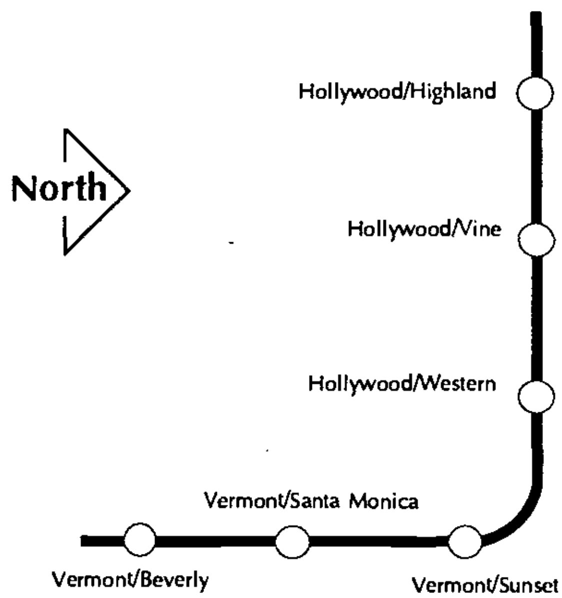
SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT

METRO RAIL PROJECT



INTERIM DRAFT

VALUE ENGINEERING STUDY #1

DESIGN CRITERIA AND DIRECTIVES MOS II

July 1989

Prepared by:

FOSTER ENGINEERING, INC.
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ENGINEERING AND ARCHITECTURE
SAN FRANCISCO SACRAMENTO SAN DIEGO

August 18, 1989

Mr. J. E. Crawley
Southern California Rapid Transit District
425 South Main Street
Los Angeles, CA 90013

Subject: Value Engineering Study No. 1, MOS II
Design Criteria and Directives

Dear Mr. Crawley:

We are pleased to submit for your consideration five copies of an interim draft report outlining the preliminary results of the VE Study work conducted to date on the District's Design Criteria and Directives for MOS II of the Metro Rail project.

We have designated this submittal as an "Interim Draft" pending receipt of comments from you and your staff, or consultants, concerning the conclusions reached, or the recommendations contained in the report.

The nature and broad character of the subject matter studied in this phase of our work has dictated that the results be presented to you in a general manner at this time, particularly for those elements of the study that will be examined further during the course of the next two VE studies that we will undertake.

Recommendations and conclusions will be applied specifically to the next phase of our work, and whereas at this time we will only identify order of magnitude or percentage cost savings, during subsequent VE studies we will recommend specific Value Engineering proposals with specific economies that will result therefrom.

We would like to thank you and others at SCRTD and MRTC for their help and cooperation with a special thanks to Al Levy. We are looking forward to our next meeting.

Very truly yours,

FOSTER ENGINEERING, INC.

H. A. Foster
President

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SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT

VALUE ENGINEERING STUDY #1
DESIGN CRITERIA AND DIRECTIVES MOS II

CONTENTS

INTRODUCTION

During the course of the next several years it is the intent of the Southern California Rapid Transit District to construct a starter or initial heavy rail Metro project which will provide a much needed alternative mode of transportation in a corridor that will extend from the central business district in downtown Los Angeles to North Hollywood, a distance of some 18 or 19 miles.

Construction of the first Minimum Operating Segment (MOS I) is well underway and plans are materializing to extend this section of the line from its current terminal at the Wilshire/Alvarado Station towards two branch lines, one on Vermont Avenue and west on Hollywood Boulevard to the intersection at Hollywood and Highland and the other on Wilshire Boulevard terminating at Wilshire and Normandie.

SCRTD has retained Foster Engineering, Inc. of San Francisco and CVS, Inc. of Portland, Oregon to undertake Value Engineering Studies of a six mile segment of the proposed extension including six proposed stations, three of which are located on Vermont and three on Hollywood Boulevard.

The overall scope of work of the study includes an examination and review of the District's Design Criteria, Directive/Standard Drawings and Baseline General Conditions for Construction Contracts. Special studies of proposed line structures constructed by tunneling methods or by cut and cover are included, as well as a special study dedicated particularly to the study of the design and proposed construction methods for the passenger stations.

The work will be presented to the District in three separate Value Engineering reports, namely:

Value Engineering Study #1	Design Criteria and Directives
Value Engineering Study #2	Line Structures
Value Engineering Study #3	Passenger Stations

This report summarizes initial findings in Value Engineering Study #1. Many aspects of the subject matter will overlap with subsequent reports, but the intent is generally to identify initially, opportunities for cost reduction in a broad sense and subsequently, examine these opportunities to identify and detail specific Value Engineering proposals.

In this report three major areas have been detailed for study viz:

- Project Management
- Tunnels
- Crossovers and Stations

Studies have been conducted with a view to examining particulars of the systems' design criteria and directives which have a substantial impact on the cost of the program.

The VE team generally concluded that for a project of this nature and magnitude, the manner in which the Project Management would be conducted during both the design and construction phases of the work would have a major impact on the total number of dollars paid for the work.

For this reason the team felt that several subject areas, including policies and criteria dictating contract packaging, construction management, claims resolution, quality control, and field engineering would be important candidates for Value Engineering review because of the substantial nature of cost savings that could be realized by the District by instituting improvements.

The team felt strongly that, economies in this area could be made not only in specific reductions in future construction bids but also, and much more importantly, from latent costs that may be incurred as a result of contract changes and claims. Such costs if actually incurred (and the current construction program would indicate that they may indeed occur) could be very substantial and could consume the majority of planned funding for contingencies, placing the project in jeopardy.

The segment of the Metro line under study contains over 60,000 linear feet of line structures that will be constructed by shield driven tunneling methods.

It was obvious from the start that the examination of the directives and criteria that would dictate the design and eventual construction of the tunneling works should be made meticulously examining the "nuts and bolts" of each detail, noting that for every $100 saved per linear foot of tunnel, some $6,000,000 or more of project costs savings would result. This simple fact led the team to conclude that fundamental issues concerned with tunnel diameter size, lining, reinforcing, and the like should again be re-examined very carefully, recognizing that potential Value Engineering proposals may in fact challenge criteria and directives that may indeed be "cast in concrete".

A very large sum of money has been budgeted for the construction of cross-over structures and passenger stations. From current cost estimates the cost of this type of facility generally specified to be undertaken by cut and cover construction is in the range of 6 to 10 times the cost of the running tunnels. This wide deviation in cost per linear foot of facility drove the VE team to seek opportunities to convert cut and cover structures to tunneling work, or at least to minimize the length, breadth, and depth of the specified work in order to reduce the impact resulting from traffic congestion, relocation, temporary support of utilities, and of course, the high cost of excavating large and deep cavities in the middle of busy streets.

Order of magnitude cost estimates have been made, and are included in this report for potential VE savings that could be realized in the three major study areas. Although these estimates are only approximate, they represent potential differentials in cost and are therefore significant and indicative of real potentials.

CONCLUSIONS AND
RECOMMENDATIONS

CONCLUSIONS AND RECOMMENDATIONS

The broad scope and complex nature of the study area, and the magnitude of the estimated cost of the present design has made it extremely difficult for the team to be able to detail in depth some of the alternative concepts that have been selected for study.

The general conclusion reached is that the District is embarking on a program of construction that will prove to be extremely costly, possibly involving some $100 million of potential cost overruns, unless positive steps are taken to streamline and simplify its policies with regard to contracting claims resolution and quality control. Potential savings of a further $100 million are possible.

General areas of recommendation in this area include:

- Improve contract packaging concepts
- Establish Claims Review Board
- Streamline and improve change order process
- Provide considerably more authority to the Resident Engineer
- Eliminate duplication of RE/PE position
- Install training program for field personnel
- Conduct major part of review of contractors submittals in field
- Install incentive type contracting policies
- Install a structured design review process
- Install a process of systems integration into plans and specifications

In specific areas of line structures and stations, the team concluded that there appeared to exist many potential areas for VE that might be labeled "sub-million", i.e., under $1 million. The team considered that spending a great deal of investigative time on such proposals would not be cost effective and selected the following major areas for further development during VE Studies Nos 2 and 3

- Reduce tunnel diameter
- Simplify tunnel lining
- Simplify tunnel cross passages
- Simplify tunnel invert and walkway
- Change alignment detail to use smaller cross-overs and more running tunnel
- Reduce ancillary spaces
- Relocate vent shafts to center of street
- Reduce platform length
- Use clear span concepts for structures
- Raise profile through station
- Open stations to atmosphere

Potential savings of a further $100 million are possible.

VE METHODOLOGY

VE METHODOLOGY

Value Engineering can provide more beneficial use of limited resources and lead to more and better construction.

By taking advantage of the rapid pace of technological advances in materials and methods of construction, the accelerated rise in construction costs can be slowed down. These costs on a national average have risen sharply in the past decade, and in almost any year the costs exceed those of the preceding year. In order to obtain the required construction within allotted funds, every available means must be used to attain the users required functions at a minimum of cost. This is what Value Engineering is all about.

DEFINITIONS

Value Engineering (VE). Is an organized effort directed at analyzing the function of design, construction, operations, systems, equipment, facilities, procedures, methods, and supplies for the purpose of achieving the required function at the lowest total cost consistent with the requirements for performance, reliability, quality, and maintainability.

Function. Is defined as the specific purpose or use intended.

> Basic Function. Is a performance feature that must be attained if the total is to work or perform.
>
> Secondary Function. Is a performance feature other than those that must be accomplished. In some cases, they represent features that are nice to have, but not necessary. In other cases, they represent features that are necessary because of the particular method selected to accomplish a basic function.

Cost. Cost is the total amount required to acquire and utilize the specified functions.

Worth. Worth is the lowest amount of funds necessary to provide the required function. In VE, worth is synonymous with "Maximum Value."

Creativity. Is thinking in a manner to develop new ideas which will satisfy some expressed or implied need.

Creative Techniques. Are schemes or plans of action which assist the individual or group to produce creative ideas.

Analytical Techniques. Are techniques characterized by a logical step-by-step approach.

Roadblock. Is a decision, attitude, or situation which prevents the development and implementation of appropriate value alternates. Examples: "We tried that five years ago and it didn't work." "The criteria won't permit it."

THE FUNCTIONAL APPROACH

A user purchases an item or service because it will provide certain functions at a cost he is willing to pay. To minimize total cost, the user must look beyond the price of the item and consider associated costs; i.e., preparation, installation, handling, operations, quality, service life, maintenance and so on. To obtain good value, the functions must be carefully defined so that their associated costs may be determined and properly assigned.

Function is the specific purpose or intended use of a given item. It is the characteristic which makes the user buy a product.

Value Engineering determines function by considering the user's actual need. The performance characteristics that justify an item's existence, in terms of the particular user's needs are determined.

Function is defined in two words -- a verb and a noun; more specifically, a transitive verb and a direct object.

The verb answers the question, "What does it do?" This question leads right to the heart of Value Engineering and is a radical departure from traditional cost reduction efforts where the question is, "What is it?", and then concentrates on making the same item less expensive.

The noun defines what is acted upon, (electricity, temperature, liquids, light, surfaces, sound . . .) and must be measurable or at least be understood in measurable terms, since a specific value must be assigned to it during the later evaluation process, that of relating cost to function.

Evaluation of Functions. Worth is the least expenditure required to provide the required function(s) and is the method most frequently used to evaluate the use value of a function.

Establish worth by comparing the existing design with the simplest device that will reliably perform the required function. Another method of determining the worth of a function is simply to reduce the design to the components that provide the user's needs. "Create" a new design by developing many alternatives and selecting the best value alternative.

Consideration of Cost. Cost applies to the specific design. Cost figures serve to pinpoint the expensive elements in a design. They also help determine the validity of VE savings. An interesting concept concerning cost distribution is Pareto's law of distribution which states that 20% or less of a design's components involve 80% or more of the cost. The credibility of any VE study rests heavily on the validity of the cost data of the specific design being studied as well as the alternate design developed by the study team. Nothing will destroy a VE proposal as completely as inaccurate or unreliable cost data.

Application of Function, Cost and Worth. Function, Cost and Worth are important elements of the Value Engineering study.

Achieving Economic Value. To achieve economic value, every material, every part, every document, all paperwork, every method, and every operation must pass the following tests:

A. Can it be eliminated without impairing function or necessary reliability?

B. Does it cost more than it is worth?

C. Does it do more than is required?

D. Can any of its features be eliminated without impairing function or necessary reliability?

E. Can it be made by a less costly method?

F. Can a standard item or specialty product be found which will be usable?

G. Considering the quantities used, could a less expensive manufacturing technique or construction method be used?

H. If it were your money, would you refuse to buy the item because it costs too much?

If the answer to any of the test questions is yes, you have not attained a good value.

