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Practical Application of Value Engineering in Capital Projects

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One of the major challenges faced by owners, designers and contractors is the right application of value engineering on their projects. This presentation will provide an overview of the value engineering job plan, function analysis system technique, and will discuss a case study so participants can apply value engineering on their projects

EXPOSITOR

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- ✓ Mr. Francisco Cruz of PMA Consultants LLC is a senior director with over 16 years of experience in cost control, cost estimating, scheduling management, risk management, value engineering, project inspection, and supervisory management. His project experience includes infrastructure, pharmaceutical, mixed-use, corporate office buildings, and municipal projects. He has worked on projects in USA, Europe, South America, Asia and the Caribbean.
- ✓ 10+ year Membership at AACE International
- ✓ AACE Dominican Republic – Current VP Communications
- ✓ SAVE International – Current Florida Chapter's Secretary
- ✓ Certified as Value Management Associate (VMA) from SAVE Int'l
- ✓ Licensed Professional Engineer (PE), PMP, RMP, VDC

ALGO QUE NO SABEN DE MÍ:

Mr. Cruz has performed cost and schedule risk analyses and value engineering studies on more than 110 pharmaceutical and infrastructure projects, including tunnels, airports, bridges, roads, and ports totaling more than US$47B

CONTENT

- Principles and Purpose of Value Engineering
- Implementing the Value Engineering Job Plan
- Case Study – Florida's State Road 826 (Palmetto Expressway)
- Conclusion

Principles and Purpose of Value Engineering

Value Engineering (VE)

- Value Engineering is the systematic application of function-oriented techniques by a multi-disciplined team to analyze and improve the value of a product, process or service, and it is designed to eliminate or prevent unnecessary cost.
- VE often realizes over 10 to 1 return and 30 percent savings
- Also known as Value Analysis (VA) or Value Management (VM)
- VE is not a cost reduction, decrease resources or scope deletion exercise!
- Common standards include ASTM E1699-14(2020) and ASTM E2013-20

Value Engineering History

- 1947 VE Methodology Established at GE during WWII
- 1954 Adopted by US Navy
- 1959 SAVE International Formed
- 1969 NASA Incorporates VE
- 1993 OMB circular requires VE
- 1995 National Highway Systems Act
- 1997 FHWA Federal Regulation (23 CFR 627)
- 2014 Updated Federal Regulation

Savings Achieved with VE - FHWA

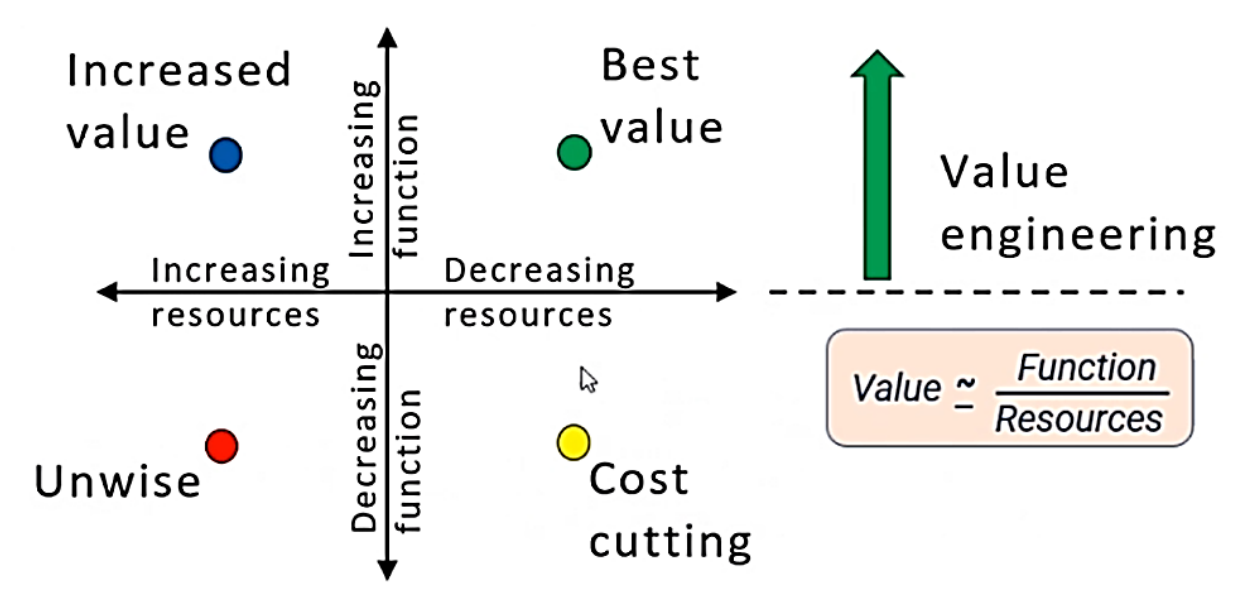
Summary Of Past VE Savings Federal-Aid and Federal Lands Highway Programs

