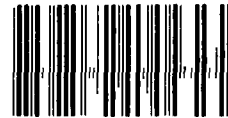


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BUDGET ISSUES

Cost Escalation on Three Major Department of Transportation Projects



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General Accounting Office
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Accounting and Financial
Management Division

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The Honorable Pete V. Domenici
Chairman, Committee on Budget
United States Senate

The Honorable William H. Gray III
Chairman, Committee on Budget
House of Representatives

In recent years, a number of Department of Defense and civilian agency projects have exceeded their original cost estimates. The Congress used these estimates to make funding decisions. When project costs are higher than originally anticipated, federal agencies must either obtain more funds, buy less, or stretch out the completion of the project, which often increases total project costs. Because of higher than anticipated costs for various federal projects and the growing pressure to reduce the federal deficit, the Senate and House budget committees added a cost study requirement (section 2905(b)) to the Deficit Reduction Act of 1984 (Public Law 98-369).

Section 2905(b) specifies, among other things, that the General Accounting Office (GAO) look at all phases of budget preparation and program evaluation in the agencies selected and examine historical patterns of funding to determine the effect of cost estimation biases.

In discussions with House and Senate budget committee staff, we agreed to focus primarily on the cost estimates for major acquisition projects and the reasons for cost growth. Cost growth or cost escalation refers to the difference between the latest estimate for the project and the initial estimate provided to the Congress. Some of the factors that can contribute to cost growth include requirement changes, technical changes, new technology, inflation, and quantity changes.

Our review included the Department of Defense and one civilian agency. We are submitting the results of our work on Defense in a separate report. This report addresses cost growth on selected Department of Transportation (DOT) projects. We selected DOT because it is one of the larger civilian agencies and it has a number of diversified, long-range, major acquisition projects.

We reviewed three DOT projects:

- U.S. Coast Guard's Short Range Recovery (SRR) helicopter project, which provides for the procurement of short range recovery helicopters (HH-65A's) to be used for search and rescue, polar ice breaking, law enforcement, and environmental missions (see appendix I);
- Federal Aviation Administration's Airport Surveillance Radar (ASR) program for the upgrade and replacement of older, obsolete radar (see appendix II); and
- Urban Mass Transportation Administration's (UMTA's) Buffalo Light Rail Rapid Transit (LRRT) System project which provides for the construction of the Buffalo, New York, transit system (see appendix III)

These projects were selected because they are major long-term acquisitions, procurement contracts had been awarded, and they were nearly complete.

What We Found

As discussed in detail in the appendixes, we found that all three projects experienced cost growth from the initial estimates provided to the Congress (or to UMTA, for the Buffalo transit system) to the latest estimates for completion of the projects. In examining the agencies' cost estimates, we found that some of the reasons for cost growth were outside of the agencies' control. In other cases, we found that certain practices, techniques, methodologies, or assumptions used by the agencies in developing cost estimates contributed to cost growth. However, this review of only three projects does not provide a basis for judging whether DOT or the three agencies systematically underestimate costs. The amount of cost escalation on the three projects reviewed is shown in table 1.

Table 1: Cost Escalation From Initial Cost Estimates Provided to the Congress to Latest Cost Estimates for Three DOT Projects Reviewed

| Dollars in Millions | | | | | | |
|---------------------------------|------------------------------------|--------------------|-----------------|--------------------|--------------------|---------|
| Project | Initial estimate provided Congress | | Latest estimate | | Cost growth | |
| | Date | Amount | Date | Amount | Amount | Percent |
| Short Range Recovery Helicopter | 3/77 | \$172.0 | 11/85 | \$457.8 | \$285.8 | 166 |
| Airport Surveillance Radar | 3/79 | 154.3 | 4/85 | 560.6 | 406.3 | 263 |
| Buffalo Subway System | 10/76 ^a | 336.3 ^b | 9/85 | 533.7 ^c | 197.4 ^d | 59 |

^aThe initial estimate provided to UMTA

^bFederal share \$269.0 million

^cFederal share \$420.3 million

^dFederal share \$151.3 million

We estimate that about \$192 million, or two-thirds of the cost growth on the SRR helicopter project, and about \$253 million, or almost three-fifths of the cost growth on the ASR project, were due to unanticipated inflation. Unanticipated inflation refers to the amount of inflation incurred or to be incurred over the acquisition phase of the project that was not included in the initial estimates to the Congress. The initial estimates were stated in constant dollars (base year prices) rather than current dollars (anticipated price levels that will exist in the years when expenditures will be made). FAA and Coast Guard officials were aware that future inflation would increase the cost of their projects, but they did not provide for inflation in their initial estimates because OMB budget guidance at that time did not require them to. We believe that a substantial part of this inflation should have been anticipated and included in the initial cost estimates that were provided to the Congress as the total project cost for the two projects. Even though the exact amount of inflation cannot be predicted with confidence, we believe that some allowance for inflation should be included in total project cost estimates for long-term acquisition projects. The amount to be included should be based on the best forecast available at the time the cost estimates are developed, and should be revised regularly during the course of the project to reflect actual experience.

With respect to the third project we reviewed—the Buffalo Light Rail Rapid Transit system—we found that even though inflation was included in the initial estimate, the latest cost estimate for this project shows that about \$21.2 million, or 11 percent of the cost growth, is

attributed to higher inflation than provided for in the initial estimate. This unanticipated inflation is due to inflation rates during the years 1978 through 1982 being higher than most forecasters expected.

Table 2 shows the amount, and percent, of cost growth attributed to unanticipated inflation and to other reasons for each of the three projects we reviewed.

Table 2: Major Reasons for Cost Growth

| Dollars in Millions | | | | | | |
|-------------------------|----------------|------------|----------------|------------|----------------|------------|
| | SRR Helicopter | | ASR | | Buffalo LRRT | |
| | Amount | Percent | Amount | Percent | Amount | Percent |
| Unanticipated inflation | \$192.4 | 67 | \$252.9 | 62 | \$21.2 | 11 |
| Other reasons | 93.4 | 33 | 153.4 | 38 | 176.2 | 89 |
| Total | \$285.8 | 100 | \$406.3 | 100 | \$197.4 | 100 |

Other reasons for cost growth on the SRR helicopter project included (1) changes in the equipment and support items for the 90 helicopters (\$20.3 million), (2) the addition of six helicopters by the Congress (\$30.6 million), (3) technological engine changes (\$2.8 million), (4) an additional helicopter site (\$2.5 million), and (5) future funding requirements (\$37.2 million).

Other reasons that contributed to the cost growth on the airport surveillance radar project were the (1) inclusion of costs for certain major components that were included in the ASR program but whose costs were omitted from the initial estimate, and the addition of features and/or costs due to requirement changes and technical changes (\$88.4 million) and (2) addition to the ASR replacement program in 1982 of the costs for relocating 56 ASR-7/8 systems to other airports (\$65 million).

Cost increases experienced on the Buffalo LRRT system in addition to the unanticipated inflation were due to (1) engineering changes based on revised and detailed specifications and drawings (\$40 million), (2) delays in starting service (\$26.7 million), (3) increases in contingency and insurance rates (\$30 million), (4) expenses incurred in implementing minority business enterprise regulations (\$0.1 million), and (5) changes in project scope such as the (a) addition of the La Salle Street station (\$25 million), (b) extension of the transit mall (\$30.0 million), (c) station artwork (\$0.9 million), (d) start-up activities (\$8 million), (e) relocation of utilities (\$4.1 million), and (f) unknown causes (\$11.4 million). Because the Congress had appropriated funds specifically for the Buffalo LRRT project as well as additional funds to assist cities in financing

the completion of their transit systems, UMTA approved additional funds for previously unfunded project elements on the Buffalo LRRT project. These funds which totaled about \$34.9 million (\$27.6 million federal share) were used for the La Salle Street station, station artwork, start-up activities, and utilities relocation.

To assist in carrying out its oversight and legislative responsibilities, the Congress needs accurate, up-to-date information concerning proposed major acquisition and construction projects supported by federal dollars, particularly in light of the tight federal budget and efforts to reduce the federal deficit. If estimates for total program costs are to be valid, cost estimates should (1) include the total cost of the project over its acquisition or construction period, (2) be based on current and reliable cost data, and (3) be stated in current dollars to recognize and realistically provide for inflation. Complete disclosure of the full costs and technical uncertainties of the project would give the Congress better information for making decisions on the authorization and appropriation of funds for major acquisition projects.

