jet fuel) are priced on a cost basis (including appropriate return on investment) rather than on the basis of the prevailing crude-oil price.

THE ECONOMIC BENEFIT REALIZED BY THE AIR FORCE

We now use the jet fuel production cost projections just developed to assess the potential benefit attributable to a multifuel propulsion capability that might result from an Air Force R&D program.

If, optimistically, the Air Force were to possess such a capability fleetwide in the early 1990s, then it could commence procurement of the lowest-cost jet fuel alternative at that time. Figure 39 indicates that based on presently available information, coal- or oil-shale-based jet fuels could be consistently less costly by then than jet fuels derived from crude oil. Hence, there could be a significant economic advantage in not having to procure crude-oil-based jet fuels.

Figure 39 also suggests that there may be time periods during which coal-based jet fuels are cheaper than oil-shale-based jet fuels, and vice versa, depending on the rate at which lower-cost surface-mineable western coal deposits are depleted, as well as on the rate at which the most readily recoverable oil-shale deposits are depleted. Thus, it would seem highly desirable not to rely on a single resource for jet fuel, but rather to develop a capability to use jet fuels derived from coal, oil shale, or crude oil. In so doing, the Air Force could procure the lowest-cost alternative at any point in time to exploit the switching phenomenon suggested by Fig. 39.

The R&D Benefit

For the case where the Air Force possesses a multifuel propulsion capability, it is assumed that the least-cost jet fuel alternative depicted in Fig. 39 is used each year. For the case in which the Air Force does not have this capability, it is assumed that the annual consumption is of a crude-oil-based jet fuel, which is procured at the cost indicated in Fig. 39. The resulting projection of annual jet fuel expenditures by the Air Force (Fig. 40) is based on the assumption that future Air Force fuel consumption remains constant at the current peacetime level of about 3.9 billion gallons per year.

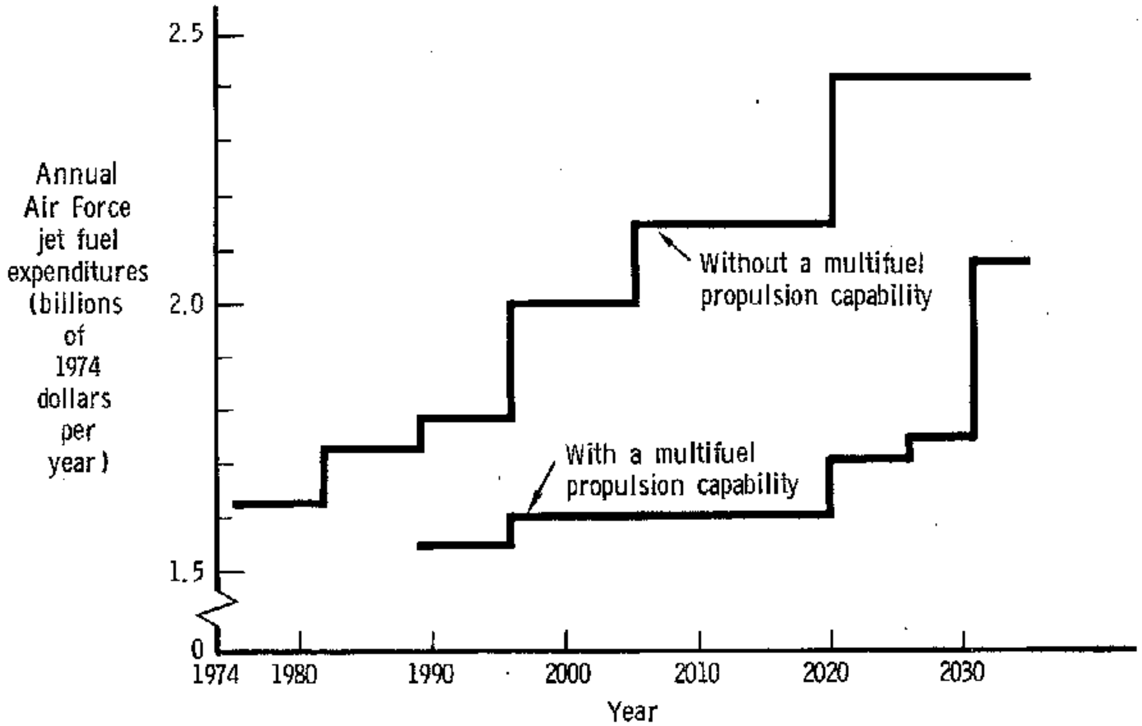

Fig. 40—Projection of annual jet fuel expenditures by the Air Force

The curves in Fig. 40 represent the annual expenditures for these two cases. The difference between the two curves represents the potential cost avoidance that can be attributed to the multifuel capability. When the Air Force could actually begin procuring synthetic jet fuel would depend on the outcome of R&D efforts and the subsequent implementation of the technical knowledge derived from the R&D effort. In one circumstance, the pacing item might be the rate at which refineries could be built or adapted to refine synthetic crude oils into jet fuels with specifications similar to those in use today, in which case only modest refinements to Air Force jet engines might be required. In another circumstance, if the results of the R&D program dictated that synthetic jet fuels would of economic necessity have characteristics different from those in use today, then the major pacing item might be the time required to develop and install new engines in the Air Force fleet.