Poor Value.

A. Reasons. Some of the most common reasons for poor value are:

1. Lack of information.
2. Decisions based on wrong beliefs.
3. Habitual thinking.
4. Negative attitudes.
5. Reluctance to seek advice.
6. Effect of shortage of time.
7. Emphasis on performance first at any cost.
8. Changing technology - impact of new processes, products and materials.
9. Lack of a yardstick for measuring value.
10. Lack of knowledge of actual requirements.
11. Poor human relations.
12. Trade-offs.

THE VALUE ENGINEERING JOB PLAN

The VE Job Plan contains a systematic procedure for accomplishing all the necessary tasks associated with a VE study. Figure I depicts the five phases of VE Job Plan used by the team. This plan is a variation of the Scientific methods used for solving routine engineering problems. The key features separating the VE Job Plan from other cost reduction techniques are functional analysis, use of creativity to develop multiple alternatives, and the principle of maintaining the quality needed by the user. In VE, as in other problem solving situations, a systematic approach will produce better results than undisciplined ingenuity. Use of the Job Plan provides:

- A vehicle to carry the study from inception to conclusion.
- A convenient basis for maintaining a written record of the effort as it progresses.
- Assurance that consideration has been given to facts that may have been neglected in the creation of the original design.
- A logical separation of the study into units that can be planned, scheduled, budgeted, and assessed.

The VE Job Plan provides a logical plan to carry the study from inception to conclusion. The Plan divides the study into sets of work elements or phases taking into consideration the resources available and the results expected, and requires those making the study to clearly define the function(s) which the item under study performs. It provides the study team with a plan for securing all of the information needed to successfully accomplish the study. Following the Job Plan assures that time is made available to create the maximum number of alternatives to thoroughly analyze the creative work so that superior choices can be made for further development. It leads those making the study to establish an effective program for selecting recommendations, data supporting these recommendations, the identification of actions necessary to implement these recommendations, a proposed implementation schedule, and a summary of benefits.

The work is carried out in sequence, phase by phase returning to a previously completed phase for additional work prior to reaching a decision. Results are documented in two documents; a proposal summarizing the results of the effort and a Work Book that contains all the detailed back-up information.

THE VE JOB PLAN

PHASE I INFORMATION

QUESTIONS

- WHAT IS IT?
- WHAT DOES IT DO?
- WHAT MUST IT DO?
- WHAT DOES IT COST?
- WHAT IS PERFORMANCE OF BASIC FUNCTION(S) WORTH?

TECHNIQUES

- USE GOOD HUMAN RELATIONS
- GET ALL THE FACTS
- GET INFORMATION FROM THE BEST SOURCES
- OBTAIN COMPLETE INFORMATION
- DEFINE THE FUNCTION(S)
- PERFORM FUNCTIONAL EVALUATION

PHASE II SPECULATION

QUESTIONS

- WHAT ELSE WILL DO THE JOB? (PERFORM THE BASIC FUNCTION(S)

TECHNIQUES

- USE GOOD HUMAN RELATIONS
- ELIMINATE!
- TRY EVERYTHING
- BLAST-CREATE
- OVER-SIMPLIFY
- MODIFY AND REFINE
- USE CREATIVE TECHNIQUES (BRAINSTORM)

PHASE III ANALYSIS

QUESTIONS

- WHAT DOES EACH COST?
- WILL EACH PERFORM THE BASIC FUNCTIONS?

TECHNIQUES

- USE GOOD HUMAN RELATIONS
- PUT $ ON EACH IDEA
- EVALUATE BY COMPARISON
- REFINE IDEAS
- USE SERVICES OF EXPERTS
- USE YOUR OWN JUDGEMENT

PHASE IV DEVELOPMENT

QUESTIONS

- WILL IT WORK?
- WILL IT MEET ALL THE REQUIREMENTS?
- WHAT DO I DO NOW?
- WHAT IS NEEDED?
- WHO HAS TO APPROVE IT?
- WHAT ARE THE IMPLE-MENTATION PROBLEMS?
- WHAT ARE THE COSTS?
- WHAT ARE THE SAVINGS?

TECHNIQUES

- USE GOOD HUMAN RELATIONS
- GATHER CONVINCING FACTS
- WORK ON SPECIFICS - NOT GENERALITIES
- TRANSLATE FACTS INTO MEANINGFUL ACTIONS
- SELECT FIRST CHOICE AND ALTERNATIVES
- PREPARE SUMMARY PROPOSAL

PHASE V PRESENTATION

TECHNIQUES

- MAKE PRESENTATIONS
  - WRITTEN PROPOSAL
  - ORAL W/ILLUSTRATIONS (BRIEF & PERTINENT)
- PRESENT PROBLEM
- EXPLAIN BEFORE & AFTER
- EXPLAIN ADVANTAGES & DISADVANTAGES
- PRESENT FACTS QUICKLY, CONCISELY & CONVINC-INGLY
- EXPLAIN IMPLEMENTATION PROBLEMS
- SUGGEST FURTHER MEETING FOLLOW-UP!
- REMOVE ROADBLOCKS
- USE GOOD HUMAN RELATIONS

FIGURE I

CANDIDATES FOR
VALUE ENGINEERING

CANDIDATES FOR VALUE ENGINEERING

In reviewing project data with a view to identifying Opportunities to Cut Costs and the selection of candidate subjects for Value Engineering, the team studied the following documents provided by SCRTD.

- General Conditions of Contract and Technical Guide Specifications
- Project Standard Drawings
- Project Directive Drawings
- Small Scale Plan and Profile Drawings of MOS-II

Given the fact that the "standard" documents and directives would be the basis of the design development work planned for MOS-II, the team concentrated on objectives to determine how the use or application of these documents to MOS-II would affect costs, and on identifying opportunities to substantially reduce projected costs by introducing additional standards or directives, or by modifying or complementing existing data.

The team was guided particularly by the results of on-going construction for MOS-I. This section of the work was contracted for construction recently and, naturally, was based on the same documents under scrutiny by the VE team, supported by site specific design and drawing work carried out by Section Engineers. Furthermore, the work was carried out based on specific contracting policies which for one thing separated the heavy construction of civil and structural work from the "building" type work which included mechanical and electrical services and architectural finishes.

In summary, the team determined for MOS-I that whereas it appeared at Bid time that the work could be conducted within the framework of expected and budgeted costs, the history to date of additional costs incurred during construction for various reasons, and the nature, magnitude and number of claims made against the District were higher than normally expected for work of this type. If predictions of the rate of cost increase continued, considerable cost overruns for the project could result.

It was with this particular scenario in mind that the team selected "Project Management" as a primary candidate for Value Engineering, but in order to make the VE process more manageable only certain specific policies or processes were reviewed, including

- Contract Packaging
- Change Order, Claims and Dispute Resolution
- Design Quality control
- Field Engineering and Management

The team felt that within these broad categories, major opportunities to reduce cost could be realized by streamlining the management work, simplifying contract packaging into specialized areas with a practical control of contract interfaces, installation of more rigorous quality control measures and a streamlined and more practical approach to the field management, particularly the authority of the Resident Engineer.

SUMMARY OF PROJECT MANAGEMENT VE PROPOSALS

VE Proposal #1. Contract Packaging

The current design divides the study segment into six contract packages. Each package contains tunnel work and a station complete.

The proposed design would include two tunnel and excavation contracts and six individual station packages complete.

Estimated Gross Savings - $12,500,000

VE Proposal #2. Change Orders, Claims, and Disputes Resolutions

The current design is controlled by general conditions of contract. Sections 34 through 42.

A Change Control Board regulates and supervises any contract changes and provides direction to the Resident Engineer. Processing change order paperwork is time-consuming and requires input from many sources. The RE has little authority to act independently and can only negotiate within bounds set by the CCB.

Current cost experience for changes and claims is about 21.6%. Potential for savings is about 16% assuming normal cost for changes to be about 5% and assuming that the rate of incurred changes and claims will decline.

The proposed design would include:

- Implementation of a policy that would include a "Disputes Review Board" section in the Contract Specifications.
- Providing the Resident Engineer with much more authority.
- Providing better trained personnel in the field.

Potential Savings in Contract Costs - $73 million

VE Proposal #3

In the present design, work on drawings and specifications for each contract is performed by "SECTION ENGINEERS" which include Lead Engineering Firms and Specialty Consultants. Quality control is organized along traditional organization hierarchies. The GEC coordinates and reviews work of Section Engineers and District personnel and also conduct milestone reviews.

Present cost experience indicates very high percentage of cost increase caused by miscoordinated or incomplete contract documents resulting in field changes. The objective of design quality control is to eliminate miscoordinated and incomplete contract documents.

The VE team considered that this could not be effectively achieved with the present diffused and duplicative organizational structure and proposes a modification of the design process as follows: Tunneling and excavation work would be designed by one organization. Station designs would be undertaken by multidisciplinary organizations or task forces. Standardized quality control specifications would be established for all design work with provisions for independent peer review, systems integrations checking and rigorous final design checking.

Potential Savings in Contract Costs - $30 million

VE Proposal #4. Field Engineering and Management

Present design requires complex and detailed schedule submittals and lengthy process for review of technical submittals. Review process is remote from field activities.

Burdensome reporting on cost breakdown required of contractor.

No formal training program for Resident Engineers and Inspectors.

Proposed design would reduce schedule submittal to simple bar chart, eliminate need for cost breakdown submittals unless pertinent to measurement and payment requirements, conduct the bulk of submittal review process in the field, minimize submittal turnaround time.

Level of required technical capability of field staff and Resident Engineers would be raised to ensure better supervisory attitude.

Dollar amount cannot be quantified.

PROJECT MANAGEMENT
VE PROPOSALS

VEP No. 1 - Contract Packaging

Value Engineering Proposal (VEP) No. 1

DATE
7/27/89

STUDY TITLE
SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT METRO RAIL PROJECT
VALUE ENGINEERING STUDY #1 - DESIGN CRITERIA AND DIRECTIVES - MOS-II

ITEM
CONTRACT PACKAGING

FUNCTION
Organize Construction

CONCEPT BEFORE VE

Divide MOS-II project into six (6) contract packages for line and tunnel construction.

Each package contains one station including excavation, shell and finish work.

PROPOSED ALTERNATIVE CONCEPT

Divide project into eight (8) contract packages with two packages consisting of tunnel and excavation work and six packages consisting of concrete and station finish work.

Advantages
1. Reduced construction periods
2. Greater efficiency
3. Less contingent risk

Disadvantages

1. Greater number of contracts

ESTIMATED COST (Concept before VE)	$ 336,312,000
ESTIMATED COST (Proposed alternative)	$ 324,062,000
EST GROSS SAVINGS	$ 12,250,000
EST IMPLEMENTATION COST	$
EST NET INITIAL SAVINGS	$ 12,250,000
EST LIFE CYCLE SAVINGS	$

DESCRIPTION OF PRESENT DESIGN

The work is divided into 6 packages including all utility work, landscaping and restoration, tunnels, line structures and one station per package. The station work includes all finishes. Package costs are in the range of $40 - $80 million and a single contractor will be responsible for the entire work of the package.

