

APPENDIX G

DETAILED DEVELOPMENT

PROGRAMME SHEETS

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PROJECT SHEET		CONTROLLER	SSP			
Development (Defence)			Previous Year 1973/74	Current Year 1974/75	1975/76	1976/77
	RPE	Systems Controller (Land) (MGO)				
Item 1 <u>Blowpipe - Crake Two</u> <u>Stage Motor</u>		CC 24-3201-01	2.8	2.4	1.8	1.1
RPE remains the Design Authority for this motor. Successful firings have now been carried out over the whole Service temperature range and the design of the motor has been finalised. RPE is carrying out the manufacture of a proportion of the production orders and is monitoring the transfer of the main motor production responsibilities to ROF Bishopton.						
Item 2 <u>Lance</u>		CC 40-6005-08	0.6	2.0	2.0	1.0
RPE continues to be involved in the technical aspects concerned with the propulsion of Lance which is being purchased by the Army. Safety and storage trials are under discussion. Studies continue of methods for detanking propellants under emergency situations, and this includes assessment of the present US equipment. RPE also has the responsibility for managing the development by Industry of equipment for leak detection.						
Item 3 <u>RS80</u>		CC 22-2603	0.5	0.2	2.3	2.3
Assistance will continue to be given to the Project Manager and Hunting Engineering Ltd (the Prime Contractor) in the interim phase between Project Definition and development. This will consist mainly of paper studies and attendance at meetings since development is not expected to commence until mid-1975.						

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PROJECT SHEET		CONTROLLER	SSP			
Development (Defence)			Previous Year 1973/74	Current Year 1974/75	1975/76	1976/77
RPE		Systems Controller (Sea) (C of N)				
Item 4 KH 793			21	20.5	16	14
Details of this project are provided under separate cover with limited distribution.						
Item 5 Under-Surface Launched Missile CC 22-2601-00			3.5	3.6	4.5	5.0
As technical advisers on propulsion, RPE and ERDE recommended that it was no longer possible to meet the performance requirements with extruded cordite, but that CDB propellant was more suitable. Accordingly propellant aspects have been passed to IMI Ltd.						
RPE will continue a support programme on rocket motor underwater noise and the measurement of thrust underwater. Further work on thrust vector control will also be undertaken in collaboration with IMI; this work is mainly to investigate sealing problems and the requirements for turn-over on water exit.						
Work on hazard assessment will also be undertaken in collaboration with AUWE and IMI.						
Item 6 Seawolf - Blackcap Motor CC 24-3201-01			1.6	0.9	0.2	0.1
RPE will complete the formal Ordnance Board Trials, including the special supplementary trials of motors conditioned to 56°C but excluding the long term storage trials and prepare reports detailing the results of the R & D trials.						
Item 7 Helicopter Launched Missile - Sea Skua			0.4	1.6	0.8	0.5
A decision has been taken to use a shortened version of the Blackcap motor for this Missile. Detailed design drawings have been prepared, and preliminary firings have commenced; the work will continue for some years until the missile enters Service.						

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PROJECT SHEET	CONTROLLER	SSP			
		Previous Year 1973/74	Current Year 1974/75	1975/76	1976/77
Development (Defence)	Systems Controller (Air) (CA)				
RPE					
Item 8 SG357 (AST 1217)					
This missile is scheduled to start Project Definition in April 1974. It is possible that development of the rocket motor will start before this date to enable the missile time-scale to be kept to the minimum.					
RPE will remain as the R & D authority for the motor during this phase.					
Item 9 Skynet II and III					
Apogee motors for both these projects are being manufactured in the USA by Thiokol. RPE has to provide technical advice and, in the case of Skynet III, may well have to monitor some of the production, if this project proceeds.					
	Systems Controller (Sea) (C of N) Systems Controller (Air) (CA)				
Item 10 Power Cartridges					
1. ERU					
Assistance and advice is given as required to ML Aviation and Wallop Industries in the design and testing of ERU cartridges for use on the Buccaneer, Phantom and Jaguar aircraft.					
2. Engine Starter					
Collaboration will be maintained with F.G. Miles Ltd in the design of a cartridge operated engine starter.					
3. BAC/RAE Gas Generator					
Firings continue at RPE using EU propellant inhibited with EC, protected by silicone rubber. Various inhibitors for Mechanite 14 charges will be investigated.					
4. Ejection Seat - Thrust Vector Control					
Discussions have taken place between RPE and RAE Fluidics Ltd concerning a contract placed by RAE Physics Department to develop an attitude controlled device for aircraft ejection seats.					

