.17
+	2200		6.12	53.00	0.225	1	77.50	7.87
+	2300		7.00	80.88	0.250	1	75.01	6.75

Avg Air-Time per PTT	Average per Hour	Intake	PTT's	Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
5.00 sec	0.00	7.05	84.87	0.260	24	71.36 %	8.24

index 4

Block Performance	Hours Included in Block: From First	Thru Last	Block Length	Parameters Weighted Over Block Lengths: % Immed Ans	Ans Delay @ 95th %-tile
Contiguous	0800	1900	12	67.00 %	9.57
non-Contig			12	79.33 %	5.80

Free time at each Radio Console was tallied from PTT durations. Intake workloads were assigned to each Radio Console in proportion to free time at that console.

APPENDIX E. CURRENT OPERATIONSS, DEDICATED INTAKE

The Erlang Tables in this Appendix are for workstations in the Model of Current Operations with Dedicated Intake and 0.00σ surges. Staffing reflects current practices.

Figure 1. Operations at the Intake Workstation, Dedicated Intake, Average Workloads.

Year	Dispatch Model	Console	Surge
2018	Model A	Intake	+ 0.00 σ

Surge	Hour of Day	Avg per Hour-of-Day					Workstation Staffing & Performance		
			Ring_Ins	Field Init	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 95th %-tile
	0000		16.76	7.52	0.468		2	91.84	7.32
	0100		14.01	5.80	0.398		2	93.80	5.54
	0200		11.31	4.15	0.318		2	95.81	3.65
	0300		9.52	3.62	0.268		2	96.93	2.59
	0400		7.78	2.60	0.230		2	97.68	2.08
	0500		6.68	1.51	0.211		2	98.03	2.02
	0600		7.53	1.92	0.252		2	97.26	2.98
	0700		12.73	5.19	0.397		2	93.82	6.10
	0800		17.33	8.83	0.527		2	90.09	9.66
	0900		22.27	11.02	0.650		2	86.24	14.19
	1000		24.59	12.43	0.718		2	84.06	17.19
	1100		24.90	10.23	0.734		2	83.55	19.34
	1200		24.24	9.64	0.724		2	83.85	19.30
	1300		24.74	9.81	0.728		2	83.72	19.24
	1400		25.67	7.29	0.782		2	81.97	25.05
	1500		26.89	8.50	0.826		2	80.54	27.61
	1600		27.11	10.21	0.837		2	80.20	27.20
	1700		25.96	9.30	0.797		2	81.50	24.77
	1800		25.04	8.54	0.770		2	82.38	23.39
	1900		23.49	9.02	0.725		2	83.83	20.16
	2000		22.55	9.32	0.692		2	84.91	17.84
	2100		21.05	7.34	0.640		2	86.56	15.88
	2200		17.65	3.73	0.560		2	89.08	14.18
	2300		17.60	6.54	0.509		2	90.64	9.43

Avg Air-Time per PTT	Average per Hour			Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
		Ring_Ins	Field Init				
sec	0.00	19.06	7.25	0.573	48	86.21 %	16.78

index 6

Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 95th %-tile
Contiguous	0800	1900	12	83.33 %	20.86
non-Contig			12	91.42 %	9.37

Figure 2. Operations at ECC_0102, Dedicated Intake, Average Workloads.

Year	Dispatch Model	Console	Surge
2018	Model A	ECC_0102	+ 0.00 σ

Surge	Hour of Day	Avg per Hour-of-Day		PTT's	Σ Erlangs		Workstation Staffing & Performance OnTask	Immediate Answer [%]	Ans Delay @ 97th %-tile
	0000			180.36	0.157		1	84.28	1.22
	0100			165.13	0.144		1	85.55	1.11
	0200			125.02	0.111		1	88.95	0.82
	0300			116.64	0.102		1	89.76	0.75
	0400			104.95	0.091		1	90.93	0.65
	0500			87.78	0.074		1	92.57	0.51
	0600			96.04	0.081		1	91.86	0.56
	0700			166.47	0.150		1	84.96	1.20
	0800			171.98	0.152		1	84.75	1.20
	0900			165.04	0.147		1	85.35	1.14
	1000			185.29	0.164		1	83.56	1.31
	1100			205.71	0.181		1	81.86	1.47
	1200			214.38	0.192		1	80.79	1.60
	1300			202.58	0.178		1	82.24	1.42
	1400			193.71	0.171		1	82.92	1.36
	1500			309.84	0.277		1	72.28	2.58
	1600			247.47	0.220		1	77.95	1.89
	1700			240.02	0.211		1	78.90	1.77
	1800			257.49	0.224		1	77.60	1.89
	1900			248.87	0.217		1	78.33	1.81
	2000			233.53	0.204		1	79.65	1.67
	2100			200.22	0.174		1	82.60	1.37
	2200			193.56	0.168		1	83.22	1.31
	2300			247.36	0.217		1	78.32	1.82

Avg Air-Time per PTT	Average per Hour		PTT's	Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
3.16 sec	0.00	0.00	189.98	0.167	24	81.87 %	1.49

index 7

Block Performance	Hours Included in Block From First	Thru Last	Block Length	Parameters Weighted Over Block Lengths % Immed Ans	Ans Delay @ 97th %-tile
Contiguous	0800	1900	12	79.90 %	1.69
non-Contig			12	84.59 %	1.22

Figure 3. Operations at ECC_03, Dedicated Intake, Average Workloads.

Year	Dispatch Model	Console	Surge
2018	Model A	ECC_03	+ 0.00 σ

Surge	Hour of Day	Avg per Hour-of-Day		PTT's	Σ Erlangs	Workstation Staffing & Performance OnTask	Immediate Answer [%]	Ans Delay @ 97th %-tile
	0000			52.00	0.054	1	94.56	0.45
	0100			44.56	0.047	1	95.34	0.38
	0200			33.53	0.035	1	96.51	0.28
	0300			32.44	0.035	1	96.47	0.30
	0400			27.65	0.030	1	97.00	0.25
	0500			31.84	0.032	1	96.81	0.25
	0600			31.98	0.031	1	96.93	0.23
	0700			56.63	0.059	1	94.08	0.49
	0800			72.16	0.078	1	92.24	0.68
	0900			81.75	0.085	1	91.48	0.73
	1000			84.47	0.087	1	91.28	0.74
	1100			84.15	0.089	1	91.11	0.77
	1200			87.22	0.090	1	90.96	0.77
	1300			85.40	0.087	1	91.28	0.73
	1400			99.64	0.101	1	89.85	0.86
	1500			107.51	0.109	1	89.14	0.92
	1600			112.25	0.115	1	88.51	1.00
	1700			87.05	0.086	1	91.35	0.71
	1800			77.87	0.079	1	92.14	0.65
	1900			65.78	0.067	1	93.27	0.55
	2000			61.40	0.062	1	93.83	0.50
	2100			63.62	0.063	1	93.72	0.50
	2200			59.65	0.059	1	94.09	0.47
	2300			62.05	0.063	1	93.74	0.51

Avg Air-Time per PTT	Average per Hour		PTT's	Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
3.69 sec	0.00	0.00	66.78	0.068	24	92.26 %	0.65

index 8

Block Performance	Hours Included in Block From First	Thru Last	Block Length	Parameters Weighted Over Block Lengths % Immed Ans	Ans Delay @ 97th %-tile
Contiguous	0800	1900	12	90.87 %	0.78
non-Contig			12	94.87 %	0.42

Figure 4. Operations at ECC_04, Dedicated Intake, Average Workloads.

