

U.S. Department of Transportation

CAPITAL COST ANALYSIS FOR URBAN TRANSIT PROJECTS

JUNE 1995

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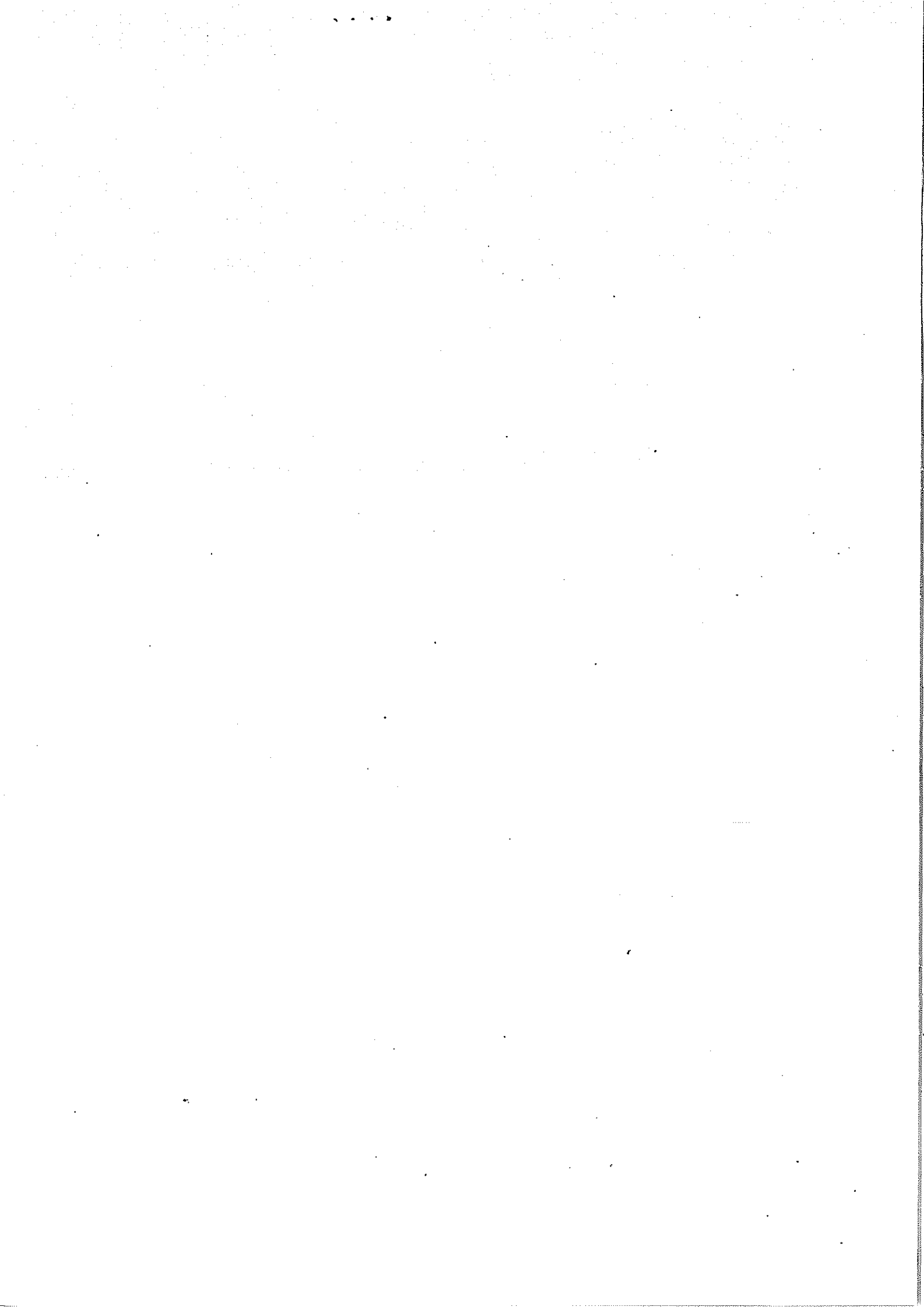



Federal Transit Administration

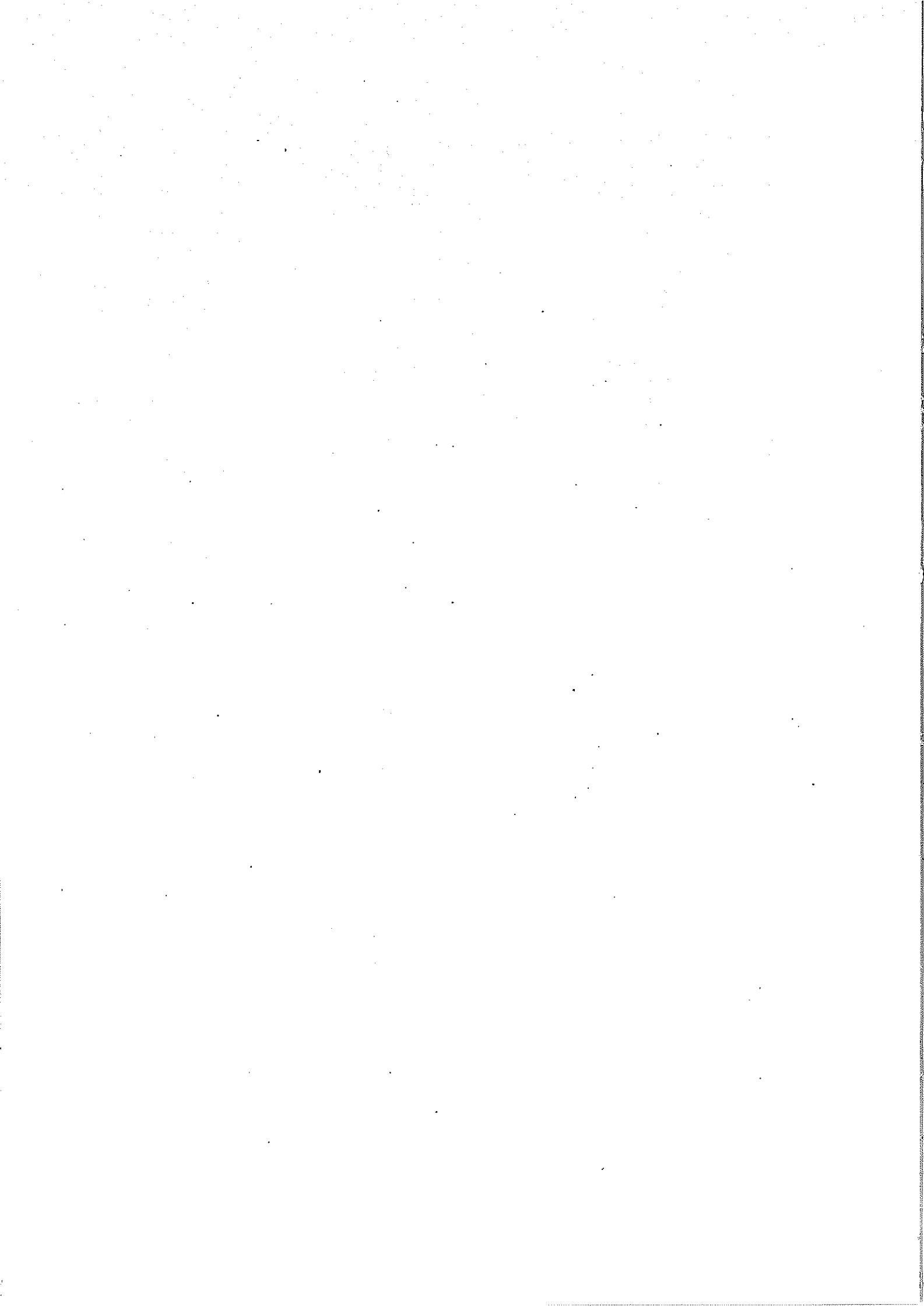
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16. Abstract As a source of information and technical guidance, this study documents and analyzes transit capital costs in far greater detail than previous studies for several major urban transit projects through the use of case studies. The projects include the Chicago Southwest Rapid Transit Extension, St. Louis Metro Link Light Rail System, Miami Metromover Extension, Sacramento Light Rail Starter Line and the Los Angeles Metro Rail MOS-1. The mission was to explain the variance between actual costs and estimates made at and after the FEIS. While one project was relatively risk free and exhibited well behave cost experience, the other projects had extensive cost growth in certain categories. Analysis suggests increased attention is required in planning, estimating and monitoring for right-of-way and real estate acquisition program, construction, construction management, administration and design/engineering. A series of specific observations and recommendations are made to provide guidance to those advancing transit capital projects including addressing project "soft costs" and establishing and managing a project contingency account.					
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FINAL REPORT

June 1995

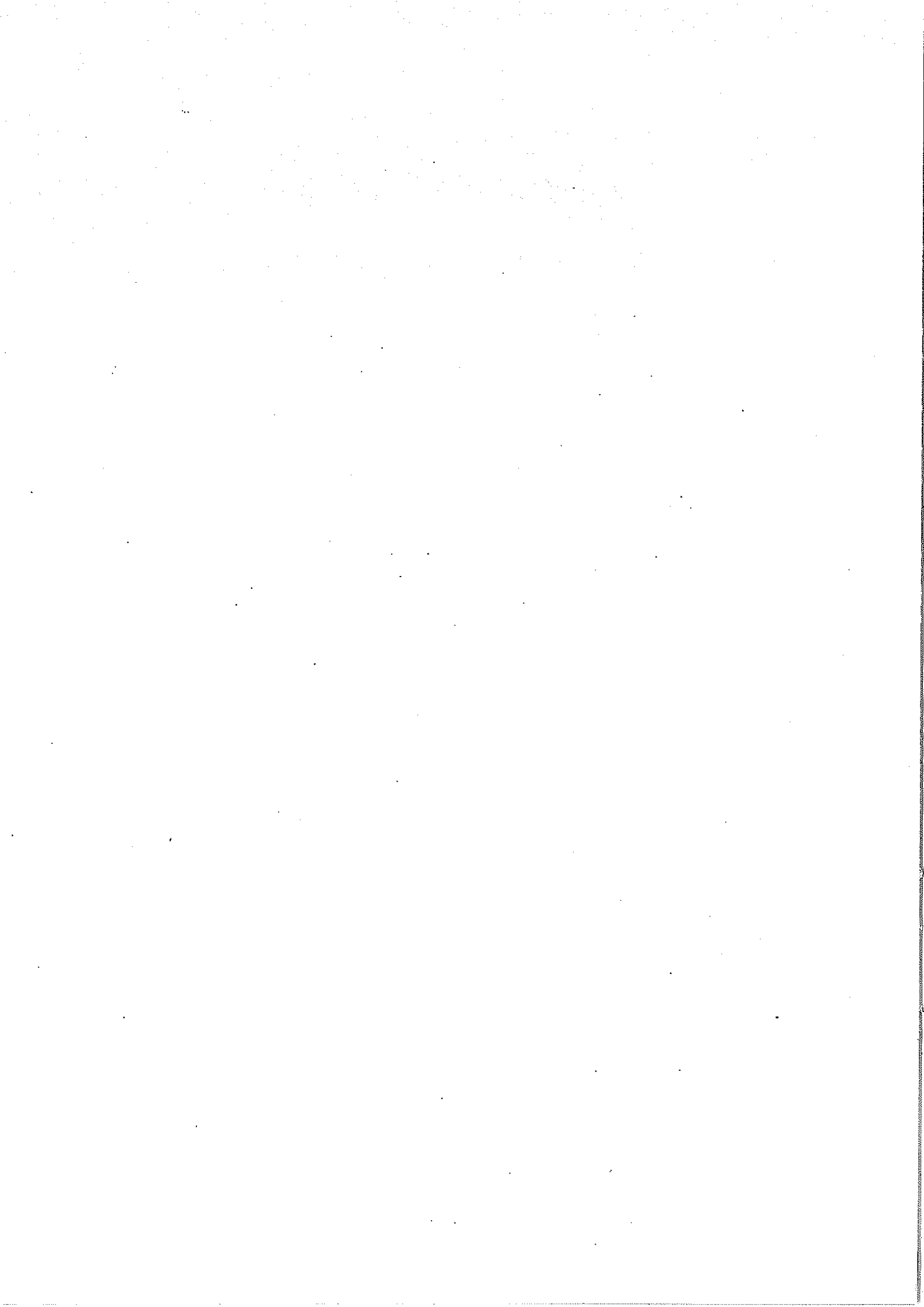
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METRIC / ENGLISH CONVERSION FACTORS

ENGLISH TO METRIC

LENGTH (APPROXIMATE)

- 1 inch (in) = 2.5 centimeters (cm)
- 1 foot (ft) = 30 centimeters (cm)
- 1 yard (yd) = 0.9 meter (m)
- 1 mile (mi) = 1.6 kilometers (km)

AREA (APPROXIMATE)

- 1 square inch (sq in, in²) = 6.5 square centimeters (cm²)
- 1 square foot (sq ft, ft²) = 0.09 square meter (m²)
- 1 square yard (sq yd, yd²) = 0.8 square meter (m²)
- 1 square mile (sq mi, mi²) = 2.6 square kilometers (km²)
- 1 acre = 0.4 hectares (he) = 4,000 square meters (m²)

MASS - WEIGHT (APPROXIMATE)

- 1 ounce (oz) = 28 grams (gr)
- 1 pound (lb) = .45 kilogram (kg)
- 1 short ton = 2,000 pounds (lb) = 0.9 tonne (t)

VOLUME (APPROXIMATE)

- 1 teaspoon (tsp) = 5 milliliters (ml)
- 1 tablespoon (tbsp) = 15 milliliters (ml)
- 1 fluid ounce (fl oz) = 30 milliliters (ml)
- 1 cup (c) = 0.24 liter (l)
- 1 pint (pt) = 0.47 liter (l)
- 1 quart (qt) = 0.96 liter (l)
- 1 gallon (gal) = 3.8 liters (l)
- 1 cubic foot (cu ft, ft³) = 0.03 cubic meter (m³)
- 1 cubic yard (cu yd, yd³) = 0.76 cubic meter (m³)

TEMPERATURE (EXACT)

$$[(x - 32) / 1.8] \text{ } ^\circ\text{F} = y \text{ } ^\circ\text{C}$$

METRIC TO ENGLISH

LENGTH (APPROXIMATE)

- 1 millimeter (mm) = 0.04 inch (in)
- 1 centimeter (cm) = 0.4 inch (in)
- 1 meter (m) = 3.3 feet (ft)
- 1 meter (m) = 1.1 yards (yd)
- 1 kilometer (km) = 0.6 mile (mi)

AREA (APPROXIMATE)

- 1 square centimeter (cm²) = 0.16 square inch (sq in, in²)
- 1 square meter (m²) = 1.2 square yards (sq yd, yd²)
- 1 square kilometer (km²) = 0.4 square mile (sq mi, mi²)
- 1 hectare (he) = 10,000 square meters (m²) = 2.5 acres

MASS - WEIGHT (APPROXIMATE)

- 1 gram (gr) = 0.036 ounce (oz)
- 1 kilogram (kg) = 2.2 pounds (lb)
- 1 tonne (t) = 1,000 kilograms (kg) = 1.1 short tons

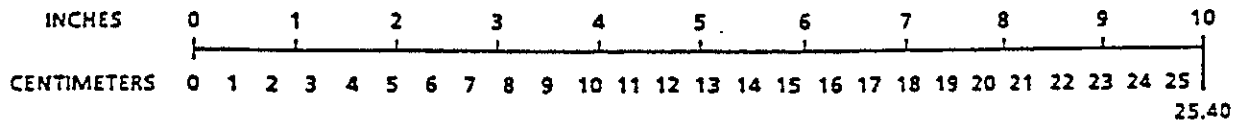
VOLUME (APPROXIMATE)

- 1 milliliter (ml) = 0.03 fluid ounce (fl oz)
- 1 liter (l) = 2.1 pints (pt)
- 1 liter (l) = 1.06 quarts (qt)
- 1 liter (l) = 0.26 gallon (gal)
- 1 cubic meter (m³) = 36 cubic feet (cu ft, ft³)
- 1 cubic meter (m³) = 1.3 cubic yards (cu yd, yd³)

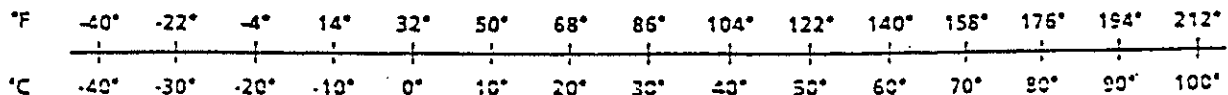
TEMPERATURE (EXACT)

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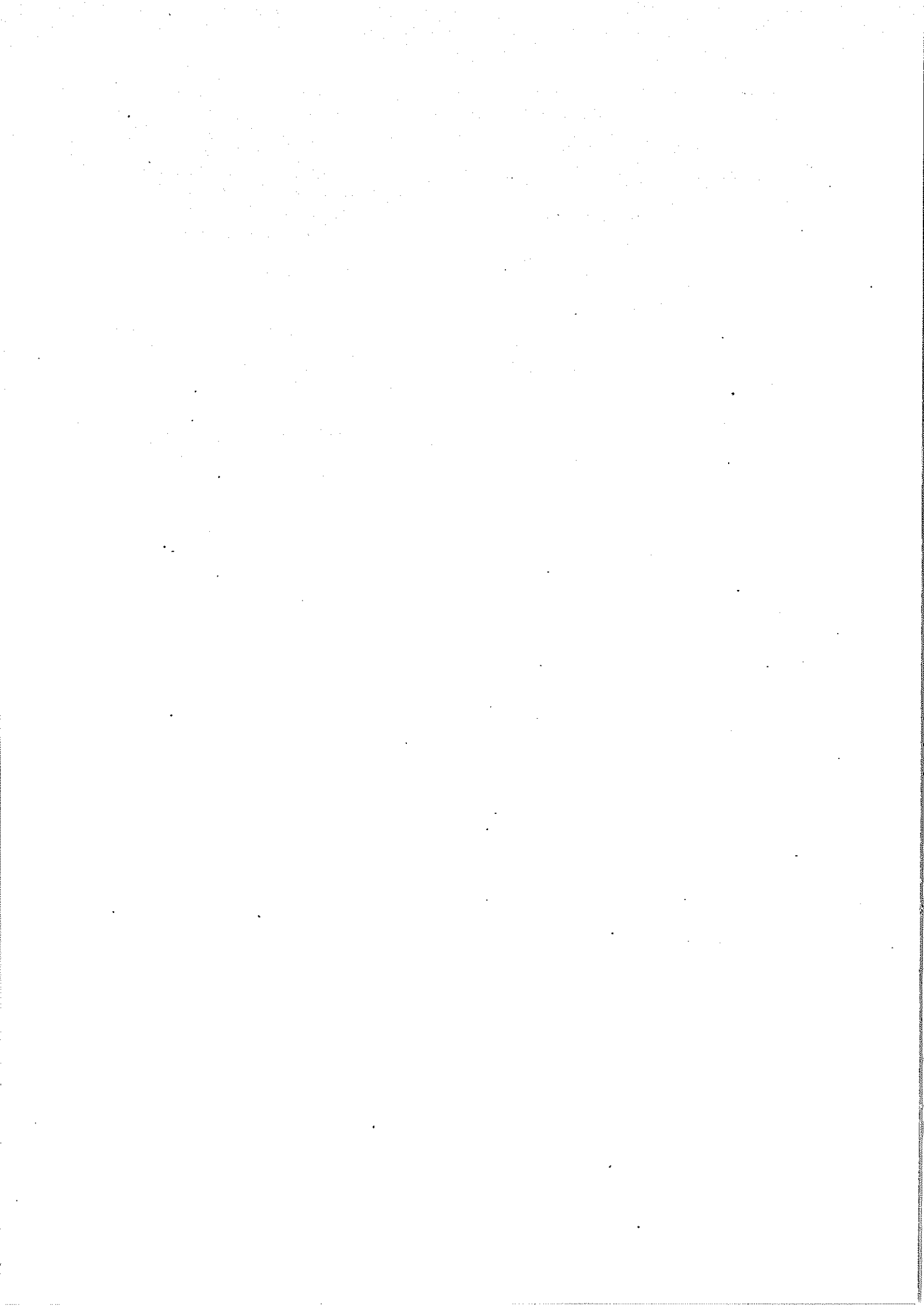
QUICK INCH-CENTIMETER LENGTH CONVERSION



QUICK FAHRENHEIT-CELCIUS TEMPERATURE CONVERSION



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Melody Hopson, FTA Region 5

St. Louis Metro Link Light Rail System

Gene Leung and Marvin Li, Bi-State Development Agency
Richard Jarrod, FTA Region 7
John Devens and Donald Ramsey, Parsons Brinckerhoff, PMO

Miami Metromover Extension

George Navarrete, Metro Dade Transit Agency
Don Sullivan and Gene Carroll, FTA Region 4
John Lopacki, Morrison-Knudsen, PMO

Sacramento Light Rail Starter Line

John Segerdell, Sacramento Regional Transit District
Robert Hom, FTA Region 9
Hill International, PMO

Los Angeles Metro Rail MOS-1

Jeffrey Christiansen, Los Angeles County MTA
James Kenna, FTA Region 9
Gerald White, Hill International, PMO

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Within EG&G Dynatrend, Alan Fleischman was responsible for management of the project, leading the case study research and interviews, analysis and report writing. Supporting him in this effort were Clark Semon for computer database management and graphical presentation, Karla Karash and Thomas Luglio for on site data collection and interviews, and Susan Clark for report production. Thomas Luglio was responsible for final report editing and incorporation of FTA comments.

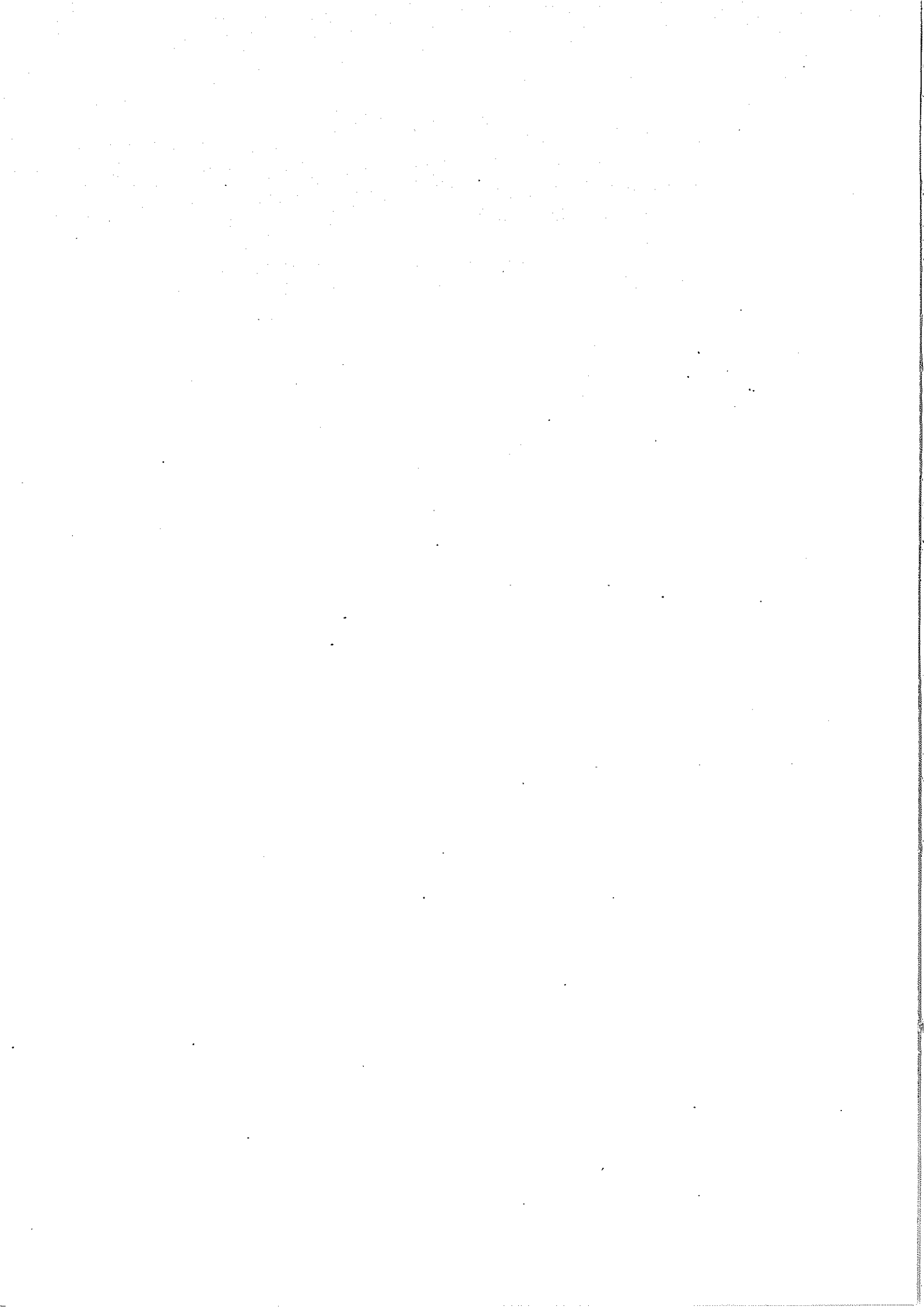


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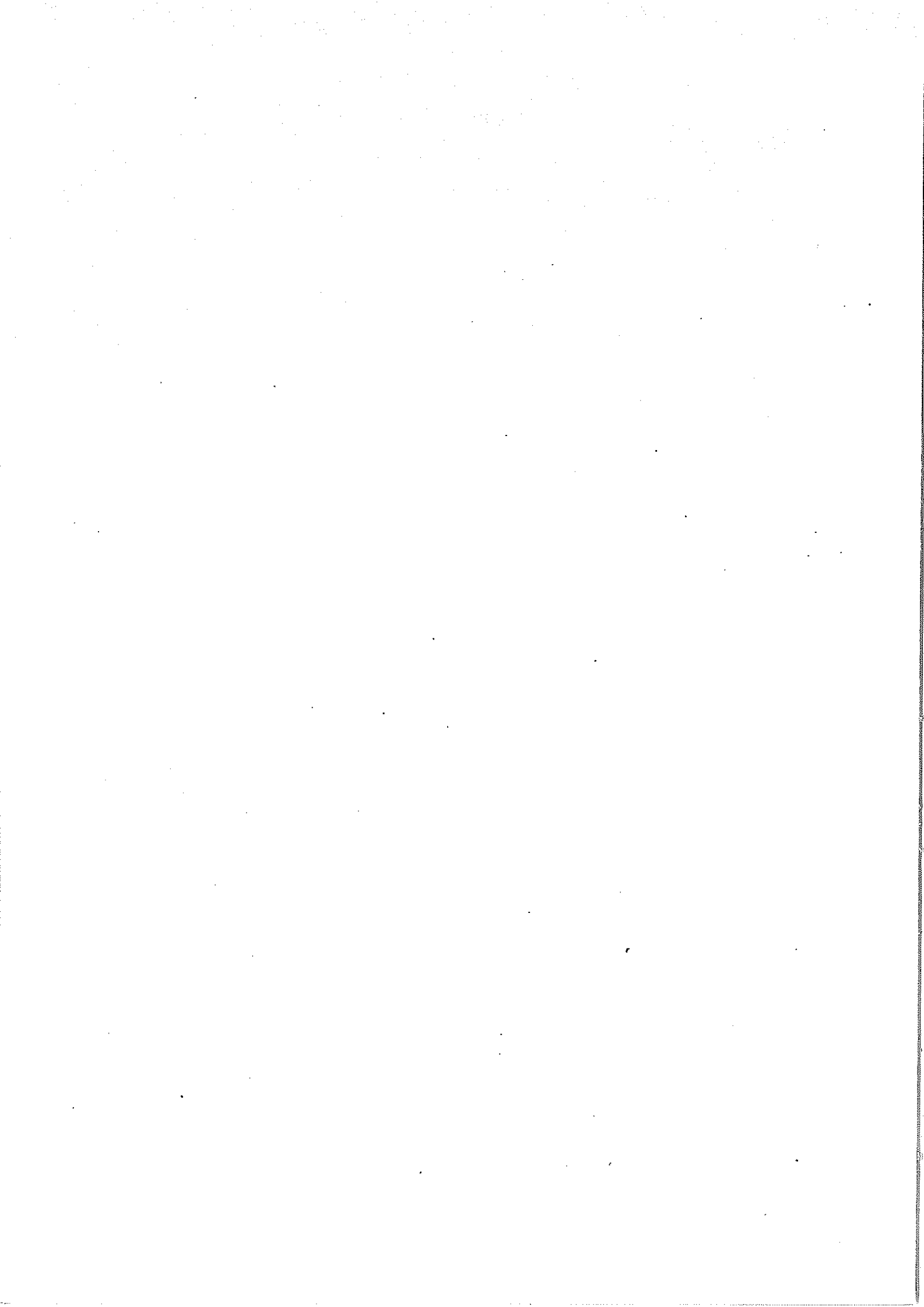


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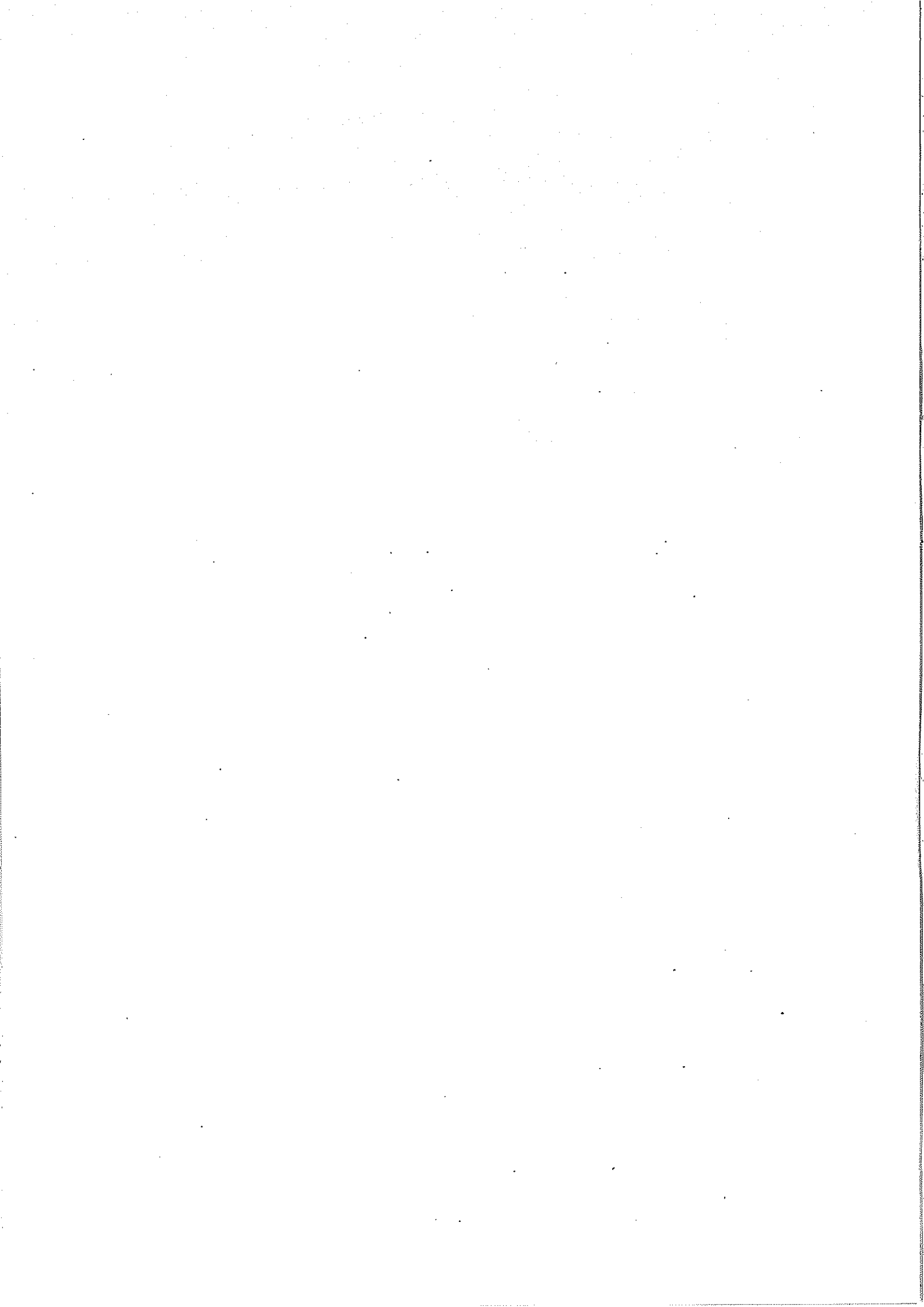
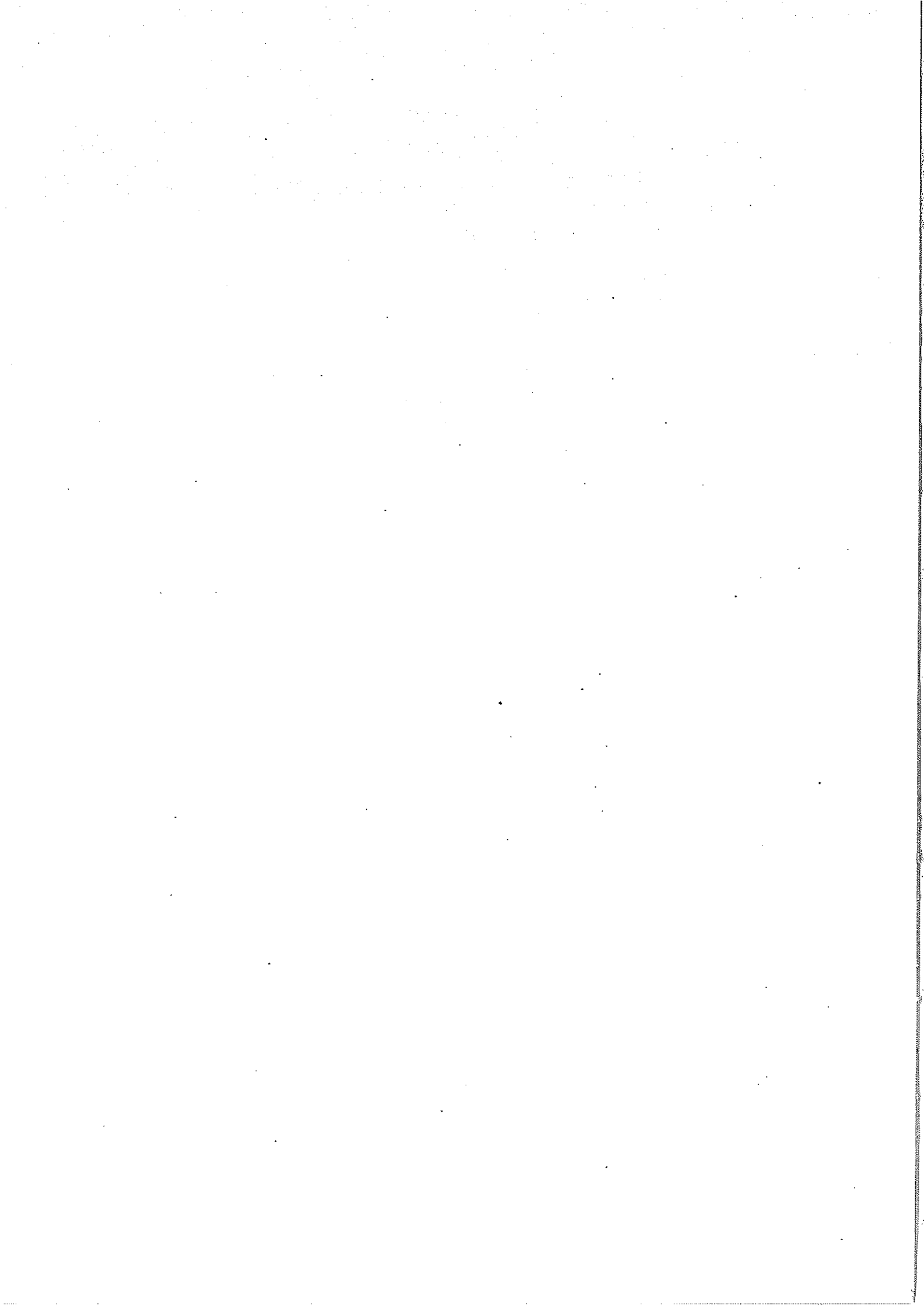


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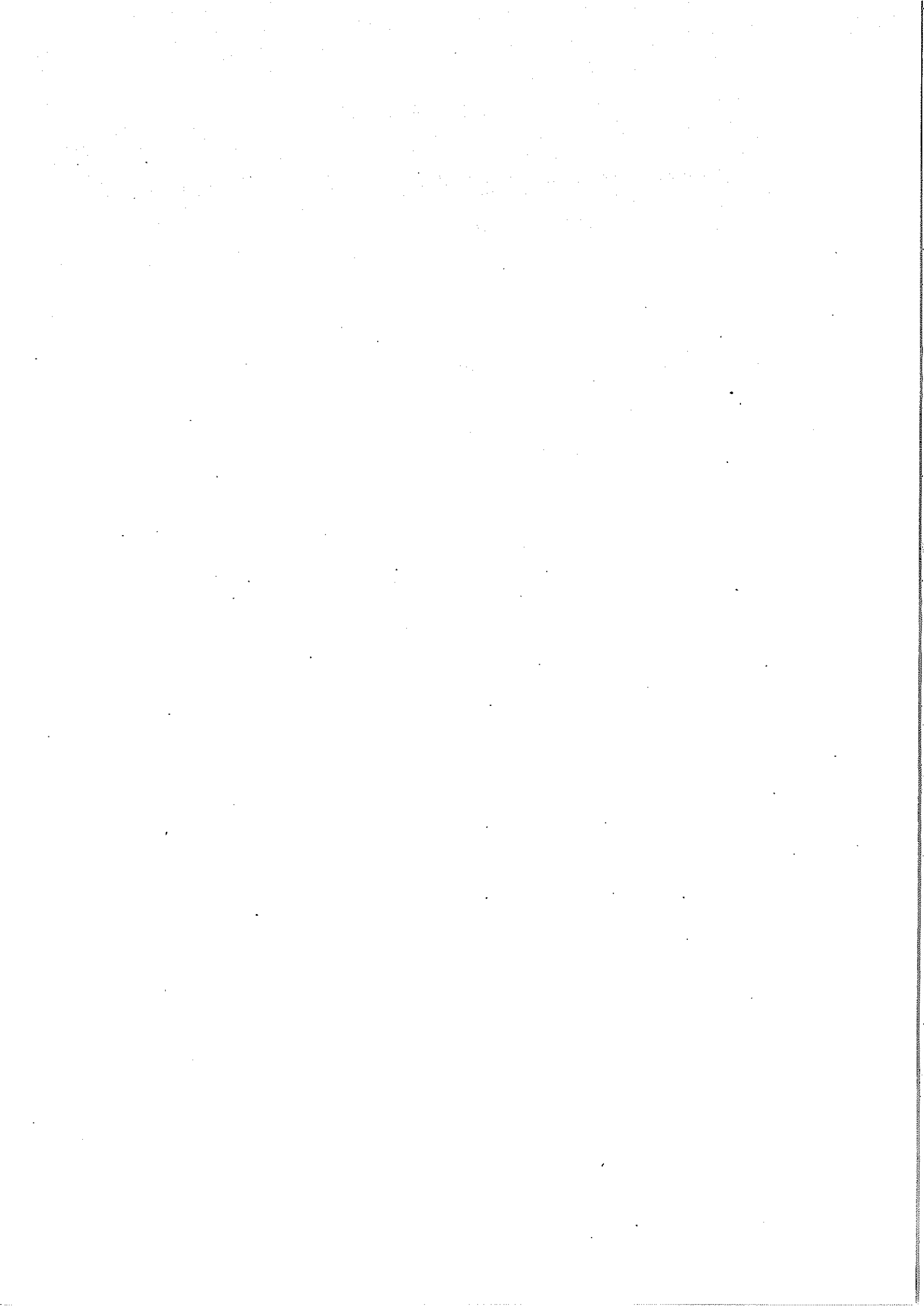


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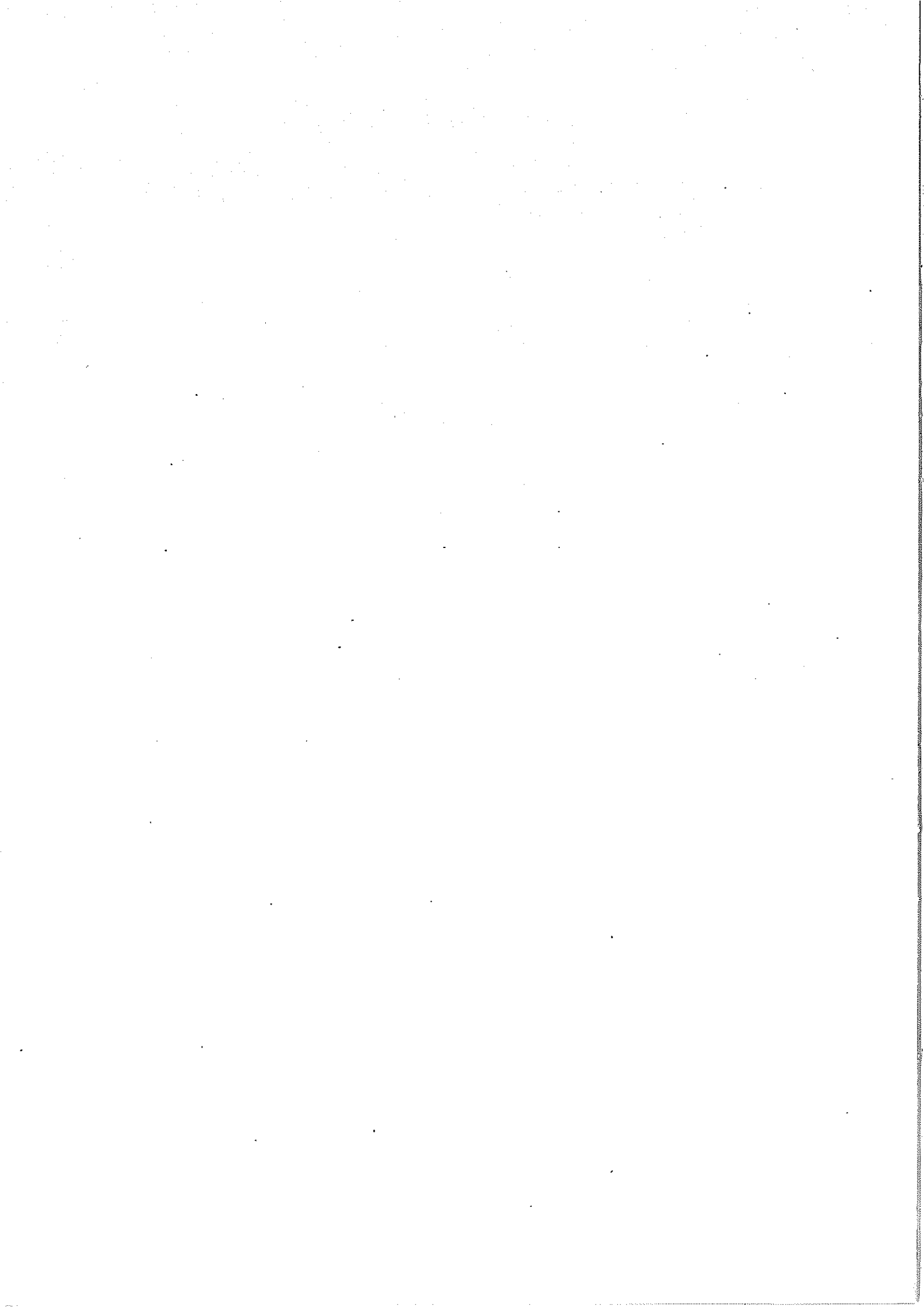
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SECTION 1.

EXECUTIVE SUMMARY

1.1 CONTEXT FOR STUDY

A number of studies have documented considerable variation between forecasted capital costs and the actual final capital costs of fixed guideway transit projects. However, these studies considered an older generation of projects and did not confirm the total cost variance. A better understanding of the unexplained causes of cost overruns requires additional in-depth analyses. This report documents, in far greater detail than past studies, the actual versus estimated costs in the planning, construction and start-up of selected transit capital projects.

The goal of the study is to provide the Federal Transit Administration (FTA), transit agencies, metropolitan planning organizations (MPOs), local governments and state agencies with information that can be used to develop more accurate estimates of transit project costs and, thereby, reduce cost overruns in the planning, construction, and start-up of major transit capital projects. This in turn, will aid in the selection of the most cost-beneficial alternatives.

1.2 ANALYTICAL APPROACH

The basic approach to the task involved conducting a variance analysis of capital cost estimates against final costs, by studying costs at a very detailed level over project life cycles starting at the Final Environmental Impact Statement (FEIS) stage. Considerable effort was devoted to collecting relevant reports, data, and interviewing personnel from both project offices and regional FTA offices. Digital data was requested from all case study projects, but most data was delivered in hardcopy format.

After a thorough review of all collected material, a data analysis approach was developed for each case study. Due to significant differences in reporting formats and types of data available, the approach to data analysis was customized for each case study. In most cases data was manually entered into a computer database. This database was then used as a central repository providing data for spreadsheet and graphical analysis. Costs were considered on a line item basis and were grouped into major cost categories for trend analysis. A variety of graphical and tabular exhibits were developed to provide insight into potential causes for cost growth and/or cost differences. This quantitative data was finally considered in light of the background provided by project reports and observations collected during interviews.

1.3 CASE STUDY PROJECTS

Five case study projects were selected for detailed analysis. Two of the projects involved heavy rail systems (Chicago Southwest Transit Project, Los Angeles MOS-1), two involved light rail

systems (St. Louis MetroLink Project, Sacramento Light Rail Starter Line), and one involved an extension of an automated guideway transit (AGT) system (Miami Metromover). Table 1 provides some detailed characteristics of the selected projects. Note that there were considerable differences in the level and types of risk faced by each project due to political/financial environment, technical requirements, project scope, contracting strategy, etc. These factors are considered within the detailed analysis of each case study.

1.4 GENERAL FINDINGS

Estimate accuracy as a function of time is graphically portrayed for all projects in Exhibit 1. This exhibit indicates the variance between final project cost and estimates at various points in time. The y-axis shows the cost estimate as a percentage of the final project cost. The x-axis attempts to place various estimates relative to time. Note that the Chicago project stands out for the well behaved nature of its graph. Also note the underestimation of the two light rail projects, St. Louis and Sacramento, and the wide swings in estimates for Los Angeles and Miami.

Given the above level of estimate accuracy, a key study objective was to uncover causes of cost overruns. Table 2 presents the cost growth (percentage difference between latest available cost and cost estimate) experienced on each case study project by major cost category. This table indicates increased attention should be devoted to planning, estimating, and monitoring in the following areas:

- Right-of-way and real estate acquisition programs
- Construction
- Construction management
- Administration
- Design/engineering

As indicated in the tables, at least three projects experienced significant cost growth in these categories over their life cycles. Note that three of the categories fall under the general cost category commonly called "soft costs", a category previously hypothesized to be a major contributor to cost growth.

Soft costs are analyzed in detail in the case studies. Exhibit 2 provides an indication of the relative importance of soft costs in the budgets of the various projects. The figure indicates the percentage of budgeted soft costs to total project budget at various points in time. Note the following:

- Soft costs for Los Angeles MOS-1 are much greater than all other case studies
- Heavy rail project soft costs tend to be higher than the light rail and AGT soft costs.

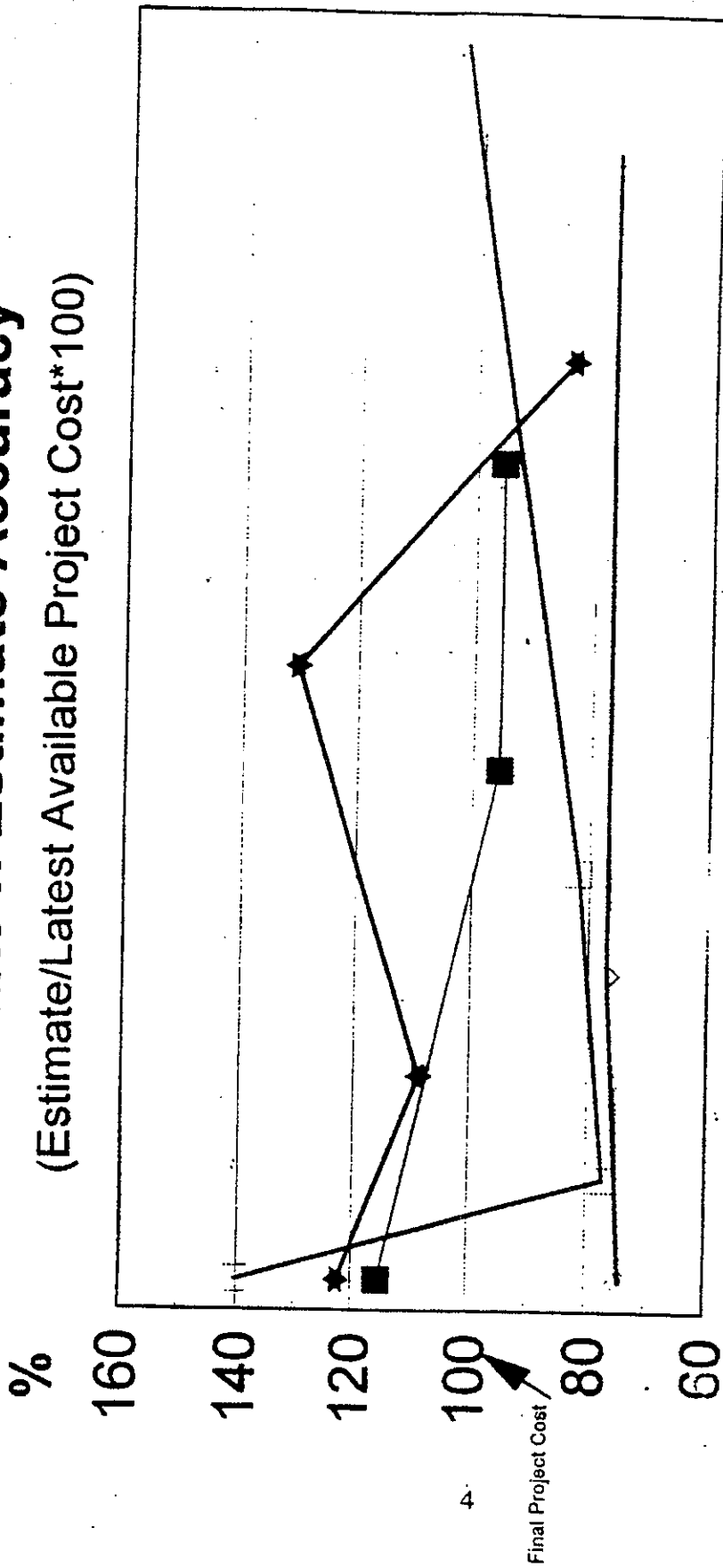
Table 1. Characteristics of Case Study Projects

Project/Type	Year FEIS/DOR	Length of Line (miles)	Construction Funding Source (ETA/Other)	Latest Project Cost	Claims	Change Orders	Key Events
Chicago SWTP/ Heavy Rail	1985/1993	9 2.7- Elevated	85%/15%	\$428,893,000	2 claims both in litigation	\$26,852,938 (6%)	Design change in 1987 decreased cost by \$40M
Los Angeles MOS-1/Heavy Rail	1983/1993	4.4 Subway	75% - 80% 25% - 20%	\$1,405,029,000	\$81,406,951	\$206,997,000 (15%)	Gas explosion/ Realignment SEIS in 1989 Mgt. Transition/ Reorganization in 1990
St. Louis MetroLink/ Light Rail	1987/1993	18 Tunnel, Bridge, Short Elevated Segment	75%/25% Local match in donated property	\$455,589,909	As of 2/2/94 settled \$3,756,826 Pending \$2,237,937 against contractors \$2,280,000	\$33,494,535 (7%)	Realignment in 1990 caused by airport master plan resulted in extraordinary costs
Sacramento Starter-Line/ Light Rail	1983/1987	18.3 At- Grade	85%/15%	\$170,072,000	As of 4/29/88 \$3,600,000	As of 4/29/88 \$3,140,000 (2%)	Mgt. Transition/ Reorganization in 1985
Miami Metromover Ext./AGT	1988/1994	2.5 Elevated	75%/25%	\$183,585,000	\$32,000,000 Unresolved	Guideway and Station Contracts 5/26/94 \$18,914,237 (10%)	Final Realignment to Mainly Public Right-of-Way in 1990

FEIS = Final Environmental Impact Statement
DOR = Date of Revenue Service
SEIS = Supplemental Environmental Impact Statement

Exhibit 1. Estimate Accuracy

(Estimate/Latest Available Project Cost*100)



	EIS	Work Est.	MK	PE	SEIS	Sup Con	FFGA	40% Rev	CM	FFGA	55%	84 (FD)	Forecast
Chicago	115.65%					95.59%			95.59%				
St. Louis	74.94%			75.48%				79.99%			80.14%		
Miami	122.68%		108.84%				130.73%			83.88%			
Los Angeles	140.42%	77.37%			81.92%								103.20%
Sacramento	74.33%			77.04%								77.05%	

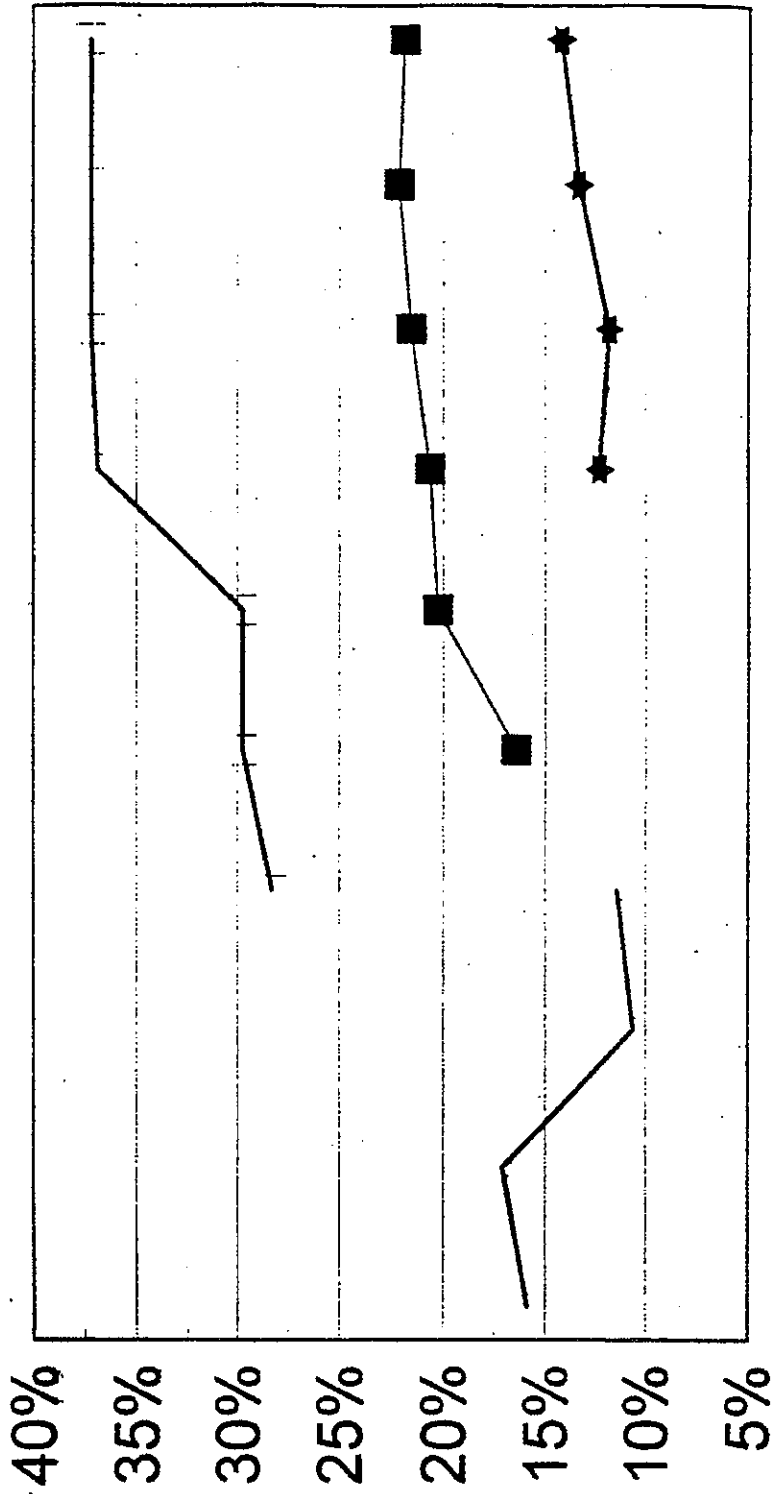
Table 2. Percentage Cost Growth by Cost Category by Project

Project	Baseline Estimate Used	Years-Baseline/Final Cost	Administration	Construction Mgmt.	Design/Eng.	Testing	Force Account	Procurement	ROW	Construction	Systems
Chicago SWTP	FEIS	85/94		36	15		77		21		
	Supervisory Consultant	86/94			1		24		3	9	
St. Louis MetroLink	FEIS	87/94							56	12	
	PE	88/94	58	18		8		72	38	38	
Miami Metromover Extension	FEIS	88/94		95	12						25
Sacramento Starter-Line	FEIS	83/87						34	23	178	
	FD	84/87	415				637		66	23	
Los Angeles MOS-1	FEIS	83/93	26				Data not detailed enough				
	SEIS	89/93		27	27				68	23	

FEIS = Final Environmental Impact Statement
 PE = Preliminary Engineering
 FD = Final Design
 SEIS = Supplemental Environmental Impact Statement

Exhibit 2. Budgeted Soft Costs

(Budgeted Soft Costs/Total Project Budget*100)



	84	85	86	87	88	89	90	91	92	93
Chicago ■					16.48%	20.29%	20.67%	21.60%	22.22%	21.93%
St. Louis ◆							8.90%	14.09%	16.03%	17.56%
Miami ★							12.33%	11.87%	13.41%	14.28%
Los Angeles ▬	15.91%	17.14%	10.67%	11.46%	28.37%	29.79%	36.90%	37.22%	37.22%	37.22%
Sacramento —										

Comparing actual soft costs expended to total project expenditures produces a very different shaped graph, as shown in Exhibit 3. For a well behaved project, one would expect to see a curve similar to that generated by the Chicago Southwest Transit Project.