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PROJECT SHEET		CONTROLLER	SSP			
Development (Defence)			Previous Year 1973/74	Current Year 1974/75	1975/76	1976/77
RPE		Systems Controller (Sea) (C of N) Systems Controller (Air) (CA)				
Item 10 <u>Power Cartridges</u> (Cont'd) If this contract is approved, following a preliminary design study, RPE will fill the gas generators and fire them. Remek Fluidics will manufacture the hardware. 5. <u>Blowpipe Gyro</u> The present Mechanite 10 charge in the Blowpipe gyro is unsatisfactory at 60°C. PU propellant was suggested as an alternative; trials continue.						
		Systems Controller (Land) Systems Controller (Sea) Systems Controller (Air)				
Item 11 <u>Development of Instrumentation and Test Equipment</u> The increased accuracy demanded by Project Managers for performance measurements requires new methods to be developed. Instrumentation must also be modified to enable it to be used in conjunction with the new RPE computer and by a smaller number of staff.			1.3	2.4	2.2	2.5
Item 12 <u>Sundry Projects</u> RPE has a post design and advisory responsibility for a number of rocket motors already in Service. These include Bloodhound II, Thunderbird II, Red Top, Firestreak, 2" Aircraft Rocket, Knebworth, USD501. In many cases queries from foreign purchasers of these missiles have to be dealt with, and motors returned from Service examined. RPE will also be filling the Stiletto Supersonic Target (liquid propellant) as required during the year. <u>Pendine Boost Motors</u> RPE is the Design Authority for these motors and will continue to provide a service as required when the users ask for modifications. The sealed drawings will be converted to the SI system.			5.0	4.0	4.1	4.4
Item 13 <u>Future Projects - Not yet defined</u>			-	-	-	4.4

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PROJECT SHEET		CONTROLLER		SSP			
Development (Defence)		Systems Controller (Land) (MGO)		Previous Year 1973/74	Current Year 1974/75	1975/76	1976/77
ERDE							
Item 14 <u>Plastics and Rubbers - Development and PDS</u>				1.25	2.5	2.75	2.75
Investigation of failures of non-metallic materials in service. Development of prototypes and small-scale production of components at the request of Design Establishments and Service users. Resolution of specific user problems with non-metallic materials. Liaison with Design Establishments on the correct choice of materials.							
		Systems Controller (Sea) (C of N)					
Item 15 <u>Polaris - Advice on Service Life of Propellant</u>				0.5	0.25	0.25	0.25
		Systems Controller (Air) (CA)					
Item 16 <u>MRCA Gun</u>				-	0.25	0.25	0.25
Liaison with DA Arm, RSAF etc. Preliminary propellant examination and experimental manufacture to cover the novel propellant aspects. Effort could increase.							
		MD/ROF					
Item 17 <u>Gun Propellants - Picrite</u>				1.5	1.5	1.5	1.5
Development of the urea/ammonium nitrate/silica gel process to replace the existing ROF process which will become obsolete due to lack of dicyandiamide supplies.							
Item 18 <u>Synthesis and Analysis</u>				0.5	1.5	1.5	1.5
Preparative chemistry in aid of work at ROFs and advice on explosive manufacture.							

