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CRANFIELD INSTITUTE OF TECHNOLOGY

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RADIAL INFLOW TURBINE STUDY

SECOND INTERIM REPORT

by

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Prof. R.L. Elder

DECEMBER 1989

United States Army

EUROPEAN RESEARCH OFFICE OF THE U.S. ARMY

London England

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19. ABSTRACT (Continue on reverse if necessary and identify by block number) The radial inflow turbine is a major component used in both small gas turbines and turbochargers. Its performance is important to the success of these systems yet the detailed aerodynamics are still largely ill-defined especially in small high speed units where small passages and high velocities are involved. Cranfield, the US Army and Turbomach (San Diego) have instigated a program of work in which the flow processes within a small high speed radial inflow turbine are to be investigated using laser anemometry. The objective of these studies is to provide a better basic understanding of the flow processes involved which will in turn provide a good basis for the design of improved components. This note forms the second (nominally six month) report on the project. It describes delays incurred in the work amounting to six months which have arisen due to technical problems on a complimentary project and have absorbed Cranfield manpower. These problems continued/.....			
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→ have now been overcome and the technology developed is both available and relevant to this programme. Good progress is predicted for the following year. No change in funding has been requested due to the delay but it is proposed that the completion date be delayed by six months. (KFF) ←

Activity	
1.1.1.1	✓
1.1.1.2	✓
1.1.1.3	✓
1.1.1.4	✓
By	
Date	
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PROGRESS REPORT

Period 1.3.89 - 31.12.89

Progress on the above project has been slower than anticipated partly due to establishing appropriate running conditions with Turbomach and, more significantly, the demands of a major programme at Cranfield, also concerned with Radial Inflow Turbines, which has taken much more of Dr. Forster's time than originally anticipated. This is not all bad news because this project is uncovering problems which are relevant to this programme and solutions being developed will help our joint objectives. I would stress that the objectives of the proposed project are both relevant and realisable and that Cranfield is very keen to complete its commitment.

Throughout the first year discussions have been held with Turbomach on running conditions, rig installation and the provision of optical access for laser measurements. One major area of difficulty has been the provision of optical access since at the time this project was proposed only a schematic drawing of the test rig was available and the actual rig differed somewhat in detail. Turbomach are unwilling to allow Cranfield to modify their rig components but have allowed considerable freedom to produce a new turbine volute and shroud design which will ease the access problems. This solution will involve extra work in the design and manufacture of new parts which are of course critical to the performance of the turbine. The installation and initial commissioning of the test rig can be carried out with the original components and this stage of the project is expected shortly.

During the first year of the programme it was proposed that Cranfield prepare the rig stand and test its operation over a range of conditions (Task 1.1) and to take the first set of laser measurements (Task 1.2). Due to the delays it is now proposed to operate the programme about six months late with completion of Task 1.1 in early 1990 and Task 1.2 in June 1990. Despite this lack of adherence to the proposed timescales steady progress has been achieved as described above.

As it is estimated that the project is running six months late, it is proposed that this note be accepted as the "normal six month" report and is provided as justification for the second (six month) payment. It is also

proposed that the project operates six months late throughout its course and that the adjusted revised annual spend be as attached. It is emphasised that no change in overall costs are implied only a delay of six months. It is also emphasised that the cause of the delay was unforeseen technical problems on an associated project, that these problems have now been overcome and the technology developed to overcome the problem is both relevant and available to this programme.

Amount of unused funds at the end of this period:

Property acquired during this period: None

APPENDIX C

BUDGET ESTIMATES

Year 1 (1st January 1989 - 31st December 1989)	£1 = US \$ 1.70
ERO	COST TOTAL (\$K)
	SHARED

A. Salaries and Wages - Cranfield Staff

Principal Investigator			
Prof. R.L. Elder (5% of effort)	.66	.66	1.32
Research Officer (Senior)			
C.P. Forster (40% of effort)	6.70		6.70
Technician (30% of effort)	2.76		2.76
Secretary (10%)		.73	.73

B. Overheads

100% of staff costs	10.13	1.40	11.53
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A1. Salaries and Wages - Turbomach
(San Diego staff) supervision
from C. Rodgers

4.00 4.00

C. Report Preparation

.09 .09 .18

D. Expendable Supplies

i Instrumentation (use maintenance and of L.A. equipment)	3.00	7.00	10.00
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ii Preparation and modification to test rigs and facilities	1.00	21.00	22.00
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iii Rig running costs
(150 hours at \$168 p.h)

iv Computer (data reduction)	.51	.51
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E. Non Expendable Items

F. Travel

Total	24.34	35.39	59.73
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G. Inflation Factor *				
(9 months at 4% p.a.)		.73	1.07	1.80

Total	25.07	36.46	61.53
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*Inflation from July 1988 to the mid-term of the first period.

