

RELIABILITY REASON FOR A COMMERCIAL INADVERTENT-INTERCHANGE SETTLEMENT STANDARD.

Attached are 2 graphs of monthly average frequency error on the Eastern Interconnection back to 1994. The error is the deviation not from 60 Hz, but from frequency scheduled by NERC in CPS1 performance measurement which may at times be 20 mHz above or below 60 mHz to correct time error. Time-error correction shifts the CPS1 frequency target to get Balancing Authorities' CPS1 behavior to automatically readjust to 0 the mean of frequency error in this era of DC clocks whose accuracy may depend less and less on frequency. The trend line from 1994 until 1999 inclusive is flat and just above +1/2 mHz and, from 2000 until 2002 inclusive, the trend has drifted to +5 mHz, which represents the statistical mean of frequency for calculating CPS1 performance and what the statistical mean of frequency WOULD BE if NERC did not reduce it to practically 0 through time-error correction.

The drift coincides with a dramatic increase in time-error correction by NERC to almost daily and explains the deterioration of frequency's average distance of 11mHz to 14mHz from scheduled frequency, closer to the CPS1 limit of 18mHz. The error variability was already deteriorating from 1994 and continued to deteriorate until 1999 inclusive, just before the mean started drifting significantly above zero. The at least +1 mHz annual drift in the mean may suggest that there are few years left before the Eastern Interconnection hits the CPS1 18mHz limit. Accordingly, time is of the essence in developing an Inadvertent Interchange settlement standard and a frequency response standard. The frequency data is posted on NERC's website at ftp://www.nerc.com/pub/sys/all_updl/oc/rs/freqerr.txt

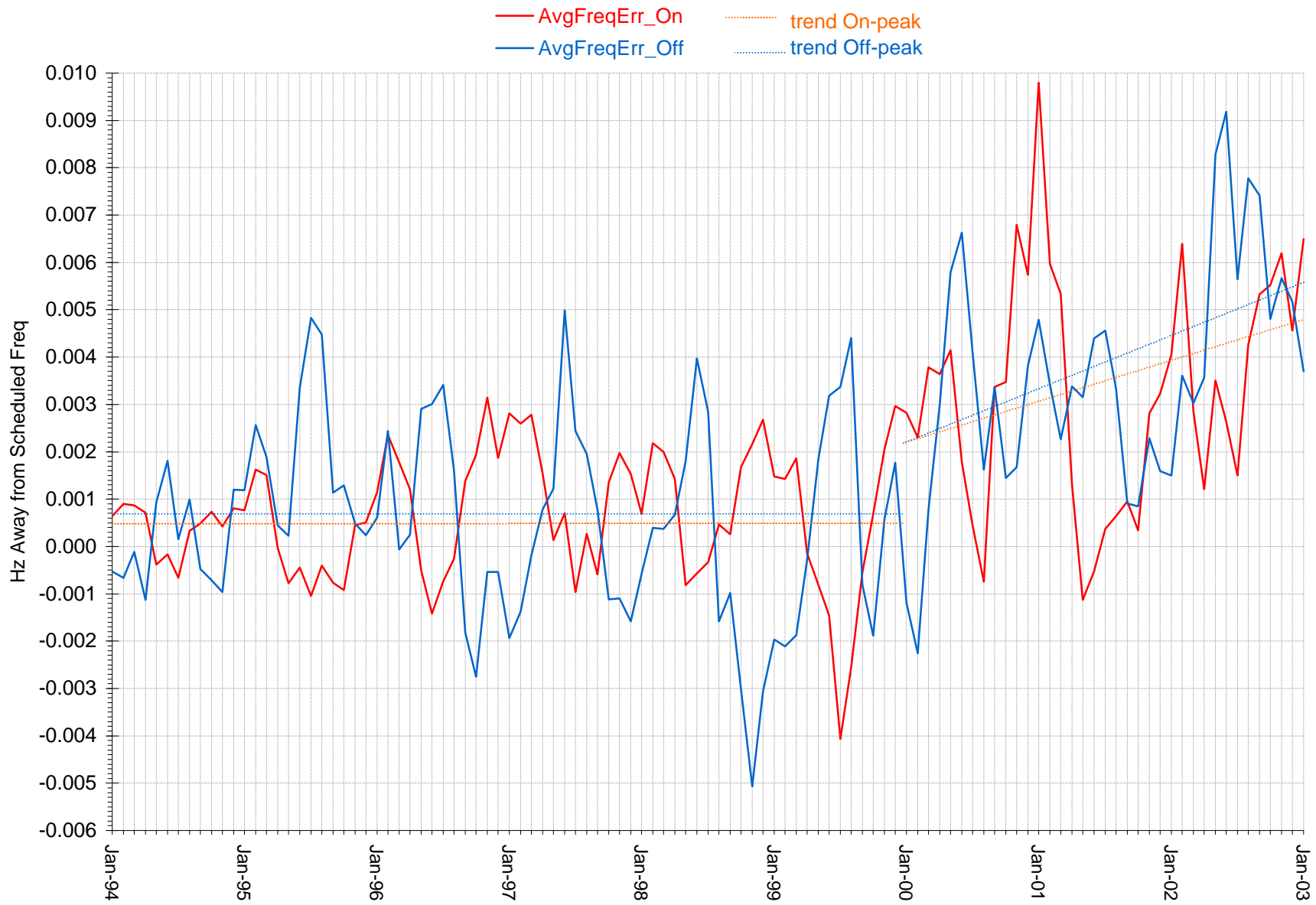
Howard Illian has offered several possible reasons for the upward drift: (1) 16-hour blocks of on-peak insisted on by operators rather than marketers and leaving some overgeneration, (2) continuing to generate between 2AM and 4AM in anticipation of the morning load, and (3) overgeneration to reduce the probability of Disturbance Control Standard (DCS) violation since loss of generation is likelier than loss of load. In other words, both the market itself, and non-marketizable rules. These interpretations all lead to the same conclusion: Inadvertent Interchange behavior needs to be price/cost incented based on trading of the frequency contribution--trading that is incented by a strong CPS1 penalty. An Inadvertent Interchange settlement standard is needed to define the tradable product.