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PROJECT SHEET	CONTROLLER	SSP			
		Previous Year 1973/74	Current Year 1974/75	1975/76	1976/77
Development (Defence)	MD/ROF				
ERDE					
<u>Item 19 Initiators and Delay Compositions</u> Development to pilot plant and factory scale of ERDE processes for manufacture of initiating and delay compositions. Assistance to ROFs, QA Directorates and licensees in the manufacture and maintenance of standards of production of ERDE developed compositions. Development of new and modified compositions to solve problems with in-service explosive stores.		3.25	4.0	4.0	4.0
Systems Controller (Land) (MGO) Systems Controller (Sea) (C of N)					
<u>Item 20 Rocket Project Support</u> (a) Preparation, evaluation and supply of special cordite additives to ROF Bishopton. Liaison on problems concerning Giant Viper, Crake, Seawolf etc. Supply of propellant etc to RPE and RARDE. (b) Replacement of PU cordite with propellant having better storage characteristics and modified ballistics. CDB: support to IMI, NEC and HQ related to specific projects (Seaslug 2, Swingfire, Rapier, Seadart etc). (c) Paper for NC manufacture: trials to establish confidence in new source of paper and to elucidate the factors that affect burning rate. (d) Examination of ballistics of propellants based on mechanical pyro (cotton) nitrocellulose.		4.0	3.5	3.5	3.5
<u>Item 21 PDS and Support Work</u> Development of composite propellants to meet the ballistic and mechanical property requirements for new RPE project and research motors. Development of filling methods for new designs of rubbery propellant charge. Filling of motors with all types of composite propellant as required by RPE.		1.5	1.5	1.5	1.5

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PROJECT SHEET		CONTROLLER	APP			
Development (Reference)	RTM	Systems Controller (Land) (MGR) Systems Controller (Sea) (C of N)	Previous Year 1915/16	Current Year 1916/17	1915/16	1916/17
Item 22 Quality Assurance			1.0	1.0	1.0	1.0
Compatibility and stability testing in connection with propellants and the provision of an advisory service; X-ray crystallography in connection with ballistic modifiers; General analysis;						
Item 23 Service Life Extension and Prediction			1.5	1.5	1.5	1.5
Work in support of GN trials on dated rocket projects; Compatibility and adhesion/storage aspects etc of new GN inhibitors, where related to projects; Storage trials of new gun charges, including CCC;						
		Systems Controller (Land) (MGR) Systems Controller (Sea) (C of N) MB/ROF				
Item 24 Gun Project Support			4.0	4.5	4.25	4.25
Manufacturing problems, safety and quality control of new propellants P527/414, 415 for MBI gun, including fine grist RDX; Supply of propellants for PMBI and 4.5 in Mk 8 guns for trials to optimise ignition systems; Barrel wear and temperature correction; Supply of combustible cartridge cases to RARDE for PMBI and 4.5 guns; Assistance to Bishopston with CCC production; assessment of possible use of thin C for 81 mm mortar charge container; Small arms support for RSKP; Propellants for US13518, 81 mm Kden and MRCA guns; Monitoring of NEC contract;						

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PROJECT SHEET		SSP			
Development (Defence)	CONTROLLER	Previous Year 1973/74	Current Year 1974/75	1975/76	1976/77
	Systems Controller (Land) (MGO)				
	Systems Controller (Sea) (C of N)				
ERDE	Systems Controller (Air) (CA)				
<u>Item 25 Hazard Studies</u> Provision of data for Safety Certificates covering primary and secondary explosives and propellants when they pass to ROFs for production. Advice to Government Departments and other Establishments on safety aspects of work with explosives and co-ordination of sensitiveness testing methods through the Sensitiveness Collaboration Committee.		1.0	1.0	1.0	1.0
<u>Item 26 Compatibility and Stability</u> Compatibility and stability testing on explosives and initiators and the provision of an advisory service.		1.25	2.0	2.0	2.0

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PROJECT SHEET	CONTROLLER	SSP			
		Previous Year 1973/74	Current Year 1974/75	1975/76	1976/77
Other Work (Defence)	Systems Controller (Land) Systems Controller (Sea) Systems Controller (Air)				
RPE					
Other Work (Defence)		0.8	0.5	0.8	0.8
<u>Item 27 Martel Rocket Motors</u> The TV sustainer motors on storage at 32°C will be withdrawn according to the programme, inspected and statically fired; these are intended to provide more information on the probable service life. Static firings of the boost, AR sustainer and TV sustainer motors will be carried out after the packaging trials in OB Proc 41180 have been completed.					
<u>Item 28 RN Ikara - Murawa M4A Motor</u> The two motors from the packaged sequential trials to OB Proc 40917 will be statically fired.					
<u>Item 29 SS11</u> It is uncertain whether a surveillance programme to confirm the predicted service life will be arranged.					
<u>Item 30 AS12</u> Long term storage of 4 motors at 32°C is continuing at ROF Bishopton. Two motors have already been withdrawn after three years storage and two further motors will be withdrawn after four years storage, and will be statically fired after examination.					
<u>Item 31 Sidewinder, Shrike, Sparrow</u> The surveillance programme for Sparrow motors in UK service will commence. The analysis of US reports on these motors will be continued so that advice can be given to AGW, Ordnance Board etc.					

