MOU FOR THE SPEY SM1A

BY

LIEUTENANT COMMANDER M. R. J. MALTBY, BSc, RN
(Sea Systems Controllerate, Bath)

ABSTRACT

The Rolls-Royce Spey SM1A marine gas turbine is in service with both the Royal Navy and the Royal Netherlands Navy and MODUK and MODNL have a joint agreement relating to the procurement, overhaul and support of the engine. This article describes the inception of that agreement, the subsequent problems it encountered and the solutions applied.

Introduction

As a general principle, all warship equipments require some form of support and for marine gas turbines this support comprises complete spare equipments, spare parts and a repair facility. Such support provisions are expensive and significantly affect the total cost of ownership, and therefore any arrangement which can reduce support costs whilst continuing to meet the support requirement is worthy of consideration.

A Memorandum of Understanding (MOU), in the support context, is one such arrangement and one which makes use of 'economies of scale' in that, proportionately, fewer support items are required for a larger fleet. These reduced support costs of a common piece of equipment can be shared between two or more operators which, in practice, means sharing these costs between two or more nations. Such an MOU has been in existence since 1975 relating to the support of Rolls-Royce Olympus and Tyne Marine Gas Turbines. The agreement, which was conceived originally between The United Kingdom, The Netherlands and Belgium was extended to include France in 1980 and now covers the support of some 254 Gas Turbine Change Units (GTCUs) of the two types. The support system used by the MOU is essentially the one defined for the RN during the early 1970s.

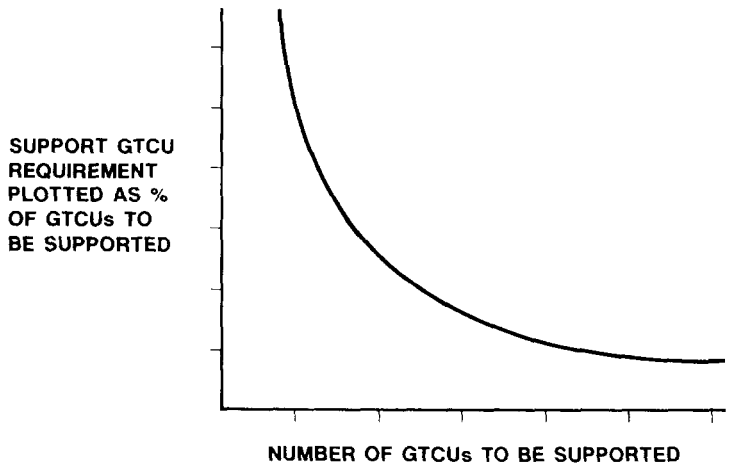

FIG. 1—THE EFFECT OF FLEET SIZE ON SUPPORT GTCU REQUIREMENT

The primary driving force behind the support MOU is the saving resulting from the fact that the total number of GTCUs and other related repairables required by the two or more nations taken as a 'group', is less than the total that would be required if the nations all operated independently. This principle is illustrated by FIG. 1. The exact shape and position of the curve will vary

according to the prevailing GTCU usage, reliability and life limitations, together with the Overhaul Facility capability. Furthermore, in reality, the graph will not be a smooth curve, but will contain some step changes since it is not possible to hold anything other than whole GTCUs in the support system. As an illustration, suppose that:

Navy A has 30 Ships (60 GTCUs) and requires 9 support GTCUs
Navy B has 20 ships (40 GTCUs) and requires 9 support GTCUs
Navy A + B has 50 ships (100 GTCUs) and requires 10 support GTCUs.

The saving in support material is therefore 8 GTCUs and the procurement saving to each navy is the cost of 4 GTCUs. The same principle can also be applied to the Initial Provisioning (IP) of spares to support the parent equipment and hence this and other aspects of GTCU support can be included in the MOU agreement to give a complete support sharing arrangement which is beneficial to all parties.

Extend this principle further to include all associated major equipments, and a picture of the full Olympus/Tyne MOU is formed as one covering the GTCU, all engine- and module-mounted repairable equipments (fuel pump, starter, HPSOC, etc.) and the power turbine—in effect the complete propulsion prime mover package. Obviously, an essential prerequisite of such an MOU is that the equipments are common to all participating navies in order that full sharing of support costs is both feasible and equitable. The MOU is based on the support system of one participating country (in this case the UK) being utilized by all participating nations with the setting up and running costs being shared accordingly.

An MOU for SM1A

The Rolls-Royce Spey SM1A, a marinized version of the successful aero-engine of the same name, entered service in the Royal Navy in 1985 installed in HMS *Brave* with plans to fit it in Type 22 Batch III and Type 23. In 1986, The Netherlands (MODNL) approached MODUK and suggested forming an SM1A MOU in the same vein as the Olympus/Tyne arrangement, following their adoption of the engine as the 'boost' propulsion in the M Class frigate for The Royal Netherlands Navy (RNLN). This was accepted in principle and it was agreed between the two partners that such an arrangement should:

- Use the same management structure and procedures as the existing Olympus/Tyne MOU;
- Incorporate any lessons learned from the Olympus/Tyne MOU;
- Be limited to Spey SM1A common items only.