Year	Dispatch Model	Console	Surge
2018	Model A	ECC_04	+ 0.00 σ

Surge	Hour of Day	Avg per Hour-of-Day		PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 97th %-tile
	0000			24.08	0.026		1	97.39	0.22
	0100			16.85	0.019		1	98.12	0.16
	0200			19.98	0.022		1	97.77	0.19
	0300			21.40	0.023		1	97.71	0.19
	0400			19.21	0.020		1	97.97	0.16
	0500			24.65	0.023		1	97.69	0.17
	0600			21.27	0.020		1	97.98	0.15
	0700			55.55	0.043		1	95.66	0.27
	0800			43.16	0.038		1	96.21	0.26
	0900			43.67	0.037		1	96.26	0.25
	1000			46.09	0.040		1	96.01	0.27
	1100			60.96	0.057		1	94.34	0.42
	1200			48.58	0.043		1	95.67	0.30
	1300			50.38	0.045		1	95.49	0.32
	1400			47.18	0.046		1	95.37	0.36
	1500			41.84	0.041		1	95.86	0.32
	1600			34.13	0.034		1	96.64	0.26
	1700			54.35	0.056		1	94.39	0.46
	1800			38.56	0.040		1	96.02	0.32
	1900			33.82	0.034		1	96.63	0.26
	2000			32.83	0.034		1	96.61	0.27
	2100			31.63	0.031		1	96.92	0.23
	2200			25.04	0.025		1	97.53	0.19
	2300			21.69	0.022		1	97.81	0.17
Avg Air-Time per PTT		Average per Hour		PTT's	Average Erlangs		Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
3.43 sec		0.00	0.00	35.70	0.034		24	96.20 %	0.28

index 9

Block Performance	Hours Included in Block: From First	Thru Last	Block Length	Parameters Weighted Over Block Lengths: % Immed Ans	Ans Delay @ 97th %-tile
Contiguous	0800	1900	12	95.63 %	0.32
non-Contig			12	97.18 %	0.21

Figure5. Operations at ECC_05, Dedicated Intake, Average Workloads.

Year	Dispatch Model	Console	Surge
2018	Model A	ECC_05	+ 0.00 σ

Surge	Hour of Day	Avg per Hour-of-Day					Workstation Staffing & Performance		
				PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 97th %-tile
	0000			15.38	0.022		1	97.76	0.25
	0100			22.02	0.033		1	96.75	0.37
	0200			19.93	0.030		1	96.99	0.35
	0300			16.86	0.026		1	97.36	0.32
	0400			14.05	0.023		1	97.71	0.29
	0500			23.83	0.034		1	96.59	0.38
	0600			25.69	0.037		1	96.35	0.41
	0700			43.16	0.059		1	94.09	0.65
	0800			42.40	0.059		1	94.13	0.65
	0900			45.07	0.063		1	93.67	0.71
	1000			61.15	0.081		1	91.90	0.88
	1100			58.87	0.077		1	92.26	0.83
	1200			55.42	0.077		1	92.30	0.87
	1300			55.09	0.074		1	92.64	0.80
	1400			57.17	0.079		1	92.07	0.90
	1500			53.78	0.074		1	92.64	0.82
	1600			45.18	0.061		1	93.91	0.66
	1700			50.78	0.068		1	93.23	0.73
	1800			46.27	0.064		1	93.64	0.70
	1900			41.30	0.058		1	94.23	0.64
	2000			30.26	0.043		1	95.72	0.47
	2100			33.04	0.046		1	95.41	0.50
	2200			24.44	0.035		1	96.46	0.40
	2300			27.60	0.042		1	95.76	0.51
Avg Air-Time per PTT		Average per Hour		PTT's	Average Erlangs		Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
5.00 sec		0.00	0.00	37.86	0.053		24	93.97 %	0.67

index 10

Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 97th %-tile
Contiguous	0800	1900	12	92.95 %	0.78
non-Contig			12	96.09 %	0.44

Figure 6. Operations at ECC_07, Dedicated Intake, Average Workloads.

Year	Dispatch Model	Console	Surge
2018	Model A	ECC_05	+ 0.00 σ

Surge	Hour of Day	Avg per Hour-of-Day					Workstation Staffing & Performance		
				PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 97th %-tile
	0000			15.38	0.022		1	97.76	0.25
	0100			22.02	0.033		1	96.75	0.37
	0200			19.93	0.030		1	96.99	0.35
	0300			16.86	0.026		1	97.36	0.32
	0400			14.05	0.023		1	97.71	0.29
	0500			23.83	0.034		1	96.59	0.38
	0600			25.69	0.037		1	96.35	0.41
	0700			43.16	0.059		1	94.09	0.65
	0800			42.40	0.059		1	94.13	0.65
	0900			45.07	0.063		1	93.67	0.71
	1000			61.15	0.081		1	91.90	0.88
	1100			58.87	0.077		1	92.26	0.83
	1200			55.42	0.077		1	92.30	0.87
	1300			55.09	0.074		1	92.64	0.80
	1400			57.17	0.079		1	92.07	0.90
	1500			53.78	0.074		1	92.64	0.82
	1600			45.18	0.061		1	93.91	0.66
	1700			50.78	0.068		1	93.23	0.73
	1800			46.27	0.064		1	93.64	0.70
	1900			41.30	0.058		1	94.23	0.64
	2000			30.26	0.043		1	95.72	0.47
	2100			33.04	0.046		1	95.41	0.50
	2200			24.44	0.035		1	96.46	0.40
	2300			27.60	0.042		1	95.76	0.51

Avg Air-Time per PTT	Average per Hour			Average Erlangs		Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
			PTT's					
5.00 sec	0.00	0.00	37.86	0.053		24	93.97 %	0.67

index 10

Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 97th %-tile
Contiguous	0800	1900	12	92.95 %	0.78
non-Contig			12	96.09 %	0.44

APPENDIX F. CURRENT OPS, DEDICATED INTAKE

The Erlang Tables in this Appendix are for workstations in the Model Current Operations with Dedicated Intake and 1.28σ surges. Staffing reflects current practices.

Figure 1. Operations at the Intake Workstation, Dedicated Intake, Challenged with 1.28σ Surges.

Year	Dispatch Model	Console	Surge
2018	Model A	Intake	+ 1.28 σ

Surge	Hour of Day	Avg per Hour-of-Day					Workstation Staffing & Performance		
			Ring_Ins	Field Init	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 95th %-tile
+	0000		25.56	14.75	0.758		2	82.76	18.60
+	0100		21.18	12.56	0.645		2	86.41	13.67
+	0200		17.72	9.15	0.531		2	89.99	9.60
+	0300		15.20	7.90	0.452		2	92.32	6.91
+	0400		12.81	5.89	0.402		2	93.68	6.07
+	0500		10.46	4.03	0.355		2	94.93	5.37
+	0600		11.61	5.59	0.414		2	93.36	7.19
+	0700		19.10	11.15	0.619		2	87.25	13.45
+	0800		25.26	19.34	0.794		2	81.60	19.36
+	0900		31.86	22.84	0.955		2	76.43	28.05
+	1000		34.88	25.90	1.039		2	73.80	33.22
+	1100		34.33	20.85	1.041		2	73.74	36.81
+	1200		32.28	19.59	1.009		2	74.73	35.34
+	1300		34.40	20.43	1.037		2	73.85	36.61
+	1400		34.99	15.18	1.097		2	72.01	48.35
+	1500		35.48	15.14	1.123		2	71.25	51.81
+	1600		36.32	17.88	1.162		2	70.07	54.62
+	1700		34.17	16.46	1.092		2	72.18	47.08
+	1800		33.78	15.56	1.083		2	72.46	46.97
+	1900		32.05	17.15	1.025		2	74.23	39.24
+	2000		31.53	17.94	1.022		2	74.31	38.71
+	2100		31.73	14.41	0.986		2	75.45	36.86
+	2200		26.81	8.99	0.873		2	79.04	32.31
+	2300		26.84	14.14	0.793		2	81.63	20.99

Avg Air-Time per PTT	Average per Hour			Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
		Ring_Ins	Field Init				
sec	0.00	27.10	14.70	0.846	48	77.46 %	32.81

index 6

Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 95th %-tile
Contiguous	0800	1900	12	73.78 %	39.82
non-Contig			12	83.56 %	21.17

Figure 2. Operations at ECC_0102, Dedicated Intake, Challenged with 1.28σ Surges.