Another cost category studied quite closely was contingencies. Exhibit 4 indicates approved budget contingency as a percentage of the total approved budgets for the five case study projects. Once again, Chicago's curve shows a slowly decreasing function, eventually approaching zero. Note that St. Louis and Miami experienced issues related to extraordinary costs and unresolved claims, respectively.

1.5 GENERAL OBSERVATIONS/RECOMMENDATIONS

Based on analytical evidence accumulated during the five case studies, some general observations/recommendations can be offered:

Standardized capital cost reporting formats appear to be lacking.

Other than the use of GMIS coding, there does not appear to be a mandated project reporting format for tracking capital cost budgets or expenditures. The lack of a standardized format means that each project must be monitored from its own unique perspective.

Recommendation: Develop a standardized reporting format for capital costs which will make project performance more transparent to Federal monitoring.

Standardized procedures for estimating the capital cost of major urban transit projects appear to be lacking.

The projects studied appeared to utilize different "rules of thumb" for estimating different classes of cost. Facilities, systems, and soft costs are often estimated quite differently.

Recommendation: Develop specific guidelines for projects to follow in developing cost estimates, based on empirical factors. Track and update factors over time.

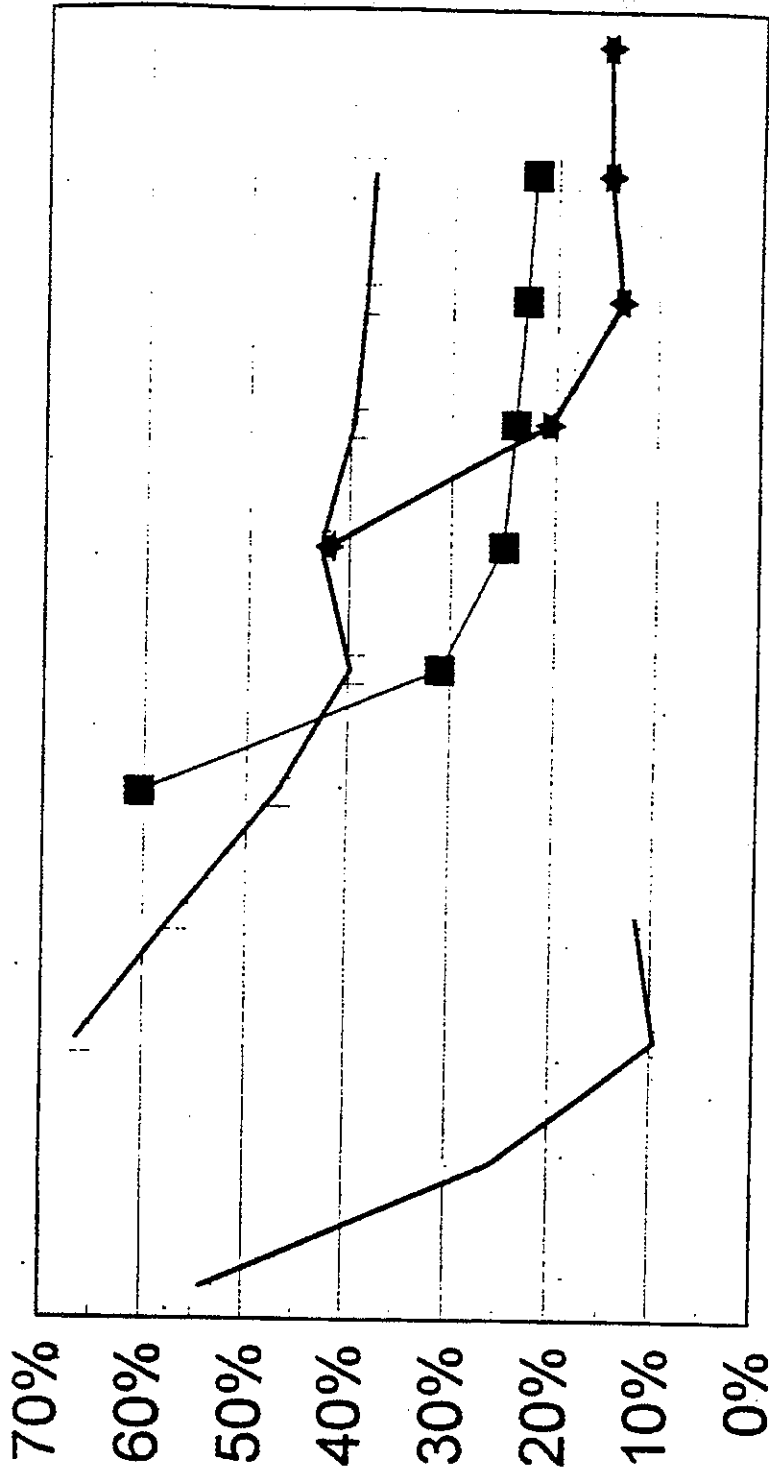
Grant budgets and working budgets often appear to be quite different.

Most of the projects seemed to develop completely different working budgets and grant budgets. It would seem that there should be a closer relationship between these budgets.

Recommendation: Mandate that grant budgets must have a direct relationship to project working budgets. This will help ease the monitoring effort and reporting requirements.

Exhibit 3. Actual Soft Costs

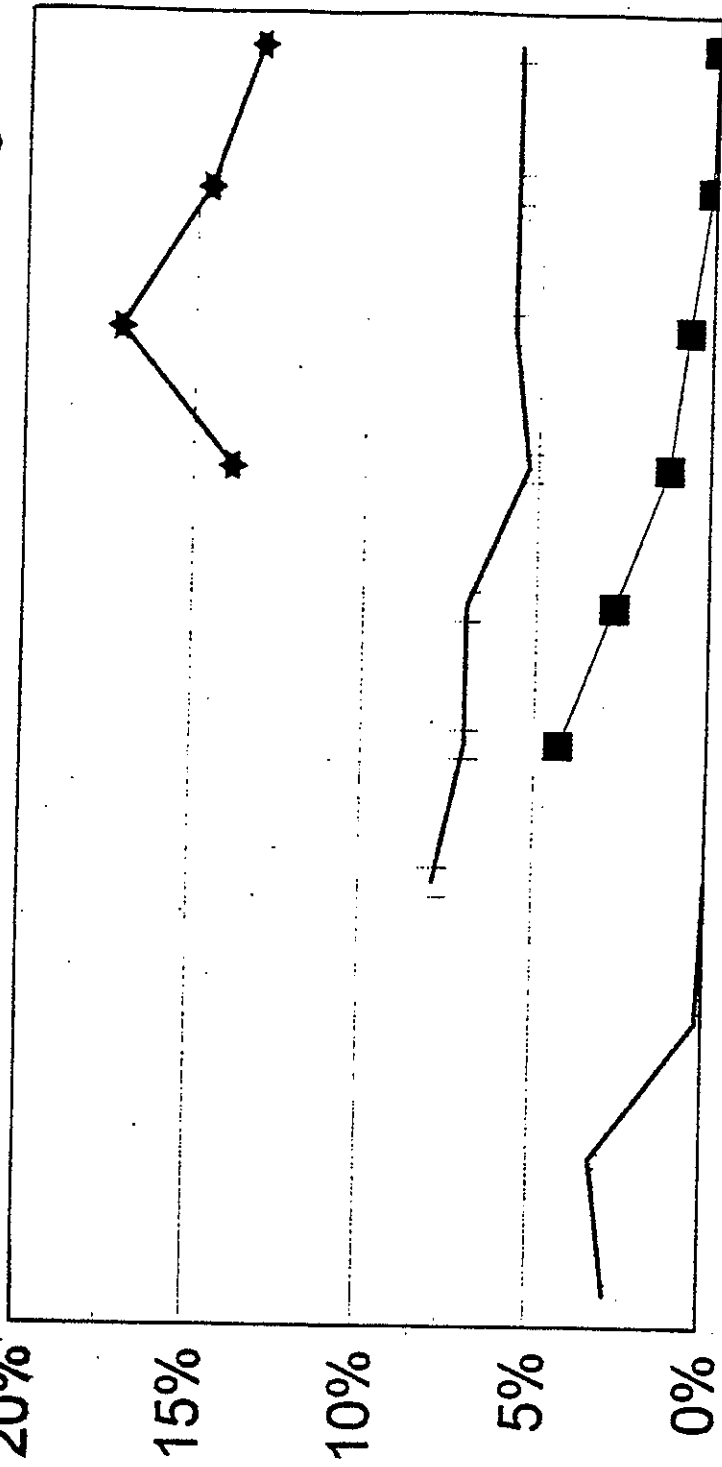
(Actual Soft Cost Expenditures/Cost Expended To Date*100)



	84	85	86	87	88	89	90	91	92	93	94
Chicago ■					60.60%	31.04%	25.00%	23.93%	22.95%	22.17%	
St. Louis ◆						5.50%	18.53%	16.92%	14.05%	13.53%	13.21%
Miami ▲							42.10%	20.63%	13.66%	14.94%	15.19%
Los Angeles ▬			66.57%	57.12%	47.07%	39.88%	42.86%	39.69%	38.57%	37.89%	
Sacramento —	54.18%	25.63%	9.72%	11.59%							

Exhibit 4. Contingencies

(Approved Budget Contingency/Total Approved Budget*100)



	84	85	86	87	88	89	90	91	92	93
Chicago ■					4.34%	2.78%	1.22%	0.69%	0.12%	0.05%
St. Louis ★							6.61%	14.97%	14.45%	14.37%
Miami ▲							13.89%	17.19%	14.67%	13.18%
Los Angeles ×				7.84%	7.00%	7.00%	5.32%	5.74%	5.74%	5.74%
Sacramento +	2.74%	3.21%	0.20%	0.00%						

Drawdown data indicates that funds are often obligated to projects well in advance of their requirement. This resulting float may be imposing a significant opportunity cost.

Recommendation: Develop an accounting system whereby funds could be assigned to projects, but not obligated until shortly before expenditure is required. This recommendation would require projects to more accurately predict their cash flow requirements.

There does not appear to be a standard method for estimating or accounting for contingencies within a project budget. Some projects consider contingency on a line item basis, some consider it on a project basis, and others consider both types of contingency.

Recommendation: Develop a procedure which relates contingency to project risk. Develop standard procedures for projects to follow to calculate level of risk and contingency levels. Mandate how contingency should be treated from an accounting standpoint.

Issues related to alignment and real estate acquisition can have major impacts on project capital cost. Many of the case study projects experienced quite significant impacts from alignment related issues.

Recommendation: Prior to the signing of any Full Funding Grant Agreement, ensure that all alignment scenarios have been fully considered and factored into the cost/budget estimates. Ensure adequacy of property market assessments and the size, experience, and skill level of the real-estate related project staff.

Relevant management/organizational experience and stability are necessary conditions to maintain project capital costs within forecasts.

Recommendation: Place project within one organization for its entire life cycle. Ensure that the project team has the requisite managerial and practical experience required to deal with the assumed level of project risk.

SECTION 2.

INTRODUCTION

This final report has been prepared as the final deliverable for Task 10 of Contract No. DTUM60-88-C-41032. The study encompassed a detailed review of capital costs for five recently implemented fixed guideway transit projects. This report will describe the goals and objectives of the project, the methodology that was used, general findings from the case studies, and recommendations for improvement. Detailed case studies are then presented for an AGT project, two light rail projects, and two heavy rail projects.

2.1 CONTEXT FOR THE STUDY

A number of reports have documented considerable variation between the forecasted capital costs and the actual final capital costs of transit projects. The "Pickrell Report"¹, a study of 10 heavy rail, light rail, and AGT projects built in the 1970s and 1980s, found that actual costs exceeded forecast costs by as much as 106%. Only one of the projects studied was completed within its original estimate. Seven of the projects exceeded original cost estimates by 50% or more.

In attempting to explain the reasons for these cost overruns, the report examined changes in the overall scope of the projects. A comparison was made of the planned versus actual number of system miles, the number of stations, and the number of vehicles. Only minor differences were found. It was concluded that changes in total project design had minor, if any, impact on capital cost overruns.

The study also examined the impact of construction delays on project financing. Delays in project construction were documented and the forecast versus actual inflation rates for the period were compared. The study found that, at best, less than one-third of the total overrun could be explained by delays and inflation. In four cases, estimates of inflation exceeded actual rates, suggesting that delays should have helped keep these projects within estimated costs.

While the Pickrell study provided information about the total cost variance in these projects, it did not identify the major contributing factors to these overruns. A major limitation of the study was that it compared estimates generated in the Alternatives Analysis (AA) stage of the projects to the final costs. Differences in costs at each of the other project milestones - Preliminary Engineering (PE), Final Design, and receipt of construction bids - were not documented. For this reason, the report could only speculate on why the documented cost overruns occurred.

¹ Pickrell, D. H., Urban Rail Transit Projects: Forecast Versus Actual Ridership and Costs, prepared for the Federal Transit Administration, October, 1990.

Studies have suggested that the following factors are probably responsible for a significant part of these capital cost overruns:

- Unrealistic or inaccurate estimates made during the Alternatives Analysis phase.
- The cumulative effect of numerous small design changes made in the construction phase (by owner or induced by the site).
- Higher than anticipated increases in "soft costs" such as planning, design, environmental impact statements, geotechnical studies, insurance, project management, public relations, testing, etc.

Some detailed analysis is available in recent studies. For example, the *Hennepin County LRT Implementation Alternatives Study*² provides a comparison of PE, FD, and final actual costs for three recently completed light rail systems in San Diego, Los Angeles, and Portland, Oregon. Costs are presented by major project line-items and are disaggregated into "construction", "services", "right-of-way", and "other" costs. Reasons for major overruns are also detailed. This study does not, however, present the initial cost estimates (at AA) for these three projects. Two of the three projects studied are also different from those examined in the Pickrell report. A thorough comparison of information between these studies is, therefore, not possible.

FTA's *Light Rail Transit Capital Cost Study*³, prepared by Booz-Allen & Hamilton, examined final actual costs for five of the most recently completed light rail systems. The objective of this study was to develop unit costs for various components of light rail systems. Because actual costs were not compared to estimates made in previous stages of the projects, an assessment of cost overruns at various stages is not possible. The study did reveal the importance of non-construction or "soft-costs" as a capital cost. Of the five systems studied, soft-cost ranged from 20% (Sacramento) to 40% (Pittsburgh) of total "as built" project costs.

A more detailed examination of cost estimates, design changes, and actual costs is needed for a greater number of recent projects. An expanded base of information will provide a better understanding of the past causes of cost overruns. This information will help local planners improve their cost forecasts. It will also assist FTA in verifying the reasonableness of projections developed at the local level.

² Capital Partnerships, Inc., *LRT Implementation Alternatives Study*, prepared for the Hennepin County Regional Railroad Authority, December, 1990.

³ Booz-Allen & Hamilton, Inc. *Light Rail Transit Capital Cost Study*. Prepared for The Federal Transit Administration, April 1991.

2.2 STRUCTURE OF REPORT

This report is composed of nine sections. Section 1 presents a concise overview in an executive summary. Section 2 introduces the reader to the material of the report by discussing the context for the study and the structure of the report. Section 3 discusses the purpose/objectives of the study and the approach that was used to satisfy those objectives. General findings from the case studies are presented in Section 4 from a comparative standpoint. Observations, lessons learned, and recommendations are also offered in Section 4. Detailed case studies are presented in Sections 5-9, respectively, for each project studied. Appendices related to individual case studies are placed at the end of the respective case study sections.

SECTION 3.

STUDY OVERVIEW

3.1 PURPOSE/OBJECTIVES

This report documents, in far greater detail than past studies, the actual versus estimated costs in the planning, construction and start-up of selected fixed guideway transit capital projects.

The goal of this study is to provide the FTA, transit agencies, MPOs, local governments and state agencies, with information that can be used to develop more accurate estimates of transit project costs and, thereby, reduce cost overruns in the planning, construction, and start-up of major transit capital projects. This, in turn, will aid in the selection of the most cost-beneficial alternative.

To meet this goal, the study examines in detail five major transit capital projects. Cost estimates made throughout the planning and construction stages of these projects are documented. These estimates are then compared to actual costs. Cost estimates and actual costs have been collected for all aspects of the projects including construction costs and non-construction or "soft costs."

The study documents and analyzes costs for several different modes including rapid rail, light rail, and AGT. Table 3 lists several recent transit capital projects by mode. As shown, eight of these were examined in the Pickrell study. General conclusions about total cost overruns based on a comparison of AA estimates and final actual costs is, therefore, already available. Three other projects listed in Table 3 were examined in detail in the Hennepin County report. Line-item comparisons of PE, FD, and final actual costs are, therefore, available to some extent.

This study gathered detailed information needed to conduct a case study analysis of capital cost for five of these projects. Detailed line-item information was collected for the following projects:

- Rapid Rail: Los Angeles (MOS-1), Chicago SouthWest Transit Project
- Light Rail: St. Louis Metrolink, Sacramento Light Rail
- AGT: Metro-Dade Metromover Extension

3.2 STUDY APPROACH

The following tasks were undertaken in order to meet the objectives noted above:

- Task 1.** A work plan was developed to describe the goals and objectives of the project, the methodology that would be used, and the deliverables. A management plan was provided including staffing and responsibilities and a proposed work schedule.

Table 3. Listing of Transit Capital Projects Reviewed by Recent Studies and Included in this Study.

Mode	Location	Picktrell	Booz-Allen	Hennepin Cty.	Task 10
Rapid Rail	LAMTA, Los Angeles, CA				✓
Rapid Rail	WMATA, Washington, D.C.	✓			
Rapid Rail	MARTA, Atlanta, GA	✓			
Rapid Rail	CTA, Chicago, Illinois				✓
Rapid Rail	MTA, Baltimore, MD	✓			
Rapid Rail	Metro-Dade, Miami, FL	✓			
Light Rail	San Diego, CA			✓	
Light Rail	Los Angeles, CA		✓	✓	
Light Rail	St. Louis, MO				✓
Light Rail	Portland, OR	✓	✓	✓	
Light Rail	Buffalo, NY	✓			
Light Rail	Pittsburgh, PA	✓	✓		
Light Rail	Sacramento, CA	✓	✓		✓
AGT	Metro-Dade, Miami, FL	✓			✓
AGT	Detroit, MI	✓			

- Task 2.** All available reports which include cost information and comparisons were collected and reviewed. This included copies of documents forwarded to FTA as part of the management of the projects, local studies undertaken to review the projects upon completion, and independent studies undertaken by FTA or others. Local project planners and managers and regional FTA staff were contacted as part of this data collection effort.
- Task 3.** Each local transit agency and regional FTA office were contacted by phone and by letter and a schedule for on-site visits was developed.
- Task 4.** On-site visits were conducted to gather cost information, change orders, schedule updates, as well as other pertinent project documentation. Where possible, data was collected in digital form. Key project staff were interviewed and contractors were contacted as needed for clarifications and insight on project development.
- Task 5.** Follow-up telephone calls were made where clarification was required. Preliminary information was also shared with local agency staff where appropriate.
- Task 6.** Data was entered into computer databases and spreadsheets for analysis. Graphical analysis was employed extensively to gauge major variances and trends.
- Task 7.** Additional contact was made with local transit agency staff to obtain insight into cost variances which could not be adequately explained by information available in reports.
- Task 8.** Interim reports were prepared. A separate report was prepared for each project studied (i.e., Chicago SouthWest, St. Louis Metro Link, etc.).
- Task 9.** A preliminary draft report detailing the findings of all case studies was prepared. Findings and recommendations were based on analyzing common cost variances across projects as well as on the qualitative information provided in interviews with local project planners and managers, regional FTA representatives, and project PMOs. Recommendations for improved cost estimation and review procedures were made.
- Task 10.** FTA reviewed the interim reports and the draft findings and recommendations. The draft findings and recommendations for improved cost estimation and review procedures were also shared with local transit agency planners and project managers and comments were received.
- Task 11.** A draft final report was prepared. This report included final findings and recommendations, and a summary of the cost and project information from the "case study" reports.

SECTION 4.

GENERAL FINDINGS FROM CASE STUDIES

This section offers some general insights across the five case study projects. The first part of the section discusses findings associated with key topics. The second part offers some recommendations for improving the capital cost estimating, review, and monitoring process.

4.1 COMPARISON OF CASE STUDY RESULTS

Table 1 presents some major characteristics for each of the case study project. Included in the table are:

- Year of Final Environmental Impact Statement, date of revenue service
- Length of line in miles
- Percentage of funding from FTA and percentage from other sources
- Latest available cost
- Cost due to claims- resolved, unresolved
- Cost due to change orders
- Key events impacting cost

The FEIS/Date of revenue service life cycle ranged from four to ten years, with two projects initiated in the early 1980s, one in the mid 1980s, and two in the late 1980s. Length of lines ranged from 2.5 miles for the Metromover Extension to 18.3 miles for Sacramento. Percentage construction funding from FTA varied between 75% and 85%. Latest available project cost spanned from Sacramento's roughly \$170M to Los Angeles MOS-1 \$1.4B. Claims experience also varied widely between projects. Sacramento experienced \$3.6M in claims, while Los Angeles totaled \$81.4M. Similarly change order costs ranged from \$3.1M for Sacramento to \$206M for Los Angeles. Most key events revolved around either realignments or management reorganizations.

4.1.1 Capital Cost Estimating Process

Documentation was available for three of the projects on the process that was used to develop capital cost estimates: two heavy rail and one AGT. For the heavy rail, estimates were available at two points in time:

Los Angeles

- FEIS - Design and construction management = 13% for facilities, 10% for systems
- Design contingency = 15% for facilities, 10% for systems

- SEIS - Design and construction management = 15% of facilities cost, 10% for systems
- Contingency = 10% of total escalated project cost

Chicago

- FEIS - Project management, design, construction management, change order reserve = 22.9% of construction cost (including contingency)
- Contingency = 10% of construction cost, 5% of procurement cost
- PE - Professional services = 13.4% of total project cost or 20% of project direct costs
- Contingency = 15% on fixed facilities, 29% on procurement, 29% on systems

Miami

- FEIS - Professional services = 8.75% of total escalated project cost
- Contingencies = 5% to 10%, 6% of total escalated project cost

Based on this evidence, there does not appear to be a standard methodology employed to develop capital cost estimates. For the same projects, different percentages were used for different time periods.

4.1.2 Project Financing

The funding profile for the five case studies varied quite widely. FTA and its predecessor (UMTA) provided between 75% and 85% of construction funding for the projects. Congressional earmarking played a major role in the Miami and St. Louis projects. St. Louis matched the Federal grant totally with donated real estate. Cash flow was an issue for St. Louis and Sacramento. Extraordinary cost provisions in the Full Funding Grant Agreements were instituted on only one project, St. Louis.

Evidence available from the case studies indicates that the timing of the commitment/obligating of federal funds to the projects may be a subject of further review. Funds appear to be obligated well ahead of project requirements. Timely need for funds more closely could free up substantial sums of money and lower the opportunity cost associated with the resulting float.

4.1.3 Project Organization

Organizational issues impacted all of the projects. Organizational experience/strength and stability had a positive impact in ensuring cost stability for the Chicago project. It appears that a minimum level of internal project support is necessary to ensure project effectiveness. Lack of sufficient internal project staff appeared to negatively impact St. Louis in the beginning stages of the project. Transitioning project management responsibility after completion of preliminary design to another organization also appeared to have a negative impact on St. Louis. Reorganizations generally followed negative experiences in project schedule and cost control. Decision making authority was also an issue, particularly in field relations related to change orders. Generally, the greater the independence of the field organization, the lower the claims experience, and the lower the cost escalation. Contracting philosophy is the last area that seemed to impact projects. Most project panels seemed to advocate the need to

minimize construction contractor interfaces as much as possible as a means to reduce project risk. Miami also had a somewhat negative experience from dividing design responsibility between two prime contractors.

4.1.4 Key Events

For Los Angeles, St. Louis, and Miami capital cost was impacted by major changes in alignments-impacting design and right-of-way acquisition programs. Los Angeles and St. Louis were impacted negatively and Miami was impacted positively. Lack of geotechnical and utility location data negatively impacted cost in more minor ways in Los Angeles and St. Louis. Reorganizations in Los Angeles and Sacramento had major positive impacts on project control, resulting in lower capital cost of the project. A major design change in Chicago had a significant positive impact on project cost.

4.1.5 Budget/Cost Growth

Comparing capital cost estimates and latest available costs across all projects showed some definite trends. Projects showed increases in all or some "soft costs" (administration, construction management, design/engineering, insurance, and testing). With the exception of the Miami Metromover Extension project, right-of-way costs outpaced estimates for all of the projects. Construction cost increases for Los Angeles, Sacramento, and St. Louis over the project life cycle were worthy of note. Miami also showed cost growth in the systems arena. Many of the reasons for the cost growth have been discussed in the prior sections. For the scope of this project, it is not possible to isolate causal factors for growth in particular cost categories.

4.2 RECOMMENDATIONS

Based on analytical evidence accumulated during the five case studies, some general recommendations can be offered:

- FTA should develop specific cost estimating guidelines for projects, to allow for cross comparisons between projects.
- Projects should be based in one organization over their entire life cycle, an organization with a substantial base of civil construction experience.
- Project management personnel should be carefully evaluated in terms of prior experience with managing outside contractors and prior project control experience.
- Careful attention should be paid to project alignment and real estate acquisition throughout the project. FTA oversight of the real estate arena probably warrants increased attention with respect to deciding on the final alignment, risks of property acquisition programs, adequacy of staff, and market assessment.

- Adequate funding of up-front planning and design/engineering costs appears to be a cost-effective investment.
- Number of contractor interfaces should be minimized to reduce both management and construction risks.
- Construction risks can also probably be decreased by allowing field personnel to exercise a maximum amount of discretionary judgement regarding change orders.
- Positive contractor relations concerning change orders and invoice payment should result in positive cost impacts.
- Grant administration/oversight also warrants some attention to bring it more into line with project budgeting and control. Grant budgets/project budgets should be closely aligned and any deviation should be justified.
- The timing of obligating funds to projects appears to be an area for potential significant savings. Evidence from this case study sampling implies that funds are obligated significantly in advance of when they are needed. There is a definite opportunity cost associated with this float.
- Reallocations between accounts should be carefully monitored with respect to percentage changes. Significant reallocations may be an indicator of project difficulty.
- Standardization of reporting formats that serve both the needs of the project team and FTA oversight should be considered.
- Standardization of estimating and accounting for contingency would also be useful in ensuring project control.

Given the magnitude of the typical urban transit project, the number of uncertainties involved, and the typical life cycle, variance can be expected between estimates and final costs. Contingency budgets are designed to deal with the cost variance. One method worthy of consideration to deal with these uncertainties would require estimators/decision makers to explicitly account for perceived risks by inputting critical costs as distributions, rather than point estimates. Within a risk analysis framework, the probability of costs would be explicitly presented. With this additional information, decision makers and FTA oversight would be able to concentrate on those areas with the greatest risk/uncertainty and would know immediately when a cost exceeded a reasonable bound.

SECTION 5.

CASE STUDY OF CHICAGO

SOUTHWEST TRANSIT PROJECT

The Southwest Transit Project (SWTP), now referred to as the Orange Line, introduced high speed rapid transit service to the Southwest Side of Chicago in 1993 by connecting downtown Chicago to Midway Airport. The project includes approximately nine miles of double track fixed guideway, eight stations, a yard, and shops. Patrons of the Orange Line can interconnect with the Chicago Transit Authority's (CTA's) transit system at the Dan Ryan line at 18th and Clark Streets near the Chicago Loop. Elevated structure is utilized for 2.7 miles of the line with the balance on embankment, mainly along railroad rights-of-way.

This case study of a heavy rail system stands out among the five projects studied for its lack of events which had major impacts on capital cost. With the exception of a train control system contract which has progressed to litigation, the project appears to have been extremely well managed and executed.

5.1 PROJECT BACKGROUND/HISTORY

Funding for the project first became available when plans for the Crosstown Expressway (FAI-494) were cancelled in 1979. As part of the Interstate Transfer Program (ITP), the Chicago region became entitled to approximately \$2.4B in federal funds to undertake a comprehensive program of transit and street substitute projects. The transit component of the ITP was to complement the FTA's regular (Section 3 and 5) capital assistance programs to the Chicago region.

The Southwest Transit Project was initiated in 1977 with a Phase I Preliminary Alternatives Analysis, which evaluated more than 600 proposals and recommended further study of 11 including: TSM, busway, and rapid rail facilities. By 1982, studies of transit alternatives to serve the Southwest sector of Chicago had resulted in the adoption of an 'L' shaped alignment for a rapid transit line using existing railroad right-of-way for about two-thirds of its length. This alignment was firmed up with the publication of a FEIS in September of 1985.

Preliminary design took place from mid 1984 to late 1986. In early 1985, a technical advisory committee was established to review drawings. About the same time a board of control was formed to oversee cost control. In 1987, several major design changes, resulting in cost savings of roughly \$40M, were initiated as a result of changes to the Midway Airport development plans. The station and parking lot at Midway Airport were changed from elevated to depressed structures. Depressing the station also resulted in a change to the track structure for the station approach. Costs associated with close to one mile of elevated structure were saved. Final design

was accomplished between late 1985 and the end of 1988. At one point work had progressed so satisfactorily that the master schedule advanced revenue service to October 1992, one year ahead of the date specified in the Full Funding Agreement.

5.2 PHYSICAL DESCRIPTION OF PROJECT/ALIGNMENT

Figure 1 depicts the basic alignment for the Southwest Transit Project. Of the nine miles of double track line construction, 2.7 miles are aerial structure and 6.3 miles are embankment construction along railroad rights-of-way. The embankment portion is mainly located parallel to 49th Street, Western Avenue and Archer Avenue. The Line begins at Midway Airport and joins the existing Dan Ryan elevated structure in the vicinity of 18th street.

Each of the eight stations has a center platform approximately 24 feet wide and about 420 feet long, sufficient to accommodate an 8-car train. At least one escalator and one elevator is provided at each station. Platform canopies reach out over the tops of trains for protection, and windbreaks with overhead heaters are added for comfort.

The below-grade-level Midway terminal has two platforms served by three tracks. Attached to the station at street level is the entrance to an enclosed elevated pedway with moving sidewalks.

Cars utilized on the Orange Line were part of a separate large purchase made by the CTA in 1989 with Morrison Knudsen. They are designed for one-person operation.

5.3 PROJECT ORGANIZATION

The Grantee for the project was the City of Chicago Department of Public Works (DPW-renamed the Chicago Department of Transportation in 1992). Due to the size and complexity of the SWTP, the DPW decided to utilize outside consultants to augment its core staff. The DPW established a technical advisory committee made up of representatives of relevant bureaus to review drawings. A board of control was also formed and held bi-weekly meetings on cost control.

As part of the Full Funding Grant Agreement, the City contracted with a Supervisory Consultant to provide oversight of the design effort and a Construction Manager to oversee construction, procurement, and system contractors. The detailed design of the line and station structures was contracted directly by the DPW to Section Design Consultants. No turnkey contracts were let, but procurement contracts were used to obtain standardized elements on a systemwide basis. Figure 2 depicts major participating organizations and their relationship to one another.

During the construction phase, zone offices were established with resident engineers having responsibility for monitoring schedules and resolving problems. No integrated master schedule was developed for the project so project float was managed as the sum of individual tasks.

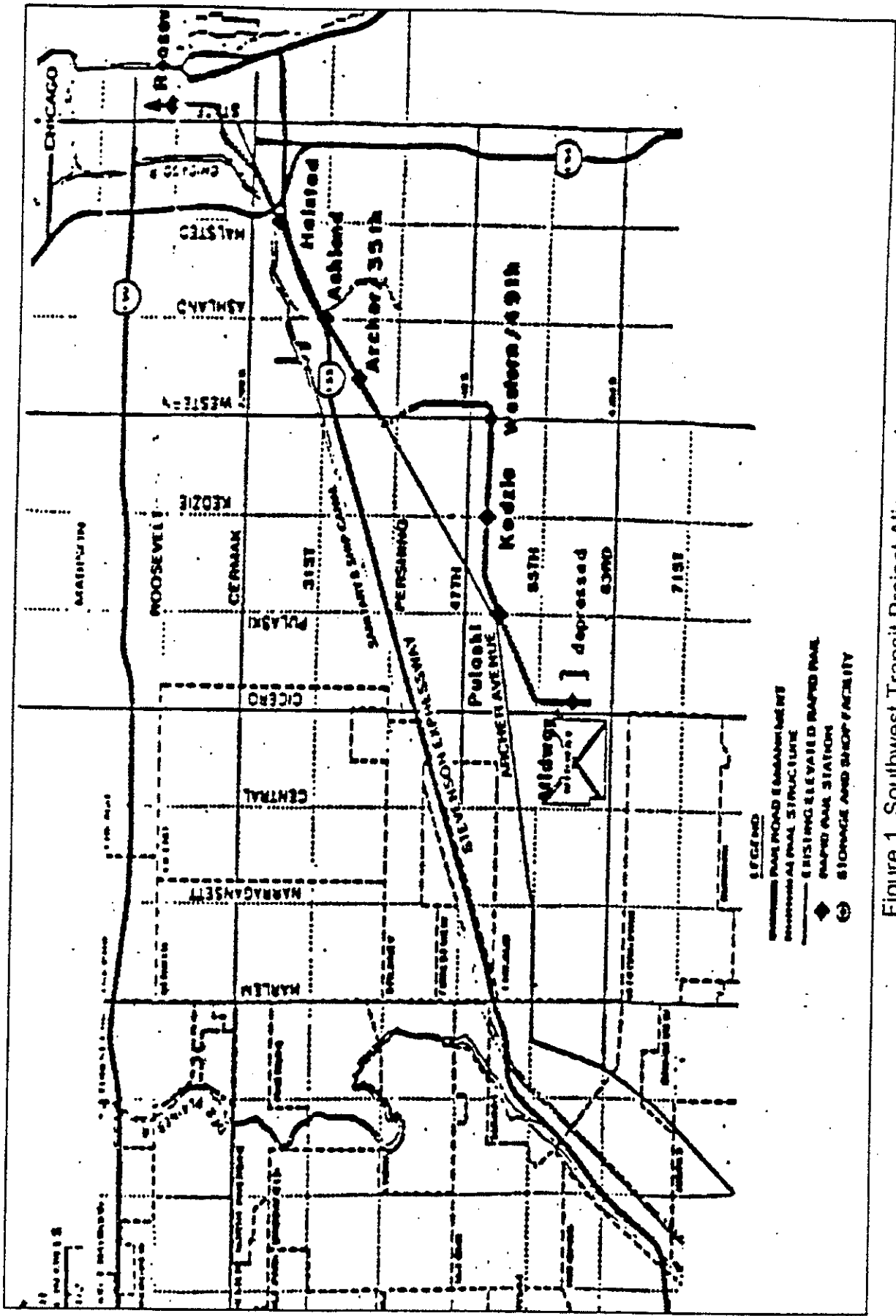
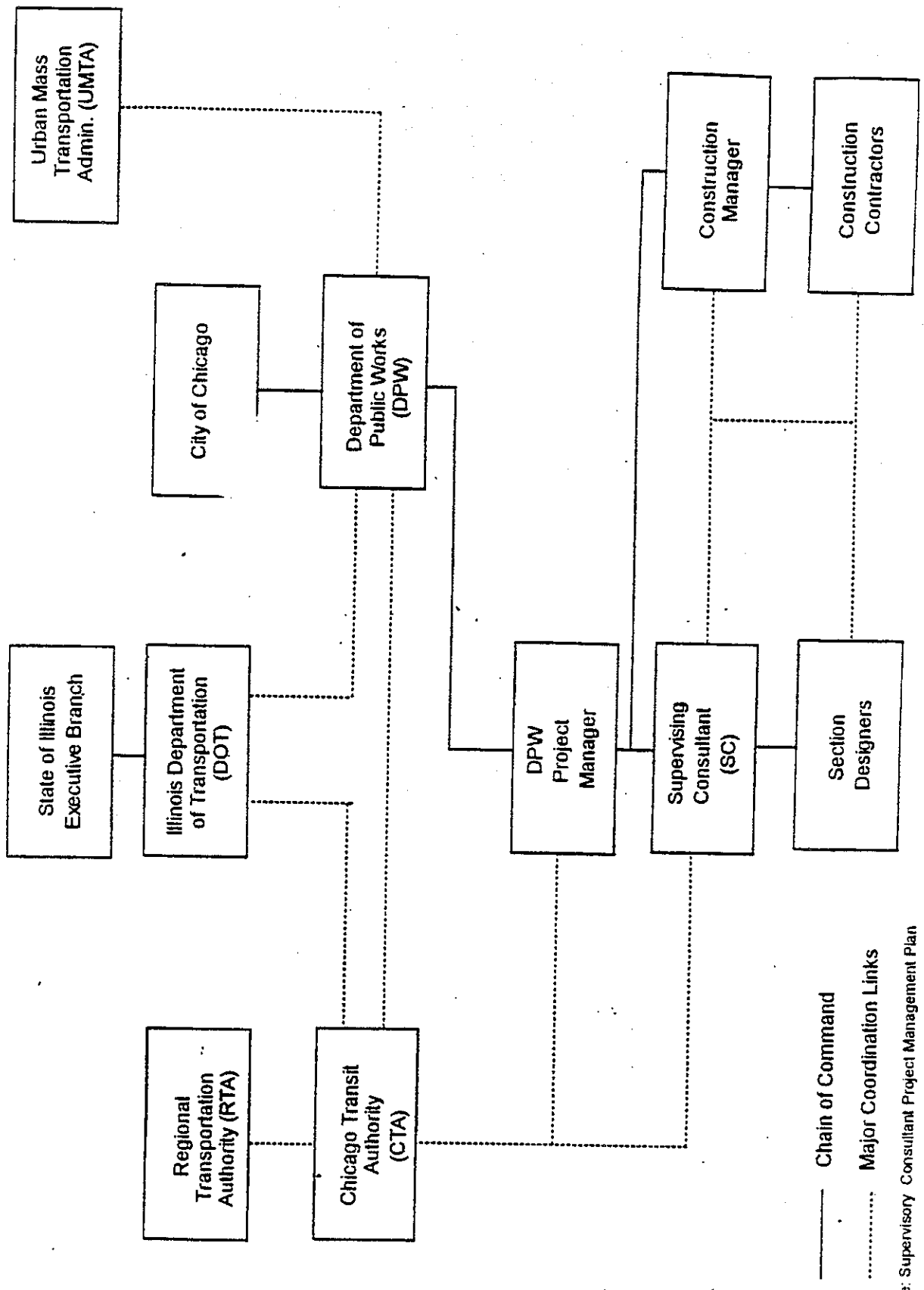


Figure 1. Southwest Transit Project Alignment

Figure 2. Participating Organizations



— Chain of Command

..... Major Coordination Links

Source: Supervisory Consultant Project Management Plan

5.4 KEY EVENTS/CHRONOLOGY

This section presents a brief overview of some of the key project events and their chronology.

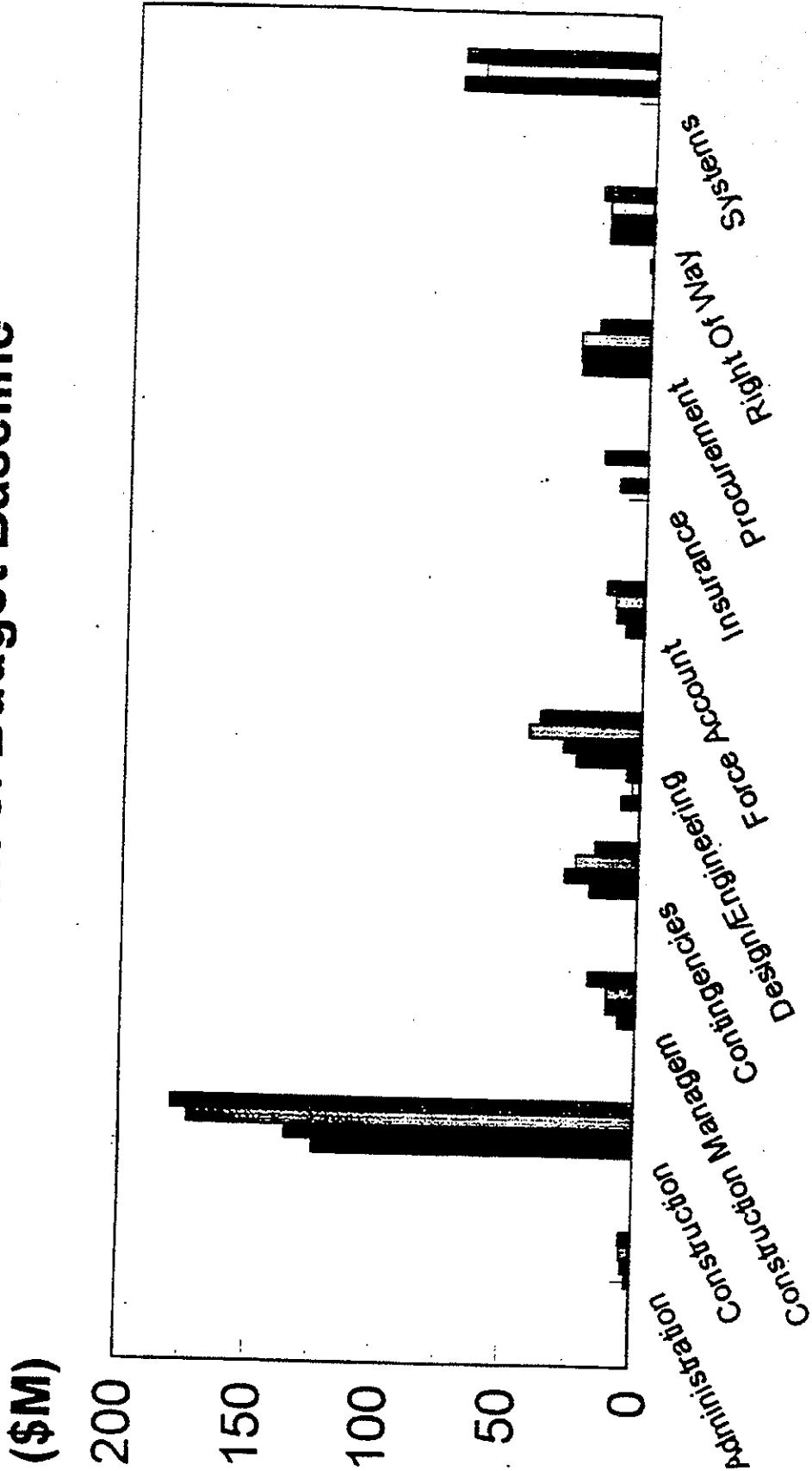
- 1979 - Interstate Transfer Program designates Crosstown Expressway, entitles Chicago region to \$2.4B in federal funds for transit
- 1983 - Original planning grant awarded in September
- 1985 - Final Environmental Impact Statement (FEIS) submitted in September
- 1986 - Full Funding Grant Agreement executed
- 1987 - Construction started in mid-year
- 1987 - Major design changes save about \$40M
- 1993 - Original date for revenue service, October 1
 - Actual date of revenue service, October 31

5.5 PROJECT FINANCING

Financing for the SWTP appears to have taken place through traditional grant funding from the Federal Transit Administration (85%) and local match by the State of Illinois Department of Transportation (15%). Appendix 1 to this case study presents (at the line item GMIS level) grant and amendment budgets from 1983 to 1989. Note the increased funding in 1986, after the signing of the Full Funding Grant Agreement. Also note that there is no Amendment 4; Amendment 5 incorporates two amendments (5.1 and 5.2). The grouping scheme used for the case study is included as Appendix 2.

Exhibit 5 provides a more easily understood representation of the buildup of a baseline budget for the project by grouping of line item costs according to the grouping scheme appearing in the appendix to this case study. This exhibit graphically shows the funding trends by major cost categories. Note the decrease in contingencies, design/engineering, and procurement; and the reversal in systems.

Exhibit 5. Budget Baseline



	Admin	Const.	Const. Mgmt	Contingencies	Design/Eng.	Force Account	Insurance	Procurement	Right-Of-Way	Systems	Totals
Original	200	0	0	480	7500	500	0	0	20	0	870
Amend1	100	0	0	500	3050	550	0	0	1300	0	550
Amend2	100	0	0	410	5590	100	0	0	0	0	620
Amend3	2295	124942	7000	19205	25300	7394	0	26743	17423	0	23030
Amend5	3825	135892	11800	28491	30015	10929	10913	27026	17298	74750	35093
Amend6	4390	173465	11800	24466	43215	11319	0	27026	17346	66087	37911
Amend7	4933	179793	18980	17193	38965	15136	17300	20365	20396	73759	40681

Table 4. Budget Baseline (\$K)

5.6 CAPITAL COST ESTIMATES

Estimates of project cost were considered at four points in time and compared with the actual costs as of March 1994. Cost estimates analyzed include: the estimate used in the Final Environmental Impact Statement, an estimate made by the Supervisory Consultant about a year later, the construction manager's estimate two years later, and the baseline budget after approval of Amendment 7. Exhibit 6 and Table 5 present this comparison of estimates. Note the relative closeness of most of the estimates versus the actual costs. Exceptions to be explained include: a steep drop off in procurement costs when the car order was deleted from the project after the FEIS; a decrease in construction cost estimates from the FEIS until 1988 when forecasted costs started increasing; a decrease in contingencies after 1988; a decrease in design/engineering and an increase in force accounts in 1989. It appears that 1988 was the date that the Construction Manager started tracking costs. As project construction began, design requirements decreased, and construction costs firmed up allowing the contingency to decrease.

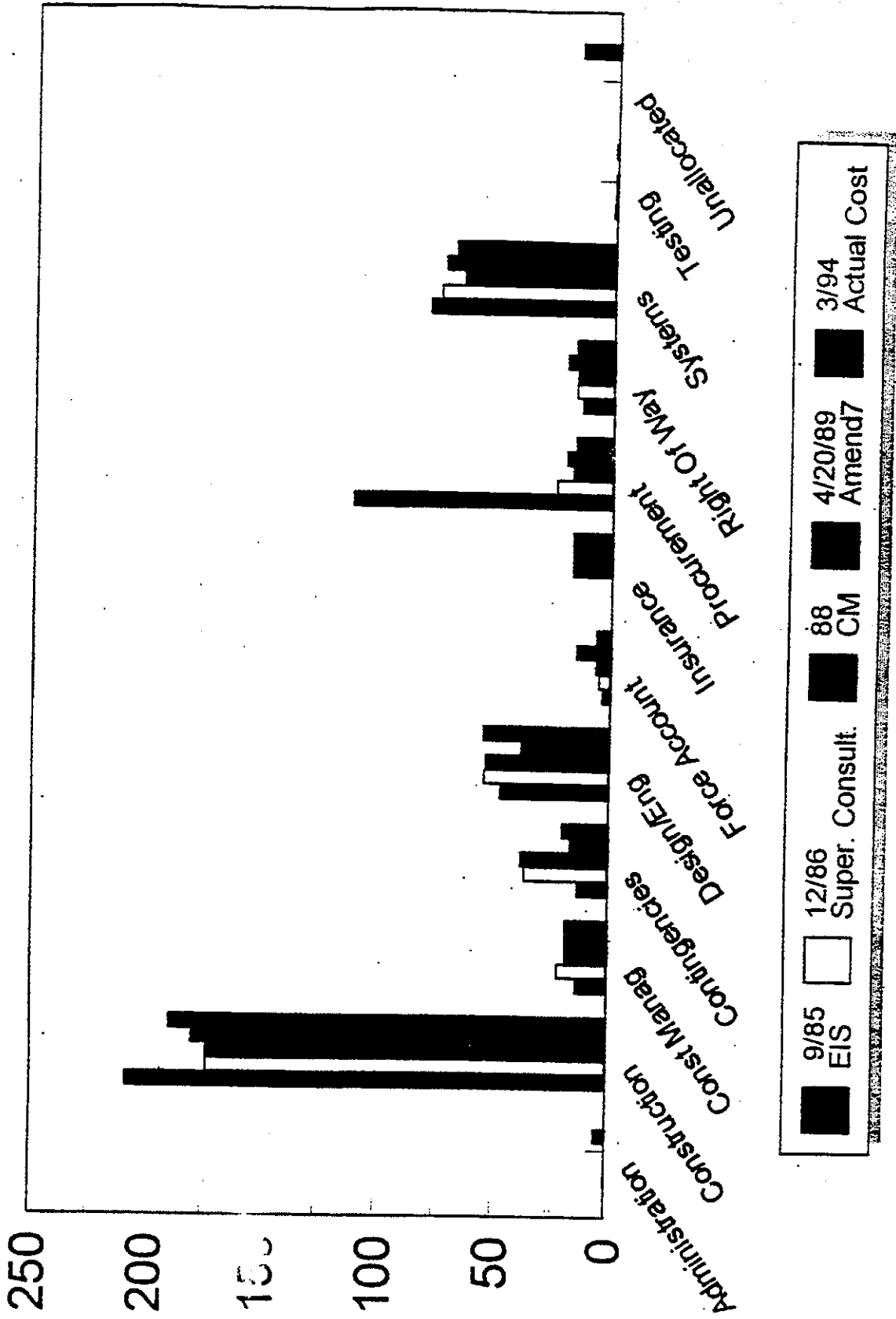
	Admin	Const.	Const Mgmt	Contingencies	Design/Eng.	Force Account	Insurance	Procurement	Right-Of-Way	Systems	Testing	Unallocated
9/85 (FEIS)	115	208900	13948	13924	48145	3666	0	112026	13844	79969	1464	0
12/86 (Super. Consult.)	0	173589	22000	37043	54928	5226	0	24721	16198	75295	1000	0
88 (CM)	0	173518	18980	38684	54358	6494	17300	17704	16198	65765	1000	0
4/20/89 (Amend7)	4933	179793	18980	17193	38965	15136	17300	20365	20396	73759	0	0
3/94 (Actual Cost)	0	189944	18980	20685	55481	6494	17300	16396	16744	69392	1000	16477

Table 5. Estimates vs Actual Costs (\$K)

Available documentation indicates that the FEIS assumed that project management, design, construction management, and change order reserve were equal to 22.9% of construction cost including contingency. Capital costs included line item contingencies estimated at 10% for construction costs and 5% for procurement costs. Contingencies appearing in the table are total project contingencies.