From the outset it was evident that such an MOU would differ from the Olympus/Tyne arrangement in that the SM1A is a modular engine comprised of six discrete sub-assemblies called Maintenance Assembly Change Units or MACUs (FIG. 2). Consequently it has a different repair/overhaul concept to other marine gas turbines[1] for which the MOU would have to provide spare MACUs as well as the spare GTCUs. In addition, certain aspects of the RN and RNLN standards of the GTCU were not identical since the design was at that time still subject to change and also there was a time difference between the MODUK and MODNL SM1A procurement programmes. Equally, the modules were fundamentally different since the RN installations were SM1A standard and the RNLN installations were of the uprated SM1C standard. The major difference resulting from this was the power turbines and thus a blanket support agreement could not be applied. Therefore, since any agreement reached needed to cover common equipments, it was decided to define these and, after due consideration and study, an MOU scope was agreed which applied to the procurement and support of the SM1A GTCU, its six associated

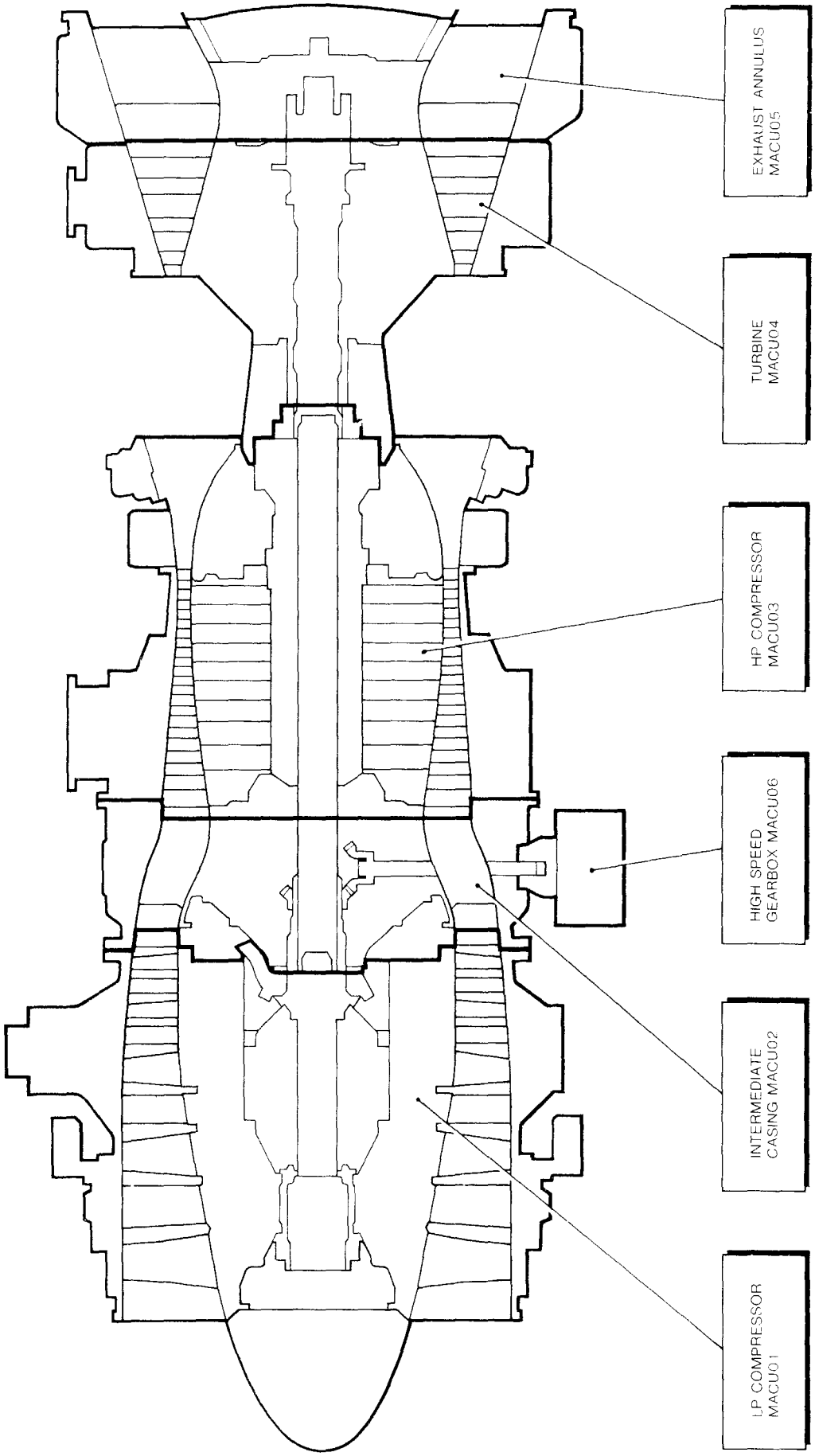

FIG. 2—MARINE SPEY SM1A MAINTENANCE ASSEMBLY CHANGE UNITS

MACUs and an agreed list of 60 engine and module-mounted repairable items (repairables) common to both navies. The MOU Document was drawn up in July 1989 and the agreement also included the sharing of the cost of procurement and reprovisioning of spares stocks for the maintenance, repair and overhaul of the MOU equipments. The associated management structure was established at the same time and this is shown in FIG. 3.