	FY 2020	FY 2019	FY 2018	FY 2017	FY 2016
Number of VE Studies	334	246	175	160	198
Cost to Conduct VE Studies and Program Administration	$11 M	$12.5 M	$7.3 M	$6.6 M	$7.7 M
Estimated Construction Cost of Projects Studied	$23.2 B	$32 B	$22.7 B	$20.8 B	$16.7 B
Total Number of Proposed Recommendations	1,894	2,310	1,376	1,451	1,565
Total Value of Proposed Recommendations	$4.4 B	$5.5 B	$3.1 B	$2.8 B	$2.6 B
Number of Approved Recommendations	792	801	578	636	579
Value of Approved Recommendations	$1.9 B	$3.1 B	$1.1 B	$1.1 B	$868 M
Percent of Project Cost Saved	8%	10%	5%	5%	5.20%
Return on Investment	172:1	247:1	157:1	159:1	113:1

Source: https://www.fhwa.dot.gov/ve/ (2021)

Purpose of VE (Why)

- Improve Constructability
- Mitigate Risks
- Reduce Stakeholder Issues
- Improve the Project Schedule
- Reduce Overall Project Costs
- Reduce Operating Costs

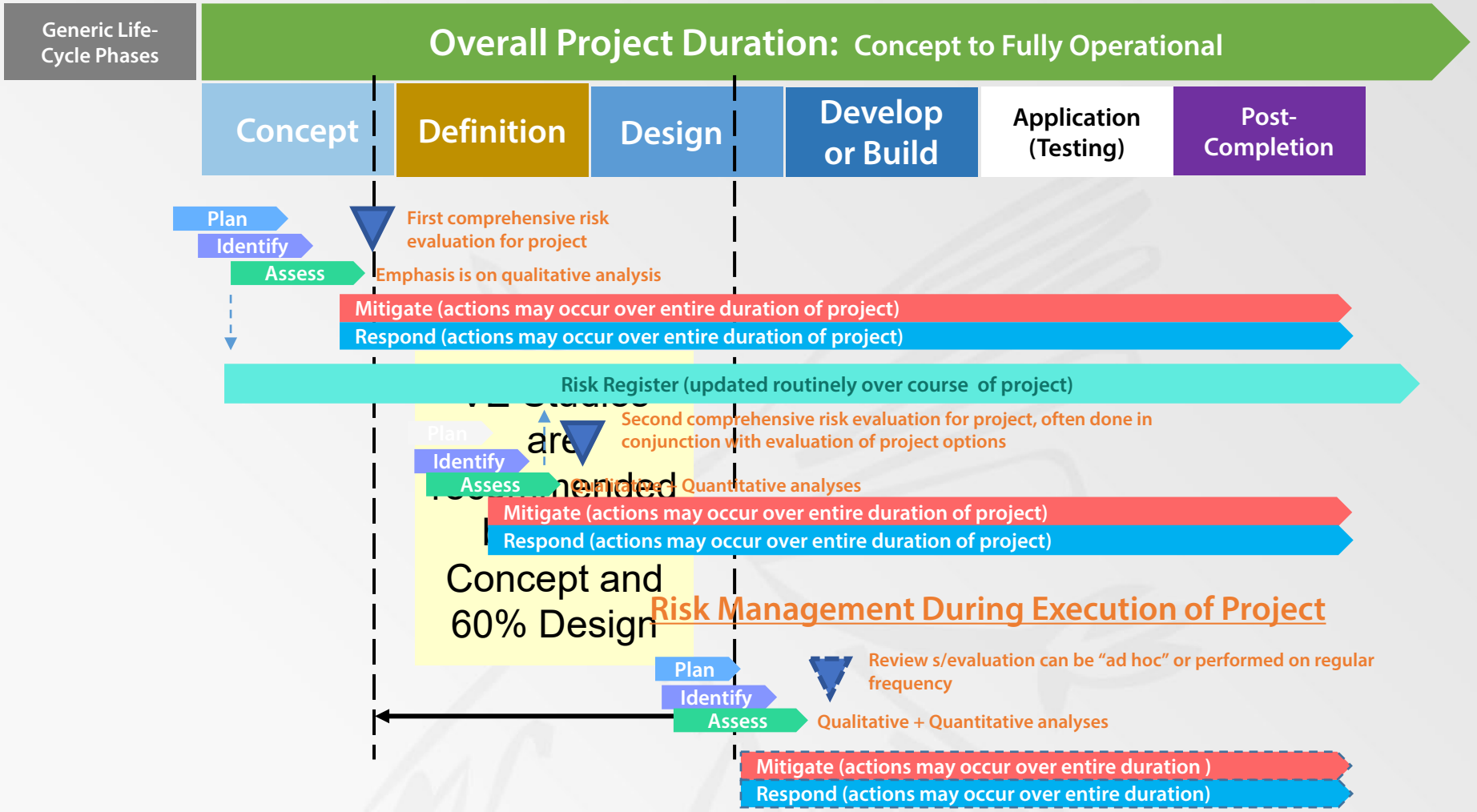


Source: Fun-tion Analysis, SAVE Int'l FL Chapter (2021)

Projects Best Suited for VE (What)

- 23 CFR 627
  - $50M Projects
  - $40M Bridge Projects
  - Not Design Build
  - Any project FHWA determines appropriate
- Some DOT's Have Their Own Thresholds
  - >$25M Projects
  - Major Bridges
  - Complex Projects
  - Based on Project Manager Requests

Application of VE (When)



Project Team Selection (Who)

- Team Leaders
  - Consultant or In-house
- Team Members
  - Civil/Structural
  - Mech./Electrical
  - Estimator, Scheduler, Claims
  - Value Specialists
  - Users/Operations/Maintenance
  - Specialized Expertise

Core team has 5-8 Participants

VE Study Location (Where)

- Key Items to Consider
  - Who is the audience?
  - What needs to be addressed?
  - Is the location a familiar place?
  - Is the meeting area accessible?
  - Is the space the right size?
- Establish Ground Rules
  - Nominate Referee: with “Red Card” just like soccer match
  - Nominate a Timekeeper
  - Use of Scribes

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Implementing the Value Engineering Job Plan

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Value Engineering Job Plan

VE Job Plan - Information

- Kickoff Meeting
- Project Overview
- Questions for the Design Team and Stakeholders' Input
  - Constraints, Issues, Risks, Exclusions
- Requirements and Performance Attributes
- Site Visit
  - Record any Observations and Take Pictures
- Post Site Visit