Exhibit 6. Estimates Over Time

(\$M)



The Supervisory Consultants estimate included: a 15% markup on fixed facilities for contingencies, 29% contingency on procurement items, and a 29% contingency on systems. Professional services were estimated as 13.4% of total project cost or 20% of project direct costs (fixed facilities, procurement, and system contracts). Construction management was estimated at 5.37% of total project cost.

5.7 PROJECT CAPITAL COST HISTORY

An analysis of the capital cost history of the SWTP indicates a project which pretty much followed its predicted course. Figure 3 presents the Quarterly Review format utilized by the project and the types of data utilized in the historical analysis.

Exhibit 7 and Table 6 show the well behaved nature of the working budget over the life of the project.

	Admin	Const.	Const Mgmt	Contingencies	Design/Eng	Force Account	Insurance	Procurement	Right-Of-Way	Systems	Testing	Unallocated
88	19877	227541	11800	15219	15236	11229	10913	22062	17061	0	0	1464
89	27385	184127	19937	11293	16927	15682	17300	19633	20096	73439	1000	1000
90	27385	189674	19937	4982	18487	16188	17300	17579	20096	74191	1000	1000
91	26635	187731	19937	2802	19316	16254	21000	17667	20096	74381	1000	0
92	26635	191934	22299	500	19469	15407	21000	17152	19889	71534	1000	1000
93	26035	191676	23520	223	19469	15236	19190	17185	19779	73505	1000	0

Table 6. Budget Of Record (\$K)

Comparing budget figures against actual costs confirms the picture of a project whose cost was under control (see Exhibit 8 and Table 7). Note the decreasing step function of the difference in budget minus cost data. Slight increases were noted in 1989 in construction management, force account, insurance, and right-of-way.

	BOR 88	COST 88	BOR 89	COST 89	BOR 90	COST 90	BOR 91	COST 91	BOR 92	COST 92	BOR 93	COST 93
Administration	19,877	15,312	27,385	19,348	27,385	22,011	26,635	24,258	26,635	25,232	26,035	25,744
Construction	227,541	5,023	184,127	79,304	189,874	141,895	187,731	168,414	191,934	182,429	191,676	190,375
Const Manag	11,800	1,969	19,937	6,615	19,937	13,658	19,937	18,891	22,299	21,930	23,520	23,518
Contingencies	15,219	0	11,293	0	4,982	0	2,802	0	500	0	223	0
Design/Eng	15,236	13,642	16,927	15,607	18,487	17,153	19,316	18,707	19,489	19,382	19,489	19,383
Force Account	11,229	2,651	15,682	5,255	18,188	9,031	16,254	10,818	15,407	12,781	15,236	13,315
Insurance	10,913	4,978	17,300	10,385	17,300	16,530	21,000	20,856	21,000	20,949	19,190	19,190
Procurement	22,062	2,310	19,633	7,147	17,579	12,764	17,887	14,156	17,152	15,710	17,185	18,422
Right-Of-Way	17,061	13,352	20,096	15,712	20,096	18,921	20,096	17,783	19,889	19,033	19,779	19,688
Systems	0	0	73,439	8,002	74,191	27,394	74,381	51,162	71,534	83,886	73,505	69,367
Testing	0	0	1,000	0	1,000	0	1,000	0	1,000	50	1,000	233

Table 7. Budget vs Costs

Grant # IL-23-9028
 Grant # CAP-83-200-1ST

QUARTERLY BUDGET STATUS REPORT

 SOUTHWEST TRANSIT PROJECT

Quarter: Fiscal Year 1993
 4th Quarter Ending 09/30/93

GNIS Code and Description of Activities	Respon. Agency/ Force Acct. (FA) or Firm	Budget of Record	Obligated \$/ Approved Force Account \$	Non-obligated \$/ Unapproved Force Account \$	Estimate of Costs Incurred	(7) as % of (5)	% of Work Done
(1) and (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
		\$	\$	\$	\$		
SW-116 Aerial	CDOT/Swenson	13,926,910	13,926,910	0	13,927,401	100	100
SW-116A Junction Structure	CDOT/Poweroy	4,028,030	4,028,030	0	4,028,030	100	100
SW-117 Roosevelt Station	CDOT/Cameron Const.	12,876,448	12,671,338	205,110	12,203,414	96	96
SW-118 Substation Bldgs.	CDOT/F.H.Paschen	4,209,466	4,209,466	0	4,209,466	100	100
SW-301 Trackwork/Yard	CDOT/Cameron Const.	28,801,107	28,756,536	44,571	28,572,140	99	99
SW-302 Train Control	CDOT/Un Swtch&Signal	21,423,188	20,267,648	1,155,540	19,254,107	95	95
SW-303 Communications	CDOT/Divane Bros.	4,678,112	4,080,919	597,193	3,778,586	93	93
SW-304 Traction Power	CDOT/Gibson-Unique	4,937,183	4,899,035	38,148	4,645,623	95	95
SW-305 Subst. Equipment	CDOT/G.M.North	1,879,914	1,784,581	95,333	1,784,581	100	100
SW-307 Escalators	CDOT/Mid American	3,327,202	3,239,425	87,777	3,110,529	96	96
SW-308 Elevators	CDOT/Reliance Elev.	2,457,580	2,399,833	57,747	2,198,968	92	92
SW-309 Fare Collection	CDOT/Cameron	3,915,059	3,887,439	27,620	3,774,118	97	97
SW-310 Signage & Graphics	CDOT/Cummings	1,336,098	1,137,064	199,026	944,343	83	83
SW-311 Commencement Insurance	CDOT/Western In CDOT/Near North - Insurers Review JV	750,000 19,189,959	731,707 19,189,959	18,293 0	399,817 19,189,959	55 100	55 **
Utilities	Saco/Peoples	431,000	327,420	103,580	327,420	100	**
Contingencies	CDOT	222,891	0	222,891	0	0	0
		=====	=====	=====	=====		
TOTALS:		406,819,513	402,664,310	4,155,203	395,296,496		
PREVIOUS TOTALS:			402,338,942	4,480,571	392,676,720		

100% of work done on engineering design line items means that contract documents have been completed for bidding. Construction support services may remain to be performed.

Figure 3. Quarterly Review Report Format

Exhibit 7. Budget of Record

(\$M)

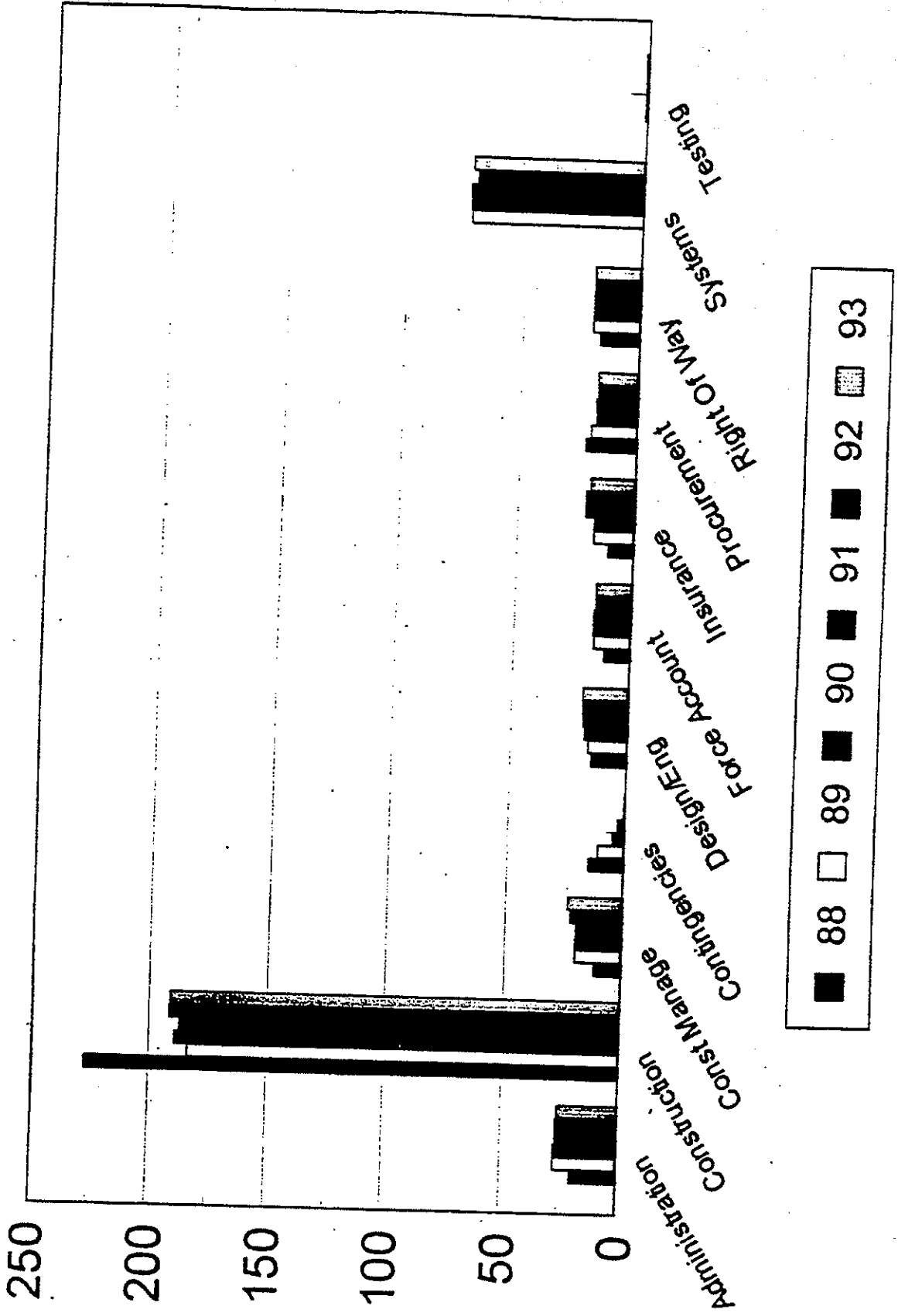
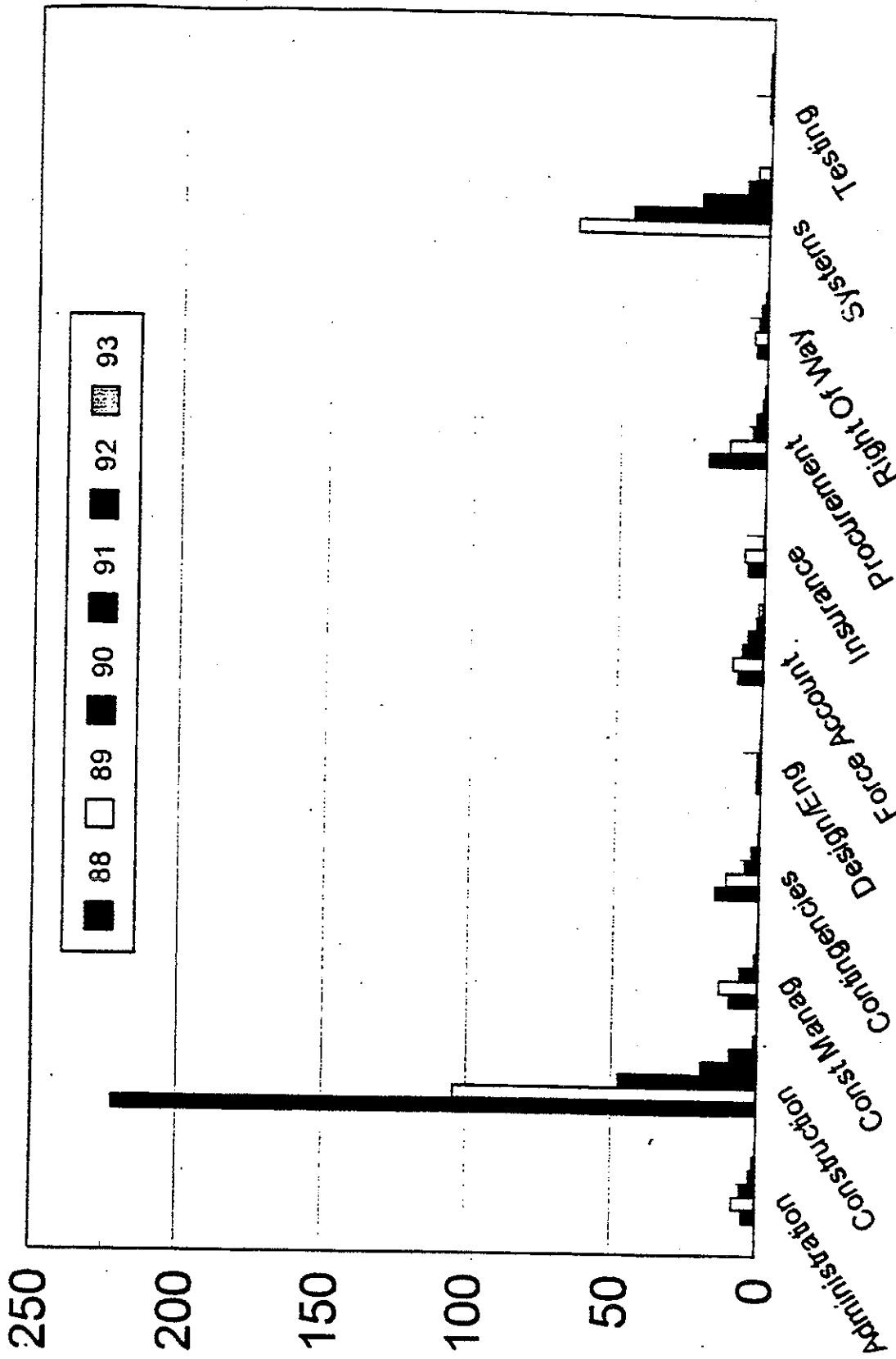


Exhibit 8. Budget of Record vs. Costs



Despite the normal well behaved trends of major cost categories, when considered on a line item basis, 1989 was a year of some major reallocations between accounts, as shown in Table 8.

	89	90	91	92	93
Budget	350938320	406819233	406819513	406819513	406819513
Line Item Changes	432774673	20004856	15592288	20295864	7592932
Percent of Budget	123.32%	4.92%	3.83%	4.99%	1.87%

Table 8. Changes Between Accounts (89-93)

An analysis was done to compare the FTA budget baseline established after approval of Amendment 7 against the budgets of record presented in the Quarterly Reports. This analysis was intended to establish where project working budgets differ from grant budgets. Significant discrepancies were noted in administration, design/engineering, and contingencies. The closeness of the design/engineering and administration differences leads one to speculate whether some costs were redefined for the different budgets.

Right-of-way acquisition costs came in about \$2M above Full Funding Contract estimates as of December 31, 1993, according to project documentation.

Comparing initial contract value against the Supervisory Consultants estimate indicates a successful procurement process produced bids lower than engineers' estimates:

	<u>Supervisory Consultant</u>	<u>Initial Contract Value</u>
Construction	173,589,469	171,225,910
Procurement	24,720,787	15,412,872
Systems	75,295,106	65,711,637

Table 9 takes a different look at the initial contract value by comparing the initial contract value against the baseline budget and actual costs by major cost category.

	BASEBUD	ICV	Actual	Actual-ICV
Construction	191,245,293	171,225,910	189,944,212	18,718,302
Procurement	17,185,238	15,412,872	16,396,123	983,251
Systems	73,505,435	65,711,637	69,391,921	3,680,284
Total	281,935,966	252,350,418	275,732,256	23,381,837

Table 9. Contract Analysis as of 3/4/94

Change order activity on the SWTP also appeared to be moderate, given the size of the project. According to project personnel, a change order reserve of 5% was included at the line item level in estimating budgets. Table 10 presents a detailed breakdown of change orders by cause, frequency, and amount. Note the relative importance of scope and design changes to the total amount of change activity.

	Frequency	Mod Amount	Percent of ICV	Pending
ADDITIONAL DEMOLITION	5	456,164	0.18%	
ADDITIONAL PROCUREMENT	20	1,150,044	0.46%	
ADDITIONAL SCOPE	357	11,548,341	4.58%	352,040
DESIGN CHANGE	659	5,820,831	2.31%	1,154,463
DIFFERING SITE CONDITIONS	251	4,481,276	1.78%	
FORCE ACCOUNT TRANSFERS	13	807,269	0.32%	
HAZARDOUS WASTE REMOVAL	11	2,589,014	1.03%	
Total	1,316	26,852,938	10.64%	1,506,502

Table 10. Change Order Analysis as of 3/4/94

5.8 DETAILED ANALYSIS OF SELECT COST CATEGORIES

This detailed analysis section will concentrate on soft costs, contingencies, and force account. Table 11 details soft costs as a percentage of total project costs over time. Note the drop in percentage of costs expended between 88 and 90 followed by a slow decline from 91 to 93.

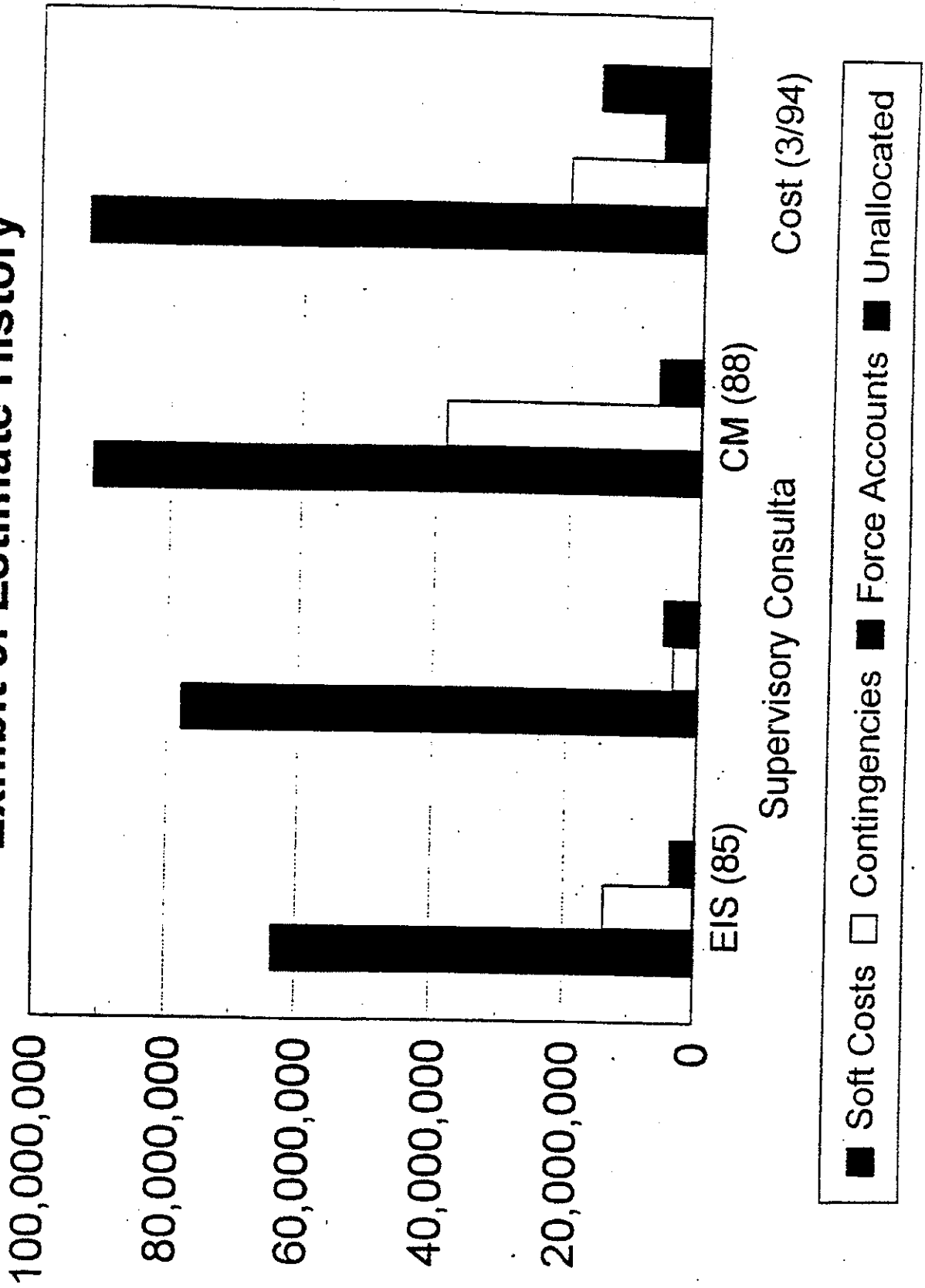
	88	%of 88 Expend	89	%of 89 Expend	90	%of 90 Expend
Administration	15311969	0.25848787	19347961	0.1155974907	22,011,290.	0.07936088
Const. Mgmt	1968525	0.0332315	6614985	0.039522287	13,657,951.	0.04924323
Design/Eng	13641662	0.2302907	15606589	0.093244065	17,152,677.	0.0618433
Insurance	4978198	0.0840391	10384525	0.062044007	16,530,000.	0.05959951
Testing	0	0	0	0	0.00	0
Total	35900442	0.606	51954149	0.3104	69,352,215.	0.25

	91	%of 91 Expend	92	%of 92 Expend	93	%of 93 Expend
Administration	24256122	0.0703396	25231532	0.066158297	25,743,827.	0.06480749
Const. Mgmt	18691063	0.0542017	21930010	0.057501546	23,518,132.	0.05920452
Design/Eng	18706683	0.054247	19382000	0.050820541	19,383,266.	0.04879542
Insurance	20855697	0.0604788	20949420	0.054930392	19,189,959.	0.04830878
Testing	0	0	50000	0.0001311	233,159.00	0.000587
Total	82509656	0.2393	87543054	0.2295	88,068,343.	0.2217

Table 11. Soft Costs Actuals and Percentage of Total Project Costs

Estimates versus actual costs as of March 1, 94 are presented in Exhibit 9 and Table 12. Comparing actuals against Supervisory Consultant estimates indicates a 19% underestimation of

Exhibit 9. Estimate History



soft costs, a 44% overestimation of contingencies, and a 24% underestimation of force account costs.

Looking at budget numbers against actuals for the three categories generally shows expected behavior.

	EIS (85)	Supervisory Consultant (86)	CM(88)	COST(3/94)
Soft Costs	63,671,700	77,928,000	91,637,500	92,761,200
Contingencies	13,923,600	37,043,000	38,684,368	20,684,500
Force Accounts	3,665,600	5,225,638	6,494,000	6,494,000
Unallocated	0	0	0	16,477,000

Table 12. Estimate History Selected Categories

5.9 FINDINGS/HYPOTHESES

The SouthWest Transit Project is a case study of a transit project which was planned with minimum risks (no tunneling, minimum land acquisition, used proven technology), devoted significant funds to the preliminary and final design efforts, and realistically estimated its project costs. The Supervisory Consultant had two full time cost estimators and schedulers on the project.

Organizationally, the project resided in one primary organization for its entire life-cycle with one project manager. Staffing of consultant organizations was carefully screened to ensure appropriate backgrounds of key personnel, such as railroad construction experience.

The project team purposefully cultivated contractor relationships by attempting to resolve disputes quickly and by paying invoices in an average of 27 days. Only two claims were denied and only one has gone to litigation, with an unresolved claim of \$4.3M. Project control was a concern from the very beginning and all major project participants were brought into the process through the formation of oversight committees in design and cost. A major design change in 1987 resulted in a cost savings of over \$40M to the project. Finally, the project was blessed with luck as Chicago winter weather was better than average for 3-4 years during construction.

Line	Description	8-23-9070 (00)		8-23-9070 (01)		8-23-9070 (02)		8-23-9070 (03)		8-23-9070 (04)		8-23-9070 (07)	
		Original	Amend	Current	Amend	Current	Amend	Current	Amend	Current	Amend	Current	Amend
100	Personnel	911,000	1,015,000	1,015,000	1,015,000	1,015,000	1,015,000	1,015,000	1,015,000	1,015,000	1,015,000	1,015,000	1,015,000
101	Personnel - State	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000	500,000
102	Personnel - Local	411,000	515,000	515,000	515,000	515,000	515,000	515,000	515,000	515,000	515,000	515,000	515,000
103	Personnel - Federal												
104	Personnel - Other												
105	Personnel - Travel												
106	Personnel - Training												
107	Personnel - Health												
108	Personnel - Pension												
109	Personnel - Unemployment												
110	Personnel - Other												
111	Personnel - Total	911,000	1,015,000	1,015,000	1,015,000	1,015,000	1,015,000	1,015,000	1,015,000	1,015,000	1,015,000	1,015,000	1,015,000
112	Travel												
113	Travel - State												
114	Travel - Local												
115	Travel - Federal												
116	Travel - Other												
117	Travel - Total												
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Appendix 2. Grouping Key

Group	GMS	CND(EIS)	EIS(BA/E)	SLP/CON(12/16)	Q-Report
A	12.79.00				Supervising Consultant
A	13.79.00				Project Administration
A		SW405	Spares		
C	13.33.02	SW117	Roosevelt Transfer Station		SW-114 Embankment
C	13.23.06	SW111	Aerial Section		Utilities
C	13.23.06	SW110	Embankment Section		Electric Power
C	13.23.06	SW106	Aerial Section		
C	12.33.02				Demolition
C	12.76.93				Various Construction
C	13.23.06	SW114	Embankment Section		SW-118 Substation Bldgs.
C	12.23.06				SW-117 Roosevelt Station
C	13.23.06				SW-116A DanRyan Mods
C	13.75.93	SW119	DEMOLITION		SW-116 Aerial
C	13.43.02	SW101	Maintenance Facility		SW-115 Halsted/Archer
C	13.33.02	SW115	Halsted/Archer & Embankment		SW-113 Ashland/Archer
C		SW116A	Dan Ryan Modifications		SW-112 35/Archer
C	13.23.06	SW116	Aerial Section		SW-111 Aerial
C	13.33.02	SW113	Ashland/Archer & Embankment		SW-110 Aerial
C	13.33.02	SW109	Western/49th & Embankment		SW-109 Western/49th
C	13.33.02	SW107	Kedzie & Embankment		SW-108 California & Emb
C	13.33.02	SW105	Pulaski & Aerial		SW-107 Kedzie & Embank
C		SW103	Midway & Aerial		SW-106 Aerial
C		SW108	California & Embankment		SW-105 51/Pulaski
C		SW104	Aerial Section		SW-104 Aerial Structure
C	13.33.00			Fixed Facilities	SW-103 Midway Station
C	13.33.02	SW112	35th/Archer & Embankment		SW-101 Maint. Facility
C	13.50.03	SW118	Substation Structures		SW-115A Archer Retain Wall
CM	13.71.04	ROW	Construction Management	Construction	Construction Management
CM	13.71.00	CONSUP	Construction Supervision		
CONT	13.73.00	ROWN	Contingency	Contingency	Contingencies
CONT	12.73.00	CORES	Change Order Reserve		
D/E					SW-113 Design
D/E					Value Engineering
D/E					Train Control Design
D/E					Miscellaneous Systems Design
D/E					Tractor Power Design
D/E					Trackwork Design
D/E					SW-118 Design
D/E					SW-117 Design
D/E					SW-116 Design
D/E					SW-114 Design
D/E					SW-112 Design
D/E					SW-111 Design
D/E					SW-110 Design
D/E					SW-109 Design
D/E					SW-108 Design
D/E	13.71.00				SW-107 Design
D/E	13.71.03				SW-106 Design
D/E	13.71.00	SW501	Professional Services	Professional Services	SW-105 Design
D/E	13.71.00				SW-104 Design
D/E	13.71.02				SW-103 Design
D/E	12.31.06				SW-101 Design
D/E					SW-115 Design
FA	13.72.02				Force Account-DOW
FA	13.72.00				Force Account-DSS
FA	13.72.00				BOCT/FA

FA	13.72.00				FA-City Construction
FA					Corridor Development
FA					Force Account - CTA(ENG)
FA					Force Account - DPW
FA					Undistributed/FA
FA					AMTRAK/FA
FA	12.72.02				CONRAIL/FA
FA	13.72.00				LIGHTNET/FA
FA	13.72.10				IHB/FA
FA	13.72.08				BRC/FA
FA	13.72.08				GTW/FA
FA	13.72.06				ICG/FA
FA	13.72.00				Force Account - Railroads
FA	13.72.04				Demolition Inspection
FA	13.72.06				Relocation Services
FA	13.72.00				Force Account - Legal Services
FA	13.72.00				FA-CTA Trackwork
FA	12.72.08	SW401	Force Account	Force Accounts	Force Account-DOS
FA					METRA/FA
I	13.71.05	INS	Insurance		Insurance
P	13.52.01	SW206	Procure Traction Power Cable		SW-206 Tract. Power Cable
P	13.52.00				SW-204 Ties
P	13.22.03				SW-208 Lighting
P	13.42.00	SW204	Procure Ties		SW-205 Subst. Equipment
P	13.52.03	SW205	Procure Substation Equipment		SW-202 Running Rail
P	13.32.00	SW208	Procure Lighting Systems		
P	13.52.03	SW207	Procure Substa Supervisory Equip	Procurement	
P		SW201	Procurement Vehicle		
P	13.52.03	SW203	Procure Contact Rail		Various Procurement
P	13.42.00	SW202	Procure Running Rail		SW-203 Contact Rail
ROW	13.75.91				RE/DPW/T Engineering
ROW	12.76.94				
ROW	13.72.00				
ROW	13.75.94				Real Estate Appraisals
ROW	13.72.11				
ROW	13.70.92				RE/DPW/Cutmore
ROW	13.75.92				Relocation Payments
ROW	13.72.00	SW404	Relocation	Relocation	RE/DPW/Mustari
ROW	13.70.94				RE/DPW/McCann
ROW	12.76.91	SW403	Right-Of-Way	Right-Of-Way	RE/DPW/Mid America
ROW	13.76.91				Real Estate Acquisition
S	13.33.09	SW310	Signage & Graphics		SW-309 Fare Collection
S		SW307	Escalators		
S		SW308	Elevators		
S		SW301	Trackwork & Storage Yard		SW-311 Commencement
S	13.33.06	SW309	Fare Collection		
S	13.43.05	SW102	Vehicle Storage Yard		SW-310 Signage & Graphics
S	13.33.20	SW311	Commencement		SW-308 Elevators
S		SW303	Communication		SW-307 Escalators
S	13.63.00	SW302	Train Control		SW-305 Subst. Equipment
S	13.23.03				SW-304 Traction Power
S		SW306	Substation Supervisory Equipment		SW-303 Communications
S	13.53.00	SW304	Traction Power	Systems	SW-301 Trackwork/Yard
S		SW305	Substation Equipment		SW-302 Train Control
T		SW402	Testing	Testing	Systems Testing
UNALLO		UNALLO	Unallocated Budget		Unallocated Budget

SECTION 6.

CASE STUDY OF ST. LOUIS METRO LINK LIGHT RAIL PROJECT

Metro Link is a modern 18-mile light rail transit (LRT) system built and run by the Bi-State Development Agency (Bi-State, BSDA) to connect downtown St. Louis to Lambert International Airport. It is the first LRT to serve an air terminal in North America. There are several aspects of this case study which are unique among the case study projects. Metro Link rehabilitated both an historic bridge (first opened in 1874) and railroad tunnels, and structured its local match to involve only the appraised value of property acquired as part of its right-of-way. The project also had to deal with state funding constraints. The State of Missouri provides no transit operating funds and state law forbids using general tax revenues for transit.

The system currently has 18 passenger stations: 13 at-grade, three subway, and two on the existing Eads Bridge structure. All stations are on exclusive right-of-way and are unattended. Fare collection is via a self-service, proof-of-purchase system. Thirty-one double-ended articulated rail vehicles, with electric power provided by an overhead catenary, serve as the passenger fleet. A 12 acre site serves as storage, maintenance, and the control center. Six park-and-ride facilities offer nearly 3,000 spaces.

In its first year of operation, Bi-State reports that at least 8.7M passengers, nearly double the 4.8M projected in preliminary engineering studies, rode the system.

6.1 PROJECT BACKGROUND/HISTORY

St. Louis first considered constructing some form of rail passenger transportation in the mid 1960s and early 1970s. Formal system planning commenced in 1981. Concurrently, public advocacy for a light rail system took hold in the early 1980s, lead by a group called Citizens for Modern Transportation (CMT). This group mobilized not only the general public, but also established relationships with local businesses. The group was so successful that they raised \$800,000 from the private sector to help with the official launch of Metro Link.

Throughout the planning process, Draft Environmental Impact Statement (DEIS- May 1984) and Final Environmental Impact Statement (FEIS- September 1987), UMTA remained skeptical about the ridership projections and the ability of Bi-State to fund the system's long term operations, given the restrictions imposed by the State of Missouri. Funding for the project was largely the result of Congressional earmarking and the project was advanced at Congressional direction.

On August 2, 1994, residents of the St. Louis area voted in favor of a one-quarter of a cent sales tax increase to fund transportation services provided by Bi-State. The tax increase is projected to

generate \$35M annually in revenue for use as operating funds, and as a local match for Federal dollars for Metro Link extensions, bus modernization, and other transit services.

6.2 PHYSICAL DESCRIPTION OF PROJECT/ALIGNMENT

The 18-mile largely double-tracked system extends from East St. Louis, Illinois, through the St. Louis, Missouri central business district (CBD) to the Lambert International Airport. The system is largely surface running with the exception of a bridge over the Mississippi River, a tunnel under the CBD of St. Louis and elevated structures over highways and local streets.

The LRT alignment crosses the river on the lower deck of the existing Eads Bridge, traverses the business district using the Washington Avenue/Eighth Street tunnel acquired from the Terminal Railroad Association of St. Louis (TRRA), follows an existing rail corridor west to Forest Park and north to the University of St. Louis near highway I-70. The route then turns northwest on newly constructed right-of-way, crosses over highways I-170 and I-70 and then divides with one line serving the Airport and a future line to serve Berkeley, Missouri.

Airport expansion plans forced a major project realignment and the acquisition of a number of additional parcels. Originally configured to bypass the Washington Park cemetery, the LRT was constructed on an easement through the cemetery which required the reburial of approximately 2,500 remains. Figure 4 depicts the current system map. The originally approved alignment was changed starting at I-70 and the Northwest park-and-ride lot and station were eliminated in favor of expanding facilities at other locations.

Bi-State opted for proven designs and components where possible. Stations incorporate 200 foot platforms and are of a modest design, some totally open air. Security at the unattended stations include CCTV monitoring and two-way passenger telephones linked to central control.

The 31 car service fleet is made up of articulated LRVs from Siemens-Duewag. The vehicles are approximately 86 feet long and 8.67 feet wide and carry 72 seated or 106 standing. Traction power is provided by a 750 volt D.C. overhead contact system powered by 12 substations. A cab signal system with overspeed protection is provided for the cars. Approximately 17 miles of automatic train protection signaling is provided by the signal system. The communications system includes a supervisory control and data acquisition (SCADA) system.

Maintenance is performed in part of a 60,000 square foot building complex situated on a 12-acre site. The complex houses shops, a control center, and an office complex. The shops have two stub-end and three through tracks for repairs plus capability for both exterior and interior cleaning.

6.3 PROJECT ORGANIZATION

Initial planning for Metro Link was the responsibility of the East-West Gateway Coordinating

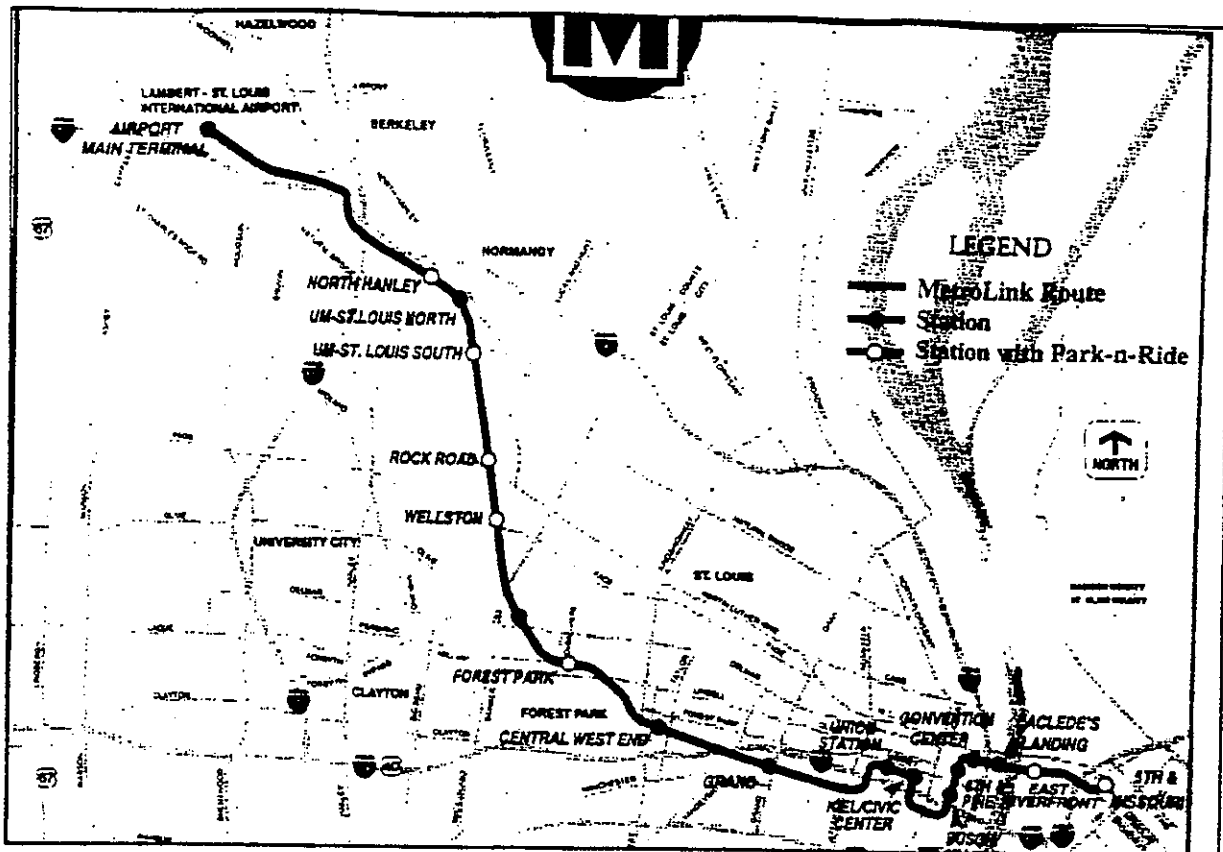


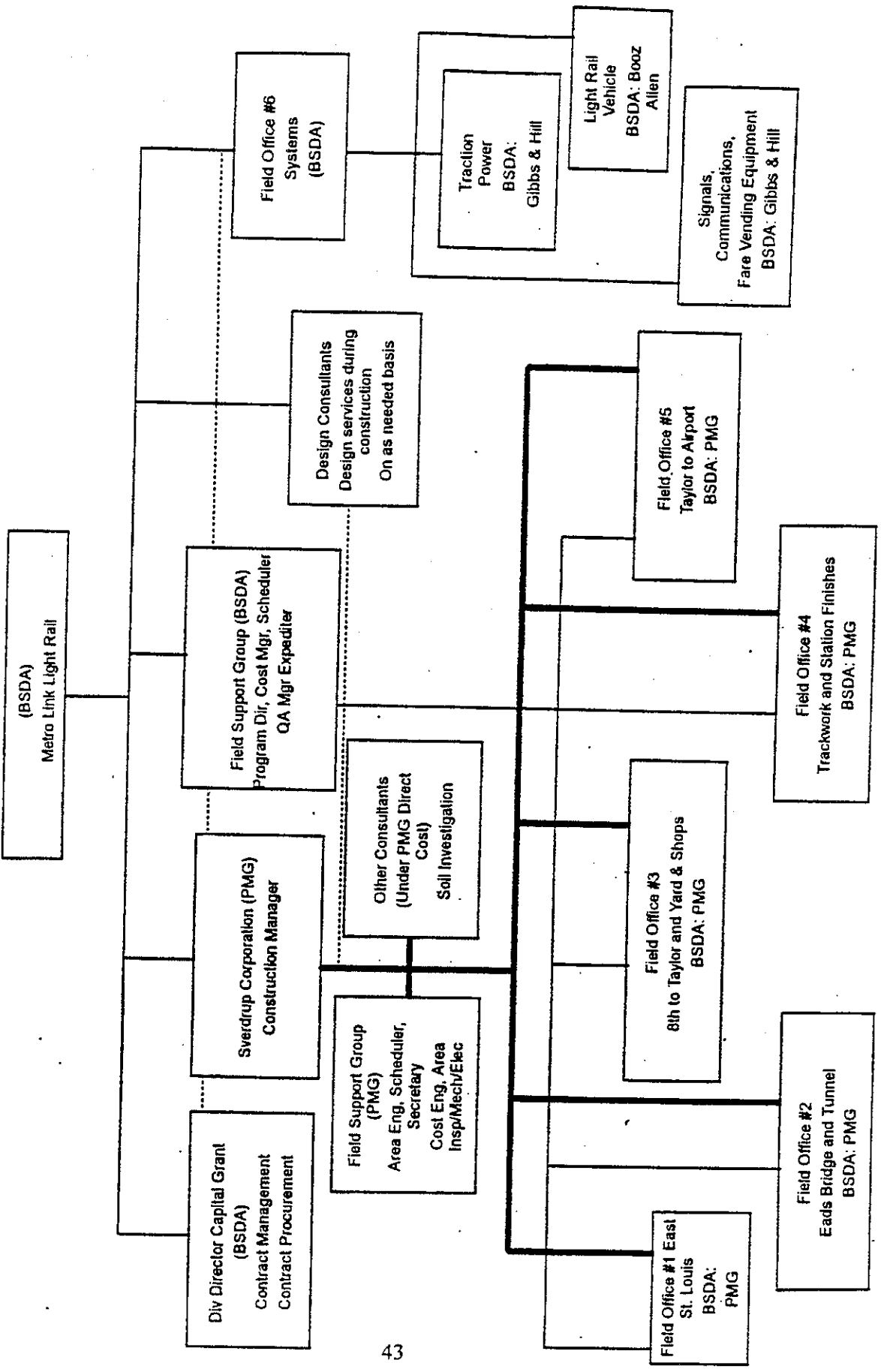
Figure 4. Metro Link System Map

Council (EWGCC) the MPO for the St. Louis Metropolitan area. East-West Gateway carried the project through the 30% design point, with a staff of only three dedicated professionals and the help of a Project Management Group (PMG), Sverdrup Corporation, before handing it off to Bi-State Development Agency for final design.

Bi-State Development Agency is the transit agency in the St. Louis Metro area. Bi-State established a separate project office within its existing organization. The Project Manager for Metro Link was also the Assistant General Manager for BSDA, reporting directly to the BSDA General Manager who reports to a Board of Directors. BSDA established separate responsibility centers for the design and construction of facilities and systems (vehicles, signals, communications, power) (see Figure 5). Sverdrup Corporation continued its involvement in the project by managing the facilities contracts. Bi-State maintained management responsibility for the systems and vehicles contracts with assistance first from Gibbs & Hill and Booz-Allen & Hamilton and then from Booz-Allen alone.

Coordination between facilities and systems contractors was a concern through most of the system design and construction.

Figure 5. Metro Link Construction Organization



6.4 KEY EVENTS/CHRONOLOGY

This section presents a brief overview of some of the key project events and their chronology.

- September 1987 - Final Environmental Impact Statement issued
- Late 1987 - Bi-State Development Agency designated Grantee
- October 1988 - Full Funding Grant Agreement executed
- May 1990 - Construction ground-breaking took place
- December 1990 - Realignment as a result of new airport master plan
- July 1, 1993 - Original date for start of Revenue Operation
- July 31, 1993 - Actual date for start of Revenue Operation
- June 25, 1994 - Metro Link connection to Lambert Airport Main Terminal opened

6.5 PROJECT FINANCING

The Metro Link project was required to operate under extremely tight financial parameters because of a lack of dedicated state funding and the fact that the local market totally in contributed property. In addition to a contingency account, FTA required the project to establish a capital reserve account equivalent to 5% of outstanding commitments. Cash flow needs eventually required the project to establish a line of credit with a private bank to meet some of their operating expenses. \$90.2M had been earmarked for the project in Congressional appropriations by the end of 1988. Figure 6 lays out the flow of funds through the Federal appropriation process. Note the use and magnitude of funds for project oversight (\$1.9M), for alternatives analysis (\$1.3M), and for preliminary engineering (\$8.0M).

With the signing of the Full Funding Grant Agreement (FFGA) in 1988, project funding flowed through the grant/amendment process. Table 13 and Exhibit 10 present the build up of the project budget, as indicated in GMIS data sheets. Table 14 indicates the changes in budgets for major

	10/25/88	09/27/90	02/12/92	07/22/92	11/18/92	01/21/94
Administration	4,352,768	9,565,479	10,427,780	10,427,780	13,005,851	14,606,638
Construction	48,694,844	78,499,628	122,344,173	133,300,048	166,631,163	175,491,890
Const. Mgmt.	10,068,447	11,203,259	10,281,072	11,684,298	13,444,613	13,444,613
Contingencies	6,446,721	13,689,892	0	0	0	0
Design/Engineering	16,448,422	18,048,940	26,101,000	26,101,000	29,032,962	29,026,179
Insurance	353,118	3,531,183	2,419,523	2,419,523	2,461,502	2,639,024
Procurement	500,000	4,950,144	4,774,550	4,774,550	4,609,550	4,392,823
Purchase Cars	57,694,753	57,694,753	45,787,851	45,787,851	41,682,271	45,929,061
Right-Of-Way	55,346,827	77,517,165	105,583,236	114,384,135	128,898,314	134,817,532
Systems	0	13,312,907	32,523,876	32,523,876	34,040,834	33,558,453
Testing	0	0	2,036,956	2,036,956	2,036,956	2,052,362
Est. Net Project Cst	9,905,900	288,013,350	362,280,017	383,440,017	435,844,016	455,958,575

Table 13. Metro Link Budget Changes

Metro Link Appropriations

28-Jan-94

Year	Appropriation	Project Management	Personnel	Materials Analysis	Preliminary Engineering	Net Appropriations	Grant Status	Obligation Date
1985	\$10,000,000					\$10,000,000		
1986	\$12,920,000	\$64,600				\$12,855,400		
1987	\$12,830,000	\$64,150				\$12,765,850		
1988	\$54,450,000	\$272,250				\$54,177,750		
1989	\$60,000,000	\$300,000				\$59,700,000	\$149,499,000	10/25/89
1990	\$67,500,000	\$202,500	\$336,488	\$490,000 (2)		\$66,511,012	\$216,010,012	09/27/90
1991	\$60,000,000	\$300,000			\$4,000,000	\$55,700,000	\$271,710,012	09/23/91
1992	\$18,055,397 (3)	\$135,397			\$2,050,000	\$15,870,000	\$287,580,012	04/21/92
1993	\$42,500,000	\$318,750	\$893,250 (4)	\$1,985,000		\$39,303,000	\$326,883,012	11/18/92
1994	\$15,200,000 (5)	\$114,000				\$15,086,000	\$341,969,012	
1995						\$0		
Subtotal	\$53,455,397	\$202,500	\$1,316,838	\$1,480,000	\$8,035,000	\$111,069,012	\$341,969,012	

(1) Project Management Oversight (PMO) was initiated by the STA of 1986. At that time .005% was deducted from Congressional earmarks to projects. This deduction was increased to .0075% in the ISTEA of 1992. Beginning in 1993, PMO deductions were made to the national appropriation amount. Therefore, PMO deductions from 1993 forward are calculated.

(2) Belleville

(3) In 1992 Congressional Appropriations exceeded authorization. All appropriations were reduced by 5112. The original 1992 St. Louis area appropriation was \$31,000,000 for Metro Link and \$4,000,000 for P.E. (Letter to J. Leary from B. Clymer - 1/23/92)

(4) St. Charles -- \$460,000 (before PMO); \$446,625 (after PMO)
 Cross County -- \$460,000 (before PMO); \$446,625 (after PMO)
 (See Federal Register 3/14/93. Published appropriation includes PMO deduction)

(5) Joint Conference Report (10/18/93). Federal Register (11/8/93) published appropriation less PMO deduction.

Data obtained from the FTA grants and the Federal Register

Figure 6. Metro Link Appropriations



Exhibit 10. Budget Build Up Grant / Admendment

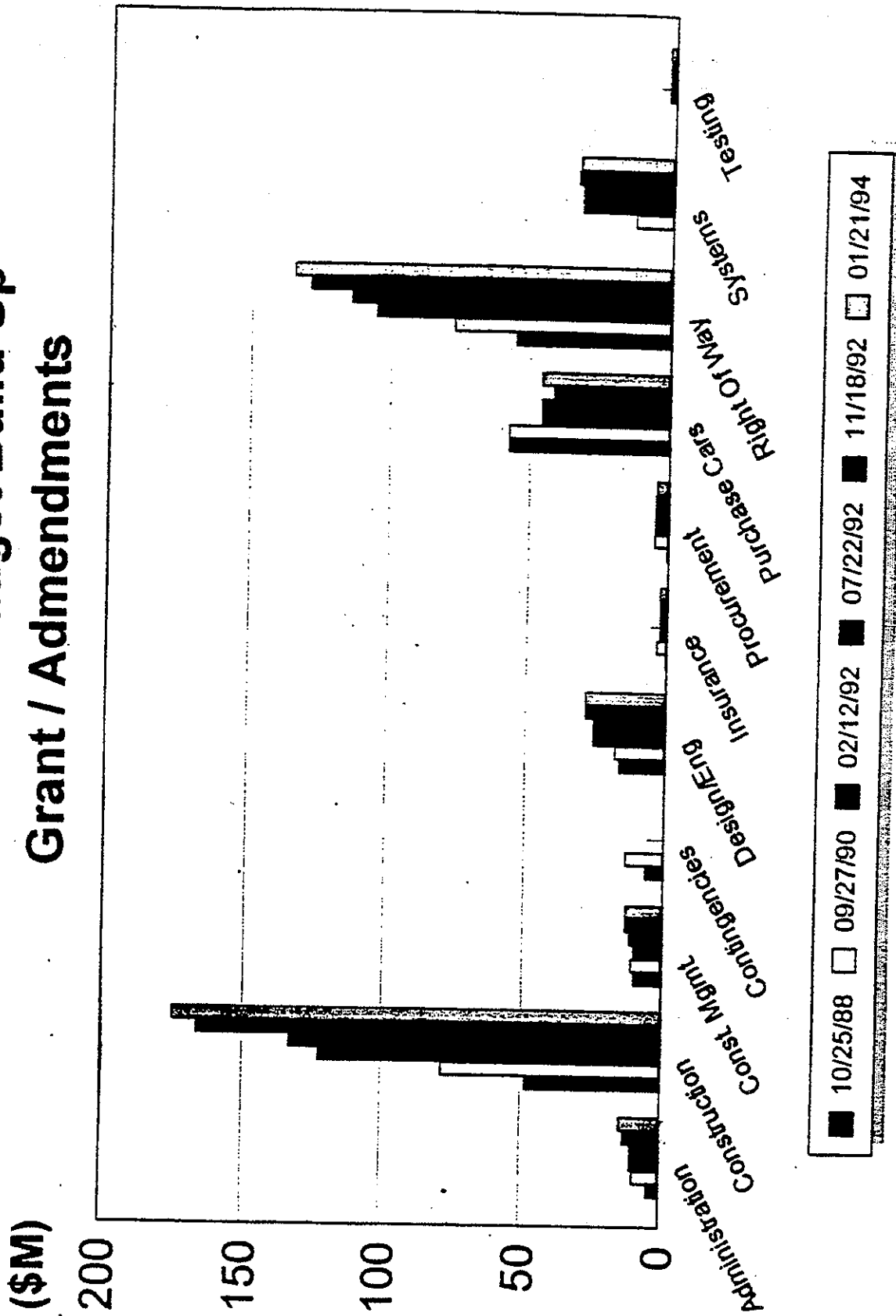


Table 14. Changes in Budgets by Amendment

	09/27/80	% Change	02/12/92	% Change	07/22/92	% Change	11/18/92	% Change	01/21/94	% Change
Administration	5,212,711	119.8	862,301	9.0	0	0.0	2,578,071	24.7	1,600,787	12.3
Construction	29,804,784	61.2	43,844,545	55.9	10,955,875	9.0	33,331,115	25.0	8,860,727	5.3
Const. Mgmt.	1,134,812	11.3	(922,187)	(8.2)	1,403,226	13.6	1,760,315	15.1	0	0.0
Contingencies	7,243,171	112.4	(13,689,892)	(100.0)	0	0.0	0	0.0	0	0.0
Design/Engineering	1,600,518	9.7	8,052,060	44.6	0	0.0	2,931,962	11.2	(6,783)	0.0
Insurance	3,178,065	900.0	(1,111,660)	(31.5)	0	0.0	41,979	1.7	177,522	7.2
Procurement	4,450,144	890.0	(175,594)	(3.5)	0	0.0	(165,000)	(3.5)	(216,727)	(4.7)
Purchase Cars	0	0.0	(11,906,902)	(20.6)	0	0.0	(4,105,580)	(9.0)	4,246,790	10.2
Right Of Way	22,170,338	40.1	28,066,071	36.2	8,800,899	8.3	14,514,179	12.7	5,919,218	4.6
Systems	13,312,907		19,210,969		0	0.0	1,516,958	4.7	(482,381)	(1.4)
Testing	0	0.0	2,036,956	0.0	0	0.0	0	0.0	15,406	0.8
TOTAL	88,107,450	44.1	74,266,667	25.8	21,160,000	5.8	52,403,999	13.7	20,114,559	4.6

categories between amendments. Note the relatively large changes in right-of-way, design/engineering, construction management, and car purchases.