For the latter case, even if engines procured as early as 1985 possessed a multifuel capability, it would probably be 2005 before most of the fleet could be converted (giving an average conversion date of 1995). Since an in-depth analysis of the conversion problem is not included in the present analysis, we will simply assume, for present purposes, that the average conversion date is 1995. We recognize, of course, that actual conversion dates would depend upon the technical difficulty, as well as economic considerations.

According to the assumption of an average fleet conversion in 1995, the Air Force would commence accrual of cost avoidances attributable to the multifuel propulsion capability in 1995, as illustrated on the top of Fig. 41 (the top curve in Fig. 41 is simply the difference between the two curves in Fig. 40). We observe that, around the turn of the century, the approximate savings would be about $400 million per year. On a cumulative basis, that would amount to nearly $12 billion (1974 dollars) over the period 1995 to 2020 (note that this is almost one-half of the Air Force's current annual budget). The discounted present value of that stream of cost avoidances is illustrated in the bottom third of Fig. 41. Even with a 10 percent discount rate applied to uninflated dollars, the 1980 present value of the savings stream from 1995 to 2020 amounts to $1 billion.*

The $1 billion (1974 dollars) 1980 present value benefit provides a tentative answer to the question of what it might be worth (from an economic standpoint) for the Air Force to possess a multifuel propulsion capability by the turn of the century. Thus, if it was felt that such a capability could be obtained for a total cost having a 1980

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*Over the years, it has been the accepted standard practice in the Office of Management and Budget (OMB) to use a 10 percent annual discount rate on an uninflated dollar stream when making comparisons between program alternatives (e.g., no multifuel program versus a multifuel program). Of course, the real interest paid on long-term treasury notes is closer to 5 percent. Thus, part of the 10 percent discount frequently used by OMB contains a margin against uncertainty. That is to say there is some possibility that the program will not achieve its original goals. (Simply as a point of arithmetic interest, the 1980 present value with a 5 percent discount rate would amount to $3 billion (1974 dollars).) The discounted present value is stated relative to 1980, because that is the year in which we expect that major R&D expenditures to develop a multifuel propulsion capability might be initiated.