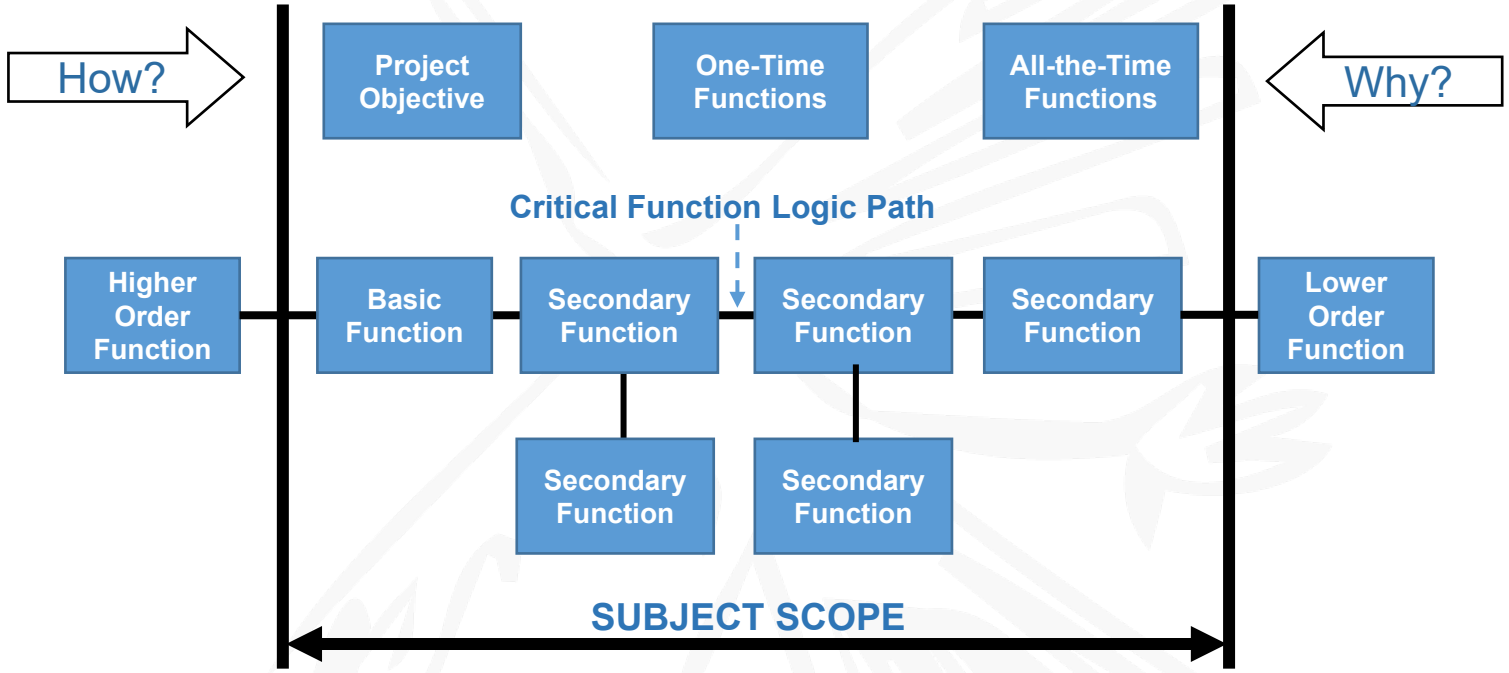
VE Job Plan – Function Analysis

- Define Functions
  - Express in 2 words: active verb and measurable noun
- Classify the Functions
  - Basic and Secondary Functions; High Order and Low Order Functions
- Estimate the Cost to Perform the Function
- Refine the Scope to Show Enhancements

VE Job Plan – Function Analysis

Information	**Function Analysis**	Creative	Evaluation	Develop Recommendations	Presentation

Function Analysis System Technique (FAST)



VE Job Plan – Function Analysis

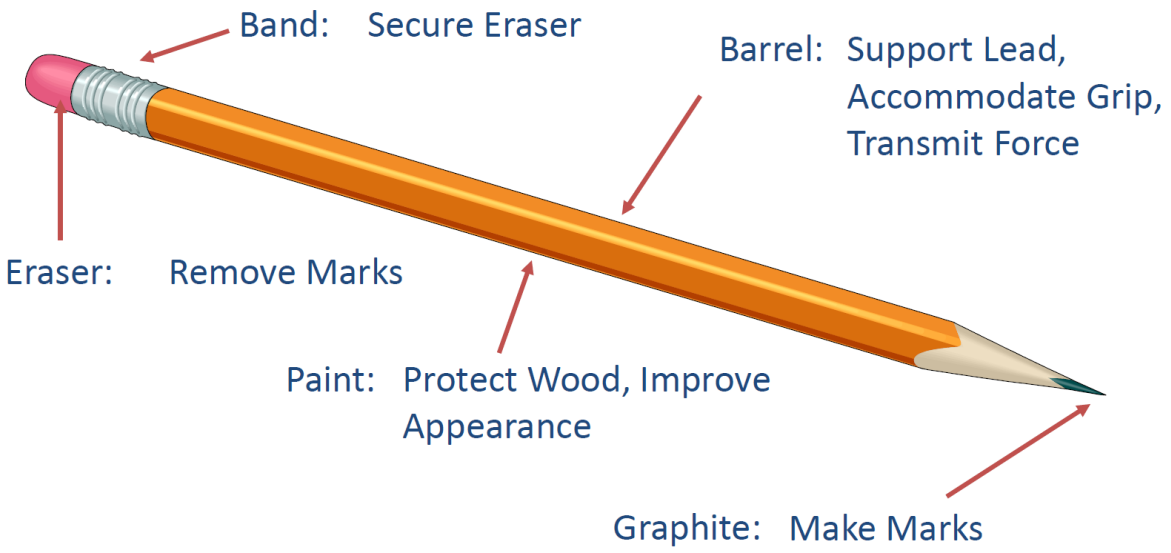
Information	**Function Analysis**	Creative	Evaluation	Develop Recommendations	Presentation

ASK DURING THE VE STUDY:

1. **What is it?**
2. **What does it do?**
3. **What does it cost?**
4. **What else can do it?**
5. **What does that cost?**

What is the function of this pencil?

