The original documents are located in Box C44, folder "Presidential Handwriting, 7/21/1976 (1)" of the Presidential Handwriting File at the Gerald R. Ford Presidential Library.

THE WHITE HOUSE

WASHINGTON

July 21, 1976

ADMINISTRATIVELY CONFIDENTIAL

MEMORANDUM FOR: BRENT SCOWCROFT
L. WILLIAM SEIDMAN

FROM: JAMES E. CONNOR JEC

SUBJECT: Approval of an International Jet Engine Cooperative Arrangement

The President has reviewed your memorandum of July 15 on the above subject and has approved Option 2:

Approve the license with several conditions:

-- Restrict technology transfers to third countries.

-- Strictly delimit the technology that could flow to the minority partners (FRG and Italy).

-- While permitting cooperation inthe development and production of the core section of the engine, would delineate the level of technology and the assignment of roles in the constituent tasks.

-- Require subsequent USG approval for the incorporation of new technology in any advanced versions of the engines.

Please follow-up with the appropriate action.

cc: Dick Cheney

THE WHITE HOUSE

WASHINGTON

July 20, 1976

MR. PRESIDENT:

Approval of an International Jet Engine Cooperative Arrangement

The attached joint memorandum prepared by Brent Scowcroft and Bill Seidman was staffed to Messrs. Buchen, Cannon, Marsh, Lynn and Gergen and resulted in the following recommendation:

Option 2: Approve the license with several conditions;

-- Restrict technology transfers to third countries.

-- Strictly delimit the technology that could flow to the minority partners (FRG and Italy).

-- While permitting cooperation in the development and production of the core section of the engine, would delineate the level of technology and the assignment of roles in the constituent tasks.

-- Require subsequent USG approval for the incorporation of new technology in any advanced versions of the engines.

Option 2 was supported by all senior advisers.

Press Plan: See Gorog memo at Tab 1. State will announce.

Jim Connor

MEMORANDUM

THE WHITE HOUSE

WASHINGTON

~~CONFIDENTIAL~~

July 15, 1976

MEMORANDUM FOR: THE PRESIDENT

FROM: BRENT SCOWCROFT
L. WILLIAM SEIDMAN

SUBJECT: Approval of an International Jet Engine Cooperative Arrangement

Problem

A private U.S. jet engine company (Pratt & Whitney Aircraft Division, United Technology Corp.) wants to collaborate with three European jet engine firms in the development and construction of an advanced engine for civil air transports. Compared to present engines, the new engine, designated JT-10D, would be quieter, have less noxious emissions, and lower fuel consumption to respond to the airlines' cost problems. The investment shares and division of work in the JT-10D joint venture would be 54% Pratt & Whitney, 34% Rolls Royce (UK), 10% MTU (Germany), and 2% Fiat (Italy). The engine and parts would be sold through a joint company with the controlling interest in the hands of Pratt & Whitney.

Any international transfer of technology connected with jet engines requires USG approval, even if the technology is company-owned and intended only for civil purposes. Because of this and the significant foreign policy issues at play, the decision on this matter has been forwarded for your consideration.

The basic foreign policy issue in this proposed venture is the US/UK relationship. Although there are two other European countries participating, their companies have too small a role to be considered full partners and are not nearly as advanced technically or commercially as either Pratt & Whitney or Rolls Royce, and hence will be relatively minor participants.

An interagency analytical study is at Tab C.

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Background

The JT-10D joint venture was foreshadowed in the 1973 collaboration to build a new civil engine by General Electric (which is the other major U.S. jet engine company and Pratt and Whitney's main competitor) and the French firm SNECMA. The GE/SNECMA engine is progressing well in its development, and Pratt & Whitney's (P&W) subsequent decision to enter the market with an engine of similar characteristics is consistent with its practice over the past several years. The new element in both these ventures is the presence of European partners. The reasons for this are twofold:

-- The cost of developing a new engine (now in the neighborhood of $1 billion) has increased to the point where the private U.S. companies are unwilling or cannot fund the full investment by themselves, and they require a financial partner.

-- The large European market for aircraft and engines may be restricted or even eventually closed to U.S. companies who do not have European partners.

In approving the GE/SNECMA deal, the USG imposed conditions which prohibited French access to the high technology part of the engine -- the core section. This was done because (1) that particular engine core was developed by GE for the B-1 engine under contract to DOD, and (2) SNECMA was a much smaller and less experienced company than GE, and any technology transfer connected with the core would have been a one-way flow to France.

Analysis

The interagency study found no reason to disapprove the JT-10D; the issues centered on what restrictions ought to be imposed to give reasonable assurance that:

-- The technology flow is balanced so that we are not permitting a competitive advantage to slip from our possession.

-- Any national security concerns are resolved.

-- Economic factors are favorable.

-- Foreign policy objectives are met vis-a-vis the UK as well as with Europe more broadly.

A. Technology Flow

Because the German and Italian partners have such a small share in the JT-10D, restrictions to keep technology flow to them to a low level creates no problem and should be a condition of our approval. The main question is whether the net technology flow between P&W and Rolls would disproportionately favor Rolls. The two companies believe they are very much on a par, and neither will gain at the expense of the other. They are already cooperating on a military engine for U.S./UK joint use.

DOD sent a technical team to the Rolls facilities in the UK to assess the relative technical strengths of the two companies. Their report (Tab D) concluded that there will be no real two-way flow of technology between P&W and Rolls for the basic JT-10D engine, but if more advanced technology were to be incorporated, that flow would predominantly be from P&W to Rolls.

NASA has analyzed the technology proposed for the JT-10D and believes that while there may be detailed differences in competence between the two firms in each engine component area, it sees both firms as basically competitive, and that P&W would acquire valuable engine technology in the course of the program. An independent evaluation by the FAA (Tab E) concludes that each company will learn from the other and there should be no net loss to the U.S.

The current generation of jet engines also suggests that a parity exists: P&W engines are used on the Boeing 747, a GE engine on the McDonnell Douglas DC-10, and a Rolls engine on the Lockheed 1011.

B. National Security Considerations

There are no obvious and direct national security problems associated with the JT-10D. The partners will agree to protect the information that is exchanged, which is their commercial inclination anyway.

In a broader context of national security, there are two principles which bear on the JT-10D, and which tend to oppose one another. Our ability to develop very advanced jet engine technology, from which the next or succeeding generations of our military engines will come, depends on the existence of an independent, vital and innovative U.S. engine industry. DOD is concerned that international collaborations in which there is a net outflow of technology (even with respect to civil engines based on technology below the most advanced military level) could compromise this vitality and independence. This general principle would argue against any jet engine collaboration where U.S. high technology is to be shared, on the assumption that we could not expect to learn enough in return. This view presents something of a dilemma, though, since DOD also in a strong supporter of the need to standardize our military technology and equipment with our NATO allies. To achieve standardization, we must be prepared to carry out joint military development and production projects with the NATO countries, which in some cases would involve sharing even more advanced technology than is embodied in a civil project such as JT-10D.

C. Economic Factors

The competition for the GE/SNECMA engine represented by the JT-10D is advantageous for our aircraft and airlines companies, who will soon be building and operating another generation of air transports. The eventual replacement airplanes for the 727, 737, DC-9, 707, and DC-8, as well as certain European aircraft, will probably be powered by one or the other of these engines.

A pertinent economic question is whether or not we are unnecessarily permitting Rolls to share a market that we would otherwise expect to capture ourselves. This might be true if P&W were prepared to proceed alone. However, P&W says today that without the Rolls it cannot accept the risk, size of investment, and long payback, and would not be able to go ahead. Nevertheless, some believe P&W -- and possibly Rolls as well -- would proceed independently rather than abandoning the market to GE/SNECMA for this size engine. Unfortunately, no evidence or analysis exists which would help to resolve this question, and it will have to remain open.

D. Foreign Policy Considerations

The main foreign policy considerations connected with the JT-10D decision involve our political relationships with the UK and France and any impact on our NATO objectives.

The U.S. and UK have had a history of technology sharing in jet engines. The British pioneered jet engines, and during the 50's the U.S. produced British engines under license. General Motors and Rolls have more recently collaborated on a military engine now used by the armed forces of both countries, and Rolls provided P&W with design information for another military engine being used by the U.S. Marine Corps Harrier force. The UK has made it clear that in light of this relationship and the past and continuing exchanges, they feel there is a prima facie case that the two countries are technologically comparable in jet engine design and manufacture, and that no net advantage would be gained by one country over the other in the JT-10D cooperation. The UK would view an unwillingness on the U.S. part to permit the JT-10D on the basis of equal participation as a serious step back in the U.S./UK relations.

The reaction of France to a JT-10D arrangement which permitted co-operation in the core section of the engine is difficult to predict. It is not unlikely, however, that France would seek some relaxation of the conditions on the GE/SNECMA license that prohibited SNECMA's participation in the core. We would not want to permit such a change, but the ability to resist it would depend on the strength and level of the French representation and also on the availability at the time of technical compromises.

The NATO angle involves the question of whether a denial of the JT-10D would have any impact on our proposal for standardization (mentioned above). Since the JT-10D is a civil program, there would be no direct link to NATO projects. However, bound up in the European attitude toward standardization -- including acquisition of a NATO AWACS fleet -- is the issue of maintaining an effective European defense and aerospace industry and the employment connected with it. There is concern among some in Europe that standardization is the road to U.S. technical and industrial domination. Our position on the JT-10D will be seen as a general measure of U.S. earnest regarding our willingness to permit the cooperative arrangements, which are at the heart of standardization.

Relationship to the Earlier Approved GE/SNECMA Engine Collaboration

In comparing the GE/SNECMA and the P&W/Rolls deals, there are certain similarities that would argue for identical treatment as regards the conditions of our approval. The engines are comparable in size, technology, and the market they are addressing. Both involve for the first time a major civil engine collaboration between a U.S. company and European partners, and in that context, we would prefer to impose stricter rather than looser controls over the flow of U.S. technology because of our uncertainty over the longer term commercial implications of these joint ventures. Further, equal treatment would have the appearance of being even handed in our relations with the UK and France.

However, significant differences need to be taken into account which would make the restrictions on SNECMA unacceptable to the UK and to P&W.

-- The JT-10D engine technology is being developed with company funds and is not the direct product of USG funding, as was the case of the GE contribution to the GE/SNECMA collaboration.

-- Rolls is one of the world's big three of jet engines. A U.S. requirement that forced them to accept a subordinate role would be rejected. SNECMA agreed to such a lesser position in recognition of it being a small company looking to improve its international standing.

-- P&W expects to receive as much technical help as it provides to Rolls. Conditions that blocked such interchanges would be unacceptable. GE was clearly technically advanced with respect to SNECMA and was primarily motivated to undertake its deal to acquire investment capital and assure a market position in Europe. GE did not expect to receive important technology from SNECMA and was privately pleased that the USG excluded SNECMA from the engine core section.

Options

There are four basic options for your decision. These are described below and have the agencies' recommendations associated with them. (The agencies' views are at Tab B.)

1. Approve the license as requested.

   No agency supports this option because there are some minimum conditions that should be imposed to control technology flow to the minority partners and to third countries.

2. Approve the license with several conditions:

   -- Restrict technology transfers to third countries.

   -- Strictly delimit the technology that could flow to the minority partners (FRG and Italy).

   -- While permitting cooperation in the development and production of the core section of the engine, would delineate the level of technology and the assignment of roles in the constituent tasks.

   -- Require subsequent USG approval for the incorporation of new technology in any advanced versions of the engines.

   State, DOD, Commerce, Treasury, NASA, CIEP, and NSC recommend this option because they believe it will permit a useful collaboration that will be of benefit to the U.S. while protecting our national security and economic interests. The details of the technical restraints on the P&W and Rolls cooperation would be negotiated by an interagency group working with the companies.

3. Approve the license but require P&W alone to develop and build the core section of the engine. This we know would be unacceptable to both P&W and Rolls and would be tantamount to disapproval. It would, however, give us a better case in rationalizing the decision to the UK than would straight disapproval, and would dispose of any possibility of a French request for greater access to the core section technology in the GE/SNECMA engine.

   No agency recommends this option.

4. Disapprove the license.

   No agency recommends this option.

Our Views

The JT-10D program will allow one of our jet engine companies to engage in a new development which it might have difficulty undertaking otherwise; will have a positive effect on domestic employment and foreign trade; will lead to competition in the next generation of engines for our commercial aircraft; and will lend some general support to our efforts to achieve NATO standardization. The risk of a net technology loss seems acceptably small, and our discussions with P&W indicate that we may be overly concerned with this issue: P&W for commercial reasons will limit the exposure of its technology to a competitor.

A decision which would require Rolls Royce to accept a subordinate role would not only abort the deal but would be a wrench on our relations with the UK. If there were a clear case -- as there was with SNECMA -- that the technical exchange would be a net loss to us, we could at least rationalize a negative decision. But given a preponderance of views indicating no such loss would occur, we would appear to the UK to be acting in a arbitrary and patronizing way.

RECOMMENDATION:

All agencies recommend you approve Option 2, approving the JT-10D license under the conditions specified in the decision memorandum at Tab A, which will protect our security and economic interests.

APPROVE ________________ DISAPPROVE ________________

I select instead:

Option 1 ______________

Option 3 ______________

Option 4 ______________

A

THE WHITE HOUSE

WASHINGTON

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MEMORANDUM FOR

THE SECRETARY OF STATE

SUBJECT: JT-10D License

The President has reviewed the issues connected with the JT-10D arrangement, and has decided that the license should be approved. The following conditions should be applied:

1. The agreement must include the provisions of Part 124 of the ITAR.

2. Satisfactory agreements must be reached with the governments of the JT-10D partners constraining all parties from divulging any technical information on JT-10D design and manufacturing technology to third countries. Such constraints must also be embodied in the company-to-company agreements among the partners.

3. In the course of the development, the transfer of advanced core design methodology and that manufacturing know-how which would otherwise be permitted under the condition of this license should be limited to only that information that is essential to carrying out the tasks of the participants.

4. In the design and development phase, P&W and Rolls alone must design and integrate the core into the engine. P&W will also take specific steps acceptable to the U.S. Government to protect this technology from unauthorized disclosure to the other parties.

5. That technical data and other information pertaining to technologies reflected in Appendix 6 of the license application designated "Crown Jewels" may not be transferred without the prior approval of the USG.

6. Development of any advanced versions of the JT-10D engine involving technology beyond the level approved by this license must be approved by the United States Government prior to initiation.

7. In the version of the Collaboration Agreement, submitted with M.C. 24-76 on February 12, 1976, now being considered, Fiat

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does not appear in the basic document. However, tasks are assigned in Appendix 4, Statement of Work. These limitations and provisos should either apply to and be binding on all partners to include Fiat or Fiat should be struck from the Work Statement.

The President directs that a detailed statement of the permissible level of technology transfer and assignment of roles in certain constituent tasks be negotiated, on an expedited basis, between the companies and a panel of representatives of interested agencies established by the Secretary of State. The agreement should avoid a continuing, intrusive role for the USG during the implementation of the JT-10D program. If these negotiations should fail to reach prompt agreement, the matter will be referred to the President.

Brent Scowcroft

cc: The Secretary of the Treasury
The Secretary of Defense
The Secretary of Commerce
The Administrator, National Aeronautics and Space Administration

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DEPARTMENT OF STATE

Washington, D.C. 20520

June 23, 1976

~~CONFIDENTIAL~~

MEMORANDUM FOR MR. BRENT SCOWCROFT
THE WHITE HOUSE

Subject: Comments and Recommendations on the JT-10 D Joint Project

This is in response to Ms. Jeanne W. Davis' memorandum of June 19, 1976, requesting the Department of State's comments and recommendations on the interagency study concerning the munitions license request of Pratt and Whitney regarding the JT-10 D joint jet engine project.

The Department of State believes that the study meets the requirements of the terms of reference outlined in Mr. Scowcroft's memorandum of May 29, 1976, and is a balanced presentation of the issues. While we would have preferred to see more analysis on the commercial/economic implications of the proposal, we recognize that this was not possible within the limited time available for the study.

The Department of State recommends adoption of Option 2A. We believe that the collaboration agreement does not raise any national security issues. We believe that the granting of the munitions license with a minimum number of conditions would most benefit and advance our foreign policy objectives with our NATO allies and particularly with the United Kingdom.

With respect to the annexes, the requirement that prior approval of the United States Government be obtained before the technical data contained in Appendix 6 of the collaboration agreement can be transferred is contained in all annexes. For the sake of clarity, we believe that the annexes should state that this restriction applies only in the event that Pratt and Whitney withdraws from the collaboration agreement or declines to participate in the development of a growth engine.

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Also, we believe that the requirement in paragraph 6 of Annex A was inadvertently omitted from Annex B. Thus, Annex B should include as a condition that the Air Force Aero Propulsion Laboratory be designated to receive information regarding the export of core technology and related manufacturing processes.

for C. Arthur Borg
George S. Springsteen
Executive Secretary

~~CONFIDENTIAL~~

THE DEPUTY SECRETARY OF DEFENSE
WASHINGTON, D. C. 20301

24 JUN 1976

MEMORANDUM FOR THE ASSISTANT TO THE PRESIDENT FOR NATIONAL SECURITY AFFAIRS

SUBJECT: JT-10D Engine Program

We are currently sending a team of Defense, Air Force, Navy and NASA experts to visit Pratt and Whitney and Rolls-Royce to ascertain the relative technology of both companies and the net technology flow involved in the subject transaction. The team is to report by 9 July 1976.

Until their report is in hand, the Department of Defense will not be in a position to make any final recommendation on the options contained in the interagency study of this program. In the meantime, our tentative position, if that will be useful to you, is to recommend Option 2C.

W. P. Clements, Jr.

~~CONFIDENTIAL~~

THE DEPUTY SECRETARY OF DEFENSE
WASHINGTON, D. C. 20301

4004

19 JUL 1976

MEMORANDUM FOR THE ASSISTANT TO THE PRESIDENT FOR NATIONAL SECURITY AFFAIRS

SUBJECT: JT-10D Engine Program

~~(C)~~ In my memorandum to you of 24 June 1976, subject as above, I said that we were sending a team of Defense, Air Force, Navy and NASA experts to visit Pratt and Whitney and Rolls-Royce to ascertain the relative technology of both companies and the net technology flow involved in the subject transaction. That team has made its report, a copy of which is attached. The report concludes that there will be no real two-way flow of technology between Pratt and Whitney and Rolls Royce in the proposed JT-10D venture.

(U) We accept the report and agree with it. We believe the program can be furthered as long as constraints and safeguards are provided.