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PROJECT SHEET		CONTROLLER		SSP				
Other Work (Civil)				Previous Year 1973/74	Current Year 1974/75	1975/76	1976/77	
RPE								
Space Work for Science Research Council and Appleton Laboratory								
Item 33 Skylark				1.0	1.0	0.5	-	
An improved version of the Skylark vehicle is required which will utilise the Raven XI motor. This motor has developed combustion instability. A modified propellant has been formulated by ERDE and tested in a T-burner at RPE. Firings in the Raven XI motor will be carried out to prove whether the instability can now be eliminated.								
Item 34 Petrel and Skua				0.9	0.8	1.0	1.0	
These are sounding rockets utilising plastic propellant for which there is a commercial demand. RPE supplies a post development service and is also endeavouring to improve the Service life and temperature range of operation.								
Item 35 INTA Sounding Rocket				0.5	0.4	-	-	
The development of a 25 cm diameter motor in conjunction with BAJ Ltd and INTA Madrid continues. RPE is also supplying some Gosling IV boost motors. RPE is responsible for technical support for the installation and commissioning of the filling portion of a plastic propellant plant due to be completed in Spain this year.								
Item 36 General Work				0.4	0.6	1.0	1.0	
This covers miscellaneous enquiries for advice about rocket propulsion and test facilities other than those directly related to Projects or foreign purchases, and general work for ROF's, other Government Departments and non-Exchequer customers.								

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PROJECT SHEET		CONTROLLER	SSP			
			Previous Year 1973/74	Current Year 1974/75	1975/76	1976/77
Other Work						
Capital Facilities						
Maintenance						
Directing Staff and Common Services	RPE		1.4	1.5	1.4	1.5
Item 37 <u>Creation of Capital Facilities</u> No major new works are at present authorised, but minor works will continue especially in re-furbishing firing emplacements.						
Item 38 <u>Maintenance</u> With a large site a steady load of maintenance work continues, especially as some facilities ought to be replaced, but decision on this has been deferred because of Rationalisation exercises.			3.9	3.0	3.0	3.0
Item 39 <u>Directing Staff and Common Services</u> Includes Division Heads and Library.			23.0	21.6	22.0	22.0

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PROJECT SHEET		CONTINUED	SSP			
Other Work (Defence and Civil)			Previous Year 1973/74	Current Year 1974/75	1975/76	1976/77
	ERDE					
Item 40 <u>Special Services for Foreign and Commonwealth Offices</u>			7.0	7.0	7.0	7.0
Item 41 <u>Advisory Service to Industry on Adhesives and Sealants</u>			0.5	0.5	0.5	0.5
Item 42 <u>Maintenance of British Calibration Service Centre for Thermal Measurements</u>			NEG	1.0	1.0	1.0
Item 43 <u>Assistance to Overseas Sales</u>			1.0	0.5	-	-
Item 44 <u>Directing Staff and Common Services</u>			26.5	26.5	26.5	26.5

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File 14

RPR(B)/P(74/75)3

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(66 pages)

MAJOR FIELD 3 RESEARCH REVIEW
ROCKET MOTORS (SOLID AND LIQUID),
PROPELLANTS AND EXPLOSIVES

MAY 1974

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MAJOR FIELD 3 SUMMARY 1974

Aims of MF3

1. The main aims of this research programme are to maintain UK expertise in both the technologies of rocket propulsion and military explosives to assist the work of associated weapon design establishments (both HMG and industry), the Ordnance Board and the ROPs, and to advise the Services on foreign purchases. The work on rocket propulsion technology includes solid and packaged liquid propellant rocket motors for all military applications plus upper atmosphere and space use. The work on explosives covers all high explosives and initiatory devices to meet the diverse requirements of conventional munitions. Work on propellants for guns and various auxiliary power units is also included. The assumptions behind the programme are listed in Annex B.