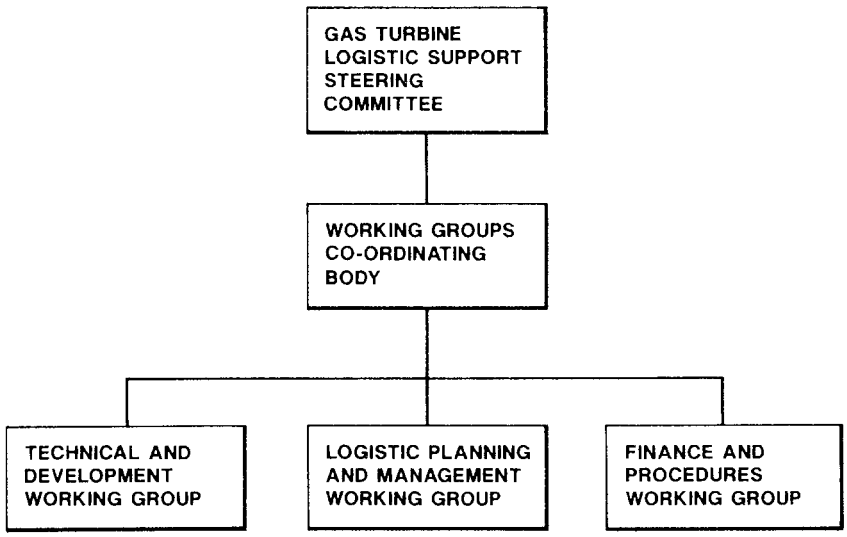

FIG. 3—SM1A MOU MANAGEMENT STRUCTURE

Who Pays for What?

The basic principle upon which the Financial and Procurement responsibilities of MODUK and MODNL are determined for support GTCUs and MACUs and Initial Provisioning of Spares for the combined MOU Fleet (i.e. the combined fleet of the RN and RNLN SM1A ships) is that each participant pays a share of the setting-up costs in proportion to his expected need for support GTCUs.

This principle is applied by determining, using computer simulation, the minimum number of support GTCUs that would be required by each participating navy if it were operating independently and expressing this as a ratio of the sum of those support GTCUs. The resulting ratios are called the GTCU Ratios. Thus if the independent operating requirements of the RN and RNLN are found to be:

$$\begin{aligned} \text{RN} &= \text{A Support GTCUs} \\ \text{RNLN} &= \text{B Support GTCUs} \end{aligned}$$

then the GTCU Ratios are:

$$\text{RN} = \frac{A}{A + B}; \quad \text{RNLN} = \frac{B}{A + B}$$

The GTCU Ratios are applied to the number of support GTCUs required to support the Combined Navy in order to determine each participating Navy's financial responsibility for those support GTCUs. The same ratios are also applied to the number of support MACUs required and to the value of the IP contracts for common pool spares in order to determine each participating navy's financial responsibility in these areas.

The minimum numbers of support GTCUs required by the RN and the RNLN if operating independently were calculated using the Gas Turbine Logistic Cycle Computer Simulation Model operated by DGME/ME414 at

Foxhill. This model, which is represented diagrammatically in FIG. 4, simulates the usage of GTCUs in a given fleet of ships and, by varying the number of GTCUs in the system at input, the theoretical minimum acceptable number of GTCUs required in support of those fitted in ships can be determined, i.e. the absolute minimum number of GTCUs with which the support system can just cope with demand. The same model can be used to determine the number of support GTCUs and MACUs actually required by the MOU fleet, given that, in real life, the support system will require to operate with an agreed level of surplus. This will be in order that a demand from a ship for a replacement GTCU can always be met whilst retaining some stock in hand (the buffer stock) for emergencies and unforeseen circumstances where operational or logistic conditions could possibly deviate markedly from those simulated. These support GTCUs/MACUs are the ones whose purchase costs will be shared in accordance with the GTCU ratios as it was agreed that the GTCUs destined for initial installation in new build ships ('first fit' GTCUs) should be a national responsibility.