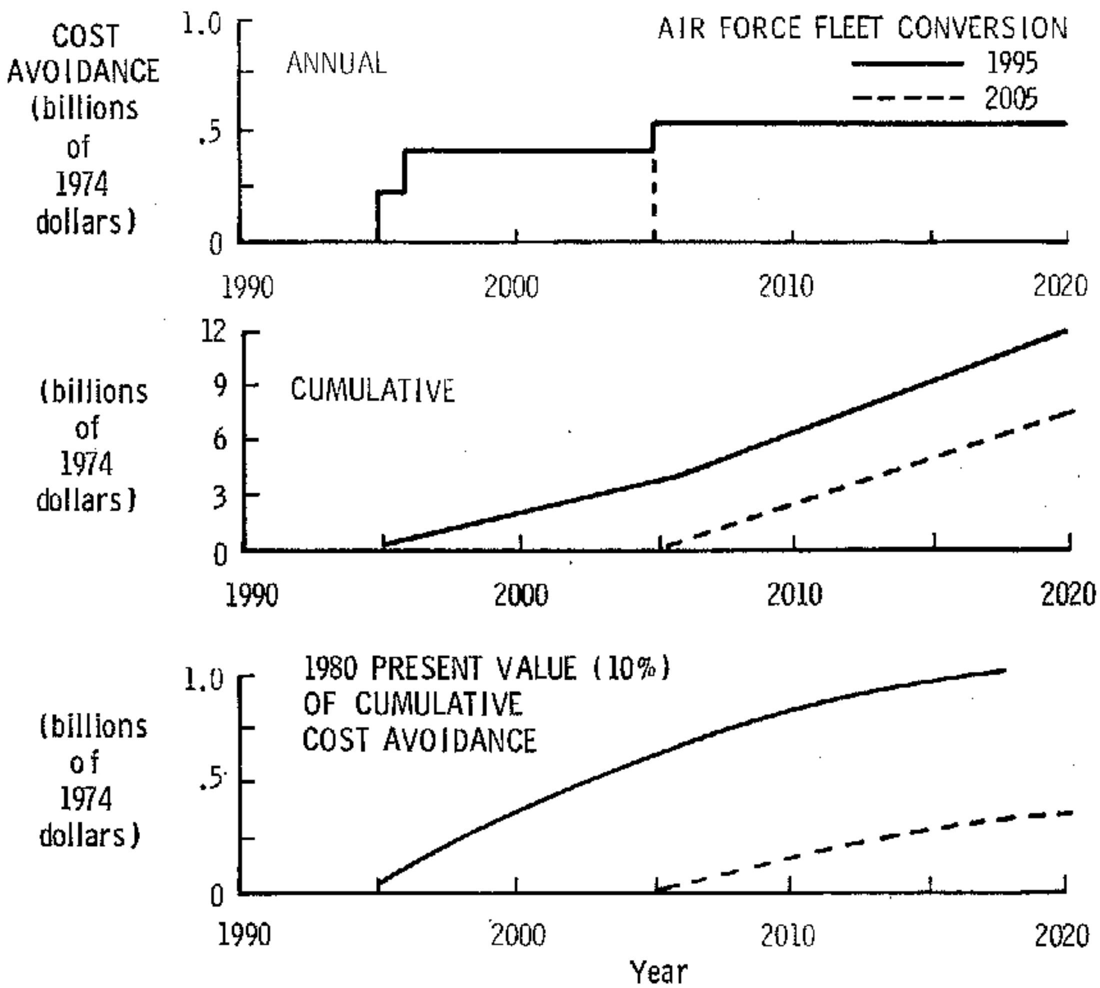

Fig. 41 — Cost avoidance attributable to a multifuel capability

present value of less than $1 billion in 1974 dollars, then the program could be justified on economic grounds (questions of enhanced military flexibility not considered).

The outstanding question at the present time is whether the 1980 present value of the expenditures required to achieve a multifuel propulsion capability would be less than the $1 billion benefit. While presently available information is not adequate to make an overall assessment of the Air Force expenditures that would be necessary to achieve a multifuel capability, we can note that one component of multifuel R&D would likely be an engine technology demonstrator program to determine possible engineering changes that would be required to burn synthetic jet fuels in military engines. This type of R&D rarely costs more than $50 million--a fairly modest expenditure when compared with the possible benefits.(82) Recognize that if new engines are required, the cost of acquiring the capability would include not only the R&D cost, but also any incremental acquisition, procurement, and operations costs. However, as long as the incremental acquisition and procurement costs are reasonably small, they may not have much effect because they would be incurred during the 1990s and thus at a 10 percent discount rate would be considerably discounted. A reasonable first-order assumption might be that the R&D costs would dominate the present value of the cost of acquiring the multifuel propulsion capability.

Cost of Deferring the R&D Program

One question that frequently arises in the evaluation of an R&D program is whether the program can be deferred a few years, or whether the initial level of effort can be reduced. The dashed curves in Fig. 41 can be used to develop some insight about the value of time for this particular R&D program. For example, if we make the assumption that a ten-year delay in the R&D program corresponds to a ten-year delay in the implementation of the multifuel capability, then the benefit stream shown at the bottom of Fig. 41 simply shifts downward an amount equal to the benefit that would be forgone during the first ten years (i.e., $0.6 billion).

In effect, we have assumed that a ten-year delay in the R&D program would cause the average fleet conversion date to slip by ten years, from 1995 to 2005. This ten-year slip would cost $0.6 billion in cost avoidances that would not be accrued. Thus the "cost" (in 1980 present value terms) of a ten-year shift in the program could amount to $600 million (1974 dollars), or $60 million per year.

This analysis (and the associated assumptions) suggest that the Air Force should be willing to spend up to $1 billion (1974 dollars, 1980 present value, 10 percent discount rate) to acquire a multifuel propulsion capability and that the cost of slipping the acquisition of such a capability by ten years could amount to $0.6 billion (1974 dollars, 1980 present value, 10 percent discount rate). One interpretation of these results is that it would not be unreasonable to invest several tens of millions of dollars per year in the early 1980s to acquire this capability. Such an investment in the early 1980s probably warrants an investment in the late 1970s of several million dollars per year in preparation for the 1980s program. One of the early objectives of this research should be to assess what the total cost of developing and procuring a multifuel capability would be. Such an assessment should be accomplished by the end of the 1970s prior to an escalation of the investment rate in the early 1980s.

The results and discussion presented thus far have been based on the ERDA synthetic fuels scenario and the nominal assessment of the domestic energy resource base, and the nominal assessment of the import price for crude oil. We will now examine the sensitivity of the 1980 present value benefit to alternative national energy policies, alternative assessments of domestic crude-oil reserves, and alternative assessments of the future import price for crude oil (e.g., see Fig. 35).

SENSITIVITY TO OTHER SCENARIOS

Since it is impossible to accurately predict the future course of national energy policy, the discovery of domestic crude-oil resources, and the trend in the import price for crude oil, it is essential that the results of the previous section be examined in the context of a wide range of alternative scenarios. To do this, we utilized a model[78] that would dynamically simulate the evolution of the entire U.S. energy system. Because of the efficient character of that model, we have been successful in exploring a wide range of alternative national energy policies, including virtually all of the new technology elements of the three ERDA energy R&D planning scenarios[17] and the five resource cases indicated in Fig. 34.

