TSR.2

PROJECT MANAGEMENT ASSIGNMENT

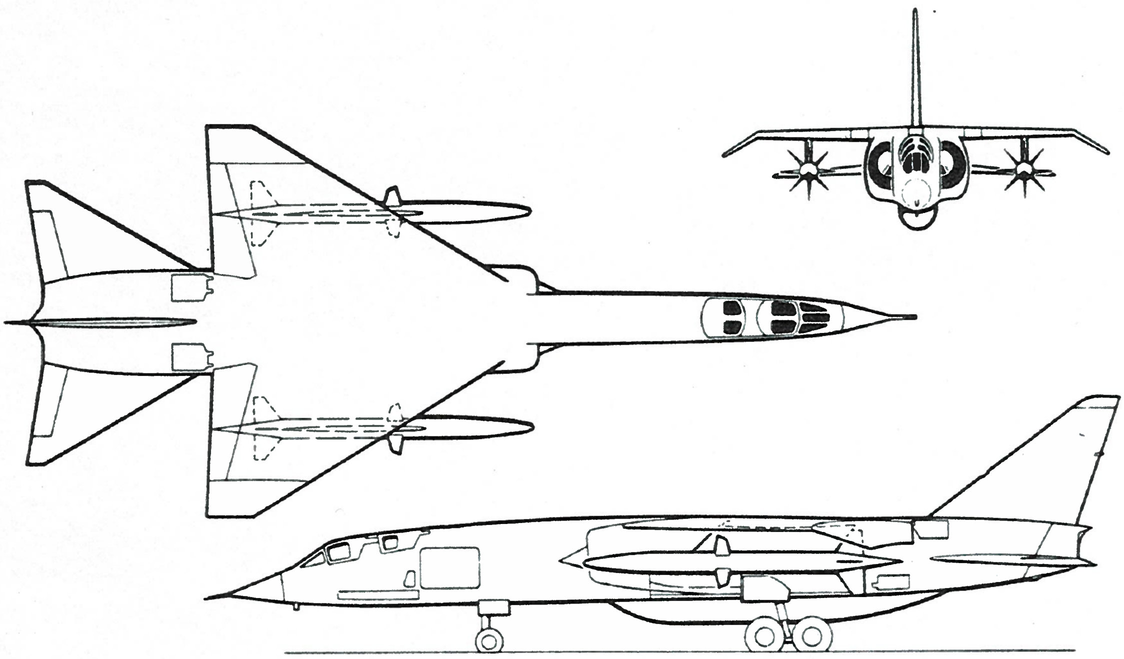

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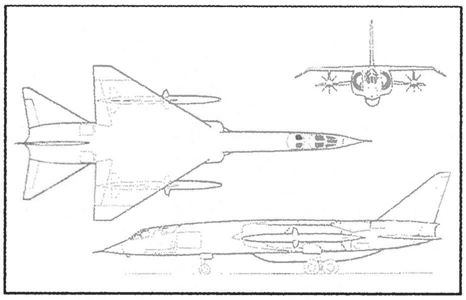
TABLE OF CONTENTS

1. Introduction

In 1955 the RAF Operational requirements Branch began to consider a possible successor to the Camberra bomber. The advent of supersonic fighters and surface-to-air guided weapons made a high level bomber vulnerable, unless much greater speed could be attained and stand-off weapons provided. The alternative was to take the aircraft down to very low levels, were radar and guided missiles were less efficient and fighters had difficulty in finding their targets. In 1957, the government issued a Defence White Paper detailing that the future of the RAF lay in unmanned aircraft and missiles. Hence, few funds were to be provided for manned aircraft development projects.

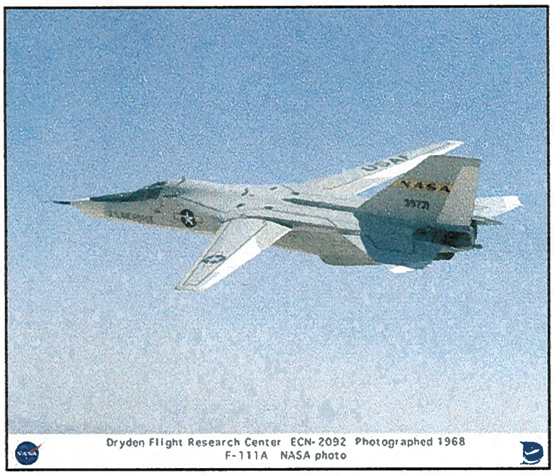
In September 1957 General Operating Requirement (GOR) 339 was issued, calling for a new bomber for the Royal Air Force. Proposals were submitted by Avro, Blackburn, Bristol, Fairey, English Electric, Handley Page, de Havilland, Shorts Brothers, and Vickers. GOR.339 was later reissued as OR.343 based on the submissions of Vickers and English Electric. OR.343 called for a aeroplane that would do virtually everything in all weathers from long range nuclear deterrent strike, though all phases of reconnaissance, down to battlefield support, with a performance in excess of the most advanced jet interceptor (the Lightning) then on order for the Fighter Command.