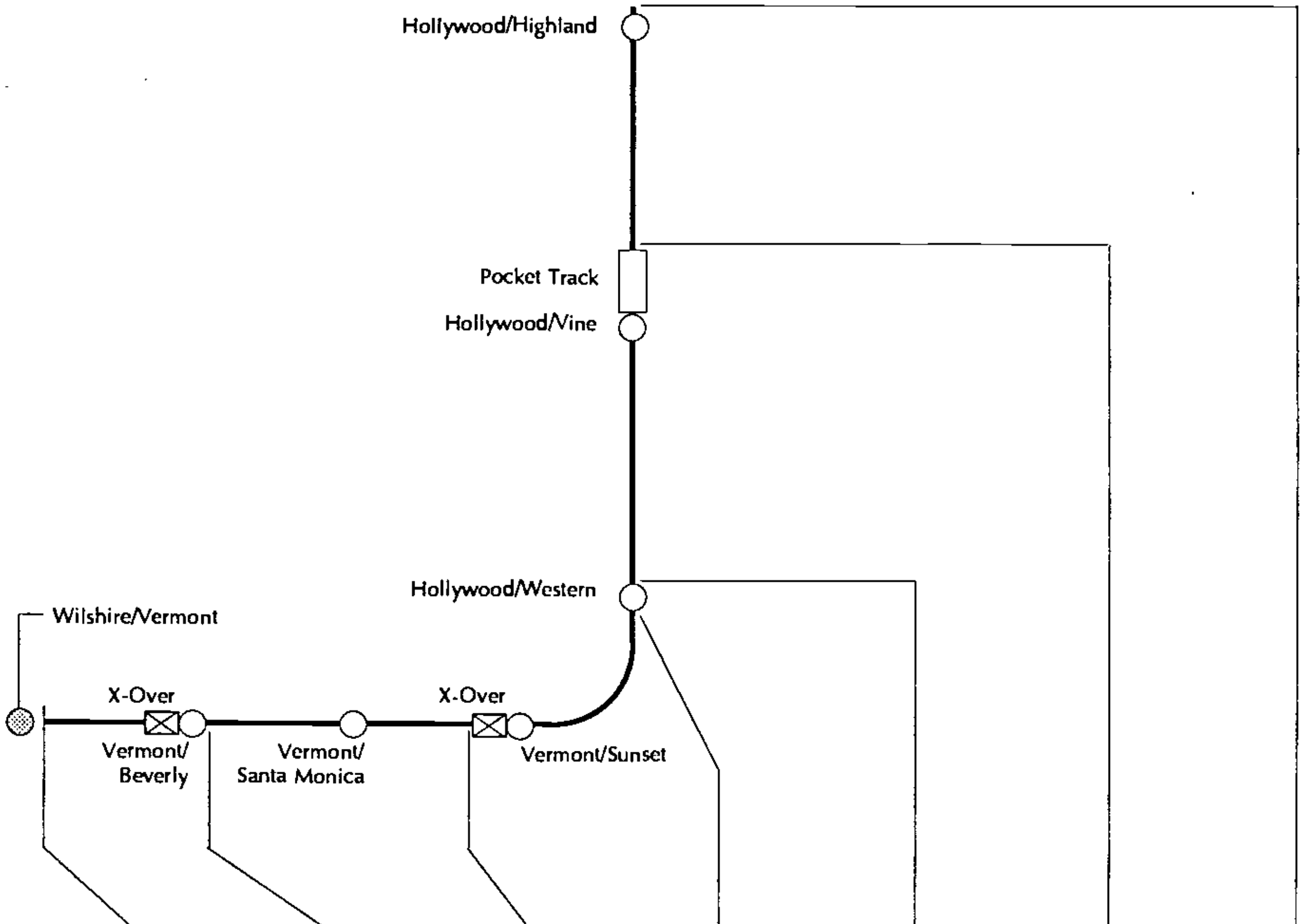
Present Design Contract Packaging

B240 - Line Section and Vermont/Beverly Station
B250 - Line Section and Vermont/Santa Monica Station
B260 - Line Section and Vermont/Sunset Station
B270 - Hollywood/Western Station
B280 - Line Section and Hollywood/Vine Station
B300 - Highland Station

STUDY TITLE

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT METRO RAIL PROJECT
VALUE ENGINEERING STUDY #1 - DESIGN CRITERIA AND DIRECTIVES - MOS-II

SKETCH OF PRESENT DESIGN



LENGTH	5,320 Feet	6,190 Feet	7,640 Feet	4,500 Feet	5,300 Feet	3,050 Feet
PACKAGE	B24	B25	B26	B27	B28	B29
COST	$57,858,000	$61,688,000	$67,653,000	$30,449,000	$78,290,000	$40,374,000

DESCRIPTION OF PROPOSED DESIGN

The packaging was first examined to determine whether savings would result from combining all tunneling into two contracts and tunneling through cut-and-cover work as necessary to maintain progress. This approach penalized the overall MOS-II because of the extra tunnel cost was not recoverable by increased efficiency.

It was subsequently determined that the best results would be obtained by maximizing construction efficiency. This would mean separating the work into "heavy construction" and "building construction" packages, so that the contractor doing the tunnel, excavation and shoring work would not be concerned with problems of coordinating multiple subcontracts while the contractor doing the concrete and finishing work would not be concerned with the inherent risks of underground construction.

Therefore, the six original packages have been reduced in scope to reflect station, concrete and finish work only, while two tunnel and excavation contracts have been added. The savings in tunnel and excavation work arise from the fact that long mobilization periods are eliminated and contractors overhead costs are halved. The resulting savings represent about 1.4% of project cost. There will also be savings in the purchase and/or rehabilitation of TBM's, projected at $1.1 million to $4.1 million.

Since the "building" contractor will handle subcontract work more efficiently, savings of 3% are projected. This amounts to 1% of project cost.

Note that the interface is clean, with the station contractor starting out in an open space with decking already in place.

Total contract time is reduced, with a consequent saving in administration costs. It is assumed that this saving will be offset against cost of preparing two additional contracts.

The following additional benefits will accrue from the proposed design:

1. Have one A/E firm prepare all the contract documents for the proposed T1 and T2 tunnel contracts. This should result in substantially lower fees maybe as much as $1,500,000

2. It should be noted that the station contracts would essentially be building type contracts and will include all structural work, mechanical/electrical services and architectural finishes.

   The interface selected is based on the assumption that all structure excavation will be free from cross-lot bracing, especially at lower levels. Tie back systems must be specified.

   The tunnel contractor will not require excavation to full depth of structure excavations and would, in fact, be inconvenienced by it. This allows the structures contractor to do finish excavation, thereby avoiding problems of invert maintenance.

DESCRIPTION OF PROPOSED DESIGN (Continued)

DATA SUMMARY

PROPOSED CONTRACT PACKAGING

T1	Tunnel Contract Vermont/Sunset to Wilshire/Vermont
T2	Tunnel Contract Hollywood Highland to Vermont/Sunset
B240	Vermont/Beverly Station Complete
B250	Vermont/Santa Monica Station Complete
B260	Vermont/Sunset Station Complete
B270	Hollywood/Western Station Complete
B280	Hollywood/Vine Station Complete
B300	Hollywood/Highland Station Complete

COSTS;

Tunnel	-	$ 4,760/route foot
Station	-	48,570/route foot*
Pocket Track	-	25,700/LF*
Tail Track	-	25,700/LF*
Cross over	-	25,700/LF*

*includes excavation, shoring, decking, structures backfill and restoration.

DESCRIPTION OF PROPOSED DESIGN (Continued)

SCHEDULE-PROPOSED DESIGN

T1 - Start at VERMONT/SUNSET station and proceed to WILSHIRE/VERMONT station.

Tunnel length - 10,270 LF

T2 - Start at HOLLYWOOD/HIGHLAND and proceed to VERMONT/SUNSET station.

Tunnel length - 13,150 LF

T1

1.	Order and deliver TBM (Excavate and store station and crossover)	8
2.	Install and test	1
3.	Drive 200 feet at reduced speed	1
4.	Install back-up equipment	1
5.	Drive 10,270 LF tunnel	5
6.	Transfer across open excavations (2)	1
7.	Remove TBM	1
8.	Concrete 4,530 LF invert	1
9.	Concrete 4,530 LF only	2
10.	Concrete 4,530 LF walkway	1
11.	Final clean-up	1
12.	Allow for overlapping construction	1
		24 months

T2

1.	Order and deliver TBM	8
2.	Install and test	1
3.	Drive 200 feet at reduced speed	1
4.	Install backup equipment	1
5.	Drive 13,150 LF tunnel	6-1/2
6.	Transfer across open excavations (2)	1
7.	Remove TBM	1
8.	Concrete 6,850 LF unit	1-1/2
		1
		1
9.	Final cleanup	1
10.	Allow for overlapping construction	1
		27-1/2 months

DESCRIPTION OF PROPOSED DESIGN (Continued)

In order to minimize concrete equipment and form costs, assume contractor will elect to concrete tunnels in sequence, then add 4 months to T1 and 6 months to T2.

Then total contract duration in contractor months will be 24 + 27-1/2 + 4 + 6 = 61-1/2 months.

For present design, items 1, 2, 3, 4, 7, 11 and 12 will apply to each contract for a total of 14 months on each of 5 contracts. Excavation and concrete work will be as follows:

	B240	B250	B260	B280	B300
Drive Tunnel	1	2-1/2	3-1/4	1-3/4	1-1/4
Reinstall TBM		1			
Concrete Invert	1	1-1/4	1-1/2	1	3/4
Arch	2	2-1/2	3	2	1-1/2
Walkway	1	1-1/4	1-1/2	1	3/4
	6	8-1/2	9-1/4	5-3/4	4-1/4

Therefore, the total contractor months will be 33-3/4 + 70 = 103-3/4 on the same basis as for the proposed packages. In addition, 6 months should be allowed for the B270 excavation and shoring, to bring the total to 110 months.

The tunneling/excavation contract scheme will, therefore, save 48-1/2 months of overhead costs at about $100,000/month, i.e., $4,850,000 in all.

EQUIPMENT COSTS

Without considering other equipment, each of the T1 and T2 contractors will purchase or refurbish 2 TBM's, 4 in all.

Because of simultaneous construction, B240-B300 contractors will purchase or refurbish 10 machines.

Only two machines in reusable condition and of the correct size can be expected to be available for refurbishment. Assume new cost at $2,000,000 and refurbishing cost at $500,000. Then T1 and T2 can outfit for 2 x $2,000,000 + 2 x $500,000 = $5,000,000.

B240-B300 contractors must purchase 8 new machines and can use two refurbished for a total of $17,000,000.

Alternatively, by allowing for extra removal, reinstallation and tunneling time, the B240-B300 contractors may buy 3 new machines + 2 refurbished for a total of $7,000,000.

The extra time amounts to 10-3/4 + 5 + 5, say 21 months at $100,000/month extra overhead. Therefore, the minimum TBM net cost for B240-B300 packaging is $9,100,000.

DESCRIPTION OF PROPOSED DESIGN (Continued)

The least savings, assuming the T1 and T2 contractors buy new machines is $1,100,000 and the possible savings are $4,100,000.

EFFICIENCY

The cost of stations may be broken up into excavation and shoring, concrete and finish work. Using costs from Alvarado and shoring amount to $6,250,000 per station. Therefore, extracting this cost at the rate of $13,880/LF from all cut-and-cover structures means that total cost of structure and finishing work will be as follows:

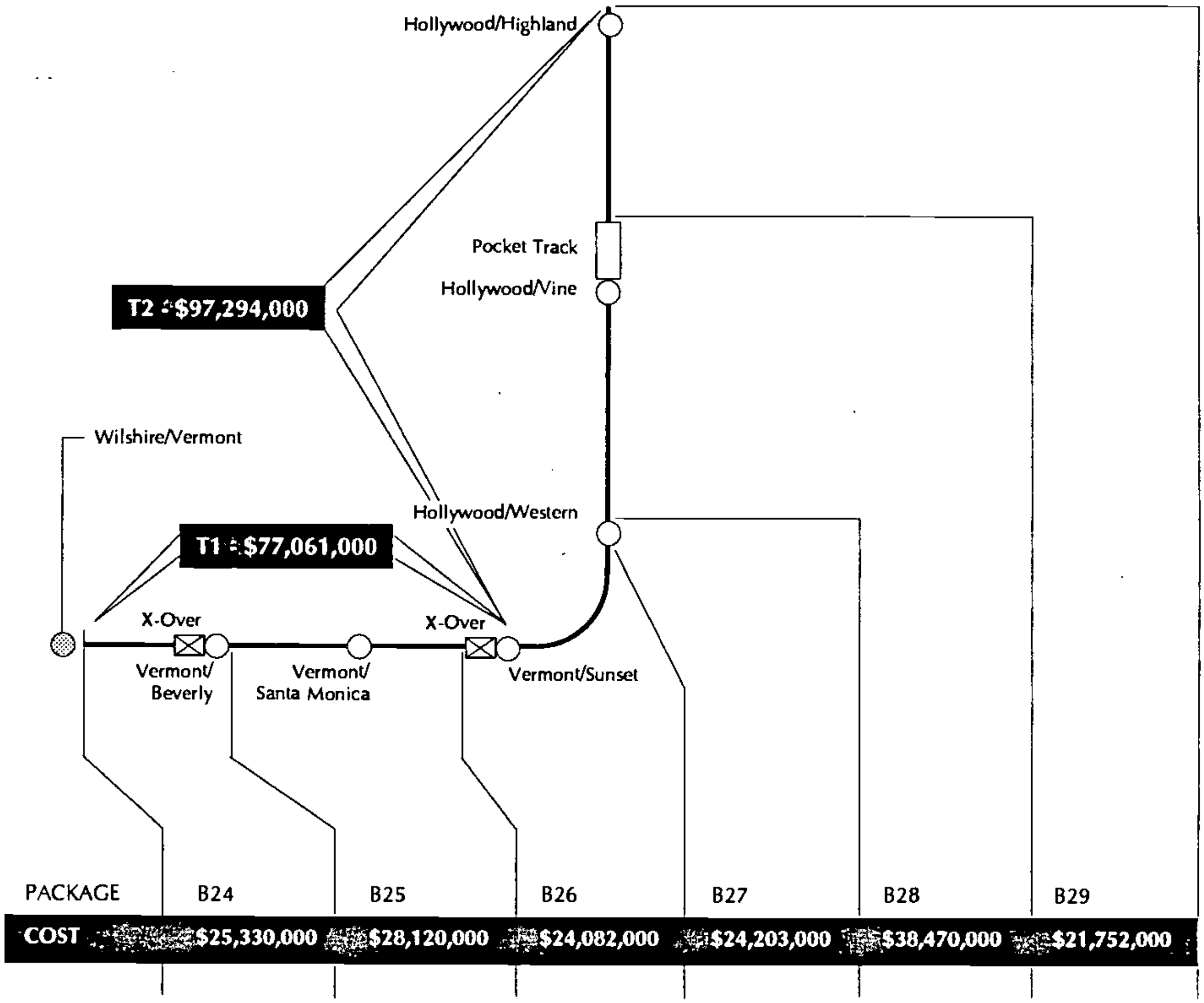
Cross overs:	680 LF @ $25,700/LF	=	$ 17,476,000
Stations:	2,700 LF @ $34,690/LF	=	$ 93,663,000
	TOTAL	=	$111,139,000

Assuming that substitution of building contractor for excavation contractor will yield efficiency savings based on better ability to coordinate sub-contract work and that this saving will be 3% yield net savings of $3,300,000.