W. P. Clements Jr.

Enclosure

CLASSIFIED BY: DIR,ST&D(ISA)
EXEMPT FROM GDS OF EO 11652
EXEMPTION CATEGORY 3
DECLASSIFY ON: UNDETERMINED

DECLASSIFIED
AUTHORITY DOD Directive 5200.30
BY MLO NARA, DATE 9/4/2012

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THE SECRETARY OF COMMERCE

WASHINGTON, D.C. 20230

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June 24, 1976

MEMORANDUM FOR Brent Scowcroft
Assistant to the President
for National Security Affairs

SUBJECT: JT-10 D Joint Project

In response to your Staff Secretary's memorandum of June 19, we recommend that the President adopt Option 2A. We believe this option will protect against transfer of sensitive technology, both to Rolls Royce and to third countries. We consider Option 1 to be too open ended; Option 3 puts the Government in a position of turning off what is essentially a commercial transaction for protective economic reasons. We believe that Option 2B would be unenforceable in practice, and that Option 2C is too restrictive. In this last respect, we believe the G.E./SNECMA case can be distinguished.

Elliot L. Richardson

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THE SECRETARY OF THE TREASURY
WASHINGTON

June 24, 1976

MEMORANDUM FOR THE HONORABLE BRENT SCOWCROFT
ASSISTANT TO THE PRESIDENT
FOR NATIONAL SECURITY AFFAIRS

SUBJECT: Pratt & Whitney Joint Venture Proposal With Rolls Royce and Others to Produce an Advanced Jet Engine

REF: NSC Memorandum of June 19, 1976 on Comments and Recommendations on the JT-10D Joint Project

Treasury supports the courses of action indicated within the area bounded by Options 2B and 2A, and would be willing to recommend approval of a collaboration agreement along these lines.

From the viewpoint of protecting that technology which is most critical to U.S. national security interests and our international competitive position, Treasury prefers Option 2B which is less flexible than Option 2A in regard to release of technology and know-how to foreign companies by Pratt & Whitney. Treasury believes, however, that it might become necessary to move closer to the terms and conditions specified in Option 2A in order to encourage the foreign firms and governments, mainly Rolls Royce and the UK, to enter into the agreement.

Determination of the degree of relaxation in the terms and conditions governing the release of eligible technology and know-how should be made by the USG on the basis of Pratt & Whitney's renewed negotiations with its proposed European partners.

George H. Dixon
Acting Secretary

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National Aeronautics and Space Administration

Washington, D.C. 20546

~~CONFIDENTIAL~~

Reply to Attn of: I

JUN 23 1976

TO : National Security Council
Attn: Jeanne W. Davis

FROM : I/Assistant Administrator for International Affairs

SUBJECT: Comments and Recommendation on the JT10D Joint Project Study

The NASA comments and recommendation concerning the subject study are herewith forwarded for consideration.

National Security Issue

1. RR is a high technology aircraft engine manufacturer with roughly equivalent technology to that of P&W, and could develop the entire engine itself for military, if not for economic purposes. Moreover, RR as well as P&W has technology beyond that which will be used in this engine.

2. We do not believe that a limited association with a U.K. firm in this project, with strict third party exclusion, in any way risks national security.

3. The availability of a second reliable source for an engine in this category could be an asset to our national security.

Conclusion:

NASA does not believe that there is an issue of national security in this case.

Foreign Policy Issue

NASA has no substantive comment to offer relative to the treatment of this issue in the study. We agree that a mandatory prerequisite to any collaboration agreement must be to provide for control of transfer of technology to third countries.

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Commercial/Economic Issue

1. We view this project as an important step for P&W to take in order to insure a strong U.S. share in future aircraft engine sales, particularly in European and other international markets. This program also admits a second U.S. company to the competition, which we think is beneficial to the U.S. economy. In our judgment, P&W's economic health could be affected and their international competitive position may be at stake in the USG decision in this case. If the JT10D is not developed, the CFM56 will probably control the free world market for advanced civil engines of this type in the foreseeable future. Denial to P&W of approval to proceed with the JT10D program would appear to unreasonably discriminate against P&W in favor of GE.

2. Advanced technology is a prime basis for future developments; therefore, stagnation in research, design and development occurs if a firm is excluded from the market. The JT10D represents technology of the early 1970's, which unquestionably will have been superseded by more advanced technology when production begins. The JT10D and the CFM56 are the only two advanced jet engines for commercial transports known to be in the offing for the 80's. Denial of this request could thereby cause reliance on one international consortium (GE/SNECMA) which could diminish or inhibit competitive developments for the future.

3. We believe that there is no reason why MTU or Fiat need to have access to P&W's core technology in order to perform their assigned duties. The technical success of the engine development program would not be affected if these two partners were excluded from access to that technology, and concerns over these firms' subsequent use of critical technology would be avoided.

4. RR is a high technology firm, capable of developing a competitive engine on their own if economic conditions permitted. While there may be detailed differences in competence between the two firms in each engine component area, we see both firms as basically quite competitive, with P&W probably enjoying an overall edge. Both P&W and RR are known to have even more advanced engine technology level competence than would be utilized in the JT10D, as a result of ongoing pro-

prietary and military R&D work. Therefore, we have concluded that both RR & P&W will likely increase its technical competence during the course of this joint development program.

5. We believe that P&W need not reveal to RR, in the course of the joint development, their advanced core design methodology, proprietary information and manufacturing know-how (and certainly no classified technology) which presently gives P&W some technical edge. We have no objection to a free interchange of designs in final form or as end-products nor to exchanges of hardware as necessary for the two partners to carry out and coordinate their respective responsibilities for core design and development.

Any requirement to deviate from the above and transfer design methodology or manufacturing know-how which P&W feels is essential for program success should receive USG review on a case-by-case basis. Our conversations with P&W indicate they view any stated restriction of this type by the USG as objectionable, but it is not possible for us to determine the effect such a constraint might have on P&W's ability to work out a suitable agreement with RR which would recognize such a constraint, particularly in view of the permissive provisions of the paragraphs immediately above.

Conclusion:

NASA believes that this program could well bring significant commercial and economic benefits to our aviation industry and the U.S. economy generally. Consequently, we strongly recommend a favorable USG position which would enable P&W to construct a program, with appropriate constraints and controls imposed by the USG.

Other Factors

NASA agrees with the working group conclusions that recoupment should not be an issue in this case as the JT10D project is not clearly identifiable as deriving directly from any USG R&D program.

Comments on Options

1. NASA believes that neither Option 1 (approve agreement in present form) nor Option 3 (disapprove agreement) is appropriate. Thus, one of the sub-options within Option 2 (express

willingness to approve an amended Collaboration Agreement) should be accepted. The key issue in choosing among Option 2A, 2B or 2C is the degree of constraint the USG wishes to place on P&W technical interchanges with RR on core technology.

2. All three sub-options define a baseline of core technology which we interpret to be the same, i.e., the JT9D-70 engine, plus 2G compressor and the high pressure turbine technology included in Appendix 4 of P&W proposal and previously approved by the Department of State for disclosure to the British Government. All three require prior USG approval for the use of more advanced technology levels.

3. While there are several apparent differences in the detailed mechanics of these sub-options, only one significant and substantive difference exist, namely, whether RR has a role in the core design, development and manufacture.

o Option 2A allows free and unrestricted interchange of core technology and information up to baseline levels between P&W and RR, in their joint core development efforts.

o Option 2B allows P&W to work with RR on core development but limits its transfer of technology to that technology which RR needs in order to accomplish their designated responsibilities, i.e., combustor and diffuser development, cooling design of high pressure turbine first stage stator vanes, and general assistance to P&W in system design and integration.

o Option 2C would preclude RR participation in core design and development.

4. All three sub-options recommend constraints on P&W early release of detailed "how-to" instructions on advanced design and manufacturing methods and processes. Annex B specifically identifies the 2G compressor design technology in this context in addition to high temperature materials and coatings processes, while Annexes A and C identify specific high temperature materials and processes. A liberal interpretation of the three annexes would be that each Annex has the same intent on this point. The timing recommended for releasibility of this technical information differs among the three Annexes, ranging from initial flight rating tests

through FAA certification or as otherwise approved by the USG. We believe this point should not be a critical issue now, but should be negotiated at a later date.

5. Annexes A and C require that the USAF Aero Propulsion Lab be designated to "receive information regarding," and to "monitor," respectively, any P&W core technology export. Annex B did not address this point. It would appear reasonable to us that the USAF APL should provide whatever surveillance by the USG as may be deemed appropriate.

6. Each of the Annexes provides for the exclusion of MTU and Fiat from core technology transfer by P&W.

7. All three Annexes restrain P&W from transferring the key proprietary and patented technology referred to as "Crown Jewels" in the Agreement without prior USG approval.

Recommendation

NASA recommends approval of the proposed Collaboration Agreement with the conditions and restrictions contained in Option 2B and Annex B, (consistent with our comments on the Options) in that this Option provides the USG a measure of control over advanced engine technology transfer, while permitting P&W flexibility in working with RR. We feel that a properly constructed agreement will reap economic benefits to P&W and the U.S. economy.

Arnold W. Frutkin

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DEPARTMENT OF STATE

Washington, D.C. 20520

~~CONFIDENTIAL~~

June 18, 1976

MEMORANDUM TO THE ASSISTANT TO THE PRESIDENT
FOR NATIONAL SECURITY AFFAIRS

SUBJECT: Proposed Collaboration Agreement Between Pratt & Whitney, Rolls Royce, MTU and Fiat on the JT-10-D Jet Engine

Attached are ten copies of the study prepared by our interdepartmental working group in response to your memorandum of May 29, 1976. The study reviews the unique issues regarding the security implications of civil jet engine technology transfer and other relevant issues and addresses a range of policy options.

The study in its present form outlines options without presenting recommendations, and does not have the concurrence of any department or agency. The document reflects the thinking of all members of the working group who understand that the NSC would subsequently recirculate the study for official agency positions and recommendations. In addition to requesting the views of the agencies to which your memorandum was addressed, we suggest that the Treasury Department be requested to comment.

The Commerce representative requested that the memorandum of transmittal state that Commerce was unable to complete its commercial/economic analysis because of the time constraints and therefore reserves the right to insert comments, if necessary, during the formal agency clearance process.

George Vest

George S. Vest
Director
Bureau of
Politico-Military Affairs

Attachment:

Report as stated.

~~CONFIDENTIAL~~
Classified by George S. Vest
Subject to General Declassification
Schedule of Executive Order 11652
Declassified on December 31, 1982

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Report to the NSC of an Interagency Working Group on the Request for a Munitions License Regarding the Proposed Collaboration Agreement Between Pratt&Whitney and Rolls Royce, MTU and Fiat on the JT-10 D Jet Engine.

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Problem

Pratt & Whitney (P&W) has submitted an application for a munitions export license to permit the company to enter into a joint venture with a British, German and Italian firm to design, develop, produce and market a 10-15 ton civil jet engine designated the JT-10 D. The proposed contract provides for extensive sharing of advanced jet engine technology, particularly with the British firm of Rolls Royce. The engine and parts would be sold through a joint company with the controlling interest in the management in the hands of the US company. Also, the agreement gives the foreign firms significant world-wide rights to sell engines and parts and to grant sublicenses without prior USG approval. The purpose of this study is to review the national security, foreign policy and commercial/ economic implications of the proposal and possible options preparatory to a decision on the application.

Background

A. The Proposal

The Pratt & Whitney (P&W) Aircraft Division of United Technologies International has requested the Department of State to approve a collaboration agreement with Rolls Royce 1971 Limited (RR) of the United Kingdom, (UK), Motoren-und Turbinen-Union Munchen GMBH (MTU) of Germany and Fiat of Italy for the design, development, production and marketing of the JT-10 D. The JT-10 D engine is a jet propulsion gas turbine aircraft engine in the 20,000 lb to 30,000 lb (10-15 tons) thrust class.

The P&W request[1] is a sequel to a limited approval we gave the company[2] on June 8, 1973, for release to its three European partners of general information necessary for preliminary evaluation, and design. One of the conditions of the June 8 license was that P&W would not release design details on the high pressure compressor and high pressure turbine. Since these approvals were of a preliminary nature due to lack of a firm definition of the JT-10 D engine program at the time, the company was requested to

[1] Assigned State Office of Munitions Control (OMC) case number 24-76.

[2] OMC license numbers 54583 through 54585.

submit within a year from the date of the licenses the details of the program plan and proposed partnership agreement for State review and approval. Subsequently, the Department of State granted UTI[3] permission to provide limited technical information on the core high pressure compressor (the 2 G compressor) and high pressure turbine to RR to permit the British Government to assess the technical risks prior to its commitment to the program.

The JT-10 D collaboration agreement was submitted by P&W on February 10, 1976, and contains the following key provisions:

-- Incorporation. The joint company will be incorporated in Delaware.

-- Management. P&W has majority vote in joint company and appoints general manager.

-- Design/Development. All companies share design/development information. P&W and RR share development of the core and engine testing.

-- Production. Shared production based on value of output with reallocation of spare parts production if necessary to maintain each partner's share of engine and spare parts production (54% P&W, 34% RR; 10% MTU, 2% Fiat).

-- Survivor Rights. Surviving party has right following withdrawal or bankruptcy to receive non-exclusive, royalty free, world-wide license with right to sublicense any technology generated, acquired or used by withdrawing party prior to withdrawal or bankruptcy. Each party also entitled to above rights if joint venture terminated.

-- Technology. Latest advanced technology (including engine core technology) will be provided and be available to each party subject to necessary government approval.

3 OMC license number GC 1285

-- Property and User Rights. Joint company obtains non-exclusive world-wide, royalty free license to use and sell with right to grant sublicenses to make, have made, use and sell engines and parts. Each party has same rights for information disclosed to it.

-- Security. Proprietary information to be protected and government security regulations observed.

B. Relationship to other licenses (GE/SNECMA)

While not identical, the P&W case is similar to a GE request we disapproved in late 1972. In that case, GE had requested authorization of an arrangement with SNECMA, a French national firm, for the joint design, development, production and sale of the CFM-56, a new turbo-fan aircraft engine having a little more than 20,000 lb thrust (10 tons). GE's part was to provide the engine core (compressor, combustor and turbine) and SNECMA would provide the rest of the engine. Specifically, GE was to provide the F-101 engine core it had developed under US Air Force contract for the B-1 bomber. In approving the preliminary design study, the USG in 1971 defined the technology base so as to exclude the B-1 core. However, GE did not interpret the license to exclude the core and discussed the joint venture with the French as if it were to include the higher levels of military technology. In requesting renewal of the license in 1972, the GE application explicitly requested authority to transfer data (assembly/disassembly and test instruction, tooling and instrumentations) and hardware involving this military engine. The request was disapproved by the President.

Following further negotiations, GE revised the co-production plan so that its contribution would be to provide engine cores manufactured in the US and provided to SNECMA in the form of a "black box". No detailed design, development or production technology was to be transferred. The revised plan was approved by the President in June 1973. The license contained the following conditions:

-- A satisfactory security agreement had to be reached with the French for the protection of non-production information on the core.

-- The French Government would agree neither to seek nor to support others in seeking new tariffs against US aircraft imports into the European Community.

-- GE would pay the US Government recoupment fees for using Government funded technology in a commercial venture.

-- All selected non-production or general core information licensed would be protected against third country transfers under a government-to-government agreement requiring prior USG approval on a case-by-case basis.

On September 26, 1973, GE was given conditional approval[4] and when all of the above requirements were met, the company was granted final authorization[5] of the revised plan.

The P&W case differs from the GE case in several significant ways:

-- Although P&W has benefited from USG R&D programs, this case does not directly involve USG technology.

-- The major partner (Rolls) is technically and commercially at a more comparable level with P&W.

-- The JT-10 D cooperation will not create a new international engine competitor (as the GE/SNECMA project tends to do) since Rolls already has that status. The joint company, however, will operate independently.

-- The UK is not pressing for higher EC tariffs on US aircraft and engines as were the French.

-- The UK is a member of NATO and a key participant in the equipment standardization policy we are proposing.

-- The risk of domestic members of the communist party in the UK acquiring the JT-10 D technology and providing it to the USSR is much less than was the case with France.

[4] OMC case GC-415

[5] OMC case GC-415A

Analysis

We have been asked to approve the proposed JT-10 D collaboration agreement as a technical assistance agreement within the meaning of the International Traffic in Arms Regulations (ITAR), issued pursuant to the authority of Section 414 of the Mutual Security Act of 1954, as amended, and administered by the Office of Munitions Control of the Department of State. The immediate effect of such approval would be to permit the export of engine technology up to the technological baseline set forth in the agreement and previous approvals related to this program without further review or licensing by the USG. For this reason, the scope, limits, and restrictions specified in the agreement are of significant importance.

P&W alleges that the technology to be transferred under the agreement is within USG constraints and practical business requirements. The company expects to gain as much technology from RR as P&W will give and believes the venture will fail without such an exchange. Although the agreement grants each party equal rights of access to advanced technology, P&W states that as a practical matter, exchanges of advanced engine core technology will not take place with the German and Italian firms.

The specific issues which the JT-10 D collaboration agreement raises are as follows:

National Security. Will US military security be adversely affected by the terms of the proposed agreement, particularly the requirement for the transfer of advanced jet engine core technology? If so, how can an acceptable proposal be constructed?

Foreign Policy. How will the USG decision on the collaboration agreement affect US relations with the UK and France and with Europe generally? What are the implications for US foreign policy of the absence of third country transfer controls?

Commercial/Economic. What are the commercial/economic implications of the decision taken on the license request?

A. National Security

The JT-10 D collaboration agreement envisages the production of high by-pass type jet engines suitable for use in wide-bodied civilian aircraft but also appropriate for strategic military airlift planes, tankers, subsonic bombers or patrol craft. The technology that is requested to be released includes engine core technology which has wide military applications and can be used across the entire spectrum of bomber and fighter aircraft, including supersonic aircraft. Follow-on technology would be provided for the life of the agreement, which runs 15 years.

The working group was not able to agree whether or not national security would be affected by the proposed collaboration agreement. Some members thought that there is no national security issue at all. Others thought that the release of jet engine technology equivalent to that used in the B-1 bomber would have adverse military effects and therefore harm the national security.

Those who defined national security in military terms believe that the collaboration agreement raises three separate but related problems.

-- The overall impact of the agreement on US strategic lead time in jet engine technology.

-- The particular impact on company-related (but partially USG financed) design and manufacturing know-how.

-- The risks of compromise (e.g. to the USSR) inherent in the transfer of strategic technology.

The analysis which follows was not accepted by a number of members of the working group.

