Development of a Hybrid Prediction Mechanism using SMA and EXS Methods for GSM Logical Channel Load Variables

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ABSTRACT
The GSM logical channel load are stochastic (random), distinct in time (Erlang) distribution data; and as such it requires robust means of its prediction. The method employed in this work for the predictions is a hybrid of Simple Moving Average (SMA) and Exponential Smoothing (ExS), which can fit in to predict logical channel load variables with it peculiarities. A three (3) month Data were used in determining the number of observations for the prediction (n) for SMA and smoothing constant (α) for ExS. The determinant values obtained are n = 28, and α = 0.077. These values are used to predict the logical control and traffic channels load variables that characterizes its utilization.

Keywords
GSM, SMA, ExS, and Logical channel.

1. INTRODUCTION
In a GSM system, the physical channels carry different messages, depending on the information that is to be sent. These messages are carried via channels called logical channels (traffic and control). The logical channels loading impact on the network due to the nature of its variability. These include Control Channel Drop Calls rate (PCDROP), Control Channel Congestion rate (PCCONG), Control Channel Failure rate (PCFAIL), Traffic Channel Congestion rate (PCONG), Traffic Channel Availability rate (PTTCH), and Traffic Channel Failure rate (PTFAIL) [1]. These channel variables (data generated) are presented in Figures 1 and 2, based on Appendix A1, to identify their characteristics and nature.

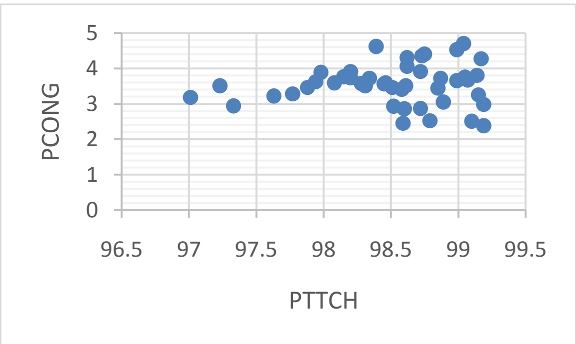

Figure 1: Plots of PCONG Vs PTTCH

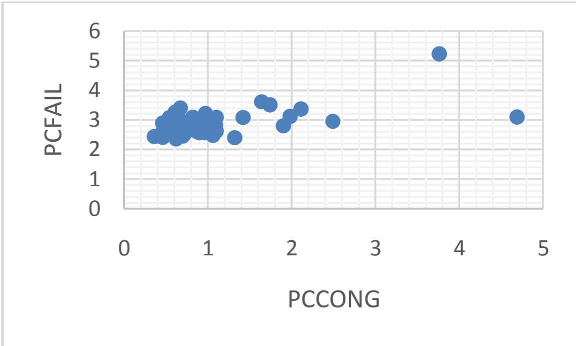

Figure 2: Plots of PCFAIL Vs PCCONG

From the plots presented, the variations are observed to be scattered, which shows that the generated data are stochastic (random) in nature and distinct in time distribution (stochastic). Stochastic variables belong to a family of variables that are non-linear, uncertain, and random [2].

These stochastic variables analyses relies in exploiting the dependence among the channel variables. And the logical channel variables (control and traffic) are distinct in time, which indicates that their analysis can be achieved using Erlang distribution [3]. The Erlang measures the average occupancy of traffic route over a period in communications. It is a dimensionless quantity, and measures to certain extent carried traffic on the network. The Erlang distribution equation is given by [4]:

$$p = \frac{\left({y^n}/{n!}\right)}{\left[\sum_{x=0}^{n}\left({y^n}/{n!}\right)\right]} \qquad (1)$$

Where, **p** = probability of loss or blocking

n = number of paths

y = traffic offered (Erlang)

Equation (1) can further be expanded to:

$$p = \frac{\binom{N}{m}\left(\frac{\lambda_o}{\mu}\right)^m}{\sum_{v=0}^{m}\binom{N}{m}\left(\frac{\lambda_o}{\mu}\right)^v} \qquad (2)$$

Where, **N** = system capacity

m = number of channels/circuits

λ_o = threshold traffic intensity

μ = service rate

v = number of busy channels at time t

In stochastic variables prediction, known values of the variables are needed up to the point in time, say, t, to predict the value at some point in the future, say, t+P. The standard method for this type of prediction is to create a mapping from **D** sample data points, sampled every **Δ** units in time **(x(t-(D-1)Δ),..., x(t-Δ), x(t))**, to a predicted future value **x(t+P)** [5].

2. METHODOLOGY

The method employed in finding an optimal continuation of the GSM logical channel load variables is a hybrid of the Simple Moving Average (SMA) and Exponential Smoothing (ExS) methods. The sequence involved in achieving the optimal hybrid involves the determinations of:

i. Data set mean (x_i);

ii. Number of observations (n); and

iii. Smoothening constant (α).