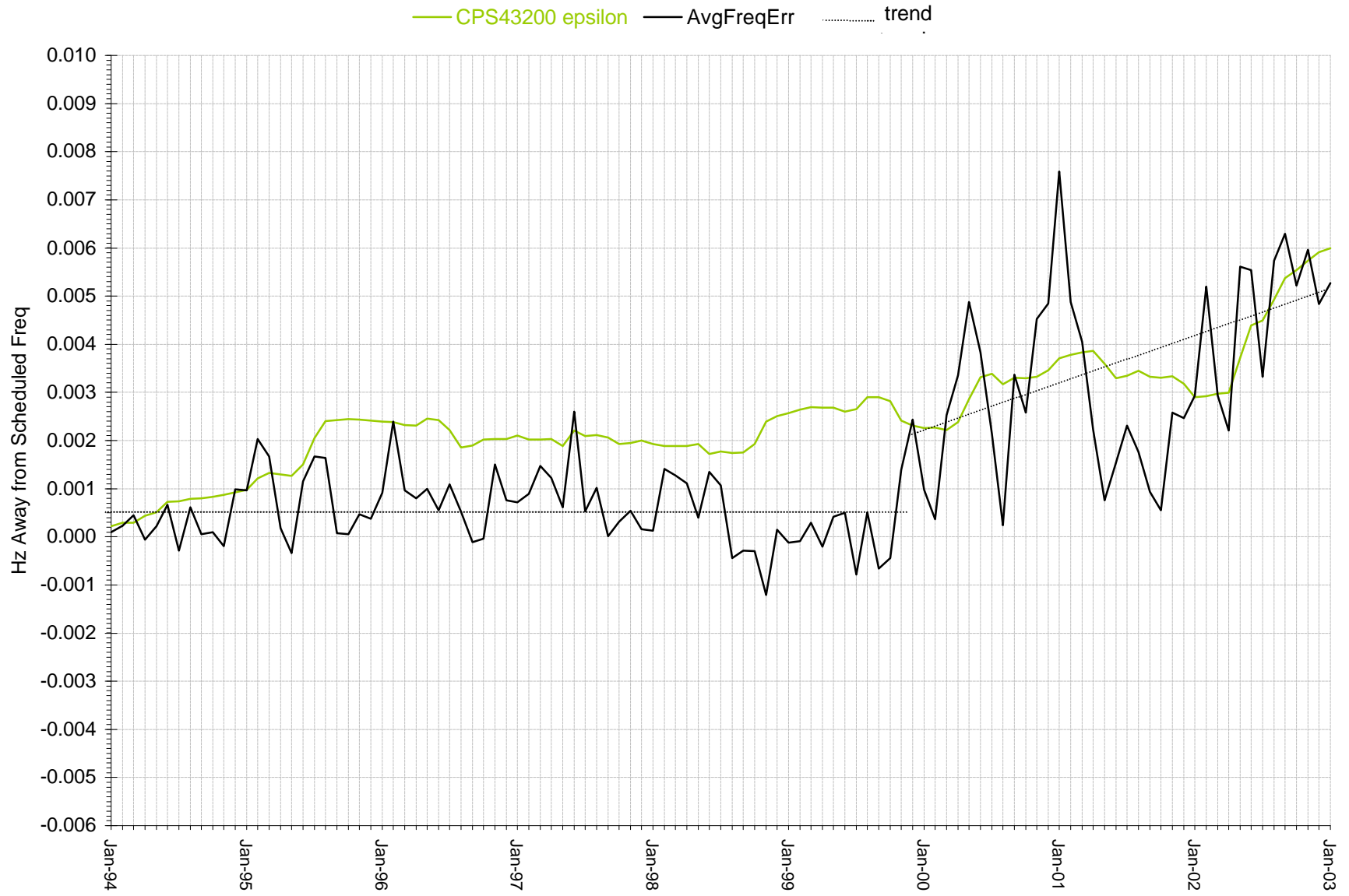
Howard's diagnosis seems to be supported by the reverse-seasonality between on-peak and off-peak error: the on-peak error is less in the longer-daytime Spring/Summer than in the shorter-daytime Fall/Winter and less than the off-peak error in Spring/Summer but greater than the off-peak error in Fall/Winter which tends to be less in the Fall/Winter (maybe because of reduced heating demand at night) than in the Spring/Summer (maybe because of demand for air conditioning at night).

