The Attorney General will be present to deal with David Wolfson's fraud worry.

MCS 26/7

PRIME MINISTER

RB211 - 535E4 ENGINE PROGRAMME

You asked to see again the graphs, charts and notes which were provided during the presentation to you in October, 1979, about aid to Rolls Royce. These are attached.

I have picked out one or two points of particular interest now:-

(i) You were told in 1979 that "with the 535, Rolls would benefit from its efforts to establish a market for the RB211 family and it has a good chance - according to Boeing - of getting half the market" (Flag A). Note that RR's and DTI's estimate has fallen to 40% (paragraph 17 of the paper by officials); the Treasury estimate (paragraph 24) is for 35%.

(ii) You were given (Flag B) a pre-tax profits forecast, dated August 1979, as follows:

1979	£	-34 m.
1980	£	-45 m.
1981	£	4 m.
1982	£	66 m.
1983	£	66 m.

What was the actual ~~outline~~ outturn? Note that a pre-tax profits forecast with the same kind of profile is being offered to you now:

assuming launch aid:			assuming no launch aid:		
1983	£	-23 m.	1983	£	-67 m.
1984	£	9 m.	1984	£	-42 m.
1985	£	37 m.	1985	£	30 m.
1986	£	176 m.	1986	£	176 m.
1987	£	256 m.	1987	£	256 m.

(These profits are out of ~~a~~ an annual turn-over of some £1½ b.)

/ (iii)

(iii) It is also worthwhile looking at paragraphs 18-23 of the Annex to the October 1979 notes (Flag C) which set out the economic case for the RB211 - 535. How many of these assumptions have been proved wrong by events?

MCS

Please see, too, note by Lord Cockfield (Flag E)

25 July 1983

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Prime Minister
Sir K. Berrill and DoI officials followed this closely in their presentation.
TL 19/x

ROLLS-ROYCE

PRESENTATION TO THE PRIME MINISTER, 16 OCTOBER 1979

1 The Company

To put Rolls in context, it is a company with a turnover last year of £760 million, broadly comparable by that yardstick with firms like Tube Investments, Babcock and Wilcox, and British Oxygen, ranking sixtieth in the British industrial league table. Worldwide it employs 59,000, of whom 56,600 are in the UK. The main centres are Derby and Bristol. Its profit record, with £12 million in 1978 and £20 million (before tax) the year before has been poor on a capital employed of some £360 million. More to its credit, 47 per cent of its output is exported and it is in the top ten of British exporters.

CHART 1

CHART 2

GEC, which is worth a mention at this point, has a turnover and payroll about three times that of Rolls-Royce and a profitability of 10 to 20 times as much.

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CHART 3A 2 The Company's products

Rolls is overwhelmingly in the aero-engine business, and its main subsidiary activity - the industrial and marine division which GEC would like to acquire - is concerned with modifying aero-engines for industrial and naval purposes.

There is also a small, but in defence terms extremely important, nuclear business making the power plant for nuclear submarines.

Turning back to the main aero-engine business, it divides at present roughly 53% to 47% between military and civil engines. Although Rolls complain strongly about the level of profitability allowed by the Ministry of Defence on the military engines, this is quietly profitable and useful profits are made on overseas sales. Rolls, for example, claim to have done very well over the sale of Jaguars to India at the turn of the year.

Within the civil engine market, where all the Company's problems have arisen, there are two main products,

> first the Spey engine, introduced 15 years ago, on which there is a good and profitable spares business as well as a fairly well maintained volume of sales of new engines, eg on the BAe 111 on which a deal has been concluded with the Romanians and on a new American business jet (Grumman Gulfstream III).

But the Spey is now on the way out, and one of the major questions for the future is whether Rolls should develop a replacement - the 432 - in collaboration with the Japanese. The Boeing Company, the biggest and most powerful civil aircraft company in the world, are enthusiastic about this proposed new engine which they would like to see providing a new power plant for one of the most important of their family of aircraft (the 737). That however is a major decision for the future.

The second major civil engine is the RB 211, a much larger engine developed in the late 1960s to power the new big wide-bodied jets. It is this engine that caused the collapse of the Company in 1971 and which is the cause of the Company's present serious problems. The importance of the engine to the Company and the family of engines being derived from it can be judged from Rolls-Royce's view that the size range covered will account for 70 per cent of the demand, by value, for commercial engines.

3 The RB 211

CHART 3B Turning specifically to the RB 211, this is a broad name for a whole family of engines derived from the same engine core.

Its early history was one of technical problems, including the failure of the carbon fibre technology which it was hoped would give it some advantage over its two American rivals. Moreover, with the collapse, and all the hiatus that this caused, Rolls fell two years be hind the American companies in the development and upgrading of the engine to meet the greater thrust requirements of the wide-bodied jets as they increased in size and range.

This two-year handicap has cost Rolls dearly in financial terms because in marketing its engines it has had to undertake when getting some key orders to match the more advanced performance standards of its rivals by undertaking to retrofit the engine originally supplied by an improved version when it was available; or to compensate in other ways eg attractive pricing and concessions. Rolls had to do this to keep in the business at all. It still has extensive refitting commitments which will be particularly heavy in 1981 and '82.

But the technical competitive situation is now much improved. The new versions of the RB 211 - 524 which have been under development and will be coming into the service over the next two years are regarded by the Ministry of Defence, who monitor the technical progress of the RB 211 as comparing satisfactorily with their competitors. For instance the Rolls engines have superior fuel consumption and are likely to retain this advantage. This becomes more important as fuel prices rise and acts as a counterweight to the thrust and weight advantages of the competition. Overall we now have a product recognised as technically competitive in the market place.

The last Government in mid-1978 gave authority for the production of a major new derivative of the RB 211 engine - the 535. For the first time, Rolls is in front of its rivals and indeed the signs are that one of the two Americans will not enter the field. It has been ordered by the first two airlines buying the new Boeing 757 aircraft and Boeing consider that Rolls should be able to take half the world market for their new aeroplane with this engine. The Ministry of Defence advise that from the technical point of view all is going well and the development of the engine is on schedule. While the Department of Industry has more cautiously assumed that Rolls will only get 40 per cent of the market and take a more cautious view of the sales potential of the 757 than either Boeing or Rolls-Royce, this engine is a major opportunity for the Company.

Much of the credit for re-establishing Rolls, and in particular for convincing Boeing that the 535 should be the launch engine on their new aircraft, goes to Sir Kenneth Keith.

CHART 4

4 The Special Features of the Aero-Engine Business

In thinking about the RR 211, it is worth noting the special characteristics of the aerospace business.

1 The high capital cost of a new engine - even a derivative engine like the RB 211-535 is expected to cost up to £300 million.

2 High technological risk, fortunately much less for a derivative engine like the 535.

3 The long term scale; 5 years is a reasonable ball-park figure for the development of a new engine with a subsequent life of say 20 years, and with spares well beyond that.

4 The importance of spares: it is reasonable to expect to sell about one and a half times the value of the original engine in terms of spares and these are where the profits are sought.

CHART 5

CHART 6

5 Finally, for any company in aerospace not based in the United States, high vulnerability to movements in exchange rates and relative rates of inflation. A combination of relatively high rates of inflation and a strengthening currency is extremely punishing for any aerospace company in Europe, as the French and German Governments have found in underwriting their industries against all the effects of currency movements in connection with their Airbus venture.

A

5 The Implications of these Special Features

These characteristics have a number of important consequences:

First no airline is willing to buy an aero-engine unless it can be sure of spares for the lifetime of the aircraft, and given the advantages of commonality unless it is confident that the engine will be available for repeat orders and will be kept abreast of developments. The ability to offer a family of engines with common parts is another important plus.

The converse of this is that any doubts about the future of an aeroengine maker means that it is out of the running; that is why the Government in 1971 had to undertake that the RB 211 would be supported throughout its service life.

Second market share is crucial if the huge costs of development are to be met. For the reasons already mentioned airlines are reluctant to become committed to a new supplier and for a company like Rolls with a less developed engine seeking to build up in the US market, which dominates the scene, the task was daunting. Rolls have had to buy market share and it is a fair argument that securing market share is as much part of the cost of entry as the development and tooling for a new engine. Rolls still has the smallest market share and this is a serious weakness. With the 535 it will benefit from the efforts by Rolls to establish a market for the RB 211 family, and it has a good chance - according to Boeing - of getting half the market.

CHART 7

CHART 8

Finally this is a business that involves large resources and large foreign exchange risks, especially for a European company. However, these factors, combined with the long learning curve, have the compensatingadvantage that entry by newcomeers (or re-entry by those who have given up) is very slow, and very costly.

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6 The Future Prospects

Finance

CHART 9A There is the daunting financial prospect already presented to Ministers, with an increase of some £640 million on the cash requirements previously notified to Government, up to 1983; an immediate prospect of substantial losses, and a return to profit-

CHART 9B ability in the period only if the exchange rate falls. Moreover, the combination of a rapid appreciation of sterling, a market upturn in the aerospace business generally and higher than expected inflation has changed the prospects for Rolls very quickly during the course of this year.

CHART 9C As set out in the paper previously circulated to Ministers, about half of the rest in cash requirement derives from the increased inventory Rolls needs to sustain the increased volume of business they have secured or have in prospect.

These figures can be improved, as both Rolls-Royce and the NEB recognise, by economies and improved performance: they could no less be improved, or made worse, by movements in the exchange rate and relative rates of inflation. The former is a matter for good management: the second is - for the Company - an unknown and it is for the Government as owner to decide whether or not the risk can be accepted.

Markets

But if the forecasts being made throughout the world aerospace

CHART 10 industry has any validity, a well managed aerospace company has a large and expanding market opportunity. This is not based simply on an extrapolation of past rates of market growth; there is a huge replacement requirement in the mid to late 80s deriving from aircraft that are reaching the end of their lives or which will need new engines if they are to carry on.

Summary

We have a tragic situation in which a buyer's market has turned into something more resembling a seller's market but where through movement in the exchange rate and erosion of cost standards during the depression years we could hardly be in a worse position to take advantage of the boom. But if we miss this boom, in what is a famine and feast business, Rolls will lose, perhaps for a decade, the opportunity to secure market share upon which its long term prospects depend so heavily.

With North Sea oil the odds are that the exchange rate will keep at a level which will make Rolls an indifferent prospect for at least five years and perhaps for the decade; but if we pull out now:-

- i) we shall lose the benefit of the large expenditure over the last decade to establish Rolls as one of the three major world civil aeroengine builders.

- ii) re-entry would be slow and extremely costly - perhaps impossibly so because by then the French and conceivably the Japanese would have taken our position. Moreover, this is the kind of business, now that we have established technical equivalence with the Americans and a lead on the new engine, in which Britain ought to have a future if we have a well managed company.

CHART 11 **7 The Strategic Alternatives**

The alternatives which face the company:-

1 Immediate withdrawal from the RB 211 - this is a course that Rolls advise would cost billions of pounds in compensation payments, particularly to airlines but also to Lockheed and to some extent Boeing.