Year	Dispatch Model	Console	Surge
2018	Model A	ECC_0102	+ 1.28 σ

Surge	Hour of Day	Avg per Hour-of-Day					Workstation Staffing & Performance		
				PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 97th %-tile
+	0000			272.00	0.239		1	76.08	2.08
+	0100			256.12	0.228		1	77.25	1.97
+	0200			200.26	0.178		1	82.22	1.44
+	0300			206.17	0.180		1	81.97	1.45
+	0400			177.61	0.156		1	84.41	1.22
+	0500			154.13	0.132		1	86.82	0.98
+	0600			143.70	0.125		1	87.49	0.93
+	0700			224.84	0.205		1	79.55	1.76
+	0800			257.60	0.232		1	76.78	2.05
+	0900			230.04	0.208		1	79.24	1.78
+	1000			259.45	0.231		1	76.88	2.01
+	1100			283.42	0.254		1	74.57	2.30
+	1200			304.48	0.277		1	72.33	2.61
+	1300			273.28	0.242		1	75.75	2.13
+	1400			261.83	0.233		1	76.73	2.02
+	1500			405.07	0.368		1	63.17	3.98
+	1600			327.53	0.296		1	70.37	2.86
+	1700			331.39	0.290		1	71.04	2.67
+	1800			345.37	0.302		1	69.77	2.85
+	1900			338.37	0.295		1	70.50	2.74
+	2000			330.99	0.288		1	71.15	2.65
+	2100			280.33	0.245		1	75.52	2.13
+	2200			293.17	0.260		1	74.02	2.34
+	2300			310.86	0.275		1	72.54	2.51

Avg Air-Time per PTT	Average per Hour			Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
			PTT's				
3.16 sec	0.00	0.00	269.50	0.239	24	74.78 %	2.30

index 7

Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 97th %-tile
Contiguous	0800	1900	12	72.43 %	2.59
non-Contig			12	77.76 %	1.93

Figure 3. Operations at ECC_03, Dedicated Intake, Challenged with 1.28σ Surges.

Year	Dispatch Model	Console	Surge
2018	Model A	ECC_03	+ 1.28 σ

Surge	Hour of Day	Avg per Hour-of-Day					Workstation Staffing & Performance		
				PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 97th %-tile
+	0000			85.48	0.089		1	91.07	0.77
+	0100			72.87	0.078		1	92.23	0.68
+	0200			63.02	0.066		1	93.44	0.55
+	0300			65.22	0.074		1	92.60	0.68
+	0400			51.22	0.057		1	94.31	0.50
+	0500			55.17	0.059		1	94.14	0.50
+	0600			53.26	0.054		1	94.64	0.43
+	0700			102.18	0.103		1	89.66	0.88
+	0800			116.03	0.128		1	87.23	1.21
+	0900			124.43	0.132		1	86.77	1.22
+	1000			131.36	0.140		1	86.03	1.30
+	1100			134.52	0.146		1	85.43	1.39
+	1200			132.38	0.140		1	86.03	1.29
+	1300			133.96	0.143		1	85.67	1.34
+	1400			151.45	0.160		1	84.00	1.51
+	1500			166.90	0.170		1	82.99	1.57
+	1600			173.31	0.178		1	82.17	1.68
+	1700			137.55	0.137		1	86.26	1.19
+	1800			132.42	0.136		1	86.44	1.21
+	1900			113.06	0.117		1	88.31	1.03
+	2000			100.38	0.105		1	89.53	0.92
+	2100			103.15	0.105		1	89.49	0.90
+	2200			93.19	0.094		1	90.64	0.78
+	2300			104.20	0.103		1	89.73	0.85

Avg Air-Time per PTT	Average per Hour			Average Erlangs		Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
			PTT's					
3.69 sec	0.00	0.00	108.20	0.113		24	87.56 %	1.13

index 8

Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 97th %-tile
Contiguous	0800	1900	12	85.40 %	1.35
non-Contig			12	91.30 %	0.74

Figure 3. Operations at ECC_04, Dedicated Intake, Challenged with 1.28σ Surges.

Year	Dispatch Model	Console	Surge
2018	Model A	ECC_04	+ 1.28 σ

Surge	Hour of Day	Avg per Hour-of-Day		PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 97th %-tile
+	0000			62.67	0.070		1	92.98	0.63
+	0100			48.01	0.058		1	94.23	0.55
+	0200			51.69	0.063		1	93.71	0.61
+	0300			59.12	0.065		1	93.45	0.58
+	0400			55.81	0.061		1	93.93	0.53
+	0500			56.15	0.059		1	94.12	0.49
+	0600			49.32	0.050		1	95.05	0.39
+	0700			94.50	0.075		1	92.54	0.48
+	0800			72.82	0.071		1	92.89	0.56
+	0900			75.50	0.071		1	92.94	0.53
+	1000			80.79	0.073		1	92.74	0.53
+	1100			120.94	0.122		1	87.78	1.06
+	1200			98.22	0.087		1	91.35	0.63
+	1300			109.29	0.105		1	89.46	0.85
+	1400			97.07	0.099		1	90.08	0.84
+	1500			79.06	0.085		1	91.45	0.76
+	1600			68.00	0.072		1	92.82	0.61
+	1700			112.93	0.123		1	87.74	1.14
+	1800			83.93	0.093		1	90.66	0.86
+	1900			72.19	0.076		1	92.36	0.66
+	2000			71.92	0.080		1	91.99	0.73
+	2100			88.44	0.092		1	90.76	0.80
+	2200			66.64	0.071		1	92.93	0.61
+	2300			44.67	0.048		1	95.22	0.40

Workstation Staffing & Performance

Avg Air-Time per PTT	Average per Hour		PTT's	Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
3.43 sec	0.00	0.00	75.82	0.078	24	91.71 %	0.70

index 9

Block Performance	Hours Included in Block: From First	Thru Last	Block Length	Parameters Weighted Over Block Lengths: % Immed Ans	Ans Delay @ 97th %-tile
Contiguous	0800	1900	12	90.69 %	0.78
non-Contig			12	93.16 %	0.58

Figure 4. Operations at ECC_05, Dedicated Intake, Challenged with 1.28σ Surges.