Strategic Lead Time

An objective of US military security policy is to maintain a substantial strategic lead over all other countries whether ally, neutral or potential adversary in the development of equipment for the use of the US Armed Forces. Fundamental to this policy is the fact that advanced technology is the basis for future developments, the starting point from which subsequent research, design and development begins. Maintaining US superiority is most critically required in those areas of technology for which product lead times are great and in which the necessary arts and skills are acquired through costly and time-consuming research and development (much of which is USG financed) not only for functional design but for superior manufacturing processes as well. Such is the case in the field of high performance gas turbine engines for aircraft.

Because development lead times for these engines are typically 5 to 10 years, an infusion of advanced technological information and know-how to a second (or third) party may not produce an immediately discernible impact. Rather, the results may not be evident for some significant period of time, probably five or more years, due to the nature of the technical product development process. The decision made on the GE request in 1972 was to prohibit access to SNECMA the F-101 engine core technology because of the important strategic lead time enjoyed by the US.

If the JT-10 D collaboration agreement should be approved and consummated substantially as proposed, it is a foregone conclusion that in addition to core technology some further exchanges of advanced technology would take place among the member companies. This is what one would expect from a commercial project. Firstly, the circumstances which would induce such transfers would likely not be limited to the deliberately planned and authorized transfers made in order to facilitate preestablished objectives. Secondly, transfers would be expected through diffusion among the technical personnel from each firm joined in the new company as they work together. The natural inclination of team members working together is to share their individual knowledge and experiences in order to accomplish their common objectives expeditiously. It is impossible to assess the extent to which this form of transfer would occur.

Still a third mechanism for technology transfer can be anticipated. In the course of every engine development program technical setbacks occur, some of which may appear so critical as to threaten the program success. It is unlikely that the program manager (i.e. P&W) would simply stand by, witnessing a serious development problem encountered by other members without throwing his available expertise into the breach, executing his responsibility for overall integration. Technology transfers beyond that presently planned and authorized could be an expected consequence.

<u>Company Effects</u>

The possible impact of gas turbine technology transfer among the JT-10 D collaboration partners on the national security objective stated previously must be based in great part on our assessment of the relative technical knowledge and skills in each company for design, development and manufacturing. An important consideration is the manner in which the partnership would implement its intent stated in the proposed agreement, that is, to make available to all partners (i.e. RR, MTU and Fiat) the most advanced information which each partner is entitled to furnish (and therefore obligated to furnish) to the enterprise. Implicit here is the question of the actual significance of that proprietary and patented information now possessed by each partner and which each has identified, in Appendix 6 to the collaboration agreement, as information having more than ordinary importance and value.

The proposed JT-10 D program includes two of the top three jet engine manufacturers in the western world, P&W and RR, the third being GE. The other two partners (MTU and Fiat) have special expertise of value to this enterprise. P&W and RR traditionally are competitors in the manufacture of engines capable of powering supersonic fighters or bombers and transports as well as a variety of commercial aircraft. As competitors, both companies can be considered roughly on par technologically if they are to continue to remain competitive, as we believe they will. However, each has taken different approaches in the process of the design and development of their specific products and the USG has funded research and advanced engine development to include manufacturing processes to a greater extent. As a result, there are certain differences in the nature of the technologies they employ whether in the areas of design, development or production. These differences have been referred to as factors that lead to the potential for relative technology flows, flows that will exist in both directions.

To these differences, it is necessary to add the effects of close collaboration. The agreement as presently constructed provides for full integration of the four partners into a design team, a development team, a production team and a marketing team. Each team will have implicit opportunities for direct though perhaps unstated transfers of technology as previously discussed in detail above. Thus, where the four partners are concerned, engine integration technologies and managerial capabilities where P&W enjoys substantial leads can only result in further diffusion of the net US advantage.

With respect to RR specifically, the Department of Defense evaluation of relative capabilities is that, in so far as can be determined, P&W has greater technological capabilities than RR in varying degree, in nearly every critical aspect of the JT-10 D engine, both in design and manufacture. It would appear, therefore, that there is greater likelihood that RR would derive the greater benefit from technology interchanges than P&W as the program is presently constructed, albeit some benefit to P&W may be expected in several specific areas. While it may be difficult to assess the specific consequences, it is the judgment of the DOD that the technological lead which P&W holds relative to RR would be reduced rather than increased and that any such reduction would be contrary to the US security policy objectives stated at the outset. Defense further believes that the transfer of core technology advances from P&W to RR constitutes the condition described by the Defense Science Board Report of February 1976. The specific concern is that premature transfer of accumulated technology so far advanced, effectively produces a step advance similar to that of a revolutionary gain to the receiving country. The specific performance advantages existing in US manufactured engines stem in large part from the use of advanced manufacturing techniques; directional solidification of materials, powdered metallurgy, hot isostatic pressing and various proprietary techniques. The US enjoys a 5-7 year lead in these technology areas.

The Defense view is not universally shared within the USG or by P&W and the importance of these accruals to the critical aspects of overall engine technology can be questioned. NASA agrees with DOD that the most critical technology for the JT-10 D engine is the core; however, they feel that the levels proposed by P&W should not be of significant concern. While there may be detailed differences in competence between the two firms in each engine component area, NASA sees both firms as basically quite competitive and that P&W would acquire valuable engine technology in the course of the program. NASA believes it is possible for P&W to engage in this program without transferring their technology to the extent and effect which concerns DOD. Specifically, NASA believes that P&W need not reveal to RR proprietary advanced core component design methodologies, development techniques and manufacturing know-how which would significantly erode their present technical superiority. With regard to the other partners, MTU and Fiat (assuming Fiat is a partner) would unquestionably become the major beneficiaries from the pooling of advanced technology, with little of value to be gained by P&W or the US in return.

Risks of Compromise

With the existence of a flow of advanced technologies in jet engine design, integration and manufacture made possible by the present form of the collaboration agreement, P&W's three partners stand to gain significant technologies. The proliferation of the technologies increases the risk, through inadvertance or otherwise, that the technologies or improved products based on these technologies will be obtained by potential US adversaries.

Of the three foreign partners, the greatest potential risk for compromise is Fiat of Italy. Italy presently faces the possibility that a government with Communist Party participation will be elected in the near future. Even if the Communist Party does not obtain a sensitive or dominant role now, the possibility remains for the future.

The potential British issue stems from recent UK aircraft-related sales to the PRC and the USSR. The sale to the PRC involves the SPEY engine, the engine that powers Britain's F-4s. As part of the arrangement, Britain will license production of the engine in China. The UK has also announced that agreement was reached to sell 100 to 150 RB-211 aircraft engines to the USSR. While the arrangement fundamentally differs from an earlier proposal involving a plant for the manufacture of the engine itself, there is a possibility that manufacture may not have been totally ruled out. As things now stand, however, no transfer of design, development and production technology is involved.

The SPEY engine case cited above does not involve US technology. The British Embassy has indicated that if we are concerned about the transfer to the USSR of RB-211 technology (which includes certain US technology), the UK would be willing to provide written assurances. It should be noted that the US and UK Governments do share classified information extensively.

With respect to transfers of US technology, a normal condition of US export licenses is to prohibit the transfer of strategic items to communist countries. Also, multilateral controls are maintained through the Coordinating Committee on Export Controls (COCOM) in which the UK, Italy and Germany participate. Although there are differences in COCOM on interpretation of strategic items, and some evidence of an increasing willingness to contravene the spirit of COCOM rules, we have not seen any evidence that other COCOM countries have reexported US technology to communist countries without US authorization. Furthermore, the only evidence of western technology transferred to communist countries in recent years without COCOM approval was the SPEY engine to PRC and this was a special case. On balance, while there are risks of compromise inherent in any proliferations of US technology, such risks should not be considered as a major issue in determining the decision on the collaboration agreement.

In evaluating the military security issue, the US must take into account the special relationship we have had historically with the UK. The US-UK defense relationsip, however, has tended to be of a strategic nature. For example, we have cooperated in providing the British with the capability to maintain an independent nuclear deterrent by providing plans for the manufacture of the Polaris missile. Despite the close relationship we have with the UK, the US does not generally share its advanced technologies, weapons systems and sensitive components which could have an impact on our future technological and industrial advantage.

Those members of the Working Group, who did not accept that there is a national security issue, did so on the following basis:

-- National policy on the issue of technology transfer is not clear and nowhere is the criterion of strategic lead time defined as an objective. To the extent that such a concept exists, it should apply only to potential adversaries.

-- An equally important national security objective is to standardize our military equipment and technology vis-a-vis our NATO allies.

-- P&W and RR are equals and both will benefit from reciprocal transfers of technology.

The analysis, which follows, was not accepted by some members of the Working Group.

US Technology Policy

The US does not have a national policy of discouraging the transfer of high technology in areas where we have a lead. To the extent that the issue is covered, NSDM 187 of August 30, 1972, holds as a national security objective "to maintain the US margin of advantage in technology of significance to our national security, and to avoid release of space hardware and technology which is considered to involve a disproportionate risk to our national security." NSDM 187 also says "We must expect to give as well as gain advantages to achieve real cooperation of mutual interest." NSDM 187 further says that US must "avoid economic disadvantage by appropriately weighing" commercial technology transfer, competitive position of US aerospace, return on space investment, and possible effects on domestic employment and balance of payments. What is clear is that NSDM 187 does not state that technology transfer is to be discouraged where the US has a lead.

NATO Standardization

As to NATO standardization, the US objective is to use appropriate means to make more effective the use of NATO defense resources, including more rational use of defense production facilities. This includes standardization of military materiel and equipment and establishing or broadening the base for common and interchangeable logistics among NATO countries.

Reciprocity

The basis of the P&W and RR agreement is reciprocity. RR is technically and commercially at a more comparable level with P&W as evidenced by the RB-211 engine in comparison with the JT-9 engine, which are both now being sold for the latest air transports. If a problem were to arise where Rolls expertise were more pertinent, Rolls would be expected to step into the breach and help find a solution. In the preliminary design work on the JT-10 D that has already gone on, there are several examples where each partner has offered answers to problems. This program has not been, nor is it expected to be, a one-way street.

B. Foreign Policy

The decision on the JT-10 D collaboration agreement will have important foreign policy implications for U.S. relations with the U.K. and France and with Europe generally.

The British Issue

The maintenance of close bilateral relations with the United Kingdom is an important objective of U.S. foreign policy. We continue to look to the British to assist us in pursuing various U.S. politico-military and economic goals, particularly in Europe. For example, the U.K. is currently supporting U.S. efforts to obtain the cooperation of several of our NATO allies to purchase a fleet of battlefield surveillance aircraft for a NATO Airborne Warning and Control System (AWACS).

Our bilateral relations with the U.K. are sufficiently broad and of such historical depth as to survive disapproval of the collaboration agreement. At the same time, we must recognize that the U.K. may not be in a position economically to isolate this kind of setback. As the sole shareholder of Rolls Royce and because of the firm's key role in this important high technology industry, the British Government has an important economic stake in Rolls Royce. Politically, the Government is committed to keeping its domestic aircraft industry alive and economically viable. The principal foreign policy concern is that a negative or overly restrictive U.S. decision on the proposal could adversely affect British attitudes on other U.S. defense and foreign policy interests (e.g., AWACS).

There is no doubt that the British Government considers the U.S. decision on the P&W/Rolls collaboration agreement as a major bilateral issue. The importance of approval of the license was communicated to the Secretary of State during the visit of Prime Minister Wilson in May 1975, and has been reiterated on several occasions by the British Ambassador.

British officials are in close touch with P&W and RR and are familiar with the nature of some of the objections to the collaboration agreement being raised within the Executive Branch. In an effort to reply to some of the criticisms, the British Embassy recently delivered an informal note which set forth the following points:

-- Whereas GE was superior to SNECMA in technology, RR and P&W are two essentially equal partners. RR's technical contribution will be at least equivalent to P&W.

-- RR's security arrangements are of a high order and whatever information is exchanged will be fully protected.

-- The engine core technology involved is not revolutionary technology but an evolutionary advance well within RR's capabilities.

-- Release of engine core technology will not prejudice U.S. strategic interests.

-- The history of British-American cooperation in jet engines has always involved transferring technology to rather than from the U.S.[6]

[6] The British note pointed out that Sir Frank Whittle invented the jet engine, and emphasized the importance that their licensing of the TAY and NENE engines had for the development of the U.S. industry in the 1950's. It called attention to the current collaboration of General Motors and Rolls Royce on the Spey/TF 41 engine now used by both the U.S. and U.K. armed forces, and the considerable design contributions made by Rolls Royce to Pratt & Whitney for the Pegasus engine, now used by the U.S. Marine Corps' Harrier force and to be the basis for the power plant for the advanced Harrier (AU8B) to be produced by McDonnel-Douglas.

The French Connection

The French Government could react negatively to USG approval of the collaboration agreement in its present form. Even if we assume the GE-SNECMA partners and the French Government are satisfied with their present arrangement and would not seek similar concessions, the USG could be open to charges of partiality and discrimination by both GE and the French Government which has vested interests in the CFM-56 engine program. Should a request be submitted for engine core technology, the argument that the U.K. firm has technology to share which cannot be supplied by the French firm will not carry much weight politically. At the time the French were informed of the USG decision to withhold core technology, French President Pompidou personally expressed his disappointment and concern to Secretary of State Rogers. Special U.S./U.K. arrangements may raise latent French political suspicions and fears of Anglo-Saxon domination. Some members of the working group do not accept the foregoing analyses and believe, that based on unofficial "soundings" with GE and French officials connected with the program, it is unlikely that an adverse reaction would occur.

Germany and Italy

The German and Italian stakes in the collaboration agreement are too small to be significant as a foreign policy issue. Efforts by the U.S. to restrict the sensitive technology flow only to the U.K., however, might raise a charge of discrimination. Since the German and Italian firms will benefit from some of the technology flows, complaints, if any, should be manageable.

The European Implications

While the main foreign policy issues are bilateral, the USG decision on the collaboration agreement has broader implications for our overall relations with Western Europe. At present, there are still forces in the Economic Community (EC) which would like to see the Community develop in an autarkic manner. Specifically, there are strong pressures to have Europe develop an indigenous aircraft industry capable of displacing U.S. dominance on the Continent. Such attitudes are contrary to U.S. interests and our foreign policy over the past several years has been to encourage an open, outward-looking Community and one in which the U.S. has reasonable market access. A negative U.S. decision on the collaboration agreement, or one which is excessively restrictive, is more likely to encourage those who deprecate US-EC cooperation, and thus would be contrary to our broader interests in Europe.

Third Country Transfer Controls

An objective of U.S. policy is to retain the right to determine the ultimate destination of transfer of munitions list items and their technology to third countries. Such controls serve as an instrument of foreign policy (e.g., may be used to implement an embargo or policy of arms restraint with respect to a particular country such as Libya when directed).

In the case of commercial jet engines, munitions controls only apply during the joint development stage when technology is being transferred. The sale of certified engines is controlled by the Commerce Department under the Export Administration Act.

As far as technology transfer is concerned, the company, according to a P&W official, is prepared to accept USG third country transfer controls as a condition of the munitions license and believes such a condition would be acceptable to the foreign firms and to their governments. In the GE/SNECMA case, a government-to-government agreement was negotiated between the U.S. and France.

The requirement that United States Government consent be obtained for such transfers of jet engine technology exported from the United States does not appear explicitly in any statute. Nevertheless, the clear intent of Congress in enacting Section 414 of the

Mutual Security Act of 1954, as amended, the statutory basis for control of the export of U.S. Munitions List items and technology, was that the discretionary authority thereby conferred be exercised in a manner best calculated to achieve the purposes of the statute. These purposes are stated to be "the furtherance of world peace and the security and foreign policy of the United States." For that reason, among others, we have required a condition of United States Government approval that all technical assistance agreements contain provisions limiting the territory in which the exported technology may be transferred, directly or indirectly, without prior express Department of State approval. At a minimum, this territory must exclude communist countries or those under communist control; in appropriate cases, additional territorial restrictions may be required. Thus, while we would have the legal authority, strictly speaking, to approve such an agreement without territorial restrictions, to do so would raise questions of conformity to the intent and purpose of the law and consistency with past practice. There is also a likelihood that statutory third country transfer provisions will be extended, and may explicitly cover cases such as this in the future.

C. Commercial/Economic Issues

Section 414 of the Mutual Security Act of 1954, as amended, authorizes the control of exports of Munitions List items and related technology "in furtherance of world peace and the security and foreign policy of the United States." This broad responsibility has been construed to extend to review of the commercial aspects of proposed transactions in order to determine their compatibility with the international economic interests of the United States. Moreover, judicial challenges to the exercise of executive discretion in this regard have proven uniformly unsuccessful, with the courts refusing to review Executive decisions as to what is or is not "in furtherance of...the security and foreign policy" of the U.S.

There will be a substantial commercial market beginning in the late 1970's for an engine in the thrust class proposed in the joint venture. The anticipated demand is a function of the need for more powerful replacement engines, improved fuel efficiency, lower noise levels and compliance with more stringent environmental standards. P&W wishes to participate in this market but believes that the financial risk is too high to go it alone, and also wants to have a European partner to assume continued access to the European market.

The commercial/economic implications of the collaboration agreement have different effects for the firms and the national economy and depend on the assumptions made regarding the transfer core technology.

For P&W, the USG decision will have an important impact on the company's future strength and competitiveness. Approval of the agreement, particularly in its present form, would greatly strengthen the company against its competitors. On the other hand, disapproval of the license or the imposition of USG conditions which prove unacceptable to its partners might give GE a monopoly in the 10 ton engine segment of the market and generally weaken P&W's financial strength and ability to support internally-generated R&D over the longer run. If P&W decided to go it alone, the investment required would be a substantial drain on the company. Moreover, P&W would find itself at a competitive disadvantage in the European market against GE/SNECMA, assuming both firms produced engines of comparable quality and performance. The net effect would be a weakening of P&W and its ability to meet U.S. military requirements.

There was no agreement in the working group regarding the effect approval of the P&W proposal will have on GE and its joint venture with SNECMA. Neither was their agreement on the relevance or importance of particular factors listed below that might be considered in an analysis.

Favorable factors:

-- French Government financing of part of the GE/SNECMA joint venture.

-- A two year lead time in design work.

Unfavorable factors:

-- Smallness of parent firms when compared with current engine output of P&W and RR.

-- Absence of access to US core technology.

Other factors:

-- Impact on future market shares.

-- Impact on competitive position.

For the national economy, it is not possible to predict with accuracy the outcome without detailed analysis which time did not permit. Generally speaking, the national economy would probably benefit from a well constituted collaboration agreement assuming P&W would not otherwise decide to produce the engine. Disapproval of the agreement would probably not benefit the economy but the precise impact would depend on the extent to which GE undertook work that would have gone to P&W.