Year 2 (1st January 1990 - 31st December 1990)

	ERO	COST SHARED	TOTAL(\$K)
A. <u>Salaries and Wages - Cranfield Staff</u>			
Principal Investigator Prof. R.L. Elder (5% of effort)	1.33	1.33	2.66
Research Officer (Senior) C.P. Forster (40% of effort)	13.40		13.40
Technician (30% of effort)	5.53		5.53
Secretary (10%)		1.47	1.47
B. <u>Overheads</u>			
100% of staff costs	20.26	2.80	23.06
Al. Salaries and Wages - Turbomach (San Diego staff) supervision from C. Rodgers		8.00	8.00
C. Report Preparation	.18	.18	.36
D. <u>Expendable Supplies</u>			
i Instrumentation (use and maintenance of L.A. equipment)	5.10	11.20	16.30
ii Preparation and modification to test rigs and facilities	3.20	5.60	8.80
iii Rig running costs (150 hours at \$168 p.h)	17.33	20.47	37.80
iv Computer (data reduction)		1.02	1.02
E. <u>Non Expendable Items</u>	----	----	----
F. <u>Travel</u>	1.68		1.68
Total	<u>68.01</u>	<u>52.07</u>	<u>120.08</u>
G. <u>Inflation Factor *</u> (21 months at 4% p.a.)	4.83	3.57	8.40
Total	<u>72.84</u>	<u>55.64</u>	<u>128.48</u>

*Inflation from July 1988 to the mid-term of the second period.

Year 3 (1st January 1991 - 30th December 1991)

	ERO	COST SHARED	TOTAL(\$K)
A. <u>Salaries and Wages - Cranfield Staff</u>			
Principal Investigator Prof. R.L. Elder (10% of effort)	1.33	1.33	2.66
Research Officer (Senior) C.P. Forster (55% of effort)	13.40		13.40
Technician (30% of effort)	5.53		5.53
Secretary (10%)		1.47	1.47
B. <u>Overheads</u>			
100% of staff costs	20.26	2.80	23.06
A1. Salaries and Wages - Turbomach (San Diego staff) supervision from C. Rodgers		8.00	8.00
C. Report Preparation	.18	.18	.36
D. <u>Expendable Supplies</u>			
i Instrumentation (use and maintenance of L.A. equipment)	4.20	8.40	12.60
ii Preparation and modification to test rigs and facilities	2.80	11.20	14.00
iii Rig running costs (150 hours at \$168 p.h)	11.55	13.65	25.20
iv Computer (data reduction)		1.02	1.02
E. <u>Non Expendable Items</u>	---	---	---
F. <u>Travel</u>	.84		.84
Total	<u>60.09</u>	<u>48.05</u>	<u>108.14</u>
G. <u>Inflation Factor *</u> (33 months at 4% p.a.)	6.60	5.29	11.87
Total	<u>66.69</u>	<u>53.34</u>	<u>119.81</u>

*Inflation from July 1988 to the mid-term of the third period.

Year 4 (1st January 1992 - 30th June 1992)

	ERO	COST SHARED	TOTAL(\$K)
A. <u>Salaries and Wages - Cranfield Staff</u>			
Principal Investigator Prof. R.L. Elder (10% of effort)	.67	.67	1.34
Research Officer (Senior) C.P. Forster (55% of effort)	6.70		6.70
Technician (30% of effort)	2.77		2.77
Secretary (10%)		.74	.74
B. <u>Overheads</u>			
100% of staff costs	10.13	1.40	11.53
A1. Salaries and Wages - Turbomach (San Diego staff) supervision from C. Rodgers			
		4.00	4.00
C. Report Preparation	.09	.09	.18
D. <u>Expendable Supplies</u>			
i Instrumentation (use and maintenance of L.A. equipment)	2.10	4.20	6.30
ii Preparation and modification to test rigs and facilities	1.40	5.60	7.00
iii Rig running costs (150 hours at \$168 p.h)	5.78	6.82	12.60
iv Computer (data reduction)		.51	.51
E. <u>Non Expendable Items</u>			
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F. <u>Travel</u>	.42		.42
Total	<u>30.06</u>	<u>24.03</u>	<u>54.09</u>
G. <u>Inflation Factor *</u> (39 months at 4% p.a.)	3.90	3.12	7.02
Total	<u>33.96</u>	<u>27.15</u>	<u>61.11</u>

*Inflation from July 1988 to the mid-term of the third period.

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Summary of Costs

	ERO	COST SHARED	TOTAL (\$K)
Year 1	25.07	36.46	61.53
Year 2	72.84	55.64	128.48
Year 3	66.69	53.34	119.81
Year 4	33.96	27.15	61.11
Totals	198.56 (53.5%)	172.59 (46.5%)	371.15

R7-4.19/IH