On January 1 1959, the government announced the award of a contract to Vickers-Armstrong and English Electric for a new light bomber to be known as the TSR.2. (*Tactical Support and Reconnaissance* and later *Tactical Strike and Reconnaissance*). This contract was based on the condition that the companies would merge, through a government drive to consolidate the aeronautics industry. Hence, Vickers and English Electric began the arduous task of getting together as the British Aircraft Corporation (BAC), while also creating joint team to define the basic TSR.2 design.

From the moment development began, the costs of the project escalated at an alarming rate due to a number of factors. The requirements in OR 343 were extremely demanding (the current Tornado is still unable to perform many of the tasks written into OR 343) and very rigid. The project was also badly managed. However the project paid somewhat a high price for being run in the midst of the aeronautical industry's consolidation. It was also attacked by some who believed in acquiring a theoretically cheaper aircraft being developed by the USA, the F-111. From the political point of view, the TSR.2 project was born in the face off strong opposition from of the Royal Navy, the chief of the Defence Staff (Mountbatten) and his Chief Scientific Adviser (Zuckerman), and the Treasury. They had wanted to RAF to adopt a version of an aircraft being developed for the Navy.

On 6 April 1965, the Prime Minister, Harold Wilson, announced the cancellation of the TSR.2 in the House of Commons. The Secretary of State for Defence, Denis Healey, explained that the government had had to cancel the project because the TSR.2 program was becoming an "intolerable burden". The total cost of 750 millions pounds amounted to 5 million per aircraft, assuming a production of 150 aircraft. He went on to declare that such expenditure could not be cost-effective. He added that even the best efforts of BAC and the government could not provide any "assurance that the Government's ultimate financial responsibility would be limited". At the end of March 1965 the Defence and Overseas Policy Committee reviewed its position. The final decision to cancel the project was made during the course of two Cabinet meetings on the first of April. An option for the F-111A was secured before announcing the cancellation, because the government did not want to be "in the hands of the Americans". The UK did not yet have to commit itself to actually buying the F-111. In January 1968 the UK cancelled its option on the F-111. The aircraft had fallen below the specifications, was seriously delayed and had become even more expensive than the TSR.2. Although the USN abandoned its F-111B carrier-borne fighter version as totally unsuitable, the F-111 was not cancelled. Later the F-111 would prove that it was an effective strike aircraft.



It was finally decided to buy the F-4 Phantom for the tactical attack role, and the Buccaneer as long-range strike aircraft. In 1969 the RAF received the first example of the aircraft it had rejected twelve years earlier. In July 1970 No.12 squadron became the first operational Buccaneer unit of the RAF.

2. Time cycle

(See appendix B)

It was difficult to make a good time line as much of the data collected was insufficiently detailed or contradicted with other information. Also, this project was characterised by complexity in the decision making and a continuous change of specification. Every time the specification was changed, the time cycle changed. In the Gantt graph in appendix B it can be seen how the project change its specification several times, which is why there are several repetitions of the definition phase. The TSR.2 project included an extensive use of fast tracking. The electronics , the engines, the landing gear and several other components were developed simultaneously. Often, the lack of communication among the different parts of the project led to serious problems in fitting everything together. An interesting fact is that the engine didn't actually fit in the aircraft when it was installed for the first time and several modifications had to be made. For this reason, and also due to the several changes in the specification, it is hard to say if the fast tracking helped reduce the cost or actually increased it.

3. Roles and Responsibilities of Client and the Project Manager

The roles and responsibilities of the client and the project manager were highly influenced by the *Report of the Committee on the Management and Control of Research and Development.* This was a committee was formed in 1958 to study the management techniques (and how to improve them) of government bodies involved in any kind of research and development. Sir Claud Gibb had been appointed chairman but was replaced in 1959 by Sir Solly Zuckerman shortly after his death. Sir George Edwards, Managing Director of BAC, was also a member of the board. The committee's work was done in the light of a recent cancellation of the Swift aircraft project, which had been a disaster both financially and on the management side. The committee drew up five clearly defined stages for all defence projects to pass through. The TSR.2 project was the first to follow this procedure.