D. Other Factors

As part of its overall analysis, the Working Group considered the issue of recoupment. The recoupment issue arises because the USG has historically made major investments in research and development (R&D) undertaken by P&W to advance jet engine design and development. As now drafted, the collaboration agreement explicitly prohibits inclusion in the manufacturing price of the JT-10 D an element for recoupment of non-recurring costs of design, development and certification of the engine.

In the GE/SNECMA case, the USG took the position that GE be required to pay recoupment charges because the technology to be used was subject to a contract with the Department of Defense which contained a provision permitting recoupment. Specifically, GE was to provide the F-101 engine core developed under US Air Force contract for the B-1 bomber. Recoupment was secured to cover domestic as well as foreign sales through a contract between GE and Defense rather than as a condition of the Munitions Control license.

The general consensus of the working group was that recoupment should not be an issue in a decision on the license application for two reasons.

(1) Other governments (notably the UK) could require the payment of recoupment charges if the USG were to assert such a right thereby affecting the potential competitiveness of the JT-10 D.

(2) There is no exact parallel between the P&W/Rolls case and the GE/SNECMA case. The P&W contribution to the JT-10 D project is not clearly identifiable as deriving directly from any USG R&D program as was GE's B-1 engine core.

As a practical matter, if recoupment were required, it would be extremely difficult for the USG to determine objectively the amount of recoupment to be required. As a legal matter, no contractual arrangement exists between P&W and the USG which would be a vehicle for recoupment on the JT-10 D technology.

Conclusions

-- A properly constructed proposal is on balance in the US national interest.

-- The collaboration agreement as drafted is deficient in certain respects.

-- It was not possible to reach an agreement on the national security implications, if any, of the proposed collaboration agreement.

-- It was not possible to reach agreement on the effects of the transfers of technology that are likely to result from the agreement.

-- There is a potential risk of compromise of US technology to potential adversaries but with proper constraints such risks are manageable.

-- There is a potential conflict of US foreign policy interests in relation to the UK and France. Of the two, the US interests with the UK would be affected most if the license request is denied or sharply limited.

-- US relations with Germany and Italy would be affected only marginally by our decision.

-- The right of the US to be consulted prior to any transfer of technology or products to third countries must be protected.

-- The impact of the USG decision is significant for the future of P&W. There was no agreement on the impact for GE.

-- The national economy is more likely to benefit from approval assuming P&W would not independently develop and produce the JT-10 D.

-- Recoupment of USG R&D investment in P&W engine technology should not be an issue in the decision.

The Options

1. Grant the P&W License Application for the Jet Engine Collaboration Agreement in its Present Form

PRO:

--Granting the license for the agreement would benefit and advance U.S. foreign policy objectives, notably with the U.K.

--Approval of the Pratt/Rolls agreement would avoid the delay that will result from renegotiation and not increase further the competitive time advantage now enjoyed by GE/SNECMA.

--Approval would give P&W the opportunity to participate in an important future segment of the commercial engine market. A successful implementation of this program would contribute to the economic health of the company, whose important defense role is a U.S. national security asset.

CON:

--Approval could subject the USG to charges of discrimination by GE and the French Government.

--Since the agreement permits third country transfers world-wide, approval would be inconsistent with U.S. policy of controlling transfers of technology and products to third countries without prior U.S. approval.

--DOD believes that there are national security objections to the transfer abroad of engine core technology. (This view was not accepted by a number of other members of the working group.)

The following options would approve the proposed collaboration agreement subject to certain conditions. The conditions are structured in an ascending order of restrictions.

2A. Express Willingness to Approve a Collaboration Agreement Provided P&W Meets the Limited Number of Conditions Set Forth in Annex A.

PRO:

--The right of the USG to invoke third country transfer controls would be preserved.

--U.S. national security concerns would be allayed.

--The U.S. economy would benefit, assuming that P&W would not otherwise produce the engine.

--Useful technology could be acquired from Rolls.

--The alterations to the arrangement would be acceptable to P&W and Rolls.

--The arrangement is consistent with our NATO standardization objectives.

CON:

--Renegotiation may delay the P&W/Rolls consortium and put them at a competitive disadvantage in relation to GE/SNECMA.

--In some circumstances, the technology flow might favor Rolls.

--GE and the French might complain that they had not received equivalent treatment.

2B. Express Willingness to Approve a Collaboration Agreement Provided P&W Meets the More Restrictive Conditions Set Forth in Annex B.

(Option 2B differs from 2A mainly in controlling transfers regarding the 2G compressor and the high temperature materiels.)

The arguments for and against this option are essentially the same specified for Option 2A above except that:

PRO:

--Additional USG controls on technology transfer are provided.

CON:

--This could result in further delay in renegotiations. It may be less acceptable to the parties.

2C. Express Willingness to Approve a Collaboration Agreement Provided P&W Meets the Even More Restrictive Conditions Set Forth in Annex C.

(Option 2C differs from 2B by precluding RR participation in engine core design and development, by requiring USAF monitoring of the specific technology transfers, and by limiting production of certain items to U.S. manufacture.)

PRO:

--The right of the USG to invoke third country transfer controls would be preserved.

--U.S. national security concerns would be substantially allayed.

--The U.S. economy would benefit, assuming that P&W would not otherwise produce the engine.

--There would be no basis for allegations that GE and SNECMA were treated differently.

--It minimizes the technology to be transferred during the critical design and development stage.

CON:

--These conditions may be unacceptable to the partners.

--Renegotiation may result in substantial delay and put the consortium at a competitive disadvantage in relation to GE/SNECMA.

--RR may be unwilling to make its technology available under these circumstances.

--The decision may adversely affect our foreign relations with the U.K.

--The investment shares of the partners could be effected thus increasing the financial risk to P&W.

3. Disapprove the Case

PRO:

--It would be consistent with the 1972 disapproval of the GE request.

--GE and the French will have no valid reason to complain or to seek core technology exports which were turned down in 1972.

CON:

--Disapproval would adversely affect our foreign relations with the U.K.

--Disapproval would give the mistaken impression that the USG opposes, in principle, another international jet engine consortium. On the contrary, U.S. national interests would be served by a well constructed program.

--Unless we indicated a willingness to entertain another submission, the USG would be open to charges of promoting a monopoly (GE/SNECMA) and giving one U.S. company (GE) a competitive advantage over another (P&W).

--The consequences for P&W would be serious. Its future economic viability and competitiveness would be brought into question.

ANNEX A

USG REQUIREMENTS IN A RESTRUCTURED PLAN FOR THE JT-10D COLLABORATION AGREEMENT.

1. The agreement must include the provisions of Part 124 of the ITAR.

2. Satisfactory agreements must be reached with the governments of the JT-10D partners constraining all parties from divulging any technical information on JT-10D design and manufacturing technology to third countries. Such constraints must also be embodied in the company-to-company agreements among the partners.

3. The final agreement limits the level of technology to the JT-10D data described as embodied in P&WA engines qualified prior to January 1, 1975, i.e. through the JT9D-70 engine, with the addition of 2G compressor technology and the technology described in Appendix 4. P&WA is given overall system and integration responsibility.

4. In the design and development phase, P&W and Rolls alone must design and integrate the core, (including the compressor, the combuster and the high pressure turbine) into the engine. P&WA will also take specific steps acceptable to the U.S. Government to protect this technology from unauthorized disclosure to the other parties.

5. Technical data and other information pertaining to technologies reflected in Appendix 6, "Crown Jewels" may not be transferred without the prior approval of the USG.

6. Air Force Aero Propulsion Laboratory be designated to receive information regarding the export of core technology and related manufacturing process.

7. P&W may not release, prior to completion of initial flight rating tests, any detailed "how-to" instructions pertaining to specific advanced design and manufacturing technology methods and processes, such as the following:

a) Transient Liquid Phase (TLPR) bonding techniques.

b) Directional Solidification (DS) of Turbine material. Raw Castings must be manufactured, heat treated, and inspected in the U.S.

c) Powdered metallurgy, and hot isostatic pressing technology for manufacturing discs and other high stress parts. Solid ingots or billets formed from powdered metal may be exported.

d) Processing and manufacturing technology for advanced nickel alloys, such as B-1900, PWA 1455, Super Waspalloy, and MERL 72 (processing only), and for the NiCrALY family of Coatings.

8. In the development and production phases, high pressure turbine discs, blades, and vanes, these components must be manufactured only in the U.S. if they are of U.S. origin.

9. Development of any advanced versions of the JT-10D engine involving technology beyond the level approved by this license must be approved by the United States Government prior to initiation.

10. In the version of the Collaboration Agreement, submitted with M.C. 24-76 on February 12, 1976, now being considered, Fiat does not appear in the basic document. However, tasks are assigned in Appendix 4, Statement of Work. These limitations and provisos should either apply to and be binding on all partners to include Fiat or Fiat should be struck from the Work Statement.

ANNEX B

USG REQUIREMENTS IN A RESTRUCTURED PLAN FOR THE JT-10D COLLABORATION AGREEMENT

1. Same as 2A.

2. Same as 2A.

3. Core engine baseline technology levels utilized by P&W in the JT-10 D engine be limited to those requested, i.e., generally the JT-9D-70 levels plus their 2G compressor technology. Any subsequent use of more advanced core technology in this engine or its later evolutionary versions would require specific U.S. Government approval.

4. P&W be authorized to work with RR in development of the core, but on the basis that P&W will provide only that design information necessary for RR to accomplish its responsibilities and refrain from transferring design know-how with respect to P&W responsibilities for the core. In the event P&W finds that specific information pertaining to its responsibilities must be disclosed in order to insure successful achievement of program objectives, such disclosure should be limited to RR only, on a case-by-case determination.

5. MTU and Fiat should not share in information transmitted under 4. above.

6. Notwithstanding any disclosures to RR by P&W as in paragraph 4. above, P&W should be constrained from transferring any "how-to" instructions on critical design, development and manufacturing techniques to any of the parties which would enable the recipient thus to attain competence equal to P&W in such areas as the 2G compressor design and high temperature materials, coatings and associated manufacturing processes required to achieve baseline or higher technology. This constraint should be enforced for an appropriate period of time subject to further review and approval of the USG.

7. Fiat does not appear in the basic agreement as a partner, however, tasks are assigned in Appendix 4, Statement of Work. The limitations and provisos of the proposed collaboration agreement should either apply to and be binding on all partners to include Fiat or Fiat should be struck from the Work Statement.

8. Technical data pertaining to "crown jewels" reflected in Appendix 5, may not be transferred without prior approval of the USG.

ANNEX C

USG REQUIREMENTS IN A RESTRUCTURED PLAN
FOR THE JT-10D COLLABORATION AGREEMENT

1. Same as 2A.

2. Same as 2A.

3. The final agreement limits the level of technology to the JT-10D data described as embodied in P&WA engines qualified prior to January 1, 1975, i.e., through the JT-9D-70 engine, with the addition of 2G compressor technology. P&WA is given overall system and integration responsibility.

4. Each participant company will provide its own technology for the portion(s) of the engine for which it is responsible.

5. In the design and development phase, P&W alone must design, develop, and integrate the core, (including the compressor, the combuster, and the high pressure turbine) into the engine. P&WA will also take specific steps acceptable to the U.S. Government to protect this technology.

6. Technical data and other information pertaining to technologies reflected in Appendix 6, "Crown Jesels" may not be transferred without the prior approval of the USG.

7. Air Force Aero Propulsion Laboratory be designated as the monitor of the export of core technology and related manufacturing processes.

8. P&W may not release, prior to completion of FAA certification, any detailed "how-to" instructions pertaining to specific advanced design and manufacturing technology methods and processes, such as the following:

a) Transient Liquid Phase (TLPR) bonding techniques.

~~CONFIDENTIAL~~

b) Directional Solidification (DS) of Turbine material. Raw Castings must be manufactured, heat treated, and inspected in the U.S.

c) Powdered metallurgy, and hot isostatic pressing technology for manufacturing discs and other high stress parts. Solid ingots or billets formed from powdered metal may be exported.

d) Processing and manufacturing technology for advanced nickel alloys, such as B-1900, PWA 1455, Super Waspalloy, and MERL 72 (processing only), and for the NiCrALY family of Coatings.

Such information shall be considered for release on a case-by-case basis and shall not be released without U.S. Government approval.

9. In the development and production phases, high pressure turbine discs, blades, and second stage vanes must be manufactured in the U.S. only.

10. Development of any advanced versions of the JT-10D engine must be approved by the United States Government prior to initiation.

11. Fiat does not appear in the basic agreement as a partner; however, tasks are assigned in Appendix 4, Statement of Work. The limitations and provisos of the proposed collaboration agreement should either apply to and be binding on all partners to include Fiat or Fiat should be struck from the Work Statement.

~~CONFIDENTIAL~~

THE WHITE HOUSE

WASHINGTON

July 16, 1976

MEMORANDUM FOR JIM CONNOR

FROM: BILL GOROG *WHG*

SUBJECT: Press Plan for Release of Information on Rolls Royce - Pratt Whitney Engine Program

Announcements of this type are normally handled directly by the State Department, and it is suggested that we conform to their regular procedures in this regard.

I have attached a short press briefing note, which may be helpful in their formulation of a release.

I suggest that Bill Rhatican handle coordination matters to see that State follows through in the best possible manner.

cc: Mr. Rhatican

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TASK FORCE REPORT ON ASSESSMENT OF US/ROLLS ROYCE GAS TURBINE TECHNOLOGY

7 July 1976

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CONTENTS

ATTACHMENTS

BACKGROUND

The Department of State issued a license on 8 June 1973 to Pratt & Whitney (P&W) Aircraft to allow release of unclassified technical data to potential European partners for use in design and installation studies of the development of a new commercial high bypass turbofan engine in the 25,000 lb class. This license and later amendments included several restrictions, the most significant of which were:

1. Design details on the core high pressure compressor and turbine was to be limited to P&W personnel.

2. Turbine rotor inlet temperature "red line" will be limited to 2485° F, with growth to higher temperatures requiring Government approval.

3. No data will be released relating to that version of any part initially incorporated into a qualified P&W engine subsequent to 31 December 1974.

Since the original license in 1973, several major changes have been made in the proposed Rolls Royce Pratt & Whitney agreement to jointly develop the JT10D engine.

In the present proposed program, Rolls Royce has the development responsibility for the fan, fan exit case, diffuser/combustor and high pressure turbine nozzle, low pressure turbine shaft and bearings 1, 2, 3 and 4.

The agreement also states that each party is to make available to the other its most advanced information, subject to the receipt of any necessary government approvals.

Purpose

The purpose of this task force (Attachment 1) was to examine the level of turbine engine technology that Rolls Royce and Pratt & Whitney are capable of employing in the proposed JT10D joint development programs and to determine if there is any possibility of technology transfer between the two concerns. If any technology flow were found to favor Rolls Royce, the team was then to provide recommendations to minimize the possibility of any loss of advanced U. S. technology. Team members are listed in Attachment 2.

TECHNOLOGY TRANSFER POSSIBILITIES

Technology may be transferred in several ways:

1. Sale of hardware. This method results in the last transfer of technology since considerable effort must be expended to "reverse engineer" a product.

2. Sale of manufacturing drawings. Permits manufacture of specific parts but does not transfer design technology.

3. Sale of materials processing data, manufacturing technology and specifications through licensing arrangements. Releases more technology than above 2 items and could lead to a shortened time for "reverse engineering."

4. Joint development and production program. This permits the greatest transfer of technology since the details of design, testing and overall management must be exposed.

"Advanced Technology" is a short-lived commodity as long as advanced programs are sufficiently supported. With this in mind it is possible to specify a time limit for technology release but some means of governmental review must be provided.

Item 4 of Dr. Currie's Terms of Reference (Attachment 1) indicates that a primary desired output is an indication of the elements of technology that should be protected or safe-guarded. **In the team's opinion, the most important element to eliminate is the clause which states, ". . . this collaboration is entered into on the basis that each party will make available to the others, for the purpose of accomplishing the effort undertaken by each party under this collaboration and subject to the terms of this agreement, the most advanced information available to it and which it is entitled to furnish for the purposes hereof without thereby incurring liabilities or obligations to any third party."** This clause forms an uncontrolled channel through which any information, classified or unclassified, can be funnelled with no review process and no time limitation. It provides absolutely zero protection for technology gained by US public funds.

The second most important element to eliminate is consideration of an artificial limit such as a "red line" temperature. The arbitrary statement that this parameter is limited to some fixed number, despite the fact that the turbine blade's temperature capability is much greater, is a poor and totally ineffective approach.

If the technology contained in the engine is to be judged, it must be examined in two ways. The first is the value to the receiver -- Rolls Royce. The second is the value it might have to a third party in terms of some later national security threat. The team's evaluation of these two approaches follows:

VALUE / COMPONENT	TO ROLLS ROYCE	TO NATIONAL SECURITY
COMPRESSOR	HIGH	LOW
COMBUSTOR	MODERATE	MODERATE
TURBINE	HIGH	EXTREMELY HIGH
CONTROLS	LOW	LOW
MATERIALS	MODERATE	HIGH
MANUFACTURING PROCESSES	MODERATELY HIGH	VERY HIGH

RELATIVE TECHNOLOGY LEVELS--EXECUTIVE SUMMARY

With the limited number of personnel and short amount of time available to the team it was impossible to cover all the aspects of technology involved in the design, development and production of an advanced turbine engine such as the JT10D. The team concentrated on the following areas of technology:

1. Compressors
2. Combustors
3. Turbines
4. Materials
5. Manufacturing Technology

A short summary of the technology assessment of each of the above areas follows with a more detailed analysis presented in the attachments.

Compressors

It is evident that Rolls Royce has less experience with advanced compression system technology than the U.S. U.S. industry has incorporated technology into engines which will be in production by 1977 which is equivalent to the technology which Rolls Royce is just now beginning to transfer from the rig test stage to demonstrator engine running. In terms of demonstrated production capability, Rolls is several years behind U.S. industry. Without incentive or transfer of capability from Pratt and Whitney, it is unlikely that they will be able to reduce their lag in this vital area to less than perhaps 4-6 years. Farther in the future, they have indicated no compressor technology programs to advance their level of aerodynamic capability beyond that which they are now beginning to put in an engine. With complete transfer of technology from Pratt and Whitney, it is likely they will be at compressor technology levels comparable to ours in the 1980-1983 time period.

Detailed comments are presented in Attachment 3.

Combustors

Advancements in UK combustor technology appears to be behind the U.S. in the following areas of potential in combustion:

1. Dome developments for uniform fuel distribution and emission reductions.

2. Demonstrated advanced liner cooling technique.

3. Ability to demonstrate pattern factors below 0.30 in order to improve turbine vane life.

4. New or innovative mixing or burning techniques to overcome shortcomings in above items.

Rolls' overall approach to the JT10D combustor appears to be one of accepting a relatively high pattern factor of 0.37 plus a disappointing acceptance of high NOX emission levels above the 1979 proposed standards.