Overall savings will, therefore, be at least $4,850,000 + $1,100,000 + $3,300,000 for a total of $9,250,000 and may be as much as $4,850,000 + $4,100,000 for a total of $12,250,000.

STUDY TITLE **SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT METRO RAIL PROJECT VALUE ENGINEERING STUDY #1 - DESIGN CRITERIA AND DIRECTIVES - MOS-II**

SKETCH OF PROPOSED DESIGN



VEP No. 2 - Change Orders, Claims and Dispute Resolution

Southern California Rapid Transit District Metro Rail Project
Value Engineering Study #1 - Design Criteria and Directives - MOS-II

Value Engineering Proposal (VEP) No. 2

DATE	7/27/89

STUDY TITLE

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT METRO RAIL PROJECT
VALUE ENGINEERING STUDY #1 - DESIGN CRITERIA AND DIRECTIVES - MOS-II

ITEM: CHANGE ORDERS, CLAIMS AND DISPUTE RESOLUTION

FUNCTION: Solve Problems

CONCEPT BEFORE VE

Contract changes, claims and disputes are controlled by General Conditions Articles 34 through 42 of the Standard Specifications.

Procedure is complicated and does not permit the Resident Engineer much authority to directly negotiate and resolve field-originated problems.

PROPOSED ALTERNATIVE CONCEPT

Adjust system to achieve the following:

1. Establish Dispute Review Board to project image of fairness and expeditiousness.
2. Enhance authority of Resident Engineer to match Contractor's Representative on a one-to-one basis. The Resident Engineer therefore should be a District employee acting as deputy to the Contracting Officer, with authority to negotiate field changes up to $100,000 or more, subject to review and approval by the Contracting Officer.
3. Keep number of inspectors and clerical staff to a minimum required for proper supervision in the District's interest.
4. Avoid duplication of responsibilities.
5. District should establish well-qualified and well-trained construction supervisiory force necessary for the conclusion of its construction program.

Advantages
1. Reduced contract conflicts
2. Quick resolution of field problems
3. Minimalized duplication of effort
4. Reduced cost

Disadvantages
1. Additional District employment
2. Personnel development cost
3. Management adjustments

ESTIMATED COST	$	ESTIMATED COST	$
		EST GROSS SAVINGS	$ 73.000,000
		EST IMPLEMENTATION COST	$
		EST NET INITIAL SAVINGS	$ 73,000,000
		EST LIFE CYCLE SAVINGS	$

DESCRIPTION OF PRESENT DESIGN

Contract changes, claims and disputes are controlled in the present design by general conditions articles 34 through 42.

Change requests are processed from the field through a complex system offering opportunities for all parties with a potential, current or future interest in the change to affect the process. Negotiation as to quantities takes place between the Resident Engineer and the contractor's Project Manager only after the Change Control Board has completed its review and the RE is authorized to negotiate only within bounds set by CCB. For change orders exceeding $100,000 in value, the District acts separately from the Change Control Board.

The following data is taken from the Contract Change/Claim Status Executive Summary Report as of 31 March 1989.

1. Total value of contract awarded	$499,464.54
2. Total number of change orders issued	416
3. Total value of change orders issued	$22,237,096.48
4. Total number of change requests pending	299
5. Estimated value of change requests pending	$23.4 million
6. Total number of claims resolved	86
7. Total value of claims resolved	$6.4 million
8. Total number of claims withdrawn	118
9. Total number of claims closed because of contract noncompliance	154
10. Total number of claims in negotiation	61
11. Value of claims in process	$1.2 million
12. Total No. of claims under evaluation	169
13. Value of claims under evaluation	$17.5 million
14. Total No. of claims in dispute	10
15. Value of claims in dispute	$0.7 million
16. Total No. of potential claims	125

DESCRIPTION OF PRESENT DESIGN

17. Value of potential claims — $1.1 million

18. Estimated proportion of C.O. and claim value admitted — 75%

From these figures, it appears that $28.6 million has already been committed for changes and claims resolved (items 3 and 7). The total of changes and claims unresolved is $43.9 million (items 5, 11, 15 and 17). Applying a 75% factor (item 18) yields a probable total settlement of $32.9 million, bringing the grand total to $61.5 million. At the time of this tabulation, 30.5% of awarded value of work had been completed for a total of $152.3 million. The extra cost experience has, therefore, been 21.6%.

The number of change requests and claims represents a higher than usual volume, straining both the capacity of the District to respond and the contractor's patience. In this situation, it becomes difficult to maintain good relationships, conducive to efficient work.

DESCRIPTION OF PROPOSED DESIGN

A proper philosophy for establishing mutually agreeable relationship between Owner and Contractor includes proper sharing of risk so that the party best able to control a risk element becomes responsible for it. One part of such risk sharing is the changed conditions clause which represents that the Owner will accept the cost of conditions different from those anticipated. It is, therefore, expected that change orders will be issued for most contracts involving work below ground. It is unusual for the level of changes to be as high as 21.6%. the amount budgeted usually being about 5%. Additional work and design changes during construction of MOS-I are especially expensive.

It is the impression of major contractors that the management system in place for Metro construction is unnecessarily cumbersome, slow and unfair. Whether correct or not, this impression will affect future bidding and experience suggests that the added cost of future contracts will be 5% to account for this perception.

In order to resolve this problem, it is proposed that SCRTD establish a Dispute Review Board for future contracts. This has generally proved very effective on other large projects as measured by absence of claims and litigation at the end of the contract.

Since 91% of the change requests on MOS-I have been settled for less than $100,000, it is proposed that a simplified system be installed to handle these smaller changes. Ideally, the authority of the Resident Engineer should be enhanced so that he can bring negotiations to finality short of final approval before processing a change request. His perception of field conditions should not be subject to review by non-field personnel. Comments by designers should be limited to technical aspects of the change.

The current duplication of supervision by PDCD and the District is cumbersome and uneconomic and makes for organizational problems. The contractor's representative in the field has full authority to negotiate for the contractor and the Resident Engineer should ideally match this authority.

It is proposed that the whole CCB apparatus be dismantled and that the work should be supervised by a District-employed Resident engineer, properly qualified by training and experience to perform this function. He should be a deputy to the contracting officer, with authority to negotiate changes in the field up to $100,000, subject to review by an Area Manager designated as the District's Contracting Officer.

The level and kind of expertise required will depend on the contract package and for smaller packages such as utility relocations, a reduced level of responsibility may be appropriate.

The number of inspectors and clerical staff should be kept to the minimum required for proper supervision of the District's interest, bearing in mind that the contractor has the legal responsibility for performing in

DESCRIPTION OF PROPOSED DESIGN *(Continued)*

accordance with the contract terms. The inspector's primary function is, therefore, to check for compliance, especially with respect to work which will be hidden later, and to maintain an accurate record of the job. He should be qualified at a level at least equal to that of a foreman and ideally at the superintendent level. In this way, given mutual respect, very many problems will be resolved in the field without ever requiring formal notice.

The District will be in the construction business for years and decades to come. It should, therefore, seek to establish a well-qualified and well-trained supervisory force of its own. Field experience with a contractor is of at least equal value to academic qualifications and should be sought.

It is anticipated that if these recommendations are adopted, a saving of 5% of future bid costs will be realized on the basis of the District's establishment of a Disputes Review Board (with a contract Bid document Escrow) and that change order experience will drop to within the normal range. This would result in further savings of up to 16.6%. The total value of potential savings is, therefore, about $73,000,000.

ADDITIONAL NOTES ON CONTRACT CHANGES AND ROLE OF RESIDENT ENGINEER

If a change is not needed, it should not be made. If it is needed, it must be made, regardless of whether future work or projects are also affected. If it is made and extra cost is involved, the Contractor must be compensated promptly. Other parties may be notified, but should have no power to interfere. Field staff have the best opportunity to assess field conditions. They are appointed to be responsible in this and other areas. If they exercise their responsibility properly, they should not be second-guessed. If they are not responsible, they should be replaced.

Duplication of supervision by PDCD and District must necessarily lead to PDCD RE to defer to the District PE, even though the contractor has to report to the RE. If the District feels that RE is not able to function alone, the PE should replace him.

The Contractor must negotiate with the RE. Both parties to a negotiation would have equal authority, ideally, pleni-potentiary. The RE is limited by decision of others as to value of work whereas the Contractor's PM has full authority. In this situation, the best the Contractor can hope for is to achieve the limit of the RE's authority, whereas, the CCB valuation should be stated at once as the District's bargaining position, just as the Contractor's request for extra compensation states his bargaining position. As presently set up the situation is inherently and intolerably unfair and is so perceived by the Contractors.

The Contractor is under obligation to make notifications to responses in a fixed time, whereas, the District accepts no such obligation. Good faith negotiations cannot be assumed in such conditions.

VEP No. 3 - Design Quality Control

Value Engineering Proposal (VEP) No. 3

DATE 7/27/89

STUDY TITLE **SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT METRO RAIL PROJECT VALUE ENGINEERING STUDY #1 - DESIGN CRITERIA AND DIRECTIVES - MOS-II**

ITEM DESIGN QUALITY CONTROL

FUNCTION Reduce Contingency

CONCEPT BEFORE VE

The system is designed to three basic levels of completion; conceptual, preliminary (60%) and final (100%).

The conceptual design is developed by the General Engineering Consultant and the preliminary and final engineering/architectural design of specific segments are performed by individual Section Design Consultants under contract to the General Engineering Consultant. These Consultants typically consist of Lead Consultants and Specialty Subconsultants. The design quality control is organized along traditional engineering and organizational hierarchies, divided among disciplines and between the Lead Consultant and Specialty Subconsultants. Products are reviewed informally and distributed for coordination purposes during the design periods and formally checked at each milestone for technical content and interdisciplinary and interorganizational coordination.

PROPOSED ALTERNATIVE CONCEPT

Introduce definitive design quality control specifications to all design contracts and require multidisciplinary task forces organized according to function for all design contracts.

System-wide elements such as route alignment, tunneling and subsurface rough work should be designed for the entire MOS-II line by a single design organization while discrete, station-specific elements may be designed by multidisciplinary organizations. Introduce independent peer review, systems integration review, implementation of design quality control specifications and independent final checking into the design process.

Encourage maximum design automation and establish computer-aided design and drafting (CADD) standards, thereby reducing miscoordination and facility component conflict potential and achieving some design personnel productivity improvement.

Advantages
1. Reduced error potential
2. Standardized procedures
3. Minimalized duplication of effort
4. Reduced contingency cost

Disadvantages
1. District specification effort
2. District compliance effort
3. Designer documentation effort

ESTIMATED COST	$	ESTIMATED COST	$
		EST GROSS SAVINGS	$ 30,000,000
		EST IMPLEMENTATION COST	$
		EST NET INITIAL SAVINGS	$ 30,000,000
		EST LIFE CYCLE SAVINGS	$

DESCRIPTION OF PRESENT DESIGN

The system is designed to three basic levels of completion, conceptual, preliminary (60%) and final (100%).

