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United States General Accounting Office

GAO

Report to the Chairman, Subcommittee on Europe and the Middle East, Committee on Foreign Affairs, House of Representatives

January 1987

FOREIGN ASSISTANCE

Analysis of Cost Estimates for Israel's Lavi Aircraft

Held for release until Feb. 23, 1987

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GAO

United States
General Accounting Office
Washington, D.C. 20548

National Security and
International Affairs Division

B-225083

January 31, 1987

The Honorable Lee H. Hamilton
Chairman, Subcommittee on Europe
and the Middle East
Committee on Foreign Affairs
House of Representatives

Dear Mr. Chairman:

In March 1986, you asked us to evaluate the United States' and government of Israel's cost estimates for Israel's fighter aircraft, the Lavi.[1] Israel is developing the Lavi to replace its aging U.S.-produced A-4 Skyhawks and Israeli-produced Kfirs. Thus far, it has been financed predominantly (over 90 percent or $1.3 billion) from U.S. assistance funds.

There are significant differences between the U.S. and Israeli figures—$22.1 million versus $14.5 million per aircraft for flyaway costs,[2] respectively. This report responds to your request that we compare the two estimates, noting any substantial differences, and provide an assessment of their reasonableness.

We found that even the lowest estimate of the funding required to produce the planned 300 Lavi aircraft will exceed the spending cap set by Israel and consume an increasingly larger share of Israel's defense resources. We estimate that annual cash flow requirements for the Lavi will be over $1 billion in 1990 and could exceed $1.4 billion by the year 2000, assuming an average inflation rate of 6 percent per year. (Even at a 3 percent inflation rate, they will be about $0.9 billion each year from 1991 through 2000.) This compares to the $1.8 billion currently authorized for annual military assistance to Israel.[3] Israeli officials expressed the hope that by the early 1990's, U.S. budgetary constraints will have run their course and that additional funding will be available from the U.S. government to ensure successful completion of the Lavi program.

[1]The U.S. Lavi cost estimate was an interagency effort led by the Department of Defense (DOD) with the participation of the Department of State, the National Security Council, and the Office of Management and Budget. It was basically prepared by a team of U.S. Air Force cost analysts. For purposes of this report we refer to the cost estimate as DOD's.

[2]As used in this report, flyaway costs include the recurring costs for the production of aircraft. They exclude other costs such as those associated with development and follow-on support.

[3]The $1.8 billion of military assistance is foreign military sales loans but, since fiscal year 1985, Congress has forgiven repayment. This effectively makes the military assistance to Israel a grant.

As agreed with you, we did not develop a "bottoms-up" or independent third cost estimate. Rather we examined the principal cost differences between the estimates and the methodologies that the Department of Defense (DOD) and Israel used in calculating costs. It is important to note that there are inherent difficulties encountered in evaluating and validating Israeli data and methodologies, particularly within the time frame permitted for this review. Therefore, for the most part, we relied on the data provided by the DOD and Israeli cost teams and did not validate the data.

As noted above, there are significant differences between the DOD and Israeli estimates. Some of the differences are due to definitional problems; for example, DOD's estimate includes engineering change orders which are not included in Israel's estimate. Revising Israel's estimate to reflect normal U.S. practice would add over $2.8 million per aircraft to Israel's flyaway cost estimate making it over $17.3 million. We also found other areas where we thought Israel's estimate was low, but we could not recalculate its estimate in all instances because we lacked specific information on Israel's methodologies. In one instance, where we were able to recalculate, Israel's flyaway cost estimate would increase by as much as an additional $400,000 per aircraft.

Other differences between the estimates were due to the unavailability of specific Israeli data, which caused DOD to draw on U.S. aircraft production experience. Based on the more complete and current data available at the time of our review, DOD's estimate appears high. We questioned about $4.3 million per aircraft of the costs estimated by DOD which, if taken together, would reduce DOD's estimated flyaway cost per aircraft to $17.8 million.

Neither estimate provides for significant slippages or other unforeseen problems, which could increase costs. For example, delays of the first test flight have already taken place and are not accounted for by either estimate (the first flight occurred in December 1986). Moreover, there are a number of uncertainties related to future contracts. In addition, both the DOD and Israeli cost estimates employ learning curves which assume cost declines over time from learning to do tasks more efficiently. U.S. estimating experience has shown that a number of factors can drive up the production cost of major weapon systems, often overwhelming cost declines from learning.

These matters are summarized below and discussed in greater detail in the attached appendixes. Our review was conducted from May 1986 to

November 1986 in accordance with generally accepted government auditing standards.

Lavi Financed Predominately by the United States

In 1979, the government of Israel decided to develop and produce a fighter aircraft named Lavi (Hebrew for lion) for interdiction and close air support and so notified the United States early the following year. In its preliminary stages, the Lavi was described as a relatively unsophisticated plane on the low end of Israel's mix of combat aircraft. The plane has since evolved into a much more technically advanced aircraft, most often compared to the F-16.

Israel plans to build 300 Lavi aircraft, with the first to be delivered in 1990. At full capacity, Israeli Aircraft Industries, the prime contractor, plans to produce 24 aircraft per year and intends to complete production in the year 2003. Planned production is intended to cover only Israel's military requirements, although Israeli Ministry of Defense officials told us that they hope to find export markets for the Lavi[4] or its major components.

For fiscal year 1984, the Congress specifically earmarked foreign military sales (FMS) funds for the Lavi[5] and waived repayment for 50 percent of Israel's FMS loans ($750 million). Also, since 1985, the United States has forgiven repayment of all additional FMS loans for Israel, which in effect makes these loans grants. Since that time, the United States has approved $1.4 billion in FMS funds for Lavi research and development activities as well as procurement of finished goods both within the United States and Israel.

According to information provided by Israel, actual expenditures on the Lavi between 1980 and 1986 totaled about $1.5 billion. As shown in table 1, the United States provided over 90 percent of this amount.

[4]DOD points out that the export market for Lavi is limited since neither Arab nor European states are serious potential buyers and export of the aircraft would require U.S. permission.

[5]Foreign Assistance and Related Programs Appropriations Act of 1984, P. L. 98-151, approved November 14, 1983.

Table 1: Lavi Aircraft Expenditures by Source

Millions of U.S. dollars

Israeli fiscal year[a]	Funding provided by United States	Israel	Total expenditures
1980	•	$17.2	$17.2
1981[b]	$10.7	40.3	51.0
1982[b]	76.5	11.5	88.0
1983[b]	190.9	2.8	193.7
1984	323.7	5.9	329.6
1985	316.5	12.8	329.3
1986[c]	411.7	42.0	453.7
Total	**$1,330.0**	**$132.5**	**$1,462.5**

[a]Israeli fiscal year basis is April 1 through March 31; i.e., fiscal year 1986 is April 1, 1986, through March 31, 1987.

[b]The United States allowed funds appropriated in U.S. fiscal year 1984 to be used for prior years.

[c]The figures for April through September 1986 are actual; the figures for October 1986 through March 1987 are forecasted by the Israeli Ministry of Defense.

U.S. industry is heavily involved in the Lavi program. As of November 1986, Israel had awarded Lavi contracts to about 120 U.S. companies (19 companies had contracts over $1.0 million). According to Israeli data, the value of these contracts and other purchase orders totaled approximately $680.7 million. This includes development and initial production contracts with Grumman Corporation for the wings and tail, with Pratt & Whitney Group, a division of United Technologies Corporation for the engines, and with Lear Siegler Incorporated, for the flight control computer. The Israeli Ministry of Defense (MOD) estimates that over 50 percent of future Lavi expenditures will be made in the United States. However, of the total expenditures ($1,307.0 million) on the program as of November 30, 1986, about 28 percent has been spent in the United States.

Controversy Over Cost

Since at least 1982, U.S. officials have been concerned about the Lavi's potential cost, because of the effect it could have on the level of U.S. military assistance to Israel and on Israel's overall defense program. In April 1985, Israel's Minister of Defense and DOD's Under Secretary for Policy agreed that the United States would examine the plane's mission, technical content, and cost.

DOD's study of the Lavi program resulting from this agreement, was released early in 1986.[6] It showed a wide disparity between DOD and Israeli cost estimates. DOD's estimate of unit flyaway costs totaled $22.1 million, which was 52 percent higher than Israel's estimate of $14.5 million.

Israel disputed DOD's estimate, stating that DOD did not adequately account for substantial differences between the financial and cost structures of U.S. and Israeli industries. Israeli officials also contended that a number of "critical misassumptions" had been made. DOD, on the other hand, contends that the U.S. cost team had asked for but never received certain necessary cost information. Since the cost study was completed, DOD has been hesitant to approve further Lavi-related procurements with FMS assistance and has pressed for consideration of alternatives to the Lavi.

Adjustments to Israel's Estimate

Some differences in the estimates arose because the DOD and Israeli estimates were not definitionally comparable. Israel's estimate was expressed in terms of fiscal year 1984 dollars, while DOD used fiscal year 1985. More significantly, DOD's estimate included certain costs that Israeli methodology excluded or treated differently.

Appendix I details the steps we took to make the Israeli estimate definitionally comparable. In making the adjustments, we followed generally accepted DOD costing methodology and used the latest data available from Israel.

- We adjusted Israel's estimate from 1984 to 1985 dollars, using a 3.6 percent factor to account for inflation.
- We added engineering change orders to Israel's procurement cost estimate. DOD had included these costs in its estimate, but Israel, in keeping with its own costing practices, had not done so. Doing so increases Israel's flyaway costs.
- We reallocated some production tooling costs identified by Israel, which it had accounted for in a different way from DOD. This had the effect of increasing unit flyaway costs.

[6]"The Lavi Program: An Assessment of Its Mission, Technical Content, and Cost," Office of the Deputy Under Secretary of Defense for Planning and Resources, undated.

These adjustments increase Israel's unit flyaway cost estimate from $14.5 million to nearly $17.4 million (versus DOD's estimate of $22.1 million).

We found other areas where we thought Israel's estimate appeared low. For example, we calculated hourly rates higher than those used by Israel. Using our hourly rate for manufacturing could increase Israel's flyaway cost estimate by as much as $400,000 per aircraft. However, because of difficulties in evaluating Israel's data and methodologies we could not recalculate Israel's cost estimate for other items we questioned.

GAO's Analysis of DOD's Estimate

Estimating the procurement costs of aircraft that are to be produced over a period of 14 years is a difficult task under the best of circumstances. In the case of the Lavi, the DOD cost estimating team faced two additional problems. First, much of the aircraft is to be produced in Israel, an economic and production environment that is different from that of the United States. Second, the cost team was given only some of the relevant historical cost and production data that is usually available for estimating the cost of U.S. systems.

Given these limitations, the DOD cost team used analogies to U.S. aerospace industry and added certain estimated factors to account for costs not identified elsewhere or to allow for the Israeli environment. The principal cost elements computed wholly or in part using this approach were the hourly rate (includes direct labor and overhead), aircraft weight, labor hours, and materials. Each of these elements affected several of DOD's development and procurement cost categories.

We reviewed DOD's methodology and calculations, using information provided to us by Israel that in many instances was more current and complete than available to DOD at the time of its study. As described below and detailed in appendix II, we believe DOD's estimates for a number of cost categories were high.

- Israel's hourly rate. For engineering costs, for example, DOD used an hourly rate of $47 based on an analogy to U.S. aerospace industry and adjusted for the Israeli environment. According to MOD, it used about $26. Based on actual Lavi development data, we calculated an engineering hourly rate of about $32.

- Lavi's weight. DOD calculated weight based on Israeli data and an analogy to the F-16. Israel provided us a more current weight estimate, which was lower than the one used by DOD.
- Labor hours. DOD estimated labor hours based on its aircraft weight estimate and analogies to the F-16. DOD used the estimated full weight of the Lavi to make certain labor-hour calculations even though Israel will produce only part of the aircraft. This resulted in overestimating the labor hours. DOD also adjusted the labor hours upward to account for low production rates and for extra time to handle composites. We believe both adjustments were inappropriate because they do not reflect actual Israeli production plans.
- Materials. DOD calculated the cost of materials based on an analogy to the F-16. DOD increased the materials estimate to account for the higher cost of composite materials, but overstated the effect.

Overall, we questioned DOD's estimate in 6 of 8 broad cost categories for the development phase and in all 10 for the procurement phase. Taken together, the areas we disagreed with or thought questionable amounted to about $4.3 million per aircraft.

