

# Comparative evaluation of a Technicon SMAC2/RA1000 System with an American Monitor Parallel during normal service work

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## Introduction

To meet the requirements of an increasing biochemical work-load, manufacturers have developed large and expensive computer-controlled analytical systems. Therefore the choice of main analyser for a clinical biochemistry department is a major decision with long-term financial implications. Advice is usually sought from current users, but this is often more anecdotal than factual and certainly not of a comparative nature. For many large departments, the choice is between two systems employing different analytical concepts. These are the Parallel (American Monitor, UK) and a combination of the SMAC2 and RA1000 analysers (Technicon, UK).

The Parallel is a recently introduced 30-channel, high-capacity, discretionary analyser, whilst the SMAC2 is an established 12–23 channel continuous-flow non-discretionary analyser which can only be made selective in terms of reporting. The RA1000 is a bench-top discretionary analyser operating like the Parallel but with much less capacity. The SMAC2 and RA1000 together form a system of similar capability to the Parallel. With both a Parallel and a SMAC2/RA1000 combination installed in the authors' separate departments in Leeds, a study has been undertaken to provide comparative data which should aid potential purchasers.

A SMAC2 was installed in the Chemical Pathology Department of the Leeds General Infirmary (LGI) in September 1982, followed by an RA1000 in October 1983. A Parallel was installed in the Chemical Pathology Department of St. James's University Hospital in January 1984. Both laboratories have a similar annual work-load and serve similar populations. The 15-week period of the evaluation took place during October to December 1984 against a background of normal routine service work. The analytical performance, reliability and running costs of both systems were investigated over this period.

## Methods

All methodologies used were as recommended by the manufacturers. For the assessment of analytical performance, sufficient quantities of unassayed Gibcotrol (Gibco Diagnostics) freeze-dried control material at three nominal levels (Low: lot No. 194; Normal: lot No. 235; High: lot No. 191) were purchased. Wellcontrol (Wellcome Reagents Ltd) SMAC High (lot No. K7519) was used on the Parallel for an elevated alkaline phosphatase level because of the analytical unsuitability of the Gibcotrol High material.

On one day a week, over a period of 15 weeks, each laboratory reconstituted one bottle of each material. The contents of the bottles were analysed randomly 10 times throughout the day for the commonly requested tests (see table 1). On each subsequent week the day was advanced by one in order that each of the five working days were covered on three occasions. For tests less frequently assayed, two aliquots of each material were measured during one analytical run per week (see table 2).

For the investigation of reliability, a detailed log of the daily working parameters, electromechanical and other failures were recorded throughout the whole three-month period. The relative running costs of the two systems were calculated for the whole of 1984, including staff, consumables and maintenance contracts.

## Results

### *Analytical performance*

The values obtained on the quality-control materials were analysed using the Statistics Package for Social Sciences (SPSS). Analysis of variance on the data showed that significant imprecision was between, rather than within, analytical runs. For each test, the overall mean, standard deviation and coefficient of variation is given in tables 1 and 2. Results are shown only for those tests common to both systems and where a test level was close to the detection limit of the assay, the results have been excluded from the tables. The data were reanalysed after removal of possible outliers using Healy's procedure [1] and the recalculated coefficients of variation are shown in brackets in tables 1 and 2.

### *Costs*

Details of capital costs can be found in a comprehensive review of large analysers based on manufacturers' information [2]. An estimate of the 1984 running costs for

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Table 1. Analysis of 150 measurements made on 15 days over a period of 15 weeks.