We will discuss only those scenarios that turned out to be most relevant with respect to their impact on the results of the previous section. These scenarios can be described in terms of the ERDA synfuels scenario and two parameters: the imported oil price and the assessment of the crude-oil and natural gas resources case. The two sets of assessments for these parameters yield the nine resource cases depicted in Fig. 42.

[PROBABILITY OF OCCURRENCE]

		ASSESSMENT OF DOMESTIC CRUDE OIL AND NATURAL GAS RESERVES		
		LOW [.1]	NOMINAL [.8]	HIGH [.1]
IMPORTED OIL PRICE	LOW [.5]	0 [.05]	0 [.4]	0 [.05]
	NOMINAL [.25]	1.0 [.025]	1.0 [.2]	1.0 [.025]
	HIGH [.25]	1.9 [.025]	1.9 [.2]	1.9 [.025]

EXPECTED COST AVOIDANCE = $.7 BILLION

NOTE: 1980 present value in billions of 1974 dollars; 10% discount rate, Air Force fleet conversion in 1995.

Fig. 42 — Sensitivity of cost avoidance to alternative scenarios (probabilities taken from Ref. 29)

The nominal result already obtained for the 1980 present value benefit is for nominal imported oil price and for a nominal assessment of domestic crude-oil reserves. With the high imported oil price assessment, the benefit is nearly doubled, whereas with the low imported oil price assessment, there is no benefit when expressed in 1980 present value terms. Thus, if the OPEC cartel collapses and the low imported price scenario is realized, it will be more economical to continue to procure a jet fuel from crude oil than from oil shale or coal well into the next century.

The current assessment of the experts who participated in the SRI decision analysis is that there is a 0.5 probability of the low imported oil price scenario occurring.[29] Given that probability, there then is a 50 percent chance that the Air Force would accrue no economic benefit from a multifuel engine technology capability (which would obviously cost something to develop and procure). On the other hand, there is a 0.25 probability that the high imported oil price scenario will occur, in which case the 1980 present value benefit of the multifuel engine technology capability would be nearly $1.9 billion. By multiplying the expected benefit in each cell in Fig. 42 by the probability (appearing in brackets), we find that the expected cost avoidance, on a probabilistic basis, would be $0.7 billion in 1980 present value (1974 dollars).

It is curious to note that the benefit appears to be insensitive to the assessment of domestic crude-oil and natural gas reserves. This is because the crude-oil resource cost (Fig. 37) is driven by the world price of oil until the year 2020. The reason for including an assessment of domestic crude-oil reserves as a sensitivity parameter will become apparent when we take up the subject of marketplace pressures.

From this sensitivity assessment, we conclude that there is a definite possibility that the Air Force might accrue no benefit between 1995 and 2020 from a multifuel propulsion capability and, in fact, could suffer a loss (that being the cost of the R&D and any incremental procurement and operating costs). However, we also conclude that, based on a probabilistic treatment of a wide range of alternative scenarios, the expected 1980 present value benefit ($0.7 billion) is quite close to the result of the nominal case.

MARKETPLACE "PRICE PRESSURES"

A potentially significant limitation of the analysis thus far stems from our deliberate avoidance of marketplace price mechanisms, except when treating the resource cost for crude oil, where it was assumed that the domestic crude-oil price would be set by the import price. One way of making a preliminary assessment of the potential marketplace "price pressure" is to consider the market share that peacetime Air Force jet fuel consumption would represent if the Air Force continued to procure only a crude-oil-derived jet fuel.

For example, recall that Fig. 36 showed that the annual consumption of crude oil was virtually eliminated by about 2020, as evidenced by the flat slope of the cumulative consumption curve for domestic crude oil. If the Air Force were to persist in using only crude oil as a jet fuel source, then it might be virtually the last crude-oil consumer in the market. Such an independent posture could potentially leave the Air Force vulnerable to price-gouging by suppliers. Furthermore, since Air Force peacetime jet fuel needs are only one-half to one-quarter those that might be required during a wartime situation, the Air Force could pay a significant economic penalty during peacetime for the underutilization of the crude-oil refiner's capacity.

The marketplace posture of the Air Force could begin to deteriorate as soon as significant synthetic fuel production capacity began being developed. For example, if the other jet fuel consuming members of the aviation sector were among the first users of crude-oil-based products to switch to synthetic fuels, the Air Force might then be the only jet fuel consumer that did not have the flexibility to use a jet fuel derived from synthetic fuels. Of course, there is no way of knowing today whether the aviation sector will be one of the first to switch.