Objective, Scope, and Methodology

The objective of our review was to identify cost estimating biases in project estimates. For purposes of this review, we defined cost estimating biases as situations in which a federal agency regularly uses cost estimating policies, practices, techniques, methodologies, or assumptions that fail to consider all the costs of a project

During our review, we looked at each project's scope and initial and subsequent cost estimates as well as the budget information presented to the Congress. We examined revised cost and budget estimates and project scope changes in order to identify reasons for cost growth. We did not try to determine the validity of a specific cost estimate or the reasonableness of the cost growth of any specific project.

In examining agency cost estimating procedures, we used the following criteria. These criteria, which are explained in appendix IV, were identified by GAO in earlier work as basic to an effective cost estimating process.

- Clear identification of task.
- Broad participation in preparing estimates.
- Availability of valid data.
- Standardized structure for estimates
- Provision for program uncertainties (risks).

- Recognition of inflation.
- Recognition of excluded costs.
- Independent review of estimates.
- Revision of estimates when significant program changes occur.

We obtained information on the three DOT projects through discussions with officials from the Coast Guard, Federal Aviation Administration, and Urban Mass Transportation Administration as well as through a review of pertinent documents and records at the three agencies' headquarters in Washington, D.C. We discussed the Buffalo LRRT project with officials at UMTA's New York regional office and reviewed their records on the project. We also reviewed pertinent records at the Niagara Frontier Transportation Authority (UMTA grantee) in Buffalo and discussed them with Authority officials.

During our review, we inquired as to whether program evaluations or audits had been made on the three projects selected for review. We found that the DOT inspector general (IG) had evaluated the Coast Guard's SRR helicopter project and concluded that the Coast Guard's needs could be met with 85 rather than 96 helicopters. The DOT deputy secretary considered the IG recommendations and allowed the Coast Guard to proceed with the procurement. The IG's evaluation is discussed in appendix I.

Our review was performed between May 1 and December 31, 1985, and it was made in accordance with generally accepted government auditing standards.

We obtained oral comments on the draft report from DOT officials. They suggested certain wording changes and additional information for clarification, and we have included these changes where appropriate.

We are sending copies of this report to the Director of the Office of Management and Budget, Secretary of the Department of Transportation,

Commandant of the Coast Guard, Administrators of the Federal Aviation Administration and the Urban Mass Transportation Administration, and other interested parties.

A handwritten signature in black ink, appearing to read "F. D. Wolf". The signature is written in a cursive, somewhat stylized script.

Frederick D. Wolf
Director

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Abbreviations

| | |
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| ASR | Airport Surveillance Radar |
| ATCBI | Air Traffic Control Beacon Interrogator |
| DOT | Department of Transportation |
| EPA | economic price adjustment |
| FAA | Federal Aviation Administration |
| GAO | General Accounting Office |
| IG | Inspector General |
| LRRT | Light Rail Rapid Transit |
| NFTA | Niagara Frontier Transportation Authority |
| OMB | Office of Management and Budget |
| SRR | Short Range Recovery |
| TSARC | Transportation Systems Advisory Review Council |
| UMTA | Urban Mass Transportation Administration |

United States Coast Guard's Short Range Recovery Helicopter Project

The United States Coast Guard is procuring 96 HH-65A Short Range Recovery (SRR) helicopters. The contract for 90 helicopters costing \$215 million was awarded to Aerospatiale Helicopter Corporation of Grand Prairie, Texas, in June 1979. In 1983, the Congress added 6 helicopters for a total of 96. The completion of the project is scheduled for March 1988.

We found that the cost estimate for this procurement increased by \$286 million, or 166 percent, from the first estimate to the Congress in March 1977 for 90 helicopters costing \$172 million to the latest estimate in November 1985 for 96 helicopters costing \$458 million. The reasons for the cost increase are categorized as unanticipated inflation and project changes such as (1) changes in the equipment and support items for 90 helicopters, (2) the addition of six helicopters by the Congress, (3) technological engine changes, (4) an additional helicopter site, and (5) future funding requirements.

Background

The SRR helicopter project is a component of the Coast Guard's search and rescue program. This program is designed to minimize loss of life, injury, and property damage by responding to distress incidents in a marine environment, including the inland navigable waters. The Coast Guard maintains a nationwide system of boats, aircraft, cutters, and rescue coordination centers to implement its search and rescue missions. One of the search and rescue objectives is to accomplish short-range recovery missions which it does primarily with small boats and a fleet of HH-52A helicopters. The HH-52A helicopters were procured over several years beginning in 1963.

In the early 1970's the Coast Guard began to experience rapidly escalating support costs for the HH-52A's. Some of the replacement parts were no longer available from manufacturers' inventories as the Coast Guard became the only major operator of an aging aircraft. When the helicopters were procured, support for many of the components was provided by a government-owned inventory of parts which was surplus from an earlier helicopter, the HH-19G, first flown in 1950. As various services retired the HH-19G from use, the surplus parts common to the HH-52A were transferred to the Coast Guard. By August 1975, supply parts had become depleted, and the Coast Guard was forced into costly, small production runs for support parts.

Thus, in 1973 the Coast Guard began to assess the need for replacing the obsolete HH-52A helicopter with a more efficient short range recovery

helicopter. In its February 28, 1975, report, the Coast Guard's Aircraft Characteristics Board (composed of experienced aviators representing operations, maintenance, management, and flight safety) specified the operational requirements for the replacement helicopter, such as radius of action, cruise speed, range, and endurance. The requirements were justified on the basis of satisfying the needs of the search and rescue program.

The Coast Guard also studied the service life of the remaining operational HH-52A aircraft and concluded that the HH-52A was at the end of its economic service life. The resulting May 1975 report recommended immediate implementation of the SRR procurement to minimize exposure to the rapidly escalating ownership costs of the HH-52A aircraft.

Initial Cost Estimates

We identified several cost estimates for the helicopter procurement that were developed between 1975 and 1977 by the Coast Guard's Aeronautical Engineering Division staff in Washington, D.C. The first internal planning estimate we identified was for 86 helicopters at a cost of \$144 million. These cost estimates are described by Coast Guard officials as "ball park" estimates.

The first estimate, presented to the Congress during March 1977 hearings on the Coast Guard's fiscal year 1978 appropriation request, was for 90 helicopters at a cost of \$172 million. Agency officials indicated that the SRR helicopter procurement would exceed 5 years. Coast Guard officials further stated that the first 10 of the 90 helicopters were planned for enforcing the 200-mile fisheries conservation zone, and the remaining units were planned as a one-for-one replacement of the aging HH-52A's.

During February 1978 hearings on its fiscal year 1979 appropriation request, Coast Guard officials indicated that the total cost estimate for the procurement of 90 SRR helicopters would be \$181 million, about \$2 million per helicopter. This estimate corresponds to a cost estimate of \$181.1 million we obtained from the Coast Guard's Selection Plan,¹ dated October 11, 1977. The DOT deputy secretary approved the Selection Plan, which authorized the Coast Guard to proceed with the project. The Selection Plan cost estimate was developed in constant 1979 dollars and projected 5-year funding requirements—from fiscal years 1979 through

¹The Selection Plan is a document developed to establish the responsibilities and procedures for evaluating proposals for the selection of a single source to produce the SRR helicopters

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1983—assuming adequate budgetary support would be provided. Table I.1 shows the total procurement estimate distributed among these 5 fiscal years.

Table I.1: Funding Requirements in 1979 Constant Dollars for SRR Helicopter Project by Fiscal Year

| Dollars in Millions | | |
|---------------------|-----------------------|----------------------|
| Fiscal year | Number of helicopters | Funding requirements |
| 1979 | 15 | \$ 29.7 |
| 1980 | 17 | 34.0 |
| 1981 | 22 | 44.8 |
| 1982 | 22 | 44.9 |
| 1983 | 14 | 27.7 |
| Total | 90 | \$181.1 |

Contract Award

In June 1979, a firm, fixed-price contract was awarded to Aerospatiale Helicopter Corporation. The contract is a multiyear procurement for 90 SRR helicopters (HH-65A's) in the amount of \$214.8 million, including options. A list of the items contained in the contract is summarized in table I.2.