The conceptual design is developed by the General Engineering Consultant. This conceptual design defines the basic route alignment, station configurations and locations, station architectural finish guidelines, and system operating standards. The conceptual design products consist of design criteria (basis of design), standard drawings which define system-wide facility features, standard specifications which govern construction materials and methods, and cost estimates. These products are prepared through manual methods, with some computer assistance, by designers and engineers. The program quality control is organized along traditional engineering hierarchies. Products are reviewed informally during the design period and formally checked at each milestone. The design team is typically organized by architectural, civil, structural, geotechnical, mechanical, electrical, and cost engineering disciplines. Interdisciplinary coordination and project direction is supplied by project engineers. Senior project managers provide administrative support, general engineering guidance, and coordination with the District. District project engineers review conceptual engineering work in progress and at the conclusion of the effort.

The route alignment is divided into separate segments and the engineering/architectural design of these segments is performed by individual Section Design Consultants under contract to the General Engineering Consultant. These Consultants typically consist of Lead Consultants and Specialty Subconsultants. This design effort defines the detailed construction features of the project components. The preliminary and final design products consist of design reports and computations, progress and final contract drawings and specifications, progress and final cost estimates. These products are prepared through manual methods, with some computer assistance, by designers and engineers. The program quality control is organized along traditional engineering and organizational hierarchies, divided among disciplines and between the Lead Consultant and Specialty Consultants. Products are reviewed informally and distributed for coordination purposes during the design periods and formally checked at each milestone for technical content and interdisciplinary and inter-organizational coordination. The General Engineering Consultant organizes the Section Design Consultant work to coordinate between themselves. The design teams are typically organized by architectural, civil, structural, geotechnical, mechanical, electrical, and cost engineering disciplines. Interdisciplinary coordination and project direction is supplied by project engineers within each design organization. Senior project managers within each design organization provide administrative support, general engineering guidance, and coordination with the District. District project engineers review preliminary and final engineering work in progress and at the conclusion of the effort.

DESCRIPTION OF PROPOSED DESIGN

The system levels of completion remain; conceptual, preliminary (60%) and final (100%). The present design is modified as follows.

The present design checking/quality control methods and procedures vary between design organizations under contract to the District. Introduce definitive design quality control specifications to all design contracts. Require a formal submittal of design completion checklists and standardized check-print documentation as a bare minimum. Establish design quality control schedules to be coordinated with design submittals to ensure completion of all design checking prior to submittals.

The present design checking/quality control functions are diffused and duplicated within the District-General Engineering Consultant-Section Design Lead Consultant-Section Design Specialty Subconsultant organizational hierarchies. Present organization along discipline and organizational lines preclude comprehensive design checks until late in the design process. Require multidisciplinary task forces organized according to function, not by design firm or discipline organizational hierarchies, and require schedule commitments of design personnel. Minimize design coordination and conflict potential by organizing design packages along functional lines. Control design interfaces by placing design responsibilities upon detailed designers with specified responsibilities for design input and general review by the District. System-wide elements such as route alignment, tunneling and subsurface rough work should be designed for the entire MOS-II line by a single design organization while discrete, site-specific elements may be designed by multidisciplinary organizations according to station geographical locations. Introduce independent peer review, systems integration review, implementation of design quality control specifications and independent final checking into the design process.

The present design implementation process appears to be geared for manual work, with very little incentive for computer-assisted design and drafting. Instead of an undefined method of design documentation, the District should require maximum design automation and establish computer-aided design and drafting (CADD) standards to ensure that designs achieve three-dimensional modeling of the project facilities with automatic facility conflict resolution. This would have the effect of reducing design errors to items of omission rather than miscoordination and facility component conflicts, thereby easing the checking/quality control process. The utilization of CADD will also have the net effect of reducing design personnel cost by increasing productivity. Industry standards at this time indicate that a 2 to 1 personnel cost saving should be achievable.

VEP No. 4 - Field Management

Value Engineering Proposal (VEP) No. 4

DATE 7/27/89

STUDY TITLE **SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT METRO RAIL PROJECT VALUE ENGINEERING STUDY #1 - DESIGN CRITERIA AND DIRECTIVES - MOS-II**

ITEM FIELD MANAGEMENT

FUNCTION Administer Contract

CONCEPT BEFORE VE

Many submittals are required by the Contractor at various times during the course of the Contract. Complex and detailed schedule information is required from the Contractor. Shop drawing review process appears to be lengthy. No training program formalized for Resident Engineers or field staff but they appear to operate under a large reporting burden.

Burdensome reporting requirements and remoteness of submittal review process from field detract from Contractor perception of inspection and contract administration efficiency with possible result in loss of contractor respect for field staff organization and less cooperative approach to the work by the Contractor.

PROPOSED ALTERNATIVE CONCEPT

Eliminate unneccessary burdens, such as:

1. Complex Critical Path Method (CPM) schedules when simple bar chart schedules are applicable.
2. Cost breakdowns which do not materially affect the measurement and payment process.

Increase perception of efficiency and responsiveness by:

1. Minimize time period for field review of submittals. Take all steps to ensure "streamlining" of the review process.
2. Maintain well-qualified RE and inspection staff with a high objective to ensure a cooperative supervisory attitude.
3. Consider incentive contracting.

Advantages
1. Reduced conflict
2. Quick response
3. Minimalized loss of effort
4. Reduced cost

Disadvantages
1. Reduced data review
2. Increased readyness cost
3. Management adjustments

ESTIMATED COST	$	ESTIMATED COST	$
		EST GROSS SAVINGS	$ Not Quantified
		EST IMPLEMENTATION COST	$
		EST NET INITIAL SAVINGS	$
		EST LIFE CYCLE SAVINGS	$

STUDY TITLE **SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT METRO RAIL PROJECT VALUE ENGINEERING STUDY #1 - DESIGN CRITERIA AND DIRECTIVES - MOS-II**

DESCRIPTION OF PRESENT DESIGN

The present system requires many submittals by the Contractor at specified times in the course of the contract. The engineer has difficulty in getting the Contractor to submit schedule information as required and the drawing review process appears to be lengthy.

There is no training program in place for Resident Engineers or staff but they appear to operate under a great burden of reporting requirements.

These factors act to degrade the Contractor's opinion as to the efficiency of the inspection and lead to loss of respect and absence of a cooperative approach to the contract work.

Potential reductions in Contract Costs are high but not quantifiable.

DESCRIPTION OF PROPOSED DESIGN

The Contractor is working under great pressure imposed by a myriad of daily crises as he seeks to conduct his work with the greatest possible efficiency while coping with problems of timely ordering, satisfying subcontractors, labor management and the need to operate profitably.

It is unwise to add unnecessary burdens, such as the production of CPM schedules of no use or value to the Contractor. He perceives himself as being forced to manufacture the rope, which the RE will later use to hang him. He also has enough trouble getting his supplier and subcontractors to provide him with information, prices and deliveries without having to cope with unyielding drawing approval policies.

His perception of the RE's staff will depend on the respect he has for their ability and knowledge and on their swift discharge of duties affecting contract work.

For these reasons, the following proposals are offered:

1. Review the use made by the District of CPM schedules submitted by the Contractor and review to reducing requirements to a simple bar chart. If the District needs to keep abreast of changed priorities, regular progress meetings, between RE and Contractor's PM can easily pin-point trouble spots so that necessary changes in priorities and working methods can be resolved cooperatively.

2. Field review of submittals should not take more than two days, even if this means hand-carrying drawings to the designers for discussion of perceived problems. There is simply no reason for the 30-day turnaround periods so frustrating to the Contractor.

3. The RE and inspection staff should be well-qualified by extensive experience and continued training. A policy of cooperative supervision should be stated and operated.

4. Consideration should be given to the use of incentive contracting, whereby the Contractor can earn an additional profit by responding to incentive categories defined in the District for it's benefit. The suggested model is that used by the Bureau of Reclamation and the Corps of Engineers.

POTENTIAL VE PROPOSALS - TUNNELS

MOS-II contains some 60,000 linear feet of running tunnel, valued at approximately $150 million.

During the course of Value Engineering Study #2, scheduled for Work Shop from August 21 through august 25, detailed Value Engineering Proposals will be presented to identify specific areas where opportunities for cost reduction occur.

In this study, a review of standard and directive drawings was made in order to determine broadly elements of these documents that are impacting the cost of the work, maybe unnecessarily.

In a Value engineering study conducted by FEI for the District in 1984, a proposal was advanced suggesting that the tunnel diameter be decreased from the current 17'-10" I.D. to 16'-6" I.D., a reduction of 1'-4". This proposal was reviewed by the District and Consultant at a presentation meeting held in the latter part of June 1984.

Following considerable discussion, the proposal was "accepted" by the District with the general comment that "...the proposal has merit, warrants further study...."

Data reviewed by the VE team during the course of this study did not reveal any change to the previously defined 17'-10" I.D. tunnel

For reference purposes, the "Description" text from that proposal is repeated here.

DEVELOPMENT NOTES OF PROPOSED DESIGN

Reduced Tunnel Diameter to 16'-6" I.D.

Discussion

Available data indicates that 17'-10" diameter tunnel dimension has been arrived at by constructing a composite dynamic clearance envelope developed by combining properties of existing or proposed vehicles in use or planned for use elsewhere in the U. S.

The VE Proposal contends that for the Wilshire Corridor and future L. A. corridors where subway construction by machine or shield-driven tunnels has been selected as the major construction method, further consideration should be given to constructing a smaller tunnel, requiring that vehicle manufacturers adjust car outlines to suit.

Typical tunnels for rapid transit in operation range from under 13'-0" (London), 16'-0" (Toronto), 16'-6" (San Francisco), under 16'-0" (New York, and so on. There is little doubt that a vehicle can be constructed economically and competitively to fit a 16'-6" diameter tunnel.

Study of the SCRTD adopted dynamic envelope reveals that minor adjustment to the "corners" of the envelope could be readily introduced in order to reduce tunnel size. Operating characteristics will not be affected, particularly if top of rail is lowered consistent with the minimum requirements of a fixed invert concept, i.e., no floating slab. This constraint on the car cross sections could be easily adopted by bidding potential car manufacturers without imposing additional costs.

There have been some observations made that operating power consumption would increase with tunnel diameter reduction. Whereas this may be true to some degree, BART studies in the Trans-Bay Tube showed that only about 5 to 8% savings are attainable. These savings in terms of hard dollars would amount to some $100,000 per year for the Wilshire line and are small enough to be neglected when compared with capital cost savings possible.

From a comparison of gross tunnel area to cross sectional area of the vehicle, we find that the minor differences arising from the smaller diameter tunnel will have no effect on the cost effectiveness of the ventilating and smoke evacuation system. Design of these air-moving systems is not sophisticated enough to be able to deal with small differences of this magnitude in any credible manner, and actual experience with the smaller diameter tunnels in San Francisco and elsewhere demonstrates that this issue is of no major importance.

Objections to tunnel diameter reduction have also included:

- Difficult to re-rail

- More difficult to maintain

- More difficult from a standpoint of operating life safety system

None of these objections can stand up to careful scrutiny and none can be quantified to a point where realistic comparisons can be made. In terms of hard money estimates, no compelling arguments can be made in favor of bigger tunnels.

Reducing the tunnel diameter by one foot will result in considerable cost savings for Segment A170. Systemwide, the savings or course would be very substantial.

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Since 1984, the District's plan for constructing a Wilshire Boulevard Metro has changed somewhat, and current plans for the alignment locate the Metro under Vermont Street and Hollywood Boulevard. Ground conditions along this route are more favorable for tunneling and the risk of encountering hydrocarbon and other "oily" materials is reduced considerably.

Also, since 1984, the District has completed its procurement plans for the Metro vehicle and has selected the BREDA Corporation (Italy) as Prime Contractor and manufacturer.

In view of the foregoing, the VE team felt that a major opportunity to reduce cost continues to exist by reducing tunnel diameter.

At this point, <u>there is still time</u> to "adjust" the vehicle's dynamic envelope in order to direct the manufacturer to fit his vehicle to the 16'-6" I.D. tunnel (16'-0" after deduction of construction tolerance).

Such a proposal should not result in "curved doors" and should not in any material way be detrimental to the manufacture of the car and its capacity.

The surprising thing that appeared to determine the larger 17'-10" I.D. tunnel seemed to be related more to the location, size and shape of the emergency walkway and the traction power third rail assembly. Recognizing that these critical elements, are concerned with important operating and life safety properties of the tunnel, the VE team continued to feel that some "<u>adjustment</u>" would certainly make it possible to reduce the tunnel diameter, possibly to suit the BREDA car "as is" clearance envelope. It is by no means impossible to consider further tunnel diameter reductions by combining potential areas for improvement.