"make marks"



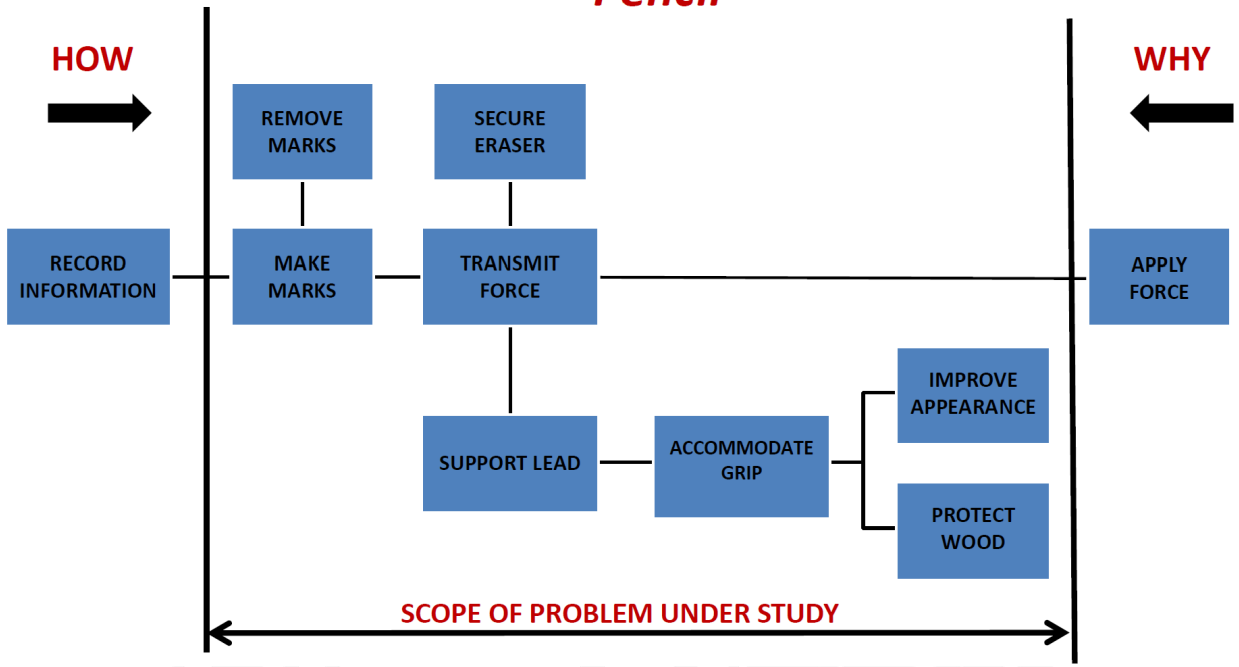
Source: FDOT Value Engineering Overview

VE Job Plan – Function Analysis

Information	**Function Analysis**	Creative	Evaluation	Develop Recommendations	Presentation

Function Analysis System Technique (FAST)

Pencil



VE Job Plan – Creative

- Generate Ideas for Alternatives Ways to Perform Identified Functions
- Involve All Team Members
  - Brainstorming
  - Checklists
  - Attribute Listing
- There Are No Bad Ideas!

VE Job Plan – Evaluation

- Remove Ideas with Low Potential
- Group and Combine Similar Ideas
- List and Evaluate Ideas including their Advantages & Disadvantages
  - Criteria includes Costs, Constructability, Operations, Maintenance
- Rank Ideas
  - Team Consensus; Weighted Matrix; Multi-Voting
- Select Ideas for Further Development

VE Job Plan – Develop Recommendations

- Determine How Each New Idea Would Work
  - Prove feasibility of each idea and test the initial assumptions
- Demonstrate That New Ideas Add Value and Meet the Basic Function
  - Perform Life Cycle Cost Analysis
  - Prepare Idea Write-Ups
- Develop Implementation Plan
  - Add description of the concept, sketches, diagrams, assumptions, cost

VE Job Plan – Presentation

- Determine How the VE Team will Present the Ideas
- Consider your Audience and Ensure Decision Makers are Present
- Reheard the Presentation and Anticipate Questions
  - Base Design versus New Ideas/Alternatives
  - Project Cost Analysis; Value-Added; Summary of Benefits
- Outline Implementation Plan