Year	Dispatch Model	Console	Surge
2018	Model A	ECC_05	+ 1.28 σ

Surge	Hour of Day	Avg per Hour-of-Day					Workstation Staffing & Performance		
				PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 97th %-tile
+	0000			39.34	0.054		1	94.64	0.58
+	0100			54.77	0.074		1	92.56	0.82
+	0200			49.43	0.072		1	92.79	0.85
+	0300			38.56	0.060		1	93.96	0.76
+	0400			32.21	0.053		1	94.70	0.69
+	0500			74.41	0.107		1	89.27	1.30
+	0600			61.19	0.087		1	91.33	1.01
+	0700			89.07	0.119		1	88.08	1.36
+	0800			80.94	0.114		1	88.55	1.37
+	0900			93.00	0.128		1	87.16	1.53
+	1000			132.48	0.176		1	82.36	2.14
+	1100			119.46	0.160		1	84.01	1.91
+	1200			133.64	0.187		1	81.30	2.42
+	1300			116.98	0.154		1	84.62	1.79
+	1400			145.20	0.198		1	80.18	2.53
+	1500			101.82	0.138		1	86.19	1.63
+	1600			92.72	0.125		1	87.52	1.44
+	1700			125.00	0.168		1	83.16	2.05
+	1800			97.22	0.133		1	86.72	1.57
+	1900			83.58	0.114		1	88.61	1.31
+	2000			60.97	0.088		1	91.24	1.04
+	2100			81.08	0.119		1	88.09	1.49
+	2200			53.00	0.076		1	92.43	0.88
+	2300			80.88	0.114		1	88.55	1.37

Avg Air-Time per PTT	Average per Hour			Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
			PTT's				
5.00 sec	0.00	0.00	84.87	0.117	24	86.72 %	1.60

index 10

Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 97th %-tile
Contiguous	0800	1900	12	84.53 %	1.88
non-Contig			12	90.77 %	1.10

Figure 5. Operations at ECC_07, Dedicated Intake, Challenged with 1.28σ Surges.

Year	Dispatch Model	Console	Surge
2018	Model A	ECC_07	+ 1.28 σ

Surge	Hour of Day	Avg per Hour-of-Day					Workstation Staffing & Performance		
				PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 97th %-tile
+	0000			79.40	0.075		1	92.54	0.57
+	0100			96.78	0.088		1	91.18	0.66
+	0200			64.51	0.062		1	93.85	0.47
+	0300			67.93	0.066		1	93.37	0.52
+	0400			42.26	0.042		1	95.77	0.33
+	0500			55.48	0.059		1	94.14	0.49
+	0600			111.94	0.101		1	89.91	0.76
+	0700			127.99	0.116		1	88.45	0.89
+	0800			109.86	0.104		1	89.62	0.82
+	0900			121.58	0.112		1	88.79	0.87
+	1000			131.53	0.124		1	87.57	1.01
+	1100			131.42	0.123		1	87.75	0.98
+	1200			122.78	0.114		1	88.57	0.90
+	1300			134.41	0.120		1	87.95	0.92
+	1400			180.26	0.165		1	83.52	1.35
+	1500			147.77	0.136		1	86.44	1.08
+	1600			138.27	0.124		1	87.60	0.95
+	1700			128.78	0.118		1	88.20	0.92
+	1800			106.34	0.101		1	89.91	0.80
+	1900			104.86	0.099		1	90.12	0.78
+	2000			99.23	0.094		1	90.57	0.74
+	2100			82.62	0.076		1	92.36	0.57
+	2200			110.26	0.105		1	89.50	0.84
+	2300			88.69	0.087		1	91.29	0.70

Avg Air-Time per PTT	Average per Hour			Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
			PTT's				
3.27 sec	0.00	0.00	107.71	0.100	24	89.17 %	0.85

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Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 97th %-tile
Contiguous	0800	1900	12	87.75 %	0.97
non-Contig			12	91.33 %	0.67

APPENDIX G. MODEL N, AVERAGE WORKLOADS

The Erlang Tables in this Appendix are for workstations in the Model N with 0.00σ surges. Staffing has been adjusted so that performance meets FITCH's operational targets.

Figure 1. Model N, Intake with MPDS & Pre-Arrival Instructions, Average Workloads

Year	Dispatch Model	Console	Surge
2018	Model N	Intake w MPDS & PreAr	+ 0.00 σ

Surge	Hour of Day	Avg per Hour-of-Day				Workstation Staffing & Performance		
			Ring-In	Field Init	Σ Erlangs	OnTask	Immediate Answer [%]	Ans Delay @ 95th %-tile
	0000		16.76	7.52	0.479	3	98.62	0.77
	0100		14.01	5.80	0.412	3	99.09	0.52
	0200		11.31	4.15	0.331	3	99.50	0.29
	0300		9.52	3.62	0.284	3	99.68	0.18
	0400		7.78	2.60	0.244	3	99.79	0.13
	0500		6.68	1.51	0.231	3	99.82	0.13
	0600		7.53	1.92	0.274	3	99.71	0.22
	0700		12.73	5.19	0.429	3	98.98	0.68
	0800		17.33	8.83	0.555	3	97.95	1.27
	0900		22.27	11.02	0.684	3	96.49	2.22
	1000		24.59	12.43	0.751	3	95.57	2.85
	1100		24.90	10.23	0.772	3	95.26	3.33
	1200		24.24	9.64	0.769	3	95.32	3.40
	1300		24.74	9.81	0.775	3	95.22	3.43
	1400		25.67	7.29	0.817	3	94.57	4.40
	1500		26.89	8.50	0.859	3	93.89	4.94
	1600		27.11	10.21	0.869	3	93.73	4.88
	1700		25.96	9.30	0.829	3	94.38	4.34
	1800		25.04	8.54	0.802	3	94.81	4.02
	1900		23.49	9.02	0.752	3	95.57	3.25
	2000		22.55	9.32	0.714	3	96.09	2.73
	2100		21.05	7.34	0.665	3	96.74	2.33
	2200		17.65	3.73	0.580	3	97.71	1.83
	2300		17.60	6.54	0.521	3	98.28	1.07

Avg Air-Time per PTT		Average per Hour		Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
		Ring-In	Field Init				
sec	0.00	19.06	7.25	0.600	72	96.25 %	2.74

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Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 95th %-tile
Contiguous	0800	1900	12	95.16 %	3.58
non-Contig			12	98.24 %	1.21

Figure 2. Model N, ECC_010203, Average Workloads.

Year	Dispatch Model	Console	Surge
2018	Model N	ECC_123	+ 0.00 σ

Surge	Hour of Day	Avg per Hour-of-Day		PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 97th %-tile
	0000			232.36	0.212		1	78.84	1.84
	0100			209.69	0.191		1	80.89	1.62
	0200			158.55	0.145		1	85.45	1.17
	0300			149.07	0.138		1	86.23	1.11
	0400			131.09	0.119		1	88.10	0.92
	0500			119.62	0.106		1	89.38	0.79
	0600			128.02	0.112		1	88.79	0.83
	0700			222.07	0.209		1	79.15	1.86
	0800			244.15	0.230		1	77.00	2.11
	0900			246.78	0.232		1	76.83	2.13
	1000			269.76	0.252		1	74.84	2.35
	1100			289.85	0.270		1	72.97	2.59
	1200			301.60	0.282		1	71.75	2.77
	1300			287.98	0.265		1	73.52	2.49
	1400			293.35	0.272		1	72.77	2.61
	1500			417.35	0.386		1	61.42	4.36
	1600			359.73	0.335		1	66.46	3.53
	1700			327.07	0.298		1	70.25	2.89
	1800			335.36	0.303		1	69.74	2.94
	1900			314.65	0.284		1	71.60	2.69
	2000			294.93	0.265		1	73.47	2.44
	2100			263.84	0.237		1	76.32	2.09
	2200			253.22	0.227		1	77.31	1.97
	2300			309.42	0.279		1	72.06	2.63

Avg Air-Time per PTT	Average per Hour		PTT's	Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
3.30 sec	0.00	0.00	256.65	0.235	24	74.40 %	2.44

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Block Performance	Hours Included in Block: From First	Thru Last	Block Length	Parameters Weighted Over Block Lengths: % Immed Ans	Ans Delay @ 97th %-tile
Contiguous	0800	1900	12	70.97 %	2.88
non-Contig			12	79.51 %	1.79

Figure 2. Model N, ECC_0405, Average Workloads.