The cost of the construction of the tunnel is directly proportional to the amount of material that must be excavated. The 1984 VE study concluded that for a 1'-0" reduction from 17'-6" to 16'-6" savings of the order of 9.1% could result. Along these lines, it would appear that for a 1'-4" diameter reduction savings of over 10% could be realized - some $15,000,000.

The VE team will study this matter in more detail; however, the team urges the District to take another hard look at the dictates of both the car manufacturer and those concerned with life safety. There are indeed opportunities to cut costs in this area. The team felt that investigative time spent in this respect, coupled with any redesign cost, would certainly be warranted.

The type and thickness of tunnel lining is another general area reviewed by the VE team both from the standpoint of continuing to look for opportunities to reduce the diameter of the tunnel and, of course, to speed up construction and reduce contractor overhead.

It appeared to the team that the design of the 12" thick poured-in-place reinforced concrete secondary (or permanent) lining could be modified in two areas.

Firstly, given the fact that the impermeability of the tunnel lining to gas and water has been dealt with by the inclusion of the tunnel membrane, it appeared to the team that minor cracking of the tunnel concrete would not be objectionable.

With this in mind, the VE team considered the elimination of all reinforcing steel from the lining and concluded that from a shrinkage standpoint, the lining would be less inclined to crack without reinforcing than it would with reinforcing.

The matter is analogous to pouring long concrete slabs on grade as specified by CALTRANS in highway construction. If the concrete is not inhibited from changing length, then it does so without stress. The tunnel lining is free to move and change length longitudinally because of the presence of the membrane. If left to do so, each 100 foot or so pour would "shrink" normally and little cracking would occur particularly if crack control joints were installed similar to pavement construction.

The reinforcing steel continuous from one pour to the next will restrain the concrete and create tensile stress during the "shrinkage" process.

In reviewing the seismic design criteria for tunnel lining, the VE team noted that essentially two forms of deformation were to be accounted for, i.e., transverse "racking" of the tunnel and longitudinal bending conforming to the distorted shape of the surrounding ground during an earthquake, (Section II, Article B, 6th paragraph of supplemental criteria for seismic design of underground structures.)

The seismic design criteria for running tunnels indicates there is a "minimum" requirement for reinforcing of the tunnel lining. The VE team considered this to be restrictive because the same degree of protection against tunnel cracking could be achieved using alternative methods, i.e., control joints, without incurring the high cost of placing and supporting the rebar during tunneling operation. The team felt that during longitudinal deformation of the ground in an earthquake, the tunnel would behave analogous to a "chain" or linkage with control joints installed in such a manner to establish a "given" chord length consistent with the degree of expected curvature.

Longitudinal strains resulting from longitudinal deformations as described to the team at the VE briefing on Tunnel Design were not clearly understood by the team; it was felt, however, that the reinforcing provided by the "MINIMUM" requirement was not developed rationally. The team felt that an unreinforced tunnel liming had not been fully explored to date.

The team felt that possibly the 12" lining thickness may have been determined by the need to provide sufficient space for the placing of the concrete within the 'REINFORCED' lining. It is well understood that a very specific and rational design for a tunnel lining of this type is not available. The selection of the tunnel lining is very often based on the judgment of those responsible for the work.

The VE team felt that an unreinforced concrete lining design approach should be permitted and that an attempt be made to reduce concrete thickness to 9" or 10". The VE team felt that opportunities to reduce tunnel concrete costs by some 50% without taking into consideration added cost savings occurred by the further reduction in tunnel diameter of between 4" and 6".

For the study section, about $7.5 million in savings could be realized by the redesign of the lining with further considerable savings, may be as much as three to four million, from the tunnel diameter reduction.

Two other general areas for investigation were identified by the VE team for further study in the next VE study. These are concerned with the cross-passages connecting the tunnels and with provisions being made for the emergency walkway and tunnel invert.

In the latter case, the team felt that a very meticulous and careful review be made of life safety requirements concerning the evacuation of patrons on the walkways. Clearances for patrons should be re-examined and the relationship between car floor and top of walkway determined so that the personnel clearance over the walkway does not become the overriding criterion for tunnel diameter.

Directive drawings and details for the physical design of the walkway are restrictive and expensive to build. Two major cost items in tunnel construction are formwork and rebar. Where possible, these should be eliminated.

The team felt that a more liberal criterion should be developed to simplify the walkway construction. Concepts involving structural steel brackets supporting self-contained prefabricated polymer concrete cable trays should be explored.

The team felt that the reinforcing steel placed in the tunnel invert served no purpose and in fact had no visible function.

Criteria and directives aimed at simplifying this area of the work could very well lead to savings in excess of $3.5 million.

Tunnel cross-passages occur at about 750 feet on center within the study area. About 40 such structures are required to be installed by the criteria. The team felt that the criteria for spacing the passenger could be relaxed to say 1000 feet. The team also felt that the cost of constructing these facilities to the details shown in the directive drawings would be very high. Savings in excess of $2-$3 million are attainable in this area.

In summary, detailed VE studies that will be identified in the forthcoming VE Study #2 will identify opportunities to reduce project costs by more than $30 million for the tunneling part of the work.

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NATM

The team considered the NATM method for tunnel construction briefly and came to the conclusion that the method was not suitable for general application to the study area. Some factors that led to the team's conclusion included the following:

Tunnel construction by NATM in soft ground is inherently slow. The contract documents for recent WMATA contracts indicate that contractors should expect to advance the heading about 10 ft/day. The procedures are complex and need the development of skills in the work force.

At a meeting in Minneapolis last March (1988) the President of STWVA indicated that in West Germany NATM no longer showed any economic benefit compared with either cut-and-cover or shield tunneling for subway construction.

The NATM construction of the Mount Lebanon tunnels in Pittsburgh resulted in cost overruns equal to the initial bid cost of the tunnel work.

In Washington D.C. an Austrian contractor offered a Value engineering Proposal for a WMATA tunnel and stations contract involving complete redesign. The proposal was accepted and, in spite of some problems with water-proofing, the project was judged successful by WMATA. However, the contractor lost $15 million on the job. WMATA then started preparing duplicate designs of tunnel contracts and offered bidders the option of bidding either conventional or NATM. For E6a, the low bidder (Shea) was the only NATM bidder. For E8a, the low bidder (Guy F. Allenson) bid the bolted segmented precast lines option. Both contractors then offered Value engineering proposals to do the work in essentially the same way as the tunnels now being built for SCRTD.

An article in Tunnels and Tunneling last year discussed the fact that, on average, NATM soft ground tunnels experience a major cave-in every 15 km of tunnel.

In these circumstances, adoption of NATM cannot be recommended.

POTENTIAL VE PROPOSALS -
CROSSOVERS & STATIONS

POTENTIAL VE PROPOSALS - CROSSOVER AND STATIONS

Major opportunities for cost reduction exist in this section of the District's proposed MOS-II.

In the present design, the proposed MOS-II segment consists of a subway section some six miles long. The line structures are generally constructed by tunneling methods and the station and cross-over structures by cut-and-cover methods.

Directive drawings for the stations are very well defined and without exception specify stations that contain island platforms and center columns.

Two cross-over structures are included and one pocket-track is located west of the Hollywood/Vine station.

From data assembled from MOS-I, it has been clearly shown that the cost of the running tunnels (twin tunnels) is many times less than for cross-over and station construction. Therefore, it was immediately apparent to the VE team that opportunities should be investigated where structures or part of structures presently designated as cut-and-cover might be changed to tunneling work.

The work effort in developing alternatives for cost comparisons along these lines is naturally very complex and cannot be undertaken in detail as part of the VE study scope.

The team, nevertheless, identified immediate possibilities for price reduction by considering the following:

a) Wherever cross-over structures occur immediately adjacent to stations alignment changes should be investigated so that upon entry into the cross-over structure the running tunnels are located at minimum spacing. The team felt that the clear distance between tunnels in this ground could be reduced safely to 5'-0". The effect of this reduction would be to drastically reduce the length and width of the cross-over structure. This reduction in length could be further reduced by considering the opportunity to hand-mine short transition sections between running tunnels and cross-over.

Such a proposal would result in a station that contained side platforms that would be "wider" generally than would normally be required for a side-platform station. This led the team to believe that probably the most viable or cost-effective solution to the combined tunnel/cross-over/station relationship would be to use side platform stations with track centers at 13'-0" or 14'-0" extending this configuration to adjacent cross-overs and constructing transition structures either by cut-and-cover or by mined methods to a point where the tunnels could be separated by a safe distance. (It is not inconceivable that spacing of tunnels could be such that the clear distance between tunnels would be less than 5'-0" for short distances.)

This basic modification to the alignment and organization of structure has potential for far reaching cost reduction proposals and these will be examined in detail during VE Studies 2 and 3.

b) Given the proposed organization for the design process, i.e., SCRTD-GEC-SECTION ENGINEERS, it would appear that once directive and standard drawings are issued, there is little that the Section Engineer, charged with the responsibility of the design development, can do to improve the work or to adapt it specifically to the task at hand. As a result, the work is 'set in concrete" early and fixed forever.

Because of the potential that modifications to the design alignment may offer, the team felt that the issuing of directive drawings was not in the interest of the District and would not result in fully cost effective work.

In the case of the cross-over structures closing the centerlines of the trackwork could provide the opportunity to reduce substantially the structure span and as a result make it possible to create a clear span "box" without any form of intermediate support which could be constructed swiftly and economically using modern structural engineering concepts.

Within the station, although the cost differentials between side platform and center platform are probably very small, the team felt that opportunities may exist with side platforms to raise the profile through the stations considerably and locate fare collection and "mezzanine activities" at or very close to street surface.

The function of the mezzanine is to distribute passengers to the station platform. With island platforms only one point of access from mezzanine to platform is required. Once a patron is at platform level he has access to both inbound and outbound trains, certainly an advantage but also a disadvantage on crowded platforms at rush hours.

In Side Platform stations, there is a better separation of inbound and outbound patrons but there are additional vertical transportation element requirements.

The team felt that much could be done to open up the stations where platforms could be connected directly to open spaces adjacent to the stations and where, under certain circumstances, the street surface could serve as the mezzanine.

In these cases, Side Platform Stations would prove to be easier to deal with and would certainly merit further study.

c) In the station areas the team felt that the criteria for design and directive drawings placing ventilation facilities in sidewalk areas were not in the District's best interest. The potential for pedestrian lawsuits is much more likely and the cost of constructing long arduous "tunnels" to connect the trainways to the surface was considered generally not cost-effective and certainly a candidate for Value Engineering.

d) It appeared to the team that the station directive drawings, data and direction concerned with the delineation of space for station equipment (ancillary space) was very general and would be difficult to site adapt given the specific conditions for determining the selection of crossover structure, fan room, etc.

The team concluded that allocation of space should be made on demonstrated need, and space should be reduced where excess exists by considering alternative construction methods. An important subject for further consideration is concerned with relocating equipment rooms, substations, etc. to "SURFACE" areas on adjacent right-of-way.

Fine tuning of space requirement may make it possible to "step" roof structures to conform to specific site conditions and possibly to raise the track profile.

e) The team considered that in stations, the need for a 450 platform was not firmly demonstrated and opportunities existed to reduce costs by shortening the platforms consistent with the berthing requirements of a maximum train length. The team felt that platforms could be shortened by at least 10'-0".

f) Directive drawings indicate that the stations <u>should</u> contain center columns. This requirement increases platform and station width and complicates construction. Although it may be possible to demonstrate savings on materials with a center column design, the overall cost of a station could be reduced by introducing prestressed concrete techniques and clear span concepts. This is more pronounced where good bearing is available for the station walls.

In summary, the team identified several candidates for Value Engineering and came to the conclusion that the directive drawings for stations and crossovers presented "final design" personnel with fixed concepts and no opportunity for ingenuity and creative design.