2.1 Simple Moving Averages (SMA)

SMA is the averaging of the absolute deviations of series of data above from their mean. Equally, it is a technique that uses a type of average that is adjusted to allow for seasonal, cyclical or stochastic variables of a series data and brings either short, mid-, long term trends clearer. In SMA only **n** most recent periods of data points need to be maintained. At the end of each sequence of **n**, the oldest sequence is discarded and the newest data is added to the database. The database is then divided by **n** and used as a forecast for the next period [6], [7].

The moving average **x(t + 1)** for stochastic data of a period **(t + 1)** is given by:

$$x(t+1) = \frac{[D_1 + D_{t-1} + \cdots + D_{t-n-1}]}{n}, \quad n \le t \qquad (3)$$

Where, **n =** number of observations used

D = stochastic data

2.2 Determination of Number of Observations (n)

The number of observations (n) is determined by selecting a value that minimizes the Mean Square Error (MSE) of prediction, given by [6]:

$$MSE = \sum_{i=1}^{n} \frac{[(D_i - x_i)]^2}{n} \qquad (4)$$

Where, x_i = mean of the data set

The value x_i was obtained using a moving window of fourteen (14)-day, twenty one (21)-day, and twenty eight (28)-day width (**n** = 14, **n** = 21, and **n** = 28) on logical channels load variables. The computed x_i is shown in Table 1.

Table 1: x_i values for logical channels variables

n	PTTCH	PCONG	PTFAIL	PCDROP	PCCONG	PCFAIL
14	98.45	3.1	1.09	0.37	0.82	2.57
21	98.41	3.12	1.11	0.38	0.87	2.56
28	98.42	3.15	1.11	0.37	0.84	2.62

Subsequently x_i was applied to the validation data on Appendix A1, for the choice of **n** to minimize the Mean Square Error (MSE). The result is shown in Table 2.

Table 2: MSE values for n

Input variables	January, 2010			February, 2010			March, 2010		
	n			n			n		
	14	21	28	14	21	28	14	21	28
PITCH	0.3219	0.3170	0.3179	0.2146	0.2160	0.2103	0.5323	0.5299	0.5302
PCONG	0.4610	0.4610	0.4610	0.5411	0,5401	0.5401	0.3936	0.3926	0.3927
PTFAIL	0.0105	0.0134	0.0134	0.0048	0.0062	0.0062	0.0058	0.0053	0.0053
PCDROP	0.0025	0.0035	0.0025	0.0029	0.0040	0.0029	0.0007	0.0009	0.0007
PCCONG	1.0604	1.0217	1.0444	0.4246	0.4186	0.4216	0.108	0.1148	0.1101
PCFAIL	0.4296	0.4388	0.3866	0.3426	0.3458	0.3295	0.0659	0.0671	0.0631

From Table 2, **n = 28** generate the least Mean Square Error (MSE) value, therefore it was chosen. The selected value of **n** is then used to determine the forecast values for the logical control and traffic channels variables from April to June, 2010.

2.3 Exponential Smoothing Method (ExS)

ExS is a forecasting technique that weighs past data in an exponential manner, so that the most recent data carries more weight. The exponentially smoothed moving average is based not on a sequential average of individual stochastic periods, but on the most recent data and the average prior to it adjusted by a smoothing constant, α. The expression for the smoothing constant is [6], [8]:

$$\alpha = \frac{1}{\frac{n}{2} - 1} \qquad (5)$$

The smoothed series is updated as new observations are recorded using the expression:

$$S(t) = \alpha D(t) + (1 - \alpha)S(t-1) \qquad (6)$$

Where, S(t) is the value of the smoothed stochastic series.

The current smoothed value S(t) is an interpolation between previous smoothed value (S(t-1)) and the current observation, and α controls the closeness of the interpolated value of the recent observation [6].

The complete forecasted values of the logical control and traffic channels variables using the hybrid of Moving Averages and Exponential Smoothing methods is shown in Appendix A2. These values are used to plot the logical control and traffic channels load variables for the next three (3) months. The plots for Control Channel Drop Calls rate (PCDROP); Control Channel Congestion rate (PCCONG); Control Channel Failure rate (PCFAIL); Traffic Channel Congestion rate (PCONG); Traffic Channel Availability rate (PTTCH); and Traffic Channel Failure (PTFAIL) are shown in Figures 3 to 8.