The application of donated real estate to project financing is depicted in Table 15. This exhibit indicates differences between cumulative appropriations and cumulative project expenditures over time. Note the \$8.6M deficit in 1993 and the capital reserve available at that time (\$341K from Exhibit 11). A deficit was probably precipitated by a forced reduction in Congressional appropriation in 1992 due to authorization levels having been exceeded. Table 15 also indicates the relative difference between the valuation of donated real estate and the application of real estate to matching federal appropriations.

It is worth noting the relatively slow build up in expenditures versus the available cumulative appropriations. It is not until 1992 that project expenditures began approaching available funding levels.

6.6 CAPITAL COST ESTIMATES

Estimates were considered at four different points in time: FEIS, at the conclusion of Preliminary Engineering, at the 40% design review point, and at the 55% design review point. These estimates were then compared against the latest costs made available for the analysis (Exhibit 12 and Table 16). It was not possible to break-out design/engineering from contingency for all estimates, making it difficult to make any statements concerning potential cost growth in design/engineering.

Significant differences between estimates and actual project cost were noted in administration (58% increase), right-of-way (56% increase), procurement (72% increase), and systems (22% decrease from 40% review estimate).

6.7 PROJECT CAPITAL COST HISTORY

Two types of reports from the quarterly submittals were utilized in analyzing the capital cost history of the project. They are included as Appendix 3 (Costs by Major Contract) and Appendix 4 (Costs by GMIS Code). The grouping scheme used for the case study is included as Appendix 5.

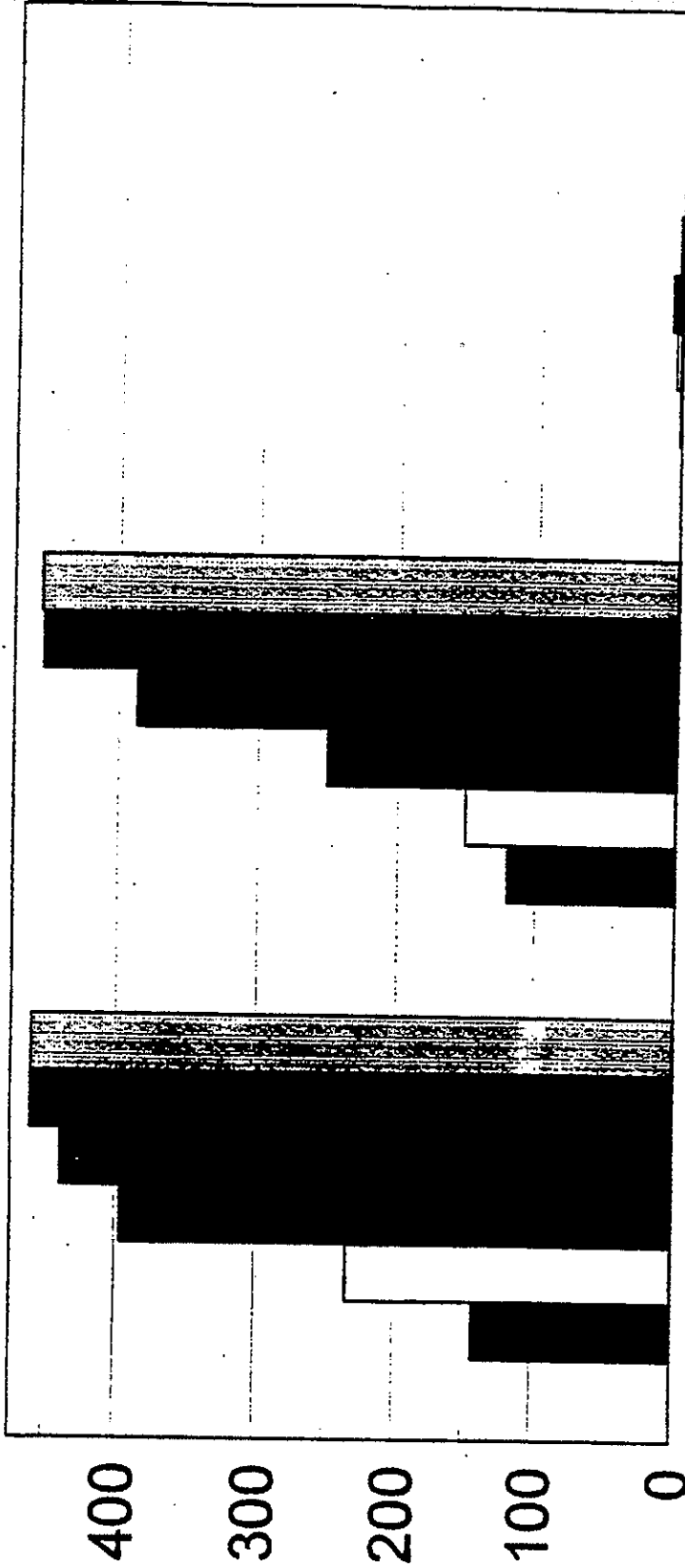
Capital cost of the Metro Link project largely revolved around issues related to right-of-way and real estate acquisition. Exhibit 13 graphically shows the discrepancies between the grant budget and actual expenditures for major cost categories. Right-of-way clearly stands out for its large negative variance. The earliest negative variance noted was in 1991 for design/engineering. Other small negative variances were noted in administration, construction, purchase cars, and systems.

Table 15. Funds Flow Analysis

	89	90	91	92	93	94
Cumulative Approp.	149,499,000	216,010,012	271,710,012	287,580,012	326,883,012	341,969,012
Cumulative Expend	7,637,322	38,680,693	138,265,017	274,517,127	335,496,949	336,947,522
Difference	141,861,678	177,329,319	133,444,995	13,062,885	(8,613,937)	5,021,490
Donated Real Estate	113,331,095	113,331,095	113,331,095	113,331,095	118,642,387	118,642,387
Estimated Project Co	199,332,000	288,013,300	288,013,000	435,844,016	435,844,000	455,958,683
Federal Share	149,499,000	216,010,012	216,010,012	326,883,012	326,883,012	341,969,012
Local Share	49,833,000	72,003,338	72,003,338	108,961,004	108,961,004	113,989,671

Source: Bi-State Monthly Reports - GMIS Format

(\$M) Exhibit 11. Estimated Capital Reserve



	Commitments/ Contrac	Life To Date Expendi	Capital Reserve
89	143,122,980	120,968,417	1,107,728
90	234,712,842	152,011,788	4,135,053
91	396,630,237	251,596,112	7,251,785
92	438,699,127	387,848,222	2,542,545
93	460,964,507	454,139,336	341,259
94	460,360,367	455,589,909	238,523

Source: Bi-State Monthly Reports - Contract Format

Exhibit 12. Estimates Over Time

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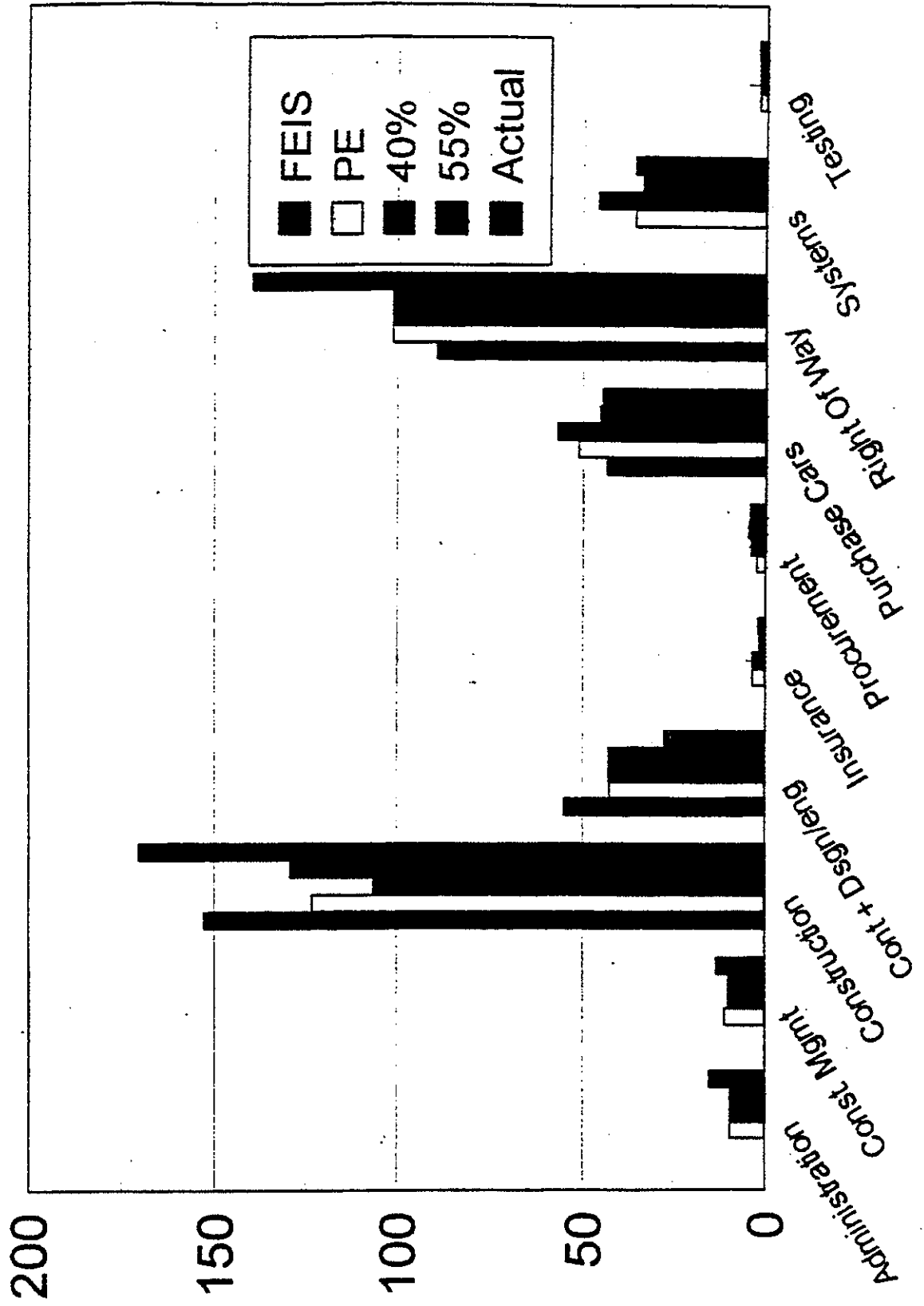


Table 16. Estimates

	FEIS*	PE**	40% Review**	55% Review**	Actual
Administration		9,565,479	9,565,479	9,565,479	15,159,256
Const. Mgmt		11,203,259	10,060,589	10,060,589	13,194,224
Construction	153,100,000	123,498,316	106,865,551	129,391,547	170,711,716
Cont + Dsgn/eng	55,300,000	42,782,153	43,073,299	43,073,299	27,569,241
Insurance		3,531,183	3,531,183	1,590,793	2,036,487
Procurement		2,472,421	3,986,450	4,630,429	4,270,673
Purchase Cars	43,600,000	51,418,620	57,131,810	45,447,351	44,700,985
Right Of Way	89,400,000	101,413,509	101,413,509	101,413,509	139,853,229
Systems		35,676,832	45,933,902	33,755,569	35,888,616
Testing		2,036,956	2,036,956	2,036,956	2,205,482
TOTAL	341,400,000	383,598,728	383,598,728	380,965,521	455,589,909

*Source: Final Environmental Impact Report
 **Quarterly Review - May 10, 1990 Concise Cost Report
 Reviews are designated design reviews

The major realignment as a result of changes in the airport master plan lead to the formulation of a re-allocated budget. Exhibit 14 compares this re-allocated budget with the construction cost estimate (CCE). Note the negative variances for construction management, contingencies, insurance, purchase cars, and systems indicating potential budget shortfalls.

From the beginning of the project, costs were projected to be considerably above estimates. Exhibit 15 indicates the differences between projected final cost and current construction cost estimates over time. Projected final cost is equal to the sum of CCE+contingency+additional cost. Construction, right-of-way, and design/engineering stand out as having the largest positive variance, a potential indicator of higher than expected cost growth.

Cost growth for Metro Link does not appear to have been caused by either excessive change orders or claims. Table 17 shows a detailed breakdown of change orders as a percentage of the current construction estimate. Note cumulative change orders totalled under 10%. As of the April 1, 1994 Quarterly Report, \$2.26M in claims were still pending, while \$3.7M had been settled.

6.8 DETAILED ANALYSIS OF SELECT COST CATEGORIES

Exhibit 16 graphically shows the growth in the land acquisition and donated land budgets. Also indicated are the full funding cost estimate (developed for the FFGA) for land acquisition and the initial appraised value of the property. Note that the acquisition budget increased to \$21.6M from an initial appraised value of \$10.2M.

Project extraordinary costs were calculated from data provided in the quarterly reports and are compiled in Exhibit 17. Extraordinary costs are those costs which are considered to be beyond the control of the grantee. For Metro Link, five categories of extraordinary cost were allowed: inflation beyond the rate utilized to develop the total costs of construction and procurement contracts; costs due to acts of God; excess property costs resulting from court orders; costs directly caused by Federal legislation, regulations, actions or decisions; and costs directly caused by the unavailability of funds from Congress. Comparing a draft submittal of extraordinary costs (See Figure 7) prepared separately from the Quarterly Reports with Exhibit 17 seems to indicate that the Quarterly Report only includes Airport-related extraordinary costs. There remains some unexplained variance between the two reports, even on an airport line item basis.

Metro Link incorporated both a construction contingency and a project contingency in its cost accounting system. A breakout of the construction contingency is provided in Exhibit 18, along with an overall project contingency. Exhibit 18 indicates major increases in contingency for construction management, construction, and systems. Project contingency doubled between 1991 and 1994.

Considering soft costs expenditures over time as a percent of total project expenditures, Table 18 shows a relatively small value in 1989, increasing significantly in 1990, and a gradual drop-off

Exhibit 14. CCE vs Re-allocated with Airport

	91	92	93	94	91	92	93	94
Administration	10,065,479	10,265,479	10,035,593	10,035,593	10,065,479	10,065,479	10,065,479	10,065,479
Const. Mgmt	10,729,059	10,729,059	10,729,059	10,729,059	12,050,074	12,050,074	12,050,074	12,050,074
Construction	156,505,010	158,860,399	158,093,264	158,108,426	140,720,884	136,082,484	136,082,484	136,082,484
Contingencies	25,355,406	47,524,913	50,726,426	50,754,582	26,483,896	59,786,376	61,629,725	61,629,725
Design/Engineering	20,160,779	22,857,140	22,888,276	22,888,276	18,269,048	18,269,048	18,269,048	18,269,048
Insurance	2,161,502	2,161,502	2,161,502	2,161,502	3,531,183	3,531,183	3,531,183	3,531,183
Procurement	4,089,550	4,089,550	4,089,550	4,089,550	2,362,090	2,362,090	2,362,090	2,362,090
Purchase Cars	45,447,351	45,447,351	45,447,351	45,447,351	57,694,753	57,694,753	57,694,753	57,694,753
Right Of Way	10,875,870	12,604,568	12,362,289	12,318,971	7,226,832	7,226,832	7,226,832	7,226,832
Systems	29,970,841	34,560,357	34,560,357	34,560,357	42,210,708	42,031,998	42,181,998	42,181,998
Testing	2,036,956	2,036,956	2,036,956	2,036,956	2,036,956	2,036,956	2,036,956	2,036,956

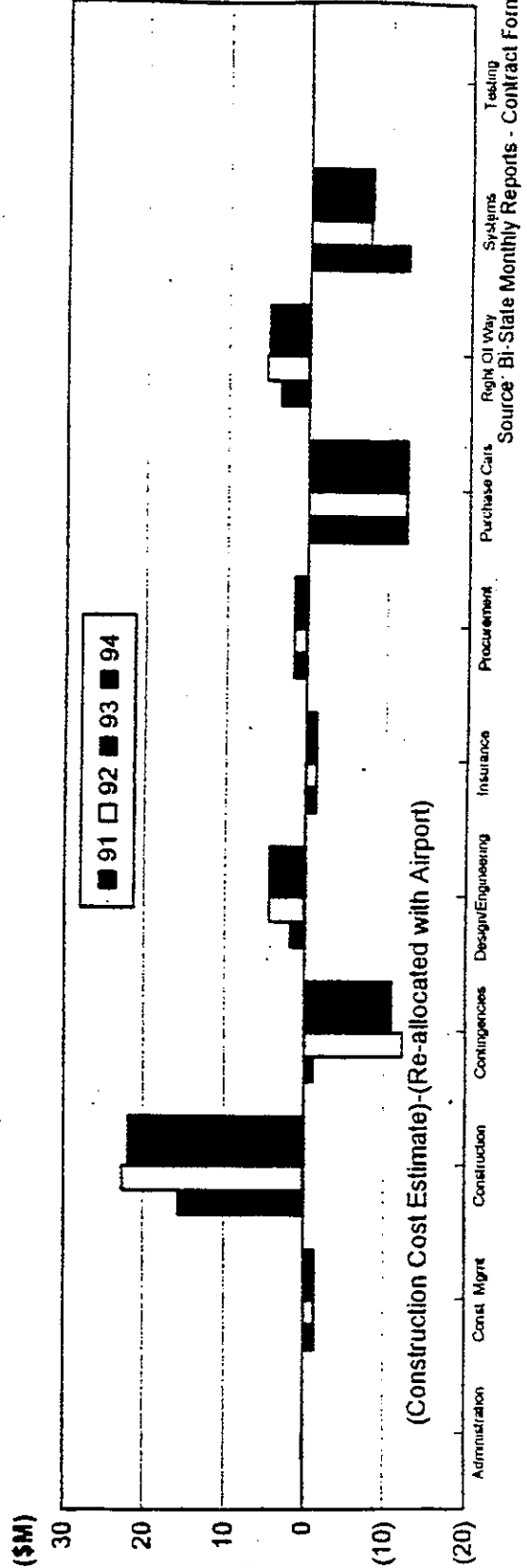
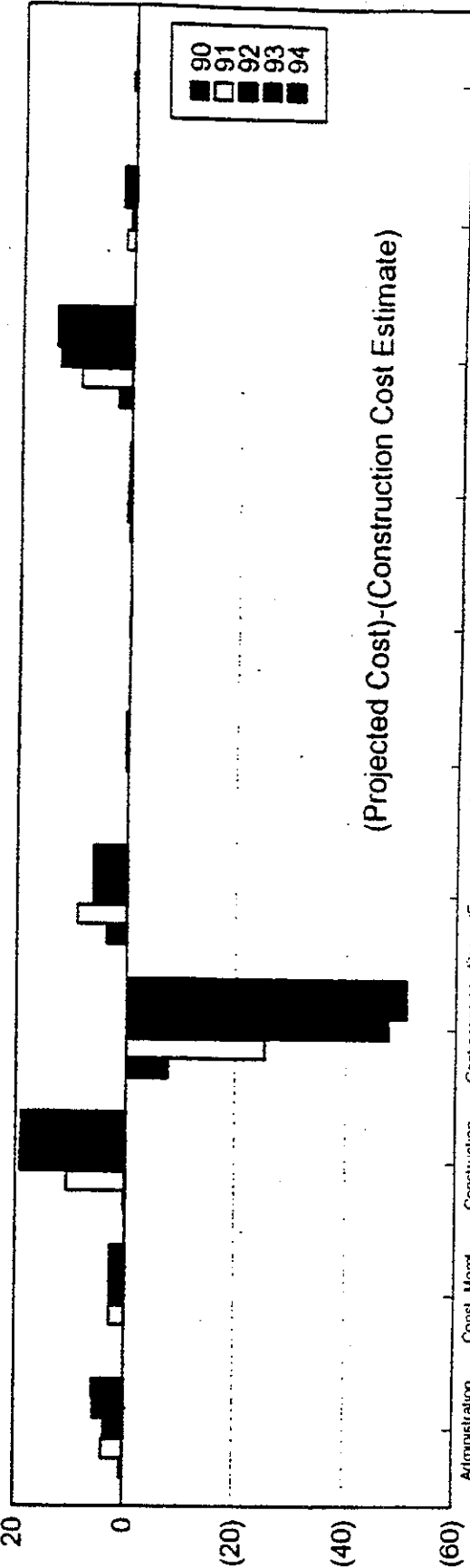


Exhibit 15. Projected Cost vs CCE

	90	91	92	93	94
Administration	10,640,479	13,946,996	13,805,851	15,563,907	15,721,422
Const. Mgmt	10,060,589	13,444,613	13,444,613	13,444,613	13,444,613
Construction	127,643,284	187,148,104	178,080,940	177,134,162	177,085,230
Contingencies	18,225,912	0	0	0	0
Design/Engineering	21,231,856	29,136,906	29,023,295	29,026,179	29,026,179
Insurance	1,590,795	2,161,502	2,591,502	2,715,502	2,715,502
Procurement	4,295,448	4,089,550	4,109,550	3,866,290	3,866,290
Purchase Cars	45,787,851	46,356,298	46,129,061	45,929,061	45,929,061
Right Of Way	10,015,632	20,117,896	25,774,825	26,288,656	26,245,338
Systems	36,010,246	31,871,317	35,470,352	36,869,670	36,878,153
Testing	2,196,956	2,036,956	2,717,285	2,292,583	2,218,835

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(\$M)



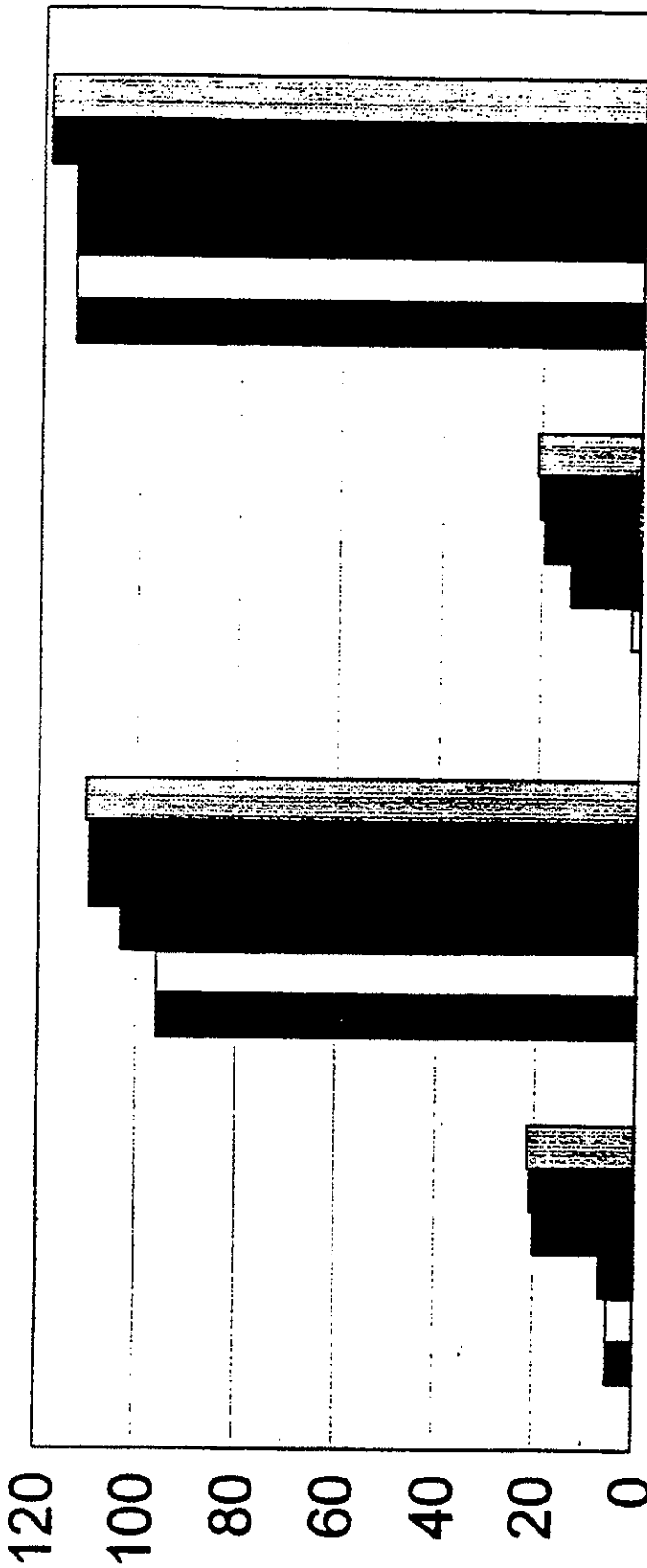
Administration Const Mgmt Construction Contingencies Design/Engineering Insurance Procurement Purchase Cars Right Of Way Systems Testing
Source: State Monthly Reports - Contract Funded

Table 17. Change Order Analysis

	90	% of EST	91	% of EST	92	% of EST	93	% of EST	94	% of EST
Current Const Est	383,598,728		317,397,803		351,137,274		353,130,623		353,130,623	
Construction	77,684	0.02	3,322,122	1.05	16,185,946	4.61	21,416,131	6.06	20,454,388	5.79
Const. Mgmt					2,255,228	0.64	2,715,554	0.77	2,715,554	0.77
Design/Eng	1,250,481	0.33	4,816,088	1.52	5,900,455	1.68	6,137,903	1.74	6,107,999	1.73
Procurement					223,260	0.06	223,260	0.06	223,260	0.06
Purchase Cars			340,500	0.11	340,500	0.10	481,710	0.14	340,500	0.10
Systems			312,720	0.10	1,469,366	0.42	2,539,177	0.72	3,652,834	1.03
Total	1,328,165	0.35	8,791,430	2.77	26,374,755	7.51	33,513,735	9.49	33,494,535	9.49

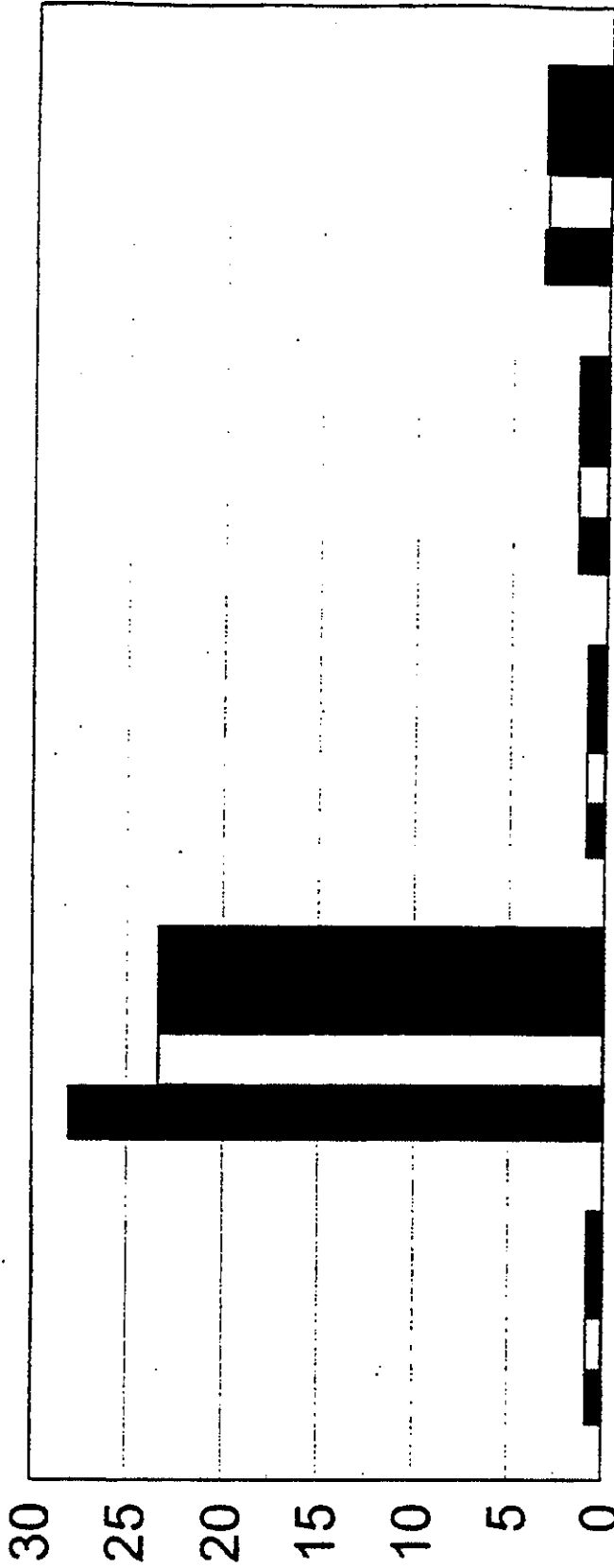
Source: Bi-State Monthly Reports - GMIS Format

Exhibit 16. Land Acquisition Analysis



*Appraised Value = \$10,224,752. FFC Est. Cost = \$2,749,856
 Source: Bi-State Monthly Reports - Contract Format

Exhibit 17. Extraordinary Cost Analysis



	Const. Mgmt	Construction	Design/Engineering	Right Of Way	Systems
91	846,815	28,070,058	954,920	1,560,000	3,521,065
92	846,815	23,431,658	954,920	1,560,000	3,342,355
93	846,815	23,431,658	954,920	1,560,000	3,492,355
94	846,815	23,431,658	954,920	1,560,000	3,492,355

Source: Bi-State Monthly Reports - Contract Format

05-Apr-94
08:33

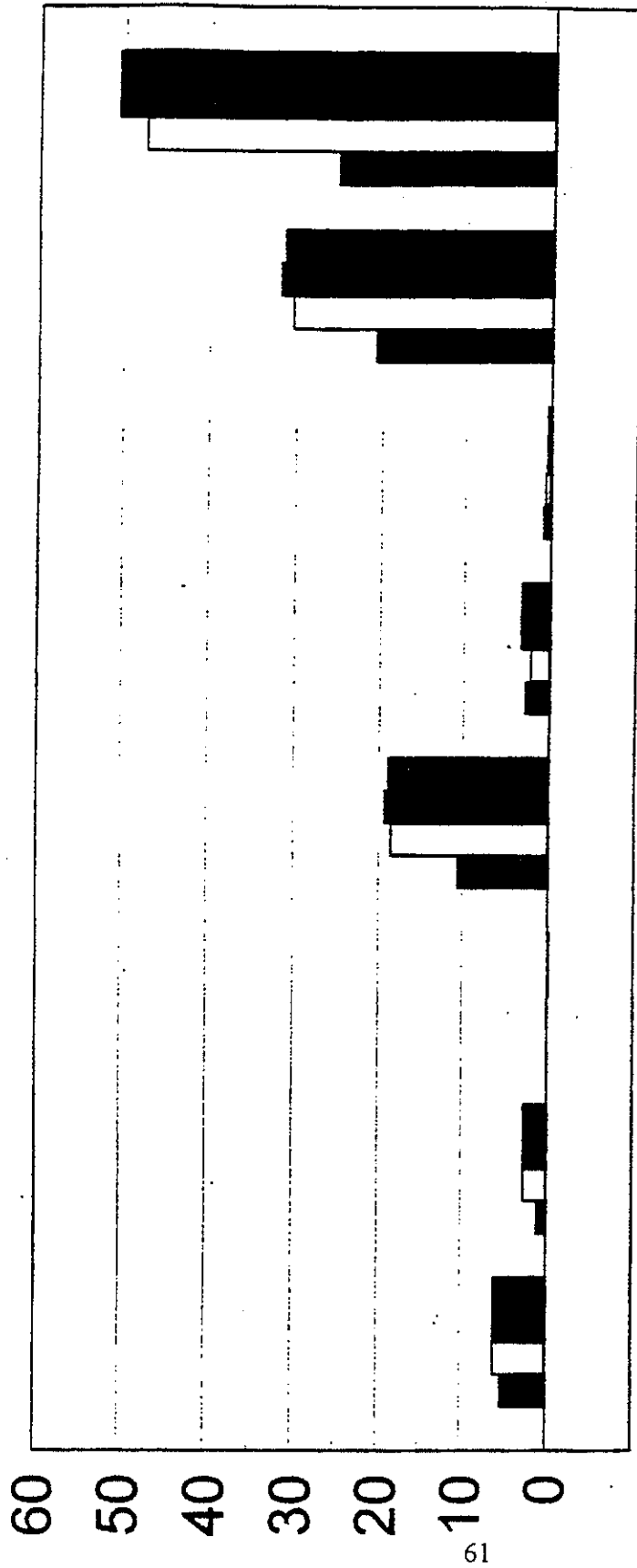
	Total Costs as of 1994(1)	Total Costs as of 1993(1)	Difference	Difference Actual Requested Amount	Difference Projected
A. INFLATION	\$0	\$0	\$0	\$0	\$0
B. ACTS OF GOD	\$132,961	\$47,777	\$85,184	\$85,184	\$0
C. PROPERTY Facility I & II	\$22,106,284	\$29,087,670	(\$6,981,386)	\$732,306	(\$7,713,692)
D. ACTS OF THE FEDERAL GOVERNMENT					
Environmental	Withdrawn and submitted under separate cover				
Remote Transmitter Receiver	\$0	\$0	\$0	\$0	\$0
Glide Slope	\$117,059	\$117,059	\$0	\$0	\$0
American With Disabilities Act	\$106,567	\$106,567	\$0	\$0	\$0
Painting of Eads Bridge	not requested	not requested	\$0	not requested	
Isolation Beanngs	\$1,261,697	\$1,261,697	(\$0)	(\$0)	\$0
Airport	\$36,500,810	\$35,646,167	\$854,643	\$890,691	(\$36,050)
Berkeley Spur	\$4,526,040	\$4,526,040	\$0	\$0	\$0
Subtotal	\$42,512,173	\$41,657,530	\$854,643	\$890,692	(\$36,050)
E. UNAVAILABILITY OF FUNDS	\$290,902	\$290,902	(\$0)	(\$0)	\$0
TOTAL EXTRA COSTS IDENTIFIED (1)	\$65,042,319	\$71,083,879	(\$6,041,560)	\$1,708,181	(\$7,749,742)
TOTAL EXTRA COSTS APPROVED			\$52,938,228		
Project Admin. Requested	\$4,168,403	\$4,298,982	(\$130,579)	\$95,142	(\$225,721)
Project Admin. Approved		\$3,770,469			

(1) Includes actual and projected expenses.

Figure 7. Metro Link Extraordinary Costs

Exhibit 18. Contingency Analysis

(\$M)



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Source: Bi-State Monthly Reports - Contract Format

between 1990 and 1994. Calculating account re-allocations between line items indicates (in Table 19) a project that experienced considerable change until 1992.

	89:	90:	91:	92:	93:	94:
Admin	1346292 (1.11%)	3829658 (2.52%)	7465498 (2.97%)	11328868 (2.92%)	14807734 (3.26%)	15159256 (3.33%)
Const. Mgmt	1917616 (1.59%)	5765684 (3.79%)	9213745 (3.66%)	12698827 (3.27%)	13194224 (2.91%)	13194224 (2.90%)
Design/Eng	3393684 (2.81%)	17004774 (11.19%)	24162861 (9.60%)	27120825 (6.99%)	28528279 (6.28%)	27569241 (6.05%)
Insurance	0 (0.00%)	1569679 (1.03%)	1660510 (0.66%)	2797041 (0.72%)	2654804 (0.58%)	2036487 (0.45%)
Testing	0 (0.00%)	4320 (0.00%)	58047 (0.02%)	535176 (0.14%)	2273035 (0.50%)	2205482 (0.48%)
Soft Costs	6657592 (5.50%)	28174115 (18.53%)	42560661 (16.92%)	54480737 (14.05%)	61458076 (13.53%)	60164690 (13.21%)

Table 18. Soft Costs

6.9 FINDINGS/HYPOTHESES

The Metro Link case study is an examination of a project which faced considerable risk—technical, financial, managerial, and political—tackle the risk head on, and achieved success through the determination of a devoted project team and the support of the general public.

Cost growth from the estimate stage to actual costs were most pronounced on a percentage basis in administration, right-of-way, and procurement. Administration increases can probably be traced to an underestimation of the staffing levels required on the project and higher than expected legal expenses due to land acquisition. Right-of-way costs have been discussed extensively with respect to the airport. Other reasons for right-of-way increases may relate to higher than expected utility relocation expenses. Increased procurement expenses may relate to enhancements in signage, station art work or station landscaping.

Increases in construction management can also probably be traced to interface issues between systems and facilities contractors, along with realignment issues and resulting contractor delays.

Table 19. Account Re-allocations

Re-allocated Full Funding with Airport

	92	93	94
Re-allocated with EO	418,551,585.0	460,849,697.00	463,507,496
Line Item Changes	51,932,332.0	2,657,799.00	0
% Change	12.4	0.58	0

Construction Cost Estimate

	91	92	93	94
CCE	383,598,728.0	317,397,803.0	351,137,274.0	353,130,623.00
Line Item Changes	115,434,033.0	44,109,252.0	4,471,949.0	86,636.00
% Change	30.1	13.9	1.3	0.02

BI-STATE DEVELOPMENT AGENCY
 Total Project Budget: \$33,398,497
 UMTA Funding/Grants: \$32,199,832 (Includes Airport Extension)

METRO LINK LIGHT RAIL PROJECT
 Grant No. A0-03-0033

Date: Dec 7, 1991
 Period Ending: Oct 31, 1991

UMS Code	Line Item	FFOA Budget Plus Airport Extension	Grant Budget Life To Date As of FY 91	Commitment/ Contract Amt	Expenditure		Life To Date	Percentage Completion	Unobligated Budget
					Current Period				
13.23.00	Construction Lines, Structures, & 20 Sta * Utilities Relocation and Miscellaneous	-	\$21,826,070	\$2,817,008	\$4,013	\$1,056,071	37.0% ^		
	Material Tasting	-	-	\$239,749	\$42,193	\$183,064	71.3%		
	1. Kern-Pfeifer - E. STL/LE Approach	-	\$10,794,000	\$10,794,000	\$1,314,312	\$3,701,343	34.3%		
	2. McCully - Eads Bridge & Tunnel	-	\$23,456,676	\$23,456,676	\$2,319,629	\$3,738,362	24.4%		
	4. MacCarthy - 8th to Taylor	\$99,331,638	\$7,468,647	\$7,830,663	\$440,601	\$2,051,478	26.2%		
	3. Keeler - Taylor to Airport Sta 1730	-	\$27,310,000	\$27,310,000	\$1,074,041	\$14,366,933	38.6%	\$2,523,330	
	10. Alaris - Systemwide Trackwork	-	\$21,917,717	\$21,764,341	\$1,661,446	\$4,946,872	22.7%		
	22. Fred Weber - N. Hasky Road	-	\$1,024,664	\$1,024,664	-	\$1,017,741	99.3%		
	30. Abandonment	-	-	\$813,403	\$41,419	\$333,909	63.5% /		
	Sta 1730 To Airport	\$18,663,028	-	-	-	\$0	0.0%	\$18,061,828	
	Sta 1730 to Berkeley	\$4,816,900	-	-	-	\$0	0.0%	\$4,816,900	
	Alaris & East Terminal	\$4,964,400	-	-	-	\$0	0.0%	\$4,964,400	
	Runway 10L, Glides Slope Conversion	\$0	-	-	-	\$0	0.0%	\$0	
	RTR #2 Relocation	\$0	-	-	-	\$0	0.0%	\$0	
13.43.00	Operations/Maint Facilities, Yards & Shops								
	1. R.O. Room Construction	\$9,446,023	\$9,400,776	\$9,671,140	\$168,001	\$4,016,462	46.2%	\$323,117	
13.50.00	Electric Power Distribution - MK Fritz	\$21,729,587	\$17,727,870	\$13,702,748	-	\$1,284,721	10.1%	\$7,376,819	
13.63.00	Signal and Train Control - MK Fritz	\$29,104,937	\$20,690,523	\$15,914,773	-	\$106,872	3.3%	\$4,690,164	
13.63.00	Communications Systems	\$447,474	-	\$1,363	-	\$1,363	0.2%	\$446,111	
13.13.20	Procurement of 31 Rail Vehicles - Siemens	\$57,094,733	\$45,787,831	\$45,787,831	-	\$126,300	23.7%	\$11,906,902	
13.42.01	Support Vehicle Procurement	\$793,994	\$940,215	\$126,926	-	\$126,926	15.9%	\$664,168	
13.33.04	Fare Collection Equipment - Schindler & Beckmann	\$1,569,996	\$3,353,231	\$3,449,333	\$118	\$126,379	0.0%	\$3,100,339	
13.33.04	Miscellaneous Office Equipment	\$100,000	\$375,000	\$600,016	-	\$0	0.0%	\$1,000,016	
13.71.02	Final Design & Landscape Architect	\$11,069,048	\$20,913,331	\$22,415,933	-	\$394,773	119.0%	\$100,816	
13.71.02	Art-in-Transit	\$200,000	\$200,000	\$173,346	-	\$158,232	129.4%	\$26,434	
13.71.03	Project & Construction Management	\$12,910,074	\$11,203,339	\$10,739,659	\$338,498	\$8,693,826	72.1%	\$1,271,013	
13.71.03	Insurance	\$3,331,183	\$3,331,183	\$1,793,423	\$5,203	\$1,460,340	47.0%	\$1,827,358	
13.71.04	Legal Services	\$437,699	\$922,333	\$1,216,548	\$82,823	\$1,216,548	190.8%	(\$578,849)	
13.71.07	Audit Services	\$423,132	\$423,132	-	-	\$0	0.0%	\$423,132	
13.73.00	Real Estate Acquisition	\$7,973,027	\$7,313,827	\$12,176,760	\$82,260	\$12,310,426	100.0%	(\$4,102,933)	
13.73.11	Testing and Start Up	\$2,036,936	\$2,036,936	\$49,000	\$27,439	\$49,000	2.4%	\$1,987,666	
13.76.00	Donated Real Estate	\$103,430,224	\$90,370,003	\$113,331,093	-	\$113,331,093	109.6%	(\$9,992,871)	
13.73.00	Contingencies	\$39,423,076	\$3,994,213	-	-	\$0	0.0%	\$39,423,076	
13.75.00	Project Administration	\$1,392,648	\$8,392,648	\$3,372,819	\$211,007	\$3,372,819	63.5%	\$2,979,729	
	Total UMTA Approved Project Budget:	\$433,391,497	\$162,780,917	\$333,982,179	\$9,806,134	\$222,052,710	51.2%	\$79,694,310	
	Local Share Match (Cash from Airport)	\$4,961,400	-	-	-	-	-	\$4,961,400	
	Local Share Match (Assets)	\$103,430,224	\$90,370,003	\$113,331,093	-	\$113,331,093	-	(\$9,992,871)	
	UMTA Project Funding/Grants	\$321,199,832	\$271,710,912	\$246,311,084	\$9,104,138	\$101,721,663	31.4%	\$84,827,789	

Appendix 3. Cost by Major Contract



RI STATE DEVELOPMENT AGENCY
METRO LINK LIGHT RAIL PROJECT

Full Funding Contract Budget Status
Month Ending: DECEMBER 31, 1991

CONTRACT	CONTRACT DESCRIPTION	(1) Original Full Funding Contract	(2) Re-allocated Full Funding Contract	(3) Re-allocated Budget with Airport	(4) Current Construction Estimate	(5) Contract Amt Committed To Date	(6) Contract/Construction Commitment % Annual	(7) Approved Change Orders	(8) Estimated Additional Cost to Project	(9)-(11)(12)(13) Projected Total Cost if Complete
CL11.01	E STL/East Bridge Approach	\$1,477,975	\$3,790,119	\$1,790,119	\$10,794,000	\$10,794,000	3.0%	\$339,700	\$0	\$11,133,700
CL11.25	East River Fixed Station	In cmt.	\$1,332,330	\$1,332,330	\$1,002,012	\$1,332,330			\$0	\$1,332,330
CL11.03	East Bridge and Tunnel	\$11,738,048	\$15,039,733	\$15,039,733	\$33,456,676	\$23,456,676	16.9%	\$1,933,976	\$0	\$15,435,212
CL11.04	8th Street to Taylor	\$11,374,407	\$10,732,769	\$10,732,769	\$7,468,647	\$7,468,647	10.0%	\$161,174	\$0	\$10,935,213
CL11.05	Taylor to Sun 1730+00	\$33,603,339	\$20,803,533	\$20,803,533	\$27,310,000	\$27,310,000	5.0%	\$773,218	\$0	\$28,083,218
CL11.22	Handy Road Retaining Wall	In cmt.	\$773,916	\$773,916	\$947,000	\$947,000	15.0%	\$77,484	\$0	\$1,024,484
CL11.23	Stations Fisher (28 Sts)	In cmt.	\$12,816,412	\$12,816,412	\$14,643,000	\$14,643,000	10.0%	\$1,464,500	\$0	\$16,107,500
CL12.01	SCR Rd & N Luddy Road P-R Lot	Contract	\$5,416,023	\$5,416,023	\$933,433	\$9,783,000	5.0%	(\$1,113,460)	\$0	\$10,374,230
CY13.01	Yard and Shops	\$33,639,071	\$33,976,071	\$33,976,071	\$31,972,719	\$31,972,719	5.0%	(\$153,174)	\$0	\$32,013,603
FS14.01	Trackwork	\$19,518,144	\$19,910,669	\$20,104,937	\$15,670,599	\$15,610,399	6.3%	(\$159,541)	\$0	\$15,450,858
FS14.02	Signals	In cmt.	\$447,474	\$447,474	\$447,474	\$447,474			\$0	\$447,474
FS14.04	Communications	\$20,349,900	\$20,349,900	\$20,349,900	\$13,702,761	\$13,702,761	5.0%	\$465,138	\$0	\$14,167,900
FS14.05	Domestic Utility Relocations	\$2,107,261	\$153,003	\$153,003	\$1,902,049	\$2,902,043		\$900,947	\$0	\$3,802,990
FS15.01	Light Rail Vehicles	\$37,694,753	\$37,694,753	\$37,694,753	\$45,447,331	\$45,447,331	2.0%	\$340,500	\$0	\$45,787,831
FS15.02	Pass Vending Equipment	\$1,563,996	\$1,563,996	\$1,563,996	\$3,449,333	\$3,449,333	0.0%	\$0	\$0	\$3,449,333
FS15.03	Maintenance Vch & Equip	\$2,206,148	\$793,094	\$793,094	\$123,931	\$123,931			(\$117,164)	\$1,176,167
**	Microtunneling Costs	\$0	\$3,303,320	\$3,303,320	\$3,664,139	\$3,664,139	10.0%	\$0	\$0	\$3,664,139
AE	Facilities B - Sun 1730 to Airport	Portion Inst	\$0	\$10,043,028	\$10,043,028	\$20,144,000		\$10,144,000	\$0	\$20,144,000
AE	Sun 1730 to Bartley (Pac & Systems)	In cmt.	\$0	\$4,816,000	\$4,816,000	\$4,816,000		\$0	\$0	\$4,816,000
AE	Alb & E Terminal Stn		\$0	\$4,961,400	\$4,961,400	\$4,961,400		\$0	\$0	\$4,961,400
AE	Runway 30L Olds Steps Conversion		\$0	\$104,032	\$104,032	\$104,032		\$0	\$0	\$104,032
AE	RTR #1 Relocation		\$0	\$1,392,419	\$1,392,419	\$1,392,419		(\$100,000)	\$0	\$1,292,419
SUBTOTAL CONSTRUCTION/EQUIPMENT:		\$17,546,188	\$311,540,317	\$313,141,740	\$239,814,395	\$232,850,243		\$14,469,602	(\$1,217,164)	\$233,663,133
AS06.01	ROW Acquisition/Relocation	\$5,313,837	\$5,313,837	\$7,073,827	\$7,073,827	\$13,950,085		\$0	\$9,242,026	\$14,313,837
SS08.01	Training and Startup	\$2,034,956	\$2,034,956	\$2,034,956	\$2,034,956	\$1,431		\$0	\$0	\$2,036,956
SS08.02	Final Design	\$17,314,120	\$17,314,120	\$18,209,048	\$20,104,779	\$19,432,180	27.4%	\$1,377,263	\$1,648,864	\$20,136,906
SS08.03	Project Management	\$19,203,239	\$19,203,239	\$12,050,072	\$10,739,039	\$10,739,039	10.0%	\$1,032,906	\$1,642,448	\$12,444,613
SS08.04	Insurance	\$3,311,103	\$3,311,103	\$3,311,103	\$2,161,502	\$1,703,433		\$0	\$0	\$2,161,502
SS08.05	Legal	\$437,699	\$437,699	\$437,699	\$437,699	\$1,383,670		\$0	\$0	\$1,821,369
SS08.06	Audit	\$423,132	\$423,132	\$423,132	\$423,132	\$431,808		\$0	\$0	\$854,940
SS09.01	Site Office Equipment	\$500,000	\$500,000	\$500,000	\$500,000	\$6,099,338		\$0	\$0	\$6,599,338
SS09.01	Project Administration	\$1,502,448	\$1,502,448	\$1,502,448	\$1,502,448	\$6,099,338		\$0	\$0	\$7,594,886
SUBTOTAL OTHER COSTS:		\$49,664,832	\$49,664,832	\$53,024,547	\$52,237,602	\$53,913,918		\$4,000,169	\$10,410,038	\$77,642,816
Total Cont/Equip & Other Costs:		\$163,211,020	\$361,115,149	\$366,166,287	\$292,051,997	\$377,774,203		\$78,849,931	\$5,931,270	\$330,110,139
PROJECT CONTINGENCY		\$25,048,033	\$25,048,033	\$25,048,033	\$25,048,033	\$25,048,033		\$0	\$0	\$25,048,033
Total Project Costs:		\$317,922,845	\$317,922,845	\$332,651,903	\$317,397,803	\$377,774,203		\$0	\$0	\$332,651,903
Local Match from Airport (Cash)		\$0	\$0	\$0	\$0	\$0		\$0	\$0	\$0
Local Share Match (Assets)		\$93,899,483	\$93,899,483	\$93,899,483	\$93,899,483	\$93,899,483		\$0	\$0	\$93,899,483
TOTAL UNFTA PROJECT:		\$318,316,727	\$318,316,727	\$318,316,727	\$318,316,727	\$318,316,727		\$0	\$0	\$318,316,727

Appendix 5. Grouping Key

GroupName	GMIS	Description	Contract	Contract Description
Administration			SS08.07	Misc. Office Equipment
Administration	13.71.06	Legal (3rd party)	SS08.05	Legal
Administration	13.71.07	Audit (3rd party)	SS08.06	Audit
Administration	13.79.00	Project Admin	MS09.01	Project Administration
Const. Mgmt			SS08.03	Project Management
Const. Mgmt	13.71.03	Contract Mgmt (3rd party)		
Construction			CL11.01	East St. Louis/East Bridge Approach
Construction			CL11.34	SCR Rd & N Hanley Road P.R Lot
Construction			CL11.28	Mill Creek Sewer Stabilization
Construction			HILL	Hill Behan & Vi. John
Construction	13.23.03	Construct Transitway		
Construction	13.23.00	Construction Lines, Structures, & 20 Stn		
Construction	13.43.00	Operation/Maint Facilities, Yards & Shops		
Construction			AE5	Remote Transmitter Receiver
Construction	AE2	Main & East Terminal	AE2	Main & E Terminal Stn
Construction			CL11.23	Facilities III - Stn 1730 to Airport
Construction			CL12.01	Station Finishes (20 Stns)
Construction			ASB	Asbestos Removal/Environmental
Construction	AE4	RTR #2 Relocation	AE4	RTR #2 Relocation
Construction			CL11.03	Eads Bridge and Tunnel
Construction			CL11.04	8th Street to Airport
Construction			CL11.05	Taylor to Stn 1730+00
Construction			CL11.22	Hanley Road Retaining Wall
Construction	AE1	Stn 1730 to Berkeley	AE1	Stn 1730+00 to Airport/Berkeley
Construction	CL11.23	Facilities III - Stn 1730 To Airport		
Construction			CY12.01	Station Finishes
Construction			DEMO	Demolitions/Utilities Relocations
Construction			ES14.01	Trackwork
Construction	13.43.05	Construct Yards/Shops	CY13.01	Yard and Shops
Construction			CL11.25	East River Front Station
Construction			MR	Misc. Repairs
Construction			MC	Miscellaneous Costs
Construction	AE3	Runway 30L Glide Slope Conversion	AE3	Runway 30L Glide Slope Conversion
Construction			CP12.01	Station Finishes (20 Stns)
Contingencies	13.73.00	Contingencies	DC	Design/Const Contingency
Contingencies			PC	Project Contingency
Design/Engineering	13.71.02	Final Design (3rd party)	SS08.02	Final Design
Insurance	13.71.05	Insurance (3rd party)	SS08.04	Insurance
Procurement			PS15.02	Fare Vending Equipment
Procurement	AIT	Arts In Transit		
Procurement	13.42.20	Acq Misc Office Equip		
Procurement			PS15.03	Maintenance Veh & Equip
Procurement	13.42.11	Acq Support Vehicles		
Procurement	13.32.06	Purchase Stationary Fare Collection Equip		
Purchase Cars	13.13.20	Purchase LRT Cars	PS15.01	Light Rail Vehicles
Right-Of-Way			ES14.05	Domestic Utility Relocations
Right-Of-Way	13.75.00	Donated Real Estate		
Right-Of-Way	13.75.91	R/E Acq & Reloc		
Right-Of-Way	13.75.91	R/E Donated Match		
Right-Of-Way	13.75.00	Real Estate Acquisition	AS06.01	ROW Acquisition/Relocation
Right-Of-Way			REI 55	Relocate 55 & 56 and IUP Interchange
Systems	16.63.00	SIGNAL & COMMUNICATION		
Systems			ES14.04	Communications
Systems	13.63.01	Signal/Comm/Secrty Const	ES14.02	Signals
Systems	13.63.00	Signal and Trans Control - MK Fritz		
Systems	13.50.00	Electric Pow. Distribution - MK Fritz		
Systems	13.53.20	Traction Pwr. - st. Elec. Pwr	ES14.03	Traction Power
Testing	13.72.11	Testing & Start-up/Force Acct. Other	SS08.01	Testing and Start-up

SECTION 7.