2. It must be stressed that this programme represents the total national effort in this important field in which there is no indigenous industrial capability other than that completely funded by HMG, such as the cast double base propellant agency factory run by Messrs IMI Limited at Summerfield and the casting powder research, development and production group provided under contract by the Nobel's Explosives Company Limited at Ardeer.

Rationalisation

3. Whilst the decision was taken this year to establish an intramural CER/MDROF rocket motor organisation (RMO), both its location and the scope of its capabilities are still under consideration; to a large extent these are inter-dependent but in any case the scale of the operation must await the outcome of the forthcoming defence review. In the meanwhile the rocket propellant research programme maintains an active interest in each of the major types of propellant. As in the 1973 review the different parts of the programme are identified against the establishment concerned.

4. Rationalisation of the work on explosives remains subjudice.

5. The main establishments and contractors concerned together with their principal areas of interest in the MF3 programme are:

ERDE/RPE at Waltham Abbey: solid propellants for rockets and guns, high explosive and initiator compounds and general chemistry.

ERDE/RPE at Westcott: solid and liquid propellant rocket motors.

RARDE: development and application of high explosives and initiatory devices.

/AWRE:

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AWRE:

contributions to programmes on explosive detection, blast attenuation and thermal response of rocket motors. Note AWRE participation in MP3 is relatively small but it is anticipated that this will increase in the future.

IMI at Summerfield:

cast double base propellants and rocket motors.

NEC at Ardeer:

double base propellants for rockets and small arms.

Bristol Aerojet Ltd:

rocket motor hardware.

Financial Position

6. The total expenditure (out-turn) for FY 1973/4 is very close to that predicted in the 1973 review; there is an underspend on the extramural vote 7J of about £100K which arises almost equally from packages 3C and 3G; in the former there was an overestimate of what could be accomplished on the packaged liquid programme (which had to take second place to the KH 793 project) plus a late start on the IPN work whilst in the latter there has been late submission of bills. Expenditure at SRS was higher than estimated due to decreased project loading.

7. The proposed intramural effort in 1974/75 is in line with LTC 74 except that at RARDE the effort on package 3G has been increased to cover urgent work for IS. The extramural figures for 1974/75 are consistent with the grant and reflect the first only of the defence budget cuts (£179M) made early in 1974. Pending the outcome of the defence review the 1975/76 and 1976/77 figures are those previously published in LTC 74.

8. Though research expenditure at IMI Summerfield was transferred to CERs Vote 7 on 1 August 1973 it is still convenient to show it as a separate entry; the 1974/75 figure has been reduced in line with other extramural expenditure referred to in para 7 above.

Programme Trends and Highlights

9. The overall aims of this research programme are broadly the same as last year; whilst the present wide interest is maintained there can be few really important trends. However there are some changes of emphasis and new items.

10. The demands of possible future projects have a marked influence on the direction of the research programme on solid propulsion and this is reflected in work on low signature motors for LRATGW successor, with a spin-off to the OL 535 (MAW) requirement, propellants with improved mechanical properties for RS 80 and new motor and propellant designs for GSR 3658 (LAW); this latter weapon introduces the problems of meeting an acceleration in excess of 4000g and a burn time of only 5 milliseconds. In addition to this applied research it is hoped to increase effort generally on 'complete motor studies' in package 3B so that both new propellant and/or motor design concepts can be adequately demonstrated.

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11. Amongst solid rocket composite propellants the castable HTPB system has continued to show itself superior to the earlier CTPB one on which research has been terminated. In the absence of a definite project motor requirement for rubbery propellants it has been decided not to proceed with the preparation of a case for a production facility. A report is in preparation detailing the capability of the existing ERDE plant and the additional effort and facilities required to provide various sizes of motor and production levels.

12. The improved plastic propellant (based on a polyisoprene binder) shows promise and will be compared with castable rubbery propellants in representative motor firings. Current plans envisage effort on plastic propellant falling in 1976/77 and subsequent years to the minimum (2 SSP) necessary to support RPE, ROF Bridgwater and other interested parties in the use of established compositions.