Table I.2: Procurement Contract Items and Options for SRR Helicopter Project

| Dollars in Millions | |
|---|----------------|
| Description | Cost |
| Basic contract: | |
| Multiyear requirement for 90 helicopters complete with avionics, test equipment, engineering and technical data, manuals, reports, documentations, conferences, support, and demonstrations and tests | \$198.9 |
| Options: | |
| Avionics reliability assurance warranty ^a | 10.9 |
| Field technical representatives | 0.9 |
| Training ^b | 3.7 |
| Helicopter leasing | 0.4 |
| Total | \$214.8 |

^aThe reliability assurance warranty provides for contractor repair of any failed avionics equipment for a period of 56 months after the helicopters have been received and tested

^bOne of the training options amounting to \$0.1 million was not exercised

The contract contains clauses for economic price adjustments (EPAs), which adjust certain line items in the contract for inflation. Price adjustments were made over 15 semiannual periods from January 1, 1979, through June 30, 1986. These periods are fixed by the contract and do

not vary with delivery. The EPA clause is applicable to the airframe, training, and reliability assurance warranty. Price adjustments are based on the labor and materials escalation indices published by the Department of Labor's Bureau of Labor Statistics.

The contract also describes the delivery schedule. The initial delivery was to start in November 1981 with all 90 helicopters delivered, at the latest, by February 1986. However, early in production, Aerospatiale experienced engine problems and could not adhere to the original delivery schedule. Aerospatiale and the Coast Guard agreed on a new delivery schedule with initial delivery starting in November 1984. As of March 30, 1986, the Coast Guard had accepted (received and tested) 26 SRR helicopters. According to Coast Guard officials, Aerospatiale is meeting the new delivery schedule.

Latest Cost Estimate

In November 1985, the Coast Guard estimated the total cost of the helicopter procurement contracted with Aerospatiale to be \$447 million for 96 helicopters. Of this amount, \$410 million is for executing the procurement through fiscal year 1985 and \$37.2 million is for future funding requirements. The total cost estimated for the flight simulator,² under a separate contract with another company, is \$10.4 million. Table I.3 shows the latest cost estimate of \$458 million by category.

²The flight simulator is used for training.

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**Table I.3: Latest Cost Estimate as of
November 1985 for SRR Helicopter
Project**

| Dollars in Millions | Latest estimate (November 1985) |
|---------------------------------------|------------------------------------|
| 90 helicopters | \$198.8 |
| Spares ^a | 50.7 |
| Support costs | 21.9 ^b |
| Six helicopters added by the Congress | 30.6 |
| Inflation | |
| Helicopters | 74.6 |
| Spares | 28.3 |
| Modifications | |
| Technological engine changes | 2.8 |
| Additional helicopter site | 2.5 |
| Total through fiscal year 1985 | \$410.2 |
| Future funding requirements | 37.2 ^c |
| Flight simulator | 10.4 |
| Total | \$457.8 |

^aSpares consist of spare parts, spare modules, and spare engines

^bAmount includes contract options, additional items not in the original contract, and economic price adjustments for training and the reliability assurance warranty

^c\$37.2 million represents an estimate for contingencies and inflation which require funding after fiscal year 1985

SRR Helicopter Appropriations

The Coast Guard received its first funding for the SRR helicopter project under the acquisition, construction, and improvements appropriation in fiscal year 1977, 2 years and 8 months prior to the award of the contract. Through fiscal year 1985, the Coast Guard had received a total of \$415.3 million in appropriations for the procurement of 96 HH-65A helicopters, including the congressional add-on of 6 helicopters in the amount of \$30.6 million. Table I.4 shows the amount appropriated each year for the project.

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**Table I.4: Appropriations by Fiscal Year
 for SRR Helicopter Project**

| Dollars in Thousands | |
|----------------------|------------------------|
| Fiscal year | Appropriations |
| 1977 | \$ 19,176 ^a |
| 1978 | 0 |
| 1979 | 9,733 |
| 1980 | 37,300 |
| 1981 | 62,700 |
| 1982 | 107,120 ^a |
| 1983 | 137,855 |
| 1984 | 41,390 |
| 1985 | 0 |
| Total | \$415,274 |

^aThese amounts were not appropriated specifically for the SRR helicopters, but were applied to the SRR helicopter project through a transfer of deferred funds which had been appropriated for other programs

Based on the Coast Guard's most recent estimate of \$458 million to complete the procurement and the appropriations of \$415 million already received, the Coast Guard will need at least \$43 million in additional funding.

**Reasons for Cost
 Growth**

Coast Guard cost estimates for the SRR Helicopter project increased by \$286 million, or 166 percent, from the initial \$172 million estimate to the Congress in March 1977 for 90 helicopters to the latest \$457.8 million estimate in November 1985 for 96 helicopters. We attribute this cost increase primarily to unanticipated inflation and project changes. The following table itemizes these reasons for cost growth, which are explained in subsequent paragraphs.

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**Table I.5: Reasons for Cost Growth on
SRR Helicopter Project**

| Dollars in Millions | |
|---|--------------------|
| | Cost |
| Initial Estimate to the Congress (90 helicopters) | \$172.0 |
| Cost Growth | |
| Unanticipated inflation | |
| Equipment and support (90 helicopters) | 192.4 ^a |
| Project changes | |
| Equipment and support (90 helicopters) | 20.3 ^b |
| Addition of 6 helicopters by the Congress | 30.6 |
| Technological engine changes | 2.8 |
| Additional helicopter site | 2.5 |
| Future funding requirements | 37.2 |
| Latest estimate for project completion | 457.8 |

^aPrimarily inflation, also includes project changes

^bPrimarily project changes, also includes inflation

Unanticipated Inflation

Projected inflation was excluded from the initial \$172 million estimate to the Congress because the estimate was stated in constant dollars rather than current dollars. Showing estimates in constant dollars excludes inflation from future cost and reflects the level of purchasing power in a base year. However, estimates developed in current dollars reflect anticipated price levels that will exist in years when expenditures will be incurred.

While the Coast Guard excluded inflation from the \$172 million estimate, the contract awarded in 1979 for the procurement of 90 helicopters provided for the treatment of inflation through the EPA clauses. Specific contract line items were to be adjusted for price increases. The late 1970's through the early 1980's was a period of high inflation which significantly affected total costs. Omitting inflation in the estimate to the Congress resulted in a total project cost estimate that was understated by about \$192 million.

Project Changes

Project changes constitute approximately \$93 million of the cost increase. This increase is, in part, due to (1) changing specific equipment and support needed to implement the helicopter's performance requirements and (2) anticipating future funding requirements for contingencies. The remainder is principally attributable to three major unanticipated project changes: (1) the addition of six helicopters by the

Congress, (2) technological engine changes, and (3) an additional helicopter site.

Addition of Six Helicopters

The addition of six helicopters by the Congress significantly increased the cost of the short range recovery helicopter project. The Coast Guard's appropriation for fiscal year 1983 included \$30.6 million for six additional helicopters. These additional helicopters were not requested by the Coast Guard in its budget submission to the Congress

Technological Engine Changes

Technological engine changes contributed to an increase of \$2.8 million. These changes were made to increase the life of the engine components and improve the air conditioner

Additional Aircraft Site

The Coast Guard did not anticipate having HH-65A's sited at the air station in Astoria, Oregon. But it was later learned that the capabilities of the new HH-65A met the demands of the search and rescue missions encountered in the Astoria area. This additional aircraft site cost \$2.5 million.

**IG Evaluation of SRR
Helicopter
Procurement**

During our review, we found that DOT's Office of Inspector General audited the procurement for the replacement SRR helicopters. The audit objective was to evaluate the requirement to purchase 96 HH-65A helicopters to replace the fleet of HH-52A helicopters

The IG reviewed the methodology and assumptions used in determining the number of helicopters to be procured and projected the requirements through fiscal year 1990. The IG also analyzed historical data on helicopter operations for fiscal years 1975 through 1983

The IG's March 21, 1984, report concluded that (1) the purchase of the 96 HH-65A helicopters exceeded the immediate and long-term needs of the Coast Guard by 11 helicopters, (2) the self-imposed search and rescue requirement readiness goal of 98 percent is beyond what is needed to sufficiently meet program requirements, and (3) a more effective use of aircraft would reduce overall helicopter needs.