Annual Outlays Will Consume a Large Share of Israel's Defense Resources

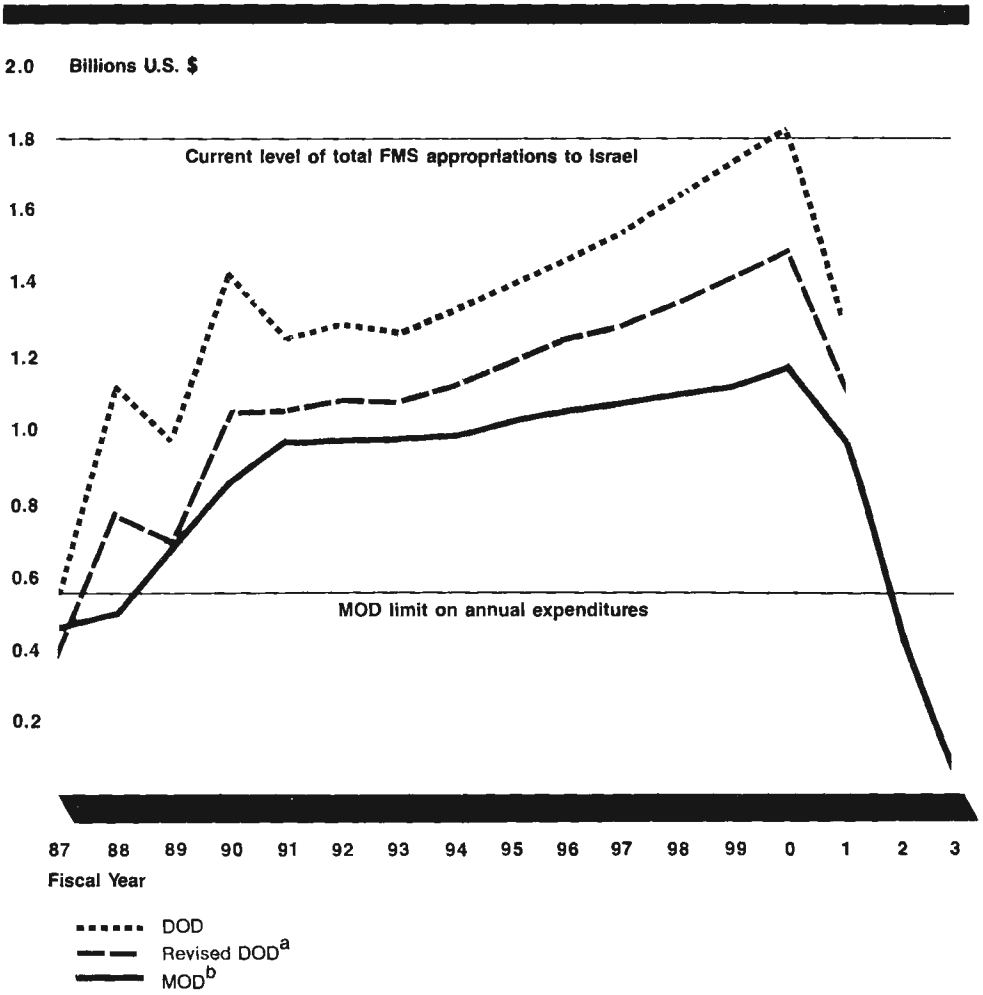
Although DOD's and Israel's estimates vary substantially, both project substantial growth in yearly cash requirements—that is, the amounts required to meet Israel's planned production. We estimate annual outlays will exceed $1 billion by 1990 and exceed $1.4 billion by the year 2000.

In April 1985, the Israeli Minister of Defense set an annual spending limit of $550 million on the Lavi program. MOD officials believe that the $550 million cap is to be an average so that, in any particular year, the actual amount spent could be greater or less than $550 million.

Regardless of which estimate one uses, projected annual outlays quickly exceed this spending cap. In fact, as production progresses, annual outlays begin to consume most of the currently authorized $1.8 billion of U.S. military assistance. Figure 1 was based on cash flow estimates provided by DOD and Israel and inflated at the rate of 6 percent. (The gross national product deflator, which DOD uses to estimate weapon systems

prices, rose at an average annual rate of 6 percent over the period from 1965 through 1985.)[7]

Figure 1: Future Value of Lavi Cash Flow Estimates (Compounded at 6 Percent)



[a]The Revised DOD line represents the yearly outlays required if all of the individual GAO adjustments to DOD's estimate are included.

[b]Based on Israeli fiscal year, April 1-March 31.

Many U.S. officials question Israel's ability to build the Lavi and meet other defense requirements. Israeli officials told us that the government

[7]The deflator we used is not intended to be a forecast of inflation. Since, over the long run, the exchange rate between the U.S. dollar and Israeli skekel will adjust to reflect differences in domestic inflation rates, we did not attempt to calculate a separate inflation rate for Israel.

of Israel does not intend to increase its expenditures for the Lavi program. Instead, they expressed the hope that by the early 1990's, U.S. budgetary constraints will have run their course and that additional funding will be available from the U.S. government to ensure successful completion of the Lavi program.

Israel and DOD do not dispute the necessity to replace Israel's aging aircraft. DOD recognizes that substantial outlays will be required for replacement aircraft during the next 15 years whether the Lavi continues or not. However, DOD officials believe that there may be less costly alternatives to meet mission requirements—alternatives that would allow Israel to stay within the annual $550 million limit. An alternatives study was recently completed by DOD to determine whether there are less costly means to meet Israeli requirements. The study presents a significant number of alternatives that DOD believes meet Israeli military and economic requirements and should cost less than what Israel plans to spend on the Lavi. The alternatives study was presented to the government of Israel in January 1987 and U.S. officials are awaiting Israel's response.

Agency Comments and Our Evaluation

Comments on our report were requested from the Departments of State and Defense. The Department of State reviewed our report and had no comments (see app. IV). DOD's comments (see app. V) are discussed here and in the appendixes, as appropriate.

DOD fundamentally agreed with the probable cash flow requirements of the Lavi program and the likely consequences for Israel's defense program and the U.S. military assistance program.

DOD agreed with the concept of trying to make the DOD and Israeli estimates definitionally comparable but could not concur that our adjustments were correct or sufficient. DOD noted that it was not provided sufficient information to determine whether Israel's basic estimate was an adequate starting point on which to make adjustments.

We, too, encountered difficulties in evaluating and validating foreign data and methodologies. Therefore, we did not attempt to make a bottoms-up estimate or to recalculate Israel's cost categories. However, we believe we had sufficient information and understood Israel's methodology well enough to make Israel's estimate definitionally comparable to DOD's. As DOD correctly pointed out, we moved certain MOD tooling costs from development to procurement because that conformed to U.S.

costing methodology. It was not our purpose, however, to validate the sufficiency of the MOD tooling costs; rather, we sought only to ensure that common definitions of the various cost categories were used.

Most of DOD's comments dealt with its disagreement with our analysis of its cost estimate. Essentially DOD contended that we understated the basic similarity (and consequent cost implications) of the Israeli production environment compared to that of the United States. Also, DOD commented that recent events (uncertainties over the Israeli engine contractor and delays of the first test flight) point to program slippages and cost growth and underscore the need for conservatively estimating Israel's cost factors. DOD again emphasized that it had difficulties in acquiring key information and had therefore relied on analogies to the U.S. production environment to determine Israeli costs.

We concur with DOD's concern about program slippages and cost growth. We clearly state that neither estimate included allowances for delays and said that many things can occur in the production of major weapon systems which drive up costs. We also recognize throughout the report the limitations on data at the time of DOD's study and agree its use of analogies is an acceptable methodology when actual data is not available. Most of our questions about DOD's estimate concern adjustments DOD made to its analogous data to account for differences in the Israeli environment. In our opinion, some of these adjustments do not properly reflect Israel's production capability, personnel support requirements, labor hours and rates, and logistical base requirements. As a result, the DOD estimate is higher than warranted. See appendixes I and II for a detailed discussion of DOD's comments.

As arranged with your office, unless you publicly announce the contents of this report earlier, we plan no further distribution until 7 days from the date of the report. At that time, we will send copies to appropriate congressional committees; the Secretaries of Defense and State; the Director, Office of Management and Budget; and other interested parties.

Sincerely yours,

Frank C. Conahan
Assistant Comptroller General

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Abbreviations

AME	Auxiliary mission equipment
DCPR	Defense Contractor Planning Report
DOD	Department of Defense
DSAA	Defense Security Assistance Agency
ECO	Engineering change orders
FMS	Foreign Military Sales
IAI	Israeli Aircraft Industries
ILS	Integrated logistics support
MOD	Ministry of Defense (Israel)
SE/PM	System engineering/program management

Adjustments to Israel's Estimate

Some differences in the estimates arose because the Department of Defense (DOD) and Israel used different methods and definitions to develop their respective estimates. Israel's estimate was expressed in terms of fiscal year 1984 dollars, while DOD used fiscal year 1985. More significantly, DOD's estimate included certain costs that Israeli cost methodology excluded or treated differently.

Our objective in reviewing Israel's Ministry of Defense (MOD) estimate was to understand how MOD developed its cost model. We concentrated on those cost categories that differed greatly from DOD's and were provided considerable information by MOD in response to our inquiries. Much of the information we obtained was not available to the DOD cost team and in other instances was more current and complete.

Adjustments to Account for Inflation

For comparative purposes, we adjusted Israel's cost estimate from 1984 to 1985 dollars, using a factor of 3.6 percent to account for inflation. This factor was developed by the Office of Management and Budget and is used by DOD and other agencies for budgeting purposes. This would increase Israel's unit flyaway costs by $.52 million.

Adding Engineering Change Orders to Israel's Estimate

MOD budgeted $460.00 million (in 1984 dollars) for engineering change orders (ECOs) but did not include it as part of its procurement costs. DOD included ECOs in its estimate in accordance with its costing practices. MOD argued that any engineering changes required would be evaluated on a case-by-case basis and that these funds would be separately managed. This contingency fund includes change orders due to unforeseen problems as well as changes to reflect technological improvements or other design enhancements. MOD officials stated that they would add the respective costs to the appropriate categories as ECOs occur. For comparison, however, we added MOD's ECO estimate, adjusted for inflation ($476.56 million), to its procurement cost estimate. On a per unit basis, this would increase Israel's flyaway estimate by $1.59 million.

Reallocation of Tooling

We moved $315.98 million from MOD's development costs to procurement costs. MOD identified this amount for airframe and engine tooling. Such tooling costs are for the procurement of jigs and tools, which the MOD considers "preproduction costs." DOD included these costs in the procurement phase. We allocated one-half of these tooling costs to recurring and one-half to nonrecurring ($157.99 million to each category). This has the effect of increasing flyaway costs by $.53 million per aircraft.

Other Adjustments

In October 1986, Israel provided updated information on costs, resulting in an $88.50 million increase in total procurement costs. About $58.60 million was added to total flyaway costs, or about $.20 million per aircraft.

The increase in the updated costs stems partly from an error we found in MOD's estimated costs for airframe production. MOD's airframe estimate was based on three separate costing techniques, two of which involved the Lavi's estimated weight. We found that MOD had used an incorrect weight definition, which resulted in a lower cost estimate. We pointed this out to MOD officials, and they made the appropriate adjustments.

Summary of Adjustments

Adding the adjustments to Israel's original unit flyaway cost estimate of $14.52 million would increase it to $17.36 million. Table I.1 summarizes the changes and their effect on MOD's estimate.

Table I.1: Effect of Adjustments to MOD Estimate

Dollars in millions

Costs	Original MOD 1984	Adjusted MOD 1985
Development	$2,210.00	$1,973.58
Procurement	6,577.56	8,019.00
Total Program	**$8,787.56**	**$9,992.58**
Unit flyaway[a]	$14.52	$17.36

[a]Flyaway cost is a subelement of procurement cost (less nonrecurring costs, peculiar support, and initial spare parts).

DOD Comments and Our Evaluation

DOD agreed with the concept of trying to make the DOD and Israeli estimates definitionally comparable but could not concur that our adjustments were correct or sufficient. DOD noted that it was not provided sufficient information to determine whether Israel's basic estimate was an adequate starting point on which to make adjustments.

We, too, encountered difficulties in evaluating and validating foreign data and methodologies. Therefore, we did not attempt to make a bottoms-up estimate or to recalculate Israel's cost categories. However, we believe we had sufficient information and understood Israel's methodology well enough to make Israel's estimate definitionally comparable to DOD's. As DOD correctly pointed out, we moved certain MOD tooling costs from development to procurement because that conformed to U.S.

costing methodology. It was not our purpose, however, to validate the sufficiency of the MOD tooling costs; rather, we sought only to ensure that common definitions of the various cost categories were used.

GAO Analysis of DOD's Cost Estimate

In reviewing DOD's estimate we had the benefit of considerable information provided to us by Israel—in many instances more current and complete information than available to DOD at the time of its study. Based on this information and our review of DOD's methodology, we questioned DOD's calculations for hourly rates, aircraft weight, labor hours, and materials costs. Each of these elements affects several cost categories. All the questionable items, if taken together, amount to $2.71 billion in total program costs (or about $4.32 million in flyaway costs per aircraft).