CASE STUDY OF MIAMI METROMOVER EXTENSION PROJECT

This case study considered a project to extend an automated guideway transit (AGT) system operating in downtown Miami. It is the only AGT project considered within the five case studies of this task. The original metromover system consisted of 1.9 miles of elevated dual-lane guideway, 9 stations, a maintenance facility, and 12 driverless rubber-tired vehicles.

The elevated superstructure of the guideway is composed of cast-in-place concrete running surfaces, a guide beam and associated power rail needed to guide and power the vehicles. During automatic mode, all train functions are monitored from a central control facility. The power distribution system consists of seven substations and five gap tie stations with the necessary transformers and switchgear. A communications system consists of CCTV cameras, a public address system and emergency telephone system. Dynamic graphic signs are available at the stations and in the vehicles to provide trip information.

7.1 PROJECT BACKGROUND/HISTORY

FTA approved funds for engineering of the original Metromover system in 1978 as part of the Downtown People Mover (DPM) program. Final design of the initial core loop area was started in 1979. In April 1986, after a 23 month delay and \$121,624,880 increase in cost, the Metromover system opened for revenue service. Final cost of the system came to \$145,624,880, with UMTA contributing \$82,224,880 and Metro Dade County and the Florida DOT contributing an additional \$63,400,000. A turnkey contract, for which Westinghouse Electric Corporation had full implementation responsibility, was used as the contracting approach.

Studies for the extension, consisting of the Omni and Brickell legs, continued for a number of years and were concluded in February 1988 with the issuance of the Final Environmental Impact Statement (FEIS).

7.2 PHYSICAL DESCRIPTION OF PROJECT/ALIGNMENT

The Extension project includes the addition of 2.5 miles of dual lane elevated guideway, 12 new passenger stations, six on each leg, 17 new vehicles, a vehicle wash/inspection facility, two additional service bays at the Maintenance Facility, improvements to the Central Control Center, and a Bus Transfer Facility. In addition, the existing fleet of Phase I vehicles was retrofit to ensure compatibility with the extension. Stations and guideway construction was for the most part tailored to the same design criteria used for Phase I. Stations are cast-in-place concrete both at grade and platform levels, are of an open air design, and predominantly have canopy roofs.

The Omni station includes a third level which connects directly to the Omni Mall, via a privately funded footbridge. All stations include elevators for handicap access, while escalators are provided at ten of the 12 new stations.

Figure 8 shows a system map of the original downtown loop, the 1.1 mile Brickell southern extension and the 1.4 mile Omni northern extension. The Omni extension connects to the existing loop at N.E. 5th Street and extends north along N.E. 2nd Avenue. The Brickell Extension connects to the existing loop between Miami Avenue and S.E. 1st Street just north of the I-95 expressway connector.

Project alignment was developed after a detailed process of analysis and evaluation. The Metromover Loop was selected as the preferred initial segment in 1979. Metro-Dade Transit Agency (MDTA) conducted further analyses for the Omni and Brickell legs in 1981 and developed an approved alignment. Further refinements to the alignment were identified in environmental studies conducted in 1988 and eventually adopted as part of the FEIS. The alignment delineated in the FEIS was subjected to further scrutiny in an effort to save costs of property acquisition by moving more into public streets. As a result of this final alignment, MDTA only needed to acquire a total of 30 parcels (instead of 54) at a cost of \$14M (instead of \$49.3M).

7.3 PROJECT ORGANIZATION

A thirteen member Board of County Commissioners (BCC), elected every four years, governs Dade County. Day to day management of the county is the responsibility of the County Manager with the support of directors of various departments and agencies. MDTA is the agency responsible for providing public transportation services within the county.

Project management responsibility for the Metromover Extension was originally assigned to the Metro-Dade Department of Public Works (MDPW), with MDTA providing only administrative support. In January 1990, the MDPW Project Director and his project team were reorganized under MDTA. Within MDTA, overall management for the project was placed with the Directorate for Planning, Engineering and Construction. The Metromover Extension Project Director is also the Assistant Director of Planning, Engineering and Construction for MDTA.

Figure 9 shows the basic organizational structure for the project, with design, project control, and construction chiefs all reporting to the Project Director. Specialized consultants were used to augment a core project team. AEG Transportation Systems Inc. was awarded an equipment turnkey for vehicles and control systems. Consultants were utilized in the following areas: project design, design review, value engineering, construction engineering and inspection, systems/vehicle design review, fabrication and testing, claims review, safety and quality assurance.

MIAMI METROMOVER SYSTEM

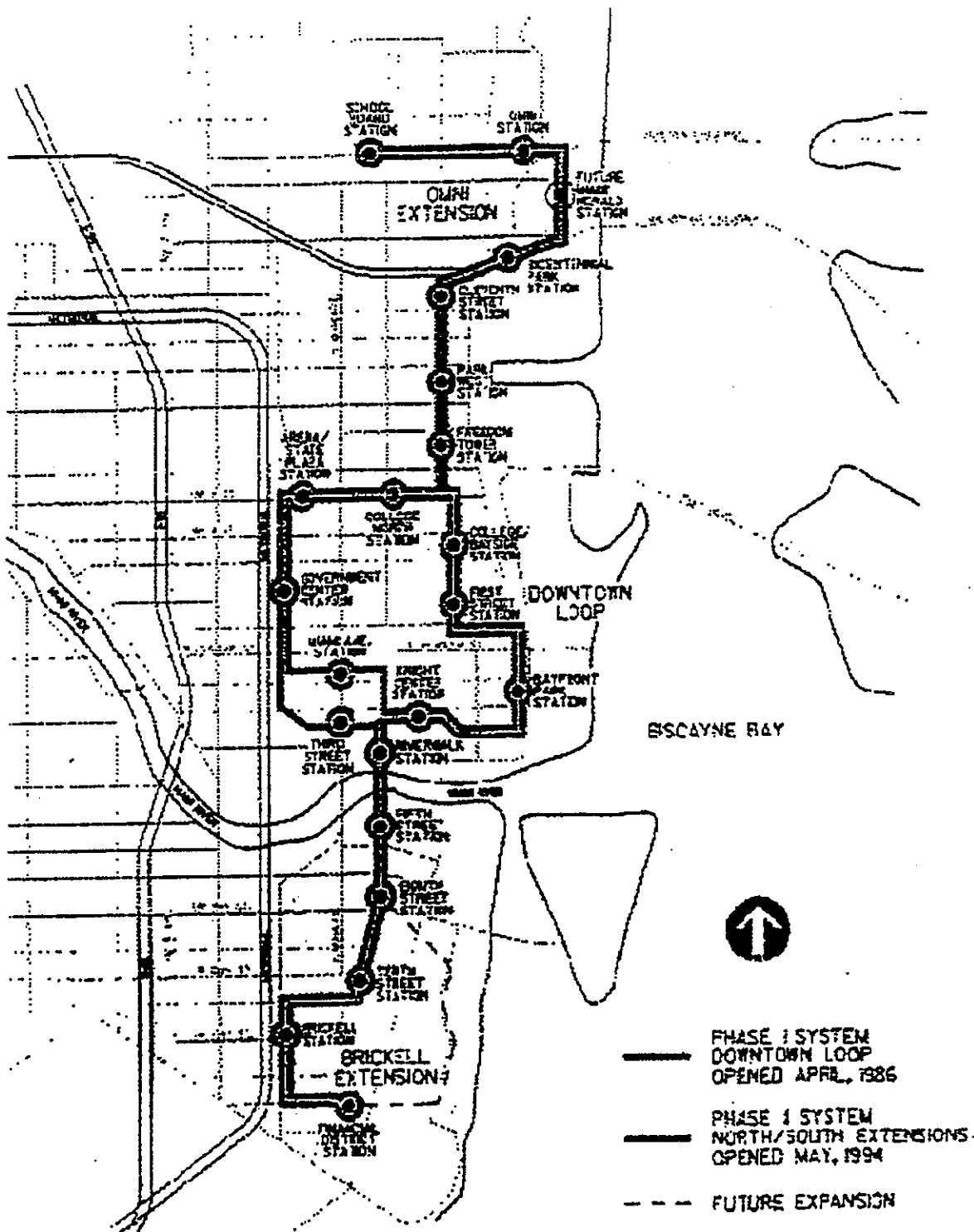
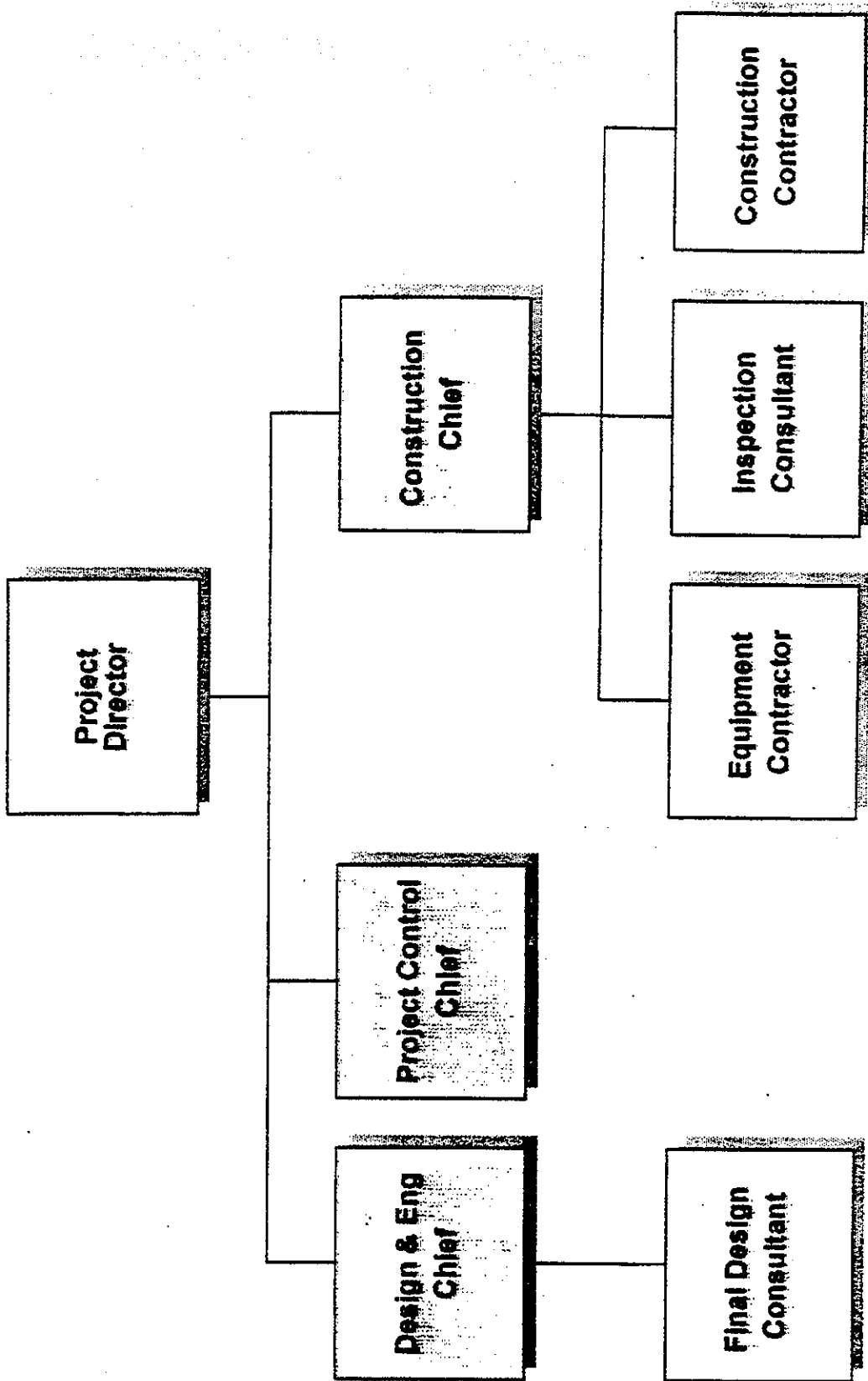


Figure 8- System Map



Figure 9. Metromover Extension Project Organization



On the contractual side, final design was done by two separate consultants, one for each leg. Civil construction was segmented into four contracts. There were separate Brickell and Omni station construction contracts, each containing six stations and separate Brickell and Omni guideway construction contracts. Interface issues resulted from the construction contract strategy because the station contracts included the guideway piers, while the guideway contracts included all the steel girders and running surfaces making up the track superstructures.

7.4 KEY EVENTS/CHRONOLOGY

This section presents a brief overview of some of the key project events and their chronology.

- 1985 - Extension project reactivated after having been deleted from original proposal because of cost overruns.
- April 1986 - Phase I Metromover became operational
- February 1988 - Final Environmental Impact Statement issued
- May 1989 - Full Funding Grant Agreement executed
- July 1989 - Contracts for design of fixed facilities awarded
- October 1989 - Notice to Proceed issued to AEG Transportation Systems, Inc. after negotiation difficulties with escalation clauses. Contract completion date extended by 46 days to March 1994.
- January 1990 - Final alignment approved by FTA
- March 1991 - Construction began on stations and guideway
- August 1992 - Hurricane Andrew hit Florida. Project completion date extended to May 1994.
- May 1994 - Metromover Extension began revenue service

7.5 PROJECT FINANCING

The Full Funding Grant Agreement indicates that between 1984 and 1989 Congress earmarked \$151,464,170 in funds for the extension. After several iterations of estimating total project cost, target cost was established at \$248M with FTA to provide 75% or \$186M. The local share was to be provided by the State of Florida, City of Miami, and through taxing all businesses within 1800 feet of a new station. The projected principal sources of funds in millions were:

	<u>Amount</u>	<u>Percent of Total</u>
• FTA	\$186	75.0
• FDOT	\$ 31	12.5
• City of Miami	\$ 7	2.8
• Taxing District	<u>\$ 24</u>	<u>9.7</u>
Totals	\$248	100.0

In January 1993, MDTA received a separate FTA grant for Hurricane Andrew expenses. The PMO final report states that approximately \$500K of this grant was appropriated for Metromover project hurricane related costs.

The Federal flow of funds to the project can be analyzed by considering the grant history of the project in combination with the schedule of drawdown of Federal funds. In considering the grant history (Table 20), keep in mind that approved total project budgets are presented—the Federal portion is 75% of the totals and line items indicated. The Full Funding Grant Agreement in 1989 provided \$115,500,000 in Federal funding. Two mods were later added to this amount: \$20.1M in 1990 and \$25.65M in 1993, bringing the total to \$161.25M.

GMS	Description	FFGA(89)	Mod 1 (90)	Mod 2 (93)
13.23.07	Transitway	30,000,000	43,800,000	52,000,000
13.43.02	Maint. Facility	3,000,000	3,000,000	3,000,000
13.62.01	Train Cntrl/Signl	10,000,000	10,000,000	19,980,000
13.53.01	Electrification	14,000,000	14,000,000	16,522,000
13.33.02	Stations	18,000,000	22,000,000	30,573,000
13.13.31	Vehicles	24,000,000	24,000,000	22,315,000
13.76.91	RE Acquisition	30,000,000	35,000,000	15,000,000
13.21.07	Final Design	9,055,000	9,055,000	11,714,000
13.71.04	Const. Mgmt.	3,000,000	5,000,000	9,734,000
13.79.00	Project Admin.	3,000,000	5,000,000	12,370,000
13.73.00	Contingency	9,945,000	9,945,000	21,792,000
	Total	154,000,000	180,800,000	215,001,000

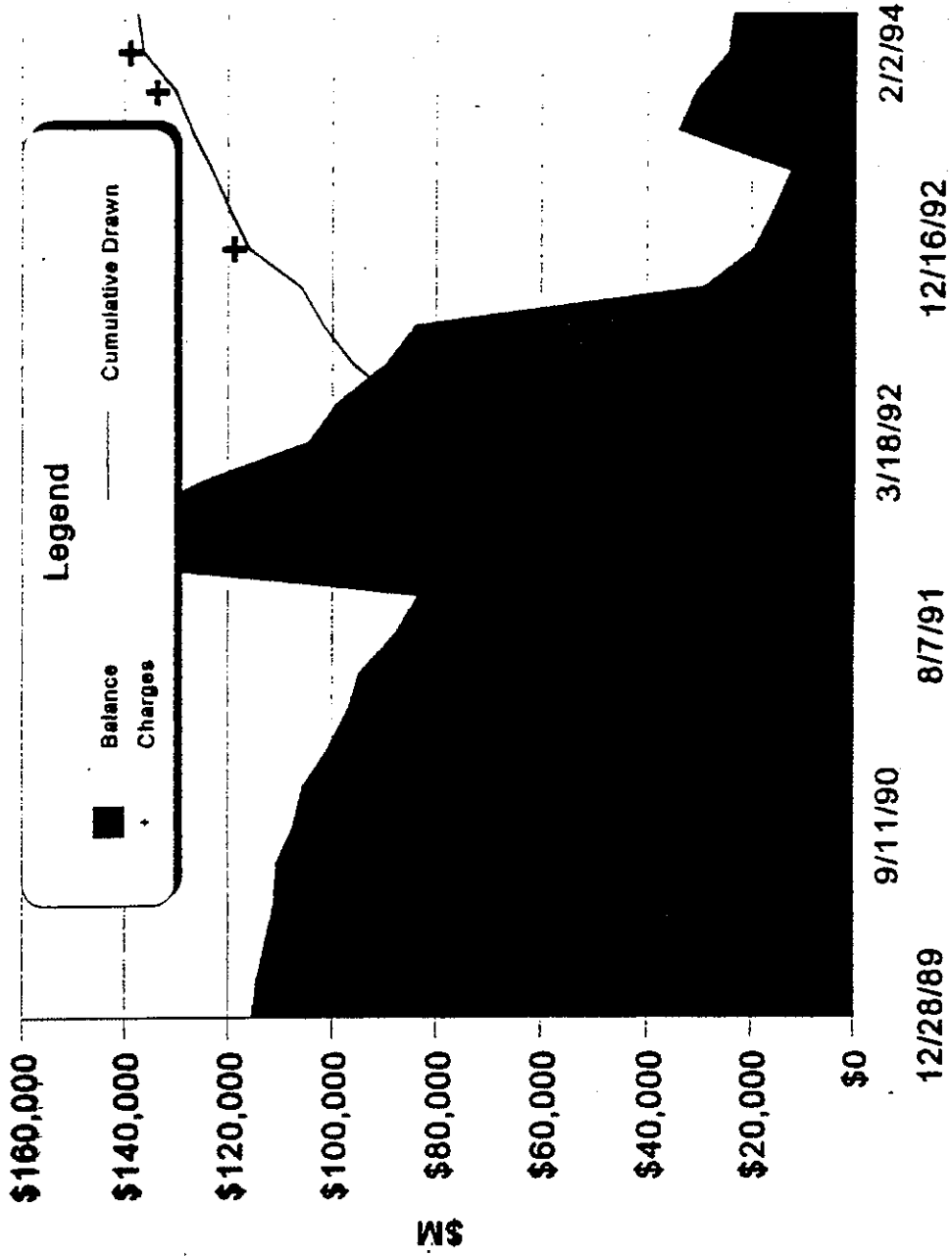
Table 20. Grant History

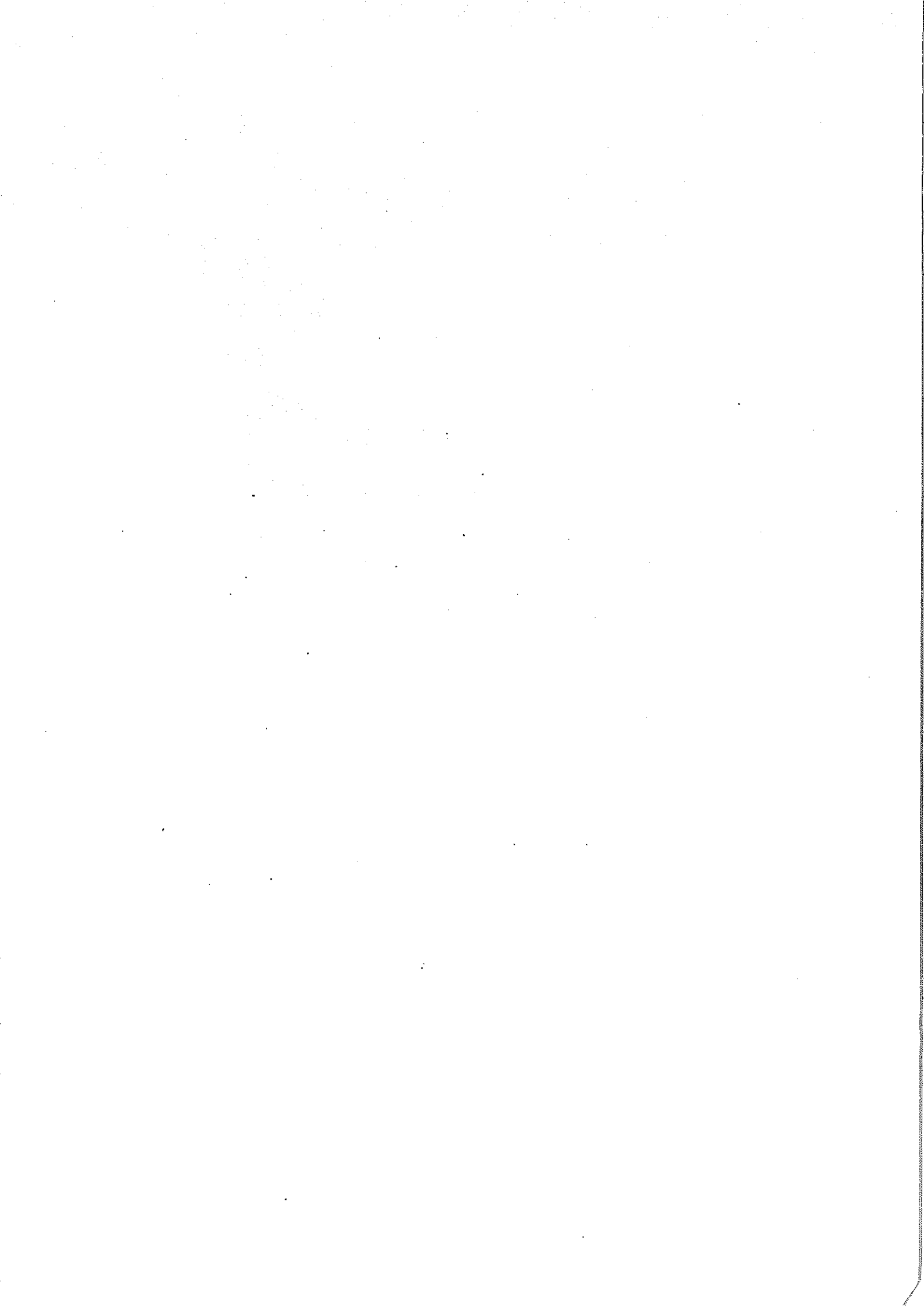
Exhibit 19 graphically depicts the drawdown of federal funds against the total project charges. As of April 1994, Federal funds in the amount of \$161.250M had been approved and \$137.423M had been drawn. Note the significant balance of funds through 1990 and 1991. The opportunity cost of this unused balance is worth consideration.

7.6 CAPITAL COST ESTIMATES

Four estimates of project cost were considered at a detailed level. These estimates were extracted from the FEIS, from an independent estimate done by Morrison-Knudsen (MK), and from Full

Exhibit 19. Drawdown Analysis





Funding Grant Agreement documentation from 1988 and 1989. On a macro level all of the estimates, with the exception of MK's, cluster around \$240M. MK doubled most of the contingency amounts utilized in the FEIS estimate yet arrived at \$221.8M. Both the FEIS estimate and the MK estimate are included as background in the appendix to this section. The engineer's estimate for construction contracts totaled \$92.6M. A construction contract bid analysis performed by the MDTA showed bids coming in \$11.8M below the engineer's estimate. Actual total charges as of June 1994 were about \$185M, not including outstanding claims totaling \$32M.

Exhibit 20 compares the estimates on a detailed level versus the most recently available project charges (1/24/94). This exhibit indicates the dramatic impact on right-of-way costs as a result of the realignment, reducing costs by over \$30M from prior estimates. Other notable cost differences between estimates and actuals occurred in: construction management; almost doubling the FEIS estimate of 1988; car purchases, coming in almost 30% less than expected; and construction coming in almost 9% less than estimated, before claims adjustments. Systems costs were underestimated by about 25% and design/engineering was underestimated by about 12%. Given the five year time horizon of the project construction, the construction estimate and design/engineering estimate appear to be within a reasonable bound of accuracy. The other variances will be explored further in the following sections.

7.7 PROJECT CAPITAL COST HISTORY

This section analyzes data provided in quarterly progress reports. Trends, variances, and major changes were analyzed by considering the data on a detailed level. Figure 10 depicts the basic financial reporting format used in the quarterly reports. This data was tabulated and regrouped according to the scheme shown in the translation table (Figure 11).

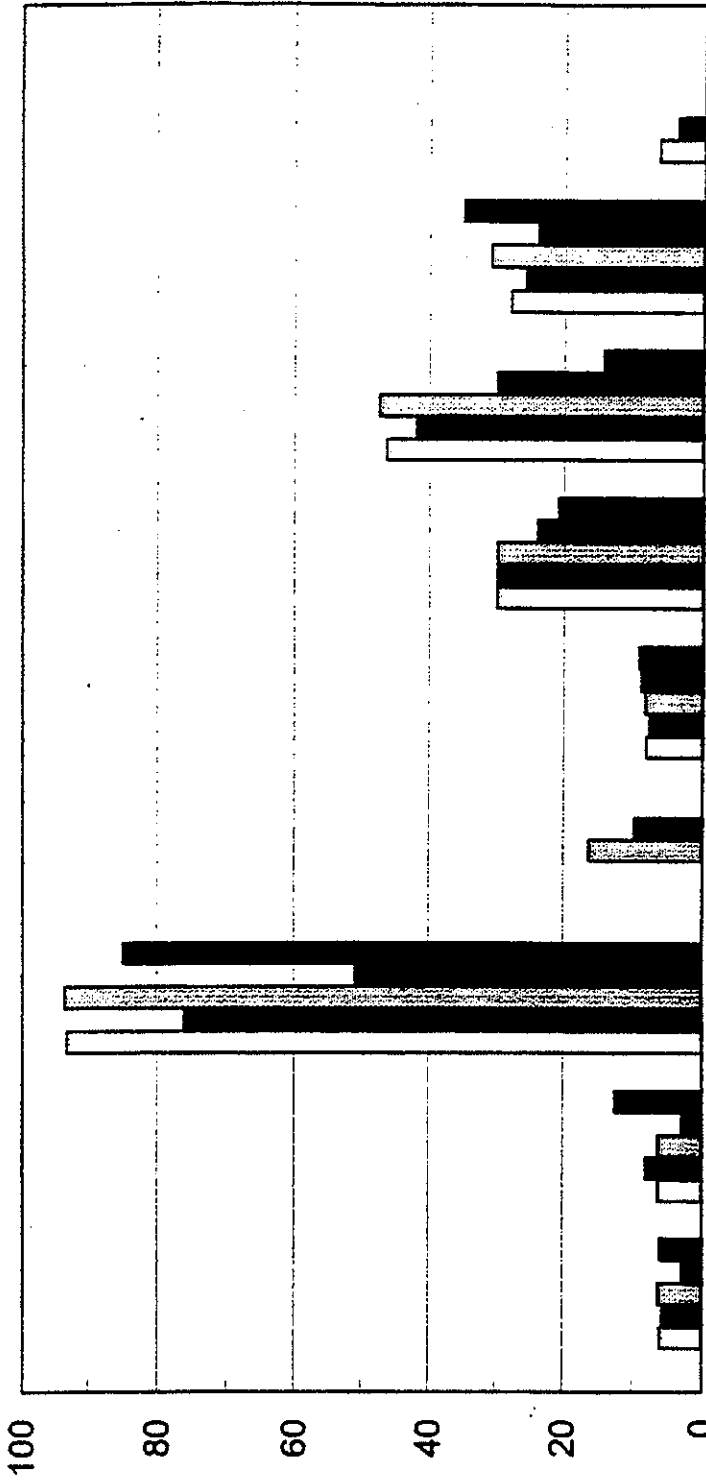
CATEGORY	SUB CATEGORY	Group Name
1	WESTINGHOUSE	Various
2	FINAL DESIGN	Design/Engineering
3	STATION/GUIDEWAY CONSTRUCTION CONTRACT	Construction
4	REAL ESTATE ACQUISITION	Right-Of-Way
5	UTILITY RELOCATION	Force Account
6	INSURANCE PREMIUMS	Insurance
7	PROJECT ADMINISTRATION	Administration
8	CONSTRUCTION MANAGEMENT	Const. Mgmt
9	PRE-OPERATIONAL EXPENSES	Various
10	CONTINGENCY	Contingencies

Figure 11. Translation Table

Exhibit 21 compares grant budgets over time against project budget ceilings. Note the changes in the ceilings. Also note the variance between the 93 grant budget and 93 budget ceilings. Differences of \$4-\$5 M are common among the categories, with a major difference of \$11M in contingencies. Major variances were also noted when comparing grant budget in 93 vs. actual 94

Exhibit 20. Estimates vs. Actuals

\$M



	Administration	Const. Mgmt	Construction	Contingencies	Design/Engineering	Purchase Cars	Right Of Way	Systems	Testing
FEIS (2/5/88)	6,206,000	6,464,000	93,250,000	0	8,326,000	29,988,000	46,304,000	27,993,000	6,700,000
MK (2/5/88)	5,836,000	8,308,000	76,160,000	0	7,827,000	29,992,000	41,984,000	25,703,000	4,011,000
FFGA (3/14/88)	6,472,000	6,472,000	93,714,500	16,521,500	8,460,000	29,944,000	47,479,000	30,937,000	0
FFGA (89)	3,000,000	3,000,000	51,000,000	9,945,000	9,055,000	24,000,000	30,000,000	24,000,000	0
94 CHARGES	6,212,210	12,594,586	85,028,989	0	9,321,961	20,887,963	14,443,915	35,094,953	0

Source: Quarterly Reports, FEIS, MK estimates, FFGA and Application

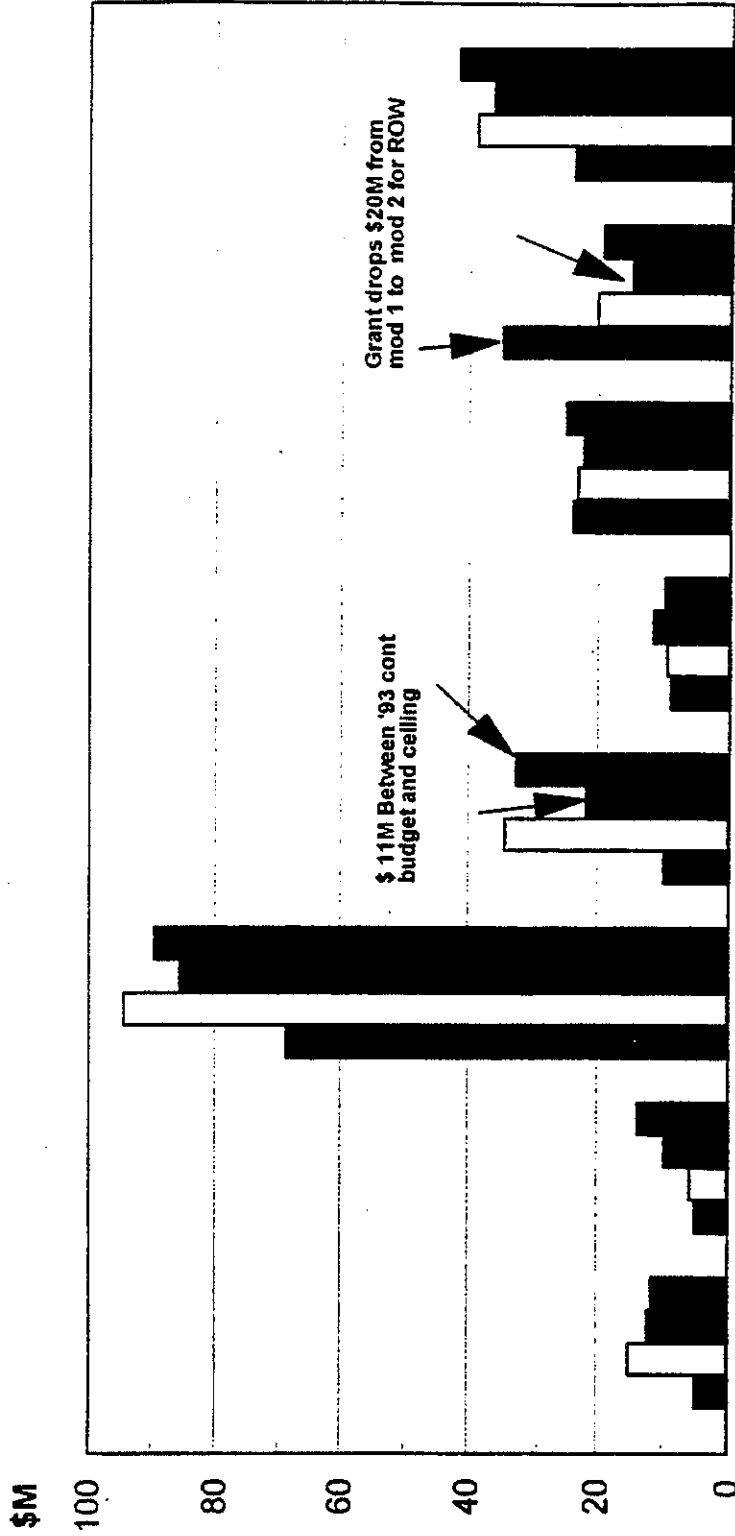
METROMOVER EXTENSION PROJECT
COST CONTROL REPORT

SUB CAT.	SUBCATEGORY NAME	INDEX CODE	PROJ. NO.	LOC. NO.	SUB OBJ	CURRENT CEILING	CHARGES TO-DATE	BALANCE
CATEGORY 1 WESTINGHOUSE								
A	WESTINGHOUSE CONTRACT	206334	663131	9200	9461	\$87,840,435	\$56,714,534	\$11,125,901
							\$87,840,435	\$11,125,901
SUBTOTAL WESTINGHOUSE								
CATEGORY 2 FINAL DESIGN								
A	OMNI EXTENSION FINAL DESIGN CONSULTANT	206391	663157	9201	9461	\$3,035,441	\$3,035,365	\$76
B	BRICKELL EXTENSION FINAL DESIGN CONSULTANT	206391	663142	9202	9461	\$3,189,281	\$3,189,431	\$19,850
C	SYSTEMS ENGINEERING CONSULTANT - JKH	206391	663155	9203	9461	\$620,000	\$436,074	\$183,926
D	SYSTEMS ENGINEERING CONSULTANT - ELLIOTT	206391	663143	9204	9461	\$865,000	\$477,495	\$387,505
E	ELECMECH TECHNICAL SUPPORT CONSULTANT-SDM	206391	663154	9205	9461	\$0	\$0	\$0
F	ELECMECH TECHNICAL SUPPORT CONSULTANT-RC	206391	663144	9206	9461	\$628,376	\$405,758	\$220,619
G	FACILITIES TECHNICAL SUPPORT CONSULTANT-METRIC	206391	663153	9207	9461	\$500,000	\$482,037	\$17,963
H	FACILITIES TECHNICAL SUPPORT CONSULTANT-FRH	206391	663145	9208	9461	\$400,000	\$382,923	\$17,077
L	TRAFFIC CONSULTANT	206391	663133	9212	9469	\$19,020	\$19,020	\$0
M	ENVIRONMENTAL ASSESSMENT (BUS TERMINAL RELOCATION)	206391	663136	9213	9469	\$25,000	\$24,199	\$801
	PIECO ENVIRONMENTAL TESTING	206391		9285	9464	\$100,000	\$88,041	\$11,959
	GRAPHICS DESIGN (PBOD W.O.#4)	206391		9364	9441	\$115,000	\$70,000	\$45,000
							\$9,495,120	\$904,778
SUBTOTAL FINAL DESIGN								

* INCLUDES MAXIMUM ESCALATION ALLOWED BY CONTRACT

Figure 10. Financial Reporting Format

Exhibit 21. Grant Budgets vs. Project Budget Ceilings



	Administration	Const Mgmt	Construction	Contingencies	Design/Engineering	Purchase Cars	Right Of Way	Systems
Mod 1 (90)	5,000,000	5,000,000	68,800,000	9,945,000	9,055,000	24,000,000	35,000,000	24,000,000
90 CEILING	15,211,396	5,813,000	94,404,390	34,456,613	9,544,778	23,268,486	20,382,512	39,094,595
Mod 2 (93)	12,370,000	9,734,000	85,573,000	21,792,000	11,714,000	22,315,000	15,000,000	36,502,000
93 CEILING	11,723,573	13,739,933	89,644,312	32,696,738	9,940,262	24,985,632	19,499,890	41,979,661

Source: Quarterly Reports and FTA Approved Budgets

charges, particularly in administration, construction management, and design/engineering.

Looking at budget ceiling (Exhibit 22) and charges to date trends does not show any major surprises. The ceiling for the ROW budget was adjusted in 1990 and showed a steady decline over time. Construction management, on the other hand, showed a steady increase over the project life-cycle. Car purchases and systems maintained a more constant ceiling. The steep drop in insurance in Exhibit 22 is due to the inability of the project to obtain blanket insurance coverage. Note the \$32M in contingency still being carried in the budget ceiling in 94.

Considering reallocations in line item budgets between time periods also offers some interesting insights. Exhibit 23 calculated the absolute percentage change in individual contract values between years. Note the relatively large changes to administration, construction management, construction, right-of-way, and systems over several years. This variability may indicate greater uncertainty or higher risk in these areas.

7.8 DETAILED ANALYSIS OF SELECT COST CATEGORIES

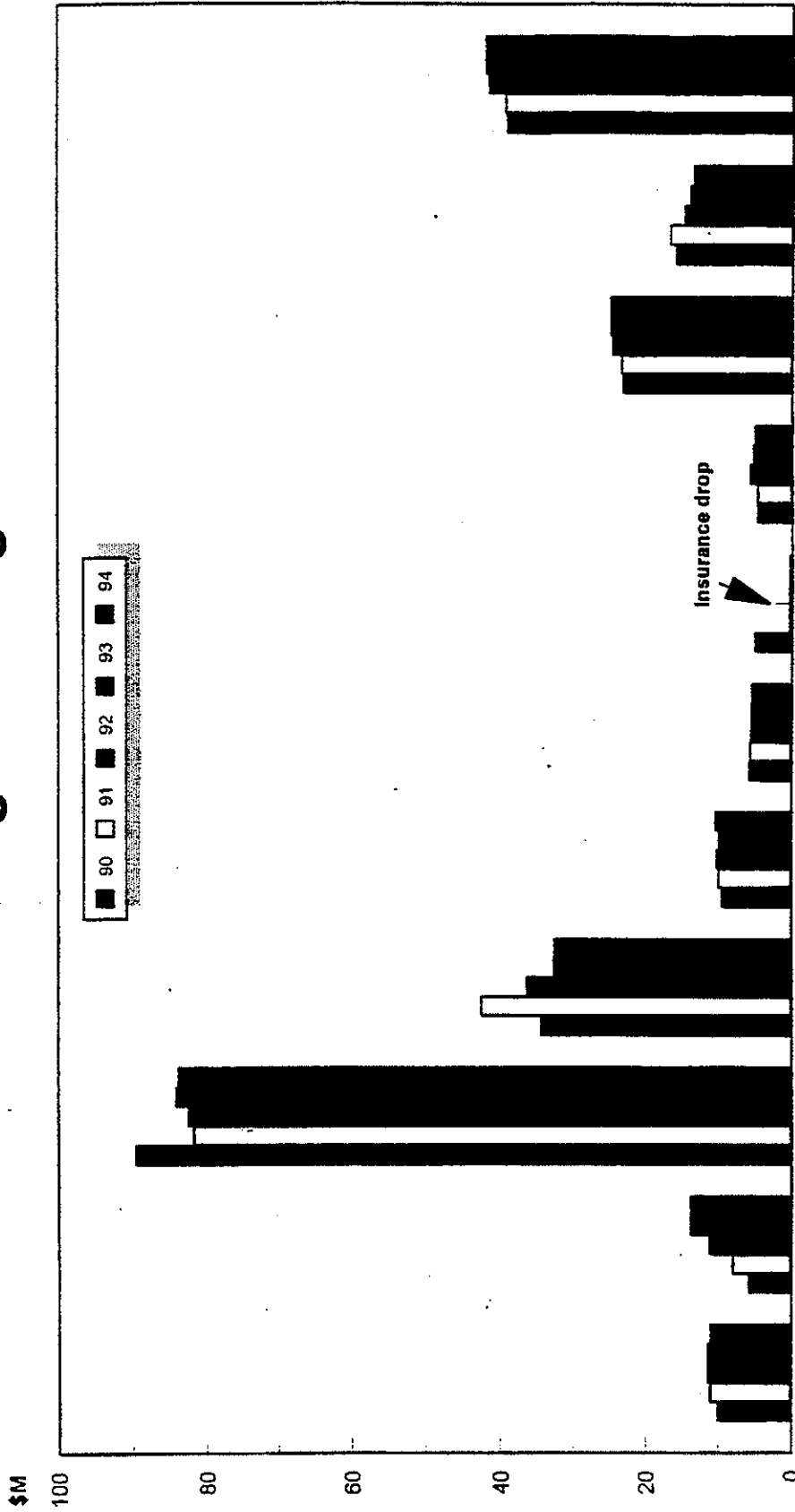
Detailed analysis of available data indicates that adjustments were made to ROW budgets in 1990 (Exhibit 24), establishing a ceiling at about \$20M and a real estate contingency of \$4.9M. These ROW related ceilings were steadily reduced between 1990 and 1994. Note that ROW contingency was budgeted separately from project contingency. At the same time that ROW budgets were decreasing, available project contingency was increasing from \$13.8M in 1990 to \$20M in 1994. Exhibit 25 presents a breakdown of how the project contingency was distributed between major categories over time. Note the direct relationship between those categories with significant cost changes from the time of the FEIS and those categories receiving the greatest contingency distributions (construction management, car purchases, and systems).

Soft costs on the Metromover Extension Project appear to have been in line with the risks of the project and followed a reasonable pattern of behavior (Table 21). The increase in charges from 92 to 94 is worthy of note and may reflect increased attention to claims by the claims consultant.

Group	90	91	92	93	94
Administration	7.03%	4.12%	2.66%	3.10%	3.40%
Const. Mgmt	0.01%	4.10%	5.56%	6.77%	6.80%
Design/Engineering	34.47%	12.16%	5.39%	5.10%	5.03%
Insurance	0.59%	0.26%	0.11%	0.10%	0.10%
Total Charges	42.10%	20.63%	13.72%	15.07%	15.33%

Table 21. Percentage of soft cost charges

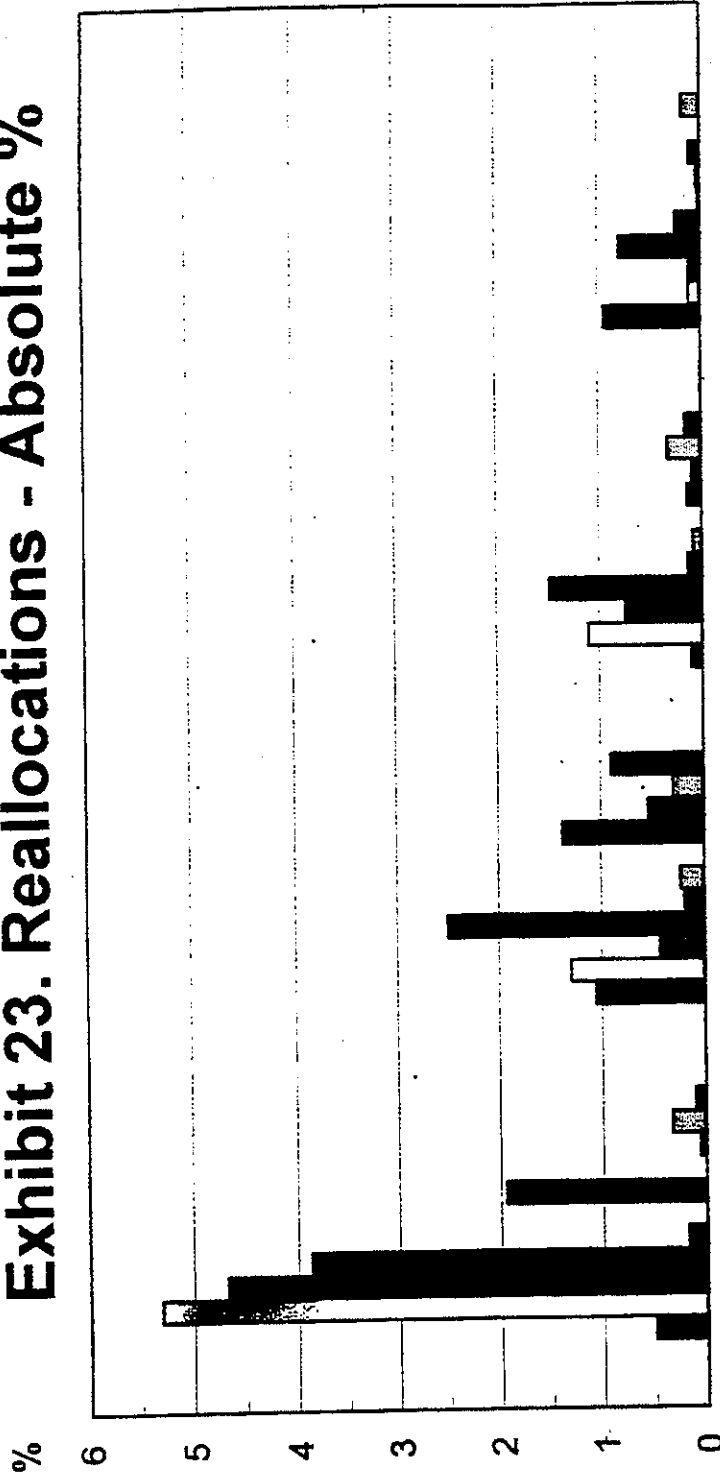
Exhibit 22. Budget Ceilings Over Time



	Administration	Const. Mgmt	Construction	Contingencies	Design/Engineering	Force Account	Insurance	Procurement	Purchase Cars	Right-Of-Way	Systems	Total
90	10,121	5,813	89,560	34,457	9,545	5,754	5,090	4,844	23,268	15,852	39,095	243,400
91	11,161	7,969	81,884	42,628	9,989	5,719	320	4,844	23,420	16,615	39,350	243,900
92	11,459	11,185	82,586	36,392	10,282	5,505	320	5,764	24,748	14,728	41,580	244,550
93	11,404	13,740	84,254	32,697	9,940	5,537	320	5,391	24,986	13,963	41,980	244,210
94	11,065	13,750	83,964	32,644	10,370	5,490	220	5,118	24,986	13,524	41,980	243,110

Source: DOT/RTD/MTA

Exhibit 23. Reallocations - Absolute %



	91	92	93	94
Administration	0.51%	1.06%	0.11%	0.94%
Const. Mgmt	5.31%	1.30%	1.11%	0.12%
Construction	4.68%	0.44%	0.75%	0.12%
Contingencies	3.87%	2.51%	1.49%	0.79%
Design/Eng	0.18%	0.20%	0.14%	0.25%
Force Account	0.01%	0.24%	0.09%	0.02%
Insurance	1.95%	0.00%	0.00%	0.04%
Procurement	0.00%	1.38%	0.15%	0.11%
Purchase Cars	0.06%	0.54%	0.10%	0.00%
Right Of Way	0.33%	0.31%	0.33%	0.18%
Systems	0.10%	0.90%	0.16%	0.00%
Total	17.00%	8.88%	4.43%	2.57%

Source: Quarterly Reports

Exhibit 24. Real Estate Acquisition Ceilings

\$M

25

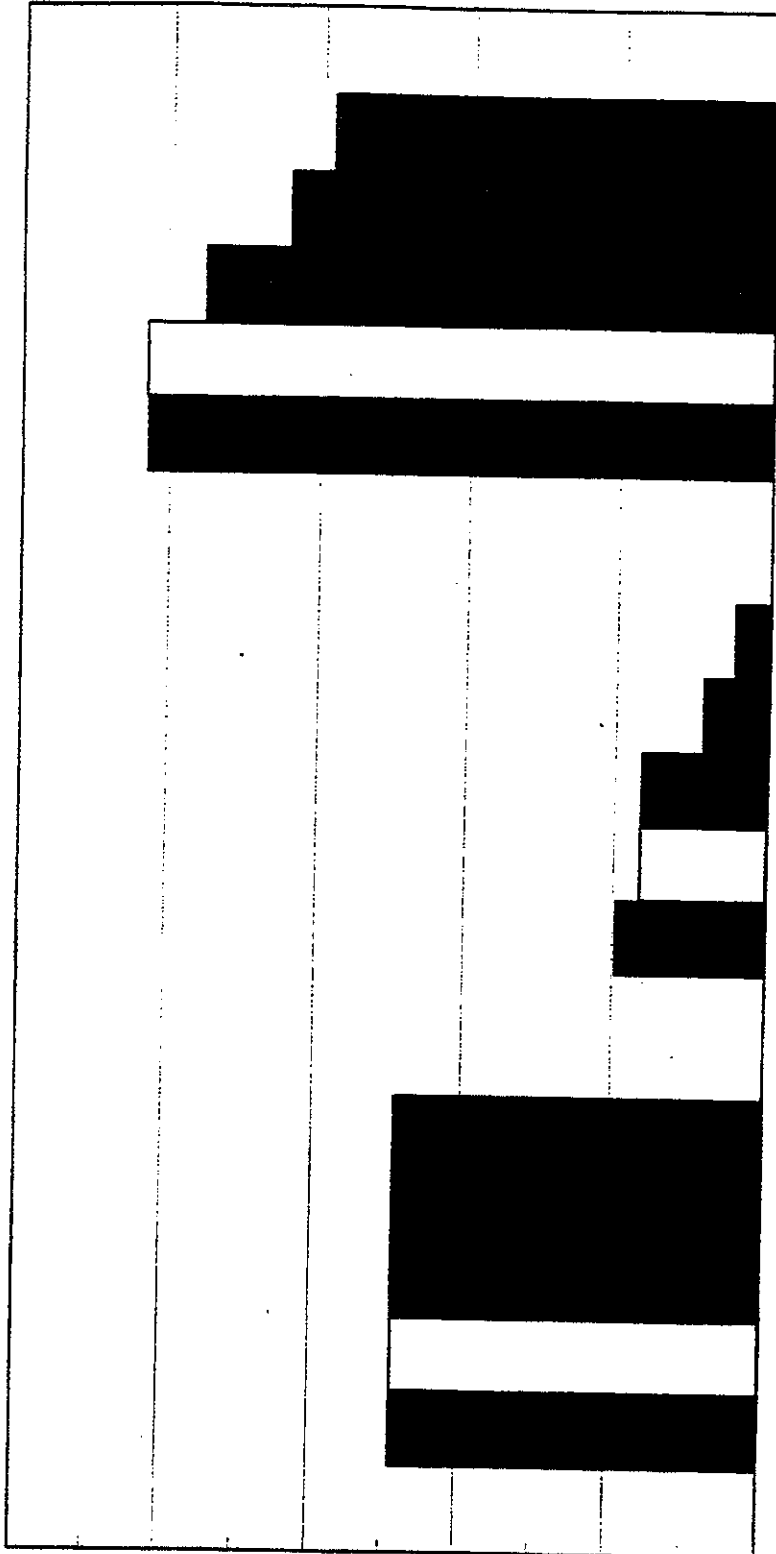
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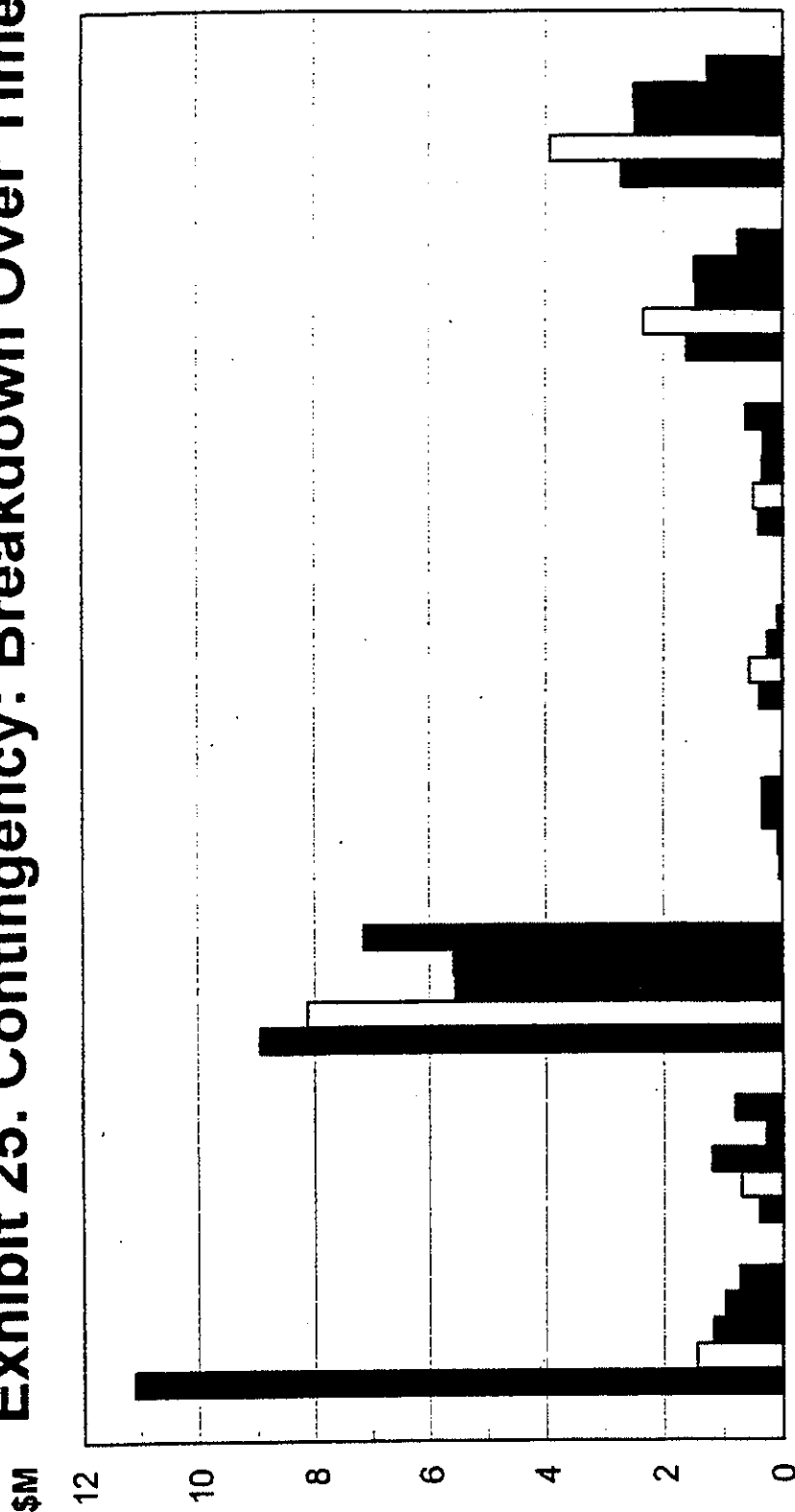
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	PARCEL ACQUISITION	CONTINGENCY	TOTAL REAL ESTATE
90	12,238,920	4,900,613	20,752,765
91	12,238,920	4,188,713	20,804,019
92	12,238,920	4,163,713	18,891,639
93	12,238,920	2,163,713	16,126,639
94	12,238,920	1,163,713	14,687,543

Source: Quarterly Reports

Exhibit 25. Contingency: Breakdown Over Time



	Administration	Const. Mgmt	Construction	Design/Engineering	Force Account	Procurement	Purchase Cars	Systems
1990	11,121,396	406,910	8,956,039	57,050	402,798	425,000	1,628,794	2,736,621
1991	1,459,269	715,199	8,135,425	82,032	571,934	510,000	2,342,038	3,934,981
1992	1,195,857	1,208,207	5,558,863	352,009	275,266	360,000	1,484,878	2,494,822
1993	1,000,000	290,000	5,600,000	352,508	100,000	339,309	1,499,138	2,518,780
1994	750,000	820,000	7,168,000	27,090	0	641,379	773,430	1,299,480

Source: Quarterly Reports

7.9 FINDINGS/HYPOTHESES

The conclusion to the Final Report on Project Management Oversight states that the Metromover Extension Project was completed on schedule, within budget, and to a high standard of quality through the concerted efforts of a dedicated MDTA team. Considerable effort was devoted to project planning, document preparation, design and drawing review, quality control, and contractor management/change control in the field. MDTA brought the project to a successful conclusion despite the impacts of a major hurricane and a resulting geographic shift in construction labor.