The IG recommended that the Coast Guard

- amend the contract with Aerospatiale Helicopter Corporation to reduce the quantity of 90 HH-65A helicopters by five,
- cancel proposed plans to procure six additional helicopters, and
- reduce the search and rescue readiness requirement from 98 to 95 percent and use a 20 percent not operationally ready rate in computing aircraft requirements.

Coast Guard officials disagreed with the IG report and stated that implementation of the report's recommendations would degrade operational capability to an unacceptable degree and that such action would subject DOT to severe public criticism. The DOT deputy secretary considered the IG recommendations and allowed the Coast Guard to proceed with the procurement.

Federal Aviation Administration's Airport Surveillance Radar Upgrade Project

The Federal Aviation Administration (FAA) is upgrading and replacing Airport Surveillance Radar (ASR) at 152 airports, including relocating 56 ASR-7/8 systems to replace older ASR-4/5/6 systems and upgrading to new, more sophisticated ASR-9 systems at 96 airports. The ASR replacement program, which was begun in 1978, is scheduled for completion in 1990. When FAA approved the project in 1978, it was estimated to cost \$154.3 million. This same estimate was provided to the Congress in March 1979 during the 1980 appropriation hearings. The latest cost estimate of \$560.6 million to complete the project is an increase of \$406.3 million, or 263 percent over the initial estimate of \$154.3 million.

The cost growth of \$406.3 million is attributed to (1) unanticipated inflation, (2) the inclusion of costs for certain major components that were included in the ASR program but whose costs were omitted from the initial estimate and the addition of features and/or costs due to requirements and technical changes, and (3) the addition to the ASR replacement program in 1982 of the costs for relocating 56 ASR-7/8 systems to other airports.

Background

The ASR systems together with associated air traffic control beacon interrogator (ATCBI) equipment are used for air traffic control at all major airports. These systems are components of FAA's National Airspace System. The ASR and the beacon survey airspace up to 20,000 feet above ground level within a 60 nautical mile radius of an airport. Data from these two systems control and separate aircraft by geographical position rather than by time and altitude to provide a safe flow of traffic in the crowded terminal environment.

In the 1970's, FAA began studying the need to repair, upgrade, or replace the older ASR's. In 1975, FAA's Agency Review Board agreed to a replacement study and FAA performed a systems requirements study as well as an economic life cycle review to justify the replacement.

During the mid to late 1970's, the National Airspace System had approximately 180 ASR/ATCBI systems in service. However, approximately half of the total ASR/ATCBI inventory consisted of aging obsolete vacuum-tube ASR-4/5/6 and ATCBI-3 equipment. These systems had been in service since at least 1965 and had an average age of 15 years when reviewed in 1977 and 1978.

FAA documents describe the ASR-4/5/6 and ATCBI-3 systems as crude by current standards. The radar detection range for small aircraft in clear

conditions varies from 25 to 35 miles, planes on a tangential course can not easily be seen, and the radar can not provide weather information in a usable form. Also, the older ASR's are not compatible with new systems being installed in the National Airspace System, and maintenance of older radar is costly.

In November 1978, as a result of the 1977 economic life cycle and systems requirements study, the FAA administrator approved the Systems Requirements Statement which authorized the agency to begin replacing the ASR-4/5/6 systems. This authorization called for developing a radar that would include moving target detection, weather detection and processing capability, and maintenance diagnostic and monitoring features. The first design concept was for a modified ASR-8 system with a contract award projected for June 1980. In September 1983, after making technical design changes and revising the implementation strategy three times, FAA awarded a contract for new ASR-9 systems to Westinghouse Electric Corporation.

Initial Cost Estimate

In 1978, FAA's Systems Requirements Statement/Acquisition Authorization estimated replacement costs for the ASR's and the ATCBI's at \$154.3 million. The acquisition paper prepared in September 1979 also indicated ASR replacement costs to be about \$154 million.

FAA requested funding for the ASR replacement program in March 1979 in its facilities and equipment trust fund budget for fiscal year 1980. FAA asked for \$24.3 million as a "first increment" to replace 15 of the 96 tube-type ASR's.³ FAA budget justification documents did not contain an estimate of total program costs. However, FAA provided this information in response to a request during hearings by the House Appropriations Subcommittee on the Department of Transportation and Related Agencies. The information provided by FAA to the subcommittee in early 1979 is summarized in table II.1 which shows the funding needed by fiscal year and the number of ASR units to be procured each year

³ATCBI replacement was deferred after procurement of the initial 15 units because it was determined that other beacon systems being developed would better accomplish the beacon function

Appendix II
 Federal Aviation Administration's Airport
 Surveillance Radar Upgrade Project

**Table II.1: Funding Requirements in
 1977 Constant Dollars for ASR
 Replacement Program by Fiscal Year**

| Dollars in Millions | | |
|---------------------|----------------|-----------|
| Fiscal year | Funding needs | ASR units |
| 1980 | \$ 24.3 | 15 |
| 1981 | 0 | 0 |
| 1982 | 48.0 | 30 |
| 1983 | 48.0 | 30 |
| 1984 | 34.0 | 21 |
| Total | \$154.3 | 96 |

In February 1980, the ASR acquisition paper submitted to the Transportation Systems Advisory Review Council (TSARC)⁴ still carried a total estimated program cost of \$154.3 million for the ASR replacement program covering fiscal years 1980 to 1984.

After reviewing available documents, we determined that the \$154.3 million estimate was understated because (1) it was based on average cost data for the ASR and ATCBI subsystems being purchased in the mid-1970's, (2) it did not include the costs for certain major components such as remote maintenance monitoring and single weather channel receivers, and (3) costs to be incurred in future years were stated in constant dollars rather than current dollars.

In July 1980, after reviewing technical questions and procurement strategy regarding implementation of the ASR replacement program raised by the TSARC, FAA revised its acquisition paper. In the 1982 appropriation hearings, FAA told the subcommittee it was developing an acquisition strategy to provide for a dual first article procurement—the manufacture of an initial ASR system by two separate companies.

Dual First Article Procurement Estimate

Dual first article procurement is intended to create competitive production units from two manufacturers which can be tested to determine the unit best suited for mission needs. Because of TSARC concerns, FAA developed a dual first article strategy in late 1980 in an attempt to meet the

⁴TSARC is the organization responsible for reviewing major transportation system acquisitions at key decision points and at other times as directed by the deputy secretary who chairs the TSARC.

**Appendix II
Federal Aviation Administration's Airport
Surveillance Radar Upgrade Project**

requirements of OMB Circular A-109, which prescribes OMB's policy on the acquisition of major systems.⁵

DOT management felt that dual first article procurement was necessary because prior production experience was practically nonexistent, systems design was not complete, increased technical risk and schedule delays were possible, and inadequate competition could result

A new estimate of \$285.8 million in 1980 constant dollars and \$444.1 million in current dollars was developed in 1981 to incorporate the dual test strategy. Table II.2 shows the estimates for dual test strategy in 1980 constant and current year dollars.

**Table II.2: Dual Test Estimate in 1980
Constant Dollars and Current Dollars
for ASR Replacement Program by
Fiscal Year**

Dollars in Millions

| Fiscal year | 1980 constant dollars | Current dollars | Quantity/description |
|--------------|-----------------------|---------------------|---|
| 1980 | \$ 2.5 ^a | \$ 2.5 ^a | |
| 1981 | 0 | 0 | |
| 1982 | 39.3 | 44.9 | 2 prototype units (dual first articles) |
| 1983 | 0 | 0 | |
| 1984 | 9.0 | 12.3 | Advance production design funds |
| 1985 | 97.5 | 143.5 | 35 units |
| 1986 | 0 | 0 | |
| 1987 | 94.5 | 162.0 | 40 units |
| 1988 | 43.0 | 78.9 | 20 units |
| Total | \$285.8 | \$444.1 | 97 units^b |

^aIn fiscal year 1980, \$24.3 million was appropriated for replacement ASR 4/5/6 s at 15 locations, however, FAA indicates that \$21.8 million was reprogrammed to cover other requirements.