2 Progressive withdrawal - a policy with various permutations each of which would need to be analysed but all of them involving losses which would need to be quantified.

3 Carrying on with no change - a high risk policy as recent events have shown.

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4 Carrying on with new management and new policy directives from the Government - the course recommended by the Secretary of State for Industry. These policy directives might include seeking a partnership with another manufacturer since it is arguable that there is only room for two major civil aeroengine manufacturers. The French have already entered the field as a subordinate partner of GE; the Japanese are seeking hard to get in and there is a risk of the numbers being actually increased. There is much to be said for Rolls entering into a larger grouping. Pratt and Whitney have indicated that they would be interested in acquiring a blocking shareholding in Rolls Royce - 26% or more - and as mentioned before the Japanese would like to link up with Rolls-Royce to manufacture a new engine.

But the time for any negotiation with Pratt is not yet: they would not be interested in Rolls in its present state. The policy here may be to keep Pratt interested but to play for time while the company is brought into better shape.

C

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ROLLS ROYCE - THE FACTUAL BACKGROUND

Introduction

1. The present Rolls Royce company was set up in 1971 as a 100% government-owned company to take over the gas turbine engine business of the old Rolls Company when it went into receivership. In 1972, its first full year of business, its turnover was £375m. In 1978 the turnover had grown to £763m, split roughly as follows

	%
military aircraft engines	40
civil aircraft engines	40
helicopter engines	5
industrial and marine engines	12*
nuclear engines for submarines	3
Total	100

Although in the period turnover appears to have grown, in fact when allowance is made for the change in the value of money there has been no growth. Exports have risen from 36% of turnover in 1972 to 47% in 1978. UK employment fell from 63,282 in 1972 to 56,600 in 1978 but has now started to rise.

2. The collapse of the old company was caused entirely by problems with the RB211 engine which was being developed as the centrepiece of the civil engine business. Then as now the military engine business, and the helicopter, marine and nuclear businesses which are also almost exclusively for defence purposes, both domestic and for export, were profitable. For this reason this paper deals primarily with the civil aeroengine business. This makes up less than half the total business at present, but it is expected to grow to about 60% by the mid-1980s, and to two thirds of the total in the 1990s.

Civil Aeroengine Business

3. In the 1960s technical developments opened the possibility of building much

* includes a substantial value of basic engines bought from Aeroengine Division

larger and more efficient jet engines. In the USA the two leading companies, Pratt and Whitney and General Electric, developed such engines initially for military transports. In the UK there was no comparable military requirement and Rolls Royce, the only other producer in the world of large engines, decided to develop the RB211 as a purely civil venture, recognising that if it did not its civil business would eventually be lost to the US. As new aircraft were designed to exploit these engines the RB211 was chosen by Lockheed as the engine for the L1011 Tristar. It was the insolvency arising from the development of this engine which caused the collapse of the old Rolls Royce company. The crisis was caused primarily by inability to meet the development timetable.

4. The new Rolls Royce company set up by the Government successfully fulfilled the original RB211 contract, and has since been engaged in a competitive battle with Pratt and Whitney and General Electric in the market for these large engines. Each of the three has extended the power range of its basic design, and has progressively improved the fuel economy, and Rolls Royce has in addition been seeking to make good a time lag of some two years which grew out of its collapse and the parallel crisis at Lockheed. A description of the RB211 family of engines, their costs and markets is annexed.

Present Market Position

5. There is a wealth of evidence to suggest that in technical terms the RB211 is now fully competitive with its US rivals. A recent technical evaluation based on Boeing data demonstrates clearly that the RB211-524 is now and is likely to remain for several years the most economical engine for the Boeing 747, and Boeing is going to certificate its new 757 aircraft first of all with the RB211-535. For some other applications such as the European Airbus the US engines have advantages. Nevertheless the broad conclusion that the RB211 at least matches its competitors is well established and confirmed by sales success. Rolls' other civil engines are now near the end of their commercial lives and it is thus increasingly dependent on the RB211, though it has two new and smaller designs one at least of which it would like to launch if market conditions justify it and capital is available.

6. The technical success of the RB211 has not been paralleled on the financial side. While the completion of the initial contract for Lockheed was achieved within the cost estimates made at the time of the rescue in 1971, the cost of matching the continued technical developments of the competition has been high and Rolls Royce has had a very much smaller market share over which to spread the costs. Furthermore the big potential advantage of lower UK wage rates has been offset by lower productivity. Assessment of the real commercial prospects for the RB211 family is bedevilled by uncertainties over future exchange rates. World aerospace business is largely priced in dollars, and Rolls Royce are obliged to price their engines similarly. Variations in the exchange rate thus directly affect sales revenue and cash flow, and affect profitability still more drastically. Uncertainties about future exchange and relative inflation rates overshadow the other factors in prospective profitability. The importance of these factors has always been made clear by Rolls Royce. For example in their 5 year forecast for 1979-83 Rolls Royce explained that the changes in their assumptions about UK and US inflation compared with their forecast of a year earlier, and about the exchange rate, reduced their profits over the 5 year period by £300 million. (In the 1978 plan they assumed an exchange rate declining from $1.65 to $1.36 over 5 years, in 1979 they assumed a constant rate of $1.80). As is set out in more detail below, further revision to the assumptions when the forecast was updated during 1979 reduced the profit projection by a further £167 million. The sensitivity to exchange rate fluctuations will increase in the coming years with the growth of the RB211 business.

<u>Rolls' Financial Position</u>

7. In late 1978 Rolls Royce prepared a 5 year forecast which took account of the Government's approval during the year of the launch of the RB211-535 and the further development of the RB211-524. After adjustments for certain proposals which were not approved the forecast was as follows -

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RR FORECASTS 1979/83 BASED ON ORIGINAL FYF

	1979	1980	1981	1982	1983	TOTAL
Profit before tax	(53)	(28)	(34)	(13)	59	(69)
Cash flow						
Operating profit & depreciation	97	127	125	143	222	714
Launch aid (1)	-	-	-	-	-	
PV R&D (1)	(131)	(120)	(113)	(102)	(98)	(564)
Growth in inventories	(86)	(50)	(45)	(65)	(52)	(298)
Capital programme	(42)	(51)	(56)	(56)	(62)	(267)
Interest	(12)	(13)	(15)	(17)	(18)	(75)
Other	49	12	16	30	7	114
TOTAL CASH FLOW	(125)	(95)	(88)	(67)	(1)	(376)

(1) This table is constructed without provision for launch aid or other financial support, and thus includes the whole cost of the -535 launch and -524 growth programme on PV R&D. It assumes a constant exchange rate of $1.80, and is in outturn prices.

8. Both Rolls Royce and the NEB believed that it would be damaging for Rolls' commercial standing for the large sums required for the RB211-524 further development and the launch of the RB211-535 to be provided as conventional capital since the capital would not earn a return for several years. It was therefore decided by the last Government to provide launch aid over a 5 year period totalling £192 million at 1978 survey prices, which is likely to be some £250 million at outturn prices, leaving some £126 million to be funded by the NEB or by commercial borrowing. (Launch aid is not shown in the balance sheet, but is credited to the profit and loss account.) Provision was made for the launching aid to be recovered by a levy on future engine sales. Simultaneously a financial duty was set, by agreement with NEB and Rolls Royce, to secure a rate of return at Rolls Royce of 10% on capital employed by 1981 and a progressive increase thereafter.

9. By the middle of 1979 it became clear to the Department that critical assumptions underlying the five year forecast were no longer realistic. The exchange rate had appreciated rapidly, the rate of UK inflation was increasing rapidly, and Rolls Royce had indicated that, as a result of increasing world demand, they had greatly increased their sales expectations for the 1980s. In view of the clear implications for Rolls' financing needs the Secretary of State for Industry asked Sir Leslie Murphy in June to provide updated forecasts. These were submitted at the end of July and after further subsequent updating showed the following picture.

LATEST RR FORECASTS 1979-83

	1979	1980	1981	1982	1983	TOTAL
Profit before tax	(39)	(52)	(10)	60	61	20
Cash flow						
Operating profit & depreciation	49	75	68	122	220	534
Launch aid	69	54	72	43	12	250
PV R&D	(127)	(124)	(112)	(106)	(98)	(567)
Growth in inventories	(110)	(175)	(116)	(116)	(144)	(661)
Capital programme	(44)	(48)	(81)	(83)	(79)	(335)
Interest	(12)	(16)	(27)	(30)	(30)	(115)
Other	36	18	2	12	61	129
TOTAL CASH FLOW	(139)	(216)	(194)	(158)	(58)	(765)

NB These totals assume no waivers of levies due to HMG. The Annex to the Officials Paper incorporated Rolls Royce's assumption that 50% of levies would be waived, the effect of which was to improve profits and cash flow in that table by £29 million ovwr the 5 years.

10. It was emphasised that the figures were an interim update only, and that this made the later years particularly uncertain. A full revision of the forecasts will be completed later this year.

11. In broad summary the changes were

Cash flow	1979	1980	1981	1982	1983	1979/83 Total	1979/83[3] Total (no waiver)
December 78[1]	(51)	(34)	(10)	(18)	16	(97)	(126)
August 79[2]	(134)	(209)	(188)	(152)	(53)	(736)	(765)
Difference	(83)	(175)	(178)	(134)	(69)	(639)	(639)
Profit (pre-tax)							
December 78[1]	21	33	44	36	76	210	181
August 79[2]	(34)	(45)	(4)	66	66	49	20
Difference	(55)	(78)	(48)	30	(10)	(161)	(161)

(1) These data assume the provision of £250m launch aid from HMG, but do not take account of 1979 Budget changes.

(2) These forecasts also assume £250m launch aid, and take account of minor revisions to the 1980 figures as presented end-July, as documented on 17 August 1979.

(3) All these annual forecasts assumed a 50% waiver of RB211-524 levies; without any waiver both cash flow and profits would be worse by £29m over the 5 year period. The final column illustrates the effect of assuming no levy waivers.

12. As has been explained in the note annexed to MISC 22(79)1 these dramatic revisions of the figures can be accounted for by

a) the increase in working and fixed capital requirements needed to support the greatly increased forecast of new engine and spares sales over the period;

b) the increase in the estimate of UK inflation in 1979 from 8% to 17%, and in 1980 from 8% to 12%;

c) revision of the assumed exchange rate from $1.80 throughout to -

1979	$2.10
1980	$2.00
1981	$1.95
1982	$1.90
1983	$1.85

The contribution of each of these to the total is as follows

MAJOR CAUSES OF INCREASE IN CASH NEEDS

	1979/83 (£m)		Effect on:-
Exchange rate		167	Profit/cash
Inflation on:-			
extra capital expenditure	18		Cash
inventory	150		Cash
		168	
Growth in demand			
add. capital expenditure	73		Cash
inventory	230		Cash
		303	
TOTAL		638	

13. The NEB, however, do not accept a number of the assumptions underlying the financial projections produced by Rolls Royce. They have queried the sales forecasts, notably with regard to the RB211, both because they consider they are over-optimistic, in terms of the present order position, and also because, in their view, sales concessions and retrofits which are not already committed should not be offered to potential customers (this could lead to a reduction in sales achievements). The NEB's view is that Rolls Royce should only work on the assumption of the sales forecasts in the original 1979/83 Five Year Forecast, and on this basis there would be significant savings on

inventory and capital expenditure. The NEB also believe that significant economies could and should be made in other areas, notably PV R&D expenditure. On the basis of the NEB analysis, a reduction of up to £250 million in the total cash requirements over the 5 year period could be achievable.