The first step consists of having an operational requirement, defined by the armed forces themselves. This demand is guided by the threats the armed forces face. From this, the military passes the requirement on to the MoA, which in turn conducts a feasibility study. At this stage, all responsibility lies with the MoA and industry is not represented. A very broad technical study and some cost estimation is done. This is step two. If the project is realistic, a formal project study is carried out. This brings us to step three. The concept is now examined in more detail, and can be handed over to industry if needed (as was done for the TSR.2). The responsibility of the client is to provide all necessary constraints, conditions, and requirements for the product, both financially and technically. The project manager's role is to make sure that people are working in the right direction and to co-ordinate the various research efforts. The cost of this phase is estimated to be about 5% of the whole project. The better defined the project is at this stage, the less cost overruns and delays there will be later on. The fourth stage is only used in case the government hesitates about carrying the project any further. If more time is needed, holding contract is signed to maintain development and research assets in place while the government ponders a decision. This stage is only supposed to last a maximum of three months but is renewable. If the programme is launched, stage five comes into being. A development contract is signed with industry, which includes detailed time scales, costs, operational requirements, and major technical problems in order of priority. During this stage, the client needs to monitor the progress of the project. The project manager must keep contact promises and report any changes to the client. He co-ordinates the financial and technical aspects of the project as well as the interests of the user, the client, and the contractor(s). What also has to be said is that the final stage is subject to Treasury approval, which is often the determining factor. The Treasury's criterion for deciding whether or not to fund a project is not clear and bypasses the project manager's influence completely.

As we have seen, the various stages of the project and the responsibilities of the client and project manager are fairly straightforward. However, this type of strategy does have its loopholes, as will be described in the project analysis.

4. ORIGINAL PROJECT OBJECTIVES

TIME

The first flight originally had to take place during March 1963, however the first TSR2 didn't fly until September 1964. The release date for the aircraft increased parallel to its cost. Originally it was expected to enter in service in early 1966, however in 1964 the release date was already 1969, more than five years late and with no guaranties of not having any further delays. It is important to note that it had now been 13 years after the need to replace the Camberra was discussed for the first time. A lot of time was spent at the beginning of the project due to specification changes and delayed decisions (both technical and political). Later technical problems arose increasing the completion time and the cost even further.

COST

The original predicted cost for the R&D of the project was estimated to be 35 million pounds in 1959. However this figure rapidly increased. This was due to several reasons. First a number of subcontractors put in unrealistically low figures for their work and the Ministry of Aviation made the same mistake in their budget submissions to the Treasury. Second of all, the difficulty of building a plane in two different places 200 miles apart, by two large industrial partners who had never worked together before was a whole different problem altogether. On top of this was an ad hoc control organisation made up of MoA committees whose exact powers and responsibilities were not well defined. Also, the RAF insisted upon an unprecedented standard of equipment reliability. All systems had to be capable of operating after initial failure. This meant that they had to be designed to accommodate as many a three levels of redundancy. Another major source of problems lay with the difficulties and delays associated with the engines. This inevitably put costs up even further. The RAF also had the tendency to stick to the original requirements with no regards to the costs. As an example, the RAF insisted that the navigation system be able follow 40 way-points to the target. In a study, it was found that £750,000 would be saved in the electronics development if only 20 way-points were used. The RAF refused this on the basis that it was not what had been originally agreed, even though 20 way-points would not alter the aircraft mission capabilities. At the end of the project, the cost of the electronic system of the TSR2 was higher than the RAF's brand new Lightning interceptor. Finally, and probably the greatest single cause of increased costs, was the repeating delay in getting official decisions. This created an atmosphere of permanent uncertainty that gravely affected the rhythm and motivation of the production teams. The lack of trust and communication from all sides was one of the most costly errors of this project.

Date	Cost (million £)	Release date
December 1959 (original estimated cost)	80-90	In 1966
March 1962	137	In 1967
January 1963	175-200	End 1968
January 1964	240-270	mid-1969

(source: reference 2)

Engine development cost:

Date	Cost (million £)
December 1959	7.3
January 1962	15
January 1963	20 (destruction of test aircraft)
October 1963	30.3
March 1964	32.5 (maximum price)

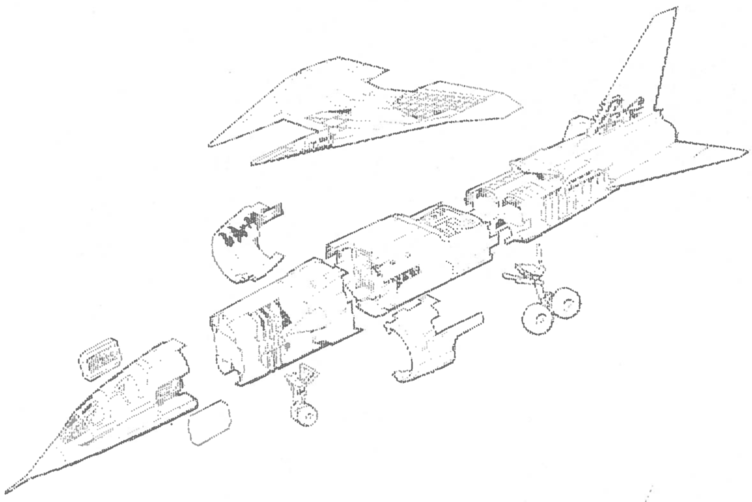
(source: reference 2)