In this appendix, we discuss the problems we identified with DOD's methodology and calculations for estimating hourly rates, aircraft weight, labor hours, and materials costs.

Hourly Rates

To calculate airframe development and procurement costs DOD used an hourly rate, or wrap rate, that accounts for all costs associated with a direct labor hour. DOD asked for, but did not get, sufficient information from MOD to develop a wrap rate based on Israeli experience. Therefore, DOD used an analogy to U.S. aerospace industry. Our wrap rates are substantially lower than those estimated by DOD but higher than those used by MOD. We calculated wrap rates using information provided by Israeli Aircraft Industries (IAI) for actual Lavi experience during the development phase. We also reviewed information from the Department of Labor and the Defense Contract Audit Agency that supports the lower wrap rates.

DOD's Computed Wrap Rates

In calculating its wrap rates, DOD used a direct labor cost based on Israeli aerospace industry experience. It then applied U.S.-based percentage factors to estimate indirect costs because Israeli data were not provided. Overall, DOD added factors for indirect costs based on information from several U.S. aerospace firms, totaling over 700 percent of Israel's direct labor cost. To this, DOD added a percentage for profit (4 percent). DOD then decreased this total by 50 percent to allow, at least in part, for MOD's contention that Israel's wrap rates are lower. Using this methodology, DOD estimated a manufacturing wrap rate of $44.00 per hour and an engineering wrap rate of $47.00 per hour.

GAO's Calculation of Wrap Rates

Rather than use percentage factors for indirect costs based on U.S. experience, we developed wrap rates from Lavi development phase data. The formula we used is based on total development labor costs and

hours for engineering and manufacturing during the period April 1983 through March 1985. Using the IAI data, we calculated a manufacturing wrap rate of $26.40 per hour and an engineering wrap rate of $32.34 per hour.

Other Information on Labor Costs in Israel

Information from the U.S. Department of Labor and the Defense Contract Audit Agency and data provided us by MOD and IAI support that hourly wrap rates are substantially lower in Israel than in the United States, and lower than the DOD cost team estimated.

Compensation, including fringe benefits for manufacturing industries in Israel during fiscal year 1985, was one-third of compensation in the United States according to a recent U.S. Department of Labor survey.[1] According to this survey, U.S. rates were $12.97 per hour compared to $4.34 per hour for Israel. The main part of any wrap rate consists of payments to direct and indirect labor; this argues for wrap rates in Israel on the order of a third of those in the United States.

In addition, the Defense Contract Audit Agency conducted an audit[2] of IAI facilities prior to awarding a maintenance contract for Kfir aircraft leased by the Navy. It recommended a rate of $26.16 per hour for the engineering division and a rate of $24.62 for the military aircraft plant. While this information is not directly applicable to programs other than the Kfir maintenance project, it indicates the order of magnitude of the Israeli wrap rates. In addition, according to IAI officials, the maximum rate IAI is permitted to charge the MOD is $35 per hour.[3]

DOD Comments and Our Evaluation

In its comments, DOD states that our $32 wrap rate seems low based on rates of $30 to $40 for work done on Israeli Navy projects and recent reports from Israel that quote IAI's wrap rates at $37 per hour.

The wrap rate we used was based on actual labor hours and costs incurred by IAI during the Lavi development phase for two fiscal years,

[1]Hourly Compensation Costs for Production Workers, All Manufacturing, 34 Countries, 1975-1985. The Department of Labor does not perform more finite industry surveys such as wages in aerospace only.

[2]Audit report number 2191-5I210011-205, dated February 28, 1985, on review of proposal for initial pricing under letter contract -Israel Aircraft Industries Ltd.

[3]The MOD does not set IAI's wage rates but "approves them." IAI is the largest industrial complex in Israel and is a wholly government-owned company.

1984 and 1985. DOD's wrap rates were based on U.S. aerospace industry experience and, in our opinion, are too high.

Our rate of $32 per hour falls within the $30 to $40 range identified by DOD (although this range applies to electronics associated with missiles and submarines, not a fighter aircraft program) while the DOD rate of $47 falls well outside the range. In discussions with DOD officials we were told that the $37 rate cited was based on an Israeli media report, not government of Israel sources. Furthermore, the GAO rate of $32, which is in 1985 dollars, amounts to almost $35 per hour when adjusted for inflation at 3.8 percent. Similarly adjusted, the DOD rate increases to over $50 per hour.

DOD also notes that any loss IAI suffered because of artificially low hourly rates would be absorbed by its sole shareholder, MOD. We have no reason to believe that these wrap rates are artificially low based on evidence presented to us by MOD officials and statements of Israeli business executives. Our rates are based on actual Lavi experience.

Aircraft Weight

Another primary factor used to estimate airframe procurement costs is the weight of the aircraft. According to DOD, an aircraft's weight closely correlates to the number of labor hours required for airframe development and procurement. Using weight to derive labor hours is an accepted technique for estimating aerospace procurement costs in the absence of actual production data.

DOD Weight Derivation

To estimate airframe procurement costs, DOD normally uses the Defense Contractor Planning Report (DCPR) weight.[4] Because neither MOD nor IAI reports aircraft weight in the same way as U.S. aerospace companies, DOD derived the Lavi DCPR weight from a combination of Israeli data and analogies to the F-16.

DOD based its estimate of airframe, wings, tail, canards, and landing gear on data provided by MOD. DOD derived the weight of avionics wiring and certain other support by analogies to similar F-16 items. DOD calculated the full DCPR weight at 9,843 pounds.

[4]The DCPR weight is the empty weight of the aircraft plus landing gear (less wheels and brakes) and avionics and other systems' support, such as wiring and connectors, that are installed in the fuselage (but not the weight of the actual systems).

MOD's Weight Estimate

MOD estimated the full DCPR weight at 9,501 pounds. This was based on information available as of October 1986. Originally MOD incorrectly calculated the Lavi DCPR weight because it failed to include several categories of equipment and accessories. We pointed this out to MOD officials and they prepared corrected weight estimates for us.

In calculating labor hours for IAI, only the weight of the aircraft that the prime contractor, IAI, is producing should be included (called a partial DCPR weight). DOD subtracted the weight of the wing, tail, and canards from the full DCPR weight in calculating its partial DCPR weight. DOD should not have excluded the weight of the canards because IAI will produce them. The MOD partial weight is 7,171 pounds compared to DOD's 7,159 pounds. Though the DOD and MOD partial weights are close, DOD used the full DCPR weight instead of the more appropriate partial DCPR weight to calculate IAI's labor hours (see the following section concerning labor hours).

DOD Comments and Our Evaluation

In its comments on our report, DOD stated that Israel continues to refuse to provide a complete engineer weight statement and noted that the estimated weight of the aircraft has continually decreased over time, which is contrary to substantial U.S. experience in aircraft development. DOD was also concerned that we did not fully explore this trend of multiple weight changes with MOD.

In our discussions with MOD officials regarding the decrease in Lavi's weight, they explained that some of the weight statements they produced were targets rather than weight estimates. However, the largest part of the reduction (72 percent) was the result of incorrect data (a substantial reserve) included by the Israelis in an early estimate. The large initial estimate made it appear that Israel's latest estimate had decreased more than it actually had. Another part was due to a program of wing weight reduction. Also, as discussed in this appendix, the Israeli weight statement was lower than it should have been because MOD failed to include several categories of equipment and accessories. When we pointed this out to MOD officials, they corrected (increased) their weight estimates (which we used in our calculations).

Labor Hours

As noted above, past U.S. aircraft acquisitions have shown that labor hours for various aircraft components and sections are closely related to weight. The DOD cost team developed an hours per pound ratio for airframe production for each of four labor categories—manufacturing,

engineering, tooling, and quality assurance—based on the F-16. They then multiplied the Lavi's full DCPR weight by the hours per pound ratio and applied a learning curve factor and certain other adjustments to get a total direct labor hours figure. Total direct labor hours were then multiplied by the respective wrap rates to get total labor cost.

In computing certain of its labor hour estimates, DOD used the full estimated DCPR weight of the Lavi. However, IAI is manufacturing just the aircraft fuselage—not the wings and tail, which are under separate contract with Grumman.

DOD used the full DCPR weight in its recurring labor cost calculations even though the full cost of the Grumman contract for the wings and tail is later added to the estimate. DOD also assumed that the Grumman contract would achieve its maximum cost. This is referred to as the contract going to "ceiling" and resulted in an estimate 25 percent over the contract target price. An award fee of 4.2 percent was also added; this means that if Grumman meets certain milestones and its performance is good, it receives additional monetary rewards. In those instances where DOD used its partial DCPR weight, we added the canards because they are being manufactured by IAI.

Since DOD also accounts for the costs associated with the Grumman contract elsewhere, use of the full DCPR weight overstates the labor hours required for the fuselage production. Therefore, we used the MOD partial DCPR weight (7,171 pounds versus DOD's full weight of 9,843 pounds) in computing the labor hours.

After calculating its labor hours estimates for recurring production, DOD adjusted them to account for the Israeli environment. The adjustments were (1) a 10 percent increase to all four labor categories because the DOD team believed IAI has not had enough experience in assembling a major weapon system, (2) a 50.6 percent increase for a low production rate, and (3) a 6 percent increase to manufacturing hours for the increased work of handling composites compared to the F-16. We do not agree with the latter two adjustments.

The formula DOD used to calculate the production rate adjustment (50.6 percent) was not appropriate. The formula was intended to adjust the cost of a large U.S. manufacturing facility for small changes in its production rate. IAI is setting up to produce two Lavi aircraft per month and is not reducing its production capacity to that level. Lavi production will occupy the same facilities used to produce the Kfir, which was also built

at a rate of two per month. Based on our examination of IAI's facilities, we believe that if IAI has any unused or under-utilized production capacity, it is not significant. Therefore, in our opinion, the production rate penalty is inappropriate.

We also disagree with the 6 percent that DOD added to airframe manufacturing direct labor hours because it concluded IAI would need increased handling time, and therefore more labor hours, when working with composites. Most of the composites are in the wings and tail, which are being made under separate contract by the Grumman Aerospace Corporation. IAI will attach the wings to the fuselage, which Grumman officials tell us will be a relatively simple process. According to Grumman engineering drawings aluminum brackets will be used to attach the wing structures to the aluminum fuselage. Therefore, IAI will not be working directly with the composites when attaching the wings or tail, nor will they have to attach composite materials to aluminum, as believed by DOD.

DOD's cost estimates for auxiliary mission equipment, engineering change orders, systems engineering/program management, initial spares, and peculiar support are also affected by the labor hours computations. Each is discussed in later sections.

DOD Comments and Our Evaluation

DOD commented that its 50.6 percent adjustment for low production rate is appropriate and was necessary to normalize the U.S. data base from a production rate of 8 to 10 aircraft to the planned Lavi production rate of two per month.

We believe the formula DOD used to "normalize" its data was misapplied and inappropriate. First, if an adjustment were warranted, it should have been made to the wrap rates rather than to labor hours. This is because the production rate formula affects how overhead, which is part of the wrap rate calculation, is distributed to each unit produced. Therefore, using this formula, in effect increases the overhead included in the wrap rate (raising DOD's wrap rate from $47 to over $70 per hour). As discussed, we believe the wrap rates used by DOD were already too high. Because the wrap rate we used was based on actual IAI data (including overhead) it already included appropriate charges. Therefore, an adjustment to increase overhead in our calculations is not necessary.

Second, because Israel is not reducing the production level, IAI's overhead will not significantly change. Therefore a production rate adjustment is not needed.

Third, the formula used by DOD was intended to determine the effect of a small change in the production rate (not a 300 percent decrease) on the distribution of overhead at a General Dynamics F-16 plant. It was designed only for use within that facility—not to match rates in different facilities, especially those in different countries.

Composite Materials

DOD's estimate of airframe materials cost was based on an analogy to the F-16 and on its assumption that 22 percent of the Lavi will be of composite material. The adjustment applied by DOD increased its estimated materials cost by 110.3 percent. DOD applied this adjustment factor because composite materials are more expensive than other materials typically used.

While DOD's assumption of 22 percent on an overall average may be correct, it was incorrectly applied. Almost all of the Lavi's composite materials will be in the horizontal wings and vertical tail, which are being produced under separate contract by Grumman. The higher costs associated with composite materials in the wings and tail will be reflected in current and future contracts IAI has with Grumman to produce these components. DOD accounts for the costs of the Grumman contract elsewhere. Therefore, a separate adjustment to reflect the higher cost of these materials would amount to double counting.