^bOne additional unit was required because, under dual production, two separate manufacturers would develop prototype models for testing.

By approving the revised acquisition paper on May 13, 1982, the TSARC, in effect, agreed to drop consideration of the dual first article approach and go forward with competitive procurement of the ASR's. It appears that FAA was able to convince the TSARC that the dual concept was not necessary by arguing that (1) most of the components of the ASR system had already been developed and tested, (2) the technical risk associated

⁵This circular addresses the identification of mission needs, systems evaluation and approval, and analysis of alternatives in an effort to reduce cost overruns. The circular also requires solicitation of alternative system design concepts through the use of short-term concurrent contracts.

with integrating the proven subsystems into a complete system was considered minimal, and (3) the production contractor would submit the first production system equipment for a system test to ensure specification compliance.⁶

Revised Cost Estimate

In 1981, FAA developed a new cost estimate for the ASR replacement program which showed that the cost for replacing 96 ASR's would be \$339 million in 1981 constant dollars. This was an increase of \$184.7 million from the first estimate of \$154.3 million. Costs increased because of requirements and technical changes including computerization of functions, the inclusion of costs for major components that were included in the ASR program but whose costs were omitted from the \$154.3 million estimate, updated cost information, and the revision of the cost estimate from 1977 constant dollars to 1981 constant dollars to reflect inflation that occurred during the 4-year period.

Addition of the Leapfrog Program

The new ASR's, now designated as ASR 9's, were originally scheduled to replace ASR 4/5/6's at 96 locations. Because DOT's deputy secretary was concerned that the nation's highest density airports would not fully benefit from the most up-to-date equipment, FAA studied airport density. As a result, 56 high-density airports with ASR-7/8 radars and 40 airports with ASR-4/5/6 radars were targeted to receive the 96 new ASR-9 radars. The 56 displaced ASR-7/8's would be relocated to replace 56 ASR-4/5/6's at other airports. The relocation of displaced ASR 7/8's to other airports is referred to as the leapfrog program. The cost of the leapfrog program was estimated to be \$65 million in 1981 constant dollars. This increased the estimated cost of the ASR replacement program from \$339 million to \$404 million.

Addition of Five ASR's by the Congress

In conference reports accompanying appropriations legislation for fiscal years 1981 and 1982, the Congress directed FAA to construct five complete ASR facilities at locations which had no ASR facilities. FAA notified the TSARC in July 1982 of the inclusion of the five additional facilities under the ASR-4/5/6 replacement program. Based on agency program documents, the five ASR facilities were estimated to cost \$8.8 million each, a total of \$44.0 million. Included in this estimate were the five ASR systems, computer and display systems, communications equipment, cables, generators, remote microwave link systems, and construction of

⁶We are performing a separate review of these issues

buildings and roads. FAA allocated \$13.4 million of these funds to the ASR replacement program for the procurement of five radars. The remaining funds were allocated to other programs to fund construction, equipment, and regional costs.

Contract Award

Specifications for building the ASR-9 were provided to over 30 interested organizations, but only Westinghouse Electric Corporation responded to the request for proposal issued in late July 1982. Its initial estimate was \$517.3 million. After negotiations, a multiyear, fixed-price contract was awarded in September 1983 with a provision for economic price adjustments. The total contract value for 101 ASR-9 systems including options for 36 additional systems (24 for the Department of Defense and 12 for FAA), installation, facility spares, technical data, related support equipment, and training was about \$480.5 million. Certain spare parts are included under the contract, but the cost is to be determined later. The contract does not include costs for dismantling and relocating 56 ASR 7/8 systems to other airports. These costs will be covered under a separate contract for leapfrog.

Post-Contract Award Estimates

In April 1984, FAA provided the first post-contract award estimate for the ASR replacement program to the Congress during its fiscal year 1985 budget hearing. FAA indicated that the total inflated cost for the ASR replacement program was \$486.1 million. The cost of leapfrog, including inflation, was \$85.3 million. Table II.3 shows FAA's funding requirements for the ASR-9 and leapfrog programs by fiscal year.

Table II.3: Funding Requirements in Current Dollars for the ASR-9 and Leapfrog Programs by Fiscal Year

| Fiscal year | ASR-9 | | Leapfrog | | Total |
|--------------|----------------|------------|---------------|-----------|----------------|
| | Amount | Units | Amount | Units | |
| | 1983 | \$ 49.2 | 7 | | |
| 1984 | 87.1 | 19 | | | 87.1 |
| 1985 | 163.9 | 38 | \$60.7 | 36 | 224.6 |
| 1986 | 124.4 | 26 | 24.6 | 20 | 149.0 |
| 1987 | 61.5 | 11 | | | 61.5 |
| Total | \$486.1 | 101 | \$85.3 | 56 | \$571.4 |

FAA officials explained that the \$486.1 million cost estimate for 101 ASR systems was derived from the fiscal year 1981 baseline estimate of \$339 million for 96 systems.

During FAA's fiscal year 1985 budget hearing, the appropriations subcommittee questioned the funding increase for leapfrog. FAA responded that leapfrog had been carried outside the ASR program budget but had been merged with it as a result of the decision by the deputy secretary. However, prior to the deputy secretary's decision to incorporate leapfrog in the ASR replacement program, we found no indications that this leapfrog component had been planned or budgeted.

FAA's 1986 budget justification estimates replacement program costs for 96 ASR's at \$560.6 million. This reflects a net reduction of \$10.8 million from the fiscal 1985 estimate. FAA attributes the reduction to (1) the transfer of \$13.4 million and the five congressionally mandated radar facilities to another program and (2) an increase of \$2.6 million for the leapfrog program.

Reasons for Cost Growth

Costs for the ASR replacement program increased about \$406.3 million from the initial \$154.3 million estimate provided the Congress to the latest estimate for project completion of \$560.6 million provided in the 1986 budget request. Because of many changes in the ASR replacement program and the lack of information⁷ for tracking these changes from one estimate to another, we are not able to identify or estimate the amount of cost growth for the components of the ASR system. However, based on available information, we have identified the major categories that account for the cost growth and an estimate of the approximate amount of the increased costs for each category. These are shown in table II.4 and discussed after the table.

⁷Certain requested information had been discarded because of the agency's policy of retaining information for only 3 years

Table II.4: Reasons for Cost Growth on the ASR Replacement Program

| Dollars in millions | | | | |
|---|------------------|----------------|-------------------------|--|
| | Initial estimate | Cost growth | | Latest estimate for project completion |
| | | Program change | Unanticipated inflation | |
| Replacement of 96 ASR's | \$154.3 | | \$146.2 | \$300.5 |
| Inclusion of costs (1) omitted from initial estimate and (2) for additional features, requirements, and technical changes | 0 | \$ 88.4 | 83.8 | 172.2 |
| Leapfrog added to ASR program | 0 | 65.0 | 22.9 | 87.9 |
| Total | \$154.3 | \$153.4 | \$252.9 | \$560.6 |

Unanticipated Inflation

The first cost estimate of \$154.3 million presented to the Congress as the cost of the ASR replacement program did not include inflation. The estimate was stated in constant dollars (base year prices) rather than current year prices (anticipated price levels that will exist in the years when expenditures will be made). The exclusion of inflation understated the cost of the ASR replacement program. Economic changes over the period of a system's development and acquisition can have a significant effect on the cost to acquire a major system. It is important, therefore, that inflation be recognized and realistically provided for if estimates for total program costs are to be valid and the Congress is to be informed of the projected total cost of the program.

Costs Omitted From Initial Estimate

Certain major components, such as remote maintenance monitoring and single weather channel receivers, were included in the ASR replacement program when the initial estimate was made, but the costs of these components were omitted from the \$154.3 million estimate. FAA omitted these costs from the initial estimate because it lacked detailed specifications and cost data at that time. It is important that all costs associated with the project be identified and included in the estimate. In addition, cost estimates should be based on current and reliable cost data for the estimate of project cost to be valid.