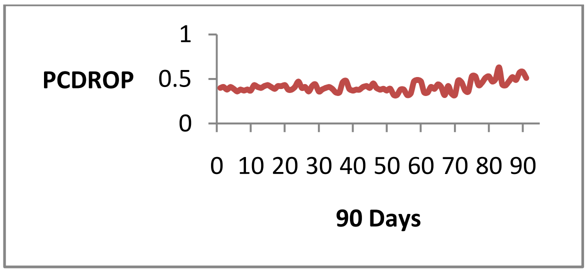

Figure 3: Plot of Control Channels Call Drop rate (PCDROP)

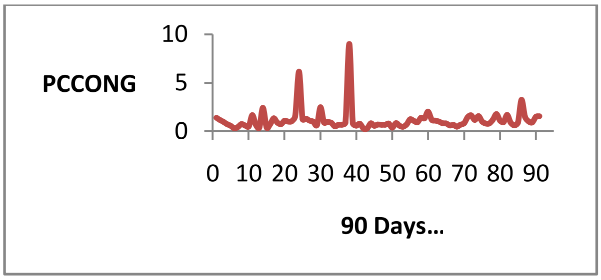

Figure 4: Plot of Control Channels Congestion rate (PCCONG).

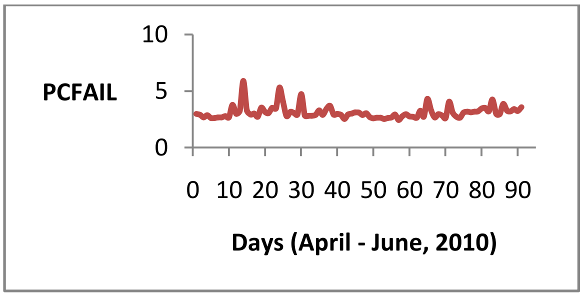

Figure 5: Plot of Control Channels Failure rate (PTFAIL).

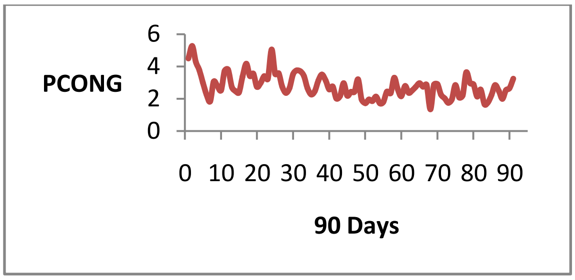

Figure 6: Plot of Traffic Channels Congestion rate (PCONG).

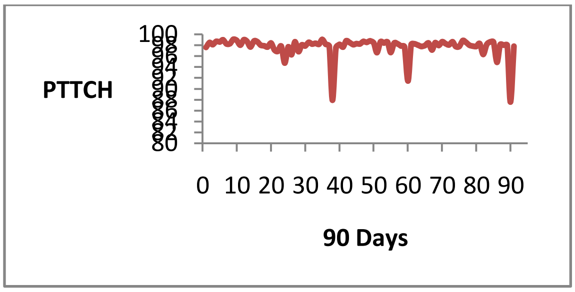

Figure 7: Plot of Traffic Channels Availability rate (PTTCH).

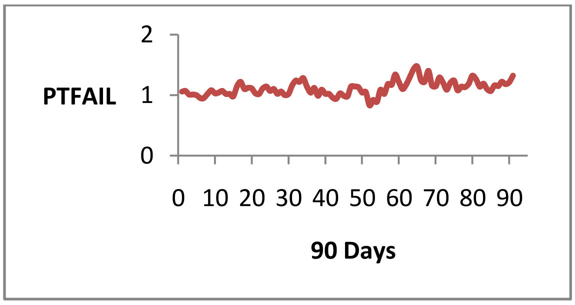

Figure 8: Plot of Traffic Channels Failure rate

3. DISCUSSION OF RESULTS

The forecasted results in Appendix A2, which is represented in Figures 4 – 9 demonstrate the viability of the mechanism (hybrid of SMA and ExS methods) for stochastic forecasting. The main features of the results (shown in Figures 1- 4) is the ability of the mechanism to convey constant closeness control and smoothening of previous and current observations. This is achieved based on consistent interpolation of previous and current observations.

4. CONCLUSIONS

This paper presents a method for prediction of stochastic (random), and distinct in time (Erlang) distribution data. The method employed is a hybrid of Simple Moving Average and Exponential Smoothing. The data used is the GSM logical (control and traffic) channel load variables which is stochastic in nature and followed the Erlang distribution pattern.

The developed hybrid method has demonstrated that it can be used to forecast for GSM logical control channel variables (call drop, failure, and congestion rates) and traffic channel variables (congestion, availability, and failure rates) of a GSM radio network. One of its major features is mapping and sampling of data points and units, weighting of past data, and sequential averaging.