QUALITY

Specifications for OR343 (source: reference 1)

- The aircraft must be able to attack targets up to an extended range of 1500 miles.
- Fly the specified portion of this range at very low level and high subsonic speed.
- Attain Mach 2.0 at medium height when specified.
- Deliver nuclear and/or conventional weapons from low and medium altitudes in poor visibility and night.
- Carry out an all-weather photo reconnaissance.
- Operate from small semi-prepared fields with restricted maintenance facilities.
- Require no defence armament.
- Primary emphasis on low-altitude penetration, particularly in Europe where defences were arranged in depth.
- Provide best gust response characteristics consistent with airfield performance to ensure maximum operating efficiency of the crew.
- Carry maximum photographic and/or radar equipment for reconnaissance without prejudicing the strike role.

- Remain serviceable in the open with no service support for three days and with only minimum support for thirty days.
- Be weather-proof in flight and suitable for global operation.
- Have sufficient forward and down view to enable control of the aircraft during all flight phases.
- Windscreen must be capable of withstanding a 3lb. bird strike at 750knots and be kept free of rain and insect debris at all times.
- An escape and survival capability is essential over the entire flight envelope of the aircraft.



Whether the TSR.2 could actually meet all the OR343 requirements is still unproven due to the short flight-testing programme. All the electronic components were never completely finished (80% finished), and there were still problems associated with the landing gear and the engines when the project was cancelled. The TSR.2 achieved supersonic speeds but was never tested at its maximum speed. Many people believe that the plane was almost finished and that it did indeed satisfy all the requirements, although there is probably a lot of subjectivity involved in this opinion. However, there is no proof that the plane wouldn't have satisfied the OR343 requirement either. Several aspects of the programme, did seem promising. This included the engines (later used for Concorde), and the electronics (used in future military aircraft such as the Tornado).

5. Project management approach

5.1 Organisational and Management Strategy

In a project of such complexity, an organisation encouraging clear lines of communication and well-defined clear responsibilities should have been the order of the day. Early on in the project, Sir George Edwards had strongly recommended that only one person from BAC be made responsible for the whole project. This person would report directly to the MoA. The MoA accepted the proposal and in specified in the development contract that the "Weapons System" procurement procedure used in the USA should be followed. This included empowering one contractor (the prime contractor) to manage the whole project while in turn delegating as much work as economically viable to sub-contractors. They would have total responsibility for the project and would reported directly to the MoA through a single project manager. In turn, the MoA was given full authority to monitor the work. This is common practice and indispensable for a project of such magnitude. However, the MoA superimposed their own management structure over what had been put in place by the contractors.

The project management roles and responsibilities were broken down in the following way. The client of the project was the MoA, which itself was part of the ministry of defence. The user was the RAF, and the main external contractor was Vickers, which was then merged with English Electric into BAC. Both BAC and the MoA had their respective project managers. There was a top project management committee in MoA, but no one actually held a project manager post. The closest job to being project manager was the Controller of Aircraft, George Gardner, within the steering Committee. However, his post was symbolic as all decisions were debated within the committees and taken upon general consent. There was no single decision taker. BAC had a strong project manager, A. 'Charlie' Houghton, who was also Managing Director for BAC's Weybridge and Warton plants. He was one of BAC's most efficient managers. He was a self-made man, having started his career as a tea-boy at Weybridge. He rose through the ranks swiftly due to his unfailing energy and motivation. His strong personality also had a role. Last but not least, he had worked extensively with Sir George Edwards during he war years as a technician and had distinguished himself by his hard work and commitment to the company. He was wholly responsible for the TSR.2 project within BAC and reported directly to BAC's Managing Director, Sir George. Henry Gardner was the Director of the TSR.2 airframe, with George Henson as his Chief Project Engineer.

The organisation of workload and assets of the project varied as time went on. During the preliminary design stages, a joint team from both merged companies met at Vicker's Weybridge plant to do the preliminary design work. Once the main aircraft design parameters were clarified, the team split into two equal parts, one staying at Weybridge, the other going off to Warton. The Weybridge section developed weapons, forward fuselage, cockpit, and also measured cost-effectiveness. Warton was in charge of the aircraft's aerodynamics, including the wings, rear fuselage, tail, and engine integration. The systems were also divided equally, with Weybridge in charge of the electrics, electronics, and air systems while Warton would be responsible for the hydraulics and the fuel system.