14. The validity of the NEB analysis is not accepted by Rolls Royce. Although sales optimism has been a feature of Rolls Royce forecasts in the past, the present rate of order intake tends to confirm Rolls Royce's views. Further orders have been received - against offers made months ago - since the updated forecasts were provided, eg TAP (the Portuguese National Airline) has ordered 3 Lockheed L1011-500s with 2 options and Saudia Airlines have told Rolls Royce that they will be ordering 6 RR powered 747s. In fact Rolls Royce production is now fully committed throughout 1981. It is therefore difficult to see how the company can keep to its original sales forecast. Likewise the inventory and capital expenditure programme could not in Rolls Royce's view be reduced.

15. The updated forecasts set out above are less reliable than the full new forecast for 1980-1985 which will be available later this year. Even that, however, will be subject to a very wide uncertainty. The critical effect of exchange rates and UK and US inflation rates, which are outside the company's control, has already been described. There are, however, a number of factors within the control of management which could have major effects within a five year period, and increasingly looking ahead for a longer period as is necessary for this business. There are grounds for thinking that there may be scope for further increases in prices, there is scope for curtailing the aggressive commercial approach which has been deliberately used to increase market share, there is substantial scope for increased productivity in manufacturing, and there is scope for greater selectivity in new projects and more collaboration with other manufacturers - a course on which the existing management has already started. It is difficult to assess how far profitability can be increased by a more commercially motivated management. The policies carried out since 1971 have created a technical reputation for the RB211 and the confidence of aircraft manufacturers, particularly Boeing, and of airlines, such that the sales potential is now great, but the ability of the present leadership to control costs so as to make those sales profitable is in doubt.

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Summary

16. (1) Rolls Royce's civil business is now very heavily dependent on the RB211 family of engines;

(2) The RB211-524 is now fully established as at least a technical match for the competing US engines. The RB211-535 will not enter service until 1982, but will be available some 8-12 months before its only American competitor;

(3) The RB211 has not so far been profitable, and the prospect for its becoming so is very heavily dependent on the view taken of the exchange rate;

(4) Rolls Royce's productivity compares unfavourably with that of its US competitors, but it is very difficult to estimate the realistic prospect for improvement with improved management;

(5) Rolls Royce has been through a period of very high marketing costs in order to increase its market share. There should be scope for greatly reducing this and perhaps increasing selling prices now that the -524 is fully established, but a similar expensive marketing phase is likely to be faced for the -535;

(6) Rolls Royce has striven to compete in almost every sector of the gas turbine market. There should be substantial scope for economy and raising profitability by limiting the scope of activity.

Air Division
12 October 1979

THE RB211

1 There are a number of versions of this engine, each of which has been developed for specific applications.

RB211 -22

2. This is the original high by-pass engine of 42,000 lbs thrust developed by RR for the Lockheed L1011 Tristar. Its mounting costs caused the company's bankruptcy in 1971.

3. As part of the company rescue, the Government agreed in 1971 to finance RR in the development and production of the engine, and undertook to Lockheed to enable RR to maintain the necessary support facilities throughout the life of the engine.

4. The Government paid for virtually all the costs of development and production of the first 555 engines - the number then under contract - and in return took the receipts on the first 555 and a levy of 7% on the sales value of all engines, thereafter, (excluding spares). Any further costs eg in-service-development (ISD) were to be met by RR.

5 The net costs of development and production of the -22, ie taking into account production receipts but not levies, were estimated in 1972 at £170m at 1972 prices. The 555th engine was delivered in April 1979, and the actual net cost was £169m in actual money paid. Taking account of inflation, the actual costs were significantly less than predicted in 1971.

6 Although there will be further sales of the -22 as existing Lockheed customers expand their fleets, these are expected to be very limited, since most versions of the Tristar now require the higher thrust versions of the RB211 (see below). There will, however, be a large continuing business in the provision of spares. At the same time continuing development expenditure of the order of £5 million per year is required to improve the reliability of the engine, and maintain RR's standing with its customers.

7 The -22 is now in service with 147 aircraft in 10 airlines.

RB211 -524

8 The -524 is a higher thrust version of the RB211. It was launched in 1974 to meet Lockheed's requirements for a 48,000 lbs thrust engine (designated -524B) to improve the range and payload of the Tristar. In approving the project, Ministers were aware that there were substantial risks, that it would lead to RR demands for still higher thrust versions and that the economics of the

project were uncertain. Also in 1974, approval was given to a 50,000 lbs thrust version for the Boeing 747 (-524B2); this was to provide a basis for RR to capture a wider market, initially through British Airways. Unlike the Tristar where the RB211 was, and still is the only engine on offer, the Boeing 747 was well established with engines from both RR's main competitors, General Electric and Pratt and Whitney. As the third engine option on offer, it was recognised that RR would have a difficult competitive struggle to extend its BA bridgehead on the B747.

9 The result of the decisions on the Lockheed, and Boeing adaptations of the RB211 -524 was a Government commitment to contribute £26.3m in launch aid towards the development costs of the Lockheed version, and £8.9m towards the Boeing version, both sums representing about 50% of the estimated development cost and both subject to a cost escalation - inflation formula. It was also recognised that further thrust development of the engine might be required to meet airline needs; in particular, BA anticipated a requirement for 53,000 lbs by 1982.

10 The Government, therefore, agreed in principle to contribute up to a further £12.3m on similar terms if such a programme was necessary. As with the -22, the Government intended to recover its contribution by a 7% levy on engine sales.

RB211 -524 Development

11 Airframe manufacturers and airlines are constantly requiring higher power and greater fuel economy from their engines. RR, therefore, proposed and the previous Government approved at the beginning of the year new C and D versions of the engine at respectively 51,500 lbs and 53,000 lbs to be available in 1980 and 1981. Both GE and P & W have already engines in service at this thrust. The development programme also included a B4 version at 50,000 lbs designed to have significantly improved fuel consumption compared with earlier versions. All these versions are now in development and are contractually committed to airlines. The total cost of the development was estimated to be £110m. An even higher thrust version (the -524G at 55,000 lbs) has not yet been approved.

12 RR's financial forecast in 1978 for the future of the -524 programme as a whole, showed a DCF rate of return of 11% on the assumption of an exchange rate of $1.70:£ over the lifetime of the project - some 20 years. In assessing the programme, the Government also looked at alternative assumptions of $1.80 and $1.95 for the exchange rate and slightly fewer sales, which reduced the expected DCF return to 4% and to a small negative rate respectively. Taking account of employment and balance of payment effects, however, improved the return to the national economy by about 3.5% in each case.

C

13. Although the financial analysis showed, at best, only a modest return and considerable sensitivity to exchange rate fluctuations, it was recognised that further development of the -524 was crucial to RR's position as a civil aero-engine supplier, and in view of existing HMG commitments to the engine, the proposed development was approved. It is proceeding very satisfactorily.

14 The -524 is in service with 26 aircraft of five airlines; RR have taken orders to supply a further 73 aircraft with 13 airlines with options on a further 54 . Amongst these airlines are some of the most influential airlines in the world; the Pan Am purchase of 12 -524 powered L1011 -500s (the long range version) and Qantas' decision to buy -524D4 powered Boeing 747 after a long standing commitment to Pratt and Whitney represent major breakthroughs.

RB211 -535

15 The -535 is a derivative of the RB211 -22, with a thrust of about 37,000 lbs, and is designed for application to new medium size (140-190 seat) aircraft such as the Boeing 757.

16 Approval was given to full launch of the engine in August 1978 after careful assessment by the NEB and HMG of the technical and commercial prospects, especially bearing in mind the difficult development problems encountered on the -524.

17 The costs of development were estimated by RR at £250m (1978 prices) including a contingency of £50m. HMG, in assessing the project added, on technical advice from MOD a further £50m contingency. A technical assessment by MOD(PE) generally endorsed RR's claim that as a derivative engine the technology involved in developing the engine is of low risk. After more than a years development work both costs and development are on schedule.

18 The economic case for the -535 rested largely on the commitment from Boeing to use the -535 as the engine to be certified first on the Boeing 757 supported by initial orders for 40 aircraft from British Airways and Eastern Airlines. General Electric with a derivative engine, the CF-32 will also be certified, but some 8-12 months behind RR while Pratt and Whitney appeared unlikely to compete - a view which remains valid. The -535 is due to be certificated in the Spring of 1981.

19 On this basis RR assumed that the -535 could achieve over 40% of Boeing 757 sales estimated to be between 1000 and 1500 over the next 15 years. DOI market estimates were somewhat less optimistic by about 20 per cent due mainly to the expectation that other manufacturers would launch aircraft similar to the Boeing 757. Nevertheless they confirmed that the -535 represented the best opportunity to expand RR's share of the civil aero-engine market and secure the company's market position in the next generation of aircraft.

20. RR estimated that the discounted rate of return over the lifetime of the project was between 10.9% and 11.5%. These estimates were based on a number of assumptions of which the two most critical were, the exchange rate and engine selling price. RR assumed an exchange rate over the next twenty years of $1.70:£. At the time the estimates were prepared, this was roughly the existing exchange rate. However, it was thought prudent on Treasury advice to consider an exchange rate of $1.80:£; this reduced the DCF return to 6.1%. Allowing for the lower DOI estimates of sales and the additional development cost contingency, the rate of return was estimated to be 1.8%. Taking into account balance of payment and employment effect, the national DCF return was 3.8% at $1.80 and 6.4% at $1.70.

21 Notwithstanding the modest DCF return expected, it was considered that the -535 was essential to RR's future in the civil aero-engine business and indeed represented an opportunity to exploit the hard won and expensive position achieved by RR in the big engine league.

22 Although orders for RR powered 757s beyond those of Eastern Airlines and BA have not yet followed, Boeing remains firmly optimistic that some 1500 will be sold and foresees a possible 50% share of RR. DOI market estimates remain of the view that 1000 units can be expected, and that RR could obtain a 40% share of them although so far no competitive aircraft has been launched. The financial return will, however, depend heavily on the exchange rate prevailing.

23 The Government undertook in March this year to provide £250m of launch aid for the -524 and -535 development programmes. The £250m represents about 70% of RR's estimated development costs, but about 50% of official estimates of those costs and is in escalated money. In PES terms the launch aid amounts to £192m (1977 PES) and unlike the earlier support does not provide for the Government to pay a percentage of the actual development costs ie if RR have to spend more in real terms, this must be found from within the company's own resources. The Government's contribution would be recovered by levies if the company achieves its sales forecast and if the exchange rate over the 20 year life of the project did not average more than $2.00.