It may be said however, that the Pratt and Whitney developments in the above items are far from mature and although on-going U.S. developments have the potential for large improvements, they are in most cases not yet ready for production.

A detailed analysis of the combustor technology is presented in Attachment 4.

Turbines

During the 1960's and 1970's the major U.S. engine companies have mounted aggressive programs in cooled turbine technology leading to production military and civil aircraft engines with gas temperatures in the range of 2550 to 2600°F. These engines use very sophisticated cooling techniques. Experimental programs have resulted in turbines operating with gas temperatures in excess of 3000°F.

The most advanced engines produced by Rolls Royce have turbine gas temperatures on the order of 200°F lower than the higher temperature U.S. engines and they use cooling technology of the early 1960's.

Rolls Royce does have an understanding of the required ingredients for advanced high temperature turbines. They are tooling up to produce directionally solidified blades, and they have demonstrated in their experimental shops some very advanced hole drilling techniques applicable to both turbines and combustors. They have, and are, building some advanced cooling configurations for testing in their High Temperature Demonstrator Unit (HTDU). However, the actual experience with high temperature turbines is quite limited. Except for their early 1960 technology in their production engines, they have only 28 hours test experience at gas temperatures in the range 2300°F to 2730°F in their HTDU.

In addition, their analytical tools for designing cooled turbines for production of heat transfer characteristics, and for predicting the low cycle fatigue life of turbines are far behind those in the U.S. Technology transfer resulting from a joint venture with Pratt and Whitney would most likely be in the area of analytical design and prediction techniques and learning from Pratt and Whitney's far greater actual experience with high temperature operation.

A detailed analysis of the combustor technology is presented in Attachment 5.

Materials and Manufacturing Technology

Attachment 6 presents the details of the assessment of the materials and manufacturing technology of Rolls Royce as compared to Pratt and Whitney.

In general, Rolls Royce is lagging the U.S. in casting techniques, powder metallurgy, hot die forging and high temperature materials capability. Rolls Royce and Pratt and Whitney appear to have equivalent capability in coatings and method of application for turbine blades. In the area of joining, Rolls Royce is using a different approach than Pratt and Whitney but the final results are equivalent.

As a general summary of Rolls Royce capability in materials and manufacturing in comparison to U.S. technology levels, the following is a combination of perceived and intuitive impressions received during the very limited time available for the assessment. Particularly noteworthy is the fact that, despite numerous requests, no actual production facilities were displayed at either Derby or Bristol, although some developmental manufacturing was observed at Bristol.

1. Casting.

a. In directional solidification of investment castings for turbine blades and vanes, Rolls Royce is at least two, and possibly four, years behind current U.S. capabilities. This refers to production yields, production quantities, and ability to make complex shapes.

b. Rolls Royce has no capability, and no stated interest, in large engine castings of either titanium or nickel alloys.

2. Joining.

a. Electron beam welding is the preferred joining technique at Rolls Royce, with more extensive application than in the U.S. Capability appears to be very good, at least equal to U.S.

b. Diffusion brazing (equivalent to Transient Liquid Phase Bonding) has been used on production hardware. Details were not available, but capability seems to be very good.

c. Inertia bonding as a manufacturing method is in its infancy at Rolls Royce, and has only very limited production application. Level of capability is considered low, and at least three years behind U.S. technology.

3. Powder Metallurgy.

a. Rolls Royce stated interest is only in superalloys, with heavy emphasis on low-carbon Astroloy for turbine disks. This activity is at the development level only; no such disk has yet been rig tested. In the U.S. similar disks are in flight engines, at least four years ahead in the state-of-the-art.

b. No capability was observed for powder metallurgy titanium, or for shapes other than "sonic" (the first machined shape made from disk forging). The attainment of this capability would represent significant improvement in material utilization and reduction in overall manufacturing cost.

4. Hot Die Forging.

a. Rolls Royce has no capability in this area. U.S. production engines have turbine disks manufactured by this method. Development lead time lag is estimated to be at least five years.

5. Coatings.

a. Current production coatings in U.S. and at Rolls Royce appear to be equivalent with respect to capability and method of application.

b. Advanced coating activity at Rolls Royce is emphasizing platinum-aluminum systems, and is still in developmental rig testing stage. Rolls Royce has no capability, and apparently little interest, in MC_rAlY coatings, now used on U.S. production engines. Such materials could fill a gap between current and planned Rolls Royce coatings.

6. Alloys.

a. For directionally solidified airfoils, Rolls Royce materials capability is at least 35°F less than current U.S. production alloys.

b. In turbine disks, the technology gap between low-carbon Astroloy and isothermally forged IN-100 is about 65°F, and five years.

c. The difference in high temperature sheet material capability, such as for combustor liners, is estimated to be about 100°F for current production engines. For advanced alloys, this variance could be as much as 200°F.

Comparison of Pratt & Whitney and Rolls Royce Engines in U. S. Air Carrier (Airline) Operation:

Comments by A. K. Forney, FAA

There are several different engines manufactured by both Pratt & Whitney and Rolls Royce in U. S. Air Carrier (Airline) Service. These engines include:

Pratt & Whitney	Rolls Royce
JT3D	Dart
JT8D	Spey
JT9D	RB-211

For the purpose of this comparison only the JT9D and RB-211 engines will be used because all the others are old and do not represent very recent technology. The Pratt & Whitney JT9D engine entered airline service in January 1970 in the Boeing 747 airplane. It is also in a version of the Douglas DC-10 airplane being operated by Northwest and Japan Air Lines. The Rolls Royce RB-211 engine entered airline service in the Spring of 1972 in the Lockheed L-1011 airplane.

One of the parameters used by airlines to evaluate engine performance is "In-flight shutdowns" per 1000 engine flight hours. None of the high by-pass ratio engines is yet as good on the basis of this parameter as the lower by-pass ratio engines which entered service earlier. However, as of this date (July 1976), all three of the high by-pass ratio engines have improved significantly from what they have been earlier. In fact, according to data available to the FAA, the in-flight shutdown rate per 1000 engine flight hours for the Rolls Royce RB-211 today is as good as that rate for the Pratt & Whitney JT9D. The rates are close to 0. 3 to 0. 4 shutdowns per 1000 engine hours. The fact that the RB-211 is as good as the JT9D indicates that Rolls Royce has demonstrated the ability to solve fairly quickly the problems that have occurred in service. This fact is significant because the RB-211 engine is in a 3-engine airplane whereas the JT9D is primarily in a 4-engine airplane. Therefore, the JT9D engine has accumulated operating time at a much faster rate than has the RB-211.

Advanced versions of both the JT9D and the RB-211 have been issued FAA Type Certificates. These advanced engines are identified as the JT9D-70 and the RB-211-524. A comparison of the usual performance parameters used to evaluate technology level for these two engines with those same parameters for the planned JT10D engine shows that all three engines are essentially the same. I conclude, therefore, that the JT10D engine is not an advanced technology engine but an existing technology level commercial engine of a new thrust size.

CONCLUSIONS AND RECOMMENDATIONS

The Task Force concludes that there will be no real two-way flow of technology between Pratt & Whitney and Rolls Royce in the proposed JT10D venture. Virtually all of the critical advanced technology flow will be from Pratt & Whitney to Rolls Royce. Although the JT10D engine as initially specified at the approximate 24,000 lb thrust level could possibly be accomplished with a technology level more or less common to the two companies, conservative design (sealing, cooling, metallurgy, manufacturing processes, etc.), plus the desire to gradually upgrade the thrust level to the vicinity of 30,000 lb will most probably involve the use of advanced technologies developed in the United States and important to the U.S. leadership both in military and civil engines. Moreover the complex technical interfaces established between the two companies guarantees transfer of much design experience and methodology.

Any decision favorable to the proposed JT10D program must, in view of the above, be based on factors other than a balanced two-way flow of technology. If such a favorable decision is reached the Task Force strongly recommends the following stipulations be part of the agreement:

1. It is recommended that the open ended statement permitting the use of the most advanced technology in the JT10D program be removed from the proposed agreement and that a time phased program for the release of any necessary advanced technology be instituted by the U.S. Government.

2. A single point of contact within the DOD should be established as the focal point for the release of any technology to be utilized in the JT10D program.

3. A Government-to-Government agreement be accomplished providing protection to "Unclassified, Advanced Technology" as in the GE SNECMA arrangement.

4. That design methods, systems, and broadly effective data in the turbine materials and manufacturing methods be given the status of "Unclassified, Advanced Technology" as most important; similarly, the compressor design system, limitations and detail, warrant similar treatment.

Ray M. Standahar

Ray M. Standahar
Task Force Chairman

DIRECTOR OF DEFENSE RESEARCH AND ENGINEERING
WASHINGTON, D. C. 20301

29 JUN 1976

MEMORANDUM FOR MR. RAYMOND STANDAHAR

Reference: DDR&E memorandum, dated 22 Jun 1976, JT10D Engine Program

SUBJECT: Terms of Reference for JT10-D Team

As discussed with you in my office 28 June 1976, the following are terms of reference for the team of experts visiting Rolls Royce to perform a technical assessment of the proposed JT10-D engine program in accordance with referenced memo.

1. Assessment of team will be used as one of a number of factors in arriving at a decision as to the allowable arrangements under which the proposed joint venture on the JT10-D engine can proceed.

2. The team should establish those production technologies which could be incorporated in a commercial JT10-D engine.

3. A principal purpose of the visit to Rolls is not to just gain a unilateral access and view of Rolls Royce technology, out of context to its relationship with a commercially-oriented JT10-D engine.

4. Under the assumption that a JT10-D program might go forward, I want to be apprised of those specific manufacturing technologies and design methodologies in which it may be in the national interest to afford some special degree of protection.

5. I would expect that this assessment will culminate in a discussion with DepSecDef Clements and myself, and later a short written report summarizing the major considerations.

Malcolm R. Currie

cc:
Team Members

Attachment I

The Task Force was formed in accordance with DDR&E Memorandum dated 29 June 1976 (see attachment 1) and consisted of 6 DOD personnel and one from FAA. Members and duty titles are as follows:

Mr. Raymond M. Standahar	Staff Specialist for Propulsion (ODDR&E)
Mr. Ernest C. Simpson	Director, Turbine Engine Division, Air Force Aero-Propulsion Laboratory
Mr. Adrian K. Forney	Chief, Engine Section, Flight Standards Service, Federal Aviation Administration
Mr. Jerome K. Elbaum	Technical Manager, Fabrication, Manufacturing Technology Division, Air Force Materials Laboratory
Mr. Jack B. Esgar	Chief, Air Breathing Engines Division, NASA Lewis Research Center, Cleveland, Ohio
Mr. Eric Lister	Head, Exploratory Development Division, Naval Air Propulsion Test Center, Trenton, New Jersey
Mr. Roger L. Spencer	Aerospace Engineer AFAPL/TBD Wright-Patterson AFB, Ohio

<u>Itinerary in United Kingdom</u>

Derby	July 2-5
Bristol	July 6
London	July 7

Fans and Compressors

While design analyses have improved markedly over the past 20 years, engine technology and development are still largely dependent on experimental test efforts. Thus, the technological capability of the gas turbine industry can be evaluated by reviewing the status of experimental efforts or rigs, engine simulation tests, prototype or flying engine programs, and finally production engine programs.

Fans: Cycle requirements for high bypass ratio turbofan engines dictate fan aerodynamic designs which are well within the state-of-the-art of U.S. industry or Rolls Royce. Mechanically, Pratt and Whitney has incorporated a hollow fan disk in the JT9D-70 engine. Rolls Royce has not pursued this approach in development but apparently does have the capability to manufacture a disk of this design. Association with Pratt and Whitney, and assimilation of Pratt and Whitney experience with this approach to weight reductions will probably result in the transfer of that capability into future Rolls Royce developments. Recent bird ingestion requirements, imposed primarily by the FAA, have resulted in the addition of several new considerations in fan structural design. While U.S. industries and Rolls Royce all have slightly differing experiences and approaches to the problem of designing for this, no one company can be assessed as having a significant technological advantage in this aspect. Other than hollow disk technology, little transfer of high bypass fan technology would be expected.

Compressors: Compressor technology which has been incorporated into production engines is illustrated on Table I. When compared on an overall basis on a plot of pressure ratio versus equivalent isentropic work with lines of constant number of stages, and lines of constant technology, it is evident that the RB-211, the Olympus 593, and the TF41 (Spey) are all of a comparable aerodynamic technology level which is somewhat lower than that in the JT9D-70 or TF39. The Rolls Royce technology is roughly equivalent to that used in U.S. production engines around 1960. Since the earliest of these Rolls engines was certified in the 1970-1971 time period, there is about a 10-year difference between Rolls Royce demonstrated production engine capability and U.S. production engine capability.

Compressor technology which has been incorporated into flyable engines, but not yet in production is an indicator of the near term future capability. This is compared on Table II. On the same type of comparison basis as above, it is evident that the compressor technology in the RB-199 is clearly comparable to that in the recent Rolls production engines, the RB-211 and the Olympus 593. The U.S. non-production but flyable engines range from slightly more advanced than current high bypass turbofans in terms of compressor technology to significantly more advanced. All the recent U.S. compressors in this category are very definitely supersonic in the tip area of the first several stages, whereas the Rolls compressors are barely transonic. This is significant in that future compressor work is tending toward more rugged designs which require higher pressure ratios in fewer stages to keep weight and volume down to reasonable levels. Supersonic designs are the only known practical way to achieve this.

Rolls Royce does not run demonstrator engines comparable to the U.S. Air Force's advanced Turbine Engine Gas Generator (ATEGG) programs and instead, rely upon the early portions of an engine development program and rig tests to further develop their compressor designs. Table III provides examples of compressor technology which has reached this status. Here, compared as before, the RB-401 compressor is only marginally lower in technology than the Pratt and Whitney S/C ATE Compressor. Both of these compressors are significantly better than any existing production engines but only slightly better than the F101 compressor. This is significant in that the RB-401 compressor is the only advanced state-of-the-art compressor on which Rolls has any engine experience. First run in December 1975, problems with the engine have kept running time to only 115 hours to date so they have much to learn about the characteristics of this machine. However, it is apparently their first major step in high pressure compressor advancement in the past 10-15 years.

Rig testing of advanced compressor designs is essential to establish a basis for future technology advancement. Table IV describes compressors at this stage of development. Significantly, all the Rolls Royce compressors shown are based on the same design. No other advanced compressor work is known. These compressors, when developed, will provide a compressor capability comparable to that in the U.S. in 1977-1979. Applied to the RB-401 this compressor technology will be available around 1980-1981. Current U.S. rig technology in compressors is now turning toward the next generation of compressors. Rolls has indicated no programs to advance the compressor technology base beyond that they have already demonstrated.

Reviewing the Rolls compressor designs it is evident that many compromises have been made in mechanical-aerodynamic design because of deficiencies in their technological base. This is evidenced by the fact that Rolls compressors operate at higher corrected speeds in the aft stages of their compressors. This is done by building constant outside diameter (OD) or increasing OD compressors. This has undoubtedly resulted in weight penalties to their engines. Advanced compressor manufacturing techniques and material will allow them to operate at high wheel speeds and improve their designs. This capability is also a major area in which they stand to gain from Pratt and Whitney experience.

SELECT PRODUCTION ENGINES

YEAR	1971	1971	1975	1975	1975	1975	1968
SOURCE	RB211 -22IP	RB211 -22HP	RB211 -524IP	RB211 -524HP	OLYMPUS 593	JT9D -70	TF39
TIP REL MACH NO.	1.005	1.004	1.08	1.05	.886	.99	.99
TIP SPEED	1203	972	1317	972	920	1028	1181
HUB-TIP RATIO	.682	.815	.711	.815	.593	.717	.48
W_A/A_A	37.0	36.2	38.6	38.7	37.3	37.6	40.5
PRESSURE RATIO	4.57	4.5	4.61	4.65	3.92	10.0	16.8
η_{AD}	86	84	85	82	86	84.8	83.8
No OF STAGES	7	6	7	6	7	11	16
VARIABLE STAGES	IGV	BLEED	ICV	BLEED	NO	IGV + 3	IGV + 6

TABLE I

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FLYING NON-PRODUCTION ENGINES

YEAR	1971	1971	1975	1974			
SOURCE	RB199HP	RB199IP	F101	J101LP			
TIP REL MACH NO.	?	?	1.29	1.5			
TIP SPEED	?	?	1345	1534			
HUB-TIP RATIO	?	?	.70	.44			
WA/AA	?	?	36.5	40			
PRESSURE RATIO	3.6	2.3	11.8	3.9			
η_{AD}	?	?	85	82			
No OF STAGES	6	3	9	3			
VARIABLE STAGES	?	?	IGV + 3	IGV + 2			

TABLE II

DEMONSTRATOR ENGINES

YEAR	1975	1976	1974				
SOURCE	RB401	P & W S/CATE	DDAD				
TIP REL MACH NO.	Approx 1.2	1.08	1.12				
TIP SPEED	?	1376	1254				
HUB-TIP RATIO	.67	.574	.76				
W_A/A_A	?	37.6	39.0				
PRESSURE RATIO	10.42	17.9	6.9				
η_{AD}	80.0	83.3	81				
No OF STAGES	8	12	6				
VARIABLE STAGES	IGV + 3 BLEED	IGV + 5	6				

TABLE III

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MULTI-STAGE AXIAL COMPRESSOR RIGS

YEAR	1973	1970	1970	(1969) 1966	1975	1975	
SOURCE	RC34B	RC34B	RC34B	RC34B	DDAD HTF	P & W ALT ATE	
TIP REL MACH NO.	1.314				1.64	.995	
TIP SPEED	1350				1500	1290	
HUB-TIP RATIO	.52	.67		.67	.325	.617	
W_A/A_A	40.4				44.8	37.4	
PRESSURE RATIO	16.5	11.53	10.1	7.01	12.0	17.4	
η_{AD}	83.5	83.6	-83.3	84.4	83.0	83.6	
No OF STAGES	9	8	7	6	5	11	
VARIABLE STAGES	IGV + 3 1 BLEED	IGV + 3 BLEED	IGV + 3	IGV + 2	IGV + 5	IGV + 4	

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TABLE IV

Combustors Summary

Advancements in UK combustor technology appears to be behind the US in the following areas of potential in combustion:

1. Dome developments for uniform fuel distribution and emission reductions.

2. Demonstrated advanced liner cooling technique.

3. Ability to demonstrate pattern factors below .30 in order to improve turbine vane life.

4. New or innovative mixing and burning techniques to overcome short-comings in items 1, 2 and 3 above.

Their overall approach to the JT10D combustor appears to be one of acceptance of a relatively high pattern factor of .37 (about what P&W has been demonstrating in the JT10D), plus a disappointing acceptance in high NOX emission levels above 1979 limits (owing to a total absence of dome and fuel staging R&D in NOX reduction). In favor of the UK's approach however, it may be said that the US developments in items 1 through 4 described below are in many cases far from mature; meaning that although the potential for vast improvements are there in the on-going US developments, they are in most cases not ready for production yet nor will they see production applications for at least the next 5-7 years.