Additional contributors to the positive capital cost history of the Metromover Extension Project can probably be traced to a somewhat conservative estimate at the FEIS stage, the major realignment approved in 1990 by the FTA, risk reduction techniques such as hiring a consultant to explore utility locations at the final design stage, and strong project management/control through the requirement of cost loaded CPMs. It should be noted that a reserve of \$12.5M has been established for final change orders and claims adjustments, while claims totaling over \$32M are still not resolved.

The most notable aspect of the capital cost of this project was the decreased real estate acquisition costs as a result of the final realignment. Changes to the ROW costs have been discussed extensively in other sections. Increases in construction management may be traced to the method of contracting for both design and construction. Design and interface issues had to be dealt with throughout the project because of the presence of multiple contractors. CE&I consultant costs came in higher than expected because of two primary reasons: design submittal reviews were much more intensive than previously estimated, and quality control was required to hire more inspectors to ensure quality.

Experience with car purchases can probably be directly traced to lower than expected inflation related price adjustments for the AEG contract. The project had assumed \$9M in price adjustments and only required \$2.5M.

In the systems arena, the interface between the systems work and construction was a constant issue. Of particular concern was the tolerance of the running surface. Some delays in system work can be directly traced to running surface rework or guideway grounding rework and probably resulted in higher than anticipated costs.

**Appendix 6. Capital Cost Estimate - Metromover Legs
(X1000 Dollars)**

ITEM	JUNE 1986 DOLLARS	MIDPOINT	ESCALATION FACTOR	ESCALATED DOLLARS
Guideways	50000	Apr. 90	1.25	62500
(5% Contingency)	2500			3125
Stations	21000	Apr. 90	1.25	26250
(10% Contingency)	21			2265
Maintenance Facility	3600	Apr. 90	1.25	4500
(10% Contingency)	360			450
Command & Control	1000	Oct. 90	1.29	13029
(10% Contingency)	1010			1303
Electrification	11600	Oct. 90	1.29	14964
(10% Contingency)	1160			1496
County Administration	5172	Aug. 89	1.2	6206
Final Design	7240	Oct. 88	1.15	8326
Construction Mgmt	5172	Apr. 90	1.25	6464
Vehicles	25200	June 89	1.19	29988
(10% Contingency)	2520			2999
System Testing	5000	July 91	1.34	6700
(10% Contingency)	500			670
Land Acquisition	40265	Nov. 88	1.15	46304
(5% Contingency)	2013			2315
Total				239854

Source: Final Environmental Impact Statement.

Appendix 7. Morrison-Knudsen Engineers, Inc. Estimate

ITEM	MAR 1987 DOLLARS	CONSTRUCTION MID-POINT	% ANNUAL COMPOUNDED FACTOR	BEGIN 1987 ESCALATED DOLLARS	MDTA/MKE DIFFERENCE(---)
Guideways	44,000	Mar 90	1.19	52,360	-10,140
(5% Contingency)	4,400			5,236	+2,111
Stations	16,000	Mar 90	1.19	19,040	-7,210
(20% Contingency)	3,200			3,808	+1,543
Maintenance Facility	4,000	Feb 90	1.19	4,760	+260
(20% Contingency)	800			952	+502
Command & Control	9,455	Feb 91	1.26	11,913	-1,116
(20% Contingency)	1,956			2,465	+1,162
Electrification	11,303	Aug 90	1.22	13,790	-1,174
(20% Contingency)	2,260			2,757	+1,261
County Admin (5%)	4,904	Feb 90	1.19	5,836	-370
Final Design (7%)	6,866	May 89	1.14	7,827	-499
Construction Management (7%)	6,866	Jun 90	1.21	8,308	+1,844
Vehicles	25,634	Nov 89	1.17	29,992	+4
(20% Contingency)	5,127			5,999	+3,000
System Testing	3,062	Nov 91	1.31	4,011	-2,689
(20% Contingency)	612			802	+132
Land Acquisition	35,676	Mar 89	1.18	41,984	-4,320
					-2,315
Total	186,121			221,840	-18,014

Source: Morrison-Knudsen Engineers, Inc.

SECTION 8.

CASE STUDY OF SACRAMENTO LIGHT RAIL TRANSIT STARTER LINE PROJECT

This case study considers a light rail project that began in the late 1970s and was constructed in the mid 1980s. System design was intentionally geared to low cost, no frills standards using off-the-shelf technology. The main segment of the light rail system, known locally as the RT Metro System, was largely single track with double or passing track sections provided on forty percent (40%) of the route. In recent years, several double track construction projects have improved this situation. There are 28 stations located along the route. Seven of the stations have park-and-ride lots and six stations have bus transfer facilities. The light rail vehicles are of a West German design developed originally for Frankfurt.

Sacramento was a project characterized by some lack of project control resulting in spiraling costs and eventually a managerial reorganization. Capital costs associated with these occurrences will be analyzed in the following sections of this report.

8.1 PROJECT BACKGROUND/HISTORY

In August 1979, the Sacramento City Council voted to delete the I-80 bypass freeway from the interstate highway system. This action signaled the beginning of the LRT project by entitling Sacramento to Federal funding to finance an alternative project. Two years of effort were then devoted to conducting an Alternatives Analysis and a Draft Environmental Impact Report which recommended selection of a light rail transit system as the locally preferred alternative. An 18.3 mile starter line was identified to serve both the I-80 (Northeast) and U.S. 50 (Folsom) corridors. The route of the line utilizes unused freeway and/or railroad branch line right-of-way.

A new agency was established in 1981, the Sacramento Transit Development Agency (STDA), with the mission to plan, design, and construct the system. Representatives of the City of Sacramento, Sacramento County, the California Department of Transportation, and the Sacramento Regional Transit District (SRTD) served as a joint powers board. The SRTD was designated as the Grantee.

In August of 1983, STDA certified an EIS that analyzed the impacts of constructing the 18.3 mile LRT system in the Sacramento area. Ground was broken on March 14, 1983 under the auspices of STDA. By late 1984, the project was two years behind schedule and projected cost had risen substantially.

A re-evaluation of the project was commissioned to identify the underlying problems which had caused the out-of-control status to occur. In the summer of 1985, project management responsibility was given to a new Transit Systems Development (TSD) Division of the Grantee. Project scope, design criteria, and master schedule were all revised based on the results of the re-evaluation study.

Revisions to the project budget saw increases from initial estimates of about \$126 million in 1983 to \$159.5 million in August 1985. Management and control were further improved by a reorganization in 1985. These changes returned construction activities to a more stable basis.

8.2 PHYSICAL DESCRIPTION OF PROJECT/ALIGNMENT

The Light Rail Transit System is an 18.3 mile interurban electric railway, built using a typical European LRT design in which existing rights-of-way and at-grade crossings are utilized. It provides the trunk line service for an integrated Bus/LRT public transportation system.

Two major transportation corridors are served by the light rail line: the Northeast Corridor and Folsom Corridor. Approximately 9.3 miles long, the Northeast Line runs from Watt Avenue and I-80 southwest to Downtown Sacramento's "K" Street Mall. A second line, the Folsom Line, serves a 9-mile corridor extending east from Downtown along a railroad right-of-way to a terminus at Butterfield Way. Figure 12 is a route map of the current system.

Since the initial construction, the system has reduced the number of single-track segments. Of the 28 stations along the route each with at-grade platforms, park-and-ride lots are located in seven and six have bus transfer facilities. Each double-ended light rail vehicle is approximately 80 feet long, operates at speeds up to 50 miles per hour and has a combined standing and seating capacity of 175. Trains composed of one to four cars are controlled by a single operator.

Traction power is provided through thirteen self-contained, automatic substations feeding fully auto-tensioned catenary. A maintenance facility and storage yard are located on the Northeast Line.

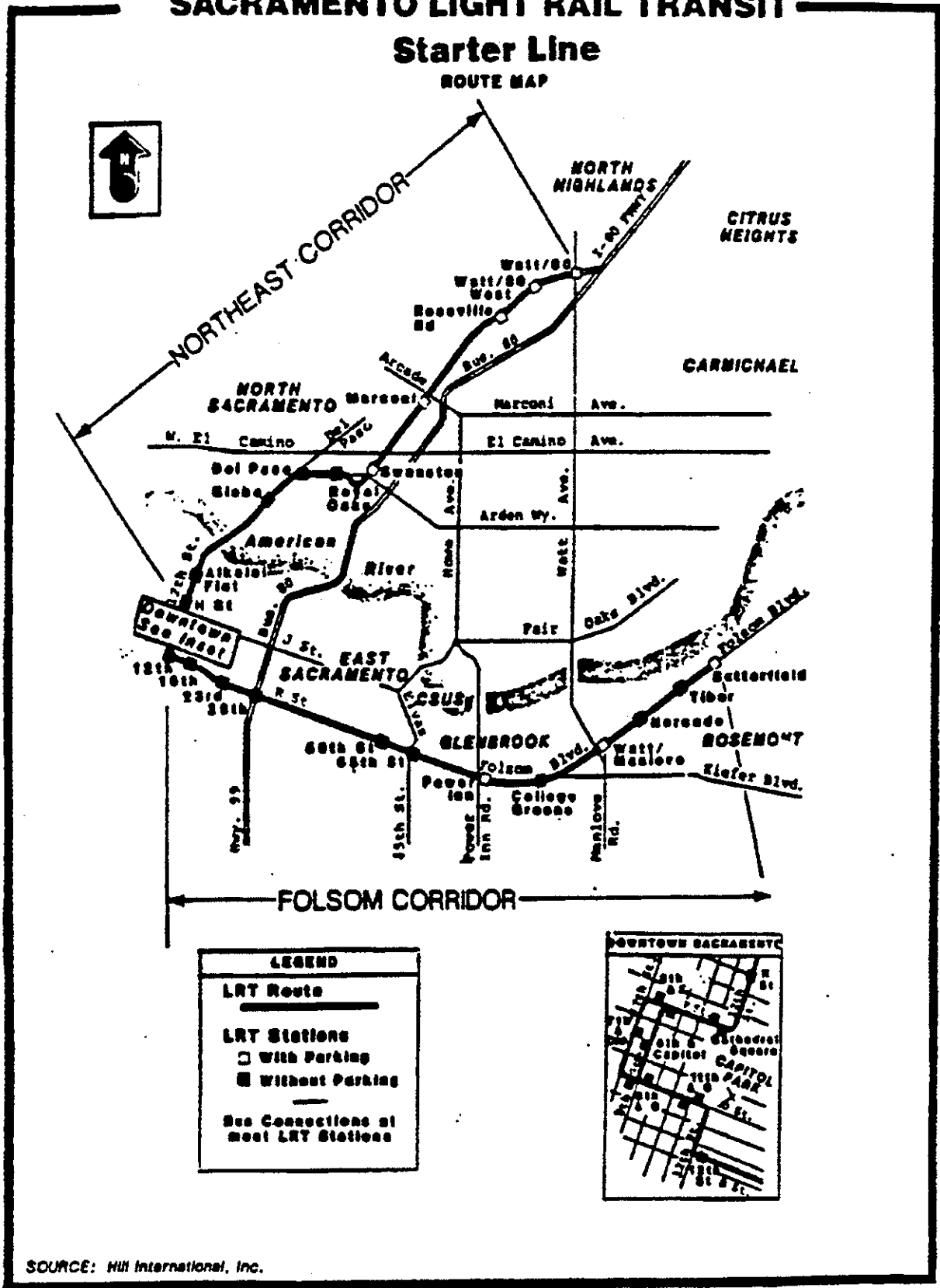
8.3 PROJECT ORGANIZATION

The Sacramento Regional Transit District was initially organized with a policy-making Governing Board of seven members, an Executive Director and a Project Director. CalTrans provided the bulk of the technical and management support for the project. Three months after groundbreaking, SRTD appointed a Manager of Light Rail Operations. By mid 1985, SRTD assumed total management responsibility for the project and set up a separate organization, the Regional Transit Development Division. Figure 13 depicts the organization of the transit development division. Note the heavy use of consultants in key positions - assistant general manager, project control, contract administration, track and roadbed design, and systems design.

SACRAMENTO LIGHT RAIL TRANSIT

Starter Line

ROUTE MAP



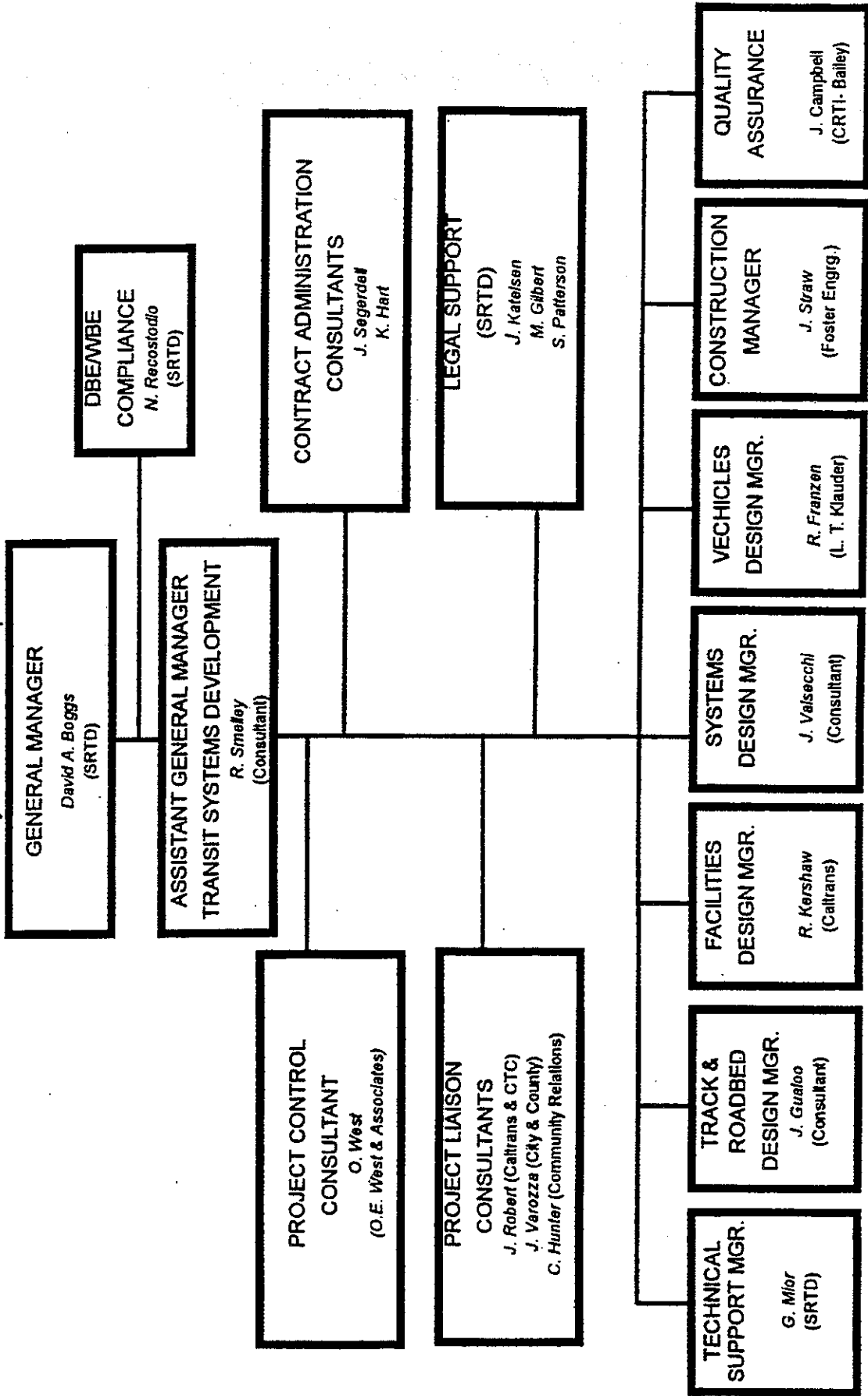
SOURCE: HMM International, Inc.

Figure 12 - Route Map

FIGURE 13. TRANSIT DEVELOPMENT DIVISION ORGANIZATION

SACRAMENTO REGIONAL TRANSIT DISTRICT

Transit Systems Development



SOURCE: Hill International, Inc.

8.4 KEY EVENTS/CHRONOLOGY

This section presents a brief overview of some of the key project events and their chronology.

- January 1981 - U.S. Secretary of Transportation signed a \$500,000 commitment to start engineering.
- March 1981 - Sacramento Transit Development Agency was formed to build a Light Rail Transit Starter Line.
- March 1983 - Ground was broken for system
- September 1983 - Full Funding Grant Agreement executed
- August 1985 - STDA was officially dissolved
- March 1987 - The Northeast Line was formally opened
- September 1987 - The Folsom Line was formally opened

8.5 PROJECT FINANCING

Financing for Sacramento is unique among the case study projects for the diversity of funding sources and the relatively low overall percentage of Federal funding. Figure 14, extracted from the PMO final report, details the sources of funding as of March 31, 1988. Major funding sources and percentages provided were:

• Federal Government	\$97,503,130	55.4%
• State of California	\$31,158,000	17.7%
• Local Governments	\$39,434,000	22.4%
• Private Funding	\$ 1,326,000	0.8%
• Funds Required	\$ 6,578,870	3.7%

Federal funding included \$7.9 M for planning, preliminary engineering, and final design activities. The actual construction grant under the Interstate Substitution provisions of Title 23 provided a total of \$84,913,130. As of the writing of the PMO report, \$6.5 M in additional funding was needed to meet forecast project costs.

Sources of Funding as of March 31, 1988

<u>Federal Government</u>	<u>Amount</u>	<u>Percent of Total</u>
Interstate Transfer-Planning	\$ 7,960,000	4.5
Interstate Transfer-Construction	84,913,130	48.2
Formula Grant	2,409,000	1.4
Federal Aid Interstate (FAI)	650,000	0.4
Federal Aid Urban Systems (FAU)	1,541,000	0.9
National Endowment for the Arts (NEA)	30,000	0.0
Total Federal Funds	\$97,503,130	55.4
State of California	\$31,158,000	17.7
Local Governments		
Sacramento Housing and Redevelopment Agency	\$22,301,000	12.7
Sacramento Regional Transit District (SRTD)	9,174,000	5.2
Reimbursement Account, City of Sacramento (RACS)	3,942,000	2.2
City of Sacramento - Other	2,403,000	1.4
County of Sacramento	1,160,000	0.7
Other Governmental Sources	454,000	0.3
Total Local Government Funds	\$39,434,000	22.4
Private Funding	\$1,326,000	0.8
TOTAL FUNDS SECURED TO DATE	\$169,421,130	96.3
Additional Funds Required		
Interstate Transfer-Construction (Pending)	\$3,231,530	1.8
Other Source(s)	3,347,340	1.9
Total Present Funding Requirement	\$6,578,870	3.7
TOTAL PROJECT BUDGET	\$176,000,000	100.0

SOURCE: Sacramento Regional Transit District (SRTD)

NOTE: Variation in addition of percent column due to rounding.

Figure 14. Sources of Funding as of March 31, 1988

More detail on the construction grants is provided in Exhibit 26 which shows the buildup in funding from 1983 to 1987 by major cost category. Note that this exhibit shows total grant funding, with Federal/Local contributions assumed to be split 85/15. Only three amendments are shown because the other two amendments were issued to make minor corrections, such as typographical or mathematical errors.

8.6 CAPITAL COST ESTIMATES

Three capital cost estimates were compared against closeout costs in Exhibit 27. Note the close clustering of the estimates between \$126 M and \$131 M even though they were developed with different levels of information at the time of: Final Environmental Impact Statement (FEIS), Preliminary Engineering (PE), and Final Design (FD). The level of detail offered in the three estimates differs significantly, with the FEIS unexpectedly providing the most detail.

Comparing the FD estimate against closeout costs shows significant underestimating of construction and construction management costs, administrative costs, force account, systems, and right-of-way. Surprisingly, there were overestimates of design/engineering and procurement.

8.7 PROJECT CAPITAL COST HISTORY

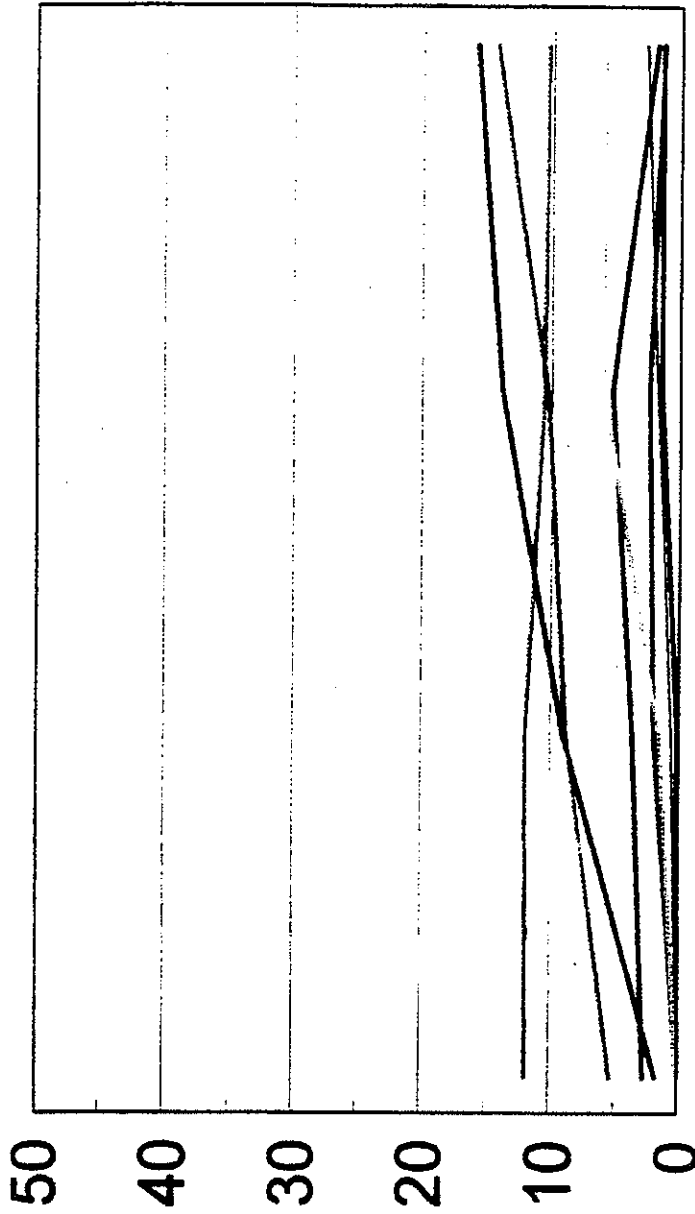
This section analyzes data provided in quarterly progress reports. Trends, variances, and major changes were analyzed considering the data on a detailed level. Unlike the other case studies, quarterly progress reports did not use a standard reporting format. Some interpretation of data was required in order to generate the time series exhibits. Data was tabulated and grouped according to the scheme indicated in the appendix to the case study.

Exhibit 28 compares approved project budgets and grant budgets by major cost category. Similar to the other case studies, there is little relationship between the project and grant budgets. Note the steep drop-off in approved budgets for contingencies and design/engineering between 1985 and 1986.

Approved budgets are compared with obligations in Exhibit 29. Note the significant lag between construction obligations and approved construction budgets up to 1986. Other cost categories appear to follow each other more closely.

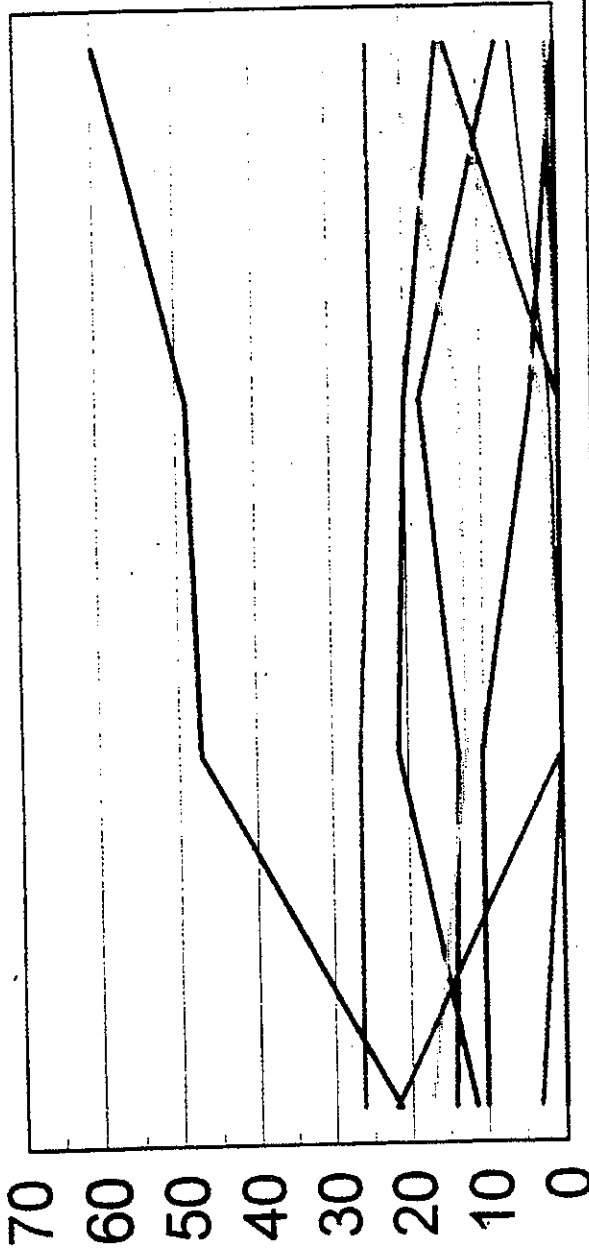
Comparing expenditures against approved budgets in Exhibit 30 shows an even greater difference for construction costs. Expenditures don't start approaching approved budgets for construction until 1987. Most expenditures seem to be in line with approved budgets, with the exception of a slight over expenditure in car purchases in 1987. Once again, design/engineering stands out for its somewhat unusual behavior.

\$M Exhibit 26. Construction Grant Buildup



	83 Base	84 Amend 1	85 Amend 3	87 Amend 5
Administration	0	600	1,776	2,824
Construction	7,000	18,000	32,736	45,363
Contingencies	2,734	3,734	5,415	1,977
Design/Engineering	0	100	1,500	1,500
Force Account	0	2,000	2,458	1,411
Procurement	0	1,600	6,069	6,069
Purchase Cars	11,880	12,000	10,675	10,481
Right Of Way	1,763	9,102	13,824	15,929
Systems	5,330	8,890	10,370	14,343
Total	28,707	56,026	84,823	99,897

\$M Exhibit 27. Estimates vs. Closeout Costs



	83 (FEIS)	83 (PE)	84 (FD)	87
Administration	0	0	1,123	5,788
Const. Mgmt	0	0	0	5,305
Construction	21,490	47,360	48,820	59,845
Contingencies	10,150	10,250	3,587	0
Design/Engineering	14,230	13,400	18,174	7,498
Force Account	0	0	2,000	14,741
Insurance	0	0	0	1,121
Procurement	11,500	21,290	20,099	15,425
Purchase Cars	26,370	26,370	24,352	24,579
Right Of Way	17,480	12,360	12,985	21,441
Systems	22,080	0	0	14,329
Testing	3,123	0	0	0
Total	126,423	131,030	131,040	170,072

FEIS-Final Environmental Impact Statement
 PE-Preliminary Engineering
 FD-Final Design

Exhibit 28. Approved Budgets vs Grants

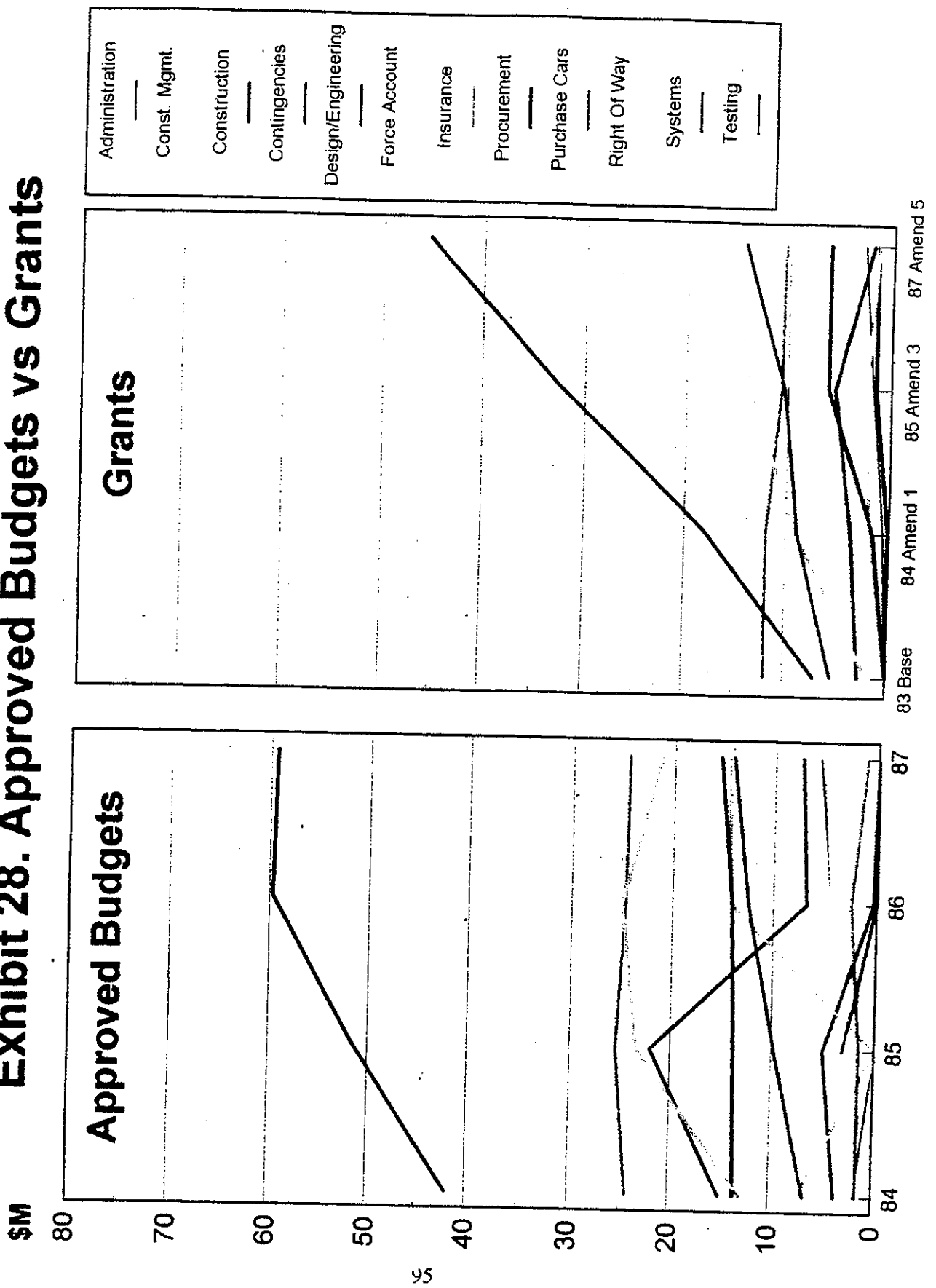


Exhibit 29. Current Budget vs Obligations

\$M

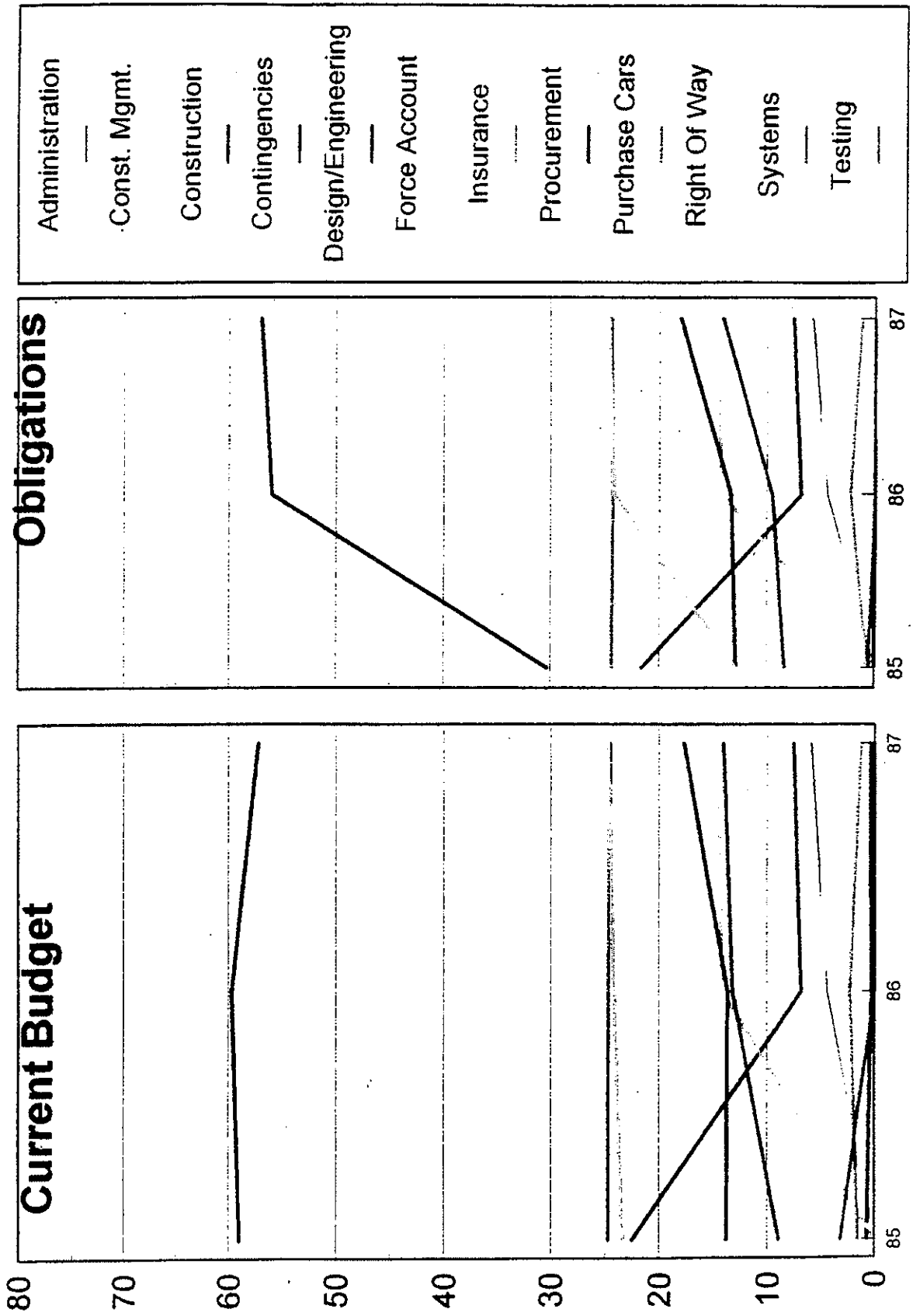
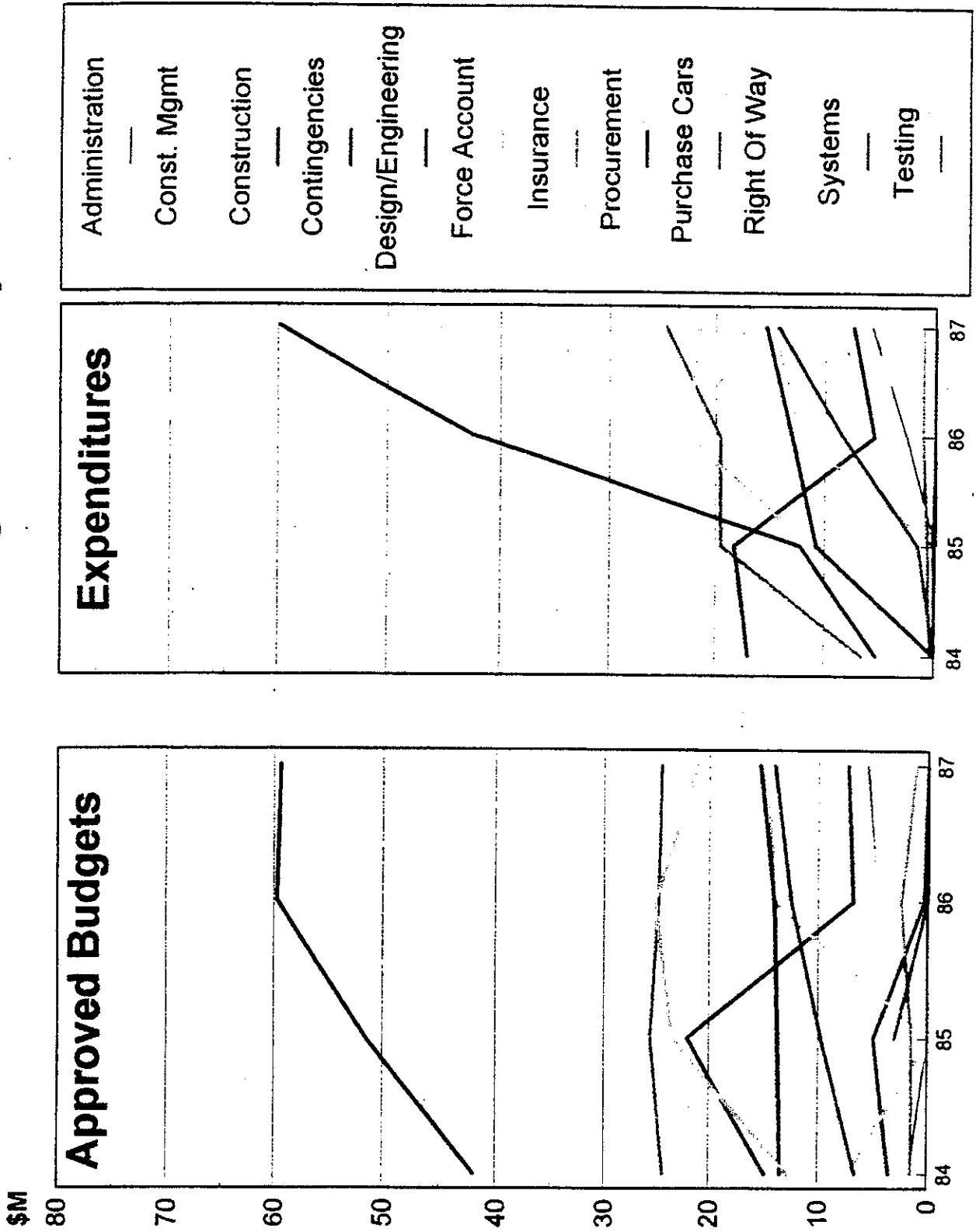


Exhibit 30. Approved Budgets vs Expenditures



Carrying the comparison through to look at expenditures against obligations, Exhibit 31 shows construction expenditures exceeding obligations in 1987. Note the deobligation of funds for design/engineering and the change in expenditures. This may indicate a change in accounting definition took place as part of the major reorganization in 1985.

Throughout the life of the project, there was significant reallocating of funds between accounts as evidenced by Exhibit 32. The magnitude and time period of these reallocations was considerably greater than the other projects studied.

8.8 DETAILED ANALYSIS OF SELECT COST CATEGORIES

Real estate acquisition turned out to be a troublesome area for Sacramento as demonstrated by Exhibit 33. Notice that the budget started out at about \$12M in 1984, rose steeply to about \$23M in 1985, increased to \$25M in 1986, and then finally closed out at about \$21M in 1987.

Contingencies exhibited some equally dynamic behavior. Exhibit 34 compares contingencies for grant budgets vs. estimates vs. approved budgets. Particular notice should be paid to an increase in the grant budget contingency from 1984 to 1985, while the approved budget showed a substantial drop in contingency from \$5M to \$331K.

Turning to soft costs, Exhibit 35 provides budget details for administration, construction management, design/engineering, insurance, and testing. The budget for 1985 was an anomaly because of the lack of line items for administration and construction management. Overall, the soft cost budget exhibit profiles a project that was in some trouble up to 1985, made some significant changes between 1985 and 1986 to bring the project under control, and completed the project under better control. Exhibit 36 compares soft cost budgets against expenditures over the project life cycle and shows some small overruns in 1987.

8.9 FINDINGS/HYPOTHESES

At the conclusion of its final report, the Sacramento Light Rail Transit Line PMO stated that the Transit Systems Development Division was capable of carrying out large-scale and complex mass transit improvement projects on time and within budget. Organizational learning had taken place during the period in which project management was revamped and additional controls were put in place. More specifically, project control and scheduling functions were strengthened, exposure to contractor claims was reduced, contract awarding and issuing Notice-to-Proceed were accelerated, and quality assurance was enhanced. Inadequacies in each of these areas had resulted in a project which was spiraling out of control with resulting escalation of capital costs.