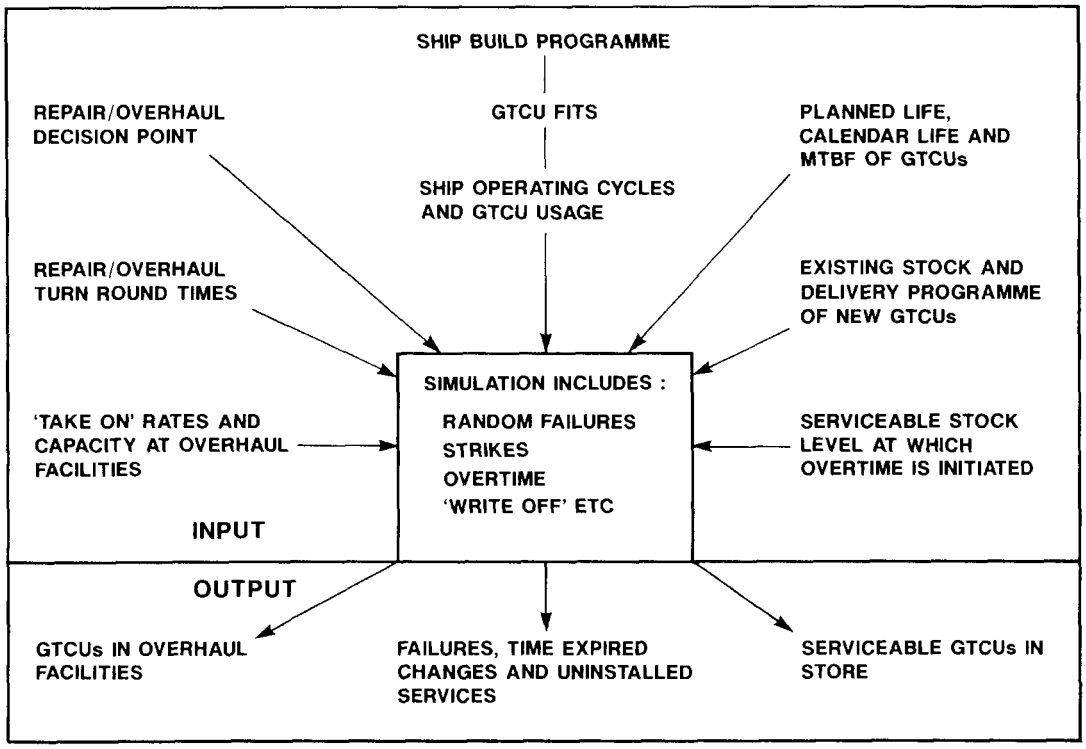

FIG. 4—THE GAS TURBINE LOGISTIC CYCLE COMPUTER SIMULATION MODEL

The above procedures allow for the cost sharing of the initial provisioning of common support in proportion to the amount of support material required by each of the participating navies if acting independently. However, in relation to repair and overhaul of the MOU equipment ashore, a different system is required since it is primarily the degree of actual usage a nation's GTCUs receive which determines the amount of support consumed rather than just the quantity of equipment itself. To this end, the annual GTCU/MACU repair and overhaul costs and the cost of contractors repair of MOU repairables, including the replenishment of spares initially provisioned for these purposes, is shared between MODUK and MODNL on the basis of their proportion of the annual total SM1A GTCU running hours achieved in the previous financial year by

both navies, regardless of which partner actually created the arisings taken on by the repair facility. These proportions are known as the Running Hour Ratios.

The final part of the agreement in relation to support material concerns onboard spares and the associated spares held ashore in support of the onboard stocks (Base Spares). It was agreed that the initial provisioning of ship sets of on-board spares should be a national responsibility, whilst the IP of common Base Spares stocks should be shared in accordance with the GTCU Ratios, Consumables subsequently issued to the RNLN are charged as a direct repayment by MODUK. A summary of these cost-sharing agreements is laid out in TABLE I.

TABLE I—*Summary of SM1A MOU cost-sharing agreement*

Cost Area	*Basis of Cost Sharing*
First Fit GTCUs	National responsibility
Support GTCUs & MACUs	GTCU ratios
IP of Overhaul Spares	GTCU ratios
Replenishment of Overhaul Spares	GTCU annual running hours
Overhaul Labour	GTCU annual running hours
IP of Common Repairables	GTCU ratios
IP of Common CRSS	GTCU ratios
Replenishment of Common CRSS	GTCU annual running hours
IP of Onboard Spares	National responsibility
IP of Common Base Spares	GTCU ratios
Replenishment of common consumable items demanded from DGST(N) by RNLN	Repayment

Note: In the above table 'Overhaul Spares' refers to those spares pre-provisioned and held at the overhaul facility (Rolls-Royce) for the repair and overhaul of GTCUs and MACUs and 'CRSS' (Contractor Repair Support Stock) refers to those spares pre-provisioned and held at the repair facility (Rolls-Royce/RNAY Fleetlands) for the repair of repairables.

At the time the MOU was finalized for signature it was intended that the RN would operate at least 16 SM1A-powered ships (HMS *Brave*, 4 Batch III Type 22s and 11 Type 23s) and the RNLN would operate 8 M Class frigates. The GTCU ratios and support GTCU/MACU requirements were calculated on this basis as described earlier. A summary of the resulting MOU support requirements is shown in TABLE II.

TABLE II—*Spey SM1A MOU initial support requirements and financial responsibility*

		Number of GTCUs and MACUs Required to Support the MOU Fleet						
		GTCU	*MA01*	*MA02*	*MA03*	*MA04*	*MA05*	*MA06*
	Total numbers / *GTCU Ratio*	7	5	4	5	10	4	4
RN Financial Responsibility	0.765	5.350	3.820	3.060	3.820	6.880	3.060	3.060
RNLN Financial responsibility	0.235	1.650	1.180	0.940	1.180	2.120	0.940	0.940

Problems Arising

Unfortunately, shortly before signature, the emergent Anglo-Dutch Spey SM1A Memorandum of Understanding was facing changes which threatened to invalidate the planned cost-sharing arrangements and to increase greatly the MOU management task. These stemmed from the following:

- The RN adopted the Spey SM1C for installation in Type 23–10 *et seq.* in place of the SM1A.
- RN SM1As were suffering from turbine damage as a result of their standard of combustionware which was different from that of the RNLN SM1As.

In addition, it was then clear that:

- The RNLN warranty on their first fit GTCUs was more extensive than the equivalent RN warranty.
- The RNLN were intending to operate their SM1As at a maximum of 14 MW compared with an RN maximum of 12.75 MW.

The impact on the MOU of each of these factors is discussed below:

Introduction of the SM1C

The RN decided to adopt the Spey SM1C, an uprated version of the SM1A, for installation in Type 23–10 *et seq.*, following installation of the engine in HMS *Brave* for a fleet trial[2], on completion of which *Brave* remained as an SM1C-fitted ship. This had two effects; firstly it reduced the number of RN ships eligible for the MOU from 16 to 12 with likely downstream effects on cost sharing and, secondly, it introduced a similar but non-identical engine into the RN support system. The impact of the former was that the existing support agreement was likely to be affected in terms of GTCU ratios and the quantity of support material required. The impact of the latter was seen to be that the SM1C which shares some common components with the SM1A could consume (improperly) support material owned and operated by the SM1A MOU. This could possibly include some or all of the MACU overhaul spares, repairables, repair spares for the repairables ('Contractors repair Support Stock' (CRSS)) and SM1A base spares, all of which were cost shared between MODUK and MODNL. It was not seen how the accounting systems would be able to differentiate between consumption by SM1A (MOU), and SM1C (RN only).