D

THE TECHNICAL COMPETITIVENESS OF THE RB211-524

1. INTRODUCTION

In MOD(PE) assessments of the RB211-524 project during its development, attention has been paid to the question of how the engine was likely to turn out relatively to its US competitors in terms of important technical aspects such as fuel consumption, weight and service reliability. The purpose of this note is to present an up-to-date comparison in the light of information now available, and to look also at how the later versions of the 524 are likely to be placed. Attention is particularly directed to the Boeing 747 application, where the three major engine manufacturers are in direct competition.

Much of the material used here has been gathered from a variety of sources by Rolls Royce, and in view of this the 'Commercial In Confidence' marking of this note deserves emphasis.

2. THE CURRENT SITUATION

2.1 Comparisons of Specific Air Range

The Specific Air Range (SAR - commonly quoted in nautical miles per gallon) is a standard measure of fuel economy at specified conditions of flight speed, altitude and aircraft weight. Thus if these three parameters are maintained constant when comparing SAR's for a given aircraft type fitted with alternative engines, the results will take account both of basic engine performance differences and of installation effects, but will not show the effect on overall fuel consumption of differences of engine weight. It is appropriate to consider this weight effect separately, at a later stage.

Boeing have carried out flight tests of the 747 aircraft enabling SAR comparisons to be made between the Pratt & Whitney, General Electric and Rolls Royce engines at Mach 0.84, 35000ft, at 630,000lb aircraft weight. These are shown in Table 1 below, taking the RB211-524B2 engine - the current standard for British Airways Boeing 747 deliveries - as the datum.

Table I

SAR Test Results - New Engines

Engine	Relative SAR, %
RR RB211-524B2	Datum
GE CF6-50E	-2.8
GE CF6-50E2	-1.3
P&W JT9D-7J	-0.9
P&W JT9D-70A	-1.7
P&W JT9D-7Q	-1.3

/An

An important point to be made concerning the above figures is that essentially new engines (lives of around 50 hours) were used for the flight tests. Differences in the performance deterioration of the different engines in long-term service operation are therefore not included; the additional effect of this factor on the comparison of engines in airline service is considered separately below.

Table I shows that when the engines are new, the current production 524B2 engine has a small measure of superiority in SAR at given aircraft weight over competing engines that are currently available. This is broadly in accordance with the expectations we expressed in our earlier assessment reports - for example, that of April 1976. As indicated in those assessments, we believe that this competitive edge derives largely from an advantage that the RB211 holds in its installation performance. Recent evidence, in the form of comparisons made by Rolls Royce of the Boeing SAR test figures with predictions based on basic engine performance data, supports this view. The short, compact, 3-shaft design of engine allows interference drag between nacelle and wing in an underwing installation to be minimised. There is also evidence that the short conical-shaped afterbody used now on RB211 engines is very efficient aerodynamically. Another, more general, factor which should favour Rolls Royce is the more integrated approach to installation design which tends to result when the engine manufacturer takes responsibility for the powerplant as awhole, and not just the flange-to-flange engine.

It is of interest to note that the JT9D-7Q, which represents an attempt by P&W to produce a generally 'cleaned-up' version of the 70A, has so far fallen short of its target. Estimates for this new variant had suggested that it would show an SAR marginally better than the 524B2

We now turn to the effect of performance deterioriation in service. The evidence here shows an appreciable spread, coming as it does from a variety of airlines with different flight operations, maintenance practices, etc. However, the overall picture in both 22B and 524 versions, shows to advantage relative to the American engines. For example, available data from British Airways and Quantas indicates that JT9D-7 engines have suffered sfc increases in the region of 4 to 5% in the course of several thousand hours operation, while RB211-524 experience to date suggests a figure of 1 to 2%. Taking a conservative estimate in the light of current evidence, we propose to use here a differential of 2% in favour of the RB211-524 to compare SAR's for typical airline operations when the engines are no longer new. Table II therefore shows such a comparison, derived from Table I simply by increasing the SAR differences relative to the 524B2 by 2%.

/Table II

Table II

SAR Comparison Allowing for Deterioration

Engine	Relative SAR, %
211-524B2	Datum
CF6-50E	-4.8
CF6-50E2	-3.3
JT9D-7J	-2.9
JT9D-70A	-3.7
JT9D-7Q	-3.3

It is appropriate to note here that both Pratt & Whitney and General Electric recognise that their large turbofans compare poorly with previous generations of civil jet engines in terms of performance deterioration rates, and are making strenuous efforts to bring about improvements in later versions.

2.2 Weight and Thrust

It is in these two areas that the RB211 compares less favourably with its rivals. It is heavier than the US engines, and up to now has lagged behind in terms of maximum rated thrust levels. Either or both of these factors can be significant depending on the aircraft duty pattern, and they operate additively to produce important penalties in range/payload capability under certain limiting airfield conditions. Although such conditions (high temperature, high altitude and/or relatively short runway) may apply for only a small minority of operations, their demands may exert a crucial influence on an airline's choice of equipment.

Quantifying first the more straightforward effects of a powerplant weight penalty on fuel consumption, an approximate exchange rate applicable to Boeing 747 operation is that 10,000lb increase of shipset weight is equivalent to 1.6% decrease in cruise SAR, as a consequence of the higher cruise thrust requirement. We can therefore now take the SAR figures of Tables I and II (which, as indicated earlier, are for constant weight) and adjust them approximately to allow for the differences in shipset powerplant weight.

Table III

SAR Comparisons Adjusted for Powerplant Weight Differences

Engine	Relative Operational Empty Weight(OEW), lb	Relative SAR, % New Engines (from Table I)	Relative SAR, % Deteriorated Engines (from Table II)
211-524B2	Datum*	Datum	Datum
CF6-50E	-6130	- 1.8	- 3.8
CF6-50E2	-5860	- 0.4	- 2.4
JT9D-7J	-11820	+ 1.0	- 1.0
JT9D-70A	-2030	- 1.4	- 3.4
JT9D-7Q	-8730	+ 0.1	- 1.9

* Total 'below pylon' shipset weight for 211-524B2 is 55600lb.

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It should be emphasised that these comparisons apply to cruise conditions. The total quantity of fuel consumed in a mission is also affected by other factors - e.g. climb rating, sfc's during descent and hold, etc. Nevertheless, the above table gives a rough impression of the relative fuel consumption for typical operations.

Where the take-off weight (TOW) is not restricted by maximum aircraft design weight or airfield limitations, an engine type requiring extra fuel for a given operation simply entails an increase in TOW. The penalty associated with the less economical engine then appears essentially as an increased fuel cost. Where the take-off is limiting, however, the situation becomes more complex. Provided the aircraft is not on its maximum design weight limit, the TOW allowable will depend on the available take-off thrust. The payload that can be carried is then determined by the combination of engine weight, fuel needed for the mission, and engine thrust rating. A high engine thrust rating, combined with an advantage in engine weight, can outweigh a disadvantage in fuel economy, enabling a greater payload to be taken. This is where some of the US engines currently score against the RB211-524B2 Although needing more fuel for the mission, their higher thrust/lower engine weight combination gives a better payload on these take-off limited missions. For a Boeing 747 operating from an 11,000ft runway at sea level, 90°F, 1% increase in take-off thrust will allow 4000lb increase in TOW. Thus the higher thrust versions of the American engines allow considerably greater TOW's than the 524B2. This, taken in conjunction with their lower weights, more than offsets their extra fuel requirement. Table IV carries the comparison through to show the approximate relative payloads for take-off for a 5000 n.m. stage at the airfield conditions quoted above.

Table IV

Relative Payloads, 5000 n.m., 11,000ft runway, sea level, 90°F, new engine

Engine	Take-off thrust rating, lb	Relative Payload, lb
211-524B2	50,000	Datum(= 93,900lb)
CF6-50E	52,500	+ 13,700
CF6-50E2	52,500	+ 17,100
JT9D-7J	50,000	- 3,700
JT9D-70A	53,000	+ 14,700
JT9D-7Q	53,000	+ 22,700

In the context of such operations as that considered above, the value of the imminent clearance of the 524C2 rating at 51,500lb thrust is very apparent. This will improve the relative position of the 524 in the above table by 7200lb. Comments are made later on the further developments in thrust which are in hand for the RB211 and the American engines.

/2.3

2.3 Other Factors

The technical competitiveness of the RB211-524 is affected by a number of factors additional to those dealt with already. Environmental characteristics being roughly similar between the competing engines, the significant remaining differences fall largely under the headings of reliability and of robustness in service. The reliability of the RB211-524, as measured by the standard indices of removal rates, in-flight shutdown rates and aborted take-off rates is not yet as good as some of its competitors, and intensive efforts are being made to improve the situation. On the other hand, the engine has, like the RB211-22B, a good reputation for robustness in terms of resistance to foreign object damage, containment characteristics, etc. These qualities, taken together with the lesser performance deterioration in service discussed earlier, reflect the good mechanical strength and rigidity of the engine. They can be regarded as representing the beneficial side of the greater weight of the RB211 relative to its competitors.

3. THE 1982/84 SITUATION

During the period 1982 to 1984, further versions of the engines, currently under development by Rolls Royce and by the US manufacturers, will enter service.

In the context of the Boeing 747 the significant new versions of the RB211-524 in this timescale are the 524C2 and the 524D4. The 524C2, already referred to in Section 2.2, is essentially an uprating of the 524B2 to give 51500lb take-off thrust with an unchanged cruise fuel consumption. Type testing is currently in progress and the engine is due for delivery later this year. The 524D4 involves much more extensive change, including a new higher performance fan and a new IP/LP turbine module, to give 53000lb take-off thrust together with cruise s.f.c. 4.8% better than the 524B2. Largely through the introduction of a lighter thrust reverser system, total ship set powerplant weight for a Boeing 747 is estimated to be 960lb less than for the 524B2. The D4 engine is due for certification in Spring 1981, with entry to service in 1982.

P & W and GE are also developing their engines to reduce s.f.c. and weight, and to increase take-off thrust. The relevant GE engines are the CF6-80 series, based on the 50 series but involving major changes including extensive structural and aerodynamic redesign in the turbine area. These engines will thus be both shorter and substantially lighter than the 50 series. The 80B is aimed at a take-off thrust of 54000lb, and a cruise s.f.c. 2% better than the 50E2. Certification is to be in Autumn 1981 with production deliveries in early 1982. A later version, the 80C, has targets of 56000lb take-off thrust and a further 2% s.f.c. improvement; the certification date is not at present known, but we understand that entry to service is planned for late 1983. Pratt & Whitney developments for the Boeing 747

/are

are the JT9D-7R4G and -7R4H. Take-off thrust targets are 54000lb for the 7R4G, and 56000lb for the 7R4H. Both engines are aimed at a cruise s.f.c. improvement relative to the JT9D-7Q brochure level of 1%, which is equivalent to 2.5% improvement over the level actually achieved on the 7Q up to now as implied by the Boeing SAR measurements quoted in Table I. Certification dates for these P & W engines are understood to be July 1981 for the7R4G and January 1982 for the 7R4H.