Year	Dispatch Model	Console	Surge
2018	Model N	꒱ ECC_0405	+ 0.00 σ

Surge	Hour of Day	Avg per Hour-of-Day					Workstation Staffing & Performance		
				PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 97th %-tile
	0000			35.69	0.044		1	95.63	0.42
	0100			35.37	0.047		1	95.32	0.49
	0200			34.43	0.045		1	95.50	0.46
	0300			33.94	0.043		1	95.67	0.43
	0400			28.53	0.037		1	96.35	0.36
	0500			48.05	0.057		1	94.33	0.53
	0600			46.49	0.056		1	94.39	0.54
	0700			96.95	0.101		1	89.93	0.87
	0800			84.02	0.094		1	90.56	0.88
	0900			87.95	0.100		1	89.99	0.95
	1000			107.24	0.121		1	87.92	1.16
	1100			119.84	0.134		1	86.60	1.30
	1200			104.00	0.120		1	87.98	1.19
	1300			105.47	0.119		1	88.13	1.14
	1400			102.27	0.123		1	87.73	1.26
	1500			94.64	0.114		1	88.63	1.16
	1600			79.31	0.095		1	90.55	0.93
	1700			104.20	0.123		1	87.74	1.23
	1800			84.84	0.103		1	89.66	1.06
	1900			73.62	0.089		1	91.07	0.89
	2000			61.95	0.075		1	92.48	0.74
	2100			63.49	0.075		1	92.47	0.72
	2200			48.11	0.058		1	94.17	0.56
	2300			47.98	0.063		1	93.73	0.66

Avg Air-Time per PTT	Average per Hour			Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
			PTT's				
4.24 sec	0.00	0.00	72.01	0.085	24	90.32 %	0.95

index 12

Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 97th %-tile
Contiguous	0800	1900	12	88.70 %	1.11
non-Contig			12	93.52 %	0.62

Figure 2. Model N, ECC_07, Average Workloads.

Year	Dispatch Model	Console	Surge
2018	Model N	ł ECC_07	+ 0.00 σ

Surge	Hour of Day	Avg per Hour-of-Day		PTT's	Σ Erlangs		Workstation Staffing & Performance: OnTask	Immediate Answer [%]	Ans Delay @ 97th %-tile
	0000			49.73	0.046		1	95.39	0.34
	0100			44.83	0.042		1	95.82	0.31
	0200			35.45	0.033		1	96.71	0.24
	0300			32.43	0.031		1	96.89	0.23
	0400			19.23	0.019		1	98.15	0.14
	0500			29.24	0.027		1	97.28	0.19
	0600			80.89	0.069		1	93.13	0.47
	0700			76.61	0.068		1	93.24	0.48
	0800			67.04	0.062		1	93.81	0.46
	0900			71.31	0.065		1	93.53	0.47
	1000			80.05	0.073		1	92.67	0.54
	1100			82.29	0.075		1	92.51	0.55
	1200			84.96	0.077		1	92.28	0.57
	1300			86.13	0.076		1	92.44	0.54
	1400			133.67	0.119		1	88.15	0.90
	1500			97.05	0.087		1	91.30	0.64
	1600			89.71	0.080		1	91.96	0.59
	1700			80.89	0.073		1	92.65	0.54
	1800			71.64	0.067		1	93.32	0.50
	1900			64.44	0.060		1	94.04	0.44
	2000			54.00	0.051		1	94.89	0.38
	2100			49.44	0.044		1	95.58	0.31
	2200			78.11	0.072		1	92.83	0.53
	2300			50.13	0.048		1	95.19	0.36

Avg Air-Time per PTT	Average per Hour		PTT's	Average Erlangs		Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
3.27 sec	0.00	0.00	67.05	0.061		24	93.09 %	0.51

index 11

Block Performance	Hours Included in Block: From First	Thru Last	Block Length	Parameters Weighted Over Block Lengths: % Immed Ans	Ans Delay @ 97th %-tile
Contiguous	0800	1900	12	92.08 %	0.59
non-Contig			12	94.80 %	0.38

APPENDIX H. MODEL N, 1.28 SIGMA SURGES

The Erlang Tables in this Appendix are for workstations in the Model N with 1.28σ surges. Staffing is unchanged from Model N in APPENDIX G in order to show the impact of surges on performance.

Figure 1. Model N, Intake with MPDS & Pre-Arrival Instructions, Challenged with 1.28σ Surges.

Year	Dispatch Model	Console	Surge
2018	Model N	Intake w MPDS & PreAr	+ 1.28 σ

Surge	Hour of Day	Avg per Hour-of-Day					Workstation Staffing & Performance		
			Ring-In	Field Init	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 95th %-tile
+	0000		25.56	14.75	0.821		3	94.52	3.65
+	0100		21.18	12.56	0.718		3	96.03	2.64
+	0200		17.72	9.15	0.589		3	97.61	1.55
+	0300		15.20	7.90	0.519		3	98.29	1.10
+	0400		12.81	5.89	0.463		3	98.74	0.87
+	0500		10.46	4.03	0.429		3	98.98	0.84
+	0600		11.61	5.59	0.494		3	98.50	1.22
+	0700		19.10	11.15	0.716		3	96.06	2.91
+	0800		25.26	19.34	0.892		3	93.35	4.50
+	0900		31.86	22.84	1.065		3	90.21	7.02
+	1000		34.88	25.90	1.156		3	88.49	8.46
+	1100		34.33	20.85	1.162		3	88.37	9.50
+	1200		32.28	19.59	1.140		3	88.78	9.45
+	1300		34.40	20.43	1.171		3	88.19	9.83
+	1400		34.99	15.18	1.222		3	87.20	12.51
+	1500		35.48	15.14	1.248		3	86.70	13.35
+	1600		36.32	17.88	1.288		3	85.94	13.92
+	1700		34.17	16.46	1.216		3	87.32	12.17
+	1800		33.78	15.56	1.206		3	87.52	12.13
+	1900		32.05	17.15	1.136		3	88.86	9.83
+	2000		31.53	17.94	1.111		3	89.34	9.04
+	2100		31.73	14.41	1.077		3	89.99	8.66
+	2200		26.81	8.99	0.954		3	92.26	7.19
+	2300		26.84	14.14	0.860		3	93.88	4.28

Avg Air-Time per PTT	Average per Hour			Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
		Ring-In	Field Init				
sec	0.00	27.10	14.70	0.944	72	90.58 %	8.10

index 16

Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 95th %-tile
Contiguous	0800	1900	12	88.36 %	10.24
non-Contig			12	94.27 %	4.56

Figure 2. Model N, ECC_010203, Challenged with 1.28σ Surges.