Behind the disguise of simply being a guiding and monitoring body, the MoA effectively designed and controlled the organisation of the project as a whole. This was done through a complex network of committees and panels as shown on the chart in appendix (A). This chart represents the control organisation in 1963, but it is needless to say that the number of monitoring committees (and the number of their members) went up exponentially (to a total of 13) as delays and costs increased. The whole project was headed by the Steering Committee that had 4 members, with the permanent Secretary of the MoA (Sir Cyril Musgrave) taking the Chair. The other three members included the MoA Controller of Aircraft (George Gardner), and the managing directors of both BAC and Bristol Siddeley. This group was supposed to give strategic direction to the project. The Management board held the day to day command on which sat representatives from the client (MoA), the user (RAF) and the main contractor (BAC). Under direct control of this board were four other panels supposed to monitor each aspect of the development: Systems Integration Panel, the Development Progress Panel, the Cockpit Steering Committee, and the Production Panel. It was common for these panels to have up to 60 members. All these teams had to oversee their own panels relating to each of the domains they controlled. Parallel to all of this was the financial control. This was done by two committees within the MoA, but not clearly integrated into the project organisational structure. As seen in appendix A, there was the Project Finance Committee, and the Internal Finance Committee. On the later, no industry official was present.

The configuration for this type of structure resembles the project organisation, or 'task force'. This type of structure was appropriate for the TSR.2 programme because it provides for the integration of complex, multi-disciplinary projects. Theoretically, it is easier to manage (from the project manager's point of view) than a matrix organisation. However, it does have the problem of using resources less efficiently than the matrix organisation. The major difference with the theoretical 'task force' is that there was no clearly defined project manager. Any form of leadership or management was spread out within the committees. The function of the project manager was simply symbolic and carried very little weight himself. Decisions were not taken by him, but by the committees as a whole.

5.2 Contract Strategy

Conforming to the US "Weapons System" procurement procedure detailed above, a fixed price for the development of the TSR.2 was agreed. On June the 3rd, 1959, a full design study fixed-price contract of £35 million was placed. On October 7th, 1960, a full development contract was signed for £90 million. BAC reluctantly accepted this, as it had not wanted a fixed-price contract for such a demanding project. However, it had proposed to bear an unknown amount of financial responsibility. This approach can easily be understood since most of the technology needed for the TSR.2 was still undeveloped. Although OR.343 was clear about the required capabilities of the aircraft, no-one knew exactly how much resources were needed for such a far reaching project. In addition, the time-scale given for the development of certain technologies was arbitrary. In reality, it was impossible to know how long the research for certain components would take. As the programme moved along, it became clear that the fixed-price contract was impractical, and unofficially moved to being a cost-plus contract. With all the delays due to technical problems, slow political decisions, and holding contracts, the fixed- price contract became outdated. This was further complicated by the fact that BAC, supposed to be the program co-ordinator, had no control over costs incurred by class one suppliers or government research agencies. In this type of programme, it was not in BAC's interest to control the cost, which instead should have been controlled by the client's project manager. However, the MoA, having supposedly given main contractor status to BAC, expected them to handle the costs. Here again was a fundamental misunderstanding through which many problems emerged. Throughout the whole project, the MoA and BAC would blame each other for cost overruns.

5.3 Discussion

Despite the original MoA claim that BAC would have total control over its suppliers for the whole of the weapons system, BAC found out that they actually had very little room to manoeuvre. It all started when the MoA refused BAC's recommendation for a Rolls Royce engine for reasons never fully understood. Instead, the government chose a Bristol Siddeley engine. BAC complained to the MoA and asked for an explanation, asserting their control over sub-contractors (of which there were over 1000). The MoA responded with a clear breach of past agreements. They specified three categories of equipment. The first included all objects that were to be chosen and purchased directly by the Ministry. As well as the engines mentioned above, the radar, the navigation system, reconnaissance system, and other high-value systems were all included in this category. All contractors participating in this category were referred to as "associate contractors". Hence, the BAC project management was completely bypassed, making cost control and systems integration immensely difficult and sometimes impossible. Category two further complicated matters. It consisted of equipment bought and specified by BAC, but only subject to MoA approval. This is almost the same as for category one and contained the aircraft's central computer, the navigational radar, and the automatic flight-control system, amongst others. Class three incorporated all equipment for which approval was not required from the Ministry as long as specifications were met and costs remained below a specified (by the MoA) ceiling. This included fuel pumps, hydraulic actuators, wheels, and other low-value components. Even class three sub-contractors would often bypass the BAC cost control and go straight to the MoA for spending approval. Having little faith in the TSR.2 project as a whole, they made little effort to fully co-operate with BAC. This lack of communication was evident by several problems encountered.