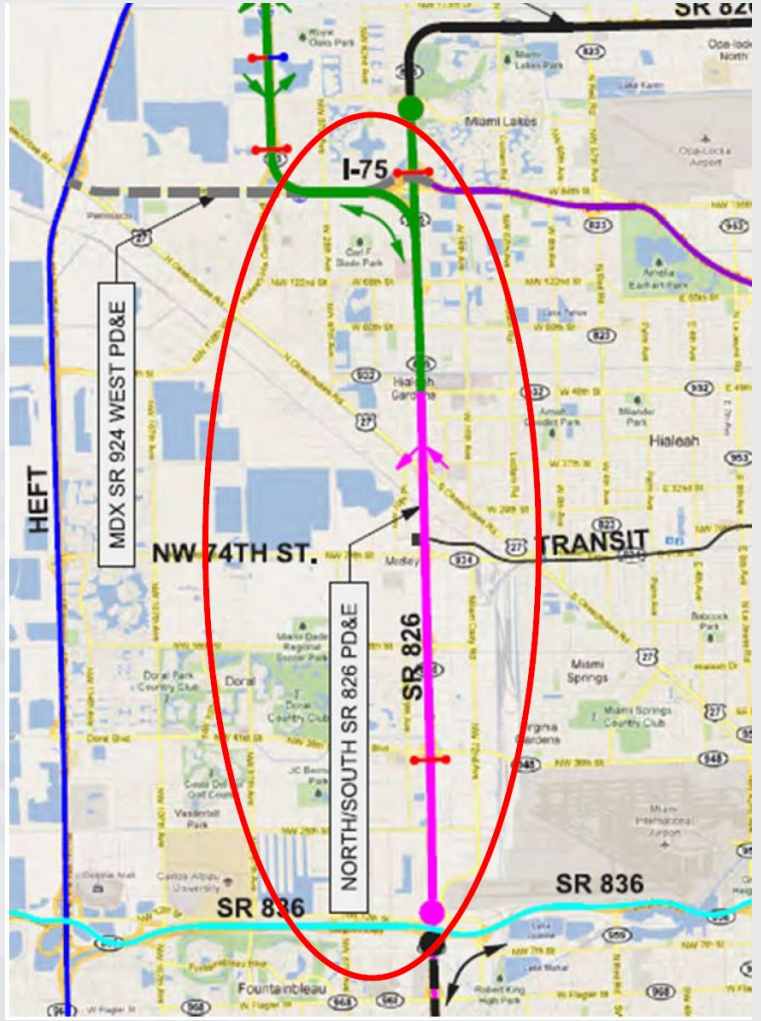
Case Study
Florida's State Road 826 (Palmetto Expressway)

Case Study – SR826 Managed Lanes

- Project length is six (6) miles
- Two (2) 11-ft managed lanes and four (4) 11-ft general lanes
- Project cost: US$291.95M
- Objective
  - Increase capacity
  - Enhance emergency response times
  - Improve connectivity in the region
  - Add two additional managed lanes in each direction in the center corridor
- Goals
  - Improve value in terms of capital cost, constructability, maintenance of traffic, and basic functional requirements

Information Phase

- Constraints
  - No additional right-of-way
  - Natural Gas mains
  - No improvements to the interchanges
  - Several flyovers along the corridor
  - Aggressive schedule
- Reviewed Documents Included
  - Design reports and drawings
  - Cost estimate and economic data
  - Right-of-way maps and estimates