However, it is relevant to note that the commercial airlines might be able to switch more rapidly than the Air Force because of the shorter average engine life (calendar life) due to higher annual utilization levels. Thus, it is conceivable that as soon as there is a significant synthetic fuel production capability, the Air Force may begin to experience marketplace "price pressures" which could drive up the price that the Air Force pays for jet fuel beyond the production cost projections in Fig. 39.*

To assess the interval of time over which the Air Force can expect the onset of marketplace "price pressures," we will consider two extreme cases: (1) the U.S. commercial aviation sector is the first to

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*We recognize that there is an alternative view of market behavior that runs counter to this argument; however, the consequences are no less foreboding to the Air Force. The alternative view is that if commercial aviation were also to persist in using jet fuels from crude oil, the increased competition for the diminishing resource could result in a bidding contest for available jet fuel supplies, in which case a greater economic penalty might be involved than if the Air Force were the only user of jet fuels derived from crude oil. In either case, an Air Force policy of relying solely on jet fuels from crude oil could place it in an awkward negotiating posture.

switch to synthetic jet fuels, and (2) the U.S. commercial aviation sector is the last to switch to synthetic jet fuels (see the bottom of Fig. 43). This switching process can be viewed in terms of the percentage of the annual jet fuel production that still comes from crude oil. For example, Fig. 43 shows that in the scenario where the aviation fuel sector aggressively pursues a switch to synthetic fuels, the switch could commence as early as 1985 and be completed by the year 2000. Of course, there is some question about whether the engine technology could be made available as early as 1985.

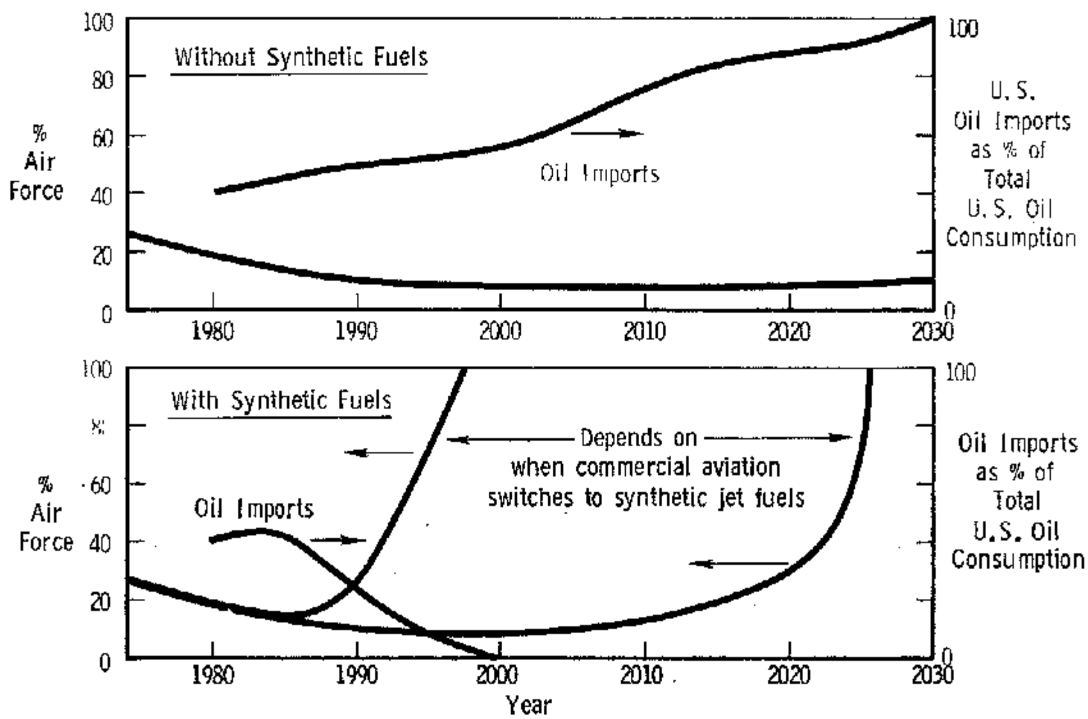

Fig. 43—Air Force share of U.S. consumption of jet fuel produced from crude oil during peacetime

If the aviation sector commences a switch to synthetic fuels in 1985, then the Air Force could begin to experience market price pressures as early as 1990, based upon an assumed wartime consumption rate of four times the current peacetime consumption rate (Fig. 44). This can be seen in Fig. 44 by observing when the Air Force's wartime