It will be noted that the 211-524D4 engine is due to enter service in the early part of this 1982/84 period. Rolls Royce have expressed the belief that this will give them a useful marketing advantage over the later American engines.

Estimates of the relative capability of 747 aircraft powered by these improved engines are made below, using the approach of Section 2 and now taking the RB211-524D4 as the datum. In making these estimates, the assumption is made that the figures quoted above, which apply of course to the engines when new, are achieved. Current development progress on the RB211 is encouraging, and on the evidence available so far we believe the 524D4 targets should be reached or closely approached. Very little is known of how the Americans are faring. Doubtless they have their share of development problems, but it would be unwise to assume at this stage that their targets will not finally be met. Regarding the question of performance deterioration in service, it has already been noted that it is a major objective of both US firms to reduce their deterioration rate. Nevertheless, this is easier said than done and Rolls Royce may well continue to enjoy a competitive edge in this area for some time to come. We therefore assign an advantage of 1% to Rolls Royce in the comparisons below for deterioriated engines - i.e. half the advantage used in the comparisons of Section 2.

3.1 Specific Air Range

Estimates of the relative SAR position for the future engine versions are presented below. These have been derived by applying the target s.f.c. improvements quoted above to the relativities established by Boeing flight test on the current engines, given in Table I. An additional adjustment made in the case of the CF6-80 engines is a further credit of 1% in recognition of the prospect that the shortening of these engines relative to the CF6-50 series may give some benefit in reduced installation drag.

Table V

Estimates of Relative SAR, 1982/84

Engine	Relative SAR, % New Engines	Relative SAR, % Deterioriated Engines
211-524D4	Datum	Datum
CF6-80B	- 3.1	- 4.1
CF6-80C	- 1.1	- 2.1
JT9D-7R 4G) JT9D-7R 4H)	- 3.6	- 4.6

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The above estimates, like those of Tables I and II, are for a given aircraft cruise weight.

3.2 Effects of Weight and Thrust

All three manufacturers are seeking substantial weight reductions in their development programmes. The prospect is therefore that the US engines will continue to hold a significant advantage relative to the RB211 in this respect. Table VI shows the differences of quoted shipset weights and the estimated relative SAR position after allowing for those differences.

Table VI

SAR Comparisons Adjusted for Powerplant Weight Differences

Engine	Relative shipset powerplant weight, lb.	Relative SAR, % New Engines (from Table V)	Relative SAR, % Deterioriated Engines (from Table V)
211-524D4	Datum	Datum	Datum
CF6-80B	- 8000	- 1.6	- 2.8
CF6-80C	- 6360	- 0.1	- 1.1
JT9D-7R 4G	- 8810	- 2.2	- 3.2
JT9D-7R 4H	- 8490	- 2.3	- 3.3

The estimates of Tables V and VI suggest that the RB211 will continue to hold some advantage in fuel consumption over the US engines in future Boeing 747 applications, though it may be closely challenged by the CF6-80C. It will be appreciated that the above estimates must involve significant uncertainty at this stage. The actual technical achievements of the three competing manufacturers over the next few years remain to be seen. However, it is relevant to state here our view that the degree of risk associated with the US engine developments is at least as great as that for the RB211-524 D4.

It is also appropriate to mention an important indication from the airline world of confidence in the RB211-524 D4 engine, in the form of a decision by Quantas to change over from P & W to RR engines for all its future Boeing 747's. It is unusual for an operator to change to a different engine supplier within a fleet of a given aircraft type. The fact that Quantas, an experienced long-range international airline which pays considerable attention to fuel consumption and technical performance generally, has made this move, can be regarded as a heartening sign of the potential future for the RB211-524 D4.

We now turn again to the question of thrust capability, whose importance in regard to payload under limiting take-off conditions was outlined in Section 2.2. With the US manufacturers raising the thrust of their engines still further, the RB211-524 D4 at 53000lb will still be at a disadvantage relative to the competition.

/This

This can be illustrated by again considering payloads for the 5000 n.m. operation used in the comparison of current engines in Table IV.

Table VII

Relative Payloads, 5000 n.m., 11,000ft runway, sea level, 90°F, new engines

Engine	Take-off thrust rating, lb	Relative Payload, lb
211-524D4	53,000	Datum
CF6-80B	54,000	+ 2500
CF6-80C	56,000	+ 9200
JT9D-7R 4G	54,000	+ 2700
JT9D-7R 4H	56,000	+ 6100

These relative payloads are the resultants of the thrust, weight and fuel consumption differences between the engines. The comparison indicates a distinct advantage in revenue carrying capability in this type of operation if a thrust in the region of 56,000lb is available.

It is also relevant to look at the benefit of increased thrust in terms of the maximum take-off weight that can be used. For the airfield conditions taken for Table VII, a 53,000lb thrust rating will just allow take-off at the current Boeing 747 maximum, namely 820,000lb. We understand that a version of the aircraft with a TOW of 833,000lb is now the subject of negotiation with airlines, and that still further increases are under consideration. Clearly, greater thrust levels than 53,000lb are needed to exploit such aircraft fully.

We believe that the question of how far to take the RB211, in terms of thrust, calls for further appraisal. The extent of its commercial disadvantage relative to the US engines if not developed beyond the 524D4 is not easy to assess, depending as it does upon the evolving needs of the Boeing 747. Nevertheless, the comparisons outlined above suggest that a significant incentive is emerging to move towards something like the 524G version, projected by Rolls Royce to achieve 55,000 lb within the existing powerplant nacelle size. The 524G design should be reviewed in the light of experience gained since it was schemed, and the possible attraction of going to some intermediate stage which would require a lower investment deserves study. An important element of any uprating would of course be the hollow titanium fan, where Rolls Royce appear to have a technical lead over the Americans and which offers benefits in both weight and performance.

3.3 Other Factors

Mention was made under this heading in Section 2.3 of the good reputation that the RB211 currently enjoys for resistance to foreign object damage, and general mechanical robustness. As these attributes are closely connected with the overall mechanical design of the engine, we believe there is a good chance that future RB211 versions will continue to show some advantage in this area over their US rivals

4. CONCLUSIONS

(a) At present the RB211-524 shows a small but useful advantage in fuel consumption over its competitors in Boeing 747 applications. The prospect is that this will still be the case when developed versions of all the engines have entered service in 1982/84.

(b) While this advantage in fuel consumption is an asset whose value will increase if fuel prices continue to rise, it can be counterbalanced in the marketplace by the combination of higher engine weight and lower take-off thrust which limits the payload of RB211-powered 747's under certain critical airfield conditions.

(c) In view of these payload limitations, the case for proceeding with further development of the RB211-524 series to thrust ratings higher than 53,000lb requires consideration. This assessment is not easy, and depends on the predicted evolution of the Boeing 747 aircraft and its pattern of usage.

(d) Increasing take-off and climb thrust ratings is likely to be a more fruitful path of long-term development than attempting major weight reduction on the basic engine. The RB211 has a good reputation for mechanical robustness and this asset should not be hazarded.