13. Work on double base propellants, which are used in the majority of UK rocket weapons, is concentrated on improving ballistic, mechanical and storage properties and various aspects of processing and quality control. Renewed attention will be directed towards the characterisation and specification of nitrocellulose for both rocket and gun propellant application. Research on gun propellants has been reduced owing to the transfer of effort to the FMBT programme.

14. The UK developed inhibitor for CDB charges, PB40/K (a polyacetal-filled methacrylic polymer), has many advantages over cellulose acetate including less tendency to absorb NG and to generate smoke during motor firing. It has been successfully evaluated in a wide range of project type motors and will be brought into service over the next few years as a replacement for cellulose acetate. Work on developing an UK source of the optical quality CA sheet needed for the CDB process has been terminated following the withdrawal by British Celanese Ltd of their offer to supply a modified CA composition to meet the requirements of TS 263.

15. Increased effort will be devoted to the study of solid propellant rocket ignition whilst that on both basic combustion processes (not combustion instability) and TVC will be terminated. Effort on rocket plume/radio wave interactions has been decreased, but the necessary expertise will be maintained, whilst more attention will be given to IR emission work in support of missile detection studies.

16. The aim of the packaged liquid bipropellant programme must be to 'sell' the system for use in a conventional weapon project. To this end emphasis has been placed on obtaining increased performance and reliability; in particular there is need to establish confidence in the safety of the system under service conditions and to develop appropriate procedures in accident situations. The main success of the last year's work has been the three technically successful flights of a representative motor with imposed lateral acceleration of 10g during boost, transition to sustain, and sustain thrust levels. Other flight trials have demonstrated the ability of a

/packaged liquid motor

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packaged liquid motor to function normally after long term storage and extensive temperature cycling over wide environmental limits (-40°C to 60°C). All available evidence indicates that a Service life for filled tankage well in excess of 10 years is feasible.

17. Extramural research has started on an IPN propulsion system as a possible solution for LRATGW; of particular interest is the laboratory demonstration by RPE of a method of reducing, and perhaps eliminating, the problem of dieseling.

18. Work on metallic structural materials for rocket motors continues to be directed towards higher strength maraging steels and aluminium alloys. The technical and economic advantages of the flow forming process are being assessed for a number of rocket motor configurations and materials. Studies on refractory materials for nozzles, rigid and flexible insulants and carbon fibre reinforced structures are continuing as previously planned.

19. There is a continuing need for improvement of non destructive inspection techniques to meet higher standards of quality control and for more precise measurements of ballistic performance. Work on ultrasonic holography and acoustic emission is now moving from the equipment development stage to examination of motors and components.

20. The emphasis of the work on high explosives has continued to be concerned with the production of higher quality charges for shell (particularly 155mm FH 70/SP 70) and GW warheads (Martel). An intensive study is being made of the effect of both additives and casting conditions to the strength, integrity, and adhesion of the basic 60/40 RDX/TNT composition. Development of the Poly X compositions for torpedo warhead application has been almost concluded and future work will be confined to supply of charges for assessment.

21. The forward looking research on initiatory devices is concentrated on thin film and bridgeless electrically initiated devices though some effort remains deployed on improving the present types of electric and non-electric devices which in many cases have to withstand adverse storage conditions in certain fuzes, safety and arming mechanisms and break-up units.

22. Research in support of the requirements for the NI security forces continues to yield dividends and its scope has been enlarged by two new work items in package 3G on explosives ordnance disposal and blast attenuation by foam.