RN SM1A Turbine Damage

This turbine damage problem first came to light during SM1A endurance trials at RAE Pyestock[3] and it was seen subsequently in engines removed from the fleet. The turbine damage is caused by carbon build-up in the combustion-ware which periodically breaks away and passes through the turbine causing erosion as it does so[1]. This resulted in RN SM1A GTCUs being removed at around 1500 hours for repair, as opposed to the specified life of 3000 hours, with a consequent disproportionately high demand on certain overhaul spares. It was perceived that such unbalanced demand on the overhaul spares would upset the equity of the planned cost-sharing arrangements since the costs of replenishing these could fall due for payment after the MOU was in place.

The RN/RNLN Warranty Disparity

It was known at the outset of the MOU that MODUK and MODNL had negotiated different warranties with Rolls-Royce on their first fit GTCUs; the RN warranty lasted for 750 hours running and the RNLN warranty lasted for 3000 hours running. Understandably, MODNL wished to preserve the benefits of their longer warranty and this was accomplished in the MOU Document by an agreement that the repair and overhaul of all first fit GTCUs would be a

national responsibility until they achieved 3000 hours running. At this point they would become MOU GTCUs like the 7 support (or pool) GTCUs and the costs of repair/overhaul would thenceforth be included in the cost shared repair and overhaul (R & O) bill. To facilitate management of the different 'classes' of GTCU, the RN first fit, RNLN first fit and the pool GTCUs were delineated by serial number. This arrangement was intended to allow MODNL to pursue freely any warranty claims relating to RNLN first fit engines. In the event, since the RNLN GTCU warranty (and indeed the RN one) was not defined solely on running hours but was in fact '3000 hours or 6 years from dispatch, which ever is sooner', it was clear that because of an extended fitting out period in the M Class build programme and a then reduced planned annual GTCU usage rate, the RNLN warranty would 'time expire' some time in advance of the GTCUs reaching the 3000 hours mark (at which they would join the MOU). Consequently there would then be a significant period during which the RNLN engines would be operating with neither the benefit of warranty cover nor the availability of MOU repair and overhaul support. Furthermore, the delay in the RNLN ship programme and the low planned GTCU usage rate meant that it could take until the year 2002 for all the RNLN GTCUs to enter the MOU fold with the attendant delay in the full benefit of the MOU being realized.

The RNLN 14 MW Application

The Staff Requirement for the M-Class frigate was such that the SM1A was specified for operation up to 14 MW and Rolls Royce predicted that the HP Turbine Blade Creep Life accumulation would be such that the initial release life (planned life) of the blading would be 5500 hours, compared with 10 000 hours in the case of the RN engines at 12.75 MW. It was considered that if this prediction proved correct then the MOU would be further complicated by a consequent (unequal) increase in overhaul spares consumption and the additional problems of managing turbine MACUs with different release lives.

Solutions Proposed

Although the problems facing the MOU had been identified, it was difficult to quantify accurately their effects on equipment management and the cost-sharing arrangements. The Logistic Planning and Management Working Group (LWG) took the lead in defining the precise nature and extent of the problems in an attempt to arrive at suitable solutions and, happily, two of the original problems were solved during that period of study. Firstly, the RN SM1A turbine damage was tackled by the introduction of modification SPG681 which aimed to cure the carbon build up on the combustionware which was the cause of the blade erosion. As a bonus, the modification also brought the RN combustionware up to the same standard as that of the RNLN first fit GTCUs. Secondly, during Contractor's Sea Trials (CSTs) on the first M Class frigate (M-1), the RNLN found that the staff requirement for full speed could be achieved with the Speys running at 12.75 MW and therefore MODNL agreed to limit their SM1A operation to a maximum of 12.75 MW except for the requirement to prove each of their new engines at 14 MW during CSTs. As a result, the RN and RNLN GTCUs were now truly common.

At that time a series of computer simulations was run to re-validate the GTCU ratios and the MOU support requirements in light of the reduced size of the RN SM1A fleet. The opportunity was also taken to attempt to quantify the effect of the low achieved life of RN SM1As (due to turbine erosion) on the equitability of the cost sharing of the R & O bill.

These simulations showed that the GTCU support requirement was reduced by one GTCU to six GTCUs and by one MACU04 (Turbine MACU) to nine MACU04s as a result of the reduced MOU fleet size. A further result of the

TABLE III—*Spey SM1A MOU revised support requirements and financial responsibility*

		Number of GTCUs and MACUs Required to Support the MOU Fleet						
		GTCU	*MA01*	*MA02*	*MA03*	*MA04*	*MA05*	*MA06*
	Total numbers / *GTCU Ratio*	6	5	4	5	9	4	4
RN Financial Responsibility	0.667	4.002	3.333	2.667	3.333	6.003	2.667	2.667
RNLN Financial responsibility	0.333	1.998	1.667	1.333	1.667	2.997	1.333	1.333

smaller RN SM1A fleet was a change in the GTCU Ratios, reflecting the change in the relative sizes of the two 'independent' fleets. The revised support requirements agreed for the MOU are summarized in TABLE III.