US Technology

In the combustion technology area of turbine engines advancement has been made in the reliability and the maintainability areas as well as in the performance category. In rig tests and the ATEGG program, the General Electric combustor with shingle liners has excelled. The shingle liner concept allows the load to be carried by the outer shell while the inner shingle cooled by a film impingement technique contains the flame. The shingles are easily replaced allowing for ease of maintenance while the cooling scheme provides long life. This combustor uses an axisymmetric pre-diffuser, high area ratio dump, low pressure fuel injectors, air atomizing domes, and combination film/impingement cooled shingle liners. The temperature rise is 2800°F with a burner exit temperature of 3700°F with a pressure drop of 5.5%. Space rate is 8 million BTU/hr-atm-ft^3 with a pattern factor less than 0.2 when everything is working right. The expectant combustor life is 3,000 hours.

Two other designs, while not sufficiently developed to be considered state-of-the-art, should be mentioned. P&W's as yet unbuilt swirl combustor promises to provide a high temperature rise, a savings in weight and a good lean blow-out limit while using only half of the cooling air that current combustors use because of its fin wall design. This swirl combustor is piloted and uses pre-mixed fuel. The design shortens the required length for a high Mach burner. Detroit Diesel Allison's vortex control diffuser, the second design of interest, provides excellent diffusion at high through-flow, high Mach numbers. Pressure recovery is about 74% with reasonably low pressure losses of about 6 1/2% in a diffuser-combustor design.

In the category of full-scale engines, the engine of the B-1 has the leading combustor. General Electric's F101 engine has an advanced short compact combustor with high heat release. The system is annular, film-cooled with central injection domes, and low pressure-drop injectors. Combustor length is 11 1/4" with a total system length of 15.2". Its pressure drop is about 5.1% with a temperature rise of 1480°F providing a 2750°F burner exit temperature. The combustor has a pattern factor of about 0.25 with a space rate of 5.5 million BTU/hr atm ft^3. Expected life is 1,000 hours.

The best combustors of current engines in production are in the GE CF6-50 and the P&W F100. The CF6-50 uses conventional film cooling in an annular arrangement. It provides a 1500° temperature rise for a burner outlet temperature of 2500°F. Pattern factor is about 0.27, and its pressure loss is about 5%. This engine designed for transport use has a 3,000 hour life.

The F100, the engine for the F-15 and F-16 fighter planes, has a combustor system which is annular with film cooling. The combustor uses an air-blast injection system, and is 10.8 inches long, with an overall length of 18.4 inches. Space rate is 6.3 million BTU/hr atm ft^3 with a pattern factor of about 0.25. Pressure loss is nearly 5.2% with a temperature rise of 1340°F providing an exit temperature of 2700°F.

<u>UK Technology vs US Technology</u>

In production and R&D fuel injection systems, both the UK and US are using injectors that essentially act as atomizing mixers to mix fuel and air before it enters the combustor: Known as airspray, airblast and carburizing fuel injectors. Unlike the US however, the UK is still working with the old J65 (UK "Sapphire") candy cane type injector and both their Hi Temp Demo Unit core as well as the RB-199 full scale engine. This type injector suffers from high carbon buildup. The JT10D will most likely use the atomizing mixer type.

In dome and fuel staging R&D there appears to be no work going on in either pre-vaporizing (mixing fuel and air before the dome) or in axial staging of fuel entry both of which have significantly reduced emissions in the US at PWA, GE and DDAD R&D efforts. No production engine in US or UK uses these items yet.

In liner cooling, both the UK and US are using film cooling of machine rings in production as well as R&D programs. In R&D both US and UK have transpiration cooled materials (Transply and Lamilloy) which could serve possibly as an advanced liner if the repair procedures can be developed. One liner area where the US is clearly ahead is in the removeable shingle advanced film cooled liner which has demonstrated excellent potential as a high heat release, short length, low cooling air, liner (as opposed to machined ring liners). This last item, however, is GE's and not PWA's.

It is considered probable that the liner in the JT10 if developed by PWA or RR/Bristol will be a machined ring type with film cooling.

Regarding pattern factor, the UK seems to accept rather poor values which makes burner development easier and turbine vane cooling design much harder. Typical values on the RB-211 and TF 41 range from .35 to .55. RB-211 and TF-41 both have vane distress problems from metal temperatures being too high owing to poor pattern factors. Pattern factor on the three JT10D's built at PWA have attained P.F.'s over .40. RR design goal is .37.

Regarding new combustion systems that use swirling flows to promote excellent mixing and burning in very short lengths, only PWA is known to be working on this in the US for both main combustors and augmentors. When quizzed on technologies in augmentor combustion which are considered to be precursors to swirl during the RB-199 review, the engineers from Bristol immediately shut-up on a topic when it was obvious that they had something to say. None of the UK personnel referred to any R&D or production using swirl flows in combustion.

TURBINES

Aerodynamics: The turbine aerodynamic capabilities in the U.S. and at Rolls Royce appear to be on a par. In both the U.S. and U.K. the Aerodynamic characteristics are evaluated in cold and warm air turbines. In the warm air turbines cooling air is injected into the gas stream from the test blades and the ratio of gas stream temperature to cooling air temperature is maintained in the warm air turbine at the same ratio as in a hot engine. Rolls Royce also tests in a cold air two-spool turbine.

Both Rolls Royce and General Electric have built engines incorporating single stage, transonic high work turbines for driving the high pressure compressor. The Rolls Royce engine is in its early stages of development, but it is believed that Rolls Royce has an adequate understanding of the transonic turbine, its advantages, and its shortcomings.

There do not appear to be any problems with technology transfer from the standpoint of turbine aerodynamics.

High Temperature Cooled Turbines: Turbine component development in the United States over the past 20 years has been characterized by advancements in the capability to operate both at higher gas temperatures and, by controlling leakages, at higher gas pressures. This advancement results largely from the continuing development of fabrication capabilities which allow safe operation at ever-higher gas temperatures and are included in new engines and as modifications to existing engines. These developments rather than signifying quantum jumps in gas temperatures, introduce a capability for growth.

Also, the industry recently became aware of another dimension in the durability of military engines, low cycle fatigue (LCF). For the last five years, turbine blading (nozzles and rotors) cooling design has centered on making the blading insensitive to LCF. The USAF believes that its technology should not be traded because of the exacting effort required to combat the problems of both high temperature, pressure, and LCF, not because of outright performance comparisons.

Starting in the 1960's U.S. development of turbine component performance capabilities centered on two concurrent approaches:

1. Improvements for immediate fabrication and use in engines, and

2. development of ultimate performance capability.

In the first approach, STEM (Shaped Tube Electrostatic Machining) drilling was developed to allow design of rotor blading with straight radial cooling holes. This capability was used in the J93 and is currently used in the TF34. Both engines are designed for use at less than 2300°F turbine rotor inlet gas temperature. The TF34's recent experience with LCF problems demonstrates the reason for superseding this type of cooling fabrication. The RB-211 rotor blading relies on the same cooling method, augmented with the film cooling. The J-58, the GE 4, and the TF39 represent the next generation of cooling schemes and rely on cast blading with a variety of cooling designs. Specifically, these are impingement, internal turbulence devices, and film cooling, primarily on the leading edge. These engines, especially the TF39, have shown a much better tolerance to LCF. Improved models of these designs are now used in the F100, F101, JT9D, and CF6. Improvements to these designs, through improved fabrication technology, are continuing.

The second approach, which aims at developing ultimate performance capability, centered on exploratory and advanced development efforts. These efforts included the following:

a. Vap Com Turbine - 4000°F TIT; 1962/64; turbine rotor run with H_2 fuel, but shop air film cooling; no damage to parts.

b. High Operating Temperature Turbine (HOT) - Modified JT4; used to run 2700°F TIT; 1962/64; damage to rotor blades, caused by sealing problems; lack of technology in burners and blading.

c. High Temperature Variable Turbine (HTVT) - rotor run to 3200°F; 1964/68; lack of understanding of cooling supply circuit pressure losses and film stability over a rotor resulted in loss of air to rotor tip case shroud; rupture of shroud, loss of nozzle cooling air, and destruction of rotor.

Efforts at increasing performance capability have continued into the 1970's. To date, the rotor has been run at a maximum TIT of 3400°F, has 1000 thermal cycles, and 60 start-stop cycles. It experienced no damage. Beginning with this high temperature program, the Advanced Turbine Engine Gas Generator (ATEGG) development began to actively coordinate with exploratory development in 1972. In a second ATEGG program, laminated construction blading has been tested up to 3500°F. In addition, two exploratory development programs are in process now to develop basic laminated cooling fabrication technique, and another effort is being conducted in an F100 core engine at PWA. The big 3 ATEGG contractors have all tested these core engines to sustained temperatures ≥ 3000°F.

Considerable effort also has been expended in ATEGG to assess leakage control. Several seal and blade cooling exploratory development programs are now in progress. All are aimed at a TIT $\geq$ 3000°F using basic designs now employed in ATEGG and/or operational engines.

In regard to development engines, F101 has a TRIT which is red-lined at $\approx$ 2600°F. The three-hundred hour qualification testing has been completed. The cooling design is basically the same as that of the ATEGG programs, and therefore has a potential for 3400°F. However, the cooling scheme was modified to reduce cost and cooling air consumption, and the design was derated to prolong life. As a result significant LCF life is available compared to the TF34. Seal development carried out in this engine follows closely the seal development in ATEGG.

The F100 and CF6 exemplify current production engines. The F100 has a TRIT which is red-lined at 2550°F. This is the highest known for a supersonic aircraft. A TIT potential of 2900°F is being developed in an exploratory development contract. Moreover, a TIT potential of 2750°F without increasing cooling air has been demonstrated in core engine testing using radial wafer blading. The CF6 has a TIT which is red-lined at 2600°F. The CF6-50 demonstrates the best turbine durability of high bypass ratios fan engines. The LCF life is adequate, but re-accels (hot rotor, cold case) are controlled to circumvent problems with seal wear. F101 development of seals is being planned for incorporation in later builds.

To provide a comparison between the level of US and UK turbine technologies, some statements on RB-211 technology follow:

RB-211 uses technology similar to that in the J93 and TF34; i.e., old technology. The TF34 has a red-line of 2200/2250°F. Initially, creep rupture was one of two limiting problems for the TF34, but more coolant cured this (radial holes and surface holes for film cooling). The second limiting factor, for TF34 the LCF problem on rotor blading, has caused the contractor extreme difficulty in developing long LCF capability because more cooling does <u>not</u> cure this problem. The TF34 experience supports US engineering conclusion that radial hole designs are LCF-limited and sensitive.

RB-211 has a good record to date, not as a result of turbine design, but because of the rigid compressor case and the resulting clearances control (no ovalization, etc.) P&W has also recognized the advantages to be gained in turbine durability by an efficient compressor because it allows reduced TIT. As a result, PWA has service bulletins recommending cold section replacement to improve hot section durability.

RB-211 rigid compressor case design has the disadvantage of requiring long warm up times before clearances close up enough to get performance. It also requires that long layover between flights be scheduled to allow the rotor to cool. TWA allows at least one-hour stops on the RB-211, which relieved the problem of re-accel seal wear. Such a problem would remain on a military application, however.

The visits to Rolls Royce at Derby and Bristol confirmed that their cooled turbine technology in production engines is similar to early 1960 U.S. technology. In general the turbine blades are either forged or cast with simple radial holes for cooling. In some cases a small amount of simple film cooling is also used.

Rolls Royce is in the process of testing advanced cooled blade and vane designs in their High Temperature Demonstrator Unit (HTDU). The HTDU is similar in concept to the U.S. ATEGG, but the emphasis is entirely on the high temperature turbine. The HTDU operates at a pressure level equivalent to a pressure ratio of 27:1 with a cooling air temperature of 900°F (somewhat lower than experienced in today's advanced engines). Their experience totals approximately 28 hours at stator outlet temperatures between 2300°F and 2730°F. As a result their high temperature experience is really only beginning, and it is far short of U.S. experience.

The cooled blade and vane configurations scheduled for investigation in the HTDU are of advanced designs similar to those in production and/or in experimental U.S. programs. It appears, therefore, that Rolls Royce has ideas of what advanced cooling schemes should look like, but as yet do not have adequate experience.

In the discussions with Rolls Royce personnel there was no evidence presented that suggested that they have analytical techniques for predicting heat transfer characteristics or low cycle fatigue life of cooled turbines that is on a par with U.S. manufacturers.

Cooled Turbine Fabrication: Most fabrication is done by Rolls Royce in-house, but they state that they always try to develop a secondary source. It is not clear that they have an adequate secondary source for advanced cooled designs. Rolls Royce has only recently (1975) began the production directionally solidified turbine blades, and their production facilities are very limited. They are clearly very much behind Pratt & Whitney in directionally solidified turbine blade technology and production, but they are at least on a par with other U.S. manufacturers.

Rolls Royce has demonstrated a capability to cast turbine blades with long small passages, and also some complex configurations. The structural reliability of their complex castings is not known.

Rolls Royce Bristol has demonstrated some very advanced fabrication techniques for providing precision small cooling holes in turbine blades. These techniques are being used in their experimental shops, but there appears to be no reasons why conversion to production is not readily feasible. Their electron beam drilling approach and their electro-chemical drilling method using glass capillaries surrounding a platinum wire produced exceptional clean and small holes at a reasonable rate. The Rolls Royce hold drilling capability is at least on a par with the U.S. capabilities. In the U.K., however, the capability seems to be concentrated at Rolls Royce, while there are multiple capabilities in the U.S.

Summary: Rolls Royce has an understanding of the required ingredients for advanced high temperature turbines. They are tooling up to produce directionally solidified blades, and they have demonstrated in their experimental shops some very advanced hole drilling techniques applicable to both turbines and combustors. They have, and are, building some advanced cooling configurations for testing in their High Temperature Demonstrator Unit. However, the actual experience with high temperature turbines is quite limited. They have early 1960 technology in their production engines, and only 28 hours test experience at gas temperatures in the range 2300°F to 2730°F. In addition their analytical tools for designing cooled turbine, prediction of heat transfer characteristics, and for predicting the low cycle fatigue life of turbines are far behind those in the U.S. Technology transfer resulting from a joint venture with Pratt & Whitney would most likely be in the area of analytical design and prediction techniques and learning from Pratt & Whitney's for greater actual experience with high temperature operation.

Materials & Manufacturing Technology

The assessment of Rolls Royce materials and manufacturing technology was performed by in-depth examination (as time permitted) of specific areas. These topics were selected based on those items previously identified as being potential sources of significant technology outflow from the US. The areas selected were:

1. Casting (including directional solidification of airfoils)

2. Joining (welding and brazing of critical components)

3. Powder metallurgy (primarily nickel-base alloys)

4. Hot die forging (isothermal forging)

5. Coatings (for oxidation and corrosion protection)

6. Alloys (superalloys for combustors, disks, turbine airfoils).

Summary charts, comparing the relative capability of US and Rolls Royce technology in these areas, are shown in Tables 1 thru 6. In these comparisons, there are several assumptions concerning the information provided by Rolls Royce:

a. It can be accepted at face value with regard to both content and timeliness.

b. It is a complete representation of their current activity.

Casting

The area of casting technology was one of particular interest in this assessment. Two aspects of this technology were considered. Primary emphasis was on the examination of capability in directional solidification of superalloy investment castings for turbine blades and vanes. Secondarily, the capability at RR for large investment castings (e.g., greater than about 15 inches diameter) was surveyed. This latter capability is easily addressed; there is none. In fact, there appears to be no interest in superalloy castings of this size. Components which might be manufactured in this way are made as extensive weldments, utilizing castings, forgings, sheet and bar stock. RR capability in directional solidification is in the advanced development stage, with establishment of a six-unit pilot production line (based on the current design of withdrawal-type units) planned for 1977. Floor-to-floor cycle time for the multi-piece castings is about 45 minutes, which is pre-programmed from the start of the melting cycle after the vacuum unit is closed. The six-station unit was stated to be capable of being operated by one man. The stations are completely independent so that malfunction of one unit does not affect operation of the others. Castings being made were small and relatively complex; these were intended for demonstrator and advanced engines. Wall thicknesses were about 30 mils overall; blade lengths were less than 5 inches. The goal for casting yield of the "production" unit was quoted as "conservatively" 50% overall for both solid and cored blades. US experience indicates that this is probably optimistic, at least for initial operation. Attainment of this yield level could easily require two to three years of production experience. This time lag is considered to be the relative differential in directional solidification capability. Beyond this, the cost goal, "equivalent to conventional investment castings", is considered unrealistically optimistic.

Joining

Rolls Royce relies heavily on electron beam welding as the joining technique for static and rotating components of titanium-base and nickel-base alloys. Some rather complex structures were displayed as examples of the utilization of this technique. The welds had a very good appearance with minimum drop-through and spatter. For rotating components, welds are placed in relatively low stressed areas; distortion was stated to be minimal, with tolerances being held to 5 mils on roundness and length. If true, this is very good control.

Frequently, weld faces are machined; but weld roots were generally left unmachined. Inspection is only by radiographic techniques. Based on fracture mechanics analyses of specific components, some weld and heat-affected zone cracking is tolerated in static structures. Process control is accomplished by pre-programming and numerical control, particularly for sloping at the start and end of welds. Repairs are made as necessary for defective welds and components. Examples of inertia welding were also observed. In one case, studs were applied to the base of titanium stator vanes as a quick fix to a development problem. For production, use of this technique is minimal, limited to joining of dissimilar materials with small joint areas (e.g., hollow shafts of Jethete about 4 inches diameter to disk stubs of Nimonic). Visually such welds were a little rough but did exhibit the existence of at least minimal capability for inertia bonding.

Diffusion brazing, at least for superalloys, was mentioned as a production manufacturing method. Typical use was for the attachment of shrouds to turbine blades, considered a fairly critical application. Details of the method (compositions; furnace times; etc.) were not available, in spite of direct questions.