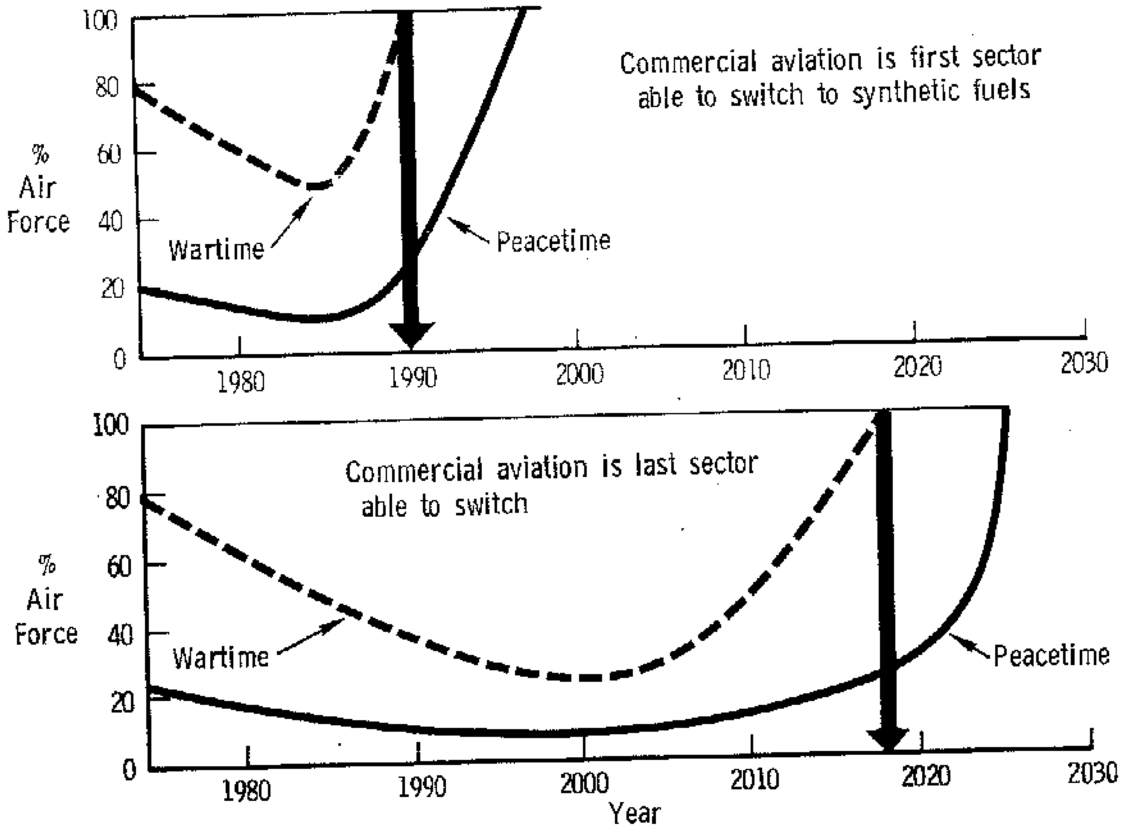

Fig. 44—Air Force share of U.S. consumption of jet fuel produced from crude oil

requirement curve goes to 100 percent of the production of crude-oil-derived jet fuel. The Air Force jet fuel consumption curve declines with time on a percentage basis because we have assumed that the Air Force consumption remains constant while the commercial sector's consumption continues to grow at a 4 percent rate (per the ERDA synfuels scenario).[17] The ERDA assessment of commercial aviation fuel consumption may be on the high side in light of recent airline experience and the projected introduction of fuel-conservative aircraft in the 1990 time period. However, these considerations do not change the central thrust of the present analysis, and therefore, for the sake of consistency, we have retained the ERDA assumptions.

If the aviation sector is the last to switch to synthetic fuels, we observe that the Air Force must switch by the year 2018 simply because beyond that time there will not be sufficient capacity on line to supply the assumed wartime requirement. However, waiting until 2018 is probably not advisable on other grounds because the Air Force can consume from two to four times as much fuel during wartime than in peacetime. The analysis of Sec. III indicated that there can be a cost penalty associated with underutilizing fuel production capacity during peacetime.

The principal point to be made from Fig. 44 is that the Air Force's marketplace posture could become increasingly more vulnerable due to the switching of other sectors to synthetic fuels during the period 1990 to 2018. The sensitivity of this result to other relevant scenarios is summarized in Fig. 45. The results in Figs. 43 and 44 are for the nominal imported oil price and the nominal assessment of domestic crude-oil reserves. The most threatening combination of scenarios is found in the lower left-hand corner of the matrix in Fig. 45. It appears that if the low assessment of domestic crude-oil reserves is realized, and if the high imported oil price scenario is realized, then the Air Force could expect marketplace "price pressures" to develop in the 1990 to 2008 time period. Fortunately, however, current expert opinion is that there is only a 0.05 probability of this outcome. Yet, the probability that marketplace price pressures will commence in the period 1990 to 2018 has been estimated to be 0.45. Thus, there does appear to be almost a 50 percent chance that the Air Force will be in, at best, an awkward marketplace negotiating posture at the turn of the century if it does not possess a multifuel propulsion capability.