5. REFERENCES

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Appendix A1: Validation data

DISPLAY	PTTCH	PCONG	PTFAIL	PCDROP	PCCONG	PCFAIL	DISPLAY	PTTCH	PCONG	PTFAIL	PCDROP	PCCONG	PCFAIL
2010-01-01	99.04	4.7	1.17	0.33	1.01	2.96	2010-02-15	98.78	2.59	1.01	0.32	0.56	2.49
2010-01-02	99.17	4.27	1.13	0.31	0.86	2.79	2010-02-16	99.01	2.14	1.03	0.32	0.69	2.48
2010-01-03	99.05	3.75	1.17	0.32	0.63	2.85	2010-02-17	98.91	2.47	1.07	0.32	0.96	2.5
2010-01-04	98.87	3.72	1.21	0.32	0.75	2.79	2010-02-18	98.86	2.15	0.99	0.3	0.76	2.37
2010-01-05	98.34	3.72	1.19	0.32	0.56	2.86	2010-02-19	98.94	2.36	1.03	0.32	0.69	2.47
2010-01-06	98.28	3.57	1.16	0.32	0.63	2.7	2010-02-20	97.81	3.49	1.12	0.35	1.75	2.61
2010-01-07	97.88	3.46	1.13	0.31	0.46	2.89	2010-02-21	97.99	2.86	1.08	0.34	0.77	2.69
2010-01-08	98.45	3.56	1.12	0.32	0.66	2.92	2010-02-22	92.76	3.77	1.04	0.37	3.72	2.47
2010-01-09	98.2	3.91	1.02	0.34	0.82	3.09	2010-02-23	98.78	2.42	1.05	0.33	0.59	3.81
2010-01-10	97.01	3.18	0.98	0.39	1.9	2.8	2010-02-24	98.51	2.27	1.13	0.34	0.31	2.82
2010-01-11	98.89	3.05	0.96	0.33	0.61	3.26	2010-02-25	98.56	4.47	1.09	0.35	0.63	2.89
2010-01-12	97.63	3.22	0.99	0.3	4.69	3.1	2010-02-26	98.93	3.31	1.22	0.31	0.67	2.54
2010-01-13	98.46	3.59	0.94	0.31	0.54	3.08	2010-02-27	98.95	2.67	1.2	0.31	0.37	2.58
2010-01-14	98.52	2.93	0.97	0.32	0.88	2.84	2010-02-28	98.48	3.42	1.25	0.33	1.48	5.13
2010-01-15	98.51	3.46	1.01	0.36	1.98	3.12	2010-03-01	98.85	3.07	1.13	0.32	0.6	2.66
2010-01-16	97.23	3.51	1.01	0.33	1.42	3.08	2010-03-02	97.91	2.96	1.12	0.33	0.49	2.76
2010-01-17	98.15	3.76	0.93	0.28	0.82	3.04	2010-03-03	99.06	2.8	1.18	0.34	0.4	2.53
2010-01-18	97.33	2.94	0.95	0.3	0.9	2.57	2010-03-04	98.91	2.89	1.16	0.34	0.44	2.56
2010-01-19	97.98	3.89	1.02	0.31	3.76	5.23	2010-03-05	98.29	3.69	1.19	0.37	0.57	2.75
2010-01-20	98.2	3.73	0.94	0.29	1.32	2.4	2010-03-06	97.51	3.97	1.17	0.38	0.78	3.21
2010-01-21	98.6	2.86	0.95	0.32	0.66	3.01	2010-03-07	97.02	3.82	1.15	0.36	1.09	3.46
2010-01-22	97.77	3.28	0.98	0.34	2.49	2.95	2010-03-08	98.55	2.78	1.07	0.35	0.3	2.72
2010-01-23	99.14	3.8	1	0.34	1.1	3.09	2010-03-09	98.68	2.81	1.02	0.31	0.71	2.37
2010-01-24	98.58	3.41	1.03	0.34	1.09	2.82	2010-03-10	99.01	2.83	1.07	0.37	0.53	2.45
2010-01-25	98.72	2.87	0.99	0.33	1.74	3.51	2010-03-11	96.82	1.9	1.11	0.37	1.33	2.34
2010-01-26	99.07	3.67	1.01	0.32	0.67	3.4	2010-03-12	97.1	4.55	1.29	0.41	1.1	2.47
2010-01-27	98.31	3.51	0.96	0.35	0.97	3.22	2010-03-13	98.81	4.63	1.29	0.42	1.34	2.66
2010-01-28	98.72	3.91	1.02	0.32	2.11	3.37	2010-03-14	99.09	3.23	1.12	0.37	0.77	2.61
2010-01-29	98.99	4.53	1.01	0.33	0.6	2.79	2010-03-15	98.82	3.18	1.11	0.41	0.78	2.52
2010-01-30	97.94	3.62	0.97	0.33	0.57	2.66	2010-03-16	98.74	3.08	1.1	0.38	0.88	3.01
2010-01-31	98.39	4.62	0.98	0.32	0.99	2.6	2010-03-17	98.96	1.51	1.03	0.34	0.5	2.31
2010-02-01	98.62	4.3	1.08	0.33	1.07	2.74	2010-03-18	98.19	2.92	1.07	0.32	0.5	2.3
2010-02-02	98.73	4.35	1.08	0.34	0.72	2.53	2010-03-19	96.91	3.39	1.2	0.35	1.86	2.49