Function Analysis Phase

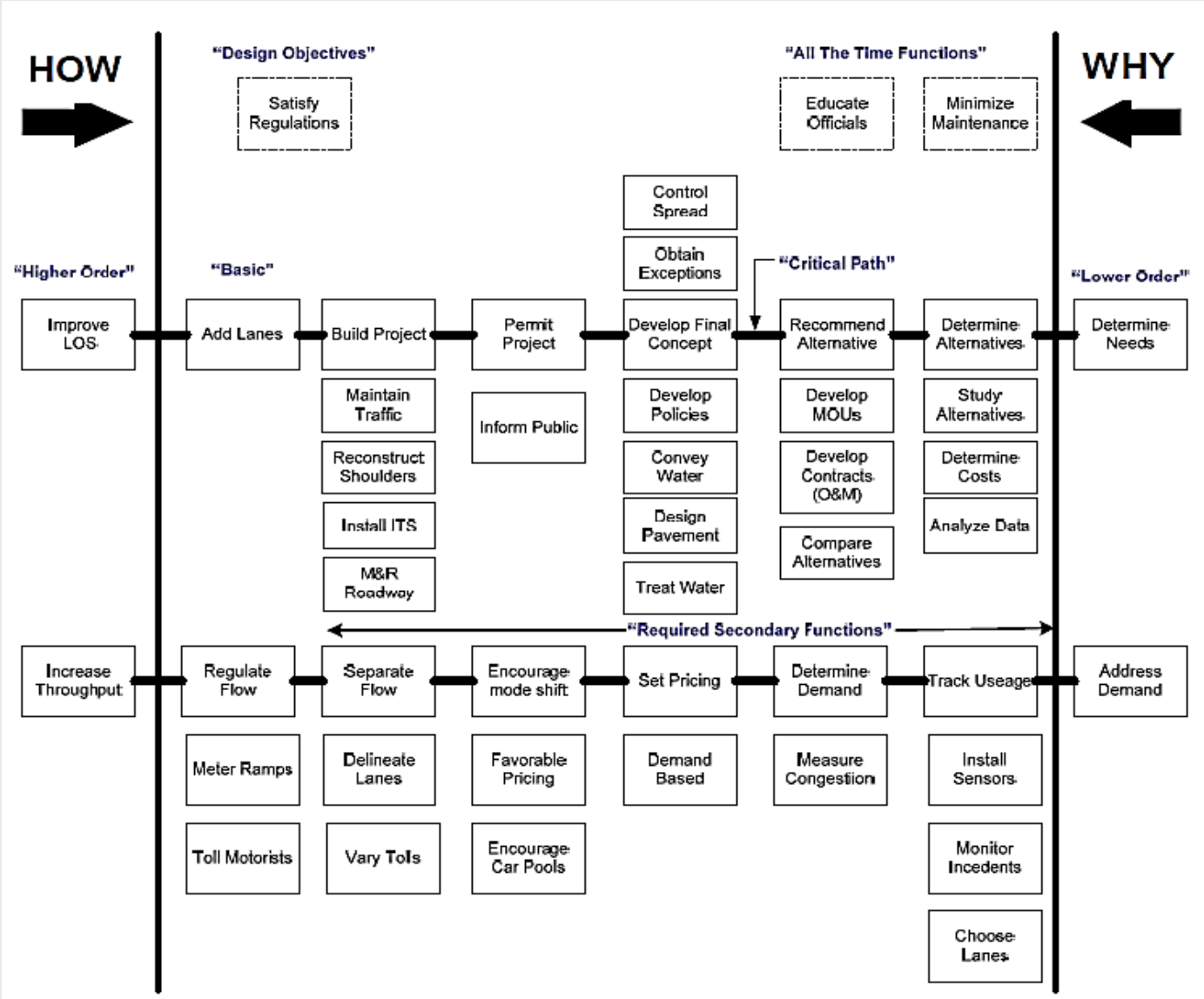
Cost Estimate Excerpt showing quantities, unit prices, cost line items and the functions determined by the VE Team

