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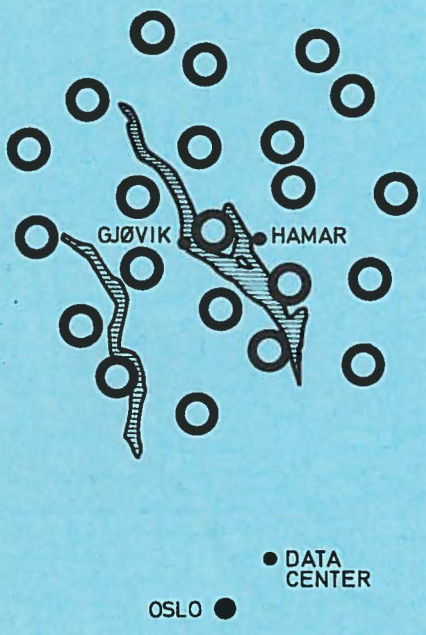

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Summary

This investigation of the NORSAR Event Processor (EP) computer time requirement is based on one month of EP data, from Oct 5 to Nov 4, 1971.

The basic results are the following:

1). Average EP time per event is 9 min 2.9 seconds.

2). Time Delay Correlation package requires 53% of EP time.

3). Depth Estimation package requires 12% of EP time.

4). A change in EP threshold from 12 to 13 dB would reduce the EP time by around 30% and the number of reported events by 12%.

5). By letting the correlation package (SP2) be entered only once per event, one would gain 11% of EP time, while 8% of the located events thereby would go to beampacking instead of finishing by correlation.

6). 44% of the EP processed detections in General Surveillance (=17% total) are also processed from Selected Surveillance, 95% of which having better or equally good solution from SS.

1. Job-Step computer time requirement

The NORSAR Event Processor (EP) is structurally subdivided in different job-steps, and each job-step is again subdivided in different packages (Table 1).

A total of 80 on-line processed events have been analyzed, from the time period Oct 5 - Nov 4, 1971. The main results are given in Table 2, which shows that the average computer time per event is about 9 minutes. Job-step SP02 is by far the most time consuming, where as much as 277 seconds is used for time delay correlation only. This is 51% of the total time in EP per event.

Table 3 shows a more detailed analysis of the computer time required by the different packages. The difference in average package-time from Table 2 arrives because one EP-run have more than one execution of the same package. One execution of SP2 takes for example 214.2 seconds, while the average per event is 277.0 seconds. Table 3 shows that in addition to this time an event using time delay correlation requires additional 31-18=13 seconds in SP3, which amounts to a total time of 290 seconds, or 53% of the total time in EP. This extra time in SP3 is caused by the reading of more data from disc.

Another interesting observation in Table 3 is the time required by the depth estimator (Cepstrum) in SP5. Depth is computed (or tried computed) only on selected P-region events, and Table 4 shows that when averaged out on all processed events, this takes 65.1 seconds per event, or 12% of the total time in EP.

In short, the time delay correlation and the depth estimation requires altogether 65% of the EP computer time, or 6 out of 9 minutes per event.

2. All EP processed detections between Oct 4 and Nov 4, 1971 were analyzed in view of the analyst decisions. The EP-threshold was for this time period 4.0 or 12 dB, the same for all regions. The main results are given in Table 5, where the detections are listed as a function of signal-to-noise ratio. The located events are grouped by the analyst into three qualities, where the quality would express the analysts view of the precision in the time delays. The events which are not located, are reported with only arrival time, period and amplitude, and sometimes phase velocity and azimuth. The rejected events are so grouped for different reasons. Most of them are rejected because the analyst cannot confirm positively that it is a seismic event, and those are grouped as EP-processed noise detections. There is no way of deciding how many of those are really true events; there may be some real events since the analyst tends to go for noise in case there is any doubt. Other reasons for rejection, as seen from Table 5, is double processing by the two partitions (Selected and General Surveillance), local events, and transmission problems (phone line outages).

Some of the information in Table 5 is shown in Figure 1, where all detections and all true detections are plotted against signal-to-noise ratio. It is quite clear that a threshold of 12 dB permits a considerable number of noise detections to be processed since a sharp bend in the curve is observed. Figure 2 shows the same data where local events, phone line detections and not localized events are removed. That figure even better shows that the noise starts to hit at a signal-to-noise ratio of about 4.4, or close to 13 dB. The effect of a possible change in threshold is shown in Table 6, where one can see that at a 12 dB threshold as much as 43% of the EP processed detections are rejected by the analyst, 24% being probable noise detections. By raising the threshold one decided one would only get a 31% rejection rate, only 10% being noise detections. The same change would reduce the number of reported events by 12%, out of which only 5% are localized. In terms of number of events,

there would be a reduction from 9 to 8 reported events per day, which would be the cost for a reduction in the number of processed events by 27%. The gain that this would give in computer time is not calculated accurately, but on the basis of the EP time statistics in Table 2 and in Table 7 below one would estimate the computer time gain as being around 30%. This is because rejected events take slightly more time in EP than accepted events.