The effects of the RN SM1A turbine erosion were simulated by adjusting the GTCU reliability data at the data input stage to reflect the low GTCU achieved life. The results showed that the effect on cost sharing was liable to be negligible as the RNLN accumulation of annual hours and therefore its associated ratios were found to be small in comparison to the RN during the period before the erosion problems were expected to have been 'modified out'. Thus any increase in the RNLN share of the R & O bill due to increased offtake of overhaul spares would be correspondingly small. Typical estimated running hour ratios applicable to that period for R & O bill sharing purposes were found to be 0.915 (RN) and 0.085 (RNLN).

Of the two remaining problems, (introduction of the RN SM1C & the RNLN 'support gap') the first one was considered to be the most difficult to solve and, after some considerable debate, the LWG came up with five options for the proposed 'way ahead', namely:

Option 1—Disband the MOU

If the current MOU were to be disbanded, the two partners would revert to individual support of their own equipment. The advantages would be:

- There would be no confusion or difficulty in costings.
- Individuals would have total control over their own machinery fit and modification state.

The disadvantages would be:

- The individual and overall costs of providing and supporting the SM1A/SM1C fleet would be much increased as the support costs reductions created by the MOU would be lost.
- Such action would go against the prevailing level of Anglo-Dutch co-operation.

Option 2—Reduce the scope of the current MOU

The MOU as agreed initially, included a limited range of module-mounted repairables (as distinct from those mounted on the GTCU) common to the RN and RNLN installations. With the introduction of the SM1C module into service in the RN a greater degree of commonality was predicted amongst the three types of module then in existence (RN SM1A, RN SM1C & RNLN SM1C). This would present a major problem in the repair/replenishment cost allocation arrangements which could be limited by reducing the scope of the current MOU to cover only GTCUs, MACUs and overhaul spares. The

support, repair and overhaul of the RN SM1C GTCU would in any case have to be separated from the MOU (SM1A) repair and overhaul loop in order to avoid any conflict i.e. be totally RN supported. The advantages would be:

- The resultant MOU would be simplified.
- The most expensive items of gas turbine repair and overhaul would still be covered by the MOU

The disadvantages would be:

- The MOU would be unable to realize its current potential i.e. some economic advantage would be lost.
- A system would have to be set up to keep RN SM1C module-related repair and replenishment separate from MOU related work.
- The RN and RNLN would have to support all of their module-related equipment independently.

Option 3—Increase the scope of the MOU to cover all SM1A and SM1C equipment

If all Spey SM1A and SM1C equipment, including those not common to both navies could somehow be included in the MOU then many of the perceived support problems created by the SM1C would be solved. The basis of the cost sharing of the R & O bills would have to be total Spey hours run, (SM1A & SM1C), whilst the cost sharing of the pool SM1A GTCUs and MACUs would remain unaffected. Advantages would be:

- As all Spey gas turbines would be included within the MOU there would be a reduction in cost allocation problems.
- The increase in the MOU fleet size would improve the cost-saving benefits of the agreement.
- The enhanced MOU would allow greater flexibility of machinery fit e.g. if the RNLN wished to introduce the SM1A in place of an SM1C.

Disadvantages would be:

- The inclusion in the MOU of non-common items would require further investigation as the exact implications were not known.
- The cost-sharing arrangements of the SM1C IP (or the common parts of it) would have to be considered.

Option 4—Leave the MOU essentially as defined and establish a separate RN accounting system for RN SM1C activities

Since the main problems surrounding the RN introduction of the SM1C involved the repair and overhaul of GTCUs, MACUs and repairables and the associated consumption of the pre-provisioned overhaul spares and CRSS, then, by keeping these activities separate for MOU SM1A and RN SM1C, those problems could be overcome. The advantages would be:

- Full separation of MOU SM1A and RN SM1C costs could be achieved.
- Existing procedures could be used.
- No amendment of the MOU document would be necessary.

The disadvantages would be:

- More contracts would be required by DGST(N) to manage the separate MOU SM1A and RN SM1C spares holdings and repair/overhaul activity.
- Separate MOU SM1A and RN SM1C bonded stores holdings would be required.
- Increased bonded store holdings would result.
- The RN would not gain any advantage from existing SM1A stocks during the SM1C IP of common items.

Option 5—Leave the MOU essentially as defined and change the method of MOU internal billing such that RN SM1C activity is effectively excluded

The MOU internal billing system for the spares element of the shared R & O bill is based upon the continuous replenishment of overhaul spares and CRSS held in the bonded stores and used at the overhaul facility (Rolls-Royce). In effect, MODUK pays Rolls-Royce annually for replenishment and labour and then bills MODNL for its share. It was considered that if the method of billing was based upon consumption of spares such that SM1A (MOU) consumption could be separately identified, rather than upon the replacement of a mixture of SM1A and SM1C spares having a common part number, then the requirement for separating SM1A and SM1C holdings would be removed. The advantages would be:

- Administration and management of the MOU would be made easier.
- Full separation of SM1A and SM1C upkeep costs could be achieved.
- There would be no need for separate SM1A and SM1C replenishment contracts and bonded store holdings.

The disadvantages would be:

- This option would be a major departure from accepted practice and contrary to a recommendation of the Mott Report[4].
- MODUK would have to unilaterally pre-fund the build up of SM1A bonded store holdings required by the increasing operational SM1A population as MODNL would no longer be involved in replenishment.
- The adoption of this option was believed to be irreversible thereby reducing flexibility for the future.