Major VE proposals will be presented during the next two studies and will include:

- o Alternates for cross-over construction
- o Relocation of ventilation facilities
- o Reduction in platform length
- o Reduction and relocation of ancillary space
- o Alternative station concepts including
    - Side platforms
    - Shallower stations
    - Stations opened-up to the surface
    - Clear span concepts

The team felt there was an opportunity to reduce costs by some $57 million

SUMMARY OF POTENTIAL
COST SAVINGS

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT
VALUE ENGINEERING STUDY #1
DESIGN CRITERIA AND DIRECTIVES - MOS-II

SUMMARY OF POTENTIAL COST SAVINGS

A. PROJECT MANAGEMENT

VE Proposal #1	$12,250,000	
VE Proposal #2	$73,000,000*	
VE Proposal #3	$30,000,000*	
VE Proposal #4	**	
SUBTOTAL		**$115,250,000**

Notes: * Latent Costs (Potential Cost Overruns)
** Not Quantifiable

B. TUNNELING

VE Proposal #1 Tunnel Size	$15,000,000	
VE Proposal #2 Tunnel Linings	$ 7,500,000	
VE Proposal #3 Cross Passages	$ 5,000,000	
VE Proposal #4 Tunnel Invert/Walkway	$ 3,500,000	
SUBTOTAL		**$ 29,000,000**

C. CROSS-OVERS AND STATIONS

VE Proposal #1 Minimum Cross-Overs	$30,000,000	
VE Proposal #2 Reduce Ancillary Space	$ 4,500,000	
VE Proposal #3 Vent Shafts	$ 2,000,000	
VE Proposal #4 Platform Length	$ 3,000,000	
VE Proposal #5 Clear Span	$ 1,500,000	
Others	$16,000,000	
SUBTOTAL		**$ 57,000,000**

TOTAL, Including Latent Cost Savings — $201,250,000

Value Engineering Workbook

Title: Value Engineering Study #1
Design Criteria and Directives - MOS II

Date: 7/27/89

VALUE ENGINEERING WORKBOOK

VALUE ENGINEERING WORKBOOK

VALUE STUDY NO: 1 DATE: 7/27/89

STUDY TITLE: SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT - VALUE ENGINEERING STUDY #1
DESIGN CRITERIA AND DIRECTIVES - MOS II

TEAM

NAME	DISCIPLINE		TELEPHONE NO.
R. H. Mitchell	Team Leader	L	(503) 223-2876
H. A. Foster	Structural & Tunnels		(415) 543-1193
R. H. Miller	Electrical		(415) 543-1193
T. McCusker	Tunnel Construction		(415) 777-5670
W. R. McCutcheon	Subway Construction		(415) 254-1197
J. W. Yee	Civil	R	(415) 543-1193

L - TEAM LEADER
R - RECORDER

Phase I Information

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT - MOS-II
VALUE ENGINEERING STUDY #1 - CRITERIA AND STANDARDS

PRESENT DESIGN COST MODEL

<u>FACILITIES BREAKDOWN</u>		
TUNNEL	$112,435,000	
REARRANGEMENT OF UTILITIES	$ 7,500,000	
STATION UTILITY WORK	$ 17,250,000	
STATION	$194,127,000	
STATION SITE RESTORATION	$ 5,000,000	
FACILITIES		**$336,312,000**
SYSTEMS		**$168,013,000**
DESIGN		**$ 51,128,000**
CONSTRUCTION MANAGEMENT		**$ 25,211,000**
CONTINGENCY, 12%		**$ 60,519,000**
TOTAL COST		**$641,183,000**

Notes:

1. Total cost excludes right-of-way, District administration, insurance and special consultant costs.
2. Systems cost is based on MOS-2 total cost. Design and Construction Management costs and contingency percentage are based on SCRTD supplied figures.

A. Design documents consisting of the Standard Directive Plans, Standard Specifications and Design Criteria were available to the VE Team for review prior to the Formal Study. The document list is as follows:

1. SCRTD Metro Rail System Design Criteria & Standards, Revision 1 dated 5/85:
   1.1. Volume I Systemwide (Contract Drawings, Fire/Life Safety, System Safety, Security, System Assurance)
   1.2. Volume II Civil/Structural
   1.3. Volume III Stations
   1.4. Volume IV Mechanical/Electrical
   1.5. Volume V Subsystems.

2. SCRTD Metro Rail Project - Structural Standard and Directive Drawings, Various Revision Dates.

3. SCRTD Metro Rail Project - Architectural Standard Drawings, Various Revision Dates.

4. SCRTD Metro Rail Project - Electrical Standard and Directive Drawings, Various Revision Dates.

5. SCRTD Metro Rail Project - At-Grade Standard and Directive Drawings, Various Revision Dates.

6. SCRTD Metro Rail Project - Baseline Specifications:
   6.1. General Conditions
   6.2. Division 1
   6.3. Technical Guide Specification Sections 2 through 16.

7. SCRTD Metro Rail Project - Wilshire/Alvarado Line - Construction Contract No. A-171, dated September 1986 (Conformed Copy) and
   SCRTD Metro Rail Project - 7th/Flower Station - Construction Contract No. A-167, Advertised November 1988 and Awarded March 1989 (Conformed Copy).

8. SCRTD Metro Rail project - Bid Form for Wilshire/Alvarado Line - Contract A171 - Addendum No. 2, dated 11/11/86.

9. Final Supplemental Environmental Impact Statement, July 1989.

10. Dynamic and Static Outline of Breda Car Body Outline

11. Metro Rail Project Contract Change/Claim Status - Executive Summary Report (As of 03/31/89).

12. Metro Rail Cost Estimate - Phase II, MOS-2, dated March 17, 1989, and Metro Rail Cost Estimate - Phase II, MOS-3, dated March 22, 1989.

B. The VE Team convened at 3:00 pm on 27 July 1989 at the offices of Foster Engineering, Inc., 847 Howard Street, San Francisco, CA. The project elements were discussed with regards to VE potential. The VE Team concluded this meeting after brainstorming potential study elements and project approach and reconvened at 1:30 pm on 28 July 1989 at the offices of Southern California Rapid Transit District (SCRTD), Los Angeles, CA, for the Briefing and Discussion with the Design Architects & Engineers. Personnel attending were:

* Robert H. Mitchell	CVS, Inc.	(Team Leader)
* Harry A. Foster	Foster Engineering, Inc.	(Subway and Tunnel Structures)
* Robert H. Miller	Foster Engineering, Inc.	(Electrical and Systems)
* Wilmot R. McCutheon	Independent Consultant	(Station Construction)
* Terence G. McCusker	Independent Consultant	(Tunnel Construction)
* Johnson W. Yee	Foster Engineering, Inc.	(Civil and Utilities)
John Bilich	RTD	Estimating
Jeff Christiansen	RTD	Estimating/Schedules
Jim Crawley	RTD	Management
Al Levy	RTD	VE Coordinator
Al Amador	MRTC	Chief Estimator
Jim Ball	MRTC	Deputy Project Director
G. M. Cofer	MRTC	Division Mgr. Facilities Design
K. N. Murthy	MRTC	Project Director
Mel Polacek	PDCD	Construction Mgmt.

* (Denotes VE Team Members)

C. The Briefing was presented by RTD and MRTC representatives. This was followed by a Question and Answer Period by all Team Members. Items of interest presented and discussed were:

1. General project description. The present MOS-II LPA was the result of significant mitigative action to contend with severe environmental constraints. The original LPA had been adjusted to avoid major pockets of methane gas and other organic soluble contaminants present in the project vicinities after a major methane-induced fire in the area. This caused a major delay in the project work.

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1. (Continued)

   General design and project management organization description. Southern California Rapid Transit District (SCRTD) is the Owner, Metro Rail Transit Consultants (MRTC) is the General Engineering Consultant (GEC) responsible for development of system standards, directives and conceptual system design, various Section Design Firms will be responsible for detailed design based on the conceptual design directives and standards, and PCDC is the Construction Manager (CM) responsible for supervising and inspecting the construction contract work.

2. General overview of the approved alignment and system configuration. This VE Study concems the design criteria and directives. Later VE studies will consider (1) the tunnel and line structures and (2) stations.

3. Discussed District General Conditions and Standard Specifications. Discussed problems with construction disputes and changes due to differing site conditions. Discussed schedule delay situations. Discussed standard specifications nominally.

4. Discussed Design Criteria. Compilation effort undertaken to identify "best" facility standards, which resulted in the project design criteria. Design criteria is "standard," with special provision to local site conditions and safety concerns. Seismic and fire life safety has had major impact upon the project design. Safety committee set rigorous criteria for the design engineering standards. Substantial effort was expended with respect to safety issues and complying with high standards set by committee. "Gassy" ground resulted in major study that developed HDPE liner system. Area-specific underpinning and other excavation support issues may be different from other system experience.

5. Discussed Standard Drawings and Directive Drawings. Standard drawings were developed to document system standard construction features. Directive drawings were developed as a product of the conceptual design process to establish guideline for detailed design by Section Designers to be selected later. Primarily guidance in purpose, with only dimensions mandatory for Section Designers

6. Discussed cost estimate basis. Present cost analysis of the MOS-II and other lines are based on historical data set derived from bid experience. System costs have been based on low bid prices plus 10%, with tunneling costs based on low bids plus 16%.

7. Discussed utility construction and contract problems caused by utility standards being constantly updated, -- thereby requiring field changes to suit new requirements, and caused by mislocated and undocumented utilities encountered during excavation.

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8. Questions and Answers. General question on operating plan. Verified composite vehicle characteristics and dynamic envelope generally conform with Breda procurement. Verified tunnel liner details. General question on construction problems; no major difficulty. Verified cross passages required every 750 feet. Verified utility trench detail; conduits required only for electromagnetic interference. Verified wet standpipe. Verified floating slabs required for noise mitigation; new "improved" design proposed, earlier failure experience discussed. Discussed noise and vibration control standards. Verified neoprene isolation for soldier piles adjacent to buildings. Verified corrosion control requirements; bonding of reinforcement, etc. Verified that bridging beam per Seismic Design Criteria. Discussed function of tunnel inverts, walkways, ditches. Verified tunnel invert reinforcement. Verified reinforced liner design. Verified that stations and adjacent structures will be constructed by cut-and-cover excavation. Verified that ticketing function is not mandatory at mezzanine level; District is open to street-level ticketing. Verified that single track twin tunnels not considered due to side platform requirement objections. Verified that Under Platform Extraction (UPE) System is for methane gas purging.

D. Briefing was concluded at 3:30 pm and the District and A/E Representatives were thanked for their attendance. The VE Team returned to San Francisco to complete the Information Phase Work.

E. The VE Team reconvened on 24 July 1989 at Foster Engineering Inc. offices in San Francisco. The Team was joined by Mr. Al Levy of SCRTD who observed the VE Process.

Various VE Team members reviewed the available documents and the information discussed in the Briefing Session above. In light of consideration of identified high cost areas disclosed in the System Cost Analysis, the team developed an initial list of items to consider for speculation, analysis and ultimate development. These items are:

<u>Project Management Items:</u>

1. Field Staff Organization. Effectiveness of present system discussed. Duplicative functions noted.

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2. Resident Engineer's Authority. Inability to act in District's interest. Subject to "second guessing" and "armchair quarterbacking" by parties remote from field experience. Need to be viewed as prime mover and contact with Contractor's Representative.
3. Inspector Training. Lack of uniform training process noted. Inspectors not all equal. Need to ensure inspector attitudes and qualifications noted.
4. Contract Packaging. Present contract packaging does not maximize contractor efficiencies. Heavy construction contractors do not usually fare well in coordinating multiple subcontractors typical of station shell construction. Building contractors do not know much about tunnel construction. Need to "tailor" contracts to achieve maximum contractor efficiencies.
5. Mobilization Payment Schedule. General discussion of mobilization and need thereof. Mobilization is not very discrete and is typically used by contractors to receive "up-front" moneys, thereby reducing financing needs during course of contract. Ideally would eliminate, but present contract pricing system may not readily permit such.
6. Demobilization Payment. Discussed as possible incentive method.
7. Contractor's CPM & Scheduling Task Requirements. Highly detailed and much complexity noted. Questioned need for such detail. Noted that heavy tunnel construction does not require such scheduling detail. Felt that construction of this type does not necessarily call for such detail in scheduling. Felt that these requirements add cost without much benefit.
8. Submittal Process. Discussed process length and complexity of transmittals. Felt that the present system was not very efficient.
9. Measurement & Payment. Noted the "unbalanced" nature of present system. Quantity measurements were noted to be primarily for progress monitoring.
10. Streamline Field Engineering. Appears to be general objective of the above items.

<u>Construction Management, Claims & Disputes Resolution:</u>

1. Design Changes. Discussed implication of this item.
2. Changed Conditions Clause. Discussed with regard to present MOS-I experience. Noted the high change order and claim experience.
3. Resolution of Disputes. Discussed the present system and noted that it appeared to be ineffective. Claim resolution time periods appear extreme. Noted that this is having major adverse impact upon the District's future bidding climate. Noted high probability of future overruns.
4. Change Order Process. Discussed present system and related to Resident Engineer authority. Should be simple, easy to implement process. Should eliminate unnecessary involvement in the process by peripherally involved parties.
5. Claims Resolution. See Above.