2010-02-03	98.75	4.4	1.03	0.3	0.7	2.5	2010-03-20	98.52	3.12	1.19	0.37	0.68	2.97
2010-02-04	98.08	3.59	1.04	0.29	1.1	2.62	2010-03-21	98.89	3.35	1.13	0.36	0.78	2.58
2010-02-05	98.61	3.51	0.96	0.29	0.62	2.36	2010-03-22	99	3.24	1.09	0.39	0.73	2.57
2010-02-06	99.15	3.25	1	0.29	1.06	2.48	2010-03-23	98.31	2.77	1.09	0.39	0.68	2.65
2010-02-07	98.85	3.44	1.03	0.31	0.87	2.61	2010-03-24	99.09	2.59	1.07	0.37	0.48	2.5
2010-02-08	98.99	3.65	1.02	0.29	0.46	2.41	2010-03-25	98.68	2.87	1.01	0.36	0.51	2.51
2010-02-09	98.59	2.45	1.04	0.33	0.36	2.44	2010-03-26	98.75	3.81	1.11	0.38	0.95	2.55
2010-02-10	99.1	2.51	1.03	0.31	0.7	2.46	2010-03-27	96.93	3.48	1.09	0.38	0.95	2.45
2010-02-11	98.79	2.52	1.04	0.3	0.43	2.49	2010-03-28	98.73	3.25	1.1	0.37	1.09	2.47
2010-02-12	99.19	2.98	1.06	0.33	0.71	2.64	2010-03-29	99.28	2.95	1.06	0.36	0.55	2.42
2010-02-13	99.19	2.38	1.06	0.34	1.64	3.61	2010-03-30	98.35	3.23	1.04	0.39	0.96	2.72
2010-02-14	98.62	4.06	1.09	0.31	0.96	2.57	2010-03-31	98.64	2.47	0.95	0.38	0.76	2.73

Appendix A2: Forecast results of Moving averages and Exponential smoothing methods

PCONG FORECAST TABLE (n = 28, and $\alpha = 0.077$)						
DAY	**APRIL**		**MAY**		**JUNE**	
1	4.49	**4.49**	3.53771	**3.75**	2.75766	**2.37**
2	4.54929	**5.26**	3.74615	**3.7**	2.38155	**2.52**
3	5.18531	**4.29**	3.67767	**3.41**	2.53694	**2.74**
4	4.25073	**3.78**	3.35148	**2.65**	2.75771	**2.97**
5	3.72071	**3.01**	2.61997	**2.26**	2.95306	**2.75**
6	2.95071	**2.24**	2.27694	**2.48**	2.75924	**2.87**
7	2.2092	**1.84**	2.53005	**3.13**	2.75296	**1.35**
8	1.93394	**3.06**	3.15849	**3.5**	1.46704	**2.87**
9	3.04075	**2.81**	3.47074	**3.12**	2.87308	**2.91**
10	2.78767	**2.52**	3.07765	**2.57**	2.85995	**2.26**
11	2.6124	**3.72**	2.58386	**2.75**	2.24152	**2.02**
12	3.72616	**3.8**	2.69379	**2.02**	1.99921	**1.75**
13	3.71607	**2.71**	2.03232	**2.18**	1.76694	**1.97**
14	2.69152	**2.47**	2.24083	**2.97**	2.03776	**2.85**
15	2.46384	**2.39**	2.90994	**2.19**	2.79071	**2.08**
16	2.46546	**3.37**	2.20848	**2.43**	2.09001	**2.21**
17	3.4316	**4.17**	2.43077	**2.44**	2.32011	**3.64**
18	4.11071	**3.40**	2.49929	**3.21**	3.58764	**2.96**
19	3.41155	**3.55**	3.11375	**1.96**	2.95384	**2.88**
20	3.48763	**2.74**	1.94152	**1.72**	2.82302	**2.14**
21	2.75925	**2.99**	1.73848	**1.96**	2.17311	**2.57**
22	3.02234	**3.41**	1.9523	**1.86**	2.49993	**1.66**
23	3.39537	**3.22**	1.88156	**2.14**	1.67001	**1.79**
24	3.36091	**5.05**	2.10766	**1.72**	1.82388	**2.23**
25	4.93373	**3.54**	1.72616	**1.80**	2.27774	**2.85**
26	3.54308	**3.58**	1.84928	**2.44**	2.82151	**2.48**
27	3.51609	**2.75**	2.43307	**2.35**	2.44304	**2.00**
28	2.71997	**2.36**	2.42315	**3.30**	2.04158	**2.54**
29	2.38464	**2.68**	3.24533	**2.59**	2.54847	**2.65**