3. EP package execution frequencies

In order to analyze the parameters which determine the number of times one particular package can be analyzed in EP, a statistics has been obtained as presented in Table 7. The data is still from Oct 5 - Nov 4, 1971.

The most time consuming package, and therefore the most interesting here, is SP2 (correlation). This has seldom been executed more than one time, and never more than three, while 6 executions are permitted. The accepted events are executed on an average 1.18 times and the rejected events 1.26 times in SP2, while the equivalent numbers for SP3 (Beampacking and Beamforming) are 0.41 and 0.93, reflecting the larger frequency of beampacked events among those rejected by analyst.

Now, to investigate the effect of a change in the number of permitted executions, Table 8 was produced. Only two packages are considered, SP2 and SP3, and the data is the same as in Table 7. By permitting SP2 (Correlation) to execute only 2 times one would save 26 SP2-executions, which according to the information in the tables above would reduce the computer time by 2%, and the only cost would be that 3 events would go to beampacking instead of finishing by correlation. In case SP2 could be entered only once per event, the gain would be 136 executions or 11% computer time (an average of one minute per event), and the cost would be that 13(8%) of the located events

would go to beampacking instead of finishing by correlation. This gain may be slightly reduced in case the EP-threshold is raised. The second half of Table 8 shows number of executions in SP3, where it is quite clear that almost nothing is gained by imposing any strict limits as to the number of executions in this package.

4. General Surveillance

Table 9 presents a comparison between Selected (SS) and General (GS) Surveillance, and the effect of a unilateral change in EP-threshold in the second partion (GS). At 12 dB, GS has a total of 117 EP-processings, 51 of which, or 44%, are common with SS, and only 4 of these events has got the best solution from GS. In addition to the 51 (=17%) common events, there are 43 (=15%) events only detected by GS, 27 of which being local. By raising the threshold for GS to 14, 15 and 16 dB respectively, one would gain 9, 12 and 15% of the total time in EP, and this is not much because one would immediately start to loose good events, and also because an overall raise in EP-threshold of only one dB (to 13 dB) would reduce EP time by 30%, as pointed out above.

Therefore, the best approach towards a more effective General Surveillance seems to be through a better reduction procedure between the two partitions. The data analyzed here has had the following chaining procedure between the two partitions:

1). The detection intervals in GS and SS should have some overlap.

2). Detection time from GS should fall within $\pm$ 10 seconds of detection time in SS.

3). The difference between the detecting beams in GS and SS should be less than 0.02 c/km.

If any of these tests failed, the event would be processed twice, otherwise the SS-detection would be used in EP. A closer analysis of the 51 double EP-processings shows that 50 of these

events were processed twice because the space test failed. It is difficult to believe that the space parameter could be made larger ($\Delta U=0.02$ c/km $\simeq 30^{o}$ for $\Delta>30^{o}$); if the space test was opened completely, one would reduce the EP-processings by 17%, but it would also mean that a number of successful GS-detections would not be processed. Any significant improvement would be difficult here so long as GS does not provide a continous coverage of the whole world. In that case, one could always vote for GS when GS and SS gave much different locations in inverse velocity space.