International Collaboration

23. There is international collaboration in MF3 topics through the following channels:

/(i) TTCP

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- (i) TTCP. During the first full year of Sub Group W, Panel 4 on rocket propulsion has been active in the following key technical areas (KTAs)
- (a) reduction of smoke and flash from rocket motors: a review paper is in preparation.
 - (b) service life assessment of solid and liquid propellant rocket motors: a review paper is in preparation.
 - (c) high pressure motor technology: this has been linked with WAG 3 (study of man and crew portable unguided anti-tank rockets) which will be the subject of a meeting in the US in June 1974.
 - (d) specification of the thermal environment: this was covered by a successful meeting held in Australia in November 1973 which reviewed progress on the joint programme of work. The task should be completed and reported by December 1974.
 - (e) Panel 1 also has a KTA relevant to MF3, replacements for NOL 130 and lead azide: this will be discussed at a meeting to be held in May 1974.
- (ii) Anglo-Norwegian-Netherlands WG III. Collaboration in this group has been mainly Anglo-Netherlands; in addition to reciprocal visits in the last year some joint work has been initiated on the stability of modified RDX/TNT compositions for use in shell. It is hoped that Anglo-Norwegian collaboration will increase following this year's meeting in Norway.
- (iii) Western European Union, Standing Armaments Committee WG 9. This group is concerned with novel barriers for defence against AFVs and aircraft. It is included here rather than in MF9 because much of the UK interest has been concerned with aqueous foams which are reported in MF3G. Despite representation from all the WEU countries the only useful collaboration is Anglo-FRG and this has extended to joint trials and reciprocal visits.
- (iv) Anglo-French Defence Research collaboration. Preliminary overtures from the French are under consideration for possible broad collaboration across all MF3 topics.

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Summary Table of Costs (COST) and Effort (EFF) in Major Field 3

			1973/4	1974/5	1975/6	1976/7
3A Solid Propellants	SSP ERDE		31.0	31.4	31.0	31.0
	I/M ERDE		740	780	790	800
	E/M		182.5	179	153.5	153
	SRS		102	114	137	137
3B The Application of Solid Propellants to Rocket Motors, Gas Generators and Power Cartridges	SSP RPE		7.5	10.2	9.3	8.7
	ERDE		4.2	4.4	5.0	5.0
	AWRE		-	0.3	-	-
	I/M RPE		220	277	258	240
	ERDE		65	70	80	80
	AWRE		-	3	-	-
	E/M		29	80	95	106
	SRS		285	211	257	257
3C The Application of Liquid Propellants to Rocket Motors	SSP RPE		10.4	11.8	14.5	14.5
	I/M RPE		380	394	534	535
			(100)			
	E/M		163	218	257	262
			(23)			
3D The Application of Materials to Rocket Motors	SSP RPE		5.3	6.0	7.0	7.0
	ERDE		2.0	3.0	3.0	3.2
	I/M RPE		171	142	187	187
	ERDE		35	50	50	50
	E/M		254	263	291	315
	SRS		110	110	129	129
3E Rocket Exhaust and Plume Technology	SSP RPE		10.0	10.0	9.7	9.0
	ERDE		3.5	-	-	-
	I/M RPE		262	233	218	200
	ERDE		60	-	-	-
	E/M		48	41	19	18
	SRS		61	35	22	22
3F Rocket Instrumentation and Non-Destructive Testing	SSP RPE		5.1	6.7	7.0	7.0
	ERDE		0.3	0.1	0.1	0.1
	I/M RPE		135	138	138	138
	ERDE		20	10	10	10
	E/M		12	10	30	35
	SRS		37	47	55	55
3G Explosives and Initiatory Devices	SSP RARDE		18.5	19.5	19.5	19.5
	ERDE		25.5	26.6	27.0	27.0
	AWRE		0.9	1.9	1.2	1.0
	I/M RARDE		460	472	469	469
	ERDE		350	380	390	400
	AWRE		20	50	32	22
	E/M		128.5	142	175.5	176

/MF3 TOTALS

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ASSUMPTIONS RELEVANT TO MF3General to MF3

1. There is a need to maintain the present level of UK Research and Development expertise in both explosives and rocket propulsion technology (ie solid and packaged liquid propellants, rocket motors, gas generators and power cartridges) to assist the work of associated weapon design establishments (both intra and extra-mural), the Ordnance Board and the ROFs, to advise the Services on foreign purchases, and to support the UK space research programme.

Propulsion: solid propellants and rocket motors

2. There will be a continuing need for solid propellants to meet the diverse requirements of rocket motors for guided and unguided weapon and space applications, gas generators, power cartridges and guns.

3. There is a need to increase the Service life whilst at the same time reducing unit costs of rocket motors, gas generators and power cartridges.