Powder Metallurgy

Low-carbon Astroloy for turbine disks appears to be the only interest in powder metallurgy at RR. This activity is still at the developmental level; in response to a direct query, it was stated that no disks had yet been in a spinning rig. The present capability for hot isostatic pressing (HIP) and cold die forging was indicated to be 30 mils overall on an 18-inches diameter disk, which is of the "sonic" shape (square, flat parallel faces). Ultrasonic inspection, to a 1/64 inch diameter flat bottom hole, is now being done after machining. Inspection of as-pressed surfaces is desired but not yet feasible. As indicated in Table 3, such disks of the same material are now in flight engines in the US. This exemplifies the relatively low level of RR capability in this area. Considering that the decision to work on this material (designated APK1) was made by RR in 1972, one could conclude from the progress that the degree of interest has not been very high.

A possible reason for the slow rate of activity is that RR is depending on Henry Wiggin for powders, and HIP processing, and that facility has only recently come on stream. No RR interest in other alloys, or in other shapes, was evident. This is in direct contrast to the extensive US interest, by both government and industry, which includes: other nickel-base alloys; titanium alloys; variety of shapes; attainment of "near-net" or "net" shapes, requiring minimal machining as well as inspection methods for such shapes.

Hot Die Forging

Discussion of this area with RR personnel elicited comments that it had been considered but is not active at the present. While there was awareness of this technology in general, and specifically of isothermal forging techniques, there was no apparent interest. This may be due in part to the RR materials philosophy which places great emphasis on close attention to material processing parameters in order to derive optimum combinations of mechanical properties through precise control of microstructure.

While isothermal forging does not obviate such control, and in some instances can provide even more control, the primary goals are cost reduction through reduced machining and material utilization improvement. The lengthy and expensive background of US, and particularly USAF, involvement in this technology would be significantly reduced in time and cost by any transfer of detailed information on current practices. The development lead time with such transfer could be as little as four years.

Coatings

Here again there are significant differences, in level, as well as direction, of capability. Current RR coatings are of the aluminide type applied by pack diffusion methods. Such coatings do not afford the same level of oxidation and corrosion protection as is available from the MCrAlY coatings now being used in US production engines. Development activity on coatings at RR appears to be concentrating on platinum modifications of aluminides based on the work at DEW in Germany. Very limited data on the capability of these coatings was presented to show an advantage over CoCrAlY coatings, but the data were inadequate for a meaningful comparison. In contrast, US activity in this area is aimed at improving the performance and extending the applicability of MCrAlY coatings by improving the deposition techniques.

Alloys

As noted in Table 6, there are considerable differences in high temperature alloy capability, all of which indicate the superiority of US materials technology. It is difficult to made direct comparisons due to those variances which result from different processing techniques (e.g., forging vs. conventional casting vs. directional solidification for turbine airfoils). On the basis of current production engine bill of materials, comparison of creep strength of high pressure turbine blade alloys shows that Nimonic 115 has about 120°F less capability than Mar M 200 with hafnium, but the latter alloy is directionally solidified while the Nimonic is conventionally cast. Even Mar M 002, which RR is planning to use as a directionally solidified blade material, shows 35°F less than Mar M 200 + Hf. For turbine disks, a more direct comparison is possible. IN-100, used in US current production high pressure turbine disks, has a 65°F higher temperature capability (for the same strength level) as compared to the Astroloy now used by RR. For advanced materials, this difference is at least doubled. The alloys used for combustor liners, Haynes 188 (US) and C263 (RR), again indicate about 100^{o}F advantage for the US material. Differences of at least this same order also obtain for disk, blade and liner materials at the various levels of development. Recognition of the time required to bring new materials along through rig, component, and flight testing, prior to production commitment indicates that the higher material capability of the US can be translated as a technology lead of about four years.

Additional Comments and Observations

During the visits at Derby and Bristol several other items relating to engine hardware surfaced. These did not fit into the specific categories selected for the assessment but are believed worthy of mention with some discussion.

a. "Transply"

This is a material configuration similar in concept to the "Lamilloy", developed by Detroit Diesel Allison. Two or more sheets containing holes and air passages on the surface are fabricated to provide a transpiration cooled structure which might be useful for combustor liners, turbine shrouds, or turbine vanes. As compared to "Lamilloy", "Transply" can be characterized as:

(1) Thicker sheet, .050 - .075 inch

(2) fewer, larger holes;

(3) brazed (not bonded).

The material is sufficiently similar to "Lamilloy" so that there have been cross-licenses arranged between Detroit Diesel Allison and Rolls Royce. Alloys which have been manufactured this way include: C263; Nimonic 75; IN 586. "Transply" is supposed to be cheaper than "Lamilloy", but RR does not yet have sufficient production experience to verify this. The major obstacle to extensive use of this material will probably be the lack of repair techniques which are easy, cheap, and do not affect performance.

b. Hole drilling

Major techniques for hole drilling at RR are electron beam, capillary (electro-chemical), and electro-discharge drilling. The electron beam drilling unit observed was labeled "Steigerwald Strahltechnik". It appeared to be capable of drilling 10 to 30 mil diameter holes in 0.100 inch thick superalloy materials, at the rate of about 10 holes per second (one shot per hole). Our guide said that removal of the recast layer is not performed. Capillary drilling is used for holes of the order of 10 mils diameter through thicknesses to about 0.200 inch. Drilling rate was quoted at 2.5 mm/minute (0.100 inch/minute). This was used for turbine blade trailing edge holes, which are not usually cored during casting. Banks of 10 to 15 holes are drilled simultaneously. Electro discharge drilling is used for transpiration (gill) cooling holes on turbine blade and vane airfoil surfaces, and for the inter-connecting holes which permit impingement cooling on the interior of blade and vane leading edges. Fine wire electrodes permit holes about 10 mils diameter, but hole depth is limited to about 50 mils. Hole quality in terms of uniformity and spacing appeared generally good. Hole size and interior location are checked by airflow and the use of fiber optics.

TABLE 1

TECHNOLOGY COMPARISON - CASTINGS

LEVEL	US	ROLLS ROYCE
DEVELOPMENT	Large superalloy frame (40 in. dia)	
RIG		
COMPONENT	Titanium bearing housing (12 in. dia)	Directionally solidified airfoils - pilot plant only
FLIGHT		
PRODUCTION	Directionally solidified blades and vanes (with complex, intricate cooling passages) Application of Hot Isostatic Pressing to improve casting yield and quality	Investment casting of solid and cored turbine blades and vanes

TABLE 2.

TECHNOLOGY COMPARISON - JOINING

LEVEL	US	ROLLS ROYCE
DEVELOPMENT	Laser welding for intricate components	
RIG		
COMPONENTS	Activated diffusion bonding of turbine blades	Inertia welding of studs on titanium vanes
FLIGHT	Transient liquid phase bonding of turbine blades	Diffusion brazing of titanium and superalloy parts
PRODUCTION	Inertia welding of large (30 in. dia) superalloy rotors	Electron beam welding of small titanium rotors Electron beam welding of static structures

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TABLE 3.

TECHNOLOGY COMPARISON - POWDER METALLURGY

LEVEL	US	ROLLS ROYCE
DEVELOPMENT	-Application to very advanced alloys possible only through PM processing -Inspection techniques for near net shapes	*Application to modified conventional alloys at sonic shape; must be machined prior to inspection
RIG		
COMPONENT	-Near net superalloy shapes including: turbine disks, disk/shafts, -Near net titanium shapes	
FLIGHT	*Superalloy disks made by hot isostatic pressing and cold die forging to sonic shape	
PRODUCTION	High temperature disks made by hot die forging	

*These descriptions both relate to the same material - low-carbon Astroloy.

NOTE: Ultrasonic inspection sensitivity is about the same for all levels (1/64 inch dia flat bottom hole)

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TABLE 4.

TECHNOLOGY COMPARISON - HOT DIE FORGING

LEVEL	US	ROLLS ROYCE
DEVELOPMENT	Titanium engine disks and airframe components to sonic shapes	(No capability)
RIG		
COMPONENT		
FLIGHT		
PRODUCTION	Superalloy disks made to sonic shapes; sizes to about 25 in. dia. with ± 20 mils tolerance	

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TABLE 5.

TECHNOLOGY COMPARISON - COATINGS

LEVEL	US	ROLLS ROYCE
DEVELOPMENT	-Advanced techniques being established for ready application of aluminides to superalloys	-Compositions of the platinum aluminum type under development
RIG		-Limited data on above coatings
COMPONENT		
FLIGHT		
PRODUCTION	-Physical vapor deposition of MCrAlY coatings	-Aluminide coatings by conventional pack diffusion methods

TABLE 6.

TECHNOLOGY COMPARISON - ALLOYS

LEVEL	US	ROLLS ROYCE
DEVELOPMENT	- AF-115 (1400F disk alloy, 150F better than Astroloy)	- No dispersion modified alloys;
RIG		
COMPONENT	-Directionally solidified eutectics in turbine airfoils -MERL 72 (about 300F better than Hastelloy X)	-Directionally solidified blades (Mar M 002; about 35F less capability than Mar M 200 + HF)
FLIGHT	- Dispersion modified superalloy turbine vanes	
PRODUCTION	- IN-100 turbine disks (about 65F better than Astroloy) - Haynes 188 combustors (100F better than Hastelloy X) - Directionally solidified turbine blades and vanes (Mar M 200 + Hf)	- Astroloy turbine disks (conventional forging) - C263 combustors (about equal to Hastelloy X) - Conventionally cast blades and vanes (Nimonics)

The personnel (and titles) contacted at Rolls Royce (Derby) during the activity are shown below:

Ernest Eltis	Engineering Director New Projects Aero Division
L. G. Dawson	Head, Advanced Engineering
David Pickerell	Chief Engr JT10D
John Cundy	Chief Perf Engr
Alan Rhodes	Mgr Prod Supt RB 211
John Sadler	Proj Devpt Engr HTDU
David Davidson	Instru Specialist HTDU
Alex Stewart	Proj Engr Turb Blade Development
Harry Tubbs	Proj Engr Blade Cooling Research
David Davies	Chief Designer Derby Engines
Mike Sherwood	Proj Engr Combustion
Tony Wassell	Chief Res Engr (High Temp)
Chris Freeman	Research Specialist Compressor Aerodynamics
Dennis Head	Managing Dir., Aero Division
James Rigg	Gen Manager Derby Site
Giles Harvey	Chief Engr Engine Development
Roy Pike	Proj Engr Installation Research
Roy Hetherington	Chief Research Engr (Compressors)
Archie Macdonald	Power Plant Aerodynamics Engr (Bristol)
David Alexander	Chief Materials Engr

Geoff Meetham	Mgr Labs Res - Devpt Group
Bill Foster	Manager Precision Casting Facility

In addition, a discussion was held with Sir Kenneth Keith, Chairman, Rolls Royce, in London.

The personnel (and titles) contacted at Rolls Royce (Bristol) during the activity are shown below:

F. T. Salt	Director and General Mgr
G. M. Lewis	Technical Director
D. J. John	Director of Marketing
P. F. Orchard	Program Manager - RB 199
J. H. Dale	Program Manager - Pegasus
J. Nock	Chief Engineer - Olympus 593
P. Torkington	Chief Engineer - Development
D. McMurtry	Program Manager - M45 SD02
M. R. Williams	Chief Engineer - RB401
J.D. Wragg	General Manager - Experimental
A. H. Meleka	Company Chief - Advanced Manufac.
I. W. Ford	Works Manager - Development East
T. F. Saunders	Works Manager - Development West
J. W. Davison	Chief Manufacturing Engr - Development
J. C. Stephens	Chief Planning Engr - Development
S. E. Lowe	Quality Manager - Development
H. J. Newman	Manager - Instrument Room

A. R. Wallington	Manufac. Proj. Mgr - Rigs & Research
A. Smith	Quality Manager - Development East
A. W. Pearce	Manager - Development Assembly
W. R. Ireland	Manager - Development Machining Shop
J. Cozens	Manager - Development Blade Shop
K. Johnson	Product Development Mgr - AMD
L. Haworth	Director of Design
Graham Andrews	Chief Test Pilot
L. G. Dawson	Head of Advanced Engineering

E

ITEM WITHDRAWAL SHEET
WITHDRAWAL ID 00857

Collection/Series/Folder ID No.	:	004700431
Reason for Withdrawal	:	NS,National security restriction
Type of Material	:	MEM,Memo(s)
Creator's Name	:	A.K. Forney
Creator's Title	:	Chief,Engine Section,Flight Standards Service
Receiver's Name	:	David Elliott
Description	:	re technology assessment
Creation Date	:	07/1976?
Volume (pages)	:	2
Date Withdrawn	:	05/20/1988

1

Draft Press Release on Approval of the
Pratt & Whitney JT10D Engine Development

The U.S. Government today gave approval to the Pratt & Whitney Aircraft Group of United Technologies to proceed with a four-nation cooperative program to develop and produce a new aircraft engine for commercial service in the late 1970's.

The authority granted the company will enable it to go ahead with plans to develop the JT10D turbofan engine jointly with Rolls-Royce (1971) Limited of the United Kingdom, Motoren-und Turbinen-Union (MTU), of West Germany, and FIAT, of Italy.

The engine, designed to be quiet and very fuel efficient and have low emissions, is aimed at the major growth area in the air transport industry. The JT10D will be in the 25,000 to 30,000 pound thrust class and will have application for the new generation of intermediate size commercial aircraft required by world airlines through the 1980-1990 time period.

Major airplane companies have been working for several years on designs of new transports using new engines to replace aging transport airplanes. These new aircraft and engines would provide up to 50% improvement in fuel efficiency, in seat miles per gallon, over the older fleet. The new transports would also meet projected new noise requirements.

The JT10D program is expected to help stabilize employment and provide new jobs in the countries of all four participants. In the U.S., the new program will provide about 50,000 jobs at its peak.

Competing with the JT10D are General Electric and its international partner, SNECMA of France. In 1973 these firms received U.S. Government approval to jointly develop the CFM 56 engine having low noise and improved fuel efficiency.

STAFFING

JC

Bud brought this in--says it needs to go fast. It has major political implications for Connecticut. They feel therefore it should come out tomorrow as a sort of low-level decision thing. But it would need to get in tonight.

It appears to have been pretty well staffed --Marsh ✓ as you know is on vacation. Do you think it needs staffing? Friedersdorf? ✓ Buchen? ✓ Lynn? Cannon?

Trudy
Hold it for now per JC 6:15

E.
7/15
5:00

THE WHITE HOUSE
WASHINGTON

On 7/16/76 discussed this with Jim Connor --- this will not go in until Tuesday of [redacted] next week - staff.

Asked Gorog for the Announcement Plan --- he said State will announce and he will write up a little paper on this and send it over.

Trudy

THE WHITE HOUSE

ACTION MEMORANDUM WASHINGTON LOG NO.:

Date: July 16, 1976 Time:

FOR ACTION: cc (for information):

✓Phil Buchen
J ✓Jim Cannon ✓Jim Lynn
✓Jack Marsh Dave Gergen

FROM THE STAFF SECRETARY

DUE: Date: Tuesday, July 20 Time: 10 A.M.

SUBJECT:

Jointe Memorandum from Brent Scowcroft and Bill Seidman re: Approval of an International Jet Engine Cooperative Arrangement

ACTION REQUESTED:

____ For Necessary Action X For Your Recommendations

____ Prepare Agenda and Brief ____ Draft Reply

X For Your Comments ____ Draft Remarks

REMARKS:

We have not attached all of the attachments to this package as they are rather voluminous. They are available on request.

Lynn - concur with other agencies - per Sanders
Marsh - option 2
Buchen option 2
Cannon option 2 per J. Hope

See note from Gergen Press Plans

PLEASE ATTACH THIS COPY TO MATERIAL SUBMITTED.

If you have any questions or if you anticipate a delay in submitting the required material, please telephone the Staff Secretary immediately.

Jim Connor
For the President

00846

MEMORANDUM

THE WHITE HOUSE

WASHINGTON

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July 15, 1976

MEMORANDUM FOR: THE PRESIDENT

FROM: BRENT SCOWCROFT
L. WILLIAM SEIDMAN

SUBJECT: Approval of an International Jet Engine Cooperative Arrangement

Problem

A private U.S. jet engine company (Pratt & Whitney Aircraft Division, United Technology Corp.) wants to collaborate with three European jet engine firms in the development and construction of an advanced engine for civil air transports. Compared to present engines, the new engine, designated JT-10D, would be quieter, have less noxious emissions, and lower fuel consumption to respond to the airlines' cost problems. The investment shares and division of work in the JT-10D joint venture would be 54% Pratt & Whitney, 34% Rolls Royce (UK), 10% MTU (Germany), and 2% Fiat (Italy). The engine and parts would be sold through a joint company with the controlling interest in the hands of Pratt & Whitney.

Any international transfer of technology connected with jet engines requires USG approval, even if the technology is company-owned and intended only for civil purposes. Because of this and the significant foreign policy issues at play, the decision on this matter has been forwarded for your consideration.

The basic foreign policy issue in this proposed venture is the US/UK relationship. Although there are two other European countries participating, their companies have too small a role to be considered full partners and are not nearly as advanced technically or commercially as either Pratt & Whitney or Rolls Royce, and hence will be relatively minor participants.

An interagency analytical study is at Tab C.

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Background

The JT-10D joint venture was foreshadowed in the 1973 collaboration to build a new civil engine by General Electric (which is the other major U.S. jet engine company and Pratt and Whitney's main competitor) and the French firm SNECMA. The GE/SNECMA engine is progressing well in its development, and Pratt & Whitney's (P&W) subsequent decision to enter the market with an engine of similar characteristics is consistent with its practice over the past several years. The new element in both these ventures is the presence of European partners. The reasons for this are twofold:

-- The cost of developing a new engine (now in the neighborhood of $1 billion) has increased to the point where the private U.S. companies are unwilling or cannot fund the full investment by themselves, and they require a financial partner.

-- The large European market for aircraft and engines may be restricted or even eventually closed to U.S. companies who do not have European partners.

In approving the GE/SNECMA deal, the USG imposed conditions which prohibited French access to the high technology part of the engine -- the core section. This was done because (1) that particular engine core was developed by GE for the B-1 engine under contract to DOD, and (2) SNECMA was a much smaller and less experienced company than GE, and any technology transfer connected with the core would have been a one-way flow to France.

Analysis

The interagency study found no reason to disapprove the JT-10D; the issues centered on what restrictions ought to be imposed to give reasonable assurance that:

-- The technology flow is balanced so that we are not permitting a competitive advantage to slip from our possession.

-- Any national security concerns are resolved.

-- Economic factors are favorable.

-- Foreign policy objectives are met vis-a-vis the UK as well as with Europe more broadly.