According to MOD, the Lavi's fuselage, which IAI is producing, will have about 4 percent composites. Since DOD used an F-16 analogy to help estimate the fuselage materials costs, the amount of composites in the F-16 (2 percent) has already been accounted for. Therefore, we adjusted DOD's composite materials factor to account for the remaining 2 percent. Accounting for composites in the same proportion as DOD (but using 2 percent instead of 22 percent for composite materials) results in an adjustment of 10 percent instead of 110.3 percent.

DOD Comments and Our Evaluation

DOD commented that our revisions to its calculations produce a materials estimate that appears low. As we noted, DOD adjusted its estimate for the extra cost of composite materials based on the Lavi being 22 percent composites in total compared to the F-16 being 2 percent composites in total. According to DOD, this approach was used because the U.S. team

could not get a material mix listing from MOD, and therefore could not verify the exact location of composites.

DOD also noted that its analysis of composites was made at the total aircraft system level (as opposed to an individual component level) because it was not informed of the location of composite materials until after its report was completed. More explicit information provided by MOD permitted us to calculate the relative percent of composite materials in the fuselage versus the wing and tail assembly.

Effect on DOD's Cost Estimate

On a per unit flyaway basis, we questioned about $4.3 million of DOD's estimate. The basis for most of our questions about DOD's estimate resulted from adjustments DOD made to its analogous U.S. data to account for differences in the Israeli environment and to account for costs it could not elsewhere identify. As previously noted, DOD was given only some of the relevant historical cost and production data usually available for estimating the cost of U.S. systems.

The factors discussed above affect most categories of development and procurement costs. We asked DOD to incorporate our revised hourly rates and weight calculations and our modified factors for labor hours and materials costs in its costing model. Table II.1 shows the combined effect of our changes by cost category.

DOD Comments and Our Evaluation

DOD commented that we should have developed our own series of models to compute costs. We used DOD's model because it is simply a spreadsheet that adds and subtracts the various data entered and spreads the totals over the life of the project. The model itself is not unique to DOD and there is nothing inherently in it that represents U.S. industrial experience. We used the DOD model because it is applicable to the cost estimation process.

Table II.1: Cost Estimates by Category
(In Millions of FY 1985 $)

Program costs	DOD Estimate	Amounts questioned	Revised DOD Estimate
Development categories			
Airframe	$646.72	($184.33)	$462.39
Engines	36.40	178.15	214.55
Avionics	612.30	(120.17)	492.13
System test & evaluation	197.77	0	197.77
Systems engineering & program mgmt.	358.37	(288.52)	69.85
Integrated logistics support	260.00	0	260.00
Peculiar support	221.91	(221.91)	0
ECOs	280.02	(76.42)	203.60
Subtotal	**2,613.49**	**(713.20)**	**1,900.29**
Procurement categories			
Airframe	3,262.58	(1,259.63)	2,002.95
Engines	1,370.00	(301.50)	1,068.50
Avionics	1,270.46	193.54	1,464.00
Armament	8.92	95.65	104.57
Systems engineering & program mgmt.	271.95	(156.11)	115.84
Auxiliary mission equipment	123.68	(28.56)	95.12
ECOs	315.38	161.18	476.56
[Flyaway costs[a]]	[6,622.97]	[(1,295.43)]	[5,327.54]
Nonrecurring cost	279.10	(37.65)	241.45
Peculiar support	1,173.35	(214.39)	958.96
Initial spares	2,415.73	(444.54)	1,971.19
Subtotal	**10,491.15**	**(1,992.01)**	**8,499.14**
Total program cost	**$13,104.64**	**($2,705.21)**	**$10,399.43**
Unit flyaway cost[a]	$22.08	($4.32)	$17.76

[a]As indicated, flyaway cost is a subelement of procurement costs. We divided the flyaway costs by 300, the expected total production of Lavis, to arrive at unit flyaway costs.

GAO Analysis of DOD's Development Cost Estimates

We questioned DOD's development cost estimates in 6 of 8 categories, resulting in 5 decreases and 1 increase. Incorporating all of our changes would reduce DOD's estimated development costs by as much as $713.20 million.

Airframe Adjustments

DOD's airframe development cost estimate of $646.72 million is the sum of recurring and nonrecurring costs. The recurring cost estimate is the sum of three cost categories: labor, materials, and subcontracts.

(1)Labor is divided into four elements—tooling, manufacturing, engineering, and quality control. DOD stated it did not receive sufficient data from MOD to compute labor costs, so it used F-16 data and adjusted it for the Lavi. DOD estimated the number of hours needed for each of the four labor elements and added 20 percent to tooling, manufacturing, and quality control and 10 percent to engineering for first-time integration efficiency. To the manufacturing labor hours DOD also added 6 percent for composite handling. Total hours for each element were then multiplied by the respective wrap rate to get labor costs.

(2)DOD's materials cost estimate is based on an analogy to the F-16. Dollars per pound figures were multiplied by the estimated Lavi DCPR weights to obtain material costs. DOD added 110.3 percent for differences in the percentage of composite material between the F-16 and the Lavi.

(3)Subcontract costs, the third DOD recurring cost category, were based on DOD's review of Lavi subcontracts on file at the Defense Security Assistance Agency. DOD determined that the subcontracts reviewed represented 90 percent of the total development subcontract effort and increased its estimate to represent 100 percent.

DOD's nonrecurring airframe development cost is the sum of nonrecurring labor and material cost estimates based on an analogy with the F-16. DOD increased them by 20 percent because, in DOD's opinion, IAI has had little experience in the complete assembly of a major weapon system. They also added the 110.3 percent adjustment for the additional cost of composite materials.

We asked DOD to incorporate our adjustments in its model for recurring and nonrecurring labor and material costs. For labor, we used the MOD partial DCPR weight and our lower wrap rates. For material, we used MOD's partial DCPR weight and our lower composite material cost estimate adjustment. Using all the adjusted factors could reduce DOD's estimate to $462.39 million.

Avionics

DOD estimated avionics development at $612.30 million. This estimate is based on a wrap rate for software engineers of $85 per hour. MOD officials commented that they believe an appropriate wrap rate for Israel would be less than half of the estimated $85 per hour—at most $35 per hour, which appears roughly in line with other information we received about Israeli wrap rates. Based on discussions with officials of the Israeli avionics subcontractor, $35 per hour is the maximum rate

approved by MOD. These officials stated that they meet expenses and make a profit at this rate. Applying $35 per hour just to the software development portion of the estimate would reduce the DOD figure by $120.17 million.

Engines

DOD's estimate of $36.40 million for engine development includes only the purchase price of nine prototype engines (plus some peculiar support equipment). The remainder of the engine development costs in DOD's estimate were allocated to the purchase price of 300 engines to be made in the procurement phase. We changed DOD's engine development estimate to reflect all engine development costs in the development phase.

Because engine development is almost complete, we used the most current data provided by MOD to adjust the DOD estimate. Also, at the time of its study, DOD did not know that MOD had accounted for $240.30 million in engine development costs in its estimate. However, we did not include all of this total in the adjusted DOD estimate. As noted previously (see app. I), MOD budgets for ECOs separately from its aircraft cost estimates, but adds them to its costs as they occur. According to MOD officials, ECOs for the engine development phase are included within its engine development estimate.

To conform with DOD methodology, we calculated what the engine development ECOs were, by using DOD's estimate that during development, ECOs increase costs by 12 percent. Therefore, of the MOD total engine development cost of $240.30 million, we allocated $25.75 million (12 percent) for ECOs and the rest, $214.55 million, for engine development.

Systems Test and Evaluation

We retained DOD's estimate for this category ($197.77 million). We agreed with DOD that the MOD estimate did not include a sufficient amount for systems test and evaluation (MOD did not list this category separately). The DOD methodology and amount appeared reasonable.

System Engineering and Program Management

DOD estimated system engineering and program management costs during development at $358.37 million. We were told that this represents 24 percent of air vehicle cost (the complete flyaway vehicle, including airframe engines, avionics, and all other installed equipment) and is based on U.S. historical experience in producing many different aircraft, mostly fighters.

DOD's figures mean that at 150 hours per person per month for 72 months (the full-scale development period), and using DOD's average wrap rate of $45, about 750 people would be needed for this effort. MOD officials stated that they do not use, or plan to use, more than 200 people to perform both functions. DOD insists that this is too low; MOD counters that the 200 staff level reflects experience on Kfir development and production, and that this is Israel's actual experience thus far for Lavi development. Our observations in Israel tended to confirm Israel's assertion of the lower staffing levels.

Using MOD's 200 man-year figure, the DOD factor of 150 hours per person per month, and our calculated wrap rate of about $32 per hour, systems engineering and program management for development would cost $69.85 million over the 72-month development phase.

DOD Comments and Our Evaluation

DOD questioned whether 200 people is an adequate level of manpower to perform this task, and whether that is all Israel has available rather than what is necessary. According to Israeli officials, this level was based on their production of the Kfir aircraft, which they are now completing, and on the Lavi program thus far. It is based on what MOD officials believe is needed to perform the required tasks, not on manpower availability.

Based on DOD's data, as many as 750 people would be required for system engineering and program management. However, DOD's estimate was based on an analogy to U.S. experience, which requires many more levels of review and evaluation than in Israel. Israel's more direct and simplified decision-making process is an example of the differences in the production environments in that country and the United States. In addition, Israeli officials told us that since Israel's inception, its economy has operated in an almost continuous war environment, making such streamlined operations a necessity.

DOD also pointed to schedule extensions in software for the flight control computer as evidence of problems in this area. The schedule extension that DOD refers to, however, resulted from technical delays by a U.S. manufacturer in meeting an agreed upon delivery date for the flight control computer. The delay did not result from internal Israeli problems with system engineering/program management.

Integrated Logistics Support and Peculiar Support Costs

DOD, using information provided by MOD and analogies to the F-16, estimated the peculiar support cost portion of development at $221.91 million. According to DOD, this includes peculiar support equipment ($154.00 million), data ($66.01 million), and training ($1.90 million). DOD then added another $260.00 million, which was a MOD estimate for Integrated Logistics Support (ILS). According to MOD, its ILS estimate included both ILS and the peculiar support cost categories. The head of the DOD cost team said this was never made clear to them. MOD's estimate for ILS appears reasonable and sufficient for the costs DOD allocated as peculiar support. Deducting the full DOD estimate for peculiar support costs would reduce DOD's estimate by $221.91 million.

DOD Comments and Our Evaluation

DOD commented that we did not fully account for all the ILS activity needed on the Lavi program.

Actually, the DOD estimate for ILS was based on data received from Israel. DOD officials stated that they had insufficient data to make an independent assessment and they used Israeli data to add amounts for support equipment, technical publications, and training. According to MOD officials and documents provided by IAI, amounts for these categories were already included within their estimate for ILS. MOD officials speculated that this may not have been made clear to the DOD cost team.

Engineering Change Orders

DOD estimated the ECO costs by taking 12 percent of other development costs. Using DOD's original development cost figures produces an ECO cost of $280.02 million. We accepted DOD's 12 percent factor but applied it to the adjusted DOD development costs. This results in an ECO estimate of $203.60 million, reducing the original DOD estimate for ECOs by $76.42 million.

GAO Analysis of DOD's Procurement Estimate

We questioned DOD's procurement cost estimates in 10 categories, resulting in 7 decreases and 3 increases. If taken together these changes could reduce DOD's procurement estimate by as much as $1,992.01 million.

Airframe

As with airframe development costs, DOD's airframe procurement cost is the sum of recurring and nonrecurring costs. The recurring cost estimate is the sum of labor, materials, and subcontracts.

DOD stated that it did not receive sufficient data from MOD to compute recurring labor costs, so it adjusted F-16 data for the Lavi. Using the F-16 analogy, DOD estimated total recurring labor hours, before adjustments, at 18.92 million hours. DOD added 10 percent to account for IAI's lack of experience in assembling a major weapon system, 50.6 percent for a low production rate, and 6 percent for composite handling (to manufacturing hours only) to get total estimated labor hours to produce 300 Lavis. Total hours for each category were then multiplied by DOD's wrap rates to get a recurring labor cost estimate.

Recurring material costs for airframe procurement were computed starting with the average material cost per aircraft established in the development estimate. DOD applied a learning curve and added a weight growth factor of 5.1 percent. This factor was based on the results of a recent U.S. cost study, according to DOD.

DOD's adjustment for the extra cost of composite materials was built into the development estimate and carried over to procurement. As before, we reduced DOD's composite material factor of 110.3 percent to 10 percent.

For the third recurring cost component, subcontracts, DOD reviewed those already awarded by the Israelis to project subcontract totals for all 300 aircraft. This figure was added to labor and materials to get a total recurring airframe cost estimate.