I graphed the combined error on-peak and off-peak which shows the trend more clearly, with no seasonality in the variation. This shows vividly that on-peak and off-peak errors had a dramatic, exactly counter-cyclical offsetting effect, or somewhat negative correlation, that dampened the overall (combined) average frequency error volatility dramatically until 2000. From then on off-peak error has drifted somewhat more in the positive direction than on-peak error, making them somewhat more positively correlated to each other and somewhat less visibly offsetting as this adds even more upward drift to the variability of the average frequency error.

The variability depicted in the graph of monthly averages of frequency error understates the variability measured by CPS1 because CPS1 takes the root of the annual average of squares of the errors which gives exponential weight to big errors. The graph of CPS I included is PS43200 whose inputs are 12 averages of 43200 minutes in a month. Since these 12 inputs pick up much less variability than the 518400 (=12 x 43200) minutes input into CPS1, the CPS43200 epsilon (or average distance of error from scheduled frequency) far understates CPS1 epsilon. However it displays the same deterioration over time as CPS1 epsilon.

Time-error correction itself increases variability because it's adjusting for more than any mean shift/drift of a few mHz by scheduling frequency to some 20 mHz away from 60 Hz. That would increase by more than the allowed 18 mHz the average distance of errors from the scheduled frequency if no Balancing Authority participated in the correction by calibrating its CPS1 performance to the scheduled frequency. Or it would so increase the average distance of errors from 60 Hz if all the Balancing Authorities participated in the time-error correction, although that variability increase would be measurable in CPS1 performance relative to 60 Hz rather than to scheduled frequency. The reality is likely somewhere between. Time error correction would minimize any negative impact on CPS1 performance, if it were limited to only the few mHz required to compensate over a long period for the mean shift/drift by being automatically set in AGC systems to respond but only to a long-term time-error. This means clocks would be accurate over the past year but maybe not day to day. Attempting day-to-day accuracy comes at the cost of deterioration in CPS1 performance through a losing game of ever more frequent time corrections.