Hence, BAC understood that it was main contractor only for the airframe and system integration. It had no input whatsoever in decisions regarding important systems or the engine. Their part represented only about a third of the total project work. The MoA directly controlled the other two-thirds. From this, we can deduce that the MoA had very little trust in BAC in keeping costs down. There might also have been political influences in choosing category one and two equipment. A lack of trust between suppliers and BAC was also evident. As a result, BAC lost most of the control that it had been promised at the start.

Even BAC was not immune to bungles, despite having a strong management team. The first flight was delayed several months because it's engineers had failed to provide several drawings to sub-contractors. Hence, certain parts of the prototype had not been made. Furthermore, many rivalries still existed between the Vickers and English Electric merged under BAC. They had been used to competing very strongly against each other and the merger did not simplify the TSR.2 development. Much effort was done to harness these feelings which often caused communication problems.

The MoA, which often lacked the technical ability needed for such a programme, ended up with too much control and too little expertise. There was also a serious lack of communication between the MoA and BAC. If a problem developed, the MoA would often attempt it to solve it themselves without consulting BAC. A classic example of this is that one of the committees of 40 members spent a whole day trying to decide where to put a simple electric switch in the cockpit. A test pilot could have given them the answer in 30 seconds. Although the committees the MoA had put in place were important for project co-ordination, most were lacking leadership and direction. This meant that decisions would often rise to a very high level because nobody wanted to accept responsibility. Even the MoA project manager in the Project Management Committee had trouble exerting any authority over other committees since their members also had to follow orders from their own departments. From this, we can see that the 'task force' organisation was weakened by the fact that an unintended matrix organisation was also present. Also, the Gibb-Zuckerman procurement procedure used by the MoA had the major weakness of the holding contract. The renewability of this stage simply delayed decision-making. During the TSR.2 project, too many holding contracts were issued, wasting time and resources. The government was not as decisive as it should have been in regards to the go/no go decision for the project.

While decision-makers were rare, what hurt the project even more was a lack of leadership. With so much influence and control, the MoA clearly should have provided most of the leadership. However, they still saw themselves as simply a set of monitoring committees not involved in leadership. Even if BAC and other contractors had good leaders, they were in most instances at the mercy of the MoA or the Treasury.

Not all the blame for the ruin of TSR.2 lies in the mismanagement and lack of understanding between BAC, other contractors, and the MoA. There was a strong opposition outside the project context. On the political side, the Conservatives had approved the project. When election time came in 1964, the TSR.2, with all its cost overruns and poor management, was an obvious candidate for the Labour opponents to prey upon. When Labour won, it seemed clear that the project had little chances of surviving. Lord Louis Mountbatten, Chief of the Defence Staffs, was strongly against the whole project. He had supported a modified version of the Navy's Buccaneer aircraft to fulfil the role of the TSR.2. This was understandable, as one TSR.2 was worth about five Buccaneers. However, he had destroyed any export possibilities when convincing Australia, a probable export customer, that the TSR.2 would never be built. Even if Mountbatten was a strong opponent to the project, it was Sir Solly Zuckerman that led the opposition. He was Chief Scientific Advisor to the Minister of Defence, and had a zoologist background. He had led the committee that wrote the defence project management paper mentioned previously. Sir Solly had a reputation for favouring American technology over British technology and had wanted to acquire the American F-

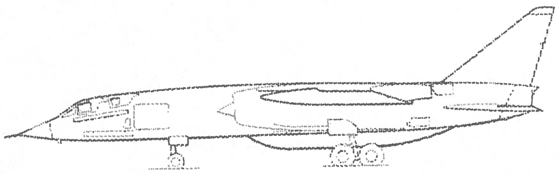
111 instead of the TSR.2. Much of the press was also against the project. This might have been partly the fault of the MoA and BAC public relations departments. Secrecy of many aspects of the project was a major factor of press mistrust, letting them speculate on what was happening.

Despite innumerable blunders by all sides in this project, we can identify several positive aspects. Much of the technology developed for the TSR.2 was used in later aircraft programmes such as the Concorde (engines), and the Tornado (electronics). This project also helped preserve the UK aeronautical industrial base at a time when the industry was lacking any other large-scale government contracts. Also, BAC developed a highly successful production control technique now used worldwide. Value Engineering is a method by which engineers examine the final design of a component and then try to reduce its cost and increase its efficiency. The MoA introduced PERT (Programme Evaluation and Review Technique) into the project. This technique is of American origin and was used with success in the Polaris programme. It consists of using a computer to calculate the most efficient and fastest project route in production and development planning. Using this, most of delays were predicted but remained secret until the project cancellation for several reasons, including politics.