Test		SMAC2			Parallel		
		Mean	SD	CV	Mean	SD	CV
Sodium mmol/l	L	123.2	1.16	0.9 (0.7)	124.5	1.99	1.6 (1.4)
	N	143.3	0.91	0.6 (0.6)	144.3	1.99	1.4 (1.2)
	H	150.6	1.20	0.8 (0.8)	151.0	2.07	1.4 (1.3)
Potassium mmol/l	L	2.24	0.082	3.7 (3.3)	2.09	0.050	2.4 (1.5)
	N	4.08	0.116	2.8 (2.9)	4.23	0.167	4.0 (1.5)
	H	6.52	0.181	2.8 (2.6)	6.68	0.100	1.5 (1.3)
Chloride mmol/l	L	85.9	0.97	1.1 (1.0)	83.6	2.37	2.8 (2.0)
	N	102.0	0.92	0.9 (0.7)	104.3	2.55	2.4 (1.8)
	H	106.3	1.04	1.0 (0.9)	110.6	2.84	2.6 (1.9)
Bicarbonate mmol/l	L	11.7	0.60	5.1 (4.4)	11.0	1.74	15.8 (10.3)
	N	24.8	0.79	3.2 (2.9)	23.4	1.79	7.7 (4.7)
	H	36.6	1.07	2.9 (2.9)	35.6	3.46	9.7 (7.5)
Urea mmol/l	L	1.75	0.16	9.1 (7.7)	2.24	0.33	14.7 (13.2)
	N	5.27	0.14	2.7 (2.3)	6.05	0.36	6.0 (5.9)
	H	26.77	0.44	1.6 (1.7)	26.01	0.91	3.5 (2.3)
Creatinine umol/l	L	111.8	3.03	2.7 (2.7)	111.9	10.83	9.7 (8.2)
	N	105.2	3.11	3.0 (2.7)	100.0	14.21	14.2 (9.0)
	H	611.5	8.96	1.5 (1.4)	576.9	15.20	2.6 (2.4)
Total protein g/l	L	41.7	0.95	2.3* (2.3)*	41.1	1.05	2.6* (2.0)*
	N	75.0	1.00	1.3 (1.2)	71.0	1.91	2.7 (1.8)
	H	90.7	1.34	1.5 (1.4)*	80.6	3.75	4.6 (1.6)*
Albumin g/l	L	21.0	0.44	2.1 (0.7)	20.8	1.60	7.7 (5.1)
	N	39.5	0.67	1.7 (1.4)	39.3	1.41	3.6 (3.3)
	H	46.0	0.68	1.5 (3.8)	44.3	1.36	3.1 (3.0)
Bilirubin umol/l	N	9.1	0.88	9.6 (7.1)	10.2	2.21	21.6 (17.3)
	H	168.0	6.65	4.0* (4.1)*	166.4	6.72	4.0* (3.7)*
Alk. Phos. K.A.U/dl	N	6.55	0.230	3.5 (3.6)	4.29	1.890	44.8 (5.3)
	H	20.74	0.660	3.2* (2.7)*	30.15	1.089	3.6* (3.2)*
Calcium mmol/l	L	1.661	0.026	1.6 (1.4)	1.755	0.043	2.4 (2.2)
	N	2.516	0.030	1.2 (1.1)	2.485	0.041	1.6 (1.5)
	H	3.422	0.046	1.3 (1.3)	3.255	0.094	2.9 (1.8)
Phosphate mmol/l	L	0.856	0.022	2.6 (2.3)	0.916	0.035	3.8 (1.7)
	N	1.128	0.025	2.2* (2.0)	1.107	0.021	1.9* (1.4)
	H	2.832	0.111	3.9* (3.4)	2.937	0.101	3.4* (1.5)

L – Gibco Low N – Gibco Normal H – Gibco High.

Figures in brackets are CV's after exclusion of outliers.

\* Imprecisions of the analysers not significantly different ( $P > 0.05$ ).

both systems is shown in table 3. Staffing costs are based on 1.2 times the mid-point of the appropriate salary scale. In the two laboratories similar functions are performed by different grades of staff. At St James's, demographic and test scheduling are performed by MLSOs, in contrast to clerical staff at the LGI. Furthermore, all samples for the Parallel are separated by the Parallel staff, whilst at the LGI samples for the SMAC2/RA1000 are processed by reception staff. These procedural differences have been allowed for by calculating the number of clerical and reception staff at the LGI employed on direct SMAC2/RA1000 work on a *pro rata* basis.

#### Reliability

Data collected throughout the three-month period on the work-load and reliability are given in table 4.

#### Discussion

The Parallel was designed to operate in a completely selective discretionary mode. However, at St. James's Hospital, because of a reluctance by clinical staff to request tests individually, three main profiles for urea and electrolytes, liver function and bone were offered, whilst remaining tests were measured individually. The order in which the samples were analysed was found to be important because, prior to any test analysis, appropriate reagent lines were purged if not immediately preceded by another analysis for the same test. This meant that the reagent consumption was much higher than expected and necessitated the grouping of the expensive tests where possible: either within the analytical run or on a less frequent batch basis. In particular, the high cost of the bicarbonate reagent discourages the dispersion of non-

Table 2. Analysis of 30 measurements made on 15 days over a period of 15 weeks.

Test		RA1000			Parallel		
		mean	SD	CV	Mean	SD	CV
ALT IU/l	L	14.2	2.4	17.0 (15.0)	8.9	4.9	54.6 (38.0)
	N	23.9	1.7	6.9 (6.7)	16.5	4.1	24.8 (23.9)
	H	159.3	9.5	10.5 (3.3)	129.3	6.8	5.3 (5.1)
Uric acid umol/l	L	0.143	0.007	4.9 (5.0)	0.103	0.018	17.5 (15.7)
	H	0.345	0.016	4.6* (2.6)	0.287	0.012	4.2* (3.9)
	H	0.569	0.022	3.9* (3.2)*	0.529	0.018	3.4* (3.2)*
Triglyceride mmol/l	N	0.29	0.19	63.7 (11.6)	0.32	0.12	35.5 (31.1)
	H	0.52	0.28	53.8 (5.4)	0.45	0.12	26.9 (26.1)
Cholesterol mmol/l	L	2.28	0.05	2.2 (2.0)	2.18	0.36	16.3 (13.8)
	N	4.13	0.09	2.1 (2.0)	3.65	0.54	14.7 (11.3)
	H	8.73	0.16	1.9 (1.8)	7.43	1.19	18.2 (12.7)
Creatine kinase IU/l	L	17.0	1.0	6.2 (6.2)	24.5	11.5	47.2 (47.1)
	N	35.4	3.4	9.5 (8.3)	78.3	17.4	22.3 (20.9)
	H	191.4	8.8	4.6 (4.6)*	439.4	27.1	6.2 (5.2)*

L- Gibco Low N - Gibco Normal H - Gibco High.  
 Figures in brackets are CVs after exclusion of outliers.  
 \* Imprecisions of the analysers not significantly different ( $P > 0.05$ ).