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ROLLS ROYCE - PRESENTATION TO THE PRIME MINISTER

16 OCTOBER 1979

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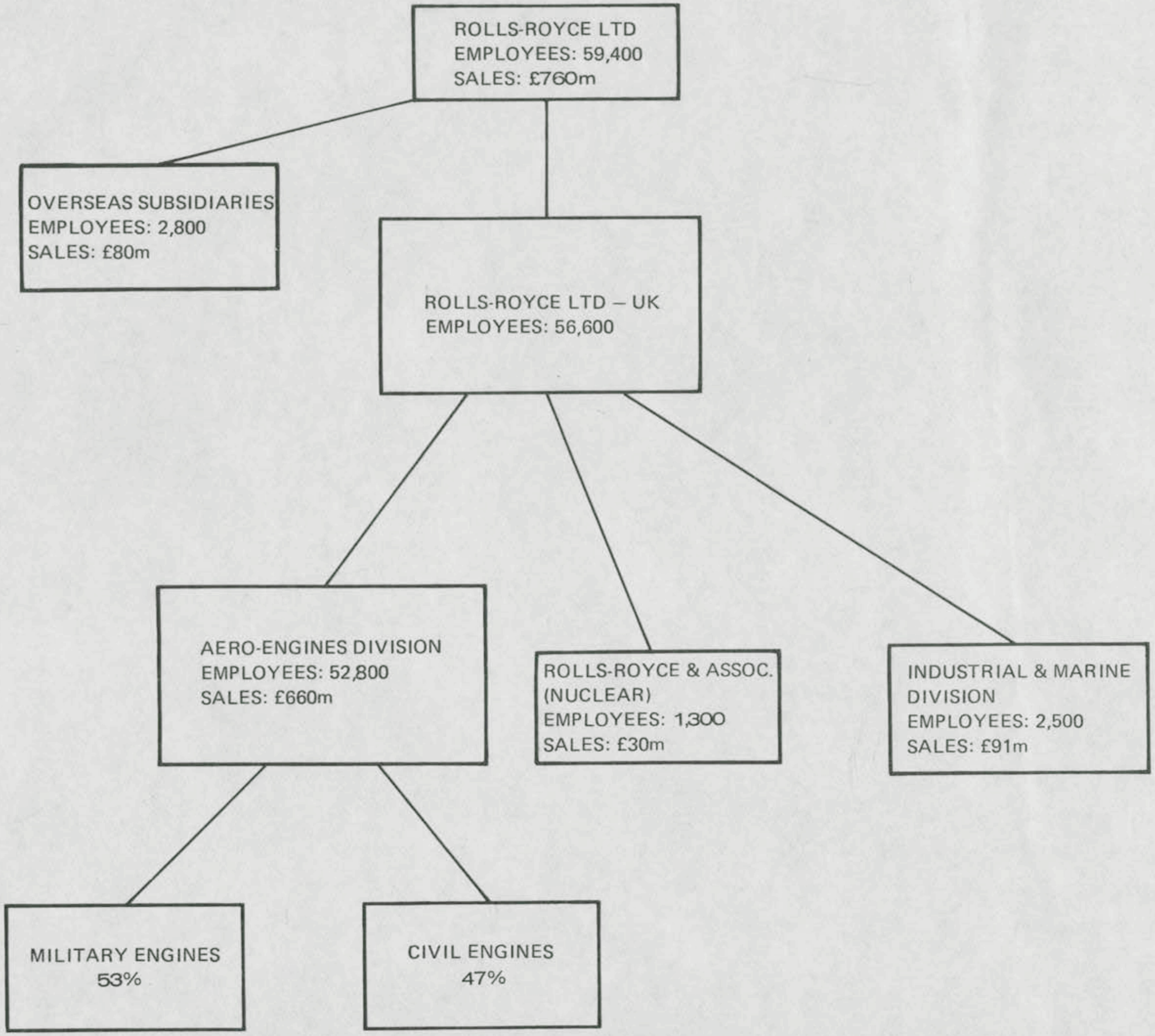
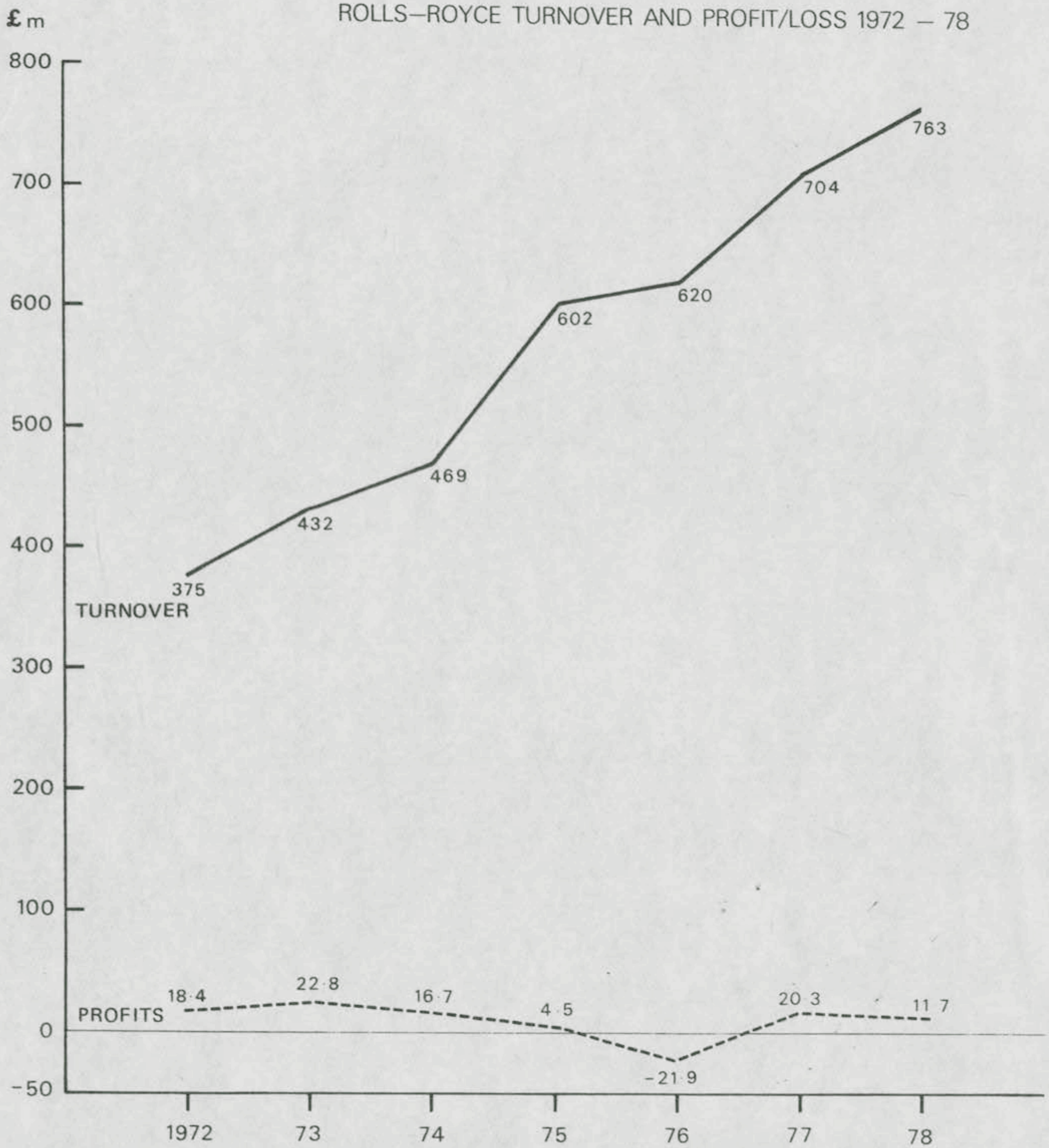
STRUCTURE OF ROLLS ROYCE

Fig. 1



ROLLS–ROYCE TURNOVER AND PROFIT/LOSS 1972 – 78

Fig. 2



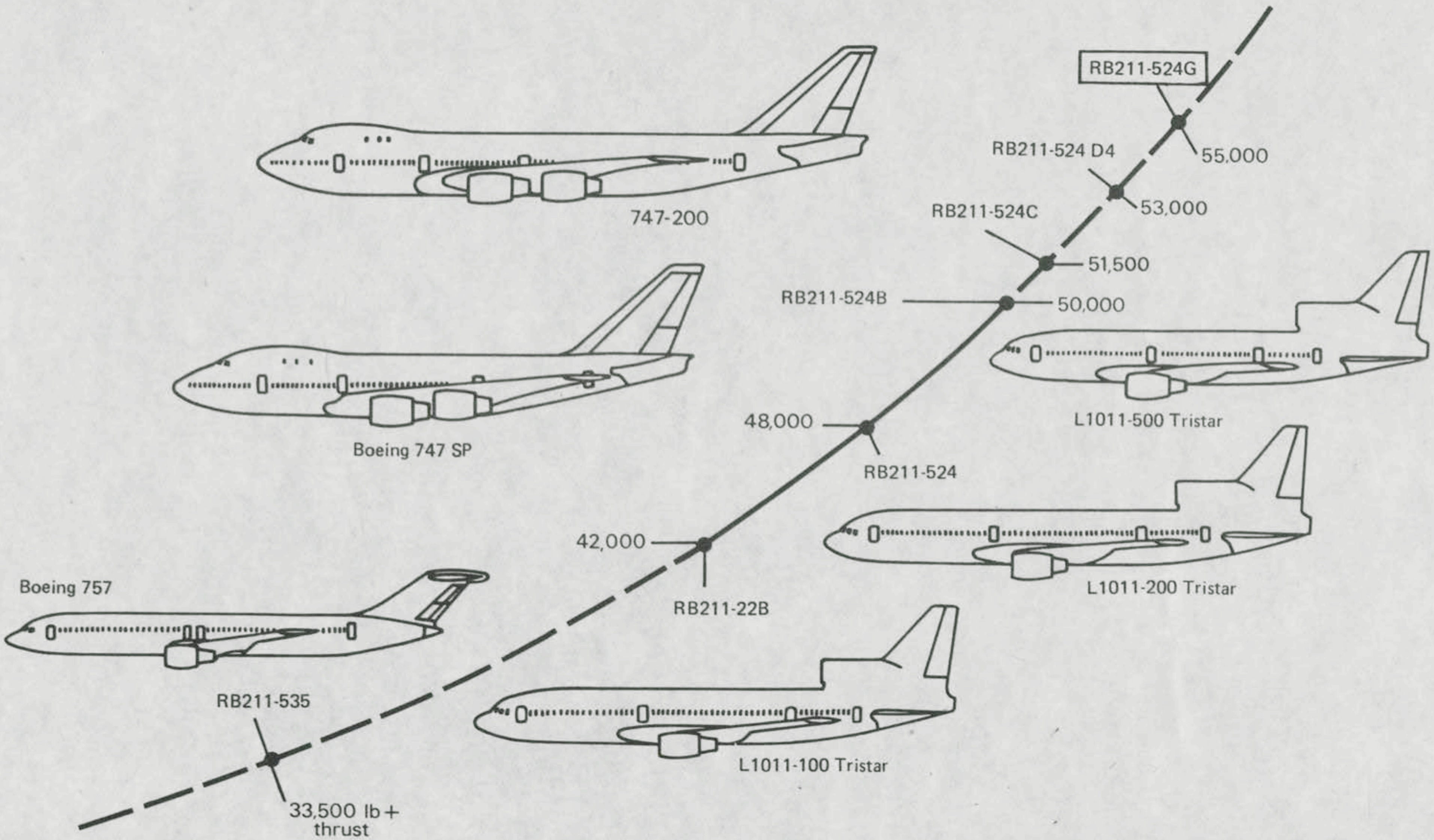
ROLLS-ROYCE - RANGE OF ENGINES

Fig. 3A

		SERVICE ENTRY	MAIN AIRCRAFT APPLICATIONS	1978 % OF AERO-ENGINE SALES
RB211	-22	1972	TRI-STAR	9
	-524	1977	TRI-STAR/B747	12
	-535	1981	B757	UNDER DEVELOPMENT
SPEY		1964	BAC 1-11/TRIDENT F28/PHANTOM	17
RB199		1979	TORNADO	5
ADOUR		1972	JAGUAR/HAWK	5
PEGASUS		1969	HARRIER/AV8A	4
GEM		1976	LYNX(HELICOPTER)	3
OTHER (Including):				
DART	Including a high proportion of spares	1953		45
VIPER		1953		
OLYMPUS		1956		
TYNE		1960		
AVON		1951		