6. Conclusion

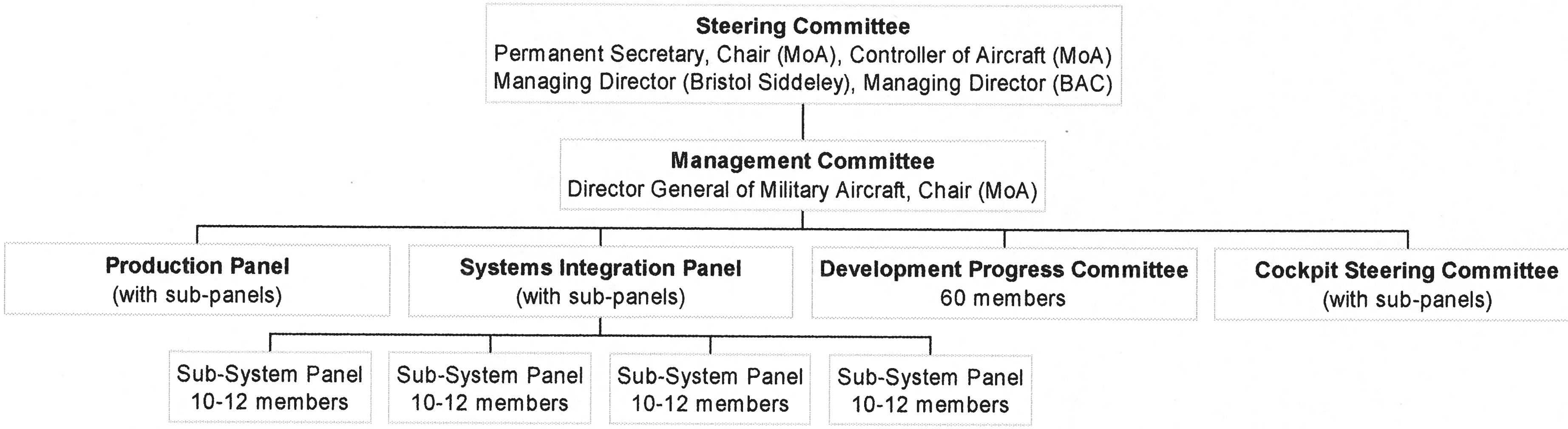
From a project point of view, the TSR.2 programme was a failure. It was far from being on time, with rampant delays. The costs were out of control, with no one really knowing exactly how much the project did end up costing (apart from several times its original estimation). It was also demoralising for the British aviation industry. Finally, although some aspects seemed promising, many technical problems were never resolved and the plane failed to reach all the original OR.343 specifications. Some benefits were realised, however, through development of several technologies used on later projects. Also, it helped the British aeronautical industry to complete much needed consolidation. Probably one of the greatest successes was providing a project management model finally was *not* to be followed. Soon after the cancellation, the government set up a project review panel to see what had gone wrong. The project would have been much better off if the review had taken place much earlier on. Unfortunately, few people talked openly about the lack of project management or other problems during the programme. Had trust and open lines of communication been present between the user, the client, and the contractors the project would have had much greater chances of surviving. Good leadership and direction in all camps would also have made an enormous difference. An important point to note is that many of these lessons were forgotten soon afterwards during the Nimrod project. The government (this time the MoD), did not appoint a main contractor, and split contracting between two main suppliers (BAC for the airframe, Marconi for the radar), which complicated matters. The RAF, instead of absolutely wanting to stick to the specifications as in the TSR.2 project, made over three thousand major changes in the original requirements. The project was mostly of research and development nature with an arbitrary time scale and a cost-plus contract, but had been run like a production project. This bears a strong resemblance to the TSR.2 project.

Overall, we can see that defence projects are extremely complicated due to the fact that there are so many influences and interests involved. They require an extraordinary amount of leadership and good management practices to be successful.



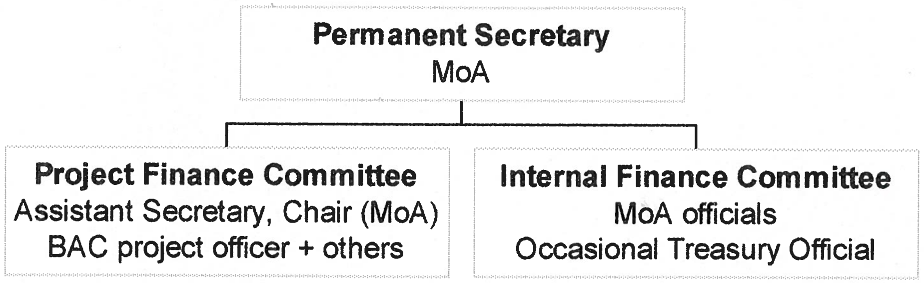
APPENDIX A.