Requirements and Technical Changes

Requirements and technical changes contributed to the increased costs on this project. For example, the initial estimate included costs for an older version of the moving target detector rather than a technically improved detector that was being developed. FAA officials estimated that

the cost of the older detector was about 20 percent of the ASR system's cost. When the new version of the detector became available, the estimated cost for the detector doubled. Another technical change included the computerization of certain functions to improve data transfer and utilization.

**Addition of the Leapfrog
Program**

The ASR replacement program was expanded in 1982 to include the relocation of ASR 7/8's from high-density airports receiving ASR 9's to 56 airports with less traffic to replace their ASR 4/5/6's. This relocation of ASR 7/8's known as the leapfrog program was not part of the original ASR replacement program. It is estimated that the leapfrog program added about \$87.9 million to the program.

Urban Mass Transportation Administration's Buffalo Light Rail Rapid Transit System

The Niagara Frontier Transportation Authority (NFTA) is building a 6.4-mile light rail rapid transit system in Buffalo, New York, which is being financed with federal funds (about 80 percent) awarded by the Urban Mass Transportation Administration and local funds (about 20 percent). The system which was begun in 1979 is scheduled to be completed in 1986. When UMTA approved the project in October 1976, the estimated cost for the system was \$336.3 million and the federal share was limited to \$269 million. The latest estimate, made in September 1985, increased to \$533.7 million and the federal share increased to \$420.3 million.

We found that the system's costs increased by approximately \$197.4 million, or 59 percent, because of (1) unanticipated inflation, (2) engineering changes based on revised and detailed specifications and drawings, (3) delays in starting service, (4) increases in contingency and insurance rates, (5) expenses incurred in implementing minority business enterprise regulations, and (6) changes in project scope, such as the (a) addition of the La Salle Street station, (b) extension of the transit mall, (c) station artwork, (d) start-up activities, and (e) relocation of utilities. Because the Congress appropriated funds to assist cities in financing the completion of their transit systems, UMTA awarded additional funds to Buffalo for previously unfunded project elements totaling about \$34.8 million (\$27.6 million federal share). These funds were used for the La Salle Street station, station artwork, start-up activities, and the relocation of utilities.

Background

The Buffalo Light Rail Rapid Transit system is a 6.4-mile transit system with sections above and below ground. The project was funded primarily by discretionary grants (maximum 80 percent federal funds) authorized under section 3 of the Urban Mass Transportation Act of 1964, as amended, and by local funds (20 percent) administered through the Niagara Frontier Transportation Authority.

The first specific proposal for the Buffalo transit system was made by NFTA after completion of an UMTA-funded study in 1971. The study recommended unification of the region's private bus lines and the construction of an 11-mile heavy rail line running from downtown Buffalo northwest past the South Campus of the State University in Buffalo to the North Campus of the University in Amherst. The estimated cost of the line was \$241 million. There was considerable local opposition to this line which was to be primarily an elevated structure.

NFTA began a preliminary design study in 1972, again with UMTA funds. The purpose of this study was to assess alternate alignments for the 11-mile rail system. The study, which was completed in 1974, showed some variation in the route between Buffalo and Amherst and an 80 percent increase in the underground section of the line. The cost estimate was increased to \$476 million.

After reviewing the preliminary design study, UMTA decided that a study of alternative transportation modes was needed in addition to alternative alignments. The decision resulted from a number of concerns including escalating construction cost estimates for the 11-mile heavy rail line and projections of possible decreases in ridership and revenues. A study was undertaken in two phases. The first phase was conducted in late 1974, and the second phase in mid-1975. A report on both phases was prepared in 1976, recommending the construction of a 6.4-mile light rail rapid transit line from downtown Buffalo to the South Campus of the State University in Buffalo.⁸ The estimated cost for the 6.4-mile line was \$336.3 million and operation was planned for 1982.

Construction of the Buffalo Light Rail Rapid Transit (LRRT) system began in April 1979 and was substantially complete by September 1985. One station and the transit mall are under construction and scheduled for completion in 1986. When complete, the system will include

- a 6.4-mile line within Buffalo, extending from Memorial Auditorium in the downtown business district to the South Campus of the State University;
- 14 stations—6 at surface level on the transit mall and 8 underground;
- a repair shop, yard facility, and operations control center; and
- 27 light rail vehicles.

As the LRRT project evolved through the planning and construction phases, NFTA revised its cost estimates to reflect changes in project scope. We were unable to precisely track additions, deletions and/or modifications of project elements from one cost estimate to the next because the historical documentation we obtained was neither sufficiently detailed nor consistent in identifying the project elements that formed the basis of each cost estimate.

⁸Light rail rapid transit systems differ from heavy rail rapid transit systems. The light rail system requires only partial separation from other forms of traffic, as compared to the full separation required by the heavy rail system; and the light rail system is less expensive to build, carries fewer passengers per vehicle, and travels at lower speeds.

Full-Funding Concept

Under the full-funding concept, UMTA enters into a contract to commit federal funds in specified, incremental amounts over the life of the project, subject to the availability of funds from the Congress.⁹ However, the federal share can increase if certain extraordinary costs are incurred. Extraordinary costs include inflation beyond the rate estimated in the grantee's application, natural disasters, eminent domain settlements, federal laws or regulations enacted after the contract award date, and unforeseen delays in the availability of funds from the Congress. According to the terms of the full-funding contract, costs in excess of those allowed under the contract's extraordinary cost provisions are the responsibility of the locality.

UMTA's position is that full-funding contracts, by establishing obligation ceilings and grantee responsibility for excess costs, give grantees an incentive to develop more accurate cost estimates. In effect, then, full-funding contracts would protect the federal government against cost overruns not covered by the extraordinary cost provisions. However, as discussed later, we found instances where UMTA assisted in financing additional project costs not provided for under the full-funding contract.

Initial Cost Estimate

In July 1976, NFTA estimated it would cost about \$336.3 million to build the LRRT system. Of that amount, the federal share was limited to \$269 million. This cost estimate was contained in NFTA's original capital grant application which UMTA approved in October 1976. The estimate was prepared by NFTA staff who built upon preliminary conceptual design plans prepared by Bechtel Associates Professional Corporation, consulting engineers. It was arrived at by computing construction materials, equipment, and labor costs in 1974 dollars. The base cost was escalated by applying a rate of 9 percent, compounded annually, to construction expenditures for the first 2 years and 7 percent, compounded annually, for the remainder of the construction schedule.

Full-Funding Contract Estimate

The cost estimate contained in the first amendment to the approved capital grant is the full-funding contract cost estimate. The contract between UMTA and NFTA was executed in November 1978 and indicated a total cost of \$449.8 million (\$359.8 million federal share). The estimate was prepared by NFTA staff and four principal consultants during the preliminary engineering phase that preceded construction. It was based

⁹This differs from the regular definition of full funding under which the budget authority (or funding) to cover a project's total cost is provided at the time the project is undertaken

on 1977 dollars escalated at a rate of 7 percent, compounded annually, to the construction schedule midpoint in the capital grant.

The \$113.5 million difference between the initial estimate of \$336.3 million and the full-funding contract estimate of \$449.8 million reflected a 34 percent cost increase. Approximately \$96.8 million was due to engineering changes, a 13-month delay in initiating revenue service, increased contingencies based on the experience of other UMTA grantees working under full-funding contracts, and an increase in insurance rates. We could not find historical documentation to explain the remaining \$16.7 million increase.

Post-Contract Award Estimates

In 1981, at the construction schedule midpoint, a revised cost estimate was prepared that showed the Buffalo project would cost \$534.4 million. NFTA explained the cost increase was due to unanticipated inflation, utilities relocation, proposed reinstatement of the La Salle Street station, and extension of the transit mall.

As of September 1985, NFTA estimated the total cost for the system would be about \$525.7 million. NFTA's September estimate did not include approximately \$8 million in expenses related to starting and equipping the system. When start-up costs are considered, the estimated total cost increases to about \$533.7 million. Through September 1985, the federal government's financial contribution to the project was \$420.3 million.

The federal government's overall financial contribution increased from the \$359.8 million limit established in the full-funding contract to \$420.3 million because UMTA amended the basic grant and, in addition, awarded NFTA four supplemental grants to fund changes in project scope and start-up expenses that were not included in early cost estimates. This was done by UMTA because the Congress appropriated additional funds to help cities complete their transit systems.