Month	Hours_On	AvgFreqErr_On	Hours_Off	AvgFreqErr_Off	AvgFreqErr	CPS43200 epsilon
Jan-03	416	0.006497	328	0.003706	0.005266559	0.005992762
Dec-02	400	0.004556	344	0.005169	0.00483943	0.005912437
Nov-02	400	0.006198	320	0.005667	0.005962	0.005739521
Oct-02	432	0.005519	313	0.004813	0.005222385	0.005540741
Sep-02	384	0.005320	336	0.007419	0.006299533	0.005369269
Aug-02	432	0.004262	312	0.007774	0.005734774	0.00493066
Jul-02	416	0.001503	328	0.005645	0.003329043	0.004494232
Jun-02	400	0.002632	320	0.009185	0.005544444	0.004390464
May-02	416	0.003509	328	0.008286	0.005614989	0.003721903
Apr-02	416	0.001209	303	0.003565	0.002201862	0.002992984
Mar-02	416	0.002852	328	0.003027	0.002929151	0.00297476
Feb-02	384	0.006389	288	0.003604	0.005195429	0.002917731
Jan-02	416	0.004052	328	0.001503	0.002928247	0.00289902
Dec-01	400	0.003225	344	0.001594	0.002470882	0.003181836
Nov-01	400	0.002816	320	0.002282	0.002578667	0.003335541
Oct-01	432	0.000345	313	0.000846	0.000555487	0.003305359
Sep-01	384	0.000948	336	0.000911	0.000930733	0.003322577
Aug-01	432	0.000637	312	0.003328	0.001765484	0.00345166
Jul-01	400	0.000370	344	0.004561	0.002307774	0.003348088
Jun-01	416	-0.000529	304	0.004391	0.001548333	0.003298543
May-01	416	-0.001127	328	0.003150	0.000758559	0.003597226
Apr-01	400	0.001309	319	0.003377	0.002226513	0.003860937
Mar-01	432	0.005331	312	0.002265	0.004045258	0.003834448
Feb-01	384	0.005966	288	0.003418	0.004874	0.003785132
Jan-01	416	0.009791	328	0.004785	0.007584054	0.003711642
Dec-00	400	0.005740	344	0.003816	0.004850409	0.003462063
Nov-00	400	0.006798	320	0.001674	0.004520667	0.003321356
Oct-00	416	0.003477	329	0.001444	0.002579205	0.00329003
Sep-00	400	0.003370	320	0.003365	0.003367778	0.003308333
Aug-00	432	-0.000748	312	0.001620	0.000245032	0.003170994
Jul-00	400	0.000448	344	0.004105	0.002138871	0.003384194
Jun-00	416	0.001789	304	0.006633	0.003834244	0.003316198
May-00	416	0.004149	328	0.005790	0.004872452	0.002859301
Apr-00	400	0.003642	319	0.002993	0.003354057	0.002380187
Mar-00	432	0.003782	312	0.000788	0.002526452	0.002219468
Feb-00	400	0.002308	296	-0.002252	0.00036869	0.002273367

Jan-00	400	0.002827	344	-0.001188	0.000970602	0.002261831
Dec-99	416	0.002972	328	0.001763	0.002439	0.002306662
Nov-99	400	0.002045	320	0.000563	0.001386333	0.00241744
Oct-99	416	0.000686	329	-0.001880	-0.000447173	0.002820692
Sep-99	400	-0.000548	320	-0.000803	-0.000661333	0.002900822
Aug-99	416	-0.002556	328	0.004404	0.000512387	0.002905436
Jul-99	416	-0.004063	328	0.003374	-0.000784323	0.002651992
Jun-99	416	-0.001457	304	0.003184	0.000502533	0.002599608
May-99	400	-0.000808	344	0.001844	0.000418194	0.002688224
Apr-99	416	-0.000145	303	-0.000295	-0.000208213	0.002685737
Mar-99	432	0.001864	312	-0.001878	0.000294774	0.002691387
Feb-99	384	0.001428	288	-0.002108	-8.74286E-05	0.002638442
Jan-99	400	0.001474	344	-0.001967	-0.000117	0.00256975
Dec-98	416	0.002682	328	-0.003064	0.000148817	0.002511856
Nov-98	384	0.002164	336	-0.005066	-0.00121	0.00239525
Oct-98	432	0.001671	313	-0.003006	-0.000293968	0.001923325
Sep-98	400	0.000262	320	-0.000983	-0.000291333	0.001746735
Aug-98	416	0.000462	328	-0.001579	-0.000437796	0.001737953
Jul-98	416	-0.000336	328	0.002843	0.001065495	0.001769615
Jun-98	416	-0.000565	304	0.003970	0.001349778	0.001718637
May-98	400	-0.000816	344	0.001800	0.000393548	0.001925358
Apr-98	416	0.001431	303	0.000672	0.001111143	0.001886748
Mar-98	416	0.001992	328	0.000375	0.001279129	0.001890415
Feb-98	384	0.002181	288	0.000388	0.001412571	0.001888053
Jan-98	416	0.000690	328	-0.000582	0.000129226	0.001926369
Dec-97	416	0.001526	328	-0.001588	0.000153161	0.001998672
Nov-97	384	0.001977	336	-0.001099	0.000541533	0.00195158
Oct-97	432	0.001355	313	-0.001122	0.000314328	0.001931873
Sep-97	400	-0.000587	320	0.000774	1.78889E-05	0.002063911
Aug-97	416	0.000272	328	0.001956	0.001014409	0.002118339
Jul-97	416	-0.000967	328	0.002439	0.00053457	0.002093354
Jun-97	400	0.000700	320	0.004980	0.002602222	0.002203371
May-97	416	0.000134	328	0.001214	0.000610129	0.00188166
Apr-97	416	0.001536	303	0.000786	0.001219936	0.002029449
Mar-97	416	0.002776	328	-0.000183	0.001471495	0.002017955
Feb-97	384	0.002597	288	-0.001380	0.000892571	0.002017337
Jan-97	416	0.002810	328	-0.001935	0.000718118	0.002099306