Year	Dispatch Model	Console	Surge
2018	Model N	? ECC_123	+ 1.28 σ

Surge	Hour of Day	Avg per Hour-of-Day					Workstation Staffing & Performance		
				PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 97th %-tile
+	0000			333.19	0.304		1	69.57	3.00
+	0100			311.70	0.287		1	71.33	2.78
+	0200			250.15	0.229		1	77.13	2.04
+	0300			256.23	0.237		1	76.30	2.16
+	0400			213.69	0.195		1	80.48	1.66
+	0500			197.22	0.176		1	82.36	1.44
+	0600			188.40	0.170		1	83.02	1.38
+	0700			309.31	0.291		1	70.90	2.90
+	0800			360.78	0.345		1	65.49	3.79
+	0900			341.37	0.324		1	67.56	3.43
+	1000			377.00	0.357		1	64.34	3.94
+	1100			400.87	0.381		1	61.91	4.39
+	1200			422.48	0.401		1	59.89	4.77
+	1300			392.70	0.369		1	63.09	4.13
+	1400			391.55	0.368		1	63.16	4.12
+	1500			552.46	0.518		1	48.18	7.58
+	1600			479.31	0.452		1	54.78	5.85
+	1700			445.11	0.403		1	59.73	4.58
+	1800			455.75	0.417		1	58.26	4.93
+	1900			427.64	0.389		1	61.07	4.36
+	2000			409.01	0.368		1	63.15	3.95
+	2100			361.03	0.327		1	67.25	3.32
+	2200			373.73	0.340		1	65.98	3.52
+	2300			394.58	0.358		1	64.24	3.79

Avg Air-Time per PTT	Average per Hour			Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
			PTT's				
3.30 sec	0.00	0.00	360.22	0.334	24	64.55 %	3.99

index 18

Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 97th %-tile
Contiguous	0800	1900	12	59.98 %	4.79
non-Contig			12	70.98 %	2.88

Figure 3. Model N, ECC_0405, Challenged with 1.28σ Surges.

Year	Dispatch Model	Console	Surge
2018	Model N	ECC_0405	+ 1.28 σ

Surge	Hour of Day	Avg per Hour-of-Day				Workstation Staffing & Performance		
				PTT's	Σ Erlangs	OnTask	Immediate Answer [%]	Ans Delay @ 97th %-tile
+	0000			79.77	0.097	1	90.33	0.97
+	0100			92.03	0.117	1	88.26	1.27
+	0200			78.32	0.105	1	89.52	1.18
+	0300			76.68	0.096	1	90.43	0.99
+	0400			68.19	0.085	1	91.54	0.86
+	0500			108.36	0.139	1	86.08	1.56
+	0600			98.20	0.122	1	87.76	1.30
+	0700			153.13	0.165	1	83.50	1.60
+	0800			132.66	0.158	1	84.19	1.68
+	0900			152.44	0.181	1	81.94	1.96
+	1000			190.22	0.225	1	77.51	2.58
+	1100			206.08	0.244	1	75.63	2.86
+	1200			198.03	0.240	1	76.03	2.87
+	1300			194.94	0.223	1	77.71	2.46
+	1400			213.66	0.264	1	73.57	3.34
+	1500			160.30	0.198	1	80.17	2.30
+	1600			144.96	0.180	1	82.04	2.04
+	1700			218.47	0.269	1	73.06	3.41
+	1800			160.09	0.199	1	80.13	2.31
+	1900			131.37	0.160	1	83.99	1.74
+	2000			111.24	0.140	1	86.04	1.53
+	2100			143.49	0.179	1	82.11	2.04
+	2200			104.36	0.125	1	87.53	1.28
+	2300			102.61	0.136	1	86.40	1.57

Avg Air-Time per PTT	Average per Hour			Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
			PTT's				
4.24 sec	0.00	0.00	138.32	0.169	24	81.36 %	2.14

index 12

Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 97th %-tile
Contiguous	0800	1900	12	78.20 %	2.55
non-Contig			12	86.82 %	1.42

Figure 4. Model N, ECC_07, Challenged with 1.28σ Surges.

Year	Dispatch Model	Console	Surge
2018	Model N	ECC_07	+ 1.28 σ

Surge	Hour of Day	Avg per Hour-of-Day		PTT's	Σ Erlangs		Workstation Staffing & Performance: OnTask	Immediate Answer [%]	Ans Delay @ 97th %-tile
+	0000			79.40	0.075		1	92.54	0.57
+	0100			96.78	0.088		1	91.18	0.66
+	0200			64.51	0.062		1	93.85	0.47
+	0300			67.93	0.066		1	93.37	0.52
+	0400			42.26	0.042		1	95.77	0.33
+	0500			55.48	0.059		1	94.14	0.49
+	0600			111.94	0.101		1	89.91	0.76
+	0700			127.99	0.116		1	88.45	0.89
+	0800			109.86	0.104		1	89.62	0.82
+	0900			121.58	0.112		1	88.79	0.87
+	1000			131.53	0.124		1	87.57	1.01
+	1100			131.42	0.123		1	87.75	0.98
+	1200			122.78	0.114		1	88.57	0.90
+	1300			134.41	0.120		1	87.95	0.92
+	1400			180.26	0.165		1	83.52	1.35
+	1500			147.77	0.136		1	86.44	1.08
+	1600			138.27	0.124		1	87.60	0.95
+	1700			128.78	0.118		1	88.20	0.92
+	1800			106.34	0.101		1	89.91	0.80
+	1900			104.86	0.099		1	90.12	0.78
+	2000			99.23	0.094		1	90.57	0.74
+	2100			82.62	0.076		1	92.36	0.57
+	2200			110.26	0.105		1	89.50	0.84
+	2300			88.69	0.087		1	91.29	0.70

Avg Air-Time per PTT	Average per Hour		PTT's	Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
3.27 sec	0.00	0.00	107.71	0.100	24	89.17 %	0.85

index 11

Block Performance	Hours Included in Block: From First	Thru Last	Block Length	Parameters Weighted Over Block Lengths: % Immed Ans	Ans Delay @ 97th %-tile
Contiguous	0800	1900	12	87.75 %	0.97
non-Contig			12	91.33 %	0.67

APPENDIX J. MODEL N, 1.28 SIGMA SURGES

The Erlang Tables in this Appendix are for workstations in the Model N, challenged with 1.28σ surges. Staffing has been increased so that performance meets FITCH's operational targets.

Figure 1. Model N, Intake with MPDS & Pre-Arrival Instructions, Challenged with 1.28σ Surges, Adjusted Staff

Year	Dispatch Model	Console	Surge
2018	Model N	Intake w MPDS & PreAr	+ 1.28 σ

Surge	Hour of Day	Avg per Hour-of-Day					Workstation Staffing & Performance		
			Ring-In	Field Init	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 95th %-tile
+	0000		25.56	14.75	0.821		3	94.52	3.65
+	0100		21.18	12.56	0.718		3	96.03	2.64
+	0200		17.72	9.15	0.589		3	97.61	1.55
+	0300		15.20	7.90	0.519		3	98.29	1.10
+	0400		12.81	5.89	0.463		3	98.74	0.87
+	0500		10.46	4.03	0.429		3	98.98	0.84
+	0600		11.61	5.59	0.494		3	98.50	1.22
+	0700		19.10	11.15	0.716		3	96.06	2.91
+	0800		25.26	19.34	0.892		3	93.35	4.50
+	0900		31.86	22.84	1.065		3	90.21	7.02
+	1000		34.88	25.90	1.156		4	96.35	1.74
+	1100		34.33	20.85	1.162		4	96.29	1.96
+	1200		32.28	19.59	1.140		4	96.50	1.92
+	1300		34.40	20.43	1.171		4	96.19	2.05
+	1400		34.99	15.18	1.222		4	95.66	2.72
+	1500		35.48	15.14	1.248		4	95.37	2.96
+	1600		36.32	17.88	1.288		4	94.92	3.17
+	1700		34.17	16.46	1.216		4	95.72	2.63
+	1800		33.78	15.56	1.206		4	95.83	2.60
+	1900		32.05	17.15	1.136		4	96.54	1.99
+	2000		31.53	17.94	1.111		4	96.77	1.79
+	2100		31.73	14.41	1.077		4	97.08	1.66
+	2200		26.81	8.99	0.954		3	92.26	7.19
+	2300		26.84	14.14	0.860		3	93.88	4.28