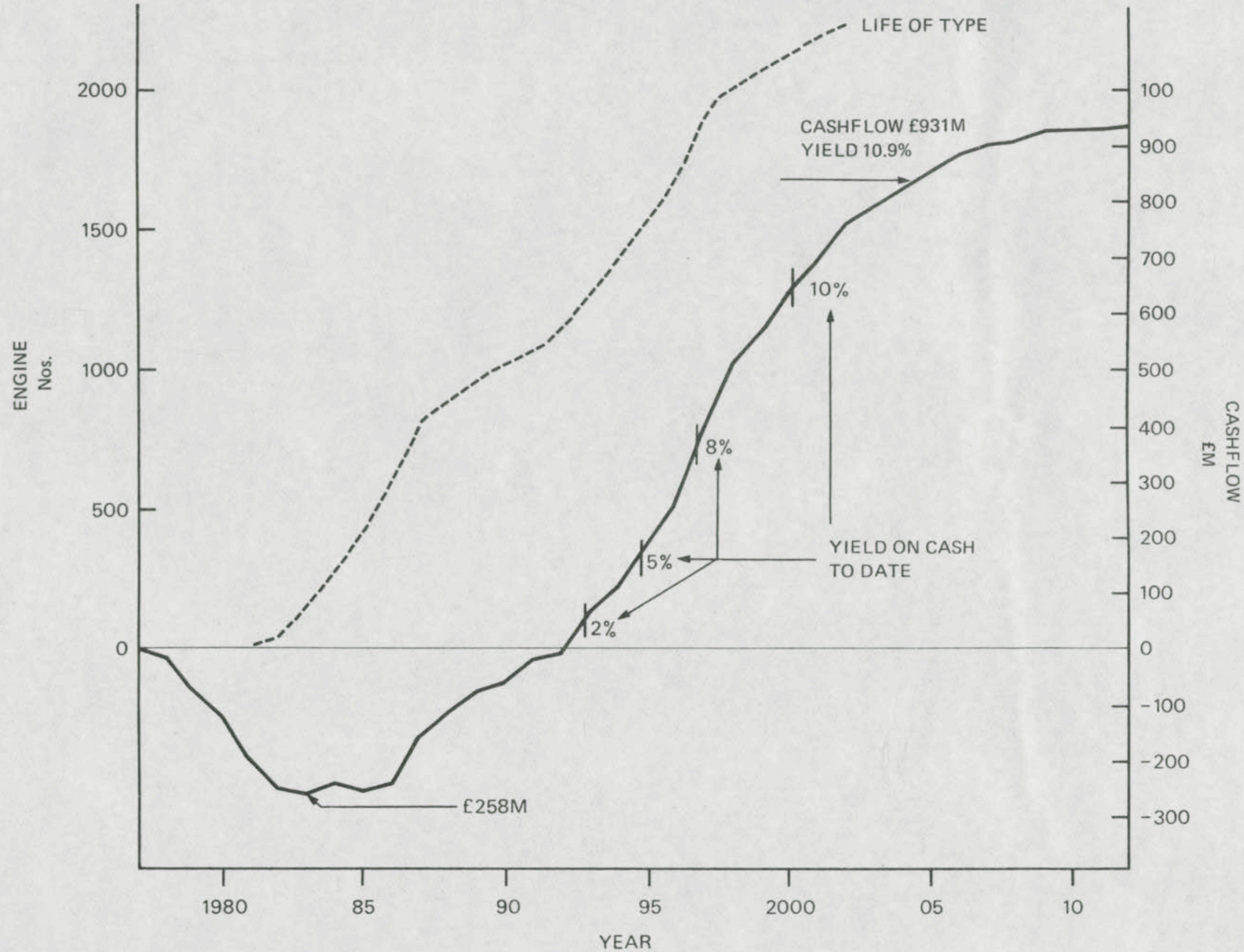
RB 211 FAMILY

Fig. 3B



RB 211 – 535 IN B757 : PROJECT CASHFLOW

Fig. 4



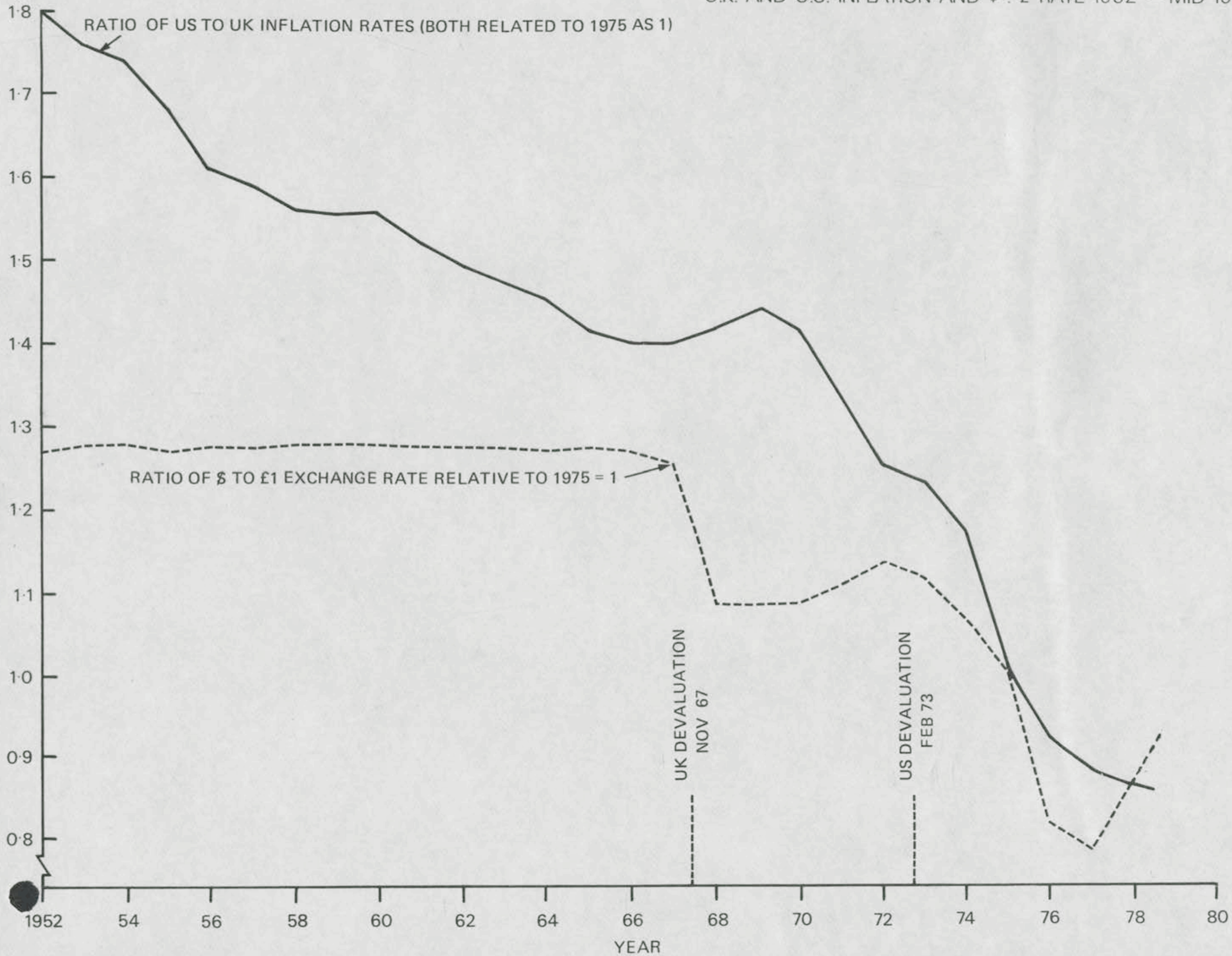
EFFECT OF EXCHANGE RATE ON PROFITS/LOSSES

Fig. 5

		$1.80	$2.10
			(£ Millions)
1979	PROFITS / (LOSSES)	(9)	(39)
1983	PROFITS / (LOSSES)	85	(59)

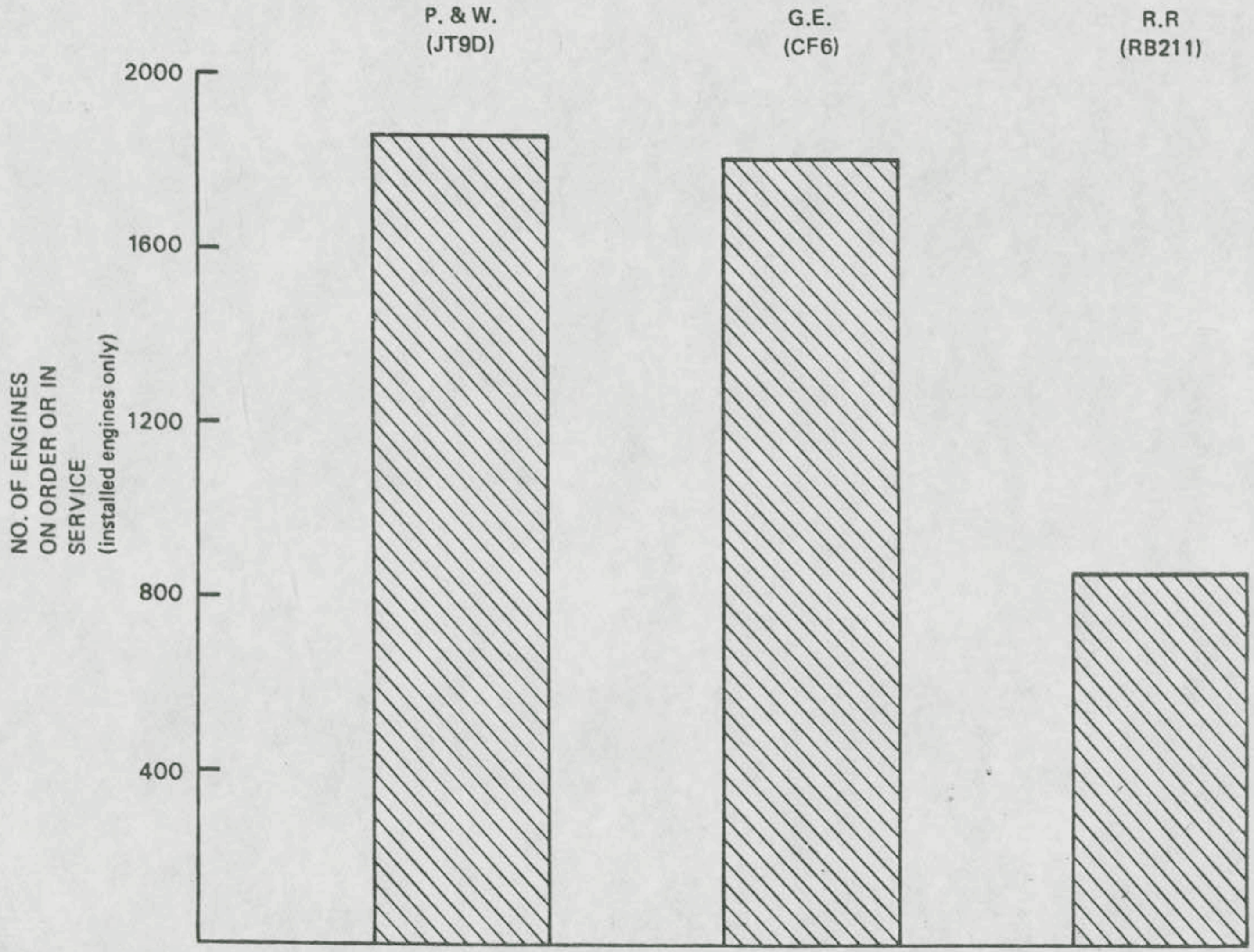
IN 1983 EVERY ONE CENT VARIATION IN THE STERLING/DOLLAR EXCHANGE RATE AFFECTS ROLLS-ROYCE'S CASH FLOW AND PROFITS BY £4.8m.