30	2.74468	**3.52**	2.55689	**2.16**	2.6962	**3.25**
31			2.20851	**2.79**		

PTTCH FORECAST TABLE (n = 28, and $\alpha = 0.077$)						
DAY	**APRIL**		**MAY**		**JUNE**	
1	97.56	**97.56**	97.89928	**98.49**	98.12847	**98.23**
2	97.63007	**98.47**	98.46767	**98.2**	98.21075	**97.98**
3	98.43997	**98.08**	98.21078	**98.34**	97.96152	**97.74**
4	98.1262	**98.68**	98.32614	**98.16**	97.75232	**97.90**
5	98.67307	**98.59**	98.22853	**99.05**	97.93619	**98.37**
6	98.61849	**98.96**	98.9807	**98.15**	98.27452	**97.13**
7	98.90302	**98.22**	98.12459	**97.82**	97.2301	**98.43**
8	98.22385	**98.27**	97.05616	**87.9**	98.3915	**97.93**
9	98.32852	**99.03**	88.64228	**97.54**	97.98313	**98.62**
10	99.0146	**98.83**	97.58389	**98.11**	98.59536	**98.30**
11	98.76455	**97.98**	98.07458	**97.65**	98.27844	**98.02**
12	98.05623	**98.97**	97.73855	**98.8**	98.06543	**98.61**
13	98.9469	**98.67**	98.77382	**98.46**	98.54455	**97.76**
14	98.59223	**97.66**	98.42997	**98.07**	97.76	**97.76**
15	97.7447	**98.76**	98.08463	**98.26**	97.84162	**98.82**
16	98.74999	**98.63**	98.25769	**98.23**	98.79767	**98.53**
17	98.57995	**97.98**	98.26311	**98.66**	98.48765	**97.98**
18	97.96999	**97.85**	98.64768	**98.5**	97.96691	**97.81**
19	97.8346	**97.65**	98.51925	**98.75**	97.80461	**97.74**
20	97.70621	**98.38**	98.72074	**98.37**	97.78235	**98.29**
21	98.28375	**97.13**	98.23448	**96.61**	98.136	**96.29**
22	97.10767	**96.84**	96.76246	**98.59**	96.43091	**98.12**
23	96.91315	**97.79**	98.57306	**98.37**	98.15311	**98.55**
24	97.55207	**94.7**	98.38386	**98.55**	98.55	**98.55**
25	94.93023	**97.69**	98.4037	**96.65**	98.2651	**94.85**
26	97.57912	**96.25**	96.78321	**98.38**	95.09871	**98.08**
27	96.43172	**98.61**	98.36845	**98.23**	98.07307	**97.99**
28	98.47063	**96.8**	98.19997	**97.84**	97.99	**97.99**
29	96.89394	**98.02**	97.82999	**97.71**	97.18689	**87.56**
30	98.00691	**97.85**	97.22413	**91.4**	88.34694	**97.78**

PTFAIL FORECAST TABLE (n = 28, and $\alpha = 0.077$)						
DAY	**APRIL**		**MAY**		**JUNE**	
1	1.06	**1.06**	1.03078	**1.16**	1.10616	**1.18**
2	1.06077	**1.07**	1.16616	**1.24**	1.18924	**1.3**
3	1.06538	**1.01**	1.23846	**1.22**	1.31001	**1.43**
4	1.01	**1.01**	1.22462	**1.28**	1.43308	**1.47**
5	1.00923	**1**	1.26922	**1.14**	1.45229	**1.24**
6	0.99615	**0.95**	1.1323	**1.04**	1.23846	**1.22**