Dec-96	400	0.001871	344	-0.000538	0.000757161	0.002031274
Nov-96	400	0.003141	320	-0.000538	0.001505889	0.002026444
Oct-96	432	0.001932	313	-0.002755	-3.71691E-05	0.00202527
Sep-96	384	0.001381	336	-0.001825	-0.000115133	0.001899558
Aug-96	432	-0.000264	312	0.001601	0.000518097	0.001854319
Jul-96	416	-0.000738	328	0.003409	0.001090247	0.002213014
Jun-96	400	-0.001420	320	0.003005	0.000546667	0.002423275
May-96	416	-0.000510	328	0.002900	0.000993333	0.002460458
Apr-96	416	0.001213	303	0.000244	0.000804645	0.002314595
Mar-96	416	0.001782	328	-0.000060	0.000969935	0.002317103
Feb-96	400	0.002357	296	0.002440	0.002392299	0.002380805
Jan-96	416	0.001147	328	0.000610	0.000910258	0.002391551
Dec-95	400	0.000505	344	0.000233	0.000379237	0.002409753
Nov-95	400	0.000458	320	0.000482	0.000468667	0.002433432
Oct-95	416	-0.000917	329	0.001292	5.85181E-05	0.002445205
Sep-95	400	-0.000770	320	0.001137	7.75556E-05	0.002425392
Aug-95	432	-0.000407	312	0.004480	0.001642387	0.002407072
Jul-95	400	-0.001050	344	0.004829	0.001668247	0.002050276
Jun-95	416	-0.000448	304	0.003348	0.001154756	0.001504133
May-95	416	-0.000782	328	0.000228	-0.000336731	0.001265795
Apr-95	400	-0.000034	319	0.000446	0.000178962	0.001292098
Mar-95	432	0.001511	312	0.001896	0.001672452	0.001326404
Feb-95	384	0.001626	288	0.002563	0.002027571	0.001208678
Jan-95	400	0.000769	344	0.001192	0.000964581	0.000974571
Dec-94	400	0.000802	344	0.001196	0.000984172	0.000924549
Nov-94	400	0.000425	320	-0.000960	-0.000190556	0.00087104
Oct-94	416	0.000736	329	-0.000715	9.52228E-05	0.000825779
Sep-94	400	0.000488	320	-0.000480	5.77778E-05	0.000799568
Aug-94	432	0.000334	312	0.000993	0.000610355	0.00078747
Jul-94	400	-0.000660	344	0.000157	-0.000282247	0.000733442
Jun-94	416	-0.000170	304	0.001813	0.000667267	0.000732041
May-94	400	-0.000380	344	0.000927	0.000224312	0.00051183
Apr-94	416	0.000714	303	-0.001130	-6.3096E-05	0.000436301
Mar-94	432	0.000863	312	-0.000116	0.000452452	0.000289742
Feb-94	384	0.000895	288	-0.000660	0.000228571	0.000287801
Jan-94	400	0.000638	344	-0.000530	9.7957E-05	0.000215706
		0.000609		0.000527	0.000572	