As in the airframe development phase, we questioned several of DOD's figures for airframe procurement. We disagree with DOD's adjustments for low production rate and composite handling and believe that the partial, instead of the full, DCPR weight should be used in all calculations since the airframe procurement cost is an estimate of what it will cost IAI to build the fuselage.

We requested that DOD recalculate airframe procurement costs using our factors. This resulted in a reduction to DOD's airframe cost estimate to $2,002.95 million.

Changes made to the nonrecurring production cost estimate are discussed later in this section.

Engines

DOD's engine procurement estimate of $1,370.00 million assumes that Pratt & Whitney will recover the entire development cost of the PW1120

engine from sales to Israel during the procurement phase. For this reason DOD added $249.00 million ($830,000 per engine) for research and development to the production engine price (average unit price of $4.57 million). Israel, on the other hand, estimated engine procurement costs of $1,068.50 million, or $3.56 million per engine.

Pratt & Whitney officials told us that they do not expect to recoup all research and development costs through the Lavi program. They added that since the PW1120 program's inception, they had planned for more sales than just for the Lavi. MOD provided us with a Pratt & Whitney proposal to Israel for 144 production engines at $2.94 million per unit (if the prime contractor is Israeli) or $3.10 million (if the prime contractor is Pratt & Whitney). DOD officials pointed out that Pratt & Whitney's proposal does not cover additional expenses for items such as start-up tooling, taxes, transportation, storage, customs, and technical assistance. MOD officials contend, however, that since they estimated the procurement price at $3.56 million per engine, the remainder (between $460,000 and $620,000) would be available to meet such expenses. Based on the preceding information, we believe the MOD estimate is reasonable.

DOD Comments and Our Evaluation

DOD commented that Bet Shemesh, the Israeli engine manufacturer, has "collapsed" which, in DOD's view, only adds to the uncertainty of the engine costing. Further, DOD asserts that although GAO correctly noted that neither the U.S. nor the Israeli estimates account for contract uncertainties, we convey the impression that the cost of subsequent contracts is already fixed.

Although Bet Shemesh has experienced financial difficulties and several management changes, an Israeli official said that the company has not "collapsed." If DOD is referring to the Israeli government's decision to sell its share of the company, it should be noted that this was a decision required by Pratt & Whitney (which designed and owns the engine to be used in the Lavi) when it purchased part ownership of Bet Shemesh 2 years ago. If Bet Shemesh, for any reason, does not become involved in the production, it may serve to clarify rather than add to the uncertainty of engine costing. According to Pratt & Whitney, the net cost to Israel would be less if Pratt & Whitney produced more of the engine, due to savings in additional tooling requirements and licensing fees. The net difference would be about $40,000 per engine. It would cost about $160,000 more per engine to produce the engines in the United States rather than in Israel, according to the latest Pratt & Whitney offer.

However, Israel can save $59 million, or $200,000 per engine, in tooling and equipment costs if the engines are not built in Israel, according to Pratt & Whitney officials.

Regarding future contracts, it was not our intention to suggest that subsequent contracts are fixed (we also acknowledge such uncertainties). In the case of the Lavi engine, according to DOD officials, their estimate assumes that Pratt & Whitney will recover all development costs of the engine from Israel. As discussed, Pratt & Whitney officials deny that this was ever their intention. Also, according to information received from Israeli officials, their contract with Pratt & Whitney includes options for future engines with agreed upon pricing rules, which indicates that recovery of development costs is not included. Using such information, we concluded that DOD overestimated the cost of the Lavi engine.

Avionics

DOD estimated total avionics costs at $1,270.46 million. At the time of its study, DOD did not have MOD's avionics estimate and instead used an analogy to U.S. systems. We reviewed MOD's avionics estimate of $1,464.00 million. This estimate was based on analogies to similar systems and an engineering estimate for four separate avionics sections plus miscellaneous components. We increased the DOD estimate to account for this more complete information.

Armament

The MOD estimate for armament hardware is the sum of four separate items—weapons rack system ($91.90 million), external fuel tanks ($21.71 million), external stores ($116.15 million), and other systems ($12.67 million). In its estimate, MOD labeled this category "armament and external loads."

DOD officials told us that because this breakdown was not made available to them, the DOD cost team estimated armaments costs using another weapon system as an analogy. DOD's estimate produced a total armaments cost of $8.92 million. This estimate, however, was for the gun only and can be compared to the MOD's estimate for the gun placed under "other systems" ($12.67 million). We reviewed MOD's estimate, which was based on engineering estimates and analogies to similar systems. We used the estimate for the weapons rack and other systems ($104.57 million) for the armament estimate. This information covered items not elsewhere identified by DOD. This more complete information increases DOD's estimate by $95.65 million.

Systems Engineering/Program Management

The DOD estimate of $271.95 million for systems engineering and program management (SE/PM) is 4.6 percent of the sum of recurring airframe, engines, avionics and armament costs. The DOD development estimate for SE/PM assumes about 750 people are needed to perform these two functions, based on U.S. aerospace industry experience.

As previously discussed, the MOD has been performing this function with 200 people throughout the development program. Israeli officials stated that no additional personnel will be used to perform these functions. We recalculated DOD's estimate for procurement SE/PM based on 200 people working 150 hours per person per month (an industry standard) for 14 years (the planned production run) at about $32 per hour (our engineering wrap rate). Total procurement SE/PM using this formula equals $162.99 million. Based on DOD's original estimate we allocated $47.15 million to nonrecurring costs and the remainder, $115.84 million, to recurring costs.

Auxiliary Mission Equipment

DOD's estimate of $123.68 million for auxiliary mission equipment (AME) was calculated as 2 percent of recurring flyaway costs (the total of airframe, engines, avionics, armament, and SE/PM, but not ECOs) because the cost team could not identify specific items to be included as AME from the data provided by MOD. This approach appears reasonable. Applying the DOD approach to the reduced flyaway cost as the result of our previous changes reduces DOD's AME estimate by $28.56 million, to $95.12 million.

Engineering Change Orders

At the time of its study, DOD did not have MOD's estimate for ECOs. As a result, DOD estimated ECOs for production at 5 percent of other recurring flyaway costs resulting in an ECO estimate of $315.38 million. Subsequently MOD provided us its ECO estimated ($460.00 million in 1984 dollars or $476.56 million in 1985 dollars). Had this information been available, we believe DOD would have used the higher estimate.

Flyaway Cost

Flyaway cost is the sum of the various recurring cost categories discussed thus far under procurement—airframe, engines, avionics, armament, SE/PM (recurring portion only), AME, and ECOs. If taken together, the net effect of the above changes to the various categories in recurring flyaway cost is a net reduction of $1,295.43 million. To arrive at an estimate for total procurement cost, three other cost categories are added to

the flyaway cost: nonrecurring costs, peculiar support costs, and initial spares.

Nonrecurring Cost

This category includes costs to set up production facilities, including labor and materials, and is not included in calculations of recurring flyaway cost. DOD's estimate of airframe nonrecurring cost is $279.10 million and is based, in part, on a wrap rate of between $44 and $49 per hour. Nonrecurring costs consist of five components—tooling labor, materials, manufacturing engineering, systems engineering/program management, and "other"—using hours and dollars per pound analogies. In some of the estimates DOD used partial DCPR weight, and in others full DCPR weight was used.

At our request, DOD recomputed the airframe nonrecurring costs based on the use of MOD's partial and full DCPR weights, our wrap rates, and the recalculated SE/PM estimate. This would reduce DOD's estimate by $37.65 million, to $241.45 million.

Peculiar Support and Initial Spares

These categories are a percentage of recurring flyaway costs. We revised the DOD estimate for peculiar support and initial spares, using the same percentage factors based on recurring flyaway cost used by DOD but applying them to our revised estimate of recurring flyaway cost. The percentage factors used by DOD were 18 percent for peculiar support and 37 percent for initial spares. As a result, DOD's peculiar support estimate can be reduced by $214.39 million, to $958.96 million, and its initial spares estimate can be reduced by $444.54 million, to $1,971.19 million.

Objectives, Scope, and Methodology

This report responds to a March 1986 request from the Chairman of the Subcommittee on Europe and the Middle East, House Committee on Foreign Affairs, to review the Israeli Lavi fighter aircraft project. Specifically, this report responds to the Chairman's request that we compare DOD and Israeli cost projections, noting any substantial differences, and provide an assessment of their reasonableness. In this report we address

- the major differences in DOD and MOD cost estimates of the Lavi project,
- areas in which we believe adjustments to cost projections are appropriate and the effect those adjustments have on bridging the gap between the respective estimates, and
- the potential that the Lavi project has for absorbing funds necessary to meet other Israeli military requirements.

In conducting our review, we examined the DOD and MOD cost estimates and sought to understand the differences between them and whether it was possible to make adjustments to narrow the gap. To assist in reviewing the cost estimates, we hired an expert cost analyst who is nationally recognized for his work in defense systems cost analysis.

We conducted our review in Washington, D.C., primarily at the Departments of State and Defense. In the Department of Defense, we worked principally within the Office of the Under Secretary of Defense for Policy, OSD's Office of International Security Affairs, and OSD's Office of Program Analysis and Evaluation. We also conducted our review within the Defense Security Assistance Agency and Air Force's Directorate of Cost and Management Analysis. In addition, we obtained relevant documents and interviewed U.S. officials at the American Embassy, Tel Aviv; cognizant Israeli officials from the Israeli Embassy, Washington, D.C.; the Israeli Military Procurement Mission, New York, N.Y.; and the Ministries of Finance and Defense, and the Israeli Defense Forces (including component services), in Israel. Finally, we received information from U.S. and Israeli industry representatives directly involved in the Lavi program. Our review was conducted in accordance with generally accepted government auditing standards.

Comments From the Department of State

United States Department of State

Comptroller

Washington, D.C. 20520

December 12, 1986

Dear Mr. Conahan:

I am replying to your letter of November 26, 1986 to the Secretary which forwarded copies of the draft report entitled "LAVI: Analysis of DOD and Israeli Cost Projections" for review and comment.

The Department has reviewed the report and does not have any comments.

You also requested a security classification review. The Department concurs with the Department of Defense's security classification determination.

We appreciate being given the opportunity to review and comment on the draft report.

Sincerely,

Roger B. Feldman

Roger B. Feldman

Mr. Frank C. Conahan
Assistant Comptroller General,
National Security and
International Affairs Division,
U.S. General Accounting Office,
Washington, D.C. 20548

Comments From the Department of Defense

OFFICE OF THE UNDER SECRETARY OF DEFENSE

WASHINGTON, D. C. 20301-2000

POLICY

2 January 1987

Mr. Frank C. Conahan
Assistant Comptroller General
National Security and
International Affairs Division
U.S. General Accounting Office
Washington, DC 20548

Dear Mr. Conahan,

This is the Department of Defense (DoD) response to the General Accounting Office (GAO) draft report entitled "Lavi: Analysis of DoD and Israeli Cost Projections," dated November 26, 1986 (GAO Code 464114/OSD Case 7173).

Readers of the GAO report should bear in mind the following significant points:

1. Growing U.S. concern about the program's cost led to a major review by the United States of the plane's mission, technical content, and cost, which was completed in February 1986.

2. This study is an inter-agency, U.S. study because it was undertaken not only by the DoD, but by the Department of State, Office of Management and Budget, and National Security Council, with DoD as the lead agency.

3. This inter-agency study indicated large disparities between the U.S. and Israeli cost estimates. In the U.S. view, LAVI's cost growth, most clearly demonstrated in the projected cash flow requirements, threatened to unbalance both Israel's military program and the U.S. military assistance program for Israel.

4. The DoD basically agrees with the concept of trying to make the estimates definitionally comparable, but notes that the Israelis did not provide the inter-agency group enough cost documentation to determine whether their basic estimate is an adequate starting point on which to make adjustments. Without the work breakdown structure "dictionary" (i.e. a definition and organization of categories of work for cost estimation purposes), only provided after the GAO insisted that Israel produce the document and long after the U.S. study was completed, and a technical team assessment of those Work Breakdown Structure (WBS) elements for completeness and associated cost estimates for each WBS, it is impossible to reconcile the two estimates. It was as a result of this lack of WBS dictionary data and similar program related documentation the U.S. inter-agency cost team took a functional approach to estimating the LAVI rather than WBS. The DoD also notes that the GAO also employed the U.S. Air Force methodology, and in doing so, implicitly accepted key elements of such a functional approach.

5. The United States is taking the initiative, by reviewing alternatives to the LAVI, because the United States is concerned about the consequences for Israel's defense program and the U.S. military assistance program. Israel's recent imposition of a

$550M cap on LAVI-related expenditures underlines the gravity of the issue, and demonstrates that unless Israel's estimates prove entirely correct--an unlikely circumstance given delays that have already afflicted the program--the impact on Israel's overall defense program and posture, as well as U.S. military assistance, is likely to be severe. The alternatives study is expected to be published and presented to Israel in January 1987.