OBSERVATIONS

Eventually, there will be a switch from crude-oil-based jet fuels to coal- or oil-shale-based fuels. This will probably occur sometime between 1990 and 2025. The switch will be motivated by comparative economics rather than by the total lack of availability of crude-oil reserves. There will still be significant crude-oil reserves available at the time the switch takes place; however, the cost of extracting these reserves will be such that crude oil will no longer be a viable

[PROBABILITY OF OCCURRENCE]

		ASSESSMENT OF DOMESTIC CRUDE OIL AND NATURAL GAS RESERVES		
		LOW [.1]	NOMINAL [.8]	HIGH [.1]
IMPORTED OIL PRICE	LOW [.5]	2024 [.05]	2026 [.4]	2026-2034 [.05]
	NOMINAL [.25]	1990-2008 [.025]	1990-2018 [.2]	1990-2026 [.025]
	HIGH [.25]	1990-2008 [.025]	1990-2018 [.2]	1990-2026 [.025]

Fig. 45—Air Force "period of critical interest"

alternative to the long-term availability of both coal and oil shale, with their relatively low extraction costs.

It will probably be easier for the commercial aviation sector to switch to a multifuel or synfuel engine technology due to: (1) shorter equipment lives, (2) steady consumption levels, (3) less stringent fuel specifications, and (4) fixed route structures. Due to the high cost and low peacetime utilization levels for military aviation equipment, it is not at all uncommon for equipment to be in the inventory for 20 to 25 years. Commercial airlines, however, generally plan on a 12 to 15 year equipment life. As an example, compare the current fleet of KC-135 tanker aircraft that still operate on turbojet engines and the commercial airline's 707. (The 707 is of the same family as the KC-135.) Virtually all of the old turbojet-powered 707s have been either retired or retrofitted with more efficient turbofans. However, the high cost of such an engine retrofit has prevented the Air Force from affording such a luxury for the KC-135 fleet. Many of the KC-135s that were procured in the 1960s will probably be inventory aircraft well into the late 1980s.

The nonsteady-state nature of Air Force fuel consumption requirements is a special problem that is not experienced by the commercial aviation sector. The surge in Air Force wartime fuel consumption could amount to more than 300 percent of the peacetime consumption level in a high-intensity conflict. The Air Force also must require a much more stringent set of specifications for the fuels used by its combat aircraft. For example, while the commercial airlines might not be unduly concerned about a moderate increase in the aromatic content of their jet fuels, it could be a significant concern to the Air Force because it might significantly increase the visual and infrared signatures of engine exhausts, thereby reducing the survivability of the Air Force aircraft in a combat environment. Finally, the airlines enjoy a fixed route structure, whereas the Air Force must be able to respond worldwide. All of these issues tend to suggest that the problem of switching fuels might be much more significant for the Air Force than for the commercial airlines and therefore would probably include other than simple economic considerations.

A NASA-developed engine technology for subsonic commercial aircraft might well focus exclusively on economic issues to which the airlines are most sensitive. This, however, might be entirely inappropriate for the Air Force. In particular, observe that there is still some sentiment within NASA that the most economic solution for the commercial airlines is to adopt liquid hydrogen as the jet fuel of the future. The results of Sec. III indicate that liquid hydrogen is an unacceptable fuel alternative for the Air Force (except, perhaps, for specialized missions).

The present value benefit of a multifuel propulsion capability for the Air Force is probably worth about $1 billion (1974 dollars) in 1980 present value terms. The cost of deferring the implementation of such a technology for five years would probably cost the Air Force about one-third of a billion dollars (1974 dollars) in 1980 present value terms. Notwithstanding the arguments of some individuals, that liquid hydrogen is the most economical future jet fuel for the commercial airlines, we tend toward the opinion that some form of a multifuel propulsion capability would also well suit the needs of the airlines. If the airlines were to adopt such an engine technology in lieu of relying solely on crude oil as the energy source for future jet fuels, the 1980 present value benefit to the commercial aviation industry could be from $4 to $10 billion, depending upon market growth and the outcome of the NASA fuel-conservative aircraft program. Furthermore, the sheer magnitude of commercial aviation's jet fuel consumption (perhaps 4 to 10 times that of the Air Force at the turn of the century) indicates that any delay in their transition to a multifuel capability could result in an economic loss greater than any the Air Force might experience from postponing the transition, despite the fact that they might be able to effect the transition in a shorter time period.

Since the commercial aviation sector stands to lose much more than the Air Force in terms of the aggregate economic impact, it is quite reasonable to ask why the Air Force should develop a multifuel propulsion capability when obviously the commercial aviation sector has much more at stake. Would it not be more reasonable for NASA to develop such a technology? However, as we indicated previously, it is not clear at this point that a NASA-sponsored solution for the commercial aviation sector would be at all suitable for the more stringent requirements that the Air Force is likely to have. If the Air Force were to acquire a significant lead in R&D in this general area, some advantage might be realized in subsequent negotiations with NASA over future cooperative R&D efforts.