Amendments to the 1978 full-funding contract increased the total approved project cost in the basic grant from \$449.8 million to \$494.7 million. In addition to the amendments, there were four grants totaling approximately \$31 million that augmented the full-funding contract. The following table shows the approved project costs and federal share of the basic grant and four supplemental grants for the Buffalo LRRT system.

Appendix III
 Urban Mass Transportation Administration's
 Buffalo Light Rail Rapid Transit System

Table III.1: Approved Project Costs and Federal Share of Basic and Supplemental Grants for the Buffalo LRRT System

| Dollars in Millions | | |
|--------------------------------------|----------------------------|----------------|
| | Approved project costs | Federal share |
| October 1976—basic grant application | \$336.3 | \$269.0 |
| November 1978—full funding contract | \$449.8 | \$359.8 |
| Amendments to full funding contract | 44.9 | 35.9 |
| Total—basic grant | 494.7 | 395.7 |
| Four supplemental grants | 31.0 | 24.6 |
| Total—all grants | \$525.7^a | \$420.3 |

^aThe total amount of grants awarded to date is about \$8 million less than NFTA's current cost estimate of \$533.7 million. If UMTA approves NFTA's application for funds to cover a construction funding shortfall, the federal share could increase by about \$1 million.

Reasons for Cost Growth

Between the 1976 initial estimate of \$336.3 million and the 1978 full-funding contract estimate of \$449.8 million, the cost to complete the project grew by \$113.5 million, or 34 percent. During this period, a survey of underground soil conditions was conducted; definitive plans, specifications, and drawings were prepared; a comprehensive schedule of design and construction activities was developed, and project costs were updated. The increase was principally attributed to engineering changes, a 13-month delay in starting service, increased contingencies based on the experience of other UMTA grantees with full-funding contracts, and higher insurance rates. The project information we obtained did not elaborate on these factors; therefore, we are unable to give them detailed treatment in the discussion of cost growth factors that follows.

Following approval of the full-funding contract in November 1978, project costs increased from \$449.8 million to \$533.7 million as of September 1985 because of unanticipated inflation, expenses incurred in implementing federal regulations, and changes in project scope. Reasons for cost growth of \$197.4 million from the initial cost estimate of \$336.3 million to the latest cost estimate of \$533.7 million are highlighted in table III.2 and discussed thereafter.

**Appendix III
Urban Mass Transportation Administration's
Buffalo Light Rail Rapid Transit System**

Table III.2: Reasons for Cost Growth on the Buffalo LRRT System

| Dollars in Thousands | |
|---|---------------------|
| | Cost |
| Initial estimate | \$336,250 |
| Cost growth factors | |
| Engineering changes | 40,050 |
| Delay in starting service | 26,700 |
| Increased contingencies and insurance rates | 30,040 |
| Utilities relocation | 4,085 |
| Unanticipated inflation | 21,006 |
| Minority business enterprise | 100 |
| Station artwork | 900 |
| La Salle Street station | 25,000 |
| Extension of transit mall | 30,000 |
| Start-up activities | 8,000 |
| Unknown | 11,535 ^a |
| Latest estimate for project completion | \$533,666 |

^aRepresents net amount after adjustment for cost underruns

Approximately \$34.8 million of the additional project costs were for previously unfunded project elements. These elements were not initially approved by UMTA in the full-funding contract and they were not considered extraordinary costs. Start-up costs and the La Salle Street station construction costs were later approved by UMTA, however, because the Congress appropriated funds specifically for these purposes. Utilities relocation and station artwork costs were also approved later by UMTA after the Congress appropriated funds for assisting cities in financing the completion of their transit systems. Items on the Buffalo system that were funded with additional funds made available by the Congress are shown in table III.3.

Table III.3: Items Approved by UMTA for Buffalo LRRT System From Additional Funds Appropriated by the Congress

| Dollars in Thousands | | |
|-------------------------|---------------------|----------------------|
| | Total | Federal share |
| Utilities relocation | \$ 4,085 | \$ 3,268 |
| Start-up | 6,021 ^a | 4,570 |
| Station artwork | 900 | 720 |
| La Salle Street station | 23,750 ^a | 19,000 |
| Total | \$34,756 | \$27,558 |

^aAlthough NFTA's estimated cost for this item was higher, this figure represents the amount UMTA recognized as an eligible project cost

Utilities Relocation

Utilities relocation costs were not included in early cost estimates because NFTA believed that New York State law required privately owned utility companies to bear the expense of relocating their lines when their paths conflicted with proposed public improvements. The affected utility companies pursued the matter through the federal and New York State courts and, in 1981, the state supreme court ruled that the utility companies were to be reimbursed for removal, relocation, and/or support and maintenance of their lines.

In response to the ruling, UMTA awarded NFTA a separate grant for utilities relocation. According to an UMTA memorandum, in awarding the grant, UMTA was acting on a congressional mandate under the fiscal year 1982 Supplemental Appropriations Act (Public Law 97-257) which directed it to fund certain items that would enhance the project and that were necessary for its construction but were not included as elements of the full-funding contract.

Unanticipated Inflation

In accordance with the extraordinary cost provisions of the full-funding contract, UMTA agreed to fund actual inflation above the 7-percent rate specified in NFTA's grant application.

In 1981, at the construction schedule midpoint in the capital grant, NFTA analyzed expenses to determine the actual increase in construction costs that had occurred since January 1, 1977. As a result of the analysis, NFTA found that the cost of labor, materials, and equipment used in constructing the LRRT system had risen by \$44.3 million.

UMTA said that NFTA's inflation calculation did not conform to provisions in the full-funding contract. UMTA advised NFTA to compute inflation by using the Engineering News Record-Building Cost Index for Cleveland. Using this, NFTA estimated that extraordinary costs due to inflation were \$21 million. UMTA accepted the figure and agreed to a federal share of \$16.9 million

Minority Business Enterprise Regulations

UMTA also agreed to fund additional administrative expenses NFTA incurred in complying with minority business enterprise regulations. The regulations were enacted after the effective date of the full-funding contract and, as a result, the administrative expenses were eligible costs under the full-funding contract's extraordinary cost provisions. Although NFTA estimated that the costs incurred in implementing the

regulations amounted to \$1.6 million, UMTA recognized only \$100,000 as a legitimate claim and agreed to contribute \$80,000 toward the expense.

Start-Up Activities

Costs of starting and equipping the system were not included in any of the cost estimates. A former NFTA official told us these costs were not included in the initial estimate because NFTA staff did not believe they could determine a cost for requirements that would not be known until much later. Another former NFTA official told us that the costs were going to be included in the estimate for the full-funding contract, but were deleted when NFTA learned that UMTA would not accept a cost estimate over \$450 million.

In 1983, NFTA submitted a request for approximately \$8 million to cover start-up expenses. UMTA rejected the request because all costs associated with revenue service initiation should have been covered under the full-funding contract. The contract requires the grantee to complete construction and start transit operations. Eventually, however, UMTA awarded two separate grants and one amendment (totaling \$6 million) to cover start-up costs. According to UMTA documents, in awarding one grant and a related amendment, UMTA officials believed they were carrying out congressional mandates in the fiscal year 1984 and 1985 Department of Transportation and Related Agencies Appropriations Acts, Public Law 98-78 and Public Law 98-473, respectively. The other grant was awarded in response to a requirement in the Surface Transportation Assistance Act of 1982.

Station Artwork

Artwork was not included in the early cost estimates. Art objects ranging from free-standing abstract sculptures to mosaic tile designs and paintings were added at locations in and around the eight underground stations. The idea to expand the project to include artwork was introduced in 1981 by NFTA's board of commissioners. UMTA approved the artwork and awarded a separate grant with a federal contribution of \$720,000. UMTA officials said the action was taken to fulfill the mandate of the 1982 Supplemental Appropriations Act (Public Law 97-257). The mandate, they said, was to fund items that would enhance the project, but were not included as elements of the full-funding contract.