Table 3. Annual running costs.

Item	SMAC2/RA1000	Parallel
Maintenance	£25 305	£20 300
Staffing	£46 254	£42 496
Dry consumables	£15 522	£4 002
Reagents	£9230	£27 921
Calibrators and controls	£5663	£3709
Total requests	99 124	80 636
Total tests	1 122 192	582 960
Total cost (-staff)	£55 720	£55 932
Total cost (+staff)	£101 974	£98 428

Table 4. Analyser work-load and reliability data.

	SMAC2		Parallel	
	Mean	Observed range	Mean	Observed range
Time 1st result (24 h)	10.24	9.55-11.30	12.57	11.00-16.10
Time last result (24 h)	15.56	14.55-17.35	16.55	15.30-20.00
Total cups sampled	601	415-779	471	296-665
Total Q.C. cups	50	35-62	78	30-197
Patient samples	473	343-616	363	176-590
Repeat analyses	62	30-192	26	0-140
Dilutions	16	6-35	1	0-6
% Samples re-run	16.8	9.4-56.5	7.7	0-57
Routine maintenance per week (minutes)	36	20-90	76	60-120
Extra maintenance per week (minutes)	11	0-30	99	45-189
Downtime per week (minutes)	47	0-220	117	15-420

electrolyte samples between those requiring bicarbonate. The Parallel was therefore operated in a mode not originally envisaged. At the LGI, a 12-channel SMAC

profile (see table 1) was used for the analysis of the majority of samples. The other tests (see table 2) were measured on the RA1000 in batches.

*Precision*

During the study period both the SMAC2 and RA1000 performed better than the Parallel and the latter's imprecision did not greatly improve on exclusion of possible outliers. These findings for the SMAC2 are in accordance with data published in the Wellcome Quality Assurance Scheme end-of-term report (October 1985), which shows that the SMAC2 analyser group have lower imprecisions than the Parallel group for corresponding

Table 5. Wellcome quality control scheme six-month imprecision values for the St. James's Hospital Parallel. (Six pairs.)

Test	Units	Period	
		May 85-October 85	November 84-March 85
		Imprecisions	
Albumin	g/l	1.19	1.08
Bicarbonate	mmol/l	0.99	1.22
Bilirubin	umol/l	1.03	3.77
Calcium	mmol/l	0.046	0.093
Chloride	mmol/l	2.08	2.22
Cholesterol	mmol/l	0.136	0.297
Creatinine	umol/l	13.7	7.4
Phosphate	mmol/l	0.035	0.045
Potassium	mmol/l	0.055	0.057
Protein	mmol/l	1.12	1.91
Sodium	mmol/l	2.20	1.24
Triglyceride	mmol/l	0.153	0.182
Urea	mmol/l	0.36	0.71
Uric acid	umol/l	0.014	0.024
ALT	IU/l	2.05	3.86
CK	IU/l	15.4	52.0

channels. However, the report shows the RA1000 and Parallel groups to be more comparable, which is not reflected in our data. Since the period of the comparison the performance of the St. James's Parallel has improved, reflected by external quality assurance scheme returns (table 5).

#### Reliability

There were considerable problems with the mechanical reliability of the Parallel during the period of evaluation, the instrument being totally unusable on two full days. The problems were due to a computer failure necessitating a replacement computer being installed overnight by American Monitor, and, secondly, an electromechanical failure in the vial wash system. A further major contribution to the excessive downtime was the occasional halting of the Parallel during analysis due to a communications failure between the two system computers (this has been rectified by American Monitor). The downtime of the SMAC2 was predominantly due to replacing membranes during a run. The RA1000 downtime was approximately 15 min per week and was contributed to by lamp and sample probe problems.

#### Costings

In this study, during which little discretionary requesting was exercised or encouraged in either hospital, the total cost of running the two systems was very similar. Because of the considerable difference in the way the two hospitals handle similar work-loads, comparison of overall cost of service is more appropriate. Theoretically it might seem to be possible to reduce the overall cost at St. James's Hospital by encouraging a higher degree of selectivity in requests but as previously stated, this would be countered by increased reagent costs.

#### Summary

Since our evaluation, there have been continuing in-the-field developments of the Parallel, in both hardware and software, which have improved the general performance of the instrument. Performance is also associated with operator familiarity with the instrument and the running-in time of a new instrument must not be underestimated. However, from the present study it is concluded that, overall, the SMAC2/RA1000 combination is more reliable and less imprecise than the Parallel.

#### References

1. HEALY, M. J. R., *Clinical Chemistry*, **25** (1979), 675.
2. FYFFE, J. A., *Communications in Laboratory Medicine*, **1** (1985), 118.

## SCIENTIFIC COMPUTING AND AUTOMATION

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