Commonality Investigation

It had thus become clear that the existing SM1A MOU, which was based on Olympus/Tyne procedures, was insufficiently flexible to cater for the complex situation presented by the introduction of the SM1C by the RN. It was also clear that the full extent of the problem could not be appreciated without some form of quantitative analysis of the situation. In order for the SM1C to fit into an SM1A MOU at all, it would have to share a significant number of common components with its sister GTCU such that purchase and use of such items could be shared by the partners. On first appraisal, the two engines were entirely different since neither they, nor any of their MACUs, were fully interchangeable. Furthermore, their structure was different, the SM1C being comprised of one less MACU than the SM1A since the SM1C Intermediate Casing and HP Compressor are combined into one assembly.

Therefore in order to ascertain whether any degree of commonality did exist an investigation was carried out at component level or, more specifically, at spare part level since this is the level at which much of the shared cost is accrued. The investigation was limited in the first instance to the GTCU/MACUs since repair and overhaul of this equipment was seen as the main area of cost and if there were significant levels of commonality here (in terms of cost) then it was conceivable that the SM1C could be integrated into the SM1A MOU. Any lack of commonality would need to be in sufficiently small proportions compared with the overall scope of the MOU to enable them to be ignored or written off. This would essentially be Option 3. However, if commonality were restricted to a relatively small number of items or to items of small relative value (nuts, bolts, washers, joints, etc.) then it would be unlikely that the SM1C could be involved directly in the MOU to the satisfaction of both partners. This being the case then the SM1C would have to be considered as a completely different engine operated by only one partner and one of the remaining four options (1, 2, 4 or 5) would have to be invoked.

For the purposes of the investigation, various categories of spares were selected and the degree of commonality between the SM1A and SM1C standards assessed by comparing the items in each category for each engine type. The categories of spares were:

- Overhaul Spares (GTCU/MACU).
- GTCU Onboard and Base Spares (Ship Support Spares).
- Agreed Common Repairables (As defined by the MOU).

These were perceived to represent a fair proportion of the costs involved whilst covering a wide range of areas where the SM1A and SM1C might differ.

The findings of the investigation are summarized in TABLE IV and these reveal the important point that commonality amongst components does not necessarily equate to commonality in monetary value. In all categories in the table except one, the financial interaction is the lesser of the two, which suggests that it is the more expensive items that are non-common.

Following on from this, it was suggested that commonality amongst overhaul spares is of the most importance since after the actual purchase of the GTCUs and MACUs it represents probably the area of greatest capital outlay. If a satisfactory degree of commonality does not exist such that the SM1C GTCU/MACU R & O bill could be added to that for the SM1A and the total shared equitably in some way, then incorporating the SM1C into the MOU would be difficult and the figures in TABLE IV suggested that this was the case.

The High Speed Gearbox revealed the greatest degree of commonality (nearly 90%), having undergone little development for the SM1C, and the relationship between this and the value of the common parts was close. The HP compressor too underwent little change from the SM1A to the SM1C but the LP compressor was revised quite markedly. Thus, taking these two MACUs together, although still nearly 60% of the components remain common to the two engine types these represent only 27% of the value of the spares outfit, due mainly to changes to the LP compressor blading discs and shafts.

TABLE IV—*Results of the investigation into the degree of SM1A/SM1C commonality*

Spare parts Category	*Number of Line Items*	*Line Items SM1A/C Common*		*Monetary Value of Common Items*
		No.	%	%
HP/LP Compressor Assy. Overhaul (SM1A)	558	332	59.4	27.3
Turbine Assy. Overhaul (SM1A)	313	124	39.6	3.5
HS Gearbox Overhaul (SM1A)	275	244	88.7	89.7
Fuel System Assy. Overhaul (SM1A)	146	98	67.1	21.8
Ship Support (SM1C)	225	204	90.7	55.8
Agreed Common Repairables	60	46	76.7	63.4
Totals	1577	1048	66.5	28.3

This trend was even more marked with the turbine assembly. As a result of almost total revision of the static and dynamic blading, discs, shafts and casings, the remaining 39% of SM1A common components account for only 3.5% of the spares outfit value. This result was particularly important as it was predicted that the turbine would account for a large proportion of the R & O bill since, due to its function, it is the most expensive MACU and the one with the shortest life.

In terms of ship support spares and repairable items the picture was somewhat better overall but there still remained significant shortfalls in SM1A/SM1C commonality in terms of monetary value, often due to a relatively small number of important but expensive items. For example, in the case of ship support spares which displayed a high number of common items (over 90%) the 44% monetary shortfall is largely caused by a few expensive items such as combustionware, fuel pump, oil pump, etc.

As a result of the commonality investigation the following conclusions were made:

- Although a large degree of component commonality could be shown to exist between the SM1A and SM1C GTCUs and associated equipment, there remained in certain areas a significant number of important and expensive items that were different.
- The SM1A/SM1C common items accounted for a disproportionately small part of the total value of the equipment.
- The amount of money that might be cost shared legitimately between the MOU partners would be small compared with the total expenditure on SM1C spares and repair/overhaul.

Further Deliberation

Following completion of the investigation into SM1A/SM1C commonality, the LWG reconsidered the five options it had defined in an attempt to decide which of them was now most appropriate.