In summary, the DoD and GAO are in fundamental agreement over the probable requirement for funds and cash flow for the LAVI program and the likely consequences for Israel's defense program and the U.S. military assistance program. The DoD also agrees there are significant differences between the U.S. and Israeli cost estimates for the LAVI. The DoD, however, cannot concur with the GAO adjustments to these estimates. The GAO adjustments understate the basic similarity, and consequent cost implications, of the Israeli production environment to that of the United States. Moreover, recent delays in the Lavi prototype flight schedule, the collapse of the Bet Shemesh engine factory (which is now in receivership), and Israeli reports of both production stretchouts and wage rate increases, all point to program slippages and further cost growth and underscore the need for conservative estimation of Israeli cost factors.

The detailed DoD comments on each finding are provided in the enclosure. Thank you for the opportunity of commenting on the draft report.

Sincerely,

Dov S. Zakheim
Deputy Under Secretary of Defense
Planning and Resources

Enclosure

GAO DRAFT REPORT - DATED NOVEMBER 26, 1986
(GAO CODE 464114) - OSD CASE 7173

"LAVI: ANALYSIS OF DOD AND ISRAELI COST PROJECTIONS"

DEPARTMENT OF DEFENSE COMMENTS

* * * *

FINDINGS

FINDING A: LAVI Financed Predominately By The United States. The GAO reported that in 1979, the government of Israel decided to develop and produce a fighter aircraft named LAVI (Hebrew for lion) for interdiction and close air support and so notified the United States early the following year. The GAO observed that the LAVI was initially described as a relatively unsophisticated plane but has evolved into a technically advanced aircraft, most often compared to the F-16. The GAO reported that planned production (a total of 300 aircraft with 24 being produced per year) is intended to cover only the Israeli military requirements, although Israel hopes to find export markets for the LAVI or its major components. According to the GAO, FY 1984 marked the first time that the Congress specifically earmarked foreign military sales (FMS) funds for the LAVI. The GAO found, however, that since FY 1984, the United States has approved $1.4 billion in FMS funds for LAVI research and development activities as well as procurement of finished goods both within the United States and Israel. The GAO also found that, according to information provided by Israel, actual expenditures on the LAVI between 1980 and 1986 totaled about $1.5 billion. The GAO concluded, therefore, that to date the United States has funded 90 percent (or $1.3 billion) of the $1.5 billion total cost of the LAVI. The GAO also observed that U.S. industry is heavily involved in the LAVI program. According to the GAO, as of March 1986, Israel had awarded about $635 million in contracts and other purchase orders to over 400 U.S. companies, with 26 companies having contracts over $1 million. The GAO concluded, however, that although the Israeli Ministry of Defense (MOD) estimates that over 50 percent of future LAVI expenditures will be in the United States, as of September 30, 1986, less than 30 percent of the total expenditures had actually been spent in the United States. (pp. 4-5/GAO Draft Report)

Now on pp. 3 and 4.

DoD Response: The DoD concurs that the nature of the plane has changed, that its costs have risen, and that it has been primarily funded by the United States. The DoD has the following observations, however, regarding Israel's export plans.

Concerning production and export markets, production increases above internal needs and favorable markets are needed to ensure exports. Production estimates have decreased, however, and export markets are not assured. Israeli hopes to export the LAVI have never been officially stated. In fact, Israel has made a point of describing LAVI as "unique" to Israel's environment. Moreover, such exports would have to compete on the world market with over a half dozen new aircraft (including, but not limited to, U.S. models). Israeli export of LAVI also would require U.S. permission, since a large proportion of LAVI is of U.S. origin. It should also be noted that Israel's market would be limited, since neither Arab nor European states are serious potential buyers.

FINDING B: Controversy Over Cost. The GAO reported that, as early as 1982, U.S. officials had become concerned about the potential cost of the LAVI, the impact it could have on the level of U.S. military assistance to Israel, and the effect that a growing LAVI program could have on Israel's overall defense program. The GAO noted that, in April 1985, the Israeli Minister of Defense and the DoD Under Secretary for Policy agreed that the DoD would examine the mission, technical, and cost factors related to the LAVI aircraft program. The GAO reported that the DoD study resulting from this agreement, which was released early in 1986, showed a wide disparity between the DoD and the Israeli cost estimates. According to the GAO, the DoD estimate of unit flyaway costs was 52 percent higher than the Israeli estimate. The GAO noted that Israel disputed the DoD estimate, claiming the DoD did not adequately account for substantial differences between the financial and cost structures of U.S. and Israeli industries. According to the GAO, Israeli officials also contended that the DoD simply made a number of "critical misassumptions." The GAO observed that since completion of its cost study, the DoD has nonetheless been hesitant to approve further LAVI-related procurements with FMS assistance and has pressed for consideration of alternatives to the LAVI. (The GAO noted that, as a result, in March 1986, the Chairman of the House Subcommittee on Europe and the Middle East requested the GAO to study the DoD and Government of Israel cost estimates for the LAVI.) The GAO also observed that, in August 1986, DoD began studying LAVI alternatives and is expected to complete this study around the end of

Now on pp. 4 and 5.

calendar year 1986. According to the GAO, the Israeli Minister of Defense has agreed to consider the DoD study, but has repeatedly stated that the Israeli decision to produce the LAVI remains firm. (pp. 6-7/GAO Draft Report)

DOD Response: The DoD concurs that there is a controversy over cost but does not agree with the summary description of that controversy or the U.S. position.

First, the study was not a DoD study but an inter-agency effort. The study resulted from active participation on the part of the Department of State, the National Security Council, and the Office of Management and Budget. These agencies participated in overseas trips and reviewed and concurred with all documentation prior to publication. In this sense, the study and efforts to develop it should be recognized as a U.S. study and U.S. efforts.

The concern expressed by U.S. officials in 1982 was borne out by dramatic increases in the Israeli estimate for the LAVI program between 1982 and the start of the inter-agency study in 1985 (actually based on 1984 data). The reduction in planned program output reflected in the reduced annual production rate, 30-36/year to 24 /year and the dramatic increase in costs across the years from 1982 to 1984 are classic symptoms of a program in trouble.

It is insufficient to report that Israel challenges the U.S. estimate on the grounds that it does not adequately account for substantial differences between the financial and cost structures of U.S. and Israeli industries without also reporting, in the same place, U.S. efforts to obtain additional data. On many occasions, through written data requests and discussions during on-site fact finding visits, the U.S. cost team asked for but never received specific financial and cost structure information on Israeli Aircraft Industries (IAI). Specific requests for labor rate changes, overhead structure, and business base assumptions were at the heart of the matter. The inter-agency team fairly accounted for differences between the two financial environments but was not provided the data needed for a ground-up engineering-based estimate.

A major area of concern that was expressed by the inter-agency team during fact finding about the financial structure of IAI was the use of a corporate allocation of money to cover the difference between "negotiated prices" versus actual cost. No

detailed explanation of this area was ever provided by the Israeli Ministry of Defense, even after repeated inter-agency cost team requests.

The statement reporting Israeli officials' assertions that the U.S. made a number of "critical misassumptions" needs further explanation. The inter-agency team has yet to see verifiable data from Israel or any other source that would allow it to change any of the "critical assumptions."

Now on pp. 14-16.

FINDING C: Adjustments To Make The Israeli Estimate Comparable To The DoD Estimate. The GAO found significant differences between the DoD and Israeli cost estimates for the LAVI. The GAO made the following adjustments to make the Israeli estimate definitionally comparable to the DoD estimate (Appendix I in the GAO Draft Report pp. 16-19, details the specific steps GAO took to make the estimate comparable):

- adjusted the Israeli estimate from 1984 to 1985 dollars, using a 3.6 percent factor to account for inflation;

- added engineering change orders to the Israeli procurement cost estimate; and

- reallocated some production tooling costs, which Israel had accounted for in a different way than DoD.

The GAO concluded that the net result of these adjustments would add over $2.8 million per aircraft to the Israeli flyaway cost estimate. The GAO also found additional areas where, in its opinion, the Israeli estimate was low. The GAO could not recalculate its estimate in all instances, however, because specific information on the Israeli methodologies was lacking. The GAO noted, for example, that neither the Israeli estimate nor the DoD estimate (1) provide for significant slippages or other unforeseen problems, which could increase costs, (2) account for a number of uncertainties related to future contracts, and (3) assume cost declines based on learning curves but U.S. estimating experience has shown that many things can occur in the production of major weapon systems, which drive costs up, often overwhelming cost declines from learning. In one instance involving hourly rates for manufacturing, the GAO was able to recalculate an estimate, and concluded

Now on pp. 2, 4-6, and 14-16.

that using GAO hourly rates higher than those used by Israel could increase the Israeli flyaway cost estimate by as much as $400,000 per aircraft. (pp. 2-3, pp. 8-9, pp. 16-19/GAO Final Report)

DoD Response: The DoD concurs that there are differences between U.S. and Israeli cost estimates, but cannot concur that the GAO adjustments are correct or sufficient. There continue to be inherent difficulties in fully validating or evaluating Israel's estimates. For instance, the GAO adjustments do not address the specific concerns identified by the inter-agency team in its cost analysis - all of which addressed difficulties in obtaining data. The major items still missing are: Kfir/IAI plant history, overhead/business base structure, engineering weight statement, priced bill of materials, and GOI estimate documentation. The DoD has greater confidence in its estimate as borne out by actual experience in other programs. For example, it is noteworthy that a recent inter-agency study of the Israeli naval modernization program reached a common work breakdown structure with the Israeli Navy as a basis for analysis; the resultant disparity in cost estimate was less than 10 percent.

The DoD basically agrees with the concept of trying to make the estimates definitionally comparable, but notes that the Israelis did not provide the inter-agency group enough cost documentation to determine whether their basic estimate is an adequate starting point on which to make adjustments. Without the work breakdown structure "dictionary"(i.e. a definition and organization of categories of work for cost estimation purposes), only provided after the GAO insistence that Israel produce the document and long after the U.S. study was completed, and a technical team assessment of those Work Breakdown Structure (WBS) elements for completeness and associated cost estimates for each WBS, it is impossible to reconcile the two estimates. It was as a result of this lack of WBS dictionary data that the U.S. inter-agency cost team took a functional approach to estimating the LAVI rather than WBS. The DoD also notes that the GAO also employed the U.S. Air Force methodology, and in doing so, implicitly accepted key elements of such a functional approach.

The MOD cost estimate for tooling demonstrates the inherent difficulties in accepting Israeli cost estimates and accepting any adjustments derived from them. The GAO accepted the MOD tooling estimate of $315.98 million, and moved it from

development to procurement costs. Use of the MOD tooling estimate without an assessment of the adequacy of the work content adds to the uncertainly of the MOD costs for the LAVI. During its visit, the U.S. cost team asked for production planning data to include tooling requirements. The team was told that the data was not available because the actual production plans would not be done until summer of 1987--at which time tooling requirements in terms of content and dollars would be known. The U.S. team questions the MOD's ability to complete an estimate for tooling prior to the time when production plans are formulated. It should also be emphasized that even if the GOI estimates do capture all the WBS cost elements, the costs applied to the estimated hours may only be the "negotiated GOI-IAI rates." It appears that the Israeli accounting system may not capture the actual rate paid as opposed to the rate allowed. This finding created much concern for the U.S. cost team. In many instances the U.S. team was told that actual costs versus allowed costs were different -- but when it queried on how this difference was handled in the accounting system it received no answer. The U.S. team also noted that the negotiated rate led to a situation wherein any losses accruing from underfunded overhead costs were transferred to the IAI's sole shareholder, the Government of Israel, in the form of foregone dividends.

The DoD agrees that the U.S. and Israeli estimates do not provide for contract uncertainties, for cost declines that may not materialize, and for program slippages. In fact, the program slipped even while the U.S. and GAO study efforts were going on. The best example is the slip of the first flight of the prototype aircraft. According to IAI officials in February 1985, the first flight was supposed to occur in February 1986; it has yet to occur. Moreover, recent Israeli reports point to additional delays and production stretchouts.