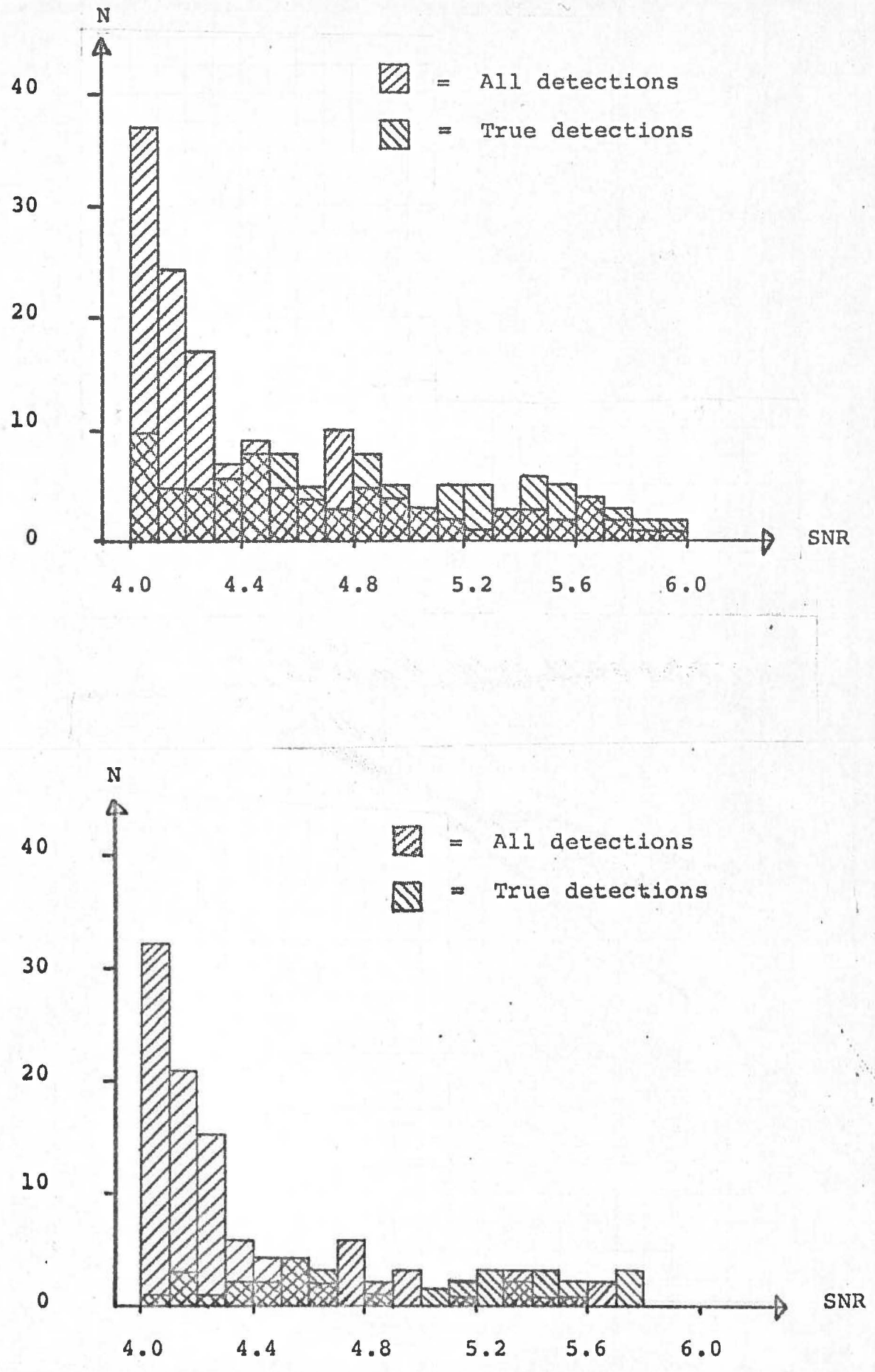

Fig. 2. Analyst decision on detection subset consisting noise and localized events.

Job Step	Package	Function
SPO 1	SPSABF(SP1)	SA beamforming
SPO 2	SP2LSE(SP2)	Correlation
	SPABFM(SP3)	Beampacking & Array Beamforming
	SPEVDP(SP4)	Event Parameter Extraction
	SPWVFM(SP5)	Prelimimary Calibration & Interpolation
	SPEVTC(SP6)	Event Characterization
	SPTALE	'Transatlantic' Package
SPO 3	SPPRPT(SP7)	Parameter Report
	SPSRPT(SP8)	Summary Report
	SPETPE(SP9)	Event Tape
	SPDBFG(SP10)	Detection /Bulletin File
	SPPTPE(SP11)	Plot Tape
SPO 4	JSTEP4	
	J4SAAB	
	J4WAVE	

Table 1. Structure of EP.

Job-Step	Package	Package Time	Job-Step Time	%
SPO 1			46.7	8.6
SPO 2	SP2 SP3 SP4 SP5 SPTAL	277.0 24.5 65.6 26.4 2.5	396.0	72.9
SPO 3			100.2	18.5
SUM			542.9 =9m 2.95	100

Table 2. EP time average per event per job-step.

Job-Step	Package	Function	Function time	Package time
SPO 1				28.9
SPO2	SP2			214.2
	SP3	Correlation Beampacking	31.0 18.0	22.9
	SP4	No depth Depth	24.2 103.2	65.6
	SP5	No depth Depth	2.7 84.6	26.4
	SPTAL			2.5

Table 3. EP time average per execution per package.

Package	No depth	Depth	Average
SP4	24.2	103.2	65.6
SP5	2.7	84.6	26.4
Sum -No depth	26.9		92.0 26.9
Depth			65.1

Table 4. EP computer time requirement for depth estimator (ceptrum).