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Construction Management, Claims & Disputes Resolution (Continued):

6. Owner/Contractor Relations (Contracting "Image"). Discussed deterioration of same. High potential of future cost overruns caused by decrease in bidder response or increased bid contingencies resulting therefrom.
7. District Controlled Delays. Noted cause of delays by late right-of-way acquistion and tardy site access resolution.
8. Risk Sharing. Noted that risk sharing would be a tenuous process because risks are not viewed equally by owner and bidders.

Program Quality Control:

1. Contract Interfaces. Noted importance of coordinated and properly defined interfaces. Lack of such will cause increased costs.
2. System Integration. Noted recent experiences in systems coordination and related to need for proper coordination and "meshing" of complex system elements to achieve a working operation.
3. Structured Design Review. Reviewed change order listing and noted that very few changes appear to be caused by designer-originated or District-originated requests, or by differing site conditions. Noted that claims seem to be due to miscoordinations, omissions, and conflicts.

Design Criteria, Standard Drawings and Directive Drawings:

1. Track Spacing. Major impact on station and crossover structure costs. Need to analyze need for such wide spacing.
2. Project excavation. Appears driven by tunnel size and spacing criteria. VE Team questions the functional criteria resulting in present design.
   2.1. Look at reducing tunnel diameter.
   2.2. Look at reducing tunnel spacing.
3. Tunnel Lining. Reinforced concrete present design. Question ACI-318 design criteria. Look for elimination.
4. Tunnel Invert. Reinforcing questionable. Bonding of steel for corrosion protection noted. Look for elimination.
5. Emergency Walkways. Present design complex and appears costly. Look at alternate design, possibly premanufactured system.
6. Cross Passages. Noted frequency and size. Question both. Analyze for reduction.
7. Tunnel Lighting System. High redundancy element in present design. Analyze.
8. Station Tunnel Interface. Conform structure should be analyzed. Possible savings.
9. Station Excavation. Present cut-and-cover very expensive. Look at reduction or alternate method, possibly mining out cavity.
10. Station Columns. Questionable. Look for prestressed or post-tensioned structural system.

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Design Criteria, Standard Drawings and Directive Drawings (Continued):

11. Crossovers - Internal Loadbearing Walls. Question need. Analyze for elimination.
12. Station Ancillary Space. Appears very generous. Very costly. Look at alternates.
13. Station Entrances. Present design not mandatory for function. Look at alternate design that achieves function at lower cost or greater value. Good potential for opening up to atmosphere. Major implications on overall costs.
14. Mezzanine. Present design not mandatory for function. Look at alternate design that achieves function at lower cost or greater value.
15. Fare Collection. Presently located in mezzanine level above platform level. Look at street-level fare collection. Will have implication on station design elements.
16. Station Air Conditioning. Question need. Analyze extent of special system requirements, such as methane removal and high local ambient air temperature.
17. Underplatform Exhaust System. Question effectiveness for intended use. Analyze.
18. Emergency Fans. Present design requires large space provisions in expensive construction.
    18.1. Look at Operation and Location.
    18.2. Look at Attenuation.
19. Platform Edges. Detail questionable. Look at alternates.
20. Platform Lengths. Length exceeds functional requirement to load and unload passengers. May be reduced without sacrificing primary function. Analyze.
21. Station Vent System. Present design very elaborate. Question need to locate in sidewalk. Team has objection to sidewalk location, primarily with respect to possible District liability. Analyze reasons cited.
    21.1. Look at relocating vents into center of streets.
    21.2. Look at placing in chimney structure.
22. Fire Protection - Wet Standpipe. Look at alternate locations within tunnel.

Other Items Considered:

1. Raceways. Question configuration and material.
2. Elevators vs. Escalators. Equivalent passenger throughput possible. Analyze.
3. Settlement Criteria. Significant cost implications. Look at this.
4. Utilities Advance Contract. Major cost implications. Look carefully at present design for possible alternates.
5. Utilities Field Change Policy. Find out more about implications.
6. Miscellaneous Tunnel Details. Some discrepancies noted when compared against directive drawings. Analyze.
7. Sump Shafts. Substantial cost item. Analyze.
8. Tunnel Lighting Fixtures. Possible savings. Analyze further.

Consultation Record

SOUTHERN CALIFORNIA RAPID TRANSIT DISTRICT
METRO RAIL PROJECT - MOS-2
VALUE ENGINEERING STUDY #1 - CRITERIA & STANDARDS

INFORMATION CONTACT (Name, Title, Company)	TELEPHONE NO. and Area Code	MAJOR POINTS OF DATA RECEIVED
AL AMADOR, CH. EST. MRTC	213·612·7061	Stage II Station work = $9570/LF
JOHN MACDONALD PROJ MGR GUY F. ATKINSON	213·627·5780	HDP costs $2/SF in place
		Rebar hangers cost $2 each.
JEFF CHRISTIASEN	213·972·3920	30.5% of dollar value of awarded
		contracts completed.
Frank DiBognara	(213) 972-3977	Vehicles have 3 doors/side; are
		equipped for regenerative braking
		as well as dynamic braking
Jim Crowley	1(213) 972-3850	7/27/89. Vent shaft outlets. Fire life
Manager Design SCRTD		safety people adamantly opposed
		to locating vent outlets in
		street because of tanker spill
		hazard.

Phase II Speculation

A. The items developed during the Information Phase were categorized into broad categories and "brainstormed".

B. Functional and creative analysis of the category items resulted in the following:

B.1. Contract Packaging

Primary Function(s): Organizes Construction
Secondary Function(s): Minimize Cost
Control Work

Creative Ideas: Retain Present Design
Separate Heavy Construction From Finish Work
Maximize contractor efficiencies

B.2. Claim, Change Order & Dispute Resolution (Construction Management)

Primary Function(s): Solve Problems
Secondary Function(s): Control Cost

Creative Ideas: Retain Present Design
Establish Disputes Board
Establish Authority of RE
Maximize Field Resolution of Problems
Reduce Response and Processing Time Periods
Reduce Conflicts

B.3. Design Quality Control

Primary Function(s): Limits Errors
Secondary Function(s): Control Cost

Creative Ideas: Retain Present Design
Increase CAD Usage
Specify QC Standards and Documentation
Structured Design Review Process
Enhance Teamwork by Task Forcing Design Work
Minimize Interorganizational Hierachies
Minimize Interdepartmental Hierarchies
Require Specific Assignment of Design Personnel to Specific Tasks
Require Systems Integration and Coordination Documentation

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B. (Continued From Previous Page)

B.4. Project Management (Streamline Field Engineering)

Primary Function(s): Administer Contract
Monitor Construction

Secondary Function(s): Control Cost

Creative Ideas: Retain Present Design
Maximize Resident Engineer's Authority
Minimize Submittal Period
Minimize Inspection and Clerical Staffing
Enhance CM Staff Training
Maintain High Qualification Standards
Maintain Proper Staff Attitudes
Reduce Burdensome Contract Scheduling Requirements

B.5. Tunnel Size

Primary Function(s): Create Space
Pass Vehicle

Secondary Function(s): None Identified

Creative Ideas: Retain Present Design
16'-0" Diameter Impact
16'-6" Diameter Impact
17'-0" Diameter Impact

B.6. Tunnel Lining

Primary Function(s): Supports Ground
Creates Barrier

Secondary Function(s): None Identified

Creative Ideas: Retain Present Design
Eliminate Reinforcing Steel
Reduce Tolerance To Actual Construction Requirements

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B. (Continued From Previous Page)

B.7. Cross Passages

Primary Function(s):	Evacuate Passengers Access Tunnels
Secondary Function(s):	Encloses Equipment
Creative Ideas:	Retain Present Design Increase Spacing Reduce by RemovingEquipment From Passages

B.8. Tunnel Invert/Walkway

Primary Function(s):	Support Tracks Support People
Secondary Function(s):	Drains Water Support Equipment
Creative Ideas:	Retain Present Design Eliminate Reinforcing Steel Replace CIP Walkway with Manufactured Item Reduce Invert To Minimum

B.9. Cut & Cover - Crossovers & Pocket Track

Primary Function(s):	Creates Space Permits Construction
Secondary Function(s):	None Identified
Creative Ideas:	Retain Present Design Reduce Track Spacing Reconfigure Crossovers Eliminate Nonfunctional Crossovers

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B. (Continued From Previous Page)

B.10. Station Ancillary Spaces

Primary Function(s):	Enclose Equipment
Secondary Function(s):	None Identified
Creative Ideas:	Retain Present Design Relocate Equipment To Surface Constructed Spaces. Size Spaces To Suit Equipment

B.11. Emergency Vent Shafts

Primary Function(s):	Conducts Air
Secondary Function(s):	Access Station Access Tunnel
Creative Ideas:	Retain Present Design Relocate To Street Centerline Extend Into Chimneys

B.12. Open Up Stations

Primary Function(s):	Ventilate System
Secondary Function(s):	None Identified
Creative Ideas:	Retain Present Design Daylight Stations Reconfigure Station Entrances

C. This Phase was concluded and the VE Team proceeded to the Analysis Phase.

Phase III Analysis

A. The results of this phase are presented in the individual Value Engineering Proposals (VEP's) in the basic report. Each VEP compares advantages and disadvantages and analyzes in dpeth costs of present design and VE proposed design.

Phase IV Development

DEVELOPMENT NOTES

Following the Information and Speculation phases of the VE process, the team analyzed and developed further all ideas considered worthy of pursuit. Some of these ideas were developed only sufficiently to show that there was no particular advantage or saving. Other ideas were carried through to completion when they showed a good potential for improvement in function and/or cost savings.

Ideas which were explored but dropped were:

1. Raceways. Present design justified. Little cost savings with alternate design.
2. Elevators vs. Escalators. Little likelihood of acceptance.
3. Settlement Criteria. Too involved for VE analysis at this time.
4. Utilities Advance Contract. Present design similar concept. No savings unless better definition of work can be achieved. Possibly more design effort required to ensure that work is properly scoped for contract bidding purposes.
5. Utilities Field Change Policy. Cannot control unforseen conditions. Can improve by streamlining process per "Field Management" ideas and "CM Change Order & Dispute Resolution" ideas. Ideally would minimize cost impacts.
6. Miscellaneous Tunnel Details. No savings.

The other ideas were characterized into the following broad categories and each category was subjected to detailed analysis.

1. Contract Packaging.
2. Claim, Change Order & Dispute Resolution.
3. Design Quality Control.
4. Field Management.

These categories were developed into specific Value Engineering Proposals (VEP's) reported in the Main Body of the Report. The following categories were not detailed during this study pending further analysis and development in forthcoming VE Studies #2 and #3.

5. Tunnels:
    - 5.1. Tunnel Size.
    - 5.2. Tunnel Lining.
    - 5.3. Cross Passages.
    - 5.4. Tunnel Invert/Walkway.

6. Crossovers and Stations:
    - 6.1. Excavation.
    - 6.2. Shoring.
    - 6.3. Configuration.
    - 6.4. Vent Shafts.
    - 6.5. Ancillary Spaces.
    - 6.6. Mezzanines.
    - 6.7. Fare Collection.
    - 6.8. Platform Lengths.
    - 6.9. Platform Edges.
    - 6.10. Station Equipment.

Phase V Presentation

DEVELOPMENT NOTES

PRESENTATION, PHASE V

The presentation of study results was made at SCRTD offices in Los Angeles, California on 28 July 1989. Present were Messrs. R. H. Mitchell, H. A. Foster, W. R. McCutheon, T. G. McCusker, R. H. Miller, and J. W. Yee comprising the VE Team; SCRTD and MRTC representatives.

The VE Team presented its findings and recommended value engineering proposals that would result in total estimated savings of $100.62 Million, order of magnitude amounts. This total was revised to $201.25 Million upon later evaluation by the VE Team in order to account for latent costs (potential cost overruns) caused by poor District contracting "image" and by field changes caused by untimely design coordination. The VE Team emphasized that the totals presented at this time would be subject to further refinement during the next two VE study phases, with a final determination to be presented at the conclusion of the entire process.

Introduction by R. H. Mitchell. Note was made by the VE Team concerning the project scope and the adjustment of the estimates to achieve the project cost model presented by this study. Specifically, the VE Team was charged to study a part of the MOS-II line and a small part of the succeeding line extension to the Hollywood/Highland station.

<u>VE Proposal Briefings</u>

Project Management:

Contract Packaging.
Claim, Change Order & Dispute Resolution (Construction Management).
Design Quality Control.
Field Management (Streamline Field Engineering)

Tunnels:

Tunnel Size.
Tunnel Lining.
Cross Passages.
Tunnel Invert/Walkway.

Crossovers and Stations:

Cut & Cover - Crossovers & Tailtrack
Large Ancillary Spaces
Emergency Vent Shaft Locations
Open Up Stations

Short Question and Answer Period.

Closed Presentation.