V. CONCLUSIONS

United States supplies of economically recoverable crude oil are rapidly being depleted. While the United States still has a significant resource base of crude oil, those resources will be extractable in the future only at costs considerably greater than those prevalent today. As the largest DoD consumer of jet fuel derived exclusively from crude oil, the Air Force faces a major problem today and in the future.

This report has focused on some of the technological options that might tend to reduce Air Force jet fuel consumption in the short term and perhaps ultimately lessen or eliminate total Air Force reliance on crude-oil-based jet fuels in the future. Our findings indicate that the Air Force propensity for keeping aircraft in the fleet over very long life cycles (15 to 20 years or more) works to their disadvantage when it comes to adopting cost-effective measures for saving jet fuel in the short term and exacerbates planning for the long term when jet fuels may be derived from domestic energy resource alternatives to crude oil.

In the short term, retrofitting high-fuel-consuming Air Force aircraft with new turbofan engines appears to be a highly energy-efficient measure; however, because of the high procurement costs for new engines, the low level of peacetime flying, and the advanced age of the aircraft at the conclusion of the retrofit program (average ages on the order of 15 years or more), savings in jet fuel expenditures would not be adequate to offset the costs of the modification, even with fuel prices significantly higher than those prevailing today.*

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*This conclusion is based on a comparison of engine retrofit costs and the fuel cost savings experienced by an entire fleet of retrofitted aircraft. We have not considered the case in which enhanced capability offered by the new engines is used to allow retirement of a portion of the fleet, which could also offer cost reductions. Or conversely, one could attach a monetary value to possible enhancements in capability (e.g., greater range) of an entire fleet undergoing an engine retrofit.

For much the same reason, most of the proposed aerodynamic modifications, while saving energy do not appear to offer the potential of full cost recovery through savings in jet fuel expenditures. One possible exception to this conclusion is an aerodynamic modification to the C-141A, in which it might be possible for costs to be fully recovered, depending on the ultimate cost of the modification and the service life of the aircraft. In general, costs may be fully recoverable through savings in jet fuel expenditures if modest aerodynamic modifications are accomplished early in the life cycle of the aircraft. Unfortunately, most of the major fuel-consuming aircraft in the Air Force fleet are well along in their life cycle.

What then are the long-term prospects for reducing the Air Force's reliance on crude-oil-based fuels, given that short-term technological modifications do not appear particularly attractive? National energy policies, and in particular the R&D policies of ERDA, will have a major impact on the availability of synthetic fuels for Air Force use in the future. Our research results indicate that there is a strong likelihood that a major coal and oil-shale synthetic fuels industry will develop in the United States between 1990 and 2025, and that the switch from crude-oil-based aviation fuels to coal- or oil-based fuels in this time period will be dictated by comparative economics rather than by a total lack of availability of crude oil. Our analysis further indicates that the most desirable jet fuel form derivable from coal or oil shale is a synthetic JP, similar to but not necessarily identical to crude-oil-based jet fuels in use today.

If the Air Force is to exploit the availability of synthetic jet fuels in the future, significant R&D remains to be accomplished to fully understand the implications of synthetic jet fuels on refinery operations and military jet engines of the future. Because NASA-directed R&D on synthetic fuels will probably focus on those economic issues about which the airlines are most concerned, it seems likely that at least part of the synthetic fuels R&D burden will have to be assumed by the Air Force, a major consumer of jet fuels, to assure a suitable fuel product for military use.

Since the life cycle through which a propulsion technology advancement evolves can represent a 25 to 50 year time period, it would seem prudent that the Air Force assign a high priority to this research now. This research should have as a goal the determination of the proper technical and economic balance between synthetic crude-oil refining requirements and possible changes to engines to accommodate synthetic jet fuels such that fuels derived from crude oil, oil shale, and coal can be utilized in military jet engines of the future. One of the immediate objectives of such a research program should be to resolve as much of the uncertainty as possible about the ultimate costs of developing and implementing a multifuel propulsion capability. Possession of the capability would allow procurement of the least costly fuel alternative in the aviation fuel marketplace and would lessen the Air Force's present total reliance on a single resource (e.g., crude oil) for its jet fuel needs.

The 1980 present value economic benefit between 1995 and 2020 of possessing such a capability resulting from the R&D program could amount to about $1 billion (1974 dollars). If the foreign oil cartel were to break, leaving no immediate economic stimulus for the development of a domestic synthetic fuels industry, any economic benefit to the Air Force between 1995 and 2020 would be postponed such that the 1980 present value benefit would be negligible. However, in this circumstance, crude-oil imports could be supplying 90 percent of U.S. crude-oil needs by 2020--an undesirable situation with many attendant national security and economic problems. With the continuance of a strong cartel, and the development of a synthetic fuels industry in the United States, an Air Force policy of relying solely on crude oil for its jet fuel needs could place it in, at best, an awkward marketplace negotiating posture by the turn of the century. Furthermore, by the time other energy users begin shifting to coal and shale oil, crude oil in the low extraction cost category will have been depleted.