FINDING D: Adjustments To The DoD Cost Estimates. The GAO reported that estimating the procurement costs of aircraft that are to be produced over a period of 14 years is a difficult task under the best of circumstances. In the case of the LAVI, the GAO observed that the DoD cost estimating team faced two additional problems--(1) much of the LAVI is to be produced in Israel, an economic and production environment that is different from that of the United States, and (2) only some of the relevant historical cost and production data was available to the DoD cost team. The GAO reported that, given those limitations, the DoD cost team used analogies to U.S. aerospace industry and added certain estimated factors to

account for costs not identified elsewhere or to allow for the Israeli manufacturing environment. According to the GAO, the principal cost elements computed wholly or in part using this approach were the hourly rate (which includes direct labor and overhead), aircraft weight, labor hours, and materials. The GAO also pointed out that, in reviewing the DoD methodology and calculations, the GAO had the benefit of considerable information provided by Israel--in many instances more current and complete information than was available to the DoD at the time of its cost study. Based on its review of the DoD methodology (using the more current information), the GAO questioned the DoD calculations for hourly rates, aircraft weight, labor hours, and materials costs, as follows:

- Israeli engineering hourly rate. For engineering costs, for example, the DoD used an hourly rate of $47, but the GAO calculated a rate of $32 based on actual LAVI development data.

- LAVI weight. Israel provided GAO a more current and complete weight estimate, which is lower than the DoD estimate.

- Labor hours. The DoD estimated labor hours on its aircraft weight estimate and analogies to the F-16. The DoD used the estimated full weight of the LAVI to make certain labor-hour calculations, even though Israel will produce only part of the aircraft. According to the GAO, this methodology resulted in overestimating the labor hours. The DoD also adjusted the labor hours upward to account for low production rates and for extra time to handle composites. According to the GAO, both of these adjustments were inappropriate because they do not reflect actual Israeli production plans.

- Materials. The DoD calculated the cost of materials based on an analogy to the F-16. According to the GAO, the DoD increased the materials estimate to account for the higher cost of composite materials, but overstated the effect.

The GAO found that each of the above cost elements affected several of the DoD development and procurement cost categories. As a result, the GAO questioned the DoD estimates in six of eight broad cost categories for the development phase and all ten categories for the procurement phase. (Appendix II in the GAO Draft Report, pp. 20-43, discusses the GAO analysis in detail.) The GAO concluded that

Now on pp. 17-34.

Now on pp. 2, 6-7, and 17-34.

the unavailability of specific Israeli data caused the DoD to draw on U.S. aircraft production experience, much of which was not closely analogous to the Israeli experience, and this caused the differences between the U.S.-Israeli estimates. The GAO further concluded that, based on the more complete and current data available at the time of its review, for all the questionable items taken together the inter-agency team may have overestimated total LAVI program costs by $2.7 billion and overestimated flyaway costs by as much as $4.3 million per aircraft. (p. 2, pp. 9-11, pp. 20-43/GAO Final Report)

DoD Response: The DoD does not concur with the GAO's adjustments to the U.S. cost estimates.

The DoD agrees that the economic environment is different but the GAO does not demonstrate how the production environment in Israel is not analogous to the United States. The tasks and activities associated with the development and production of a high technology fighter aircraft are the same no matter which country builds it. The production process is much the same in the United States and in Israel. The type of work and type of personnel required are the same. The hours required to do the work will depend upon how much prior experience ("learning") is inherent in their factory. This is especially true when compared to a company such as General Dynamics, which has the benefit of many high technology aircraft in their experience base. In fact, a tour of IAI facilities by the inter-agency team revealed many of the same manufacturing equipment and procedures used by U.S. aerospace companies.

Use of analogous systems to estimate future requirements is a widely accepted way of achieving high confidence estimates. This is particularly true if the physical and performance characteristics of the two systems match as they did in the current analysis. Both through on-site examination and review of technical data, the U.S. technical team assessed the LAVI to be analogous to current U.S. fighter systems. For the GAO to report that the production environment in the two countries is different, it should also explain the differences and develop its own series of models.

The GAO statement that it received more current and complete data in no way signifies that the data was of a better quality for cost estimation purposes. Review

of the GAO data reveals no facts that would alter U.S. assumptions or change the original U.S. study results. For example, the Pratt & Whitney engine contract only covers the first 30 out of a requirement for approximately 450 engines. The DoD understands that Pratt & Whitney has offered an option for an additional 140 engines. Nevertheless, the collapse of Bet Shemesh, the Israeli engine manufacturer, only adds to the uncertainty of the engine costing, since Pratt & Whitney could manufacture the remaining engines without the cost discipline imposed by competition. The GAO correctly reported that both the U.S. and Israeli estimates do not account for contract uncertainties, but at the same time the GAO adjustments do not account for the incomplete nature of these production contracts and conveys the impression that the cost of subsequent contracts is already fixed.

Following are some specific comments relating to the GAO adjustments of the inter-agency team's calculations:

Israeli Engineering Hourly Rates (U.S. study used $47, the GAO calculated $32)

- The DoD questions the source of the data provided by the GAO. Moreover, it is significant that Israel provided hourly wrap around rates of between $30 and $40 for electronics industry work related to the Saar Missile Boats/Dolphin submarine. It is difficult, if not impossible, to accept an overall Israeli rate of $26 in light of what is acceptable for a naval program. Even the GAO rate of $32 seems low, especially in light of recent reports emanating from Israel that quote IAI's wage rates at $37/hour.

- There is no evidence that the data on compensation, including fringe benefits applies to high technology airframe manufacturers type of workers. Use of Israeli domestic manufacturing industry rates are not comparable to the type of salaries commanded by specialized engineers.

- In addition, contracts between IAI and the MOD are misleading. If a contract is built on an artificially low hourly rate, the loss IAI would absorb would be transferred to its sole shareholder, the Government of Israel, with the same consequences for the MOD budget that would apply if a higher wrap-around rate were built into the contract.

- Finally, GAO's citation of the DCAA audit was inappropriate. The DCAA report has many disclaimers not to be used for any other studies. In addition, the personnel cited in the DCAA report are maintenance workers, who comprise a significantly different production category from the airframe manufacturers being estimated in the LAVI program. Moreover, the DCAA recommended rates differ greatly from the IAI proposed rates which approach the upper $30 range. The assertion that the maximum rate IAI is permitted to charge MOD is $35/hr begs the question of how the "actual cost" vs. "permitted cost" is reconciled.

LAVI Weight

- The full weight provided by Israel to the GAO was 9,501 lbs and partial weight was 7,171 lbs. The inter-agency team used a higher full weight figure of 9,843 lbs and 7,159 lbs for partial weight.

- Since receipt of the June 1985 package of weight data, the U.S. team has received or had access to 4-5 different weight data packages. The track of the weights over time has consistently decreased. This trend is contrary to the substantial U.S. experience in aircraft development. The U.S. team remains uncertain whether the weight reductions are due to changes in material mix (for example, weight can be saved if composites are added) or changes in goals. The absence of the materials mix statement leaves a very important gap in the data.

- The U.S. inter-agency team employed an engineering team's assessment of the adequacy of the weights. The GOI continues to refuse to provide a complete engineer weight statement to match a materials mix listing.

- The GAO never fully explored this trend of multiple weight changes over time, or its implications for costs.

Labor Hours

- The GAO statement that DoD made an inappropriate adjustment to labor hours to account for low production rate missed the study team's purpose in making that adjustment. The adjustments were to normalize the U.S. data base from a production rate of from eight to ten aircraft per month to the two per month to make it comparable to the planned Lavi rate. This inter-agency adjustment is similar in principle to the adjustments the GAO made to the Israeli estimate to make it comparable to the U.S. estimate. The adjustment recognizes that LAVI is being procured at rates much less than the analogous data base and employs materials that require more handling than those used in the analogous data base. Without these adjustments the analogous data base cannot be normalized properly.

Materials

- The GAO's assessment that the adjustment for composite materials was being overstated is due to the GAO attempting to derive an adjustment at the component level. The inter-agency team's adjustment was performed at the total aircraft system level. Without a material mix listing, the U.S. technical team could not verify the exact location of composite components. Since that was not possible, the examination was based on the F-16 being 2% composites in total vs. LAVI being 22% composites in total. Any subdivision is outside the bounds of the cost team's model for estimating the additional cost of composites. It is probable that some additional adjustment should have been made by the inter-agency team. No basis has available for making such an adjustment nor would it in any event have been as large as that which the GAO has accepted. It is noteworthy that during its fact finding visit to IAI, the U.S. team examined the prototype facility where the work on composite materials was being done. Discussions with IAI technical personnel revealed the additional time, handling, and storage requirements of the composite components.

- There are areas of the aircraft in which IAI will work directly with composites. They are:
  - Canard
  - Seals around canopy
  - Access panels
  - Other misc

The GAO estimate appears to be low.

Other Areas of Concern

System Engineering/Program management. The GAO statement that MOD officials stated that they do not use, or plan to use, more than 200 people to do this effort does not mean this is an adequate level of manpower to perform the task. If its true that only 200 people are available, then an assessment of schedule to match activity level is required. In the view of the U.S. team, system engineering will be a major cost driver in terms of schedule and dollars. Even today, there is evidence of this area experiencing schedule extensions, notably in software for the flight control computer.

Integrated Logistics System (ILS). The GAO assessment does not fully account for all the ILS activity that needs to be performed on this program. In MOD's LAVI program, ILS program elements are as follows:

- ILS Planning
- Logistic Support Analysis
- Initial Provisioning/Supply Support
- Technical Pubs*

- Support/Test Equipment*
- Training*
- Facilities Planning
- Packaging, handling, transportation, storage
- Logistic Data Management
- Customer Support

The U.S. team estimate for peculiar support only covers the 3 categories indicated by an asterisk (*). Costs for the remaining 7 activities is covered in the $260 million estimate.

FINDING E: Annual Outlays Will Consume A Large Share Of The Israeli Defense Resources. The GAO reported that, although the DoD and the Israeli estimates vary substantially, both project substantial growth in yearly cash requirements--that is, the amounts required to meet the Israeli planned production. The GAO estimated annual outlays using inflation rates of 3, 6 and 9 percent. Using a 6 percent rate, the GAO found that annual outlays will exceed $1 billion by 1990 and exceed $1.4 billion by the year 2000. At a 3 percent inflation rate, the GAO found annual outlays will be about $0.9 billion each year from 1991 through 2000. (The GAO reported its estimates are based on cash flow estimates provided by the DoD and Israel. Appendix III to the Draft Report, pp. 44-49, discusses the GAO computations it used for its estimates.) The GAO reported that, in April 1985, the Israeli Minister of Defense set an annual spending limit of $550 million on the LAVI program. The GAO concluded however, that regardless of which estimate one uses--the Israel, the DoD, or the GAO estimate--projected annual outlays quickly exceed this spending gap. The GAO observed that many U.S. officials question the Israeli ability to build the LAVI and meet other defense requirements. According to the GAO, Israeli officials advised that the government of Israel does not intend to increase its shekel expenditures for the LAVI program. The GAO found that, instead, the Israelis hope U.S. budgetary constraints will have run their course by the early 1990s so that

Now on pp. 1 and 7-9.

additional U.S. funding will be available to complete the LAVI program. The GAO reported that the DoD recognizes that substantial outlays will be required for replacement aircraft during the next 15 years, whether the LAVI continues or not--Israel and the DoD do not dispute the necessity to replace the Israeli aging aircraft. According to the GAO, however, DoD officials believe that there may be less costly alternatives to meet mission requirements--alternatives that would allow Israel to stay within its annual $550 million limit. The GAO reported that the DoD is currently studying available options and plans to present its findings to Israel around the end of calendar year 1986. The GAO concluded that the funding required to produce the planned 300 LAVI aircraft will consume an increasingly larger share of the Israeli defense resources. The GAO further concluded that as production progresses, annual outlays will begin to consume most of the currently authorized $1.8 billion of U.S. military assistance. (p. 3, pp. 11-14, pp. 44-49/GAO Draft Report)

DoD Response : The DoD concurs that the annual cost for the Lavi will rapidly exceed the Israeli's self imposed $550 million annual cap. It should be noted that the inter-agency-directed alternatives study currently underway has verified that a significant number of alternatives exist that will meet Israeli military and economic requirements as well as cost less than the $550 million annual cap. This alternatives study is now expected to be published and presented to Israel in January 1987.

RECOMMENDATIONS

None.

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U. S. Approves Technology Transfer To Israel for Lavi

Washington—The Reagan Administration has approved the transfer of composite wing technology to Israel to develop the Israel Aircraft Industries Lavi tactical fighter aircraft.

Defense Secretary Caspar W. Weinberger told Israeli government officials during a recent trip to Israel that the U. S. will permit Grumman Aerospace Corp. to make available composite material technology to manufacture wings for the future fighter, which is expected to replace the McDonnell Douglas A-4 and the Kfir C2 aircraft in the Israeli air force (AW&ST Oct. 22, p. 17).

Israel is planning to build five prototype aircraft, with the final three incorporating a composite wing built by Grumman. The aircraft also will be developed as a trainer, and three prototypes will be configured with two seats.

The development cost of the Lavi is estimated to be $1.37 billion in fiscal 1982 dollars. Plans call for production of more than 300 of the Lavis for the Israeli air force.