A. Technology Flow

Because the German and Italian partners have such a small share in the JT-10D, restrictions to keep technology flow to them to a low level creates no problem and should be a condition of our approval. The main question is whether the net technology flow between P&W and Rolls would disproportionately favor Rolls. The two companies believe they are very much on a par, and neither will gain at the expense of the other. They are already cooperating on a military engine for U.S./UK joint use.

DOD sent a technical team to the Rolls facilities in the UK to assess the relative technical strengths of the two companies. Their report (Tab D) concluded that there will be no real two-way flow of technology between P&W and Rolls for the basic JT-10D engine, but if more advanced technology were to be incorporated, that flow would predominantly be from P&W to Rolls.

NASA has analyzed the technology proposed for the JT-10D and believes that while there may be detailed differences in competence between the two firms in each engine component area, it sees both firms as basically competitive, and that P&W would acquire valuable engine technology in the course of the program. An independent evaluation by the FAA (Tab E) concludes that each company will learn from the other and there should be no net loss to the U.S.

The current generation of jet engines also suggests that a parity exists: P&W engines are used on the Boeing 747, a GE engine on the McDonnell Douglas DC-10, and a Rolls engine on the Lockheed 1011.

B. National Security Considerations

There are no obvious and direct national security problems associated with the JT-10D. The partners will agree to protect the information that is exchanged, which is their commercial inclination anyway.

In a broader context of national security, there are two principles which bear on the JT-10D, and which tend to oppose one another. Our ability to develop very advanced jet engine technology, from which the next or succeeding generations of our military engines will come, depends on the existence of an independent, vital and innovative U.S. engine industry. DOD is concerned that international collaborations in which there is a net outflow of technology (even with respect to civil engines based on technology below the most advanced military level) could compromise this vitality and independence. This general principle would argue against any jet engine collaboration where U.S. high technology is to be shared, on the assumption that we could not expect to learn enough in return. This view presents something of a dilemma, though, since DOD also in a strong supporter of the need to standardize our military technology and equipment with our NATO allies. To achieve standardization, we must be prepared to carry out joint military development and production projects with the NATO countries, which in some cases would involve sharing even more advanced technology than is embodied in a civil project such as JT-10D.

C. Economic Factors

The competition for the GE/SNECMA engine represented by the JT-10D is advantageous for our aircraft and airlines companies, who will soon be building and operating another generation of air transports. The eventual replacement airplanes for the 727, 737, DC-9, 707, and DC-8, as well as certain European aircraft, will probably be powered by one or the other of these engines.

A pertinent economic question is whether or not we are unnecessarily permitting Rolls to share a market that we would otherwise expect to capture ourselves. This might be true if P&W were prepared to proceed alone. However, P&W says today that without the Rolls it cannot accept the risk, size of investment, and long payback, and would not be able to go ahead. Nevertheless, some believe P&W -- and possibly Rolls as well -- would proceed independently rather than abandoning the market to GE/SNECMA for this size engine. Unfortunately, no evidence or analysis exists which would help to resolve this question, and it will have to remain open.

D. Foreign Policy Considerations

The main foreign policy considerations connected with the JT-10D decision involve our political relationships with the UK and France and any impact on our NATO objectives.

The U.S. and UK have had a history of technology sharing in jet engines. The British pioneered jet engines, and during the 50's the U.S. produced British engines under license. General Motors and Rolls have more recently collaborated on a military engine now used by the armed forces of both countries, and Rolls provided P&W with design information for another military engine being used by the U.S. Marine Corps Harrier force. The UK has made it clear that in light of this relationship and the past and continuing exchanges, they feel there is a prima facie case that the two countries are technologically comparable in jet engine design and manufacture, and that no net advantage would be gained by one country over the other in the JT-10D cooperation. The UK would view an unwillingness on the U.S. part to permit the JT-10D on the basis of equal participation as a serious step back in the U.S./UK relations.

The reaction of France to a JT-10D arrangement which permitted co-operation in the core section of the engine is difficult to predict. It is not unlikely, however, that France would seek some relaxation of the conditions on the GE/SNECMA license that prohibited SNECMA's participation in the core. We would not want to permit such a change, but the ability to resist it would depend on the strength and level of the French representation and also on the availability at the time of technical compromises.

The NATO angle involves the question of whether a denial of the JT-10D would have any impact on our proposal for standardization (mentioned above). Since the JT-10D is a civil program, there would be no direct link to NATO projects. However, bound up in the European attitude toward standardization -- including acquisition of a NATO AWACS fleet -- is the issue of maintaining an effective European defense and aerospace industry and the employment connected with it. There is concern among some in Europe that standardization is the road to U.S. technical and industrial domination. Our position on the JT-10D will be seen as a general measure of U.S. earnest regarding our willingness to permit the cooperative arrangements, which are at the heart of standardization.

Relationship to the Earlier Approved GE/SNECMA Engine Collaboration

In comparing the GE/SNECMA and the P&W/Rolls deals, there are certain similarities that would argue for identical treatment as regards the conditions of our approval. The engines are comparable in size, technology, and the market they are addressing. Both involve for the first time a major civil engine collaboration between a U.S. company and European partners, and in that context, we would prefer to impose stricter rather than looser controls over the flow of U.S. technology because of our uncertainty over the longer term commercial implications of these joint ventures. Further, equal treatment would have the appearance of being even handed in our relations with the UK and France.

However, significant differences need to be taken into account which would make the restrictions on SNECMA unacceptable to the UK and to P&W.

-- The JT-10D engine technology is being developed with company funds and is not the direct product of USG funding, as was the case of the GE contribution to the GE/SNECMA collaboration.

-- Rolls is one of the world's big three of jet engines. A U.S. requirement that forced them to accept a subordinate role would be rejected. SNECMA agreed to such a lesser position in recognition of it being a small company looking to improve its international standing.

-- P&W expects to receive as much technical help as it provides to Rolls. Conditions that blocked such interchanges would be unacceptable. GE was clearly technically advanced with respect to SNECMA and was primarily motivated to undertake its deal to acquire investment capital and assure a market position in Europe. GE did not expect to receive important technology from SNECMA and was privately pleased that the USG excluded SNECMA from the engine core section.

Options

There are four basic options for your decision. These are described below and have the agencies' recommendations associated with them. (The agencies' views are at Tab B.)

1. Approve the license as requested.

   No agency supports this option because there are some minimum conditions that should be imposed to control technology flow to the minority partners and to third countries.

2. Approve the license with several conditions:

   -- Restrict technology transfers to third countries.

   -- Strictly delimit the technology that could flow to the minority partners (FRG and Italy).

   -- While permitting cooperation in the development and production of the core section of the engine, would delineate the level of technology and the assignment of roles in the constituent tasks.

   -- Require subsequent USG approval for the incorporation of new technology in any advanced versions of the engines.

   State, DOD, Commerce, Treasury, NASA, CIEP, and NSC recommend this option because they believe it will permit a useful collaboration that will be of benefit to the U.S. while protecting our national security and economic interests. The details of the technical restraints on the P&W and Rolls cooperation would be negotiated by an interagency group working with the companies.

3. Approve the license but require P&W alone to develop and build the core section of the engine. This we know would be unacceptable to both P&W and Rolls and would be tantamount to disapproval. It would, however, give us a better case in rationalizing the decision to the UK than would straight disapproval, and would dispose of any possibility of a French request for greater access to the core section technology in the GE/SNECMA engine.

   No agency recommends this option.

4. Disapprove the license.

   No agency recommends this option.

<u>Our Views</u>

The JT-10D program will allow one of our jet engine companies to engage in a new development which it might have difficulty undertaking otherwise; will have a positive effect on domestic employment and foreign trade; will lead to competition in the next generation of engines for our commercial aircraft; and will lend some general support to our efforts to achieve NATO standardization. The risk of a net technology loss seems acceptably small, and our discussions with P&W indicate that we may be overly concerned with this issue: P&W for commercial reasons will limit the exposure of its technology to a competitor.

A decision which would require Rolls Royce to accept a subordinate role would not only abort the deal but would be a wrench on our relations with the UK. If there were a clear case -- as there was with SNECMA -- that the technical exchange would be a net loss to us, we could at least rationalize a negative decision. But given a preponderance of views indicating no such loss would occur, we would appear to the UK to be acting in a arbitrary and patronizing way.

<u>RECOMMENDATION:</u>

All agencies recommend you approve Option 2, approving the JT-10D license under the conditions specified in the decision memorandum at Tab A, which will protect our security and economic interests.

APPROVE G.R.F. DISAPPROVE ______

I select instead:

Option 1 ______

Option 3 ______

Option 4 ______

00847

THE WHITE HOUSE

WASHINGTON

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MEMORANDUM FOR

THE SECRETARY OF STATE

SUBJECT: JT-10D License

The President has reviewed the issues connected with the JT-10D arrangement, and has decided that the license should be approved. The following conditions should be applied:

1. The agreement must include the provisions of Part 124 of the ITAR.

2. Satisfactory agreements must be reached with the governments of the JT-10D partners constraining all parties from divulging any technical information on JT-10D design and manufacturing technology to third countries. Such constraints must also be embodied in the company-to-company agreements among the partners.

3. In the course of the development, the transfer of advanced core design methodology and that manufacturing know-how which would otherwise be permitted under the condition of this license should be limited to only that information that is essential to carrying out the tasks of the participants.

4. In the design and development phase, P&W and Rolls alone must design and integrate the core into the engine. P&W will also take specific steps acceptable to the U.S. Government to protect this technology from unauthorized disclosure to the other parties.

5. That technical data and other information pertaining to technologies reflected in Appendix 6 of the license application designated "Crown Jewels" may not be transferred without the prior approval of the USG.

6. Development of any advanced versions of the JT-10D engine involving technology beyond the level approved by this license must be approved by the United States Government prior to initiation.

7. In the version of the Collaboration Agreement, submitted with M.C. 24-76 on February 12, 1976, now being considered, Fiat

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does not appear in the basic document. However, tasks are assigned in Appendix 4, Statement of Work. These limitations and provisos should either apply to and be binding on all partners to include Fiat or Fiat should be struck from the Work Statement.

The President directs that a detailed statement of the permissible level of technology transfer and assignment of roles in certain constituent tasks be negotiated, on an expedited basis, between the companies and a panel of representatives of interested agencies established by the Secretary of State. The agreement should avoid a continuing, intrusive role for the USG during the implementation of the JT-10D program. If these negotiations should fail to reach prompt agreement, the matter will be referred to the President.

Brent Scowcroft

cc: The Secretary of the Treasury
The Secretary of Defense
The Secretary of Commerce
The Administrator, National Aeronautics and Space Administration

7612902

DEPARTMENT OF STATE

Washington, D.C. 20520

June 23, 1976

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MEMORANDUM FOR MR. BRENT SCOWCROFT
THE WHITE HOUSE

Subject: Comments and Recommendations on the JT-10 D Joint Project

This is in response to Ms. Jeanne W. Davis' memorandum of June 19, 1976, requesting the Department of State's comments and recommendations on the interagency study concerning the munitions license request of Pratt and Whitney regarding the JT-10 D joint jet engine project.

The Department of State believes that the study meets the requirements of the terms of reference outlined in Mr. Scowcroft's memorandum of May 29, 1976, and is a balanced presentation of the issues. While we would have preferred to see more analysis on the commercial/economic implications of the proposal, we recognize that this was not possible within the limited time available for the study.

The Department of State recommends adoption of Option 2A. We believe that the collaboration agreement does not raise any national security issues. We believe that the granting of the munitions license with a minimum number of conditions would most benefit and advance our foreign policy objectives with our NATO allies and particularly with the United Kingdom.

With respect to the annexes, the requirement that prior approval of the United States Government be obtained before the technical data contained in Appendix 6 of the collaboration agreement can be transferred is contained in all annexes. For the sake of clarity, we believe that the annexes should state that this restriction applies only in the event that Pratt and Whitney withdraws from the collaboration agreement or declines to participate in the development of a growth engine.

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Also, we believe that the requirement in paragraph 6 of Annex A was inadvertently omitted from Annex B. Thus, Annex B should include as a condition that the Air Force Aero Propulsion Laboratory be designated to receive information regarding the export of core technology and related manufacturing processes.

for C. Arthur Borg
George S. Springsteen
Executive Secretary

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THE DEPUTY SECRETARY OF DEFENSE
WASHINGTON, D. C. 20301

19 JUL 1976

MEMORANDUM FOR THE ASSISTANT TO THE PRESIDENT FOR NATIONAL SECURITY AFFAIRS

SUBJECT: JT-10D Engine Program

(~~C~~) In my memorandum to you of 24 June 1976, subject as above, I said that we were sending a team of Defense, Air Force, Navy and NASA experts to visit Pratt and Whitney and Rolls-Royce to ascertain the relative technology of both companies and the net technology flow involved in the subject transaction. That team has made its report, a copy of which is attached. The report concludes that there will be no real two-way flow of technology between Pratt and Whitney and Rolls Royce in the proposed JT-10D venture.

(U) We accept the report and agree with it. We believe the program can be furthered as long as constraints and safeguards are provided.

W. P. Clements Jr.

Enclosure

CLASSIFIED BY: DIR,ST&D(ISA)
EXEMPT FROM GDS OF EO 11652
EXEMPTION CATEGORY 3
DECLASSIFY ON: UNDETERMINED

DECLASSIFIED
AUTHORITY DoD Directive 5200.30
BY MLD NARA, DATE 9/5/2012

~~CONFIDENTIAL~~ Sec Def Cont Nr. X-2038

00849

THE DEPUTY SECRETARY OF DEFENSE
WASHINGTON, D. C. 20301

24 JUN 1976

MEMORANDUM FOR THE ASSISTANT TO THE PRESIDENT FOR NATIONAL SECURITY AFFAIRS

SUBJECT: JT-10D Engine Program

We are currently sending a team of Defense, Air Force, Navy and NASA experts to visit Pratt and Whitney and Rolls-Royce to ascertain the relative technology of both companies and the net technology flow involved in the subject transaction. The team is to report by 9 July 1976.

Until their report is in hand, the Department of Defense will not be in a position to make any final recommendation on the options contained in the interagency study of this program. In the meantime, our tentative position, if that will be useful to you, is to recommend Option 2C.

W. P. Clements Jr.

THE SECRETARY OF COMMERCE

WASHINGTON, D.C. 20230

~~CONFIDENTIAL~~/GDS

June 24, 1976

MEMORANDUM FOR Brent Scowcroft
Assistant to the President
for National Security Affairs

SUBJECT: JT-10 D Joint Project

In response to your Staff Secretary's memorandum of June 19, we recommend that the President adopt Option 2A. We believe this option will protect against transfer of sensitive technology, both to Rolls Royce and to third countries. We consider Option 1 to be too open ended; Option 3 puts the Government in a position of turning off what is essentially a commercial transaction for protective economic reasons. We believe that Option 2B would be unenforceable in practice, and that Option 2C is too restrictive. In this last respect, we believe the G.E./SNECMA case can be distinguished.

Elliot L. Richardson

~~CONFIDENTIAL~~/GDS

GDS

THE SECRETARY OF THE TREASURY
WASHINGTON

June 24, 1976

MEMORANDUM FOR THE HONORABLE BRENT SCOWCROFT
ASSISTANT TO THE PRESIDENT
FOR NATIONAL SECURITY AFFAIRS

SUBJECT: Pratt & Whitney Joint Venture Proposal With Rolls Royce and Others to Produce an Advanced Jet Engine

REF: NSC Memorandum of June 19, 1976 on Comments and Recommendations on the JT-10D Joint Project

Treasury supports the courses of action indicated within the area bounded by Options 2B and 2A, and would be willing to recommend approval of a collaboration agreement along these lines.

From the viewpoint of protecting that technology which is most critical to U.S. national security interests and our international competitive position, Treasury prefers Option 2B which is less flexible than Option 2A in regard to release of technology and know-how to foreign companies by Pratt & Whitney. Treasury believes, however, that it might become necessary to move closer to the terms and conditions specified in Option 2A in order to encourage the foreign firms and governments, mainly Rolls Royce and the UK, to enter into the agreement.

Determination of the degree of relaxation in the terms and conditions governing the release of eligible technology and know-how should be made by the USG on the basis of Pratt & Whitney's renewed negotiations with its proposed European partners.

George H. Dixon
Acting Secretary

~~CONFIDENTIAL~~
GDS

ITEM WITHDRAWAL SHEET
WITHDRAWAL ID 00865

Collection/Series/Folder ID No. ..... : 004700431
Reason for Withdrawal .... : NS,National security restriction
Type of Material .... : MEM,Memo(s)
Creator's Name .... : Arnold Frutkin
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Description .... : re comments and recommendations o
n the joint project study
Creation Date .... : 06/23/1976
Volume (pages) .... : 5
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THE WHITE HOUSE

ACTION MEMORANDUM WASHINGTON LOG NO.:

Date: July 16, 1976 Time:

FOR ACTION: cc (for information):

Phil Buchen
Jim Cannon Jim Lynn
Jack Marsh Dave Gergen

FROM THE STAFF SECRETARY

DUE: Date: Tuesday, July 20 Time: 10 A.M.

SUBJECT:

Joint Memorandum from Brent Scowcroft and Bill Seidman re: Approval of an International Jet Engine Cooperative Arrangement

ACTION REQUESTED:

___ For Necessary Action   X For Your Recommendations

___ Prepare Agenda and Brief   ___ Draft Reply

X For Your Comments   ___ Draft Remarks

REMARKS:

We have not attached all of the attachments to this package as they are rather voluminous. They are available on request.

I concur inOption 2.

P.W.B.

Philip W. Buchen
Couns el to the President

PLEASE ATTACH THIS COPY TO MATERIAL SUBMITTED.

If you have any questions or if you anticipate a delay in submitting the required material, please telephone the Staff Secretary immediately.

Jim Connor
For the President

ACTION MEMORANDUM WASHINGTON LOG NO.:

Date: July 16, 1976 Time:

FOR ACTION: cc (for information):

due Tues, 7/~~16~~ 20

Phil Buchen
Jim Cannon
Jack Marsh
Jim Lynn
Dave Gergen

FROM THE STAFF SECRETARY

DUE: Date: Tuesday, July ~~16~~ 20 Time: 10 A.M.

SUBJECT:

Joint Memorandum from Brent Scowcroft and Bill Seidman re: Approval of an International Jet Engine Cooperative Arrangement

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___ Prepare Agenda and Brief	___ Draft Reply
X For Your Comments	___ Draft Remarks

REMARKS:

We have not attached all of the attachments to this package as they are rather voluminous. They are available on request.

Approve option #2

PLEASE ATTACH THIS COPY TO MATERIAL SUBMITTED.

If you have any questions or if you anticipate a delay in submitting the required material, please telephone the Staff Secretary immediately.

Jim Connor
For the President