U.K. AND U.S. INFLATION AND $: £ RATE 1952 – MID 1979 Fig. 6

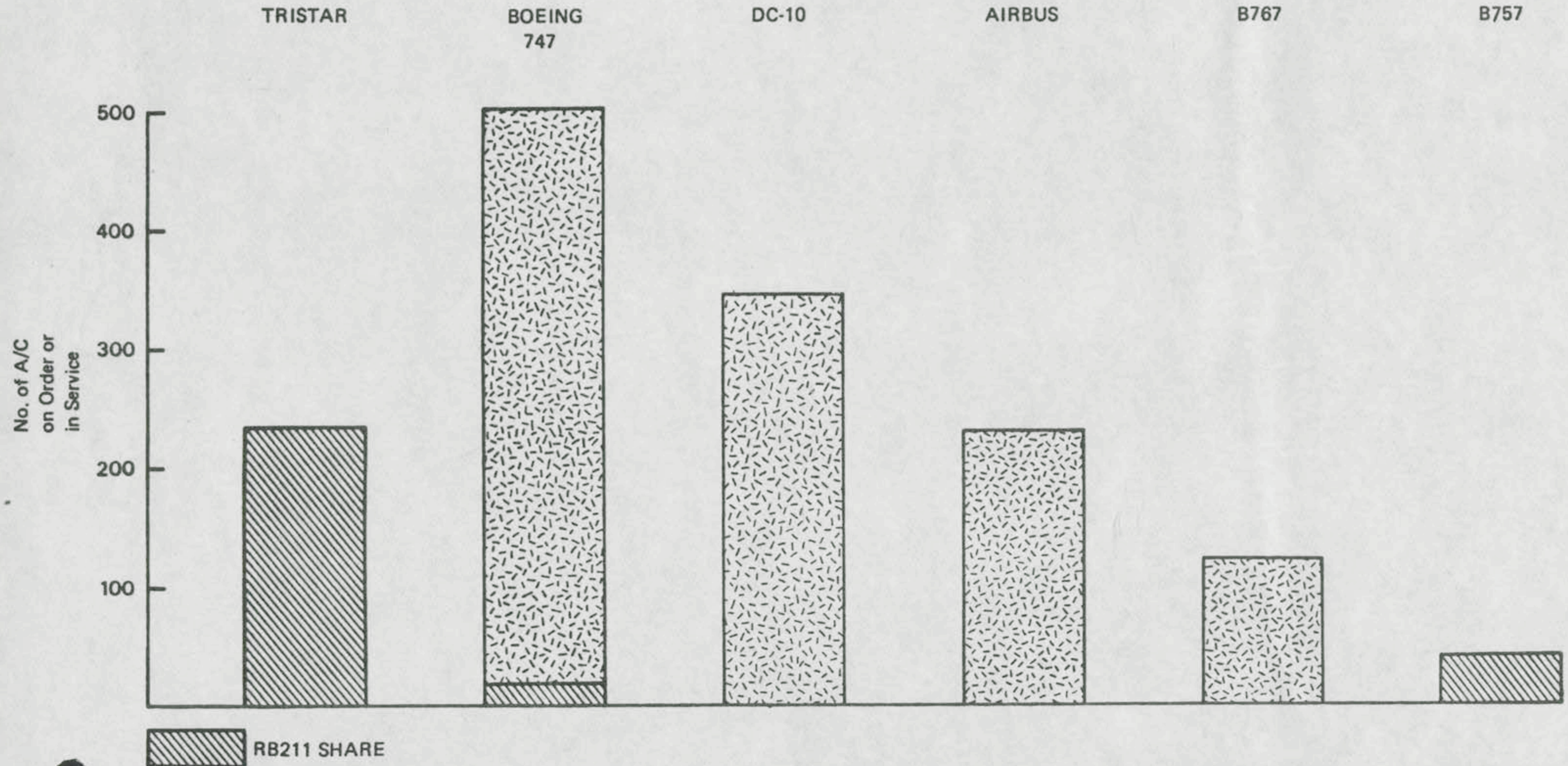


MARKET SHARE OF ROLLS–ROYCE AND COMPETITORS IN BIG ENGINES

Fig. 7



AIRCRAFT SALES AND RB 211 SHARE



B

Fig. 9A

CHANGES IN ROLLS-ROYCE FORECASTS OF CASH FLOW AND PROFITS

(£ Millions)

CASH FLOW	1979	1980	1981	1982	1983	1979/83 TOTAL	1979/83 TOTAL (NO WAIVER)
DECEMBER 78	(51)	(34)	(10)	(18)	16	(97)	(126)
AUGUST 79	(134)	(209)	(188)	(152)	(53)	(736)	(765)
DIFFERENCE	(83)	(175)	(178)	(134)	(69)	(639)	(639)

PROFIT (PRE-TAX)	1979	1980	1981	1982	1983	1979/83 TOTAL	1979/83 TOTAL (NO WAIVER)
DECEMBER 78	21	33	44	36	76	210	181
AUGUST 79	(34)	(45)	(4)	66	66	49	20
DIFFERENCE	(55)	(78)	(48)	30	(10)	(161)	(161)

LATEST ROLLS–ROYCE FORECASTS 1979 – 83

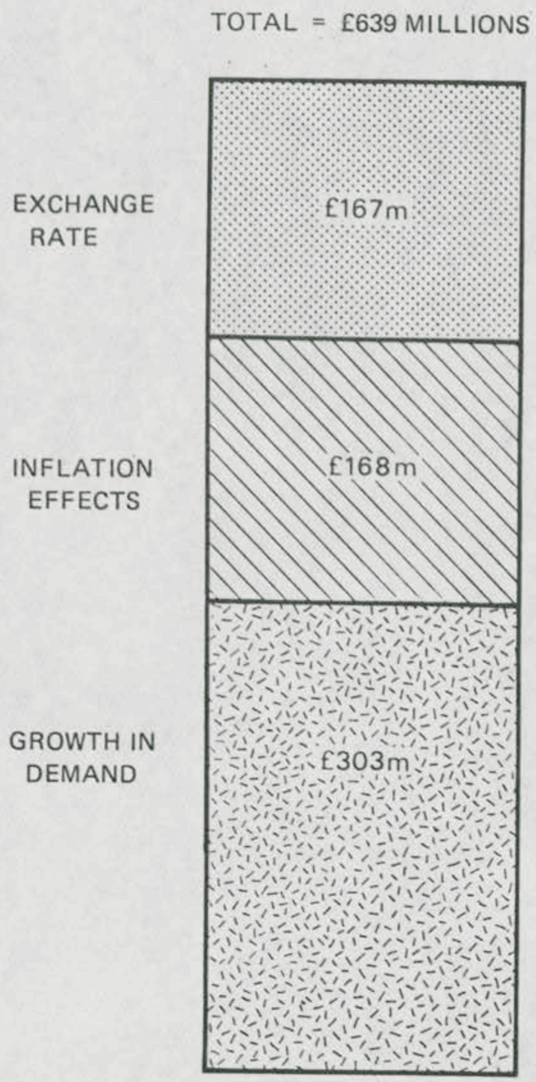
Fig. 9B

(£ Millions)

CASH FLOW	1979	1980	1981	1982	1983	TOTAL
OPERATING PROFIT & DEPRECIATION	49	75	68	122	220	534
LAUNCH AID	69	54	72	43	12	250
PV R & D	(127)	(124)	(112)	(106)	(98)	(567)
GROWTH IN INVENTORIES	(110)	(175)	(116)	(116)	(144)	(661)
CAPITAL PROGRAMME	(44)	(48)	(81)	(83)	(79)	(335)
INTEREST	(12)	(16)	(27)	(30)	(30)	(115)
OTHER	36	18	2	12	61	129
TOTAL	(139)	(216)	(194)	(158)	(58)	(765)
PROFIT BEFORE TAX	(39)	(52)	(10)	60	61	20

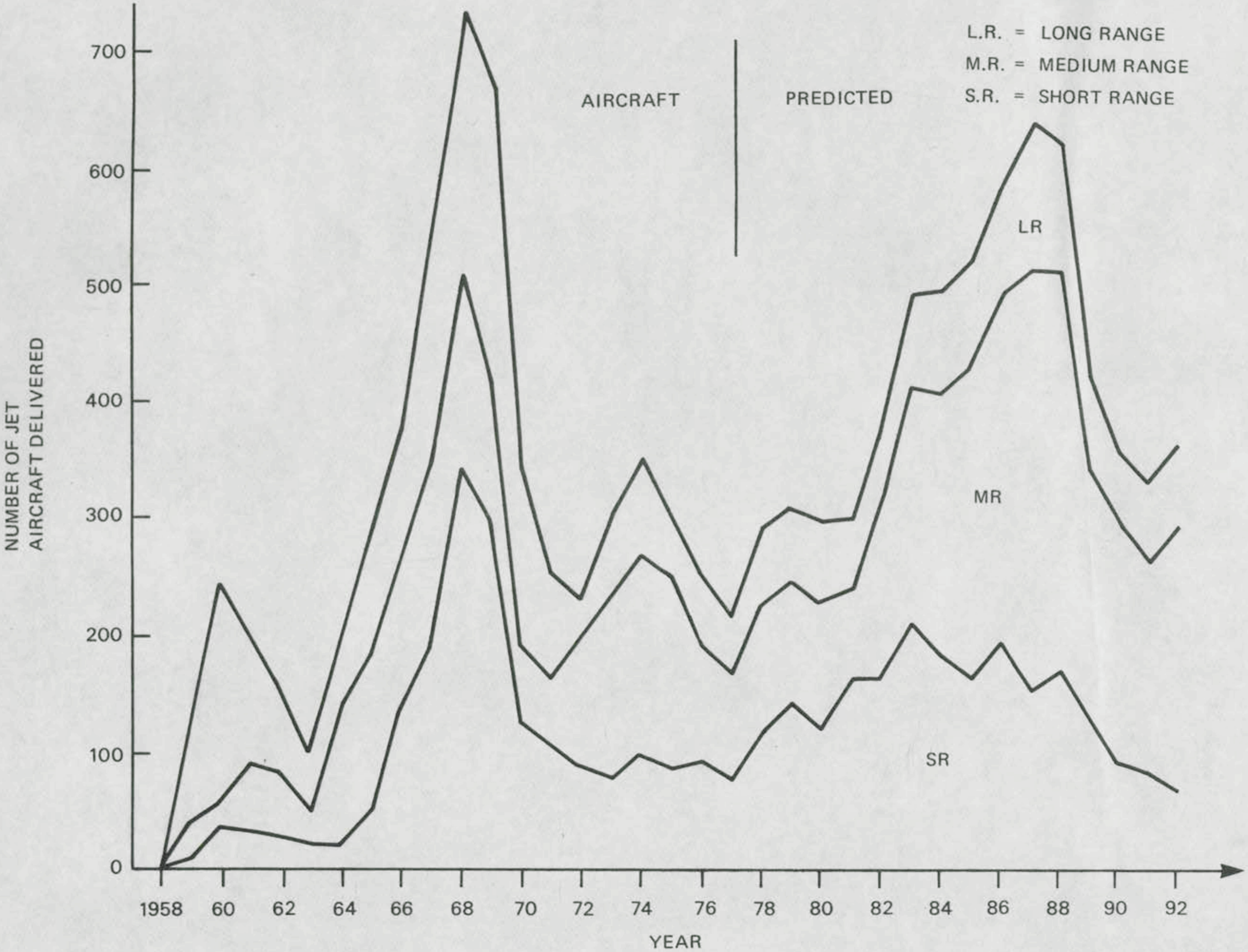
CAUSES OF INCREASED CASH REQUIREMENTS IN UP–DATED FORECAST

Fig. 9C



JET AIRCRAFT DELIVERIES BY YEAR

Fig. 10



THE STRATEGIC ALTERNATIVES

Fig. 11

IMMEDIATE WITHDRAWAL FROM RB211

PROGRESSIVE WITHDRAWAL

NO CHANGE

NEW MANAGEMENT AND NEW POLICY DIRECTIVES