4. In view of the well established thermochemical limitations on propulsive performance of the known and foreseeable solid propellants, increases in overall motor performance will be found mainly by reduction in hardware mass and/or charge designs giving a higher loading density. However, improved internal ballistics, propellant mechanical properties, processing characteristics and safety are also needed.

5. There will be increased emphasis on low signature rocket motors for applications such as ATGW, SAM and USGW (first and second propulsion stages) in addition to requirements for clean propellant charges for gas generators and power cartridges. Such requirements will be met in the main by cast or extruded double base propellants.

6. The superior capabilities of operating temperature range and motor size of cast composite propellants will be needed for some future applications where smoke is not a disadvantage; in particular the potential of the HTPB system merits further study.

7. In the absence of a definite requirement for a Service motor containing a cast composite propellant a case cannot be made for a new production facility until the capacity of the ERDE 'Blue Water' plant has been reassessed and its viability established against possible requirements in terms of capital money and staff which would be needed for various sizes and quantities of motors.

8. There will be a continuing need to maintain a design and production capability in plastic propellant to meet specific motor requirements for both space and defence application and to fulfil the considerable PDS obligation.

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Propulsion: air breathing engines

9. Any requirement for air breathing engines (both rotary and non-rotary) for missile application will be met by overseas purchase.

Propulsion: packaged liquid propellants and rocket motors

10. There is a need to maintain the research programme on packaged liquid propulsion systems (both mono and bi-propellant systems) to provide longer term backing to Lance procurement, the KH 793 programme and possible future LRATGW and medium SAM. The potential of an air augmented monopropellant system merits further consideration.

Propulsion: gun propellants

11. There is a need to improve the performance of gun propellants and combustible cartridge cases; reductions in barrel wear, temperature co-efficients and smoke, are all desired for both tank and field guns.

Explosives and initiatory devices

12. There will continue to be a need for a wide range of high explosives and initiatory devices to meet the diverse requirements of conventional munitions. Emphasis will continue to be placed on extending the Service life of initiator systems; initiator compounds are required which are fully compatible with the other components of detonators and the weapon environment.

13. IS requirements will require improved techniques for both identification and detection of explosives and EOD.

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Supporting Statement to 3A/74

Solid Propellants

Introduction

The overall objectives of research on solid propellants remain much the same from year to year. It is necessary to meet a continuing demand for improved propellants for both rocket and gun applications and to maintain a centre of expertise from which advice can be obtained on all aspects of solid propellant technology. Many of the items in this research programme, are therefore, the same as for 1973 with minor changes in staffing levels which reflect changes in emphasis rather than a complete redirection of effort.

There are still significant improvements which can be achieved in the areas of processing, mechanical properties and storage behaviour. These could result in corresponding improvements in one or more performance aspects, eg, higher overall motor performance, wider temperature range capability, increased safety, longer Service life, improved reliability or reduced cost. Considerable emphasis will continue to be placed on reducing visual signature, while seeking to maintain or even improve overall performance.

3A1 Double Base Propellants

Double-base propellants are used in a wide range of existing tactical weapons and, in view of their low smoke (and potential low luminosity) characteristics, will be essential for many future rocket motor applications, despite their moderate performance and limited temperature range capability as compared with some composite propellants. They will also continue to be needed as a source of cool, clean and non-corrosive gas for power cartridges and gas generators.

Renewed attention will be given to the characterisation and specification of nitrocellulose for both rocket and gun propellant application. The need for this has been highlighted by the difficulties which have arisen recently in the manufacture of casting powders, thought to be associated with a change in the source of cotton linters. Also, problems due to variations in nitrocellulose quality continue to arise in the manufacture of extruded cordites (see 3A1.1 below). There is, furthermore, a need to consider the general question of future nitrocellulose supplies and usage, including actions resulting from the proposed change from displacement to mechanical nitration at ROF Bishopton.

3A1.1 Extruded Propellants (Rocket Cordites)

Much of the work is concerned with the maintenance of expertise and the quality of current supplies. The quality of nitrocellulose, for example, is dependent upon many variables including the nature of the washing water, the source of the paper and others which cannot yet be adequately covered by specification. A constant requirement exists to modify formulations to cope with changes in the raw materials so that the standard performance is maintained.

/The major emphasis

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