Exhibit 31. Expenditures vs Obligations

\$M

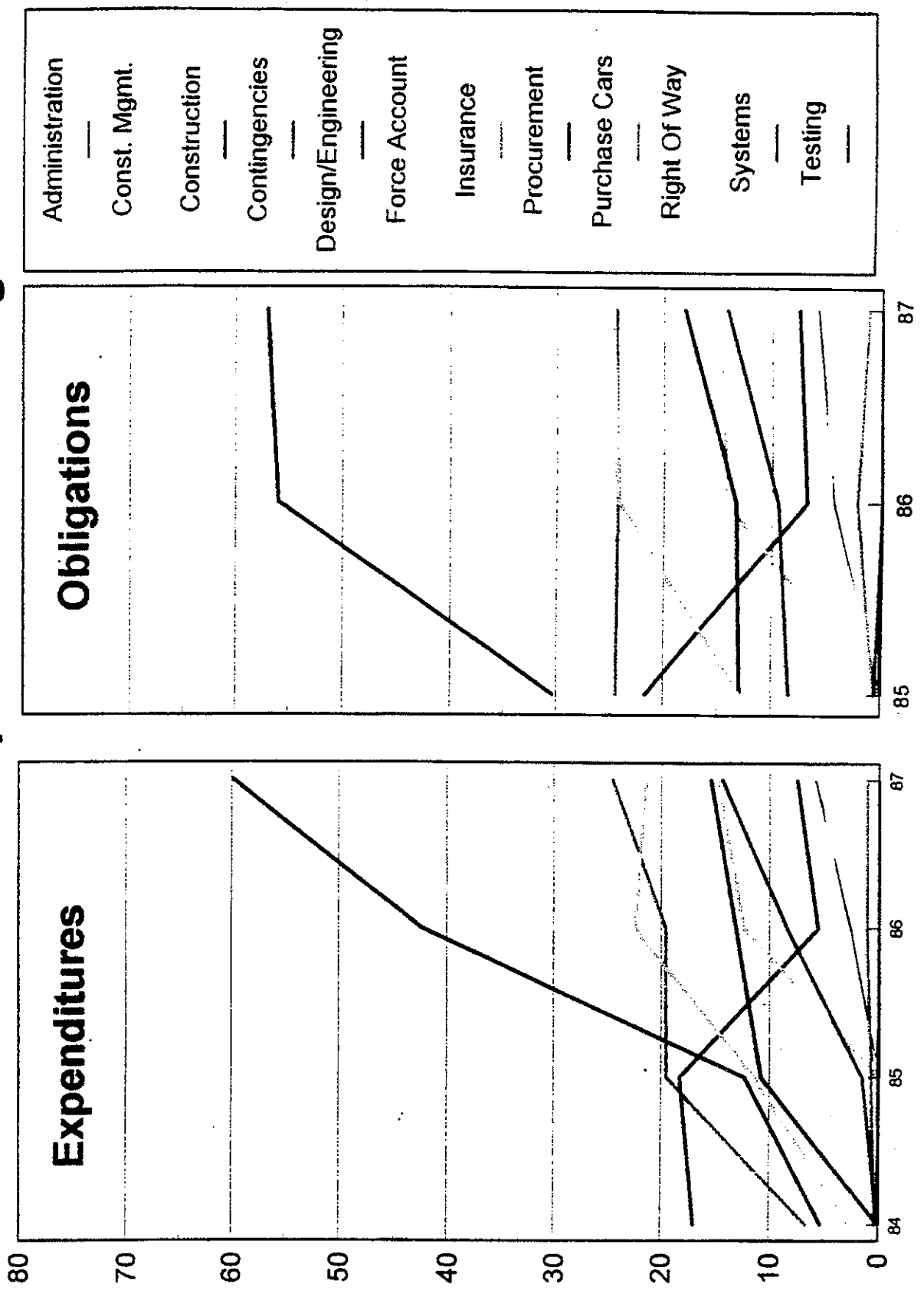
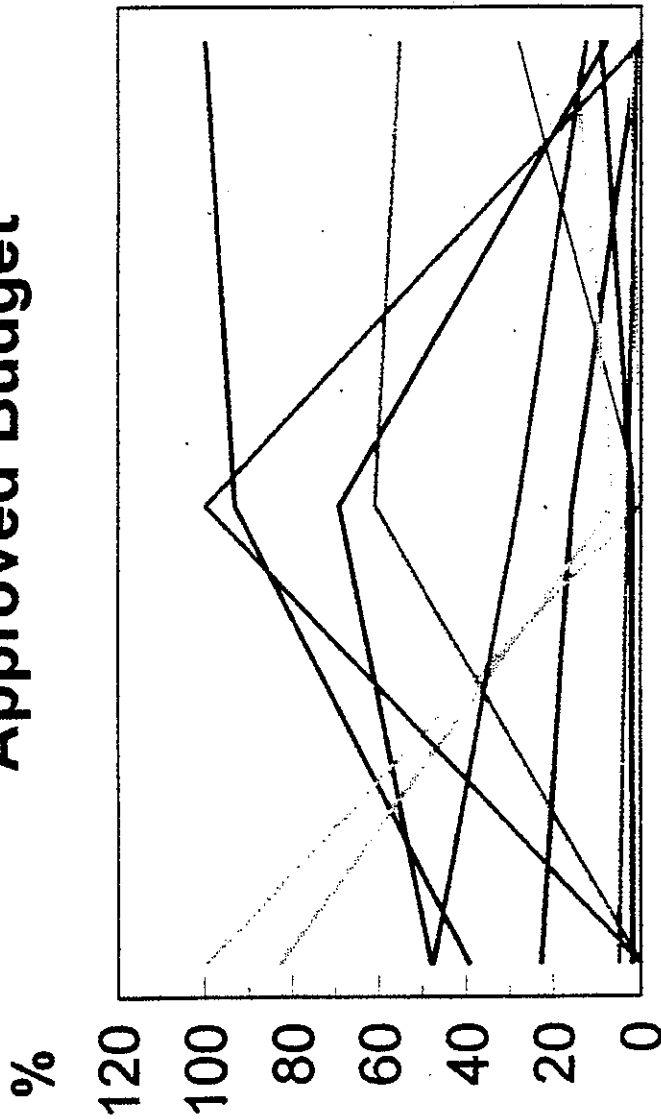


Exhibit 32. Reallocations: Total % Change of Approved Budget



	85	86	87
Administration	100.00%	0.00%	28.19%
Const. Mgmt.	100.00%	0.00%	21.76%
Construction	22.88%	15.86%	0.53%
Contingencies	39.39%	93.38%	100.00%
Design/Engineering	47.93%	69.14%	7.83%
Force Account	100.00%	0.00%	2.47%
Insurance	0.00%	61.29%	55.56%
Procurement	1.94%	2.03%	9.17%
Purchase Cars	5.00%	3.13%	0.95%
Right Of Way	62.84%	6.34%	15.36%
Systems	47.55%	28.18%	12.69%
Testing	0.00%	100.00%	0.00%
Total	547.54%	379.35%	254.50%

\$M Exhibit 33. ROW - Budgets vs Expenditures

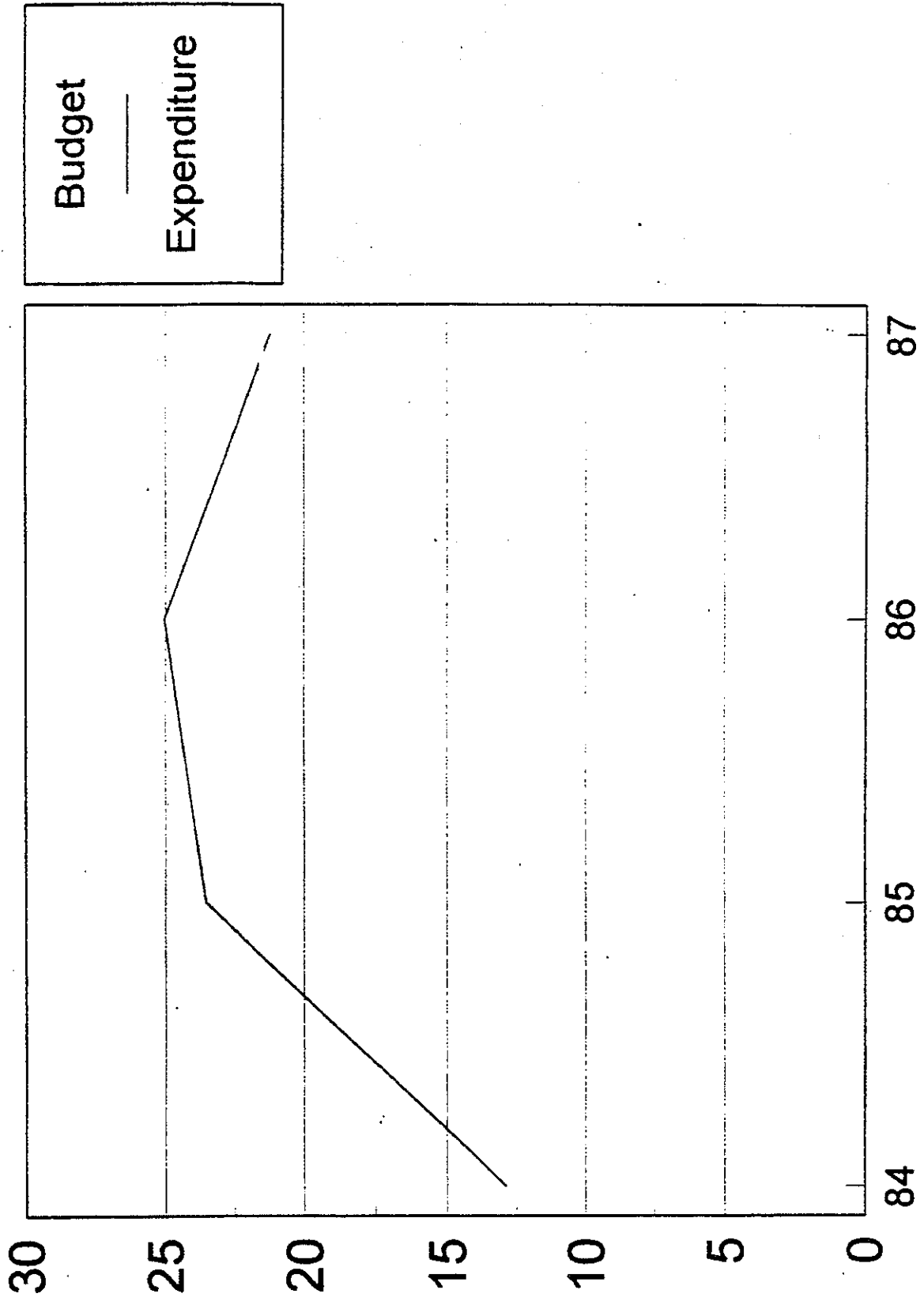
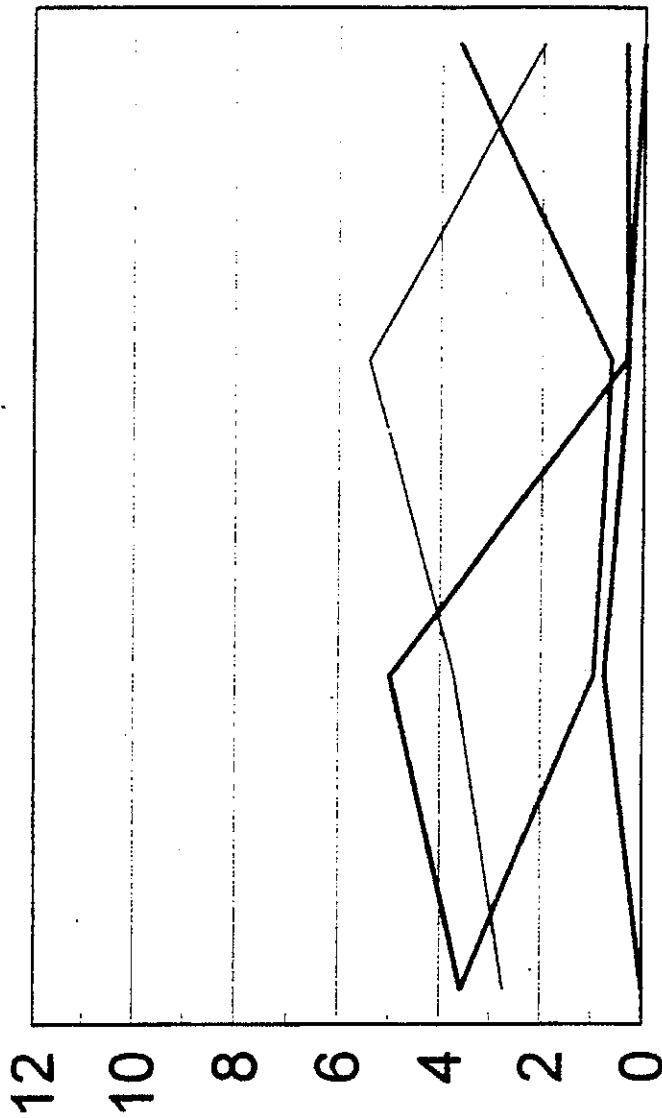


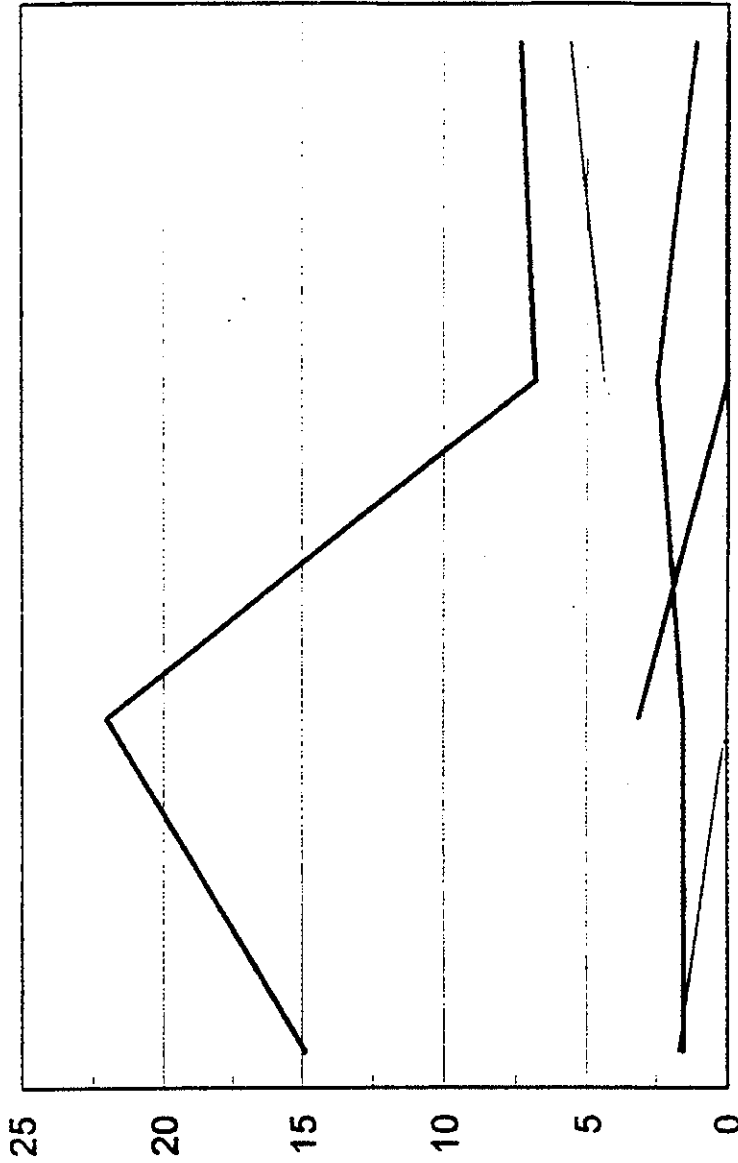
Exhibit 34. Contingencies

\$M



	84	85	86	87
Grant	—	3,734	5,415	1,977
Estimates	10,250	10,150	3,587	0
Approved	3,587	5,000	331	0
Hill	3,587	971	640	3,645
Current Expend	0	742	288	358

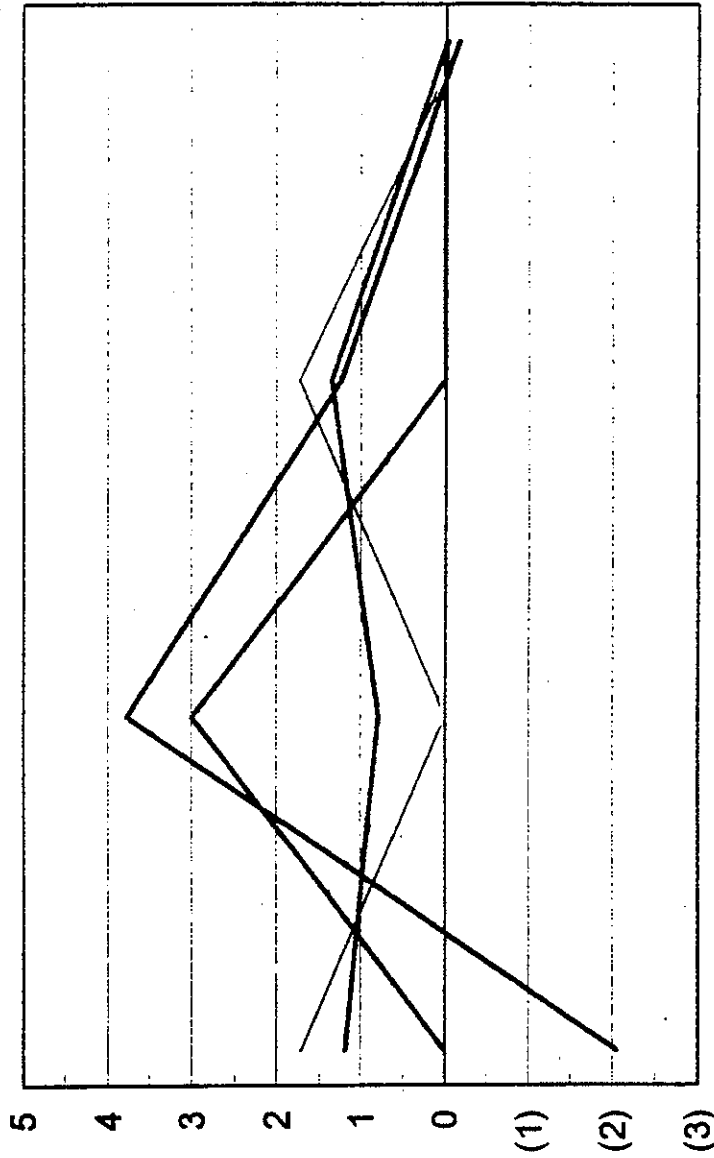
\$M Exhibit 35. Soft Cost: Budget



	84	85	86	87
Administration	1,726	0	4,377	5,611
Const. Mgmt	2,660	0	4,307	5,244
Design/Engineering	14,911	22,058	6,806	7,339
Insurance	1,550	1,550	2,500	1,111
Testing	0	3,123	0	0
Total Soft	20,847	26,731	17,990	19,305

Exhibit 36. Soft Costs: Budget - Expenditures

\$M



	84	85	86	87
Administration	1,726	0	1,738	(177)
Const. Mgmt	2,660	0	898	(61)
Design/Engineering	(2,047)	3,778	1,247	(159)
Insurance	1,199	803	1,360	(10)
Testing	0	3,003	0	0
Total	3,538	7,584	5,243	(407)

Appendix 8. Grouping Key

Group	DESCRIPTION	MACS CODE	CU#
A	Legal & Real Estate	20.08.00	48
A	Regional Transit Support	-	45D
A	Marketing	20.15.00	45D
A	Operations Support	20.13.00	45F
A	Operations Support	20.11.00	45F
A	General Administration Expense	20.15.00	45C
A	TSD-Mgmt. Admin & Eng.	20.15.00	45A
A	Operations Support	20.15.00	45F
A	Appraisers	20.08.00	49
A	TSD-Mgmt. Admin & Eng.	20.16.00	45A
A	Regional Transit	-	45A
A	Administration	20.15.00	45
A	Financing Charges	32.00.00	96
A	O Street Office & Misc Expenses	20.15.00	45B
C	18th/R - Stockton	20.13.00	4H
C	12th/K - 18th/R	20.13.00	4G
C	Arden/Del Paso - 12th/K	20.13.00	4E
C	Mali Demolition	20.10.00	4
C	Maint. Building	20.11.00	3
C	Line & Stas - Mayhew OH to Butte	20.13.00	5B
C	Trackwork Maintenance	20.13.00	2B
C	Line & Stas - Stockton to Mayhew	20.13.00	5C
C	Watt/80 Term.	20.11.00	6
C	Stations - NE Corr	20.11.00	7
C	Stations - Fol Corr	20.11.00	7A
C	No. Sac. Grade	20.13.00	1&1A
C	Shelters	20.11.00	7E
C	Parking Lots	20.11.00	7F
C	Misc. Civil Work	20.02.00	13A
C	Yard Grading	20.13.00	8
C	34th - Butterfield	20.13.00	5A
C	No. Sac. SPRR Relocation	20.13.00	1A
C	Grade Line-NE Corr	20.13.00	2
C	Watt/80 Median	20.13.00	2A
CM	Construction Management	20.08.00	44
CONT	Construction Contingency	-	98
CONT	General Contingency	32.00.00	99
D/E	TSD - Management	20.15.00	40
D/E	Program Control Consultant	20.08.00	42
D/E	System Integration	20.08.00	43
D/E	Management & Engineering	20.08.00	40
D/E	Surveying - NE Corridor	20.13.00	71A
D/E	Consultants	20.08.00	41
D/E	Design Consultants	20.08.00	46
FA	Caltrans Project Support	20.15.00	47
FA	Caltrans Project Support	20.16.00	47
FA	Metro Division (Operation & St.)	20.13.00	45E
FA	Metro Division	20.15.00	45E
FA	Metro Division	20.16.00	45E
I	Risk Management	20.11.00	50
I	Risk Management	20.08.00	50
P	Additional Graphics	20.11.00	71
P	Temp. Fencing	20.11.00	8A
P	Rubberized Safety Tile	20.11.00	7K
P	Yard Security	20.13.00	8B

P	Trejillo Way Fences	20.13.00	8C
P	Fare Vending Braile	20.02.00	7J
P	Additional System Signage	20.11.00	7H
P	Tree Grates	20.11.00	7G
P	Graphics	20.11.00	7D
P	Art Program	20.11.00	7C
P	Trees	20.11.00	7B
P	Trees	20.13.00	4B&4C
P	Add'l Fencing along NE Corr	20.13.00	8D
P	Wheel Truing Machine	-	18B-1
P	Art Program	20.13.00	7C
P	Line Maint. Equipment	20.03.00	18C
P	Copper Wire Procurement	20.14.00	21A0
P	Cable/Wire Proc.	20.14.00	21
P	Catenary/Poles	20.14.00	20
P	Substation Proc.	20.14.00	19
P	Procurement of Collection Van	-	18C-8
P	Booster pump for car wash	-	18C-7
P	Hyrrail Utility Body	-	18C-6
P	Car Cleaning Carts	-	18C-5
P	Utility Track	-	18C-4
P	Car Mover	-	18C-3
P	Sedans and Pickups	-	18C-1
P	Portable Re-railing Equipment	-	18B-4
P	One 2.5 Ton Forklift	-	18B-3
P	Rail Proc.	20.14.00	14A
P	Wheel Truing Machine	20.03.00	18B
P	Special Track Work	20.14.00	16
P	Tie Proc.	20.14.00	15
P	Direct Fix. Fstnrs	20.14.00	14C
P	OTM	20.14.00	14B
P	Portable Jacks and Body Stands	-	18B-2
P	Six Pickups	-	18C-2
PC	LRVs	20.01.00	17
ROW	Utility Relocation	20.13.00	70
ROW	ROW	20.06.00	60
S	LRT Signaling	20.02.00	10
S	Grade Crossings	20.02.00	10A
S	Traffic Signals	20.13.00	11
S	Security Equipment	20.02.00	13
S	Fare Vending Equipment Proc.	-	18A-1
S	Electrification	20.13.00	9
S	Fare Vend. Equipment	20.02.00	18A
S	Radio Proc.	20.02.00	12
T	Start-Up	-	45

SECTION 9.

CASE STUDY OF LOS ANGELES METRO RAIL PROJECT (MOS-1)

This case study deals with the initial project of the Los Angeles Metro Rail System. Termed "Minimum Operable Segment 1" or MOS-1, the project consisted of the design, construction, testing and start-up of operations for a 4.4 mile subsurface two-track rapid transit line including five stations.

In terms of technical requirements/risks, organizational complexity, and size of project budgets, MOS-1 is clearly the most complex undertaking analyzed among the five case studies. From a design point of view, the project team faced a number of challenges, including:

- Tunneling in a densely populated central business district beneath skyscrapers
- Establishing all-new design criteria for the mitigation of earthquakes
- Uncharted oil and natural gas wells that were abandoned in the early 1900s
- Unrecorded underground utilities from the development of downtown Los Angeles in the 1920s.

The project experienced a number of swings in terms of setbacks and successes, as will be reflected in the capital cost history.

9.1 PROJECT BACKGROUND/HISTORY

The Southern California Rapid Transit District (SCRTD) initiated a transit alternatives analysis for the regional core of Los Angeles in 1977. In September of 1979, the SCRTD Board of Directors selected its preferred alternative, an 18 mile rapid transit line extending from the central business district through the Wilshire Boulevard area to Fairfax Avenue, and then north through Hollywood to the San Fernando Valley. Preliminary Engineering was started in June 1980 with investigation of alternative configurations and estimation of costs.

In December of 1983, a Final Environmental Impact Statement evaluated the entire Metro Rail Project, an aerial option, and a minimum operable segment. The entire Metro Rail Project was found to be cost-effective, but the availability of Federal and matching local funds forced the project to be divided into three phases. Segment one, or the initial project phase, became known as "Minimum Operable Segment 1" or MOS-1.

SCRTD began the Metro Rail Project and oversaw initial feasibility studies, environmental impact work, and preliminary engineering. Federal participation in project funding began in 1986 along with final design and some preliminary construction work. Criticism of SCRTD's

project management started early in 1987. An unsuccessful attempt to consolidate SCRTD with the Los Angeles County Transportation Commission (LACTC) was tried in late 1987, but did not have sufficient political support.

By 1989, the continued poor performance of the project generated enough political support for an agreement to be reached between LACTC and SCRTD to transfer project management responsibility. A new organization, the Rail Construction Corporation (RCC), was activated in August of 1989 as an LACTC subsidiary. The RCC was given responsibility for the design, construction, and start-up of all rail transit systems within Los Angeles County. Despite this reorganization, FTA insisted that the SCRTD retain its fiduciary responsibility as Grantee for the project.

Both the SCRTD and LACTC were disbanded in 1992 through legislation and replaced by one agency, the Metropolitan Transit Administration (MTA), which assumed overall control of planning, design, construction and operation of rail and bus facilities in February 1993.

9.2 PHYSICAL DESCRIPTION OF PROJECT/ALIGNMENT

The MOS-1 project consisted of the design, construction, testing and start-up of operations for a 4.4 mile two-track heavy rail rapid transit line, all in subway. Five stations, a maintenance facility, a rail vehicle storage facility and thirty passenger vehicles were also included within the project's scope. Figure 15 shows the final alignment.

Soft ground tunneling techniques were used to construct the underground line segments, while cut-and-cover construction techniques were used to build stations and crossovers. Facility construction was divided into 15 major contracts.

Passenger vehicles are stainless steel, standard gauge, 75-foot-long rail cars, configured in dependent pairs. Each can accommodate up to 180 passengers, 59 seated, and are capable of operating at speeds up to 70 miles per hour.

9.3 PROJECT ORGANIZATION

Prior to July 1990, the Transit Systems Development (TSD) Department within SCRTD had responsibility for the design, construction and operation of the Metro Rail Project. Other organizations within SCRTD provided matrixed support (accounting, contracts administration and legal). Four consultant organizations were retained by TSD to round out the core team, including: a General Consultant, a Systems Engineering and Analysis Consultant, a Construction Management Consultant, and an Insurance Consultant.

A transition team was formed in February 1990 to facilitate transfer to the RCC. Construction and procurement contracts were transferred to RCC effective July 1, 1990. Responsibility for fiscal functions, oversight of quality and cost, and EEO activities remained with SCRTD.

The RCC was originally structured as a complete matrix organization. In early 1992, it was

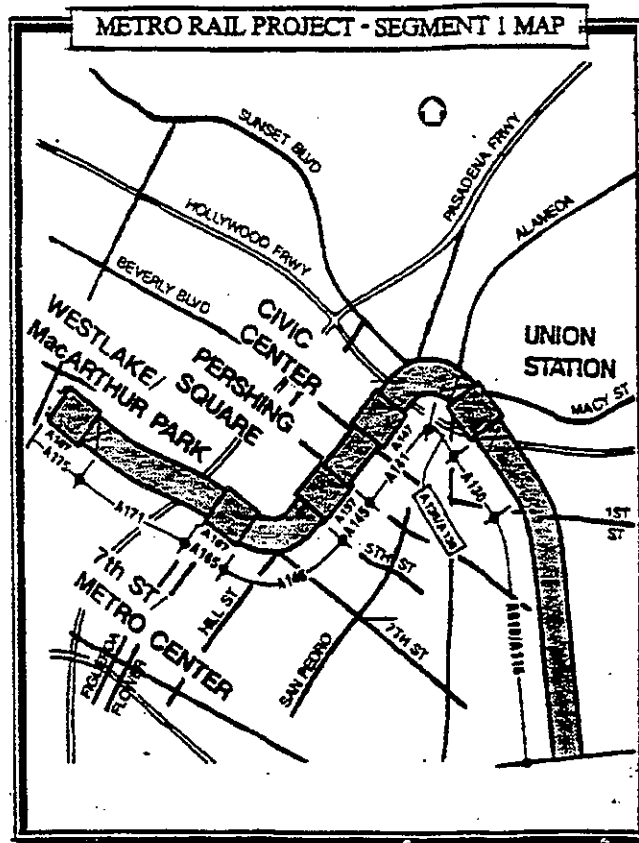


Figure 15. MOS-1 Map

restructured to a project/matrix organization to provide management and technical support to each Project Manager.

To augment its core staff, the RCC utilized an Engineering Management Consultant (EMC), a Construction Manager (CM), specialty consultants, and DBE subconsultants.

9.4 KEY EVENTS/CHRONOLOGY

This section presents a brief overview of some of the key project events and their chronology.

- December 1983 - Final Environmental Impact Statement issued.
- August 1986 - Full Funding Grant Agreement executed. Revenue Operation Date (ROD) scheduled for April 30, 1992. ROD is the date revenue operations are commenced.
- January 1988 - Scheduled ROD slipped to January 4, 1993 due to realignment at Union Station and unanticipated delays in bid/award of construction contracts.

- April 1988 - Design activities substantially completed. ROD changed to September 10, 1993 due to lack of progress on some major construction packages.
- July 1989 - Supplemental Environmental Impact Statement issued after realignment caused by a gas explosion
- July 1990 - Design and construction activities transferred to RCC
- April 1991 - RCC sets target for ROD at June 1993
- September 1991 - Tunnel work and track installation complete
- June 1992 - RCC revises ROD to March 1993
- January 1993 - Actual ROD

9.5 PROJECT FINANCING

Funding related to MOS-1 began in June of 1980 with the start of preliminary engineering. Incremental funding was provided in 82, 83, and 84. In August of 1986, the FTA entered into a Full Funding Grant Agreement (FFGA) with the SCRTD under which the FTA would provide \$695.9M toward the estimated cost of \$1.25B. The City of Los Angeles, LACTC and the State were obligated to provide \$218M to match the federal funding as well as give assurances to independently fund the remaining portion of the undertaking.

Los Angeles County voters authorized an increase in the sales tax of one half percent in 1980 to help fund the transit system development. In addition, a special Benefit Assessment Tax District was established and administered by SCRTD.

Exhibit 37 depicts by major cost category, the buildup of the grant budget for the FTA funded portion of the project over time. Note that the amendments dated 9/28/84 and 3/9/92 did not increase the funding level, but redistributed funds previously allotted.

Exhibit 38 shows the status of funds by major funding source starting in 1987. This exhibit confirms the time gap between obligation of funds and the expenditure of those funds. Also note the formation of a cost overrun account in 1991. MTA assumed LACTC's share of responsibility for funding the overrun account in February of 1993; the City had the remaining responsibility.

9.6 CAPITAL COST ESTIMATES

Estimates for project cost were collected for four points in time: at the FEIS in 1983, a working estimate developed in May 1984, the estimate associated with the Supplemental Environmental Impact Statement of July 1989, and a forecast made in December of 1990. Estimates for 1983

Exhibit 37. Grant Budget Buildup

\$M

500

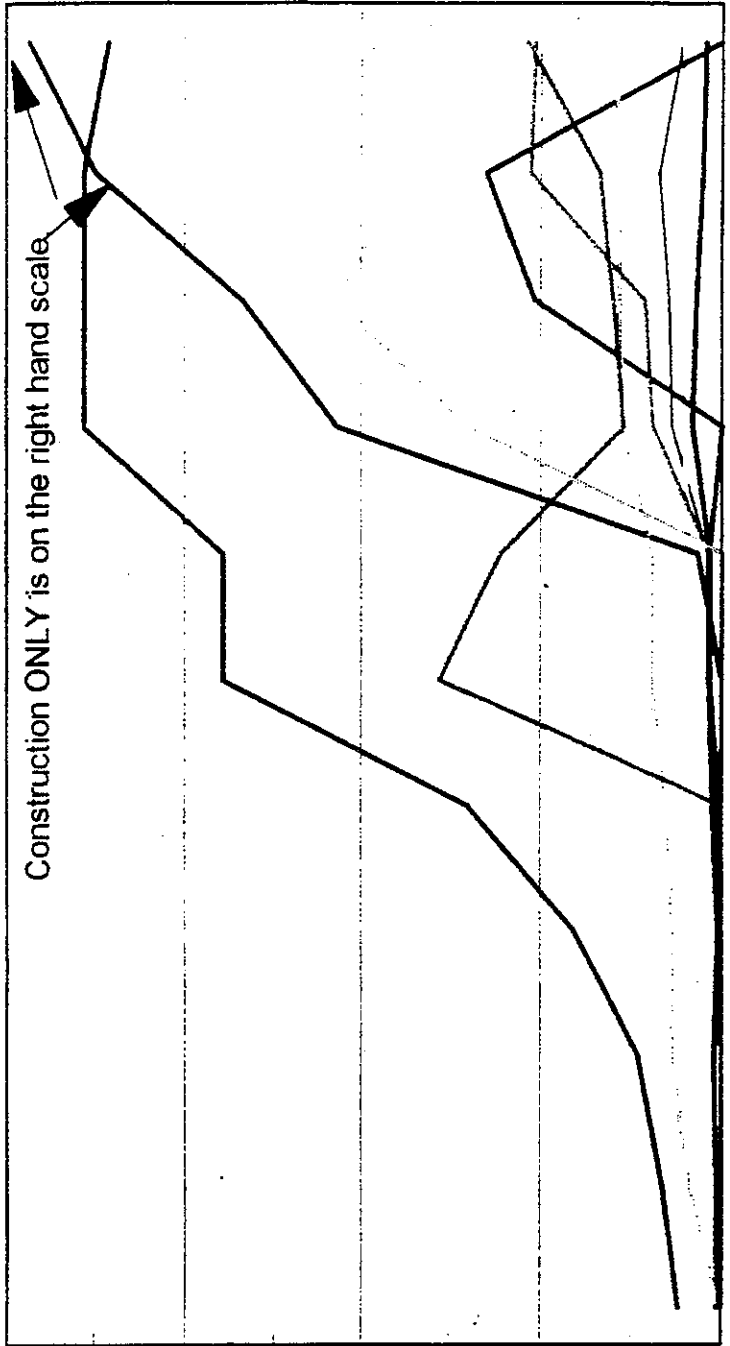
400

300

200

100

0



\$M

200

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100

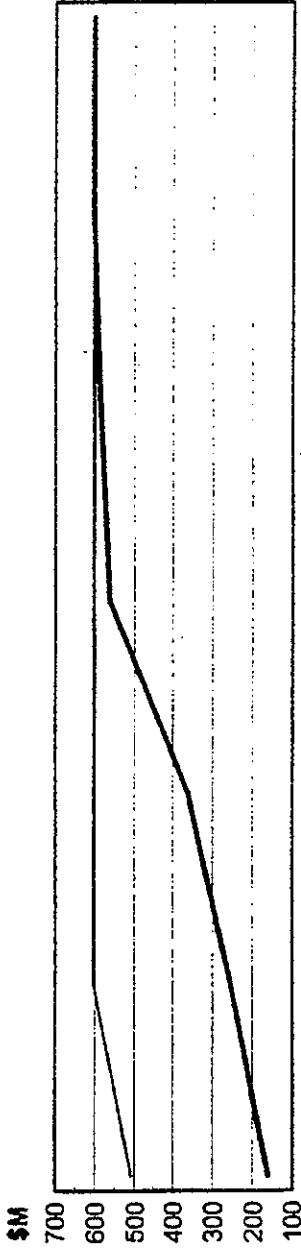
50

0

	06/04/80	(1) 05/26/82	(2) 07/15/82	(3) 09/24/82	(4) 04/01/83	(5) 05/29/84	(6) 09/28/84	(7) 09/26/86*	(8) 12/07/87	(9) 09/30/88	(9-3) 03/09/92
Admin	195	0	0	892	2,675	4,175	4,175	13,987	14,720	17,560	11,048
Const. Mgmt	0	0	0	0	0	9,000	9,000	10,947	10,526	10,526	10,802
Construction	0	0	0	0	0	0	17,000	267,516	335,011	436,073	483,569
Contracting	1,365	1,563	2,132	1,037	2,537	3,537	3,537	0	51,983	64,987	0
Design/Eng	12,000	16,656	23,145	40,958	69,958	139,475	139,475	177,771	177,771	177,771	171,000
Force Acc	1,000	9,032	13,566	13,766	15,916	19,416	19,416	27,786	28,431	28,431	30,081
Insurance	0	0	0	0	0	4,000	4,000	19,335	21,565	53,071	51,835
Procure	440	0	0	940	840	3,360	3,360	8,303	7,228	5,492	4,574
ROW	0	0	0	0	0	77,863	60,863	27,395	30,332	33,936	53,926
Systems	0	0	0	0	0	100	100	70,297	108,252	86,527	97,538
Total	15,000	27,251	38,843	57,593	91,926	260,926	260,926	623,337	785,819	914,374	914,373

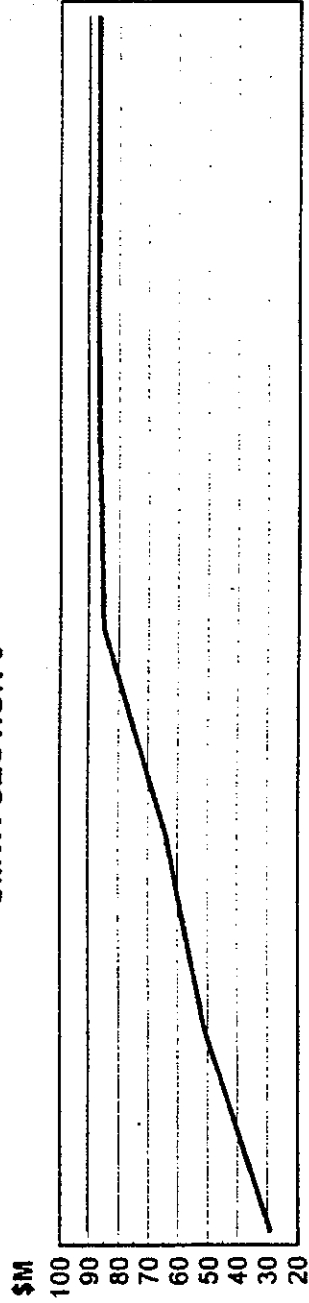
Exhibit 38. Status Of Funds

UMTA-SECTION 3



	87	88	89	91	92	93	94
Funds Approved —	510,051	605,299	605,299	605,300	605,300	605,300	605,300
Expenditures —	160,919	257,167	363,084	564,421	587,029	605,300	605,300

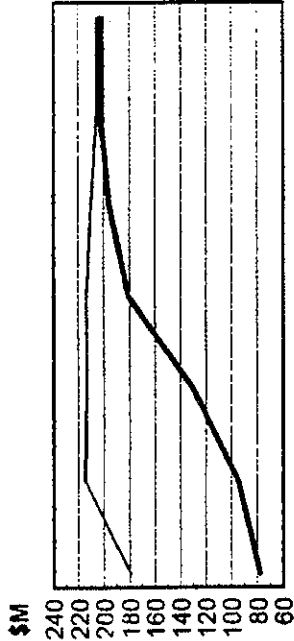
UMTA-SECTION 9



	87	88	89	91	92	93	94
Funds Approved —	90,583	90,583	90,583	90,584	90,584	90,584	90,584
Expenditures —	29,264	51,435	64,755	85,330	86,716	87,006	87,006

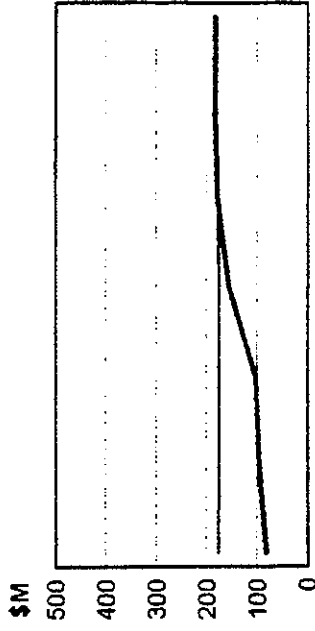
Exhibit 38. Status of Funds (Continued)

STATE



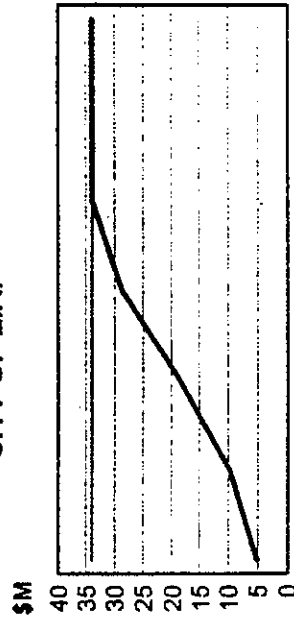
	87	88	89	91	92	93	94
Funds Approved	179,537	214,015	214,016	214,016	210,268	206,077	206,077
Expenditures	77,990	95,019	130,656	181,511	195,830	203,320	203,320

LACTC



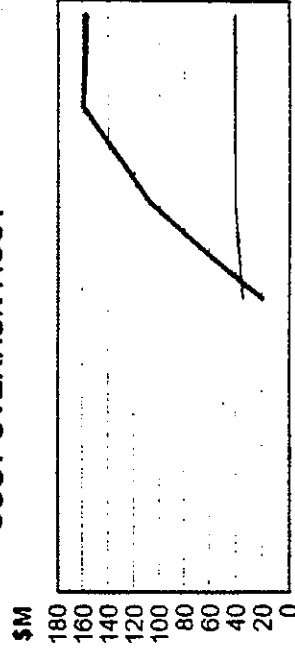
	87	88	89	91	92	93	94
Funds Approved	176,639	175,700	175,700	175,701	179,448	183,639	183,639
Expenditures	81,434	96,579	103,103	156,104	179,448	183,639	183,639

CITY OF L.A.



	87	88	89	91	92	93	94
Funds Approved	34,000	34,000	34,000	34,000	34,000	34,000	34,000
Expenditures	5,201	9,755	18,548	28,835	34,000	34,000	34,000

COST OVERRUN ACCT



	87	88	89	91	92	93	94
Funds Approved	34,818	34,818	34,818	40,902	41,302	41,302	41,302
Expenditures	20,125	107,669	160,057	160,057	160,057	160,057	157,429

and 1984 did not include escalated values as line items, permitting escalation using latest available Means data. The other estimates escalated individual values and were thus used as presented in the original documentation. Note that the level of detail presented in the estimates differed significantly, resulting in the cost grouping scheme appearing in Exhibit 39 and Table 22. Table 22 displays estimate accuracy—the numbers represent how much of a difference there was between each estimate and the 1993 costs to date.

	FEIS 12/05/83	Working est 5/29/84	SEIS 7/89	Forecast 12/31/90
Construction Procurement	82.57%	-15.62%	-18.58%	1.58%
Contingencies Design/Eng. Construct Mgmt	2.78%	-37.41%	-17.17%	63.06%
Insur. Agency Other	-20.74%	49.74%	11.44%	
Right-Of-Way	-1.22%		-40.38%	0.97%
Total	40.42%	-22.63%	-0.1808	3.20%

Table 22. Estimates vs 93 Costs to Date

The original FEIS included consideration of all three segments of the Metro system. Isolating costs for just MOS-1 was complex because of difficulty in allocating preliminary engineering costs between segments. The estimate includes a design contingency of 15% for facilities and 10% for systems. Design and construction management were estimated at 13% for facilities and 10% for systems.

In the SEIS, contingency was estimated at 10% of the total escalated project cost. Design and construction management were estimated at 15% of facility cost. For systems, design and construction management were estimated at 10% of cost.

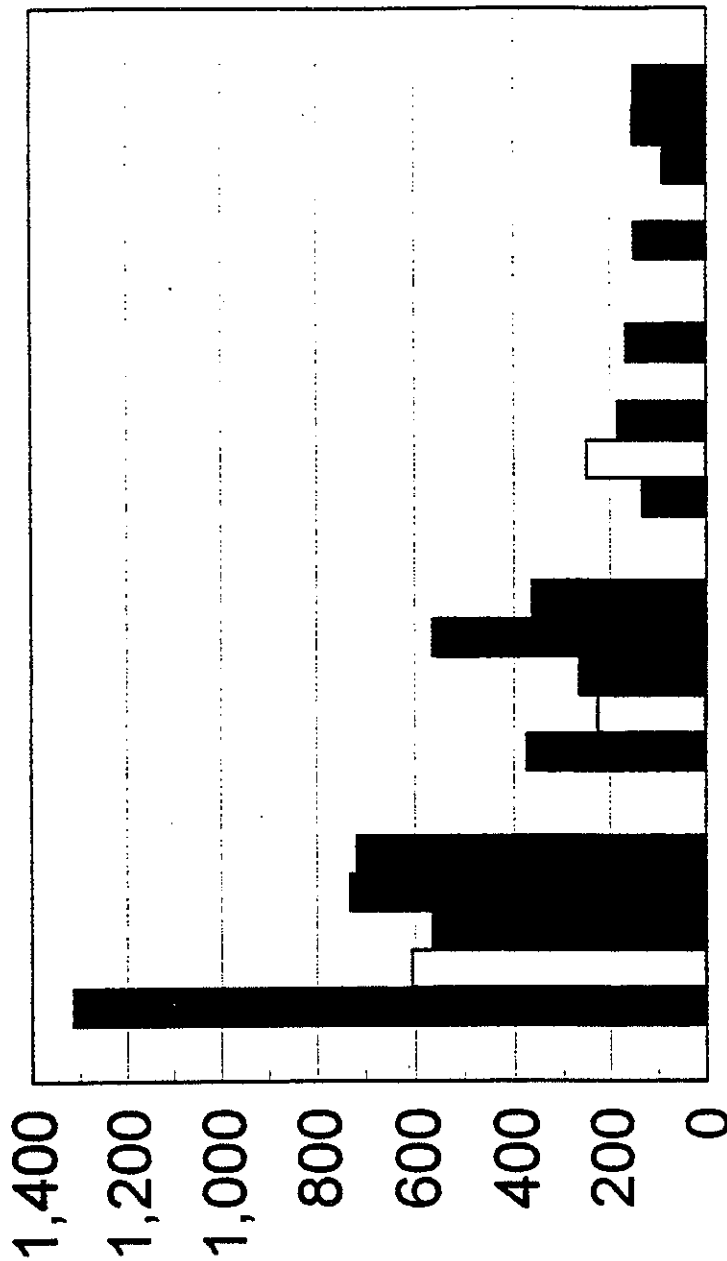
9.7 PROJECT CAPITAL COST HISTORY

This section analyzes data provided in quarterly progress reports. Figure 16 is a typical summary page extracted from one of the reports to indicate the basic format used. The trends, variances, and major changes discussed in this case study were derived from combining detailed level data into major cost groups. Appendix 9 details the grouping scheme utilized for Los Angeles.

Exhibit 40 presents a condensed picture of a project with significantly increasing budgets through 1991. Construction, design/engineering, administration, construction management, and right-of-way stand out for the magnitude of their increases. The intersection between administration and force accounts leads one to speculate that there was a change in account definition that took place with the transition to the RCC. Exhibit 41 provides a more focused look at these cost categories, with the exception of construction. 1990 is clearly the start of a new management philosophy and new budget. Exhibit 42 confirms this transition point through the large percentage of account reallocations performed in 1990 and in 1991.

Exhibit 39. Estimates vs. 93 Costs to Date

\$M



	Const/Procurement	Cont/Design Mgmt	Insurance/Agency/Oth	Right Of Way
FEIS- 12/05/83	1,314,466	374,685	133,031	150,794
Working est-5/29/84	607,510	228,198	251,325	0
SEIS-7/89	566,167	267,083	187,041	91,020
Forecast-12/31/90	731,333	565,122	0	154,136
93 Costs	719,962	364,566	167,844	152,657

RAIL CONSTRUCTION CORPORATION
PROJECT COST REPORT
COST BY ELEMENTAL ITEM

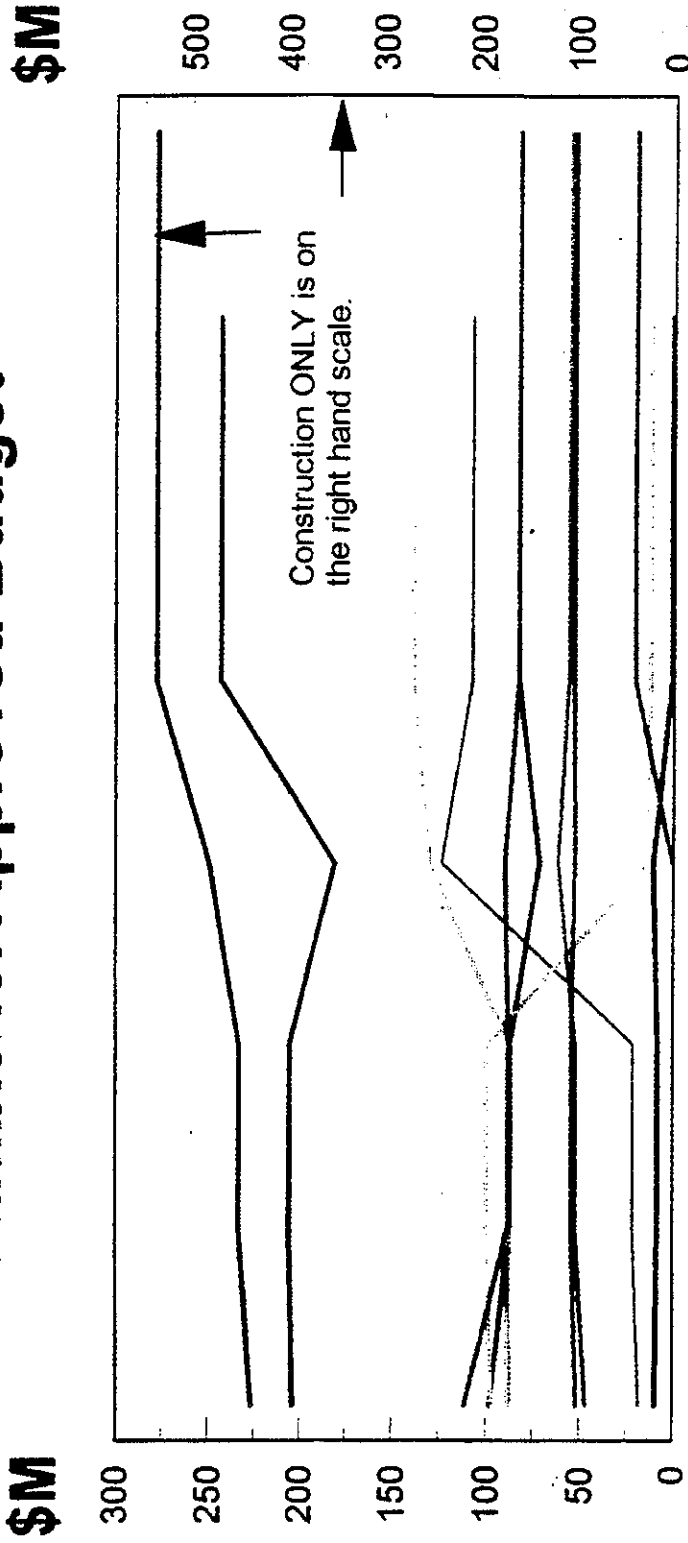
STATUS PERIOD: NOVEMBER 30, 1961 TO DECEMBER 27, 1961
 STATUS DATE : DECEMBER 27, 1961
 UNITS : DOLLARS IN THOUSANDS

PROJECT : NEW METRO RAIL REQUIREMENT I
 ELEMENT : T CONSTRUCTION

LINE ITEM	DESCRIPTION	ORIGINAL BUDGET		CURRENT BUDGET		COMMITMENTS		INCURRED COST		EXPENDITURES		CURRENT FORECAST		VARIANCE (11-3)
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	
01	UNDERWAY/STRUCTURE/PAC	240,550	0	410,127	1,557	344,059	4,250	382,920	12,300	301,444	075	401,828	45,000	
02	MAINTENANCE FACILITIES	123,007	0	87,803	722	71,003	210	77,070	115	75,007	1,278	81,287	(5,016)	
03	HAZARDOUS MATERIAL HANDLING	0	0	2,700	0	2,400	0	1,700	2	1,610	0	2,320	31	
04	VEHICLE ALLOCATIONS	5,003	0	1,253	0	1,000	0	1,002	0	1,002	0	1,000	127	
05	ALL PASSENGER VEHICLES	51,405	0	83,742	0	61,003	0	21,430	1	21,234	0	55,212	1,070	
06	ELECTRIFICATION	12,347	0	13,501	103	16,003	310	16,403	351	16,200	114	16,705	2,374	
07	GYE/STORAGE EQUIPMENT	50,564	0	80,010	1,510	53,011	1,770	47,233	1,655	40,243	20	71,400	1,000	
08	TRACKWORK	10,640	0	31,315	97	30,531	0	31,273	0	31,170	(174)	24,037	(3,000)	
09	TESTING AND OPERATIONS	0	0	20,044	14,501	11,455	243	1,230	203	1,250	100	20,004	507	
10	OWNER'S EXPENSE	40,430	0	50,010	404	60,543	404	60,542	404	60,642	0	61,035	5,053	
	T CONSTRUCTION	516,150	0	751,372	16,095	706,611	7,110	677,950	15,840	677,504	2,722	707,514	46,642	

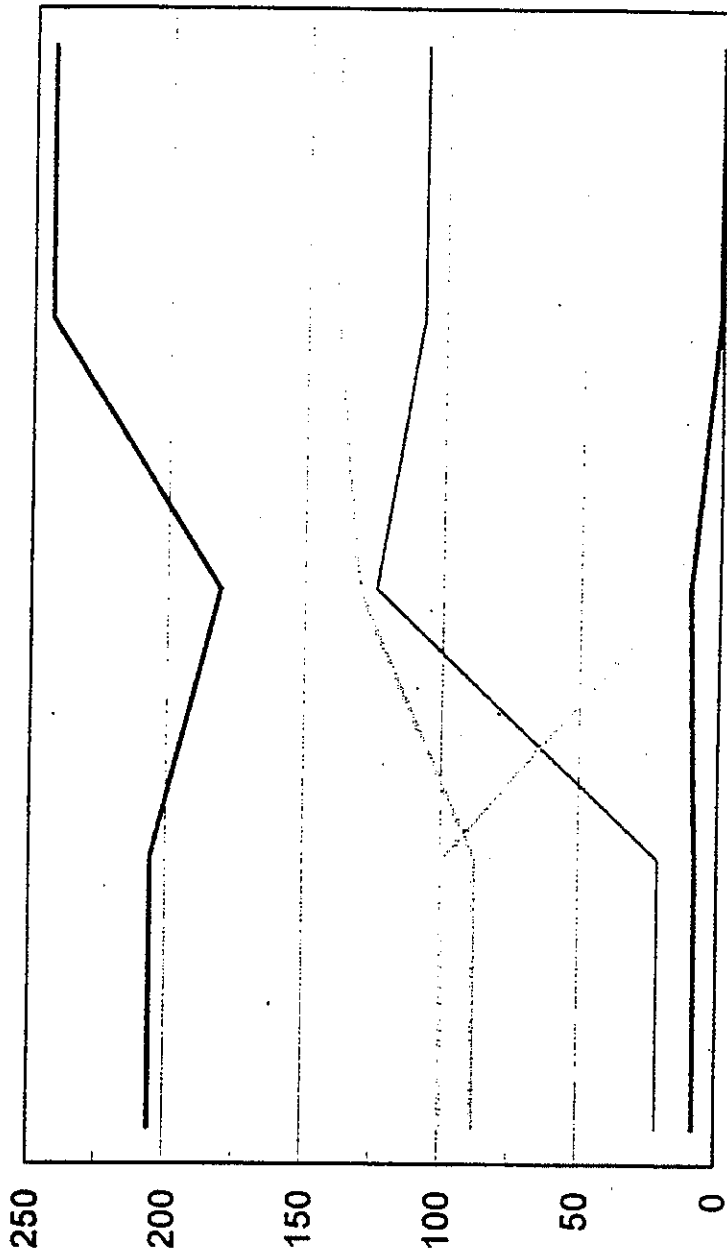
Figure 16. Quarterly Progress Report

Exhibit 40. Approved Budget



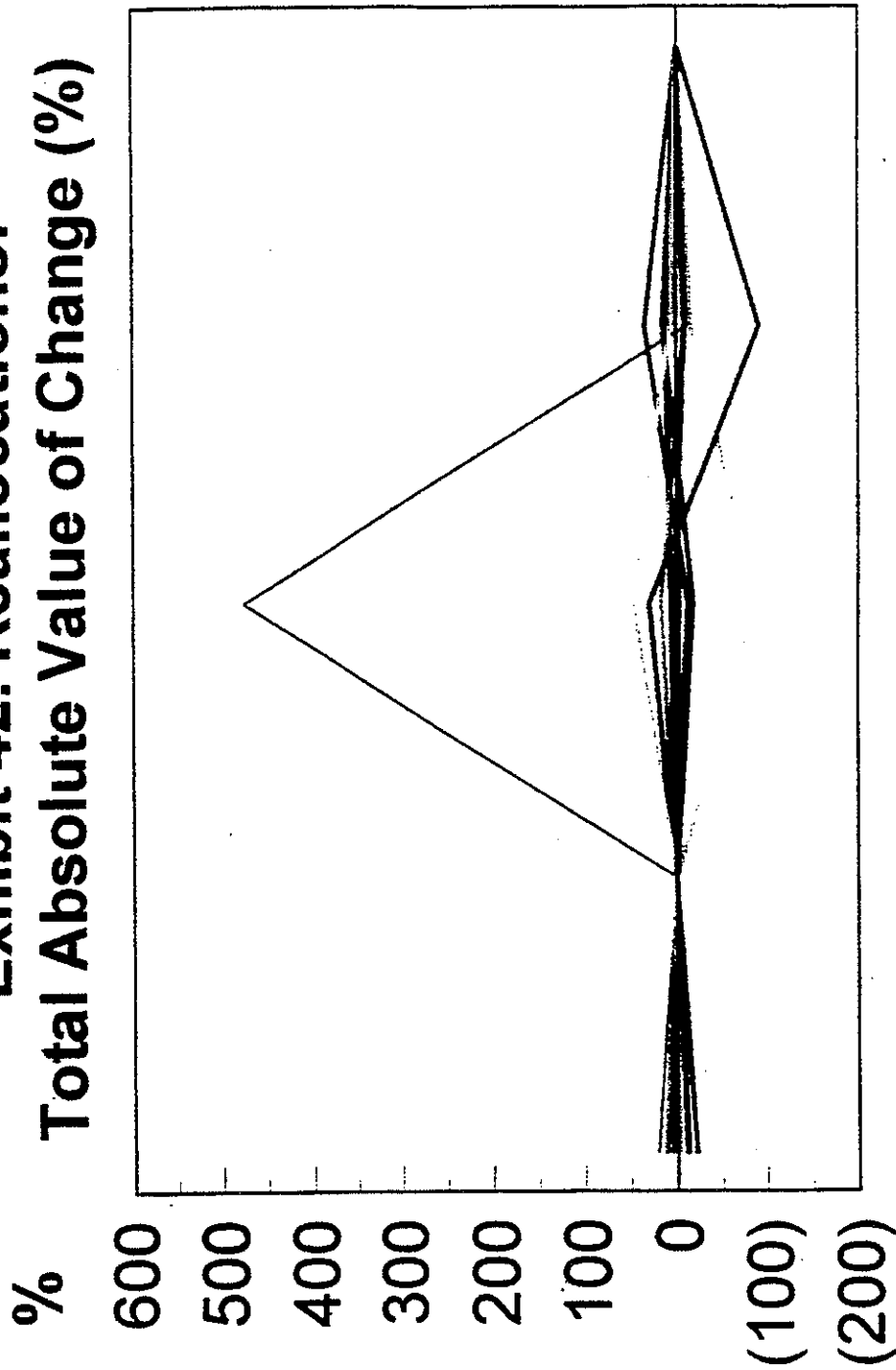
	87	88	89	90	91	92	93	94
Administration	17,902	21,548	21,548	124,412	107,939	107,939	107,939	
Const. Mgmt	85,488	92,070	92,070	131,116	110,828	110,828	110,828	
Construction	438,347	451,379	451,379	482,283	537,117	537,117	537,117	537,117
Contingencies	98,031	87,528	87,528	72,041	83,209	83,209	83,209	
Design/Engineering	204,057	205,638	205,638	181,141	243,163	243,163	243,163	
Force Account	97,504	99,748	99,748	14,425	12,140	12,140	12,140	
Insurance	47,089	53,071	53,071	62,339	56,888	56,888	56,888	
Procurement	9,104	8,184	8,184	10,649	948	948	948	
Purchase Cars	52,263	54,616	54,616	53,423	53,742	53,742	53,742	
Right-Of-Way	88,751	87,965	87,965	131,047	139,820	139,820	139,820	
Systems	111,364	88,153	88,153	90,385	83,281	83,281	83,281	
Testing				639	20,944	20,944	20,944	
Total	1,249,900	1,249,900	1,249,900	1,353,900	1,450,019	1,450,019	1,450,019	751,972

\$M Exhibit 41. Approved Budget (Focused)



	88	89	90	91	92
Administration	21,548	21,548	124,412	107,939	107,939
Const. Mgmt	92,070	92,070	131,116	110,828	110,828
Design/Engineering	205,638	205,638	181,141	243,163	243,163
Force Account	99,748	99,748	14,425	12,140	12,140
Procurement	8,184	8,184	10,649	948	948
Right-Of-Way	87,965	87,965	131,047	139,820	139,820

Exhibit 42. Reallocations: Total Absolute Value of Change (%)



	88	89	90	91	92
Administration	20.37%	0.00%	477.37%	-13.24%	0.00%
Const. Mgmt	7.70%	0.00%	42.41%	-15.47%	0.00%
Construction	2.97%	0.00%	6.85%	11.37%	0.00%
Contingencies	-10.71%	0.00%	-17.69%	15.50%	0.00%
Design/Engineering	0.77%	0.00%	-11.91%	34.24%	0.00%
Insurance	2.30%	0.00%	-85.54%	-15.84%	0.00%
Procurement	12.70%	0.00%	17.46%	-8.74%	0.00%
Purchase Cars	-10.11%	0.00%	30.12%	-91.10%	0.00%
Right Of Way	4.50%	0.00%	-2.18%	0.60%	0.00%
Systems	-0.89%	0.00%	48.98%	6.69%	0.00%
Total	-20.84%	0.00%	508.40%	-7.86%	0.00%

With respect to the pace of expenditures, approved budgets were adequate through 1991 (see Exhibit 43), with the exception of design/engineering in 1990 (in deficit by over \$13M). Beginning in 1992, expenditures began exceeding approved budgets in certain categories: construction management, construction, and systems. 1993 saw budget shortfalls also in design/engineering, insurance, and right-of-way. Note that the overall budget remained adequate through 1993, despite these group shortfalls.