	ACCEPTED EVENTS					REJECTED EVENTS					
	Loc. Events					Reason for rejection					
SNR Interval	Q=1	Q=2	Q=3	Not loc.	Sum	Small SNR	Double Proc.	Local Events	Transm. Problem	Sum	Sum
4.0 - 4.1			1	9	10	32			5	37	47
4.1 - 4.2		1	2	2	5	21	1		2	24	29
4.2 - 4.3			1	4	5	15	2			17	22
4.3 - 4.4			2	4	6	6			1	7	13
4.4 - 4.5			2	6	8	4	4		1	9	17
4.5 - 4.6			4	4	8	4		1		5	13
4.6 - 4.7		1	2	2	5	2		2		4	9
4.7 - 4.8				3	3	6	3		1	10	13
4.8 - 4.9			1	7	8	2	2		1	5	13
4.9 - 5.0				5	5	3	1			4	9
5.0 - 5.1			1	2	3		3			3	6
5.1 - 5.2			2	3	5	1			1	2	7
5.2 - 5.3		1	2	2	5		1			1	6
5.3 - 5.4		1	1	1	3	3				3	6
5.4 - 5.5		1	2	3	6	1	1		1	3	9
5.5 - 5.6		1	1	3	5	1	1			2	7
5.6 - 5.7				4	4	2	2			4	8
5.7 - 5.8			3		3		2			2	5
5.8 - 5.9				2	2		1			1	3
5.9 - 6.0				2	2		1			1	3
6.0 - 6.1			1	4	5		1			1	6
6.1 - 6.2		1	1	5	7	2	1			3	10
6.2 - 6.3			3	1	4						4
6.3 - 6.4		1	1	1	3		1			1	4
6.4 - 6.5											
6.5 - 6.6				3	3			1		1	4
6.6 - 6.7		1	2	1	4	1				1	5
6.7 - 6.8		1		3	4		1			1	5
6.8 - 6.9		1	1	1	3						3
6.9 - 7.0				1	1						1
> 7.0	20	71	32	17	140	6	38	1	5	50	190
Sum	20	82	68	105	275	112	67	5	18	202	477

Table 5: Analyst decision on EP-processed data from 5 October to 4 November 1971.

	THRESHOLD					
	4.0(12dB)		4.5(13dB)		Reduction	
	N	%	N	%		%
Sum Processed Detections	477	100	349	100	128	27
Rejected on Small SNR	112	24	34	10	78	70
Rejected on Other Reasons	90	19	71	21	16	18
Sum Rejected Processings	202	43	108	31	94	43
Located Events	170	36	161	46	9	5
Not Located Events	105	22	80	23	25	24
Sum Reported Events	275	58	241	69	34	12

Table 6: Effect of a change in EP-threshold by one dB, from 12 to 13 dB.

	ACCEPTED EVENTS					REJECTED EVENTS					
	Loc. Events					Reason for Rejection					
	Q=1	Q=2	Q=3	Not Loc.	Sum	Small SNR	Double Proc.	Local Event	Trans. Probl.	Sum	Sum
Number of Events	20	85	69	113	287	112	67	6	18	203	490
SP1 Executions	21	93	80	191	385	180	125	15	28	348	733
SP2 Executions	21	93	78	148	340	144	99	11	23	277	617
SP3 Executions	0	3	13	102	118	105	56	7	21	189	307

Table 7: Number of executions in different EP packages as a function of analyst decision.

	ACCEPTED EVENTS					REJECTED EVENTS					
	Loc. Events					Reason for Rejection					
	Q=1	Q=2	Q=3	Not Loc.	Sum	Small SNR	Double Proc.	Local Event	Trans. Probl.	Sum	Sum
SP2 - max=2			3	11(10)	14	5(5)	5(4)	2(2)		12	26
SP2 - max=1	1	8	6(2)	34(30)	49	27(27)	27(17)	3(3)	4(4)	61	110
SP3 - max=3						1					1
SP3 - max=2						2	2				4(5)
SP3 - max=1				19	19	8	10	1	3	22	41(46)

Table 8: The effect of changes in parameters governing the number of executions in each EP package. The number in paranthesis are events going to beampacking.

	Processed by GS and SS					Processed only by GS				Rejected		
	Best Solution			Not Located		Located		Not Located		Reason:		GS
Threshold	AS	SS	Same		Local	Q=2	Q=3		Local	Local	SNR	Sum
4.0(12dB)	4	11	16	12	8	2	4	10	27	5	18	117
5.0(14)	3	10	14	9	7	2	2	6	16	2	12	83
5.6(15)	3	9	14	8	4	2	1	6	12	2	9	70
6.3(16)	2	9	12	7	3	2	0	5	5	2	8	55

Table 9: Relation between efficiency between General and Selected Surveillance (AS, SS), and the effect of changes in EP thresholds.