Avg Air-Time per PTT	Average per Hour			Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
		Ring-In	Field Init				
sec	0.00	27.10	14.70	0.944	84	95.58 %	2.86

index 16

Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 95th %-tile
Contiguous	0800	1900	12	95.26 %	2.92
non-Contig			12	96.12 %	2.75

Figure 2. Model N, ECC_010203, Challenged with 1.28σ Surges, Adjusted Staff

Year	Dispatch Model	Console	Surge
2018	Model N	؟ ECC_123	+ 1.28 σ

Surge	Hour of Day	Avg per Hour-of-Day					Workstation Staffing & Performance		
				PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 97th %-tile
+	0000			333.19	0.304		1	69.57	3.00
+	0100			311.70	0.287		1	71.33	2.78
+	0200			250.15	0.229		1	77.13	2.04
+	0300			256.23	0.237		1	76.30	2.16
+	0400			213.69	0.195		1	80.48	1.66
+	0500			197.22	0.176		1	82.36	1.44
+	0600			188.40	0.170		1	83.02	1.38
+	0700			309.31	0.291		1	70.90	2.90
+	0800			360.78	0.345		2	95.17	0.21
+	0900			341.37	0.324		2	95.67	0.18
+	1000			377.00	0.357		2	94.88	0.22
+	1100			400.87	0.381		2	94.26	0.25
+	1200			422.48	0.401		2	93.72	0.28
+	1300			392.70	0.369		2	94.56	0.24
+	1400			391.55	0.368		2	94.58	0.23
+	1500			552.46	0.518		2	90.36	0.46
+	1600			479.31	0.452		2	92.30	0.35
+	1700			445.11	0.403		2	93.68	0.27
+	1800			455.75	0.417		2	93.28	0.29
+	1900			427.64	0.389		2	94.03	0.25
+	2000			409.01	0.368		1	63.15	3.95
+	2100			361.03	0.327		1	67.25	3.32
+	2200			373.73	0.340		1	65.98	3.52
+	2300			394.58	0.358		1	64.24	3.79

Avg Air-Time per PTT	Average per Hour			Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
			PTT's				
3.30 sec	0.00	0.00	360.22	0.334	36	84.24 %	1.36

index 18

Block Performance	Hours Included in Block			Parameters Weighted Over Block Lengths	
	From First	Thru Last	Block Length	% Immed Ans	Ans Delay @ 97th %-tile
Contiguous	0800	1900	12	93.70 %	0.28
non-Contig			12	70.98 %	2.88

Figure 3. Model N, ECC_0405, Challenged with 1.28σ Surges, Adjusted Staff

Year	Dispatch Model	Console	Surge
2018	Model N	ECC_0405	+ 1.28 σ

Surge	Hour of Day	Avg per Hour-of-Day		PTT's	Σ Erlangs	Workstation Staffing & Performance: OnTask	Immediate Answer [%]	Ans Delay @ 97th %-tile
+	0000			79.77	0.097	1	90.33	0.97
+	0100			92.03	0.117	1	88.26	1.27
+	0200			78.32	0.105	1	89.52	1.18
+	0300			76.68	0.096	1	90.43	0.99
+	0400			68.19	0.085	1	91.54	0.86
+	0500			108.36	0.139	1	86.08	1.56
+	0600			98.20	0.122	1	87.76	1.30
+	0700			153.13	0.165	1	83.50	1.60
+	0800			132.66	0.158	1	84.19	1.68
+	0900			152.44	0.181	1	81.94	1.96
+	1000			190.22	0.225	1	77.51	2.58
+	1100			206.08	0.244	1	75.63	2.86
+	1200			198.03	0.240	1	76.03	2.87
+	1300			194.94	0.223	1	77.71	2.46
+	1400			213.66	0.264	1	73.57	3.34
+	1500			160.30	0.198	1	80.17	2.30
+	1600			144.96	0.180	1	82.04	2.04
+	1700			218.47	0.269	1	73.06	3.41
+	1800			160.09	0.199	1	80.13	2.31
+	1900			131.37	0.160	1	83.99	1.74
+	2000			111.24	0.140	1	86.04	1.53
+	2100			143.49	0.179	1	82.11	2.04
+	2200			104.36	0.125	1	87.53	1.28
+	2300			102.61	0.136	1	86.40	1.57

Avg Air-Time per PTT	Average per Hour		PTT's	Average Erlangs	Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
4.24 sec	0.00	0.00	138.32	0.169	24	81.36 %	2.14

index 12

Block Performance	Hours Included in Block: From First	Thru Last	Block Length	Parameters Weighted Over Block Lengths: % Immed Ans	Ans Delay @ 97th %-tile
Contiguous	0800	1900	12	78.20 %	2.55
non-Contig			12	86.82 %	1.42

Figure 4. Model N, ECC_07, Challenged with 1.28σ Surges, Adjusted Staff

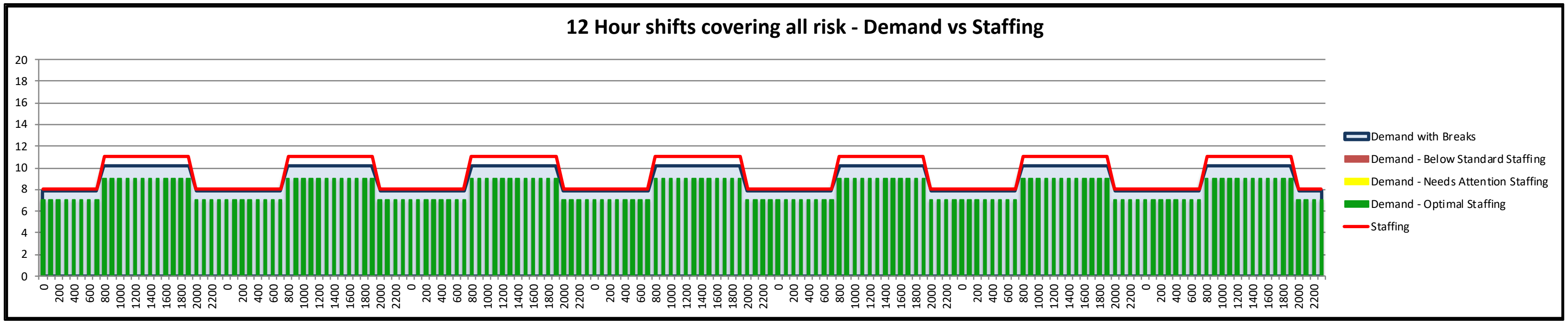
Year	Dispatch Model	Console	Surge
2018	Model N	ECC_07	+ 1.28 σ