Clearly, the need for budget increases did not come as a surprise starting in 1989. Exhibit 44 traces the difference between approved budgets and forecasted budgets by major cost group. Groups experiencing budget problems stand out clearly in this exhibit: construction, construction management, design/engineering, right-of-way, and systems.

9.8 DETAILED ANALYSIS OF SELECT COST CATEGORIES

This section will consider the cost categories of real estate, soft costs, and contingency in more detail. Exhibit 45 shows the \$43M increase in the real estate budget in 1990 and the accompanying increase in expenditures. Real estate expenditures exceeded the real estate budget in 1993 by almost \$3M.

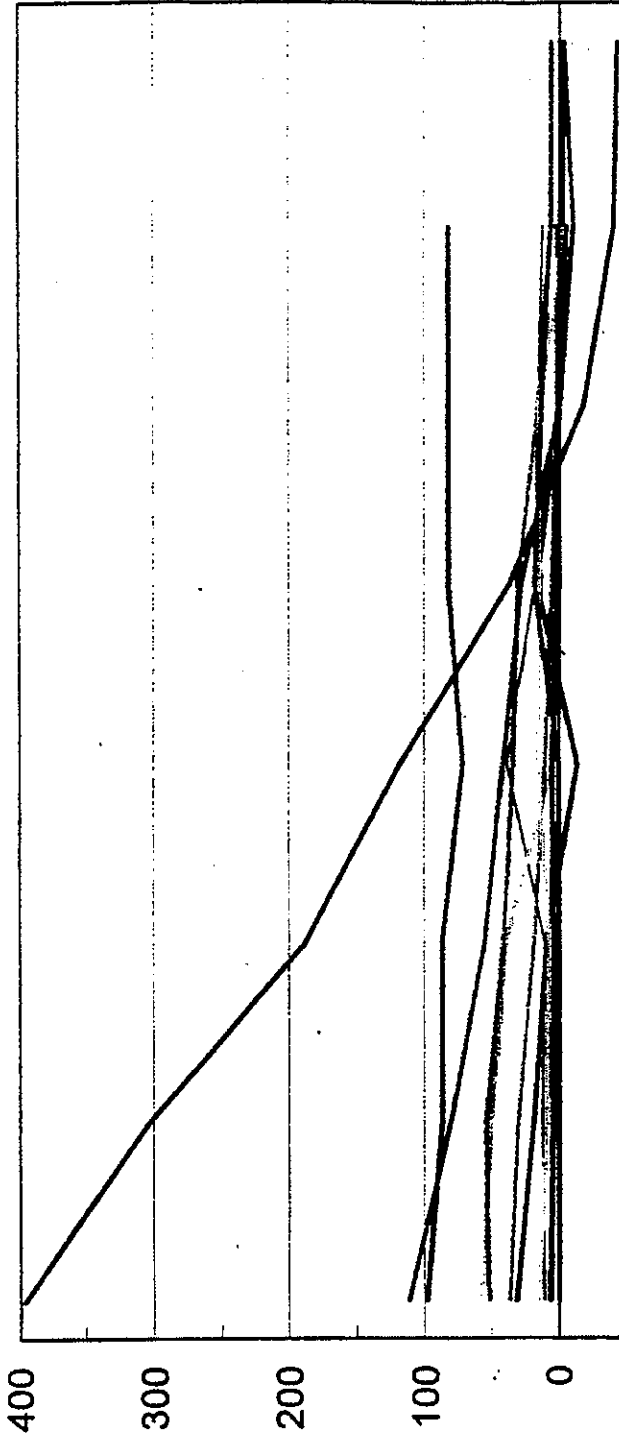
Exhibit 46 presents budgeted soft costs over time and budgeted soft costs as a percentage of the total project budget. Note the relatively high percentage starting in 1990 and continuing through 1993. Soft costs on an expenditure basis and as a percentage of total expenditures appear in Exhibit 47. Note that the percentages are even higher in this exhibit. Subtracting expenditures from budgets in Exhibit 48 indicates major categories experiencing budget shortfalls: design/engineering in 1990 and 1993, construction management in 1992 and 1993, and insurance in 1993 and 1994.

Exhibit 49 depicts project contingency from 1986 to 1994. This exhibit presents a profile of a project that is in some confusion until 1990. Note the decrease in forecasted budget from 1987 to 1988, followed by an increase in 1989 and 1990. In 1990, the forecasted contingency actually exceeded the approved amount. Starting in 1991, the contingency profile seems to show a project that is much more in control, as the forecasted contingency steadily decreases.

9.9 FINDINGS/HYPOTHESES

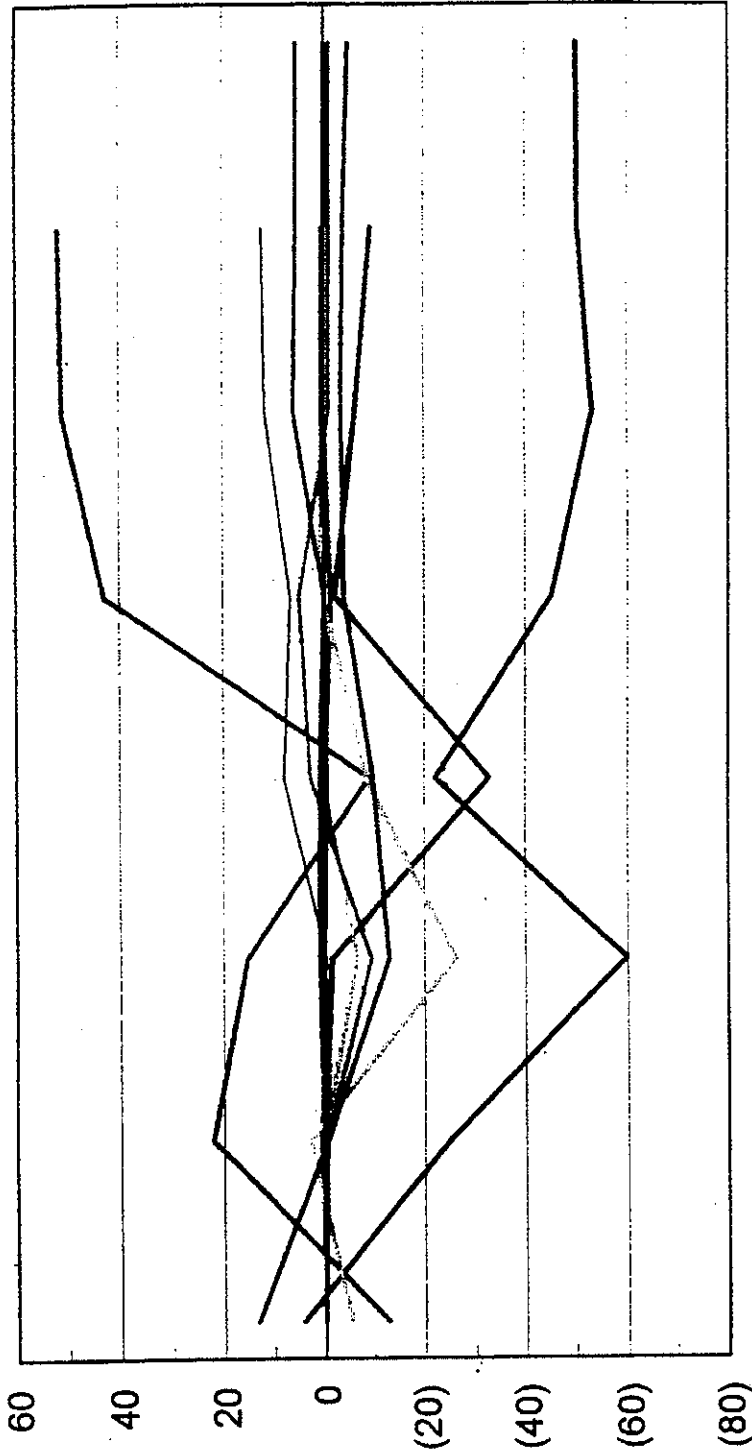
The capital cost overruns of MOS-1 appear to have been driven by three major cost categories: real estate (right-of-way), construction, and soft costs. As depicted in the prior exhibits, the project history can almost be considered in two parts, before and after 1990. The project environment before 1990 was characterized by some lack of preliminary engineering/geotechnical surveys, scope and design changes resulting in schedule delays, heavy claims activity, and ultimately higher costs. On the real estate side, more condemnations were required than originally projected which resulted in more legal activity, higher awards, and increased costs.

\$M Exhibit 43. Approved Budget - Expenditures



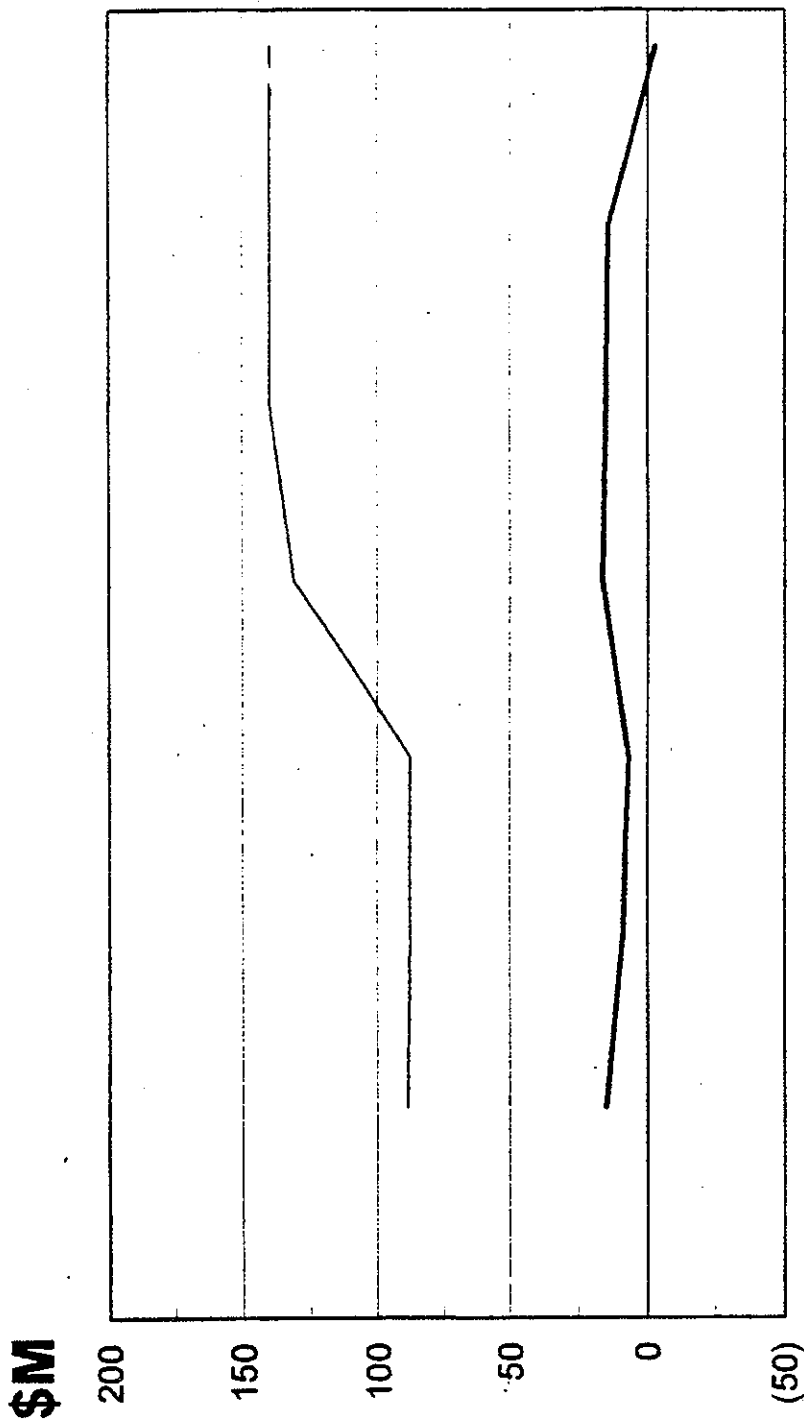
	87	88	89	90	91	92	93	94
Administration	10,940	12,613	10,781	39,782	19,170	16,097	12,789	
Const. Mgmt	63,139	53,363	32,484	42,464	11,435	(1,466)	(5,331)	
Construction	395,852	303,324	188,651	118,460	38,170	(18,626)	(40,603)	(42,963)
Contingencies	98,031	87,528	87,528	72,041	83,209	83,209	83,209	
Design/Engineering	31,567	19,040	9,482	(13,777)	16,394	1,431	(5,244)	
Force Account	57,957	50,152	40,106	5,515	3,807	3,119	2,239	
Insurance	37,439	31,358	19,583	11,235	6,346	738	(2,325)	(2,350)
Procurement	6,049	4,583	4,215	5,100	449	346	267	
Purchase Cars	52,263	54,616	42,124	34,906	31,528	16,260	6,218	6,218
Right Of Way	15,138	9,061	7,057	16,641	15,291	14,824	(2,936)	
Systems	111,316	80,482	55,568	42,594	28,676	(300)	(10,756)	(3,581)
Testing	0	0	0	639	19,688	13,395	7,463	7,462
Total	879,691	706,120	497,579	375,600	274,163	129,027	44,990	(35,214)

\$M Exhibit 44. Approved Budget - Forecast



	87	88	89	90	91	92	93	94
Administration	5	908	(343)	8,038	5,660	11,666	12,289	
Const. Mgmt	461	0	(4,572)	(26,031)	(2,084)	(5,601)	(5,601)	
Construction	4,395	(24,966)	(59,049)	(22,088)	(45,193)	(53,250)	(50,466)	(50,076)
Contingencies	(12,836)	22,132	15,487	(6,909)	42,947	51,082	51,769	
Design/Engineering	(10)	0	(1,311)	(32,779)	(2,204)	(6,350)	(9,457)	
Force Account	0	9	(6,455)	161	122	1,131	1,129	
Insurance	0	(463)	(9,268)	2,865	5,053	(912)	(1,031)	(1,031)
Procurement	0	125	850	743	(40)	77	81	(69)
Purchase Cars	(2)	0	554	(319)	(1,470)	(98)	(69)	
Right Of Way	(5,328)	2,877	(26,032)	(8,454)	141	(180)	(180)	(4,871)
Systems	13,315	(622)	(12,862)	(9,806)	(3,982)	(3,530)	(3,924)	
Testing	0	0	0	(549)	50	5,965	5,480	5,474
Total	0	0	(104,001)	(96,128)	0	0	0	(50,573)

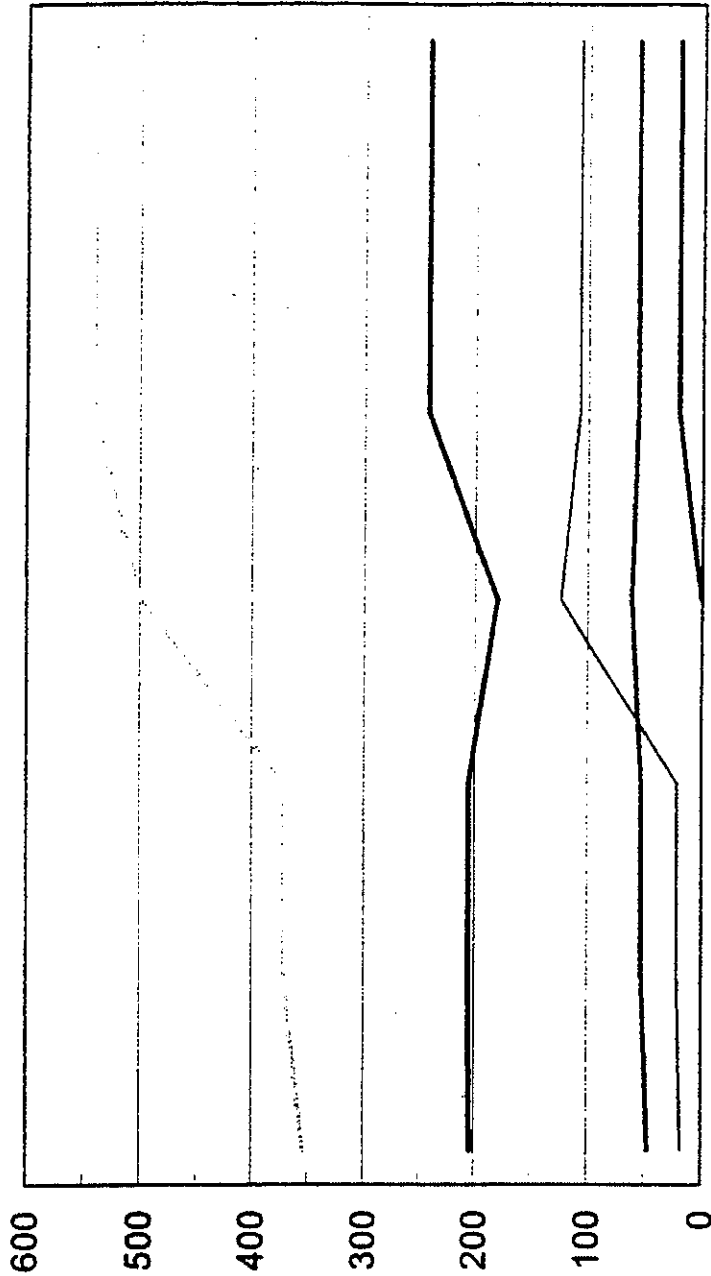
Exhibit 45. Real Estate: Budget vs. Expenditures



	86	87	88	89	90	91	92	93
Budget		88,751	87,965	87,965	131,047	139,820	139,820	139,820
Expenditures	50,381	73,613	78,904	80,908	114,406	124,529	124,996	142,756
B-E		15,138	9,061	7,057	16,641	15,291	14,824	(2,936)

Exhibit 46. Soft Cost: Budget

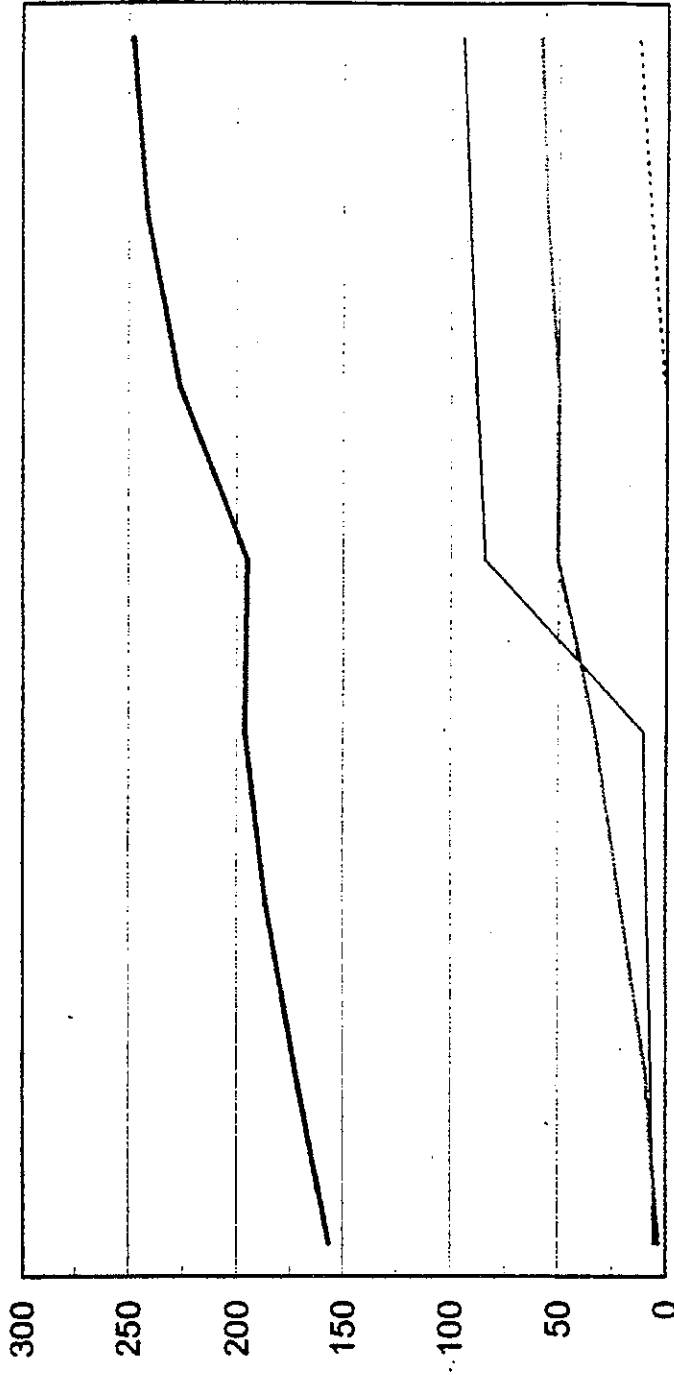
\$M



	87	88	89	90	91	92	93
Const. Mgmt	17,902	21,548	21,548	124,412	107,939	107,939	107,939
Design/Engineering	85,488	92,070	92,070	131,116	110,828	110,828	110,828
Insurance	204,057	205,638	205,638	181,141	243,163	243,163	243,163
Testing	47,089	53,071	53,071	62,339	56,888	56,888	56,888
Total Soft	354,536	372,327	372,327	499,647	539,762	539,762	539,762
% of Total Budget	28.4%	29.8%	29.8%	36.9%	37.2%	37.2%	37.2%

Exhibit 47. Soft Costs: Expenditures

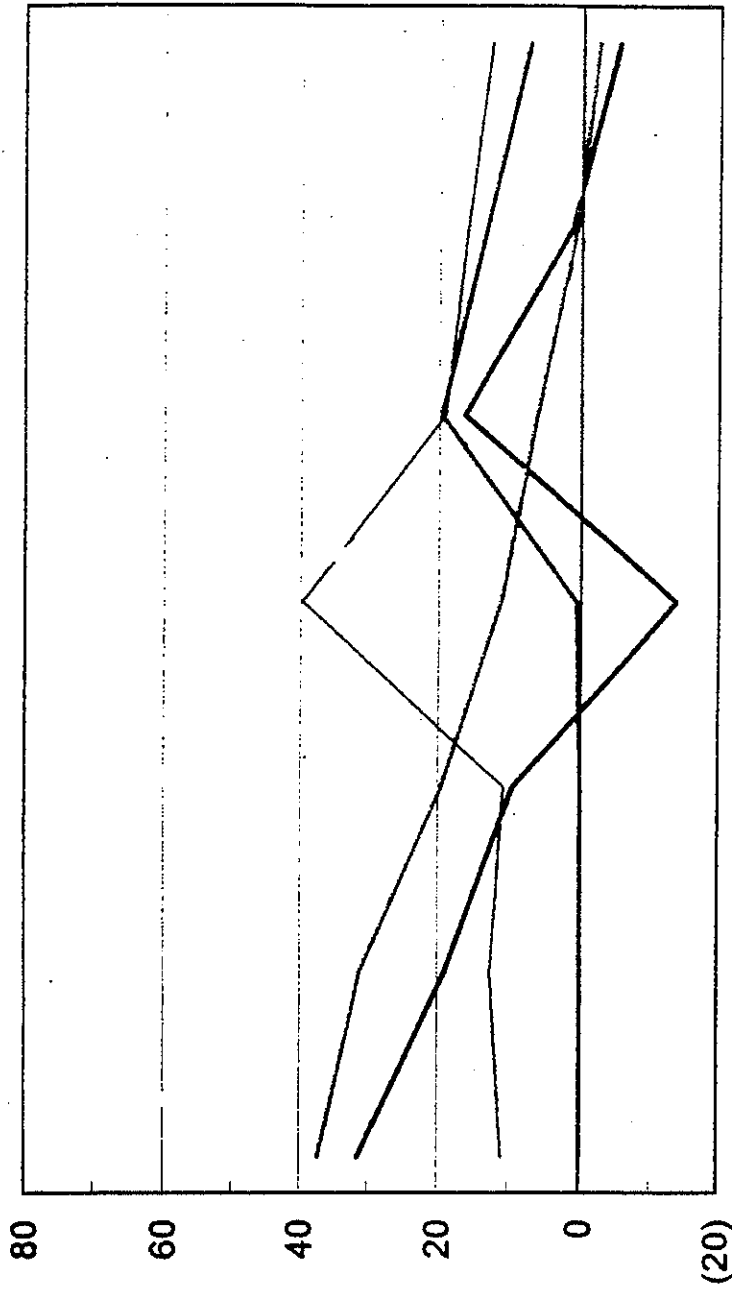
\$M



	86	87	88	89	90	91	92	93
Administration	5,561	6,962	8,935	10,767	84,630	88,769	91,842	95,150
Const. Mgmt	11,820	22,349	38,707	59,586	88,652	99,393	112,294	116,159
Design/Engineering	156,844	172,490	186,598	196,156	194,918	226,769	241,732	248,407
Insurance	3,672	9,650	21,713	33,488	51,104	50,542	56,150	59,213
Testing						1,256	7,549	13,481
Total Soft	177,897	211,451	255,953	299,997	419,304	466,729	509,567	532,410
% of Total Expend	66.6%	57.1%	47.1%	39.9%	42.9%	39.7%	38.6%	37.9%

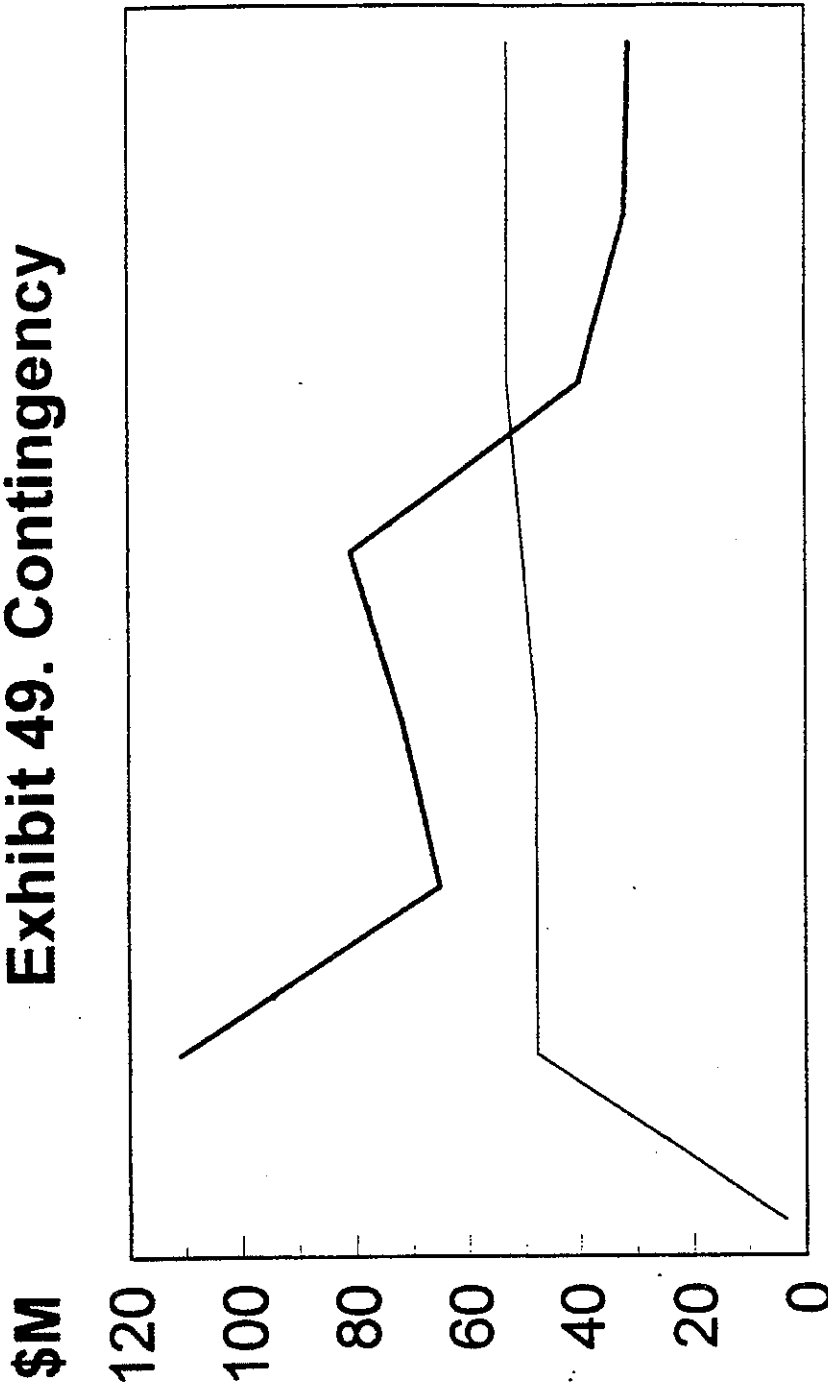
Exhibit 48. Soft Costs: Budget Expenditures

\$M



	87	88	89	90	91	92	93
Administration	10,940	12,613	10,781	39,782	19,170	16,097	12,789
Const. Mgmt	63,139	53,363	32,484	42,464	11,435	(1,466)	(5,331)
Design/Engineering	31,567	19,040	9,482	(13,777)	16,394	1,431	(5,244)
Insurance	37,439	31,358	19,583	11,235	6,346	738	(2,325)
Testing	0	0	0	639	19,688	13,395	7,463
Total	143,085	116,374	72,330	80,343	73,033	30,195	7,352

Exhibit 49. Contingency



	86	87	88	89	90	91	92	93
Original	3,537	47,974	47,974	47,974		53,225	53,225	53,225
Approved		98,031	87,528	87,528	72,041	83,209	83,209	83,209
Forecasted		110,867	65,396	72,041	80,950	40,262	32,127	31,440

Figure 17 presents data on one of the presumed causal factors for increased costs, the change activity as of May 1994. Change cost equates to almost 15% of total project cost, a figure significantly higher than that of other projects studied. On the claims side, 39% of change cost resulted from claims (Figure 18).

After 1990, MOS-1 appears to be a project in firmer control of its budgets and expenditures. The exceptions to this statement involve soft cost expenditures—construction management and design/engineering which continued to significantly increase.

	# CN'S	% Total Volume	Change Cost	% Total Change Cost	
WORK SCOPE					
100	WORK SCOPE	5	0.10%	\$12,884.00	0.01%
110	EXTRA WORK	2043	40.01%	\$81,724,667.45	39.48%
115	ADDITIONAL/NEW WORK	7	0.14%	\$216,241.22	0.10%
120	DELETION OF WORK	103	2.02%	(\$7,339,987.03)	-3.55%
		2158	42.26%	\$74,613,805.64	36.05%
SCHEDULE CHANGES					
200	SCHEDULE CHANGES	34	0.67%	(\$599,404.38)	-0.29%
210	DELAY OF WORK (COMPENSABLE)	57	1.12%	\$21,331,014.22	10.30%
220	ACCELERATION OF WORK	58	1.14%	\$4,878,362.00	2.36%
230	MILESTONE REVISIONS (NON-COMPENSABLE)	16	0.31%	\$0.00	0.00%
		165	3.23%	\$25,607,961.83	12.37%
DIFFERING CONDITIONS					
300	DIFFERING CONDITIONS	4	0.08%	\$87,245.80	0.04%
310	DIFFERING SITE CONDITIONS	530	10.38%	\$16,111,678.89	7.30%
320	HAZARDOUS MATERIALS	7	0.14%	\$438,657.00	0.21%
		541	10.60%	\$15,637,582.49	7.55%
TERMS AND CONDITIONS					
400	TERMS AND CONDITIONS	33	0.65%	\$3,424.00	0.00%
410	TERMS AND CONDITIONS (OWNER ORIGINATED)	92	1.80%	\$522,383.74	0.25%
430	EDITORIAL CLARIFICATIONS/DOCUMENT MAINTENANCE	5	0.10%	\$16,708.00	0.01%
		130	2.55%	\$542,525.74	0.26%
DESIGN CHANGES					
500	DESIGN CHANGES	5	0.10%	\$18,246.00	0.01%
510	DESIGN CHANGES/ENHANCEMENTS (OWNER ORIGINATED)	446	8.73%	\$22,757,457.12	10.99%
520	DESIGN CHANGES/ENHANCEMENTS (MTA OPERATIONS ORIGINATED)	178	3.49%	\$2,568,381.21	1.24%
530	CORRECTIONS TO PLANS AND SPECIFICATIONS	1229	24.07%	\$13,813,794.24	6.57%
540	VALUE ENGINEERING CHANGES (CONTRACTOR ORIGINATED)	14	0.27%	(\$737,235.74)	-0.36%
		1872	36.66%	\$38,418,641.83	18.56%
MANAGEMENT ISSUES					
600	MANAGEMENT ISSUES	2	0.04%	\$33,367.00	0.02%
610	DISRUPTION/INEFFICIENCY (CLAIMS ONLY)	9	0.18%	\$2,828,464.37	1.42%
620	COMPREHENSIVE CLAIMS	11	0.22%	\$4,838,328.24	2.34%
		22	0.43%	\$7,801,150.51	3.77%
OUTSIDE AGENCY REQUESTS					
730	TERMS AND CONDITIONS (OUTSIDE AGENCY ORIGINATED)	18	0.35%	\$231,205.98	0.11%
		18	0.35%	\$231,205.98	0.11%
EXERCISE OF CONTRACT OPTIONS					
800	EXERCISE OF CONTRACT. OPTIONS	8	0.16%	\$6,913,084.00	3.34%
		8	0.16%	\$6,913,084.00	3.34%
OTHER					
900	OTHER	192	3.76%	\$37,231,042.23	17.99%
		192	3.76%	\$37,231,042.23	17.99%
PROJECT TOTALS:		5106	100.00%	\$4206,997,000.25	100.00%

Figure 17. Executed Changes as of 5/24/94

		# CN'S	% Total Volume	Change Cost	% Total Change Cost
<u>CLAIMS</u>					
		64	4.46%	\$3,394,529.72	4.17%
		64	4.46%	\$3,394,529.72	4.17%
WORK SCOPE					
100	WORK SCOPE	1	0.07%	\$5,000.00	0.01%
110	EXTRA WORK	416	29.01%	\$8,123,153.23	9.98%
120	DELETION OF WORK	10	0.70%	(\$1,763,375.23)	-2.17%
		427	29.78%	\$6,364,778.00	7.82%
SCHEDULE CHANGES					
200	SCHEDULE CHANGES	7	0.49%	\$16,331.61	0.02%
210	DELAY OF WORK (COMPENSABLE)	23	1.60%	\$11,439,268.18	14.05%
220	ACCELERATION OF WORK	15	1.05%	\$2,681,408.08	3.31%
		45	3.14%	\$14,147,007.87	17.38%
DIFFERING CONDITIONS					
310	DIFFERING SITE CONDITIONS	226	15.76%	\$9,302,877.64	11.43%
320	HAZARDOUS MATERIALS	4	0.28%	\$68,814.00	0.07%
		230	16.04%	\$9,362,691.64	11.50%
TERMS AND CONDITIONS					
400	TERMS AND CONDITIONS	1	0.07%	\$0.00	0.00%
410	TERMS AND CONDITIONS (OWNER ORIGINATED)	8	0.56%	\$26,085.14	0.03%
		9	0.63%	\$26,085.14	0.03%
DESIGN CHANGES					
510	DESIGN CHANGES/ENHANCEMENTS (OWNER ORIGINATED)	129	9.00%	\$3,163,995.80	3.89%
520	DESIGN CHANGES/ENHANCEMENTS (MTA OPERATIONS ORIGINATED)	35	2.44%	\$1,028,282.73	1.26%
530	CORRECTIONS TO PLANS AND SPECIFICATIONS	459	32.01%	\$4,123,430.05	5.07%
540	VALUE ENGINEERING CHANGES (CONTRACTOR ORIGINATED)	2	0.14%	\$26,728.26	0.03%
		625	43.58%	\$8,340,416.94	10.25%
MANAGEMENT ISSUES					
600	MANAGEMENT ISSUES	2	0.14%	\$33,387.00	0.04%
610	DISRUPTION/INEFFICIENCY (CLAIMS ONLY)	8	0.56%	\$3,248,463.27	3.99%
620	COMPREHENSIVE CLAIMS	7	0.49%	\$4,789,263.44	5.88%
		17	1.19%	\$8,069,093.71	9.91%
OUTSIDE AGENCY REQUESTS					
730	TERMS AND CONDITIONS (OUTSIDE AGENCY ORIGINATED)	5	0.35%	\$12,966.18	0.02%
		5	0.35%	\$12,966.18	0.02%
OTHER					
900	OTHER	8	0.56%	\$31,682,337.75	38.92%
999		4	0.28%	\$7,044.00	0.01%
		12	0.84%	\$31,689,381.75	38.93%
PROJECT TOTALS:		1434	100.00%	\$81,406,950.95	100.00%

Figure 18. Executed Changes (Claims) as of 6/23/94

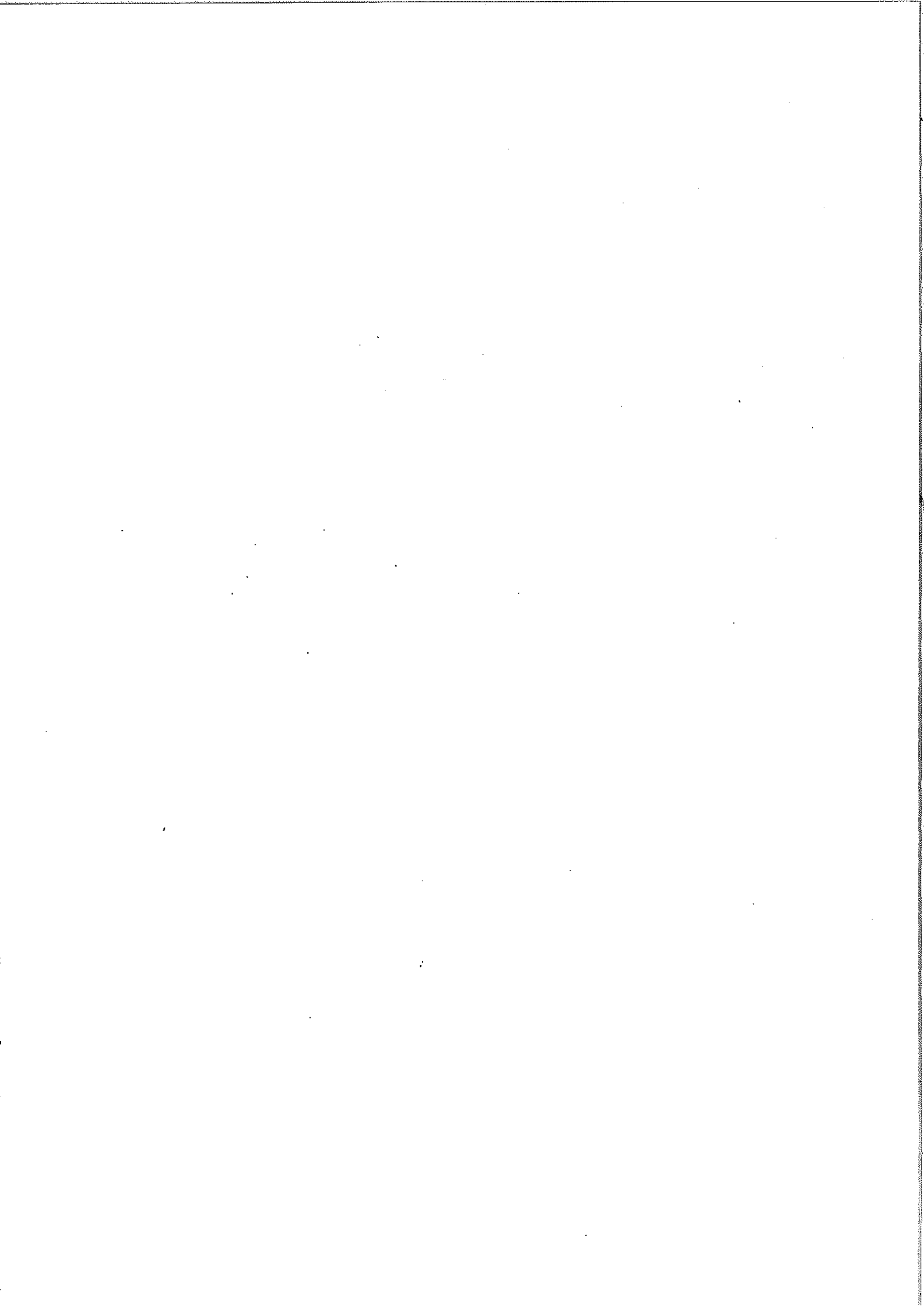
Appendix 9. Grouping Key

GroupName	MAC Code	Description
Administration		agency cost
Administration		owner's costs
Administration		Pre. Rev. Operation
Administration		Project Administration
Administration		SCRTD
Administration	13.79.00	G&A/OTHER SUPPORTING SERVICES/WATER REPLENISHMENT
Administration	15.16.00	proj. admin-G&A
Administration	15.16.90	other support serv
Administration	MY001	RCC
Const. Mgmt		construct. mgr.
Const. Mgmt		Construction Management
Const. Mgmt		Other Construction Related
Const. Mgmt	13.71.04	PROF. SERVICES CONST. MGMT.
Const. Mgmt	20.08.02	constr. mgt
Const. Mgmt	3369	Construction Manager
Construction		construct./procure
Construction		construction
Construction		guideways
Construction		Guideways/Structures/Fac.
Construction		Hazardous Material Handling
Construction		Maintenance Facilities
Construction		parking
Construction		special projects
Construction		stations
Construction		total facil. cost
Construction		Trackwork
Construction		trk relocation
Construction		utilities
Construction		Utility Relocations
Construction	13.23.04	SUBWAY TUNNEL CONSTRUCTION
Construction	13.23.04	tunnel(guideway)
Construction	13.24.92	RAILROAD RELOCATION
Construction	13.33.02	const. stations
Construction	13.33.02	CONSTRUCTION OF STATIONS AND PARKING FACILITY
Construction	13.42.02	const. mnt/repair
Construction	13.42.02	CONST. OF MAINT. & REP. FAC.
Construction	13.42.06	serv/maint.equip
Construction	13.75.95	utility relocation
Construction	13.75.95	UTILITY RELOCATIONS
Construction	13.76.93	demolition
Construction	16532	Stauffer Chemical
Construction	16533	Calgon Carbon Corp.
Construction	3321	John S. Gordon (Art Program)
Construction	35616	Calgon Corp.
Construction	37444	Western States
Construction	42264	Van Waters and Rogers
Construction	4988	Chemtech
Construction	A111	Santa Fe Avenue Restore
Construction	A112	Main Shop Building
Construction	A113	Main Shop Building Repair Work
Construction	A115	Yard Storage Area
Construction	A118	Yard Site Landscaping
Construction	A121	M.O.W. Building

Group Name	MAC Code	Description
Construction	A123	Demolition, Westranco Building
Construction	A124	Ducomm St. & Jackson St. Rest.
Construction	A130	Yard Leads/Transfer Zone
Construction	A132	Demo Struct on A1-024.
Construction	A133	Union Station Baggage Facility
Construction	A134	Demolition, A1-032
Construction	A135	Union Station - STAGE I
Construction	A136	Union Station - STAGE II
Construction	A138	Union Station Site Work
Construction	A139	Union Station Site Landscaping
Construction	A141	Civic Center Station - STAGE I
Construction	A141	Union Station to 5th/Hill Tunnel
Construction	A144	Water Treatment Plant Ops
Construction	A145	5th/Hill Station - STAGE I
Construction	A146	5th/Hill to 7th Flwr Tunnel
Construction	A147/157	5th/Hill - CC Station STAGE II
Construction	A149	Utility Relocation/ Vault Modi.
Construction	A165	7th/Flwr Station - STAGE I MRT
Construction	A167	7th/Flwr Station - STAGE II MRT
Construction	A171	7th/Flwr to WIL/ALV Tunnel
Construction	A172	Demolition, A1-208
Construction	A173	Demolition, A1-221-2, 224-5
Construction	A175	WIL/ALV Station - STAGE I
Construction	A185	Restore WIL/ALV Station
Construction	A186	WIL/ALV Site Landscaping
Construction	A187	Wilshire/Alvarado Station
Construction	A610/115	Track Work / Yard Storage
Construction	A750	Hazardous Material Removal
Construction	T	SPECIAL PROJECTS
Contingencies		conting/design/con mgt
Contingencies		contingency
Contingencies		Project Contingency Fund
Contingencies		project reserve
Contingencies	10.73.00	CONTINGENCIES
Contingencies	32.00.00	contingencies
Contingencies	T	PROJECT RESERVE
Design/Engineering		design/const. mgt
Design/Engineering		Gen. consult. & design
Design/Engineering		General Engineering
Design/Engineering		pro-services
Design/Engineering		Schimpler - Coronado
Design/Engineering		Specialty Consultants
Design/Engineering	13.71.02	PROF. SERVICES ENG. & DES.
Design/Engineering	15.08.01	eng./design
Design/Engineering	2997	General Consultant
Design/Engineering	3136	Vehicle Consultant
Design/Engineering	4344	Archeological Services
Design/Engineering	E0017	High - Point Schaer
Force Account		Utility/Agency Force Accts.
Force Account		utility/agency/force
Force Account	13.72.00	FORCE ACCOUNT
Force Account	137	So. Pacific - Communication
Force Account	145	5th and Hill Utility
Force Account	15.15.02	force account
Force Account	161	7th and Flower Utility
Force Account	2963	Santa Fe Rail Spur
Force Account	3090	Consolidated Fire Dist.
Force Account	3138	City of Los Angeles
Force Account	3172	Pacific Bell

Group Name	MAC Code	Description
Force Account	3173	DWP, Power
Force Account	3237	Western Union
Force Account	3301	Caltrans
Force Account	3371	Cable TV
Force Account	3464	DWP, Water
Force Account	3520	Southern California Gas
Force Account	3535	County of Los Angeles
Force Account	3787	Chevron
Insurance		insurance
Insurance		insurance/agency/oth
Insurance		Owner's Insurance
Insurance	13.71.05	OWNER CONTROLLED INSURANCE
Insurance	20.11.01	owner insurance
Insurance	3504	RCC Insurance
Insurance	3504	SCRTD Insurance
Procurement		Art-In-Transit Program
Procurement		vehicle-auxiliary
Procurement	13.42.06	SERVICE AND MAINT. EQUIP.
Procurement	13.42.07	MIS EQUIPMENT
Procurement	13.42.11	SUPPORT VEHICLES
Procurement	13.42.20	SUPPORT EQUIPMENT
Procurement	15.02.01	purch supp vehic
Procurement	15.02.02	pur/inst sup. equip
Procurement	20.02.07	pur/inst.MIS equip
Procurement	A116	Yard Site Security Fencing
Procurement	A117	Yard Site Lighting
Procurement	A143	Water Treatment Chemicals
Procurement	A612	Contact Rail
Procurement	A615	Contact Rail Coverboard
Procurement	A616	Rail Fasteners - MRT
Procurement	A671	Locomotive Procurement
Procurement	A672	Flat Car Procurement
Procurement	A675	Crane Procurement (Flat car)
Procurement	A730	Fixed Shop Equipment
Procurement	A732	Wheel Truing Machine
Procurement	A735	Free Standing Shop Equipment
Procurement	A770	Trucks and Trailers
Procurement	A775	Mobile Emergency & Maint. Equip.
Procurement	A780	Furniture Procurement
Procurement	A785	Fire Equipment
Procurement	A790	First Stores and Consumables
Purchase Cars		Rail Passenger Vehicles
Purchase Cars		vehicle-passenger
Purchase Cars	13.13.00	PASSENGER VEHICLES
Purchase Cars	A650	Passenger Vehicles
Right-Of-Way		Real Estate Acquisition
Right-Of-way		real-estate
Right-Of-Way		ROW
Right-Of-Way	13.76.91	RIGHT-OF-WAY ACQUISITION
Right-Of-Way	20.06.10	ROW
Right-Of-Way	T	REAL ESTATE
Systems		central control fac
Systems		communications
Systems		Electrification
Systems		fare collection
Systems		main yard
Systems		Systemwide Equipment
Systems		total systems cost
Systems		traction power

Group Name	MAC Code	Description
Systems		train control
Systems	13.32.06	FARE COLLECTION EQUIPMENT
Systems	13.43.04	CONST. OF STOR. YD & LEADS
Systems	13.43.04	const.strg yard
Systems	13.62.01	auto train cntrl
Systems	13.62.01	AUTOMATIC TRAIN CONTROL
Systems	13.62.08	COMMUNICATION EQUIPMENT
Systems	20.02.08	pur/inst.com equip
Systems	4239	Telephone Equipment
Systems	5283	Operational Graphics Procure
Systems	A620	Automatic Train Control
Systems	A630	Traction Power Equipment - MRT
Systems	A631	Traction Power Inst. - MRT
Systems	A640	Communications - MRT
Systems	A660	Fare Collection
Systems	A710	Elevators & Escalators - MRT
Systems	A720	Elevator Procurement/Installation
Systems	A740	Ventilation Equipment - MRT
Systems	A745	TPSS/Air Handling Equip. - MRT
Systems	A760A	Signing
Systems	A760B	Edge Lighting
Systems	A795	UPS 50 KVA - MRT
Systems	A796	UPS 100 KVA
Systems	A832	F.O. Trans. Cable
Systems	H840	Fare Collection Equipment
Testing		Testing and Operations
Testing	A655	Transportation Test Center



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