The Reagan Administration earlier approved Phase 1 and Phase 2 of the Lavi program, which included the preliminary design and cost proposals for the aircraft from U. S. industry and a full-scale engineering development phase.

Composite wing technology is Phase 3 in the Lavi development program.

The State Dept. delayed transfer of composite materials technology from three U. S. aerospace companies, Grumman, LTV Aerospace and General Dynamics, after differences developed between the U. S. and Israel over Middle East policy, especially concerning Lebanon (AW&ST Sept. 13, 1982, p. 31).

The wing and vertical tail for the Lavi will be developed by subcontracting in the U. S. by Israel Aircraft Industries for composite structures. Israel also plans to apply composite technology to the all-moving canard and other control surfaces and to structural doors, panels and air brakes (AW&ST Jan. 10, 1983, p. 20).

Grumman officials said Phase 3 calls for the company to manufacture the first 20 composite wings for the Lavi and transfer the manufacturing process to Israel.

Full-scale production of the Lavi is scheduled to start in about 1990 with the first 20 wing sets to be delivered in the late 1980s.

While plans call for Israel to build a composite technology facility in the country, a decision may be made to order all the composite wings from Grumman because of the capital outlays required to set up a manufacturing plant.

"The way the contract with Grumman is written, they've [the Israelis] got options to go to 20, to 50, to any number they want as far as continuing to buy from Grumman built in the U. S.," a Grumman official said.

A decision to exercise the option is not pressing and could be made in several years without affecting the ability of Grumman to deliver additional wings.

The Lavi is also scheduled to replace the McDonnell Douglas F-4 Phantom in the Israeli air force in 1995.

Israel Aircraft Industries will produce about 12 Lavis a month once full-scale production is under way. □

LAVI

POINT PAPER
ON
DOD RESPONSE TO GOI COMMENTS ON DOD ASSESSMENT
LAVI COST ESTIMATE

GOI Comment: DoD conclusions reached are not based on an analysis of industries in Israel, but rather on direct analogies to comparable activities by US industry. (IA)

DoD Response: The DoD team did do an analyses of the technical aspects of IAI. In the area of cost, Israel peculiar/IAI peculiar data was requested but not received. (i.e. KFIR history, IAI learning curve history)

GOI Comment: Inappropriate application and loading of labor rates. US analyses does not reflect structure of Israeli industry rates and the actual average fully - loaded hourly rate in Israel is only $25/hr. (IIA)

DoD Response: During the DoD team visit (Oct 85), we requested information on business base assumptions, overhead structure, and labor cost breakouts. We were not provided this information until our April 14, 1986 meeting. The information provided was a handwritten sheet (Atch 1). It addressed only their rate for IFY 1984 and not their business base assumptions or ground rules for overhead structure. Because of differences in accounting systems and a lack of detailed definitions of their labor rate categories, it is impossible to determine if the make up of their wrap rate is complete. Atch 2 is a listing of all the cost categories the U.S. wrap rate contains. Exact matching of these cost categories to Atch 1 is impossible. This is part of the reason a WBS dictionary and definitions is so important.

We suspect, because of accounting system differences, labor categories not included in their wrap rate is paid for by corporate allocation and not directly chargeable to the LAVI program.

We question how they applied the direct and indirect labor costs. We requested a specific explanation of how the direct and indirect labor costs fit into their wrap rate. Whether the $13.60/Hr for engineering includes total direct and indirect or if the $13.60/Hr is the cost for each direct hour plus each indirect hour to total $27.20/Hr. This question was never answered to our satisfaction.

GOI Comment: "The first problematic area of adjustment was to account for the DoD assumption of a reduced monthly production rate from a normal rate... It is therefore inappropriate to upwardly adjust the Israeli and overhead factors as if there will be a reduction in planned production rate." (IIB (1))

DoD Response: The production rate adjustment was not used to adjust the Israeli overhead factors. The production rate adjustment was used to adjust the US manufactures analogous data base to normalize the data to reflect a lower production rate than the U.S. data base experienced.

Classified By: Multiple Sources
Declassify On: OADR

GOI Comment: "DoD Assessment also makes an adjustment for efficiencies related to the fact that a program of the LAVI scope is being performed in Israel for the first time...we did not receive an explanation of the source." (IIB (1))

DoD Response: During the April 14-17, 1986 meetings we informed the Israeli team that the adjustment for first time integration/efficiency was an assessment made by the US technical team to account for differences between a US technical team to account for differences between a US manufacturing capability and IAI.

GOI Comment: A composite materials adjustment factors were based on the DoD assumption that the proportion of composite materials in the fuselage will be 22%. The actual proportion of composite materials in the fuselage is only 4%. (IIB (2) a)

DoD Response: The composite materials adjustment factor was built to include the entire airframe, to include wing/tails where 16-18% (information obtained April 1986) of the composite materials is used, not just the fuselage. Part of this dilemma was created by the lack of detailed engineering weight statements and material mix percentage data received during the October 1985 fact finding trip. This caused us to choose a methodology that would capture all the materials cost including an adjustment for composite materials of which we only knew the total percentage in the aircraft, not individual pieces of composite percentages.

The model used to make the adjustment for composite materials deals with the entire airframe, therefore, it was applied that way in the U.S. estimate. Use of a model outside the range of its data base (splitting the airframe into two parts) increases the risk of the error term associated with the result.

Even with respect to the wings/tail being a separate contract with Grumman, we see the Grumman contract going to ceiling, plus additional risk associated with the engineering change orders that have already occurred. We expect Grumman to continue to encounter additional risk and our methodology attempts to cover some of that risk.

If we were to accept the Israeli position that the airframe be treated as two separate components, the resultant change in the unit price is only -$400K.

GOI Comment: Using a manhours per pound factor applied to total LAVI airframe weight, including the weight of the wing/tail, is inappropriate.

DoD Response: We did use a partial DCPR weight (minus wing/tail) in cost categories where it was appropriate. For most categories full DCPR weight was used because the integration of the wing/tail and all other subcontracts must be performed by the prime contractor. The man hours per pound (MH/LB) factor captures these integration hours.

GOI Comment: DoD double counted the cost of Peculiar Support Equipment (PSE)/Data/Training when they used Israel's estimate for Integrated Logistic Support (ILS), since it already includes PSE/Data/Training. (IIC (1))

DOD Response: We did not receive enough data to perform an independent estimate for their ILS program. Instead we did a check of reasonableness of their ILS estimate of $260M and found it reasonable but on the low side. Our check of reasonableness assumed the ILS cost category did not include PSE/Data/Training and was used in our estimate. No double counting occurred.

GOI Comment: Double counting of engine PSE. (IIC (2))

DoD Response: Factor applied to recurring air vehicle is to calculate PSE for the airframe/avionics excluding the engine, since the PSE engine is included in engine cost line. No double counting occurred.

GOI Comment: Subcontracts/vendor items "Since DoD did not use consistent method of estimation, but rather two separate ones which overlap at various points, there exists a real risk of duplication of costs." (IIC (3))

DoD Response: Methodologies used are a function of data availability. We did not receive a Priced Bill of Materials listing or a complete subcontractor/vendor listing to price out all the materials required. To alleviate this situation our approach was to build a materials factors that captures raw materials, standard hardware and purchased parts/equipment. The Israelis counter that most of these items are vendor items. But in our estimate they are included as material costs since we could not get to the level of visibility required.

GOI Comment: System Engineering (SE)/Program Management (PE) estimate would result in a manpower profile of 1000 employees which exceeds the 200 employees they have. (IID (1))

DoD Response: SE/PM refers to the activity IAI has to do not the SPO's 200 employees. Also the correct calculation of bodies required is closer to 700 not 1000 employees.

GOI Comment: Materials used for LAVI vs. US fighters are different. Israel experiences a step decrease in material cost at the point of transition from development to production. Whereas the US has a gradual learning curve. (IID (3))

DoD Response: Materials used for LAVI is not much different from any US fighter. Material purchases usually do not experience much learning (95% slope at the most, usually 98%). DoD has never experienced a step down of the learning curve at the point of production start.

GOI Comment: DoD should have used the engine contract value for their estimate. (IIE)

DoD Response: The current engine contract is only for 30 engines and does not include costs for R&D recoupment. Since the total program buy is 450 engines it is more appropriate to do an analogy estimate than use one data point for only 30 engines.

GOI Comment: Problems occurred due to misunderstandings of cost categories and definitions. (IIF)

DoD Response: Agree. That's the exact reason we asked for a WBS dictionary.

I.A.I - HOUR RATE - AFY 84

(BASED ON I.F.Y 83 AUDITING)

DESCRIPTION	ENG. $/HRS	MAN. $/HR.
DIRECT & INDIRECT LABOR (SALARIES)	13.60	11.60
ADDITIONAL SALARY ELEMENTS	0.96	0.96
REIMBURSMENT COST OF PRIVAT CAR OWNED BY EMPLOYER	1.88	1.08
OTHER REIMBURSMENT COST	1.61	1.41
INDIRECT MATERIALS	0.30	0.91
INSURANCE EXPENSES	0.01	-
RENTAL COST (CARS, EQUIPMENT, BUILDINGS)	0.26	0.25
TRAVEL EXPENSES (OVERSEAS)	0.04	0.03
KNOW HOW, LITERATURE, TRAINING	0.15	-
TELEPHONE, TELEX, TAXES	0.04	0.01
CLEANING, SERVICES (S/C)	-	0.09
JOB SHOPPERS	2.16	-
MAINTANANCE TOOLS & MATERIALS	1.20	0.31
—" — AND SERVICES RECIEVED FROM OTHER DEP.	0.41	0.62
TRANSFER EXPENSES	(-) 0.14	3.33
SERVICES RECIEVED FROM CENTRAL DEP.	1.10	0.69
CREDITS FOR SERVICES GIVEN TO OTHER DEP.	(-) 0.07	(-) 0.33
NON-MANUFACTURING WORKS	(-) 0.97	-
OTHER MAINTANANCE EXPENSES	0.01	0.14

DESCRIPTION	ENG. $/HRS	MAN. $/HR
COMPENSATION	(1) 0.89	(1) 0.76
DEPRECIATION	0.91	1.09
SURPLUS EXPENSES (CREDIT)	(1) 0.14	(1) 0.12
ADDITIONAL SALARY TO R&D WORKERS (A DIFFERENT UNION)	0.21	0.01
TAX ON IMPORTED SERVICES	0.47	0.09
OTHER CORRECTIONS	-0.96	-0.69
TOTAL EXPENSES PER HOUR	23.15	20.72
G&A PER HOUR	1.10	1.50
HOURLY RATE (EXC. R&D)	24.25	22.12
R&D PER HOUR (1%)	0.24	0.22
TOTAL HOURLY RATE	24.49	22.44
RETURN FOR CAPITAL INVEST.	0.18	0.22
PROFIT (4.5%)	1.06	0.96
TOTAL	25.73	23.62

Plant Wide Overhead Cost Categories

Indirect Labor

- Administrative Personnel
  - Accounting
  - Budgeting
  - Computer Services
  - Contract Adm
  - Marketing
  - Personnel
  - Product Support
  - Production Control
  - Public Relations
  - Planning & Purchasing
- Management & Supervision
  - Factory Fireman
  - Engineering Supervisor
  - G&A Management
- Repair & Maintenance Workers
  - Secretaries
  - Security Guards
  - Janitorial Service Workers
  - Cafeteria Workers

Fringe Benefits

- ✓ Vacation
- ✓ Sick Leave
- ✓ Jury Duty/Misc Absences
- ✓ Pension (Retirement)
- Grp Medical, Dental & Life Insurance
- ✓ Payroll Taxes (SS. Unemployment Taxes
- Disability Insurance
- ? Saving Plan
- Incentive Comp
- Ed Scholarship
- Workmen Comp
- Severence Pay

Facilities

- Depreciation ✓
- ✓ Amortization
- ✓ Insurance
- ✓ Taxes
- ✓ Rent
- Misc MATERIAL /Supplies
- UTILITIES
- Plant Rearrangement

Data Processing

Usage charges including indirect labor, fringe benefits, facilities-related and other costs

Corporate office allocation (based on total employment & sales of subsidaries)
- Personnel services (pension fund mgmt)
- Contract adm
- Financing
- Public relations

IR&D/Bid and Proposal
- Direct labor and Eng & factory OH

Other Costs

- Communications
- Indirect Supplies & Material
- Outside Services
- Persible Tools & Equip
- Personnel - Oriented EXPENSE
- Purchased Labor Variance
- Travel and Transportation
- Advertising
- Airplane Operations
- Business Conferences
- Contributions
- Dues & Membership
- Entertainment
- Patent Expenxe
- Postage
- Reproduction & Graphics
- Subscription and Books

G + A

C.O.M.

PROFIT