La Salle Street Station

UMTA awarded additional funds for the La Salle Street station construction. The original project plan described 14 stations, one of which would

be underground at La Salle Street. Initially, the station was to be constructed at a total cost of \$15.2 million. During 1980 and 1981, NFTA asked for approval to withdraw the station from the plan and use the funds to assist in financing an extension to the transit mall. UMTA approved NFTA's request to delete the station. About a year later, however, NFTA asked that the station be reinstated in the plan at an estimated total cost of \$25 million. Project records indicate that UMTA did not intend to approve the request. However, funds were made available because the Congress earmarked \$19 million in federal funds for the station when passing the Emergency Jobs Supplemental Appropriations Act of 1983 (Public Law 98-8).

In July 1985, NFTA submitted a request for another \$1.3 million (federal share \$999,999) in additional funds to complete the station. At the time of our review, UMTA officials did not know whether the request for a supplemental grant would be approved.

Extended Transit Mall

In August 1983, UMTA awarded additional funds so that NFTA could extend and enhance the transit mall. The original project plan included a \$12 million mall on Main Street, which was to be a basic structure housing four of the six surface stations. Because of the business community's interest in promoting economic revitalization downtown, NFTA redesigned the transit mall to include all six surface stations and various enhancements such as a skywalk and redesigned square at an estimated cost of \$42.1 million. UMTA awarded a separate grant for \$17.8 million (\$14.2 million federal share) that was to supplement mall funds available under the full-funding contract.

According to UMTA officials, the extended transit mall was funded with discretionary grant funds because they felt it was a worthwhile addition to the Buffalo LRRT project.

Criteria Basic to an Effective Cost Estimating Process

These criteria were adapted from GAO's July 24, 1972, report entitled Theory and Practice of Cost Estimating for Major Acquisitions (B-163058).

1. Clear Identification of Task

To prepare a cost estimate, the estimator must be provided with the system description, ground rules and assumptions, and technical and performance characteristics of the system. A well-defined system description which specifies conditions and constraints of the estimate is essential in clearly identifying the scope of the estimate and documenting how it was prepared.

2. Broad Participation in Preparing Estimates

The acquisition of a major system¹⁰ involves many agency and contractor organizations in deciding mission need and requirements, and defining performance parameters, force structures, and other system characteristics for a given project. The cost estimate should ensure that all organizations which have had an input into the system design have participated in preparing the project cost estimate. Each organization should have had its data independently verified for accuracy and completeness and have cost controls in place to ensure the reliability of its data.

3. Availability of Valid Data

Numerous sources of data are available to the cost estimator. These data sources vary in reliability. Historical data bases from which cost estimators project costs of new systems from previously similar or comparable systems are useful data sources. The estimator should use care in determining whether such data are suitable for the purposes identified. The data should reflect current cost trends and be directly related to the system's performance characteristics and specifications.

4. Standardized Structure for Estimates

There should be a standard method, called a work breakdown structure, for dividing the acquisition effort into specific work packages peculiar to the type of system. The identification of these work packages becomes more detailed as the system progresses through the acquisition cycle.

¹⁰A major system is defined as a combination of elements that will function together to produce the capabilities required to fulfill a mission need. The elements may include, for example, equipment, construction, real property, hardware, or improvements

The work breakdown structure ensures that

- estimates can be related to the total program,
- relevant cost categories are not omitted,
- the estimate can be refined as the system design becomes more defined, and
- estimates for similar types of systems can be compared by estimators and decisionmakers.

An estimate derived from the work breakdown structure assists management in monitoring and directing diverse project activities being contracted by the agencies and the contractors.

**5. Provision for Program
Uncertainties**

One of the most difficult and often criticized aspects of cost estimating concerns identifying uncertainties and developing a realistic allowance for their cost impact. Work objectives should be divided into knowns and unknowns and provisions made for their resolution.

6. Recognition of Inflation

Economic changes over the period of a system's development and acquisition can have a significant effect on the cost to develop, produce, and operate major systems. It is important that inflation be recognized and realistically provided for if estimates for total program costs are to be valid.

**7. Recognition of Excluded
Costs**

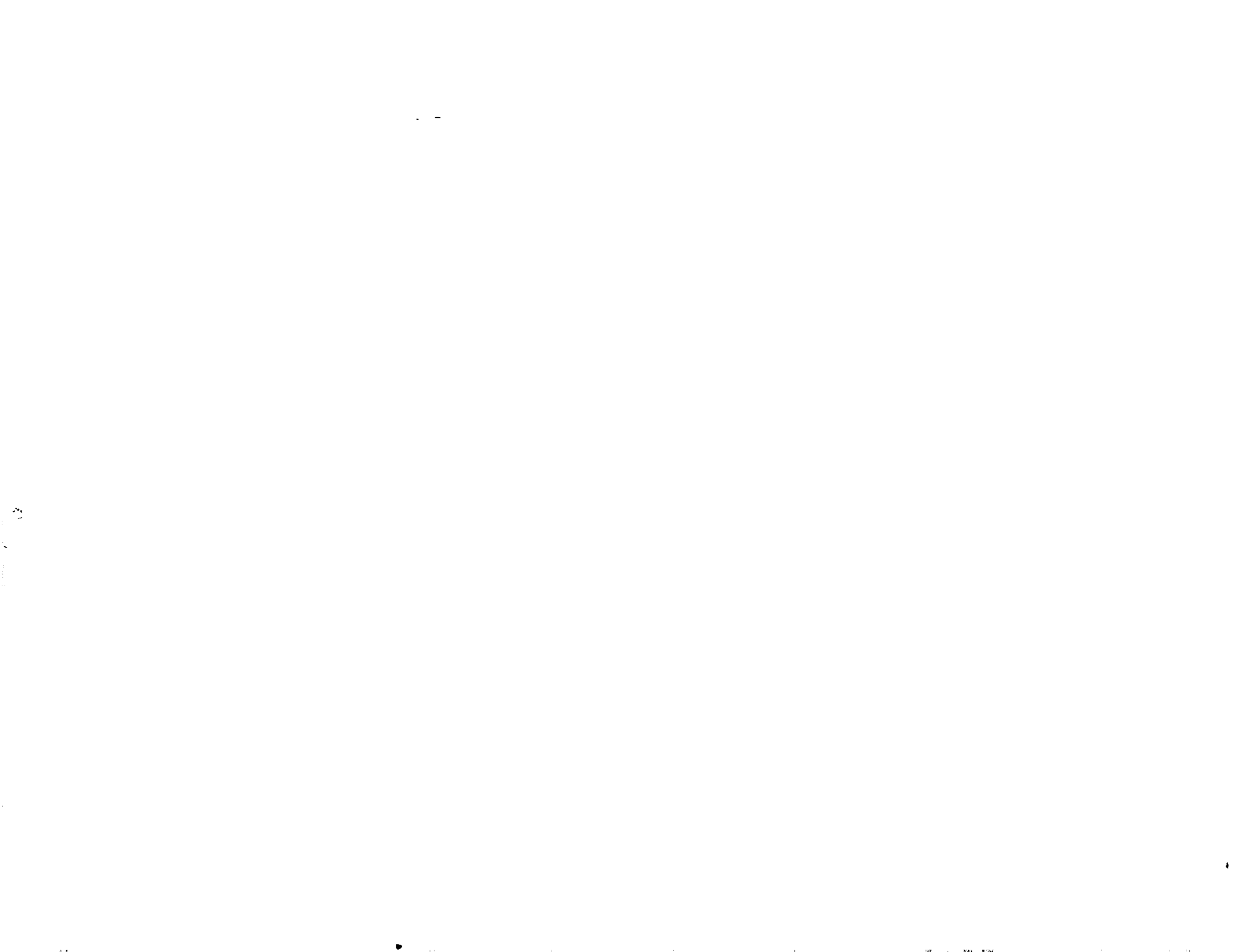
Major system cost estimates should contain provisions for all costs associated with the system. If major costs have been excluded for an estimate or included under another category, it is important that the estimator disclose this information and include its rationale.

**8. Independent Review of
Estimates**

An independent review of a cost estimate is crucial to the establishment of confidence in the estimate. The independent estimator must examine the original estimate and verify, modify, and correct it as necessary to ensure completeness, consistency, and realism of the information contained in the cost estimate.

**9. Revision of Estimates
When Significant Program
Changes Occur**

It is important that cost estimates be updated to reflect changes because changes in the system's design requirements drive the cost. Large changes in the cost of an acquisition significantly influence decisions to continue, modify, or terminate a program.



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