7	0.95	**0.95**	1.04616	**1.12**	1.23386	**1.40**
8	0.95539	**1.02**	1.10999	**0.99**	1.38152	**1.16**
9	1.02462	**1.08**	0.9977	**1.09**	1.15923	**1.15**
10	1.07615	**1.03**	1.08461	**1.02**	1.16078	**1.29**
11	1.03077	**1.04**	1.02	**1.02**	1.28307	**1.2**
12	1.04231	**1.07**	1.01538	**0.96**	1.19153	**1.09**
13	1.06615	**1.02**	0.95846	**0.94**	1.09847	**1.2**
14	1.02	**1.02**	0.94693	**1.03**	1.20308	**1.24**
15	1.01692	**0.98**	1.02692	**0.99**	1.22768	**1.08**
16	0.99309	**1.15**	0.98923	**0.98**	1.08462	**1.14**
17	1.15539	**1.22**	0.99232	**1.14**	1.13923	**1.13**
18	1.21076	**1.1**	1.14	**1.14**	1.13462	**1.19**
19	1.10154	**1.12**	1.13923	**1.13**	1.20001	**1.32**
20	1.11923	**1.11**	1.12307	**1.04**	1.31538	**1.26**
21	1.10384	**1.03**	1.04077	**1.05**	1.25076	**1.14**
22	1.02923	**1.02**	1.03306	**0.83**	1.14385	**1.19**
23	1.02693	**1.11**	0.83693	**0.92**	1.18307	**1.1**
24	1.11231	**1.14**	0.91769	**0.89**	1.09769	**1.07**
25	1.13461	**1.07**	0.9054	**1.09**	1.07693	**1.16**
26	1.07231	**1.1**	1.08461	**1.02**	1.15923	**1.15**
27	1.09384	**1.02**	1.03232	**1.18**	1.15539	**1.22**
28	1.02308	**1.06**	1.17923	**1.17**	1.21692	**1.18**
29	1.05538	**1**	1.18309	**1.34**	1.18231	**1.21**
30	1.00154	**1.02**	1.32999	**1.21**	1.21847	**1.32**
31			1.20153	**1.1**		

PCDROP FORECAST TABLE (n = 28, and $\alpha = 0.077$)						
DAY	**APRIL**		**MAY**		**JUNE**	
1	0.40012	**0.4**	0.36154	**0.38**	0.35	**0.35**
2	0.40077	**0.41**	0.38154	**0.4**	0.35462	**0.41**
3	0.40769	**0.38**	0.40077	**0.41**	0.40846	**0.39**
4	0.38231	**0.41**	0.40846	**0.39**	0.39385	**0.44**
5	0.40846	**0.39**	0.38692	**0.35**	0.43769	**0.41**
6	0.38769	**0.36**	0.35	**0.35**	0.40307	**0.32**
7	0.36154	**0.38**	0.35847	**0.46**	0.3277	**0.42**
8	0.37923	**0.37**	0.46154	**0.48**	0.41384	**0.34**
9	0.37077	**0.38**	0.47307	**0.39**	0.33846	**0.32**
10	0.37923	**0.37**	0.38846	**0.37**	0.33232	**0.48**
11	0.37462	**0.43**	0.37077	**0.38**	0.47846	**0.46**
12	0.42846	**0.41**	0.38	**0.38**	0.45307	**0.37**
13	0.40923	**0.4**	0.38231	**0.41**	0.36923	**0.36**
14	0.40154	**0.42**	0.41077	**0.42**	0.37309	**0.53**
15	0.42077	**0.43**	0.41846	**0.4**	0.53	**0.53**
16	0.42846	**0.41**	0.40385	**0.45**	0.5223	**0.43**

17	0.40846	**0.39**	0.44615	**0.4**	0.43231	**0.46**
18	0.39231	**0.42**	0.39846	**0.38**	0.46385	**0.51**
19	0.42	**0.42**	0.38077	**0.39**	0.51154	**0.53**
20	0.42077	**0.43**	0.38846	**0.37**	0.52538	**0.47**
21	0.42615	**0.38**	0.37154	**0.39**	0.47231	**0.5**
22	0.38	**0.38**	0.38461	**0.32**	0.51001	**0.63**
23	0.38231	**0.41**	0.32	**0.32**	0.61537	**0.44**
24	0.41462	**0.47**	0.32462	**0.38**	0.43923	**0.43**
25	0.46461	**0.4**	0.38	**0.38**	0.43385	**0.48**
26	0.40077	**0.41**	0.37538	**0.32**	0.48308	**0.52**
27	0.40615	**0.36**	0.32154	**0.34**	0.51769	**0.49**
28	0.36462	**0.42**	0.35001	**0.47**	0.49616	**0.57**
29	0.42154	**0.44**	0.47154	**0.49**	0.57077	**0.58**
30	0.43384	**0.36**	0.48846	**0.47**	0.57461	**0.51**
31			0.46076	**0.35**		