MoA Management Organisation



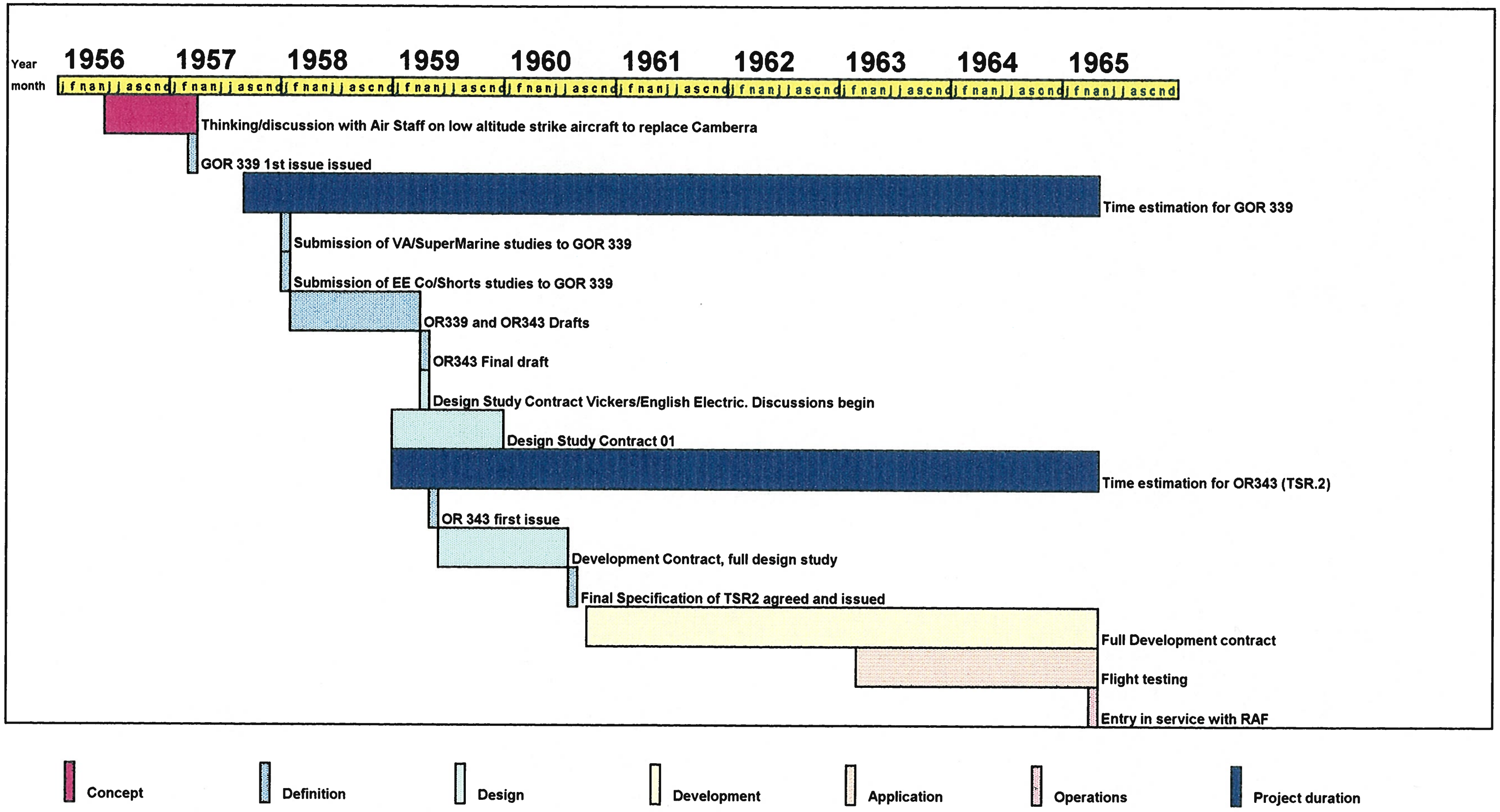
Independently
(within the MoA):

Financial Organisation



APPENDIX B.

TSR 2 PROJECT LIFE CYCLE (Gantt Chart)



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TSR2 UNDER CONSTRUCTION

Now on the production line, TSR-2 is being built to an advanced requirement which will result in delivery to the Royal Air Force of the world's most flexible tactical strike reconnaissance weapon system.

Cruise at mach 2 plus, operation from short and primitive airfields, extreme low altitude capability, and high accuracy reconnaissance and weapon delivery under blind conditions are a few of the features which give the TSR-2 the degree of freedom required to meet the needs of the Royal Air Force at home and overseas.

TSR2

TACTICAL · STRIKE · RECONNAISSANCE

Powered by Bristol Siddeley **Olympus** *Turbo-jets*

BRITISH AIRCRAFT CORPORATION

ONE HUNDRED PALL MALL LONDON SW1 ENGLAND