- *Option 1*—Disbanding the MOU assumed that the problems arising from the introduction of the SM1C were insurmountable and that dispensing with the MOU was the only possible solution. This was not really considered to be a realistic approach and was included only for the sake of completeness.
- *Option 2*—This option assumed that the SM1C GTCU was outwith the MOU whilst proposing a reduction in the scope of the existing agreement to exclude module-mounted repairable items. This was intended to avoid the cost allocation problems created by the RN operation of SM1C rather than cater for them and by so doing some of the benefit of the original MOU would be lost. As a result of this and the shortfall of financial interference shown, Option 2 was discarded.
- *Option 3*—This option advocated incorporating fully the SM1C into the SM1A MOU using established procedures, including cost sharing a combined annual SM1A/SM1C R & O bill. This would be quite a radical step since, by definition, MOUs are concerned with common equipments but it was believed that, given certain circumstances, such an arrangement could be made to work provided that the partners were prepared to tolerate a little 'give and take' in cost-sharing terms. However, it was concluded that there was insufficient commonality between SM1A and SM1C in monetary terms (only 28% of value of items in TABLE IV) to allow the, probably substantial, costs arising from non-commonality to be included in cost-shared bills. On top of this, despite the attractions of the option in management terms, there would be little or no benefit to the RNLN from

the inclusion of the RN SM1C equipment since the extra GTCUs and MACUs would not be available for use in their ships. Consequently, Option 3 was discarded.

- *Option 4*—This option essentially treated the RN SM1C as a completely different installation to the SM1A and allowed the MOU to function as conceived originally. However, it also recognized the problem of commonality of components and allowed for totally separate management of all aspects of support for the two engines, whilst acknowledging the increased management task. This option was considered viable.
- *Option 5*—This option proposed a consumption-based material cost accounting system instead of the current replenishment-based one used by the Olympus/Tyne MOU and by doing so it addressed all the problems seen to arise from the introduction of the SM1C. However, although this option was considered viable, it was recognized that the change in the cost accounting system was a major departure from accepted practice and one which had been specifically advised against in the Mott Report on the Olympus/Tyne MOU in 1983. Accordingly, the LWG decided to look at this option in some depth prior to making a final recommendation to the Co-Ordinating Body on the way ahead.

Option 5 Validation

It was agreed that if the basis of internal MOU billing (cost sharing) were to be consumption of spares from the Bonded Stores at Rolls-Royce then the MOU partners had to have confidence that the issue and use of spares could be accurately tracked and accounted for such that SM1A and SM1C costs would be truly separated. Accordingly, discussions were held with Rolls-Royce covering all aspects of repair and overhaul including scrap and salvage operations, control of part-lifed components, provision of spares and allocation of labour costs to ascertain that these could all be allocated accurately to the appropriate (SM1A or SM1C) bill. As a result, the LWG concluded that this was indeed possible and consequently that Option 5 was a workable solution to the MOU's problems relating to the RN introduction of the SM1C.

The Chosen Option

The choice had now been narrowed down to Option 4 or Option 5 both of which had advantages and disadvantages. Option 4 was the preferred solution since it retained proven existing procedures but it required separate bonded store facilities for RN SM1C equipment and it increased the support management task. DGST(N) held a meeting with Rolls-Royce to discuss the stores problem and re-negotiated the Bonded Store agreement to include a separate accounting system for RN SM1C spares which would allow MOU SM1A and RN SM1C offtake and their respective replenishment to remain separate. DGST(N) subsequently accepted the additional task of managing separate 'families' of MOU SM1A and RN SM1C contracts and, following this, Option 4 was recommended to, and endorsed by, the Co-ordinating Body for adoption by the MOU.

A Revised Warranty Agreement

At this point, solutions had been found for all the problems identified in this article as facing the SM1A MOU with the exception of the question of the RNLN warranty, the MOU agreement on warranty and the resultant RNLN 'support gap'. This problem had arisen as a result of delays in the M Class build programme and reduced planned RNLN SM1A running hours such that an amendment to the MOU Document was the only possible solution. This task

was taken up by the Finance and Procedures Working Group (FWG) and a new MOU warranty agreement was approved which allowed for all first fit SM1A GTCUs to be part of the MOU from point of installation in a ship (as opposed to 3000 hours running) whilst allowing the partners free rein during their respective warranty periods which effectively sealed the support gap.

The new agreement was subsequently endorsed by the Co-Ordinating Body and a corresponding amendment to the MOU Document was signed in May 1992. This brought to an end a lengthy period of investigation, study and discussion during which, on one or two occasions, Option 1 had looked very attractive!

The Future

Some three years after the MOU initial agreement, problems emerging at the time have been identified and solved and an amendment to the MOU actioned. It was fortunate in many ways that, due to delays in the M Class build programme, the MOU had not gathered much way at the time these problems came to light, as this allowed the partners an opportunity to find appropriate solutions before they could have much impact on the MOU itself. There are now three operational M Class frigates and the full MOU fleet should be at sea by mid-1995. From there and for the following 20 years or so the two partners will enjoy the proven mutual benefits of a Gas Turbine Support MOU and the possibility exists that new members will join along the way.

All good things come to an end of course and the MOU will die a natural death as its participating ships are decommissioned but by then it is probable that new MOUs will exist for the support of the next generation of Marine Gas Turbines. There may even be an SM1C MOU somewhere.

In the meantime, investigations are under way to generate procedures whereby all SM1A repairables can be included in MOU cost sharing and not just the common ones. Such a move would simplify the repairables management task whilst enhancing the scope and the benefits of the MOU.

Conclusion

Despite its early teething troubles, caused by a rather unique set of circumstances, the Anglo-Dutch Spey SM1A Memorandum of Understanding has emerged as a worthwhile and beneficial example of international cooperation. Its predecessor set the pace and although the Olympus/Tyne MOU also had its problems in the past it has been a good example for the SM1A to follow, particularly in the present climate of ever closer European harmony.

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