Surge	Hour of Day	Avg per Hour-of-Day		PTT's	Σ Erlangs		OnTask	Immediate Answer [%]	Ans Delay @ 97th %-tile
+	0000			79.40	0.075		1	92.54	0.57
+	0100			96.78	0.088		1	91.18	0.66
+	0200			64.51	0.062		1	93.85	0.47
+	0300			67.93	0.066		1	93.37	0.52
+	0400			42.26	0.042		1	95.77	0.33
+	0500			55.48	0.059		1	94.14	0.49
+	0600			111.94	0.101		1	89.91	0.76
+	0700			127.99	0.116		1	88.45	0.89
+	0800			109.86	0.104		1	89.62	0.82
+	0900			121.58	0.112		1	88.79	0.87
+	1000			131.53	0.124		1	87.57	1.01
+	1100			131.42	0.123		1	87.75	0.98
+	1200			122.78	0.114		1	88.57	0.90
+	1300			134.41	0.120		1	87.95	0.92
+	1400			180.26	0.165		1	83.52	1.35
+	1500			147.77	0.136		1	86.44	1.08
+	1600			138.27	0.124		1	87.60	0.95
+	1700			128.78	0.118		1	88.20	0.92
+	1800			106.34	0.101		1	89.91	0.80
+	1900			104.86	0.099		1	90.12	0.78
+	2000			99.23	0.094		1	90.57	0.74
+	2100			82.62	0.076		1	92.36	0.57
+	2200			110.26	0.105		1	89.50	0.84
+	2300			88.69	0.087		1	91.29	0.70
Avg Air-Time per PTT		Average per Hour		PTT's	Average Erlangs		Req'd Hrs OnTask	Wt'd 24 Hr % Immed Ans	Wt'd 24 Hr Ans Delay
3.27 sec		0.00	0.00	107.71	0.100		24	89.17 %	0.85

index 11

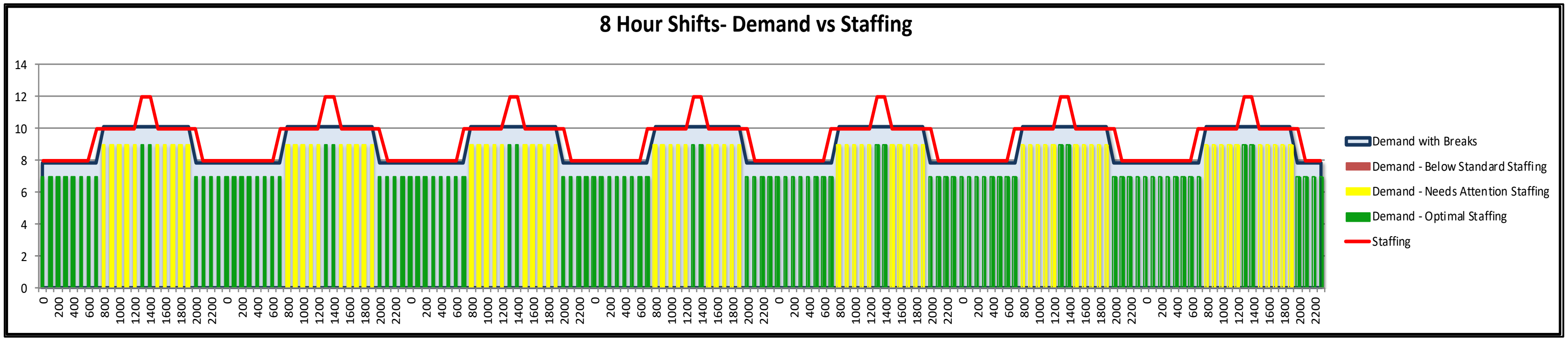
Block Performance	Hours Included in Block: From First	Thru Last	Block Length	Parameters Weighted Over Block Lengths: % Immed Ans	Ans Delay @ 97th %-tile
Contiguous	0800	1900	12	87.75 %	0.97
non-Contig			12	91.33 %	0.67

APPENDIX K. SHIFT SCHEDULES

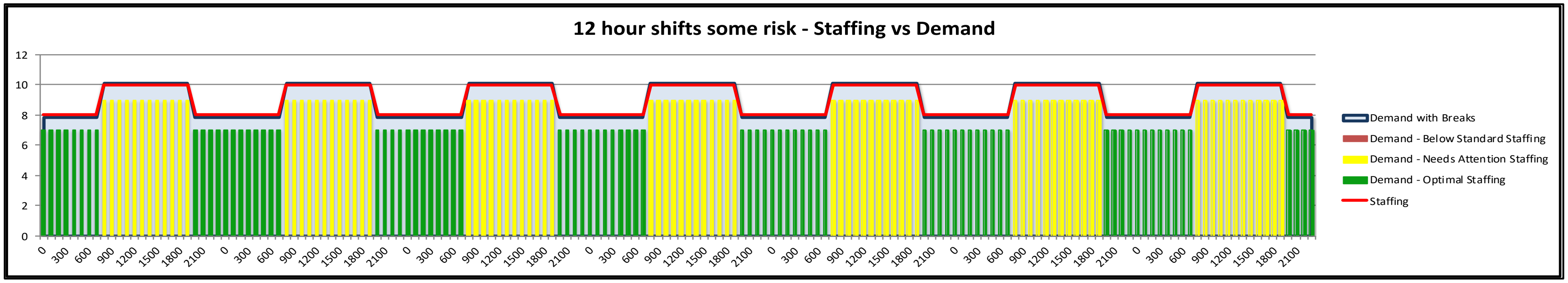


	Week 1													
	Sunday		Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
Shifts	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT
Supervisor Shift	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Position 1	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Position 2	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Position 3	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Position 4	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Position 5	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Position 6	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Position 7	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Position 8	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Position 9	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Position 10	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Supervisor	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800
Shift 1	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800
Shift 2	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800
Shift 3	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800
Shift 4	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800
Shift 5	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800
Shift 6	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800
Shift 7	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800

	Week 2													
	Sunday		Monday		Tuesday		Wednesday		Thursday		Friday		Saturday	
Shifts	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT
Supervisor Shift	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Position 1	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Position 2	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Position 3	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Position 4	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Position 5	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Position 6	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Position 7	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Position 8	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Position 9	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Position 10	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Supervisor	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800
Shift 1	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800
Shift 2	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800
Shift 3	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800
Shift 4	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800
Shift 5	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800
Shift 6	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800
Shift 7	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800



	Week 1														Week 2													
Shifts	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT
Supervisor A Shift	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500
Supervisor B Shift	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300
A Shift	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500
B Shift	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300
A Shift	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500
B Shift	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300
A Shift	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500
B Shift	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300
A Shift	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500
B Shift	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300
A Shift	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500
B Shift	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300
A Shift	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500
B Shift	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300
A Shift	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500
B Shift	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300	1500	2300
A Shift	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500
B Shift	1300	2100	1300	2100	1300	2100	1300	2100	1300	2100	1300	2100	1300	2100	1300	2100	1300	2100	1300	2100	1300	2100	1300	2100	1300	2100	1300	2100
A Shift	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500	700	1500
B Shift	1300	2100	1300	2100	1300	2100	1300	2100	1300	2100	1300	2100	1300	2100	1300	2100	1300	2100	1300	2100	1300	2100	1300	2100	1300	2100	1300	2100
Supervisor C Shift	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700
Shift C	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700
Shift C	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700
Shift C	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700
Shift C	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700
Shift C	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700
Shift C	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700
Shift C	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700	2300	700



	Week 1														Week 2													
Shift	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT	BOT	EOT
Supervisor Shift	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Shift 1	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Shift 2	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Shift 3	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Shift 4	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Shift 5	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Shift 6	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Shift 7	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Shift 8	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Shift 9	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000
Supervisor	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800
Shift 1	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800
Shift 2	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800
Shift 3	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800
Shift 4	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800
Shift 5	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800
Shift 6	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800
Shift 7	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800	2000	800

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