PCCONG FORECAST TABLE (n = 28, and $\alpha = 0.077$)						
DAY	**APRIL**		**MAY**		**JUNE**	
1	1.410976	**1.410976**	2.34911	**0.9**	1.17461	**1.11**
2	1.38998	**1.15**	0.90616	**0.98**	1.1023	**1.01**
3	1.13691	**0.98**	0.97076	**0.86**	0.99691	**0.84**
4	0.95998	**0.72**	0.83151	**0.49**	0.83769	**0.81**
5	0.70922	**0.58**	0.50309	**0.66**	0.79383	**0.6**
6	0.55844	**0.3**	0.66154	**0.68**	0.60462	**0.66**
7	0.31001	**0.43**	0.69694	**0.9**	0.64614	**0.48**
8	0.45387	**0.74**	1.5237	**9**	0.49463	**0.67**
9	0.72999	**0.61**	8.37168	**0.84**	0.68309	**0.84**
10	0.60153	**0.5**	0.81921	**0.57**	0.88774	**1.46**
11	0.58932	**1.66**	0.58617	**0.78**	1.47386	**1.64**
12	1.58377	**0.67**	0.73996	**0.26**	1.60458	**1.18**
13	0.6469	**0.37**	0.26308	**0.3**	1.20926	**1.56**
14	0.52631	**2.4**	0.33927	**0.81**	1.51611	**0.99**
15	2.24369	**0.37**	0.79075	**0.56**	0.9746	**0.79**
16	0.39926	**0.75**	0.57001	**0.69**	0.79	**0.79**
17	0.79543	**1.34**	0.68846	**0.67**	0.82003	**1.18**
18	1.30535	**0.89**	0.67077	**0.68**	1.22466	**1.76**
19	0.87922	**0.75**	0.68924	**0.8**	1.70918	**1.1**
20	0.77618	**1.09**	0.76843	**0.39**	1.08845	**0.95**
21	1.08307	**1**	0.42388	**0.83**	1.00621	**1.68**
22	1.00231	**1.03**	0.80998	**0.57**	1.61994	**0.9**
23	1.07081	**1.56**	0.5623	**0.47**	0.87613	**0.59**
24	1.91343	**6.15**	0.48771	**0.7**	0.61464	**0.91**
25	5.7727	**1.25**	0.74158	**1.24**	1.08941	**3.24**
26	1.25385	**1.3**	1.22691	**1.07**	3.10448	**1.48**

27	1.28537	**1.11**	1.05845	**0.92**	1.44381	**1.01**
28	1.10153	**1**	0.95542	**1.38**	1.00384	**0.93**
29	0.97151	**0.63**	1.37615	**1.33**	0.97389	**1.5**
30	0.77168	**2.47**	1.3839	**2.03**	1.50462	**1.56**
31			1.96455	**1.18**		

PCFAIL FORECAST TABLE (n = 28, and $\alpha = 0.077$)						
DAY	**APRIL**		**MAY**		**JUNE**	
1	2.982104	**2.982104**	4.58524	**2.85**	2.70384	**2.63**
2	2.97384	**2.9**	2.84692	**2.81**	2.67774	**3.25**
3	2.88229	**2.67**	2.81	**2.81**	3.21073	**2.74**
4	2.68463	**2.86**	2.81693	**2.9**	2.86089	**4.31**
5	2.84075	**2.61**	2.92926	**3.28**	4.22915	**3.26**
6	2.61077	**2.62**	3.24997	**2.89**	3.2138	**2.66**
7	2.62308	**2.66**	2.93081	**3.42**	2.6831	**2.96**
8	2.66154	**2.68**	3.44002	**3.68**	2.95076	**2.84**
9	2.68693	**2.77**	3.62148	**2.92**	2.82306	**2.62**
10	2.7623	**2.67**	2.92462	**2.98**	2.73011	**4.05**
11	2.75393	**3.76**	2.9723	**2.88**	3.97685	**3.1**
12	3.69994	**2.98**	2.85228	**2.52**	3.07074	**2.72**
13	3.00079	**3.25**	2.5508	**2.92**	2.71461	**2.65**
14	3.45251	**5.88**	2.9277	**3.02**	2.68388	**3.09**
15	5.6798	**3.28**	3.02693	**3.11**	3.09616	**3.17**
16	3.25228	**2.92**	3.10846	**3.09**	3.16615	**3.12**
17	2.92616	**3**	3.07383	**2.88**	3.12385	**3.17**
18	2.97921	**2.73**	2.89155	**3.03**	3.17231	**3.2**
19	2.79083	**3.52**	3.00459	**2.7**	3.21925	**3.45**
20	3.49074	**3.14**	2.69076	**2.58**	3.45308	**3.49**
21	3.13307	**3.05**	2.58385	**2.63**	3.46844	**3.21**
22	3.08542	**3.51**	2.63	**2.63**	3.29008	**4.25**
23	3.50615	**3.46**	2.6223	**2.53**	4.15144	**2.97**
24	3.60168	**5.3**	2.53539	**2.6**	2.96923	**2.96**
25	5.20452	**4.06**	2.60462	**2.66**	3.0293	**3.86**
26	3.96221	**2.79**	2.68002	**2.92**	3.8138	**3.26**
27	2.81849	**3.16**	2.88381	**2.45**	3.25615	**3.21**
28	3.15153	**3.05**	2.47387	**2.76**	3.22386	**3.39**
29	3.03999	**2.92**	2.77386	**2.94**	3.37768	**3.23**
30	3.05937	**4.73**	2.92537	**2.75**	3.25695	**3.58**
31			2.74692	**2.71**		