QTY TOTAL	QTY SR 826	QTY I-75	UNIT	ITEM NO.	PAY ITEM DESCRIPTION	UNIT PRICE	AMOUNT TOTAL	FUNCTION
2,865	2,640	225	LF	430-175-142	42" OPTIONAL PIPE (STORM DRAIN AND CROSS DRAIN)	$94.66	271,201	Remove Water
3,590	2,640	950	LF	430-175-148	48" OPTIONAL PIPE (STORM DRAIN AND CROSS DRAIN)	$111.85	401,542	Remove Water
24,521	24,521	0	LF	436-1-1	TRENCH DRAIN (15" STD.)	$158.25	3,880,448	Remove Water
25,196	21,166	4,030	LF	443-70-4	FRENCH DRAIN (24" DIAMETER PIPE)	$105.03	2,646,336	Remove Water
2,625	1,375	1,250	LF	443-70-5	FRENCH DRAIN (30" DIAMETER PIPE)	$67.30	176,663	Remove Water
1,415	1,000	415	LF	443-70-6	FRENCH DRAIN (36" DIAMETER PIPE)	$83.80	118,577	Remove Water
170	25	145	CY	400-1-2	CLASS I CONCRETE (ENDWALLS)	$666.92	113,336	Remove Water
2,848	2,848	0	CY	400-2-1	CLASS II CONCRETE (CULVERTS)	$616.47	1,755,707	Remove Water
40	40	0	CY	400-2-2	CLASS II CONCRETE (ENDWALLS)	$668.80	26,752	Remove Water
523	523	0	CY	400-2-10	CLASS II CONCRETE (APPR. SLAB)	$355.70	186,005	Remove Water
427,200	427,200	0	LB	415-1-6	REINFORCING STEEL (MISCELLANEOUS)	$0.76	324,672	Remove Water
167,919	167,919	0	SF	455-133-3	SHEET PILING STEEL (F&I) PERMANENT	$17.84	2,995,679	Remove Water
58,353	34,147	24,206	LF	521-1	MEDIAN CONCRETE BARRIER WALL	$82.29	4,801,877	Separate Traffic
28,127	27,003	1,124	LF	521-8-1	CONC. TRAFFIC RAILING BARRIER (32" F-SHAPE)	$123.73	3,480,134	Separate Traffic
13,705	13,705	0	LF	521-72-4	SHOULDER BARRIER WALL CONC (RIGID-RETAINING)	$152.62	2,091,707	Provide Refuge
62,327	62,327	0	LF	521-73	BARRIER WALL REMOVAL	$30.95	1,929,023	Provide Refuge
39,268	15,062	24,206	LF	539-80-111	CONCRETE BARRIER WALL (OPAQUE VISUAL)	$27.85	1,093,614	Provide Refuge
516,295	496,625	19,670	SF	548-12	RETAINING WALL SYSTEM (PERMANENT)	$24.56	12,680,208	Provide Refuge
7,598	7,598	0	EA	705-11-1	DELINEATOR FLEXIBLE TUBULAR	$50.00	379,885	Guide Traffic
3,799	3,039	760	EA	706-3	RETRO-REFLECTIVE PAVEMENT MARKER	$3.07	11,662	Guide Traffic
60,150	60,150	0	SF		BRIDGE DEMOLITION	$60.00	3,609,000	Span Obstacles
212,482	212,482	0	SF		BRIDGE SEGMENTAL	$200.00	42,496,400	Span Obstacles
47,303	47,303	0	SF		BRIDGE AASHTO (WIDENING)	$160.00	7,568,480	Span Obstacles
ROADWAY					**SUBTOTALS**		**128,658,570**	
			LS		LIGHTING		800,667	Illuminate Surroundings
			LS		SIGNING & MARKING		4,156,048	Inform Public
			LS		NOISE WALL		4,700,000	Abate Noise
			LS		ITS & TOLLING		18,658,590	Manage Traffic/Collect Revenue
			LS		ENVIRONMENTAL MITIGATION		1,500,000	Cure Damage
			LS		LANDSCAPE		4,000,000	Improve Aesthetics
			LS		UTILITIES		8,300,000	Maintain Utility
			LS		FIRE SUPRESSION SYSTEM		432,006	Improve Response
					SUBTOTALS		**171,205,882**	
			LS		CONTAMINATION		2,000,000	Remediate Site
			LS	101-1	MOBILIZATION	10%	17,120,588	Start Project
			LS	102-1	MAINTENANCE OF TRAFFIC	10%	18,832,647	Maintain Traffic
					CONTINGENCY	20%	41,431,823	Manage Unknowns
			LS		CEI	8%	18,380,663	Ensure Quality
			LS		DB DESIGNING FEE	10%	22,975,829	Prepare Documents
PROJECT					**TOTALS**		**291,947,433**	

Function Analysis Phase

A FAST diagram was developed to identify and display the critical functions path for the overall project.

The basic and supporting secondary functions are also illustrated



Creative and Evaluation Phases

There were 31 creative ideas and 11 that were evaluated and scored. The table is an excerpt of the complete ideas' matrix

During the evaluation process the VE team redefined some of the creative ideas as questions for the designers or design suggestions.

Idea No.	Ideas	Capital Costs	Ease of Construction	Future Maintenance	Schedule Impacts	Traffic Operations	MOT	Requires Variation or Exception	Meets Future Needs	Public Buy-in
	Original Concept									
	PD&E Documents	3	3	3	3	3	3	3	3	3
	Managed Lanes									
1	Relocate the north managed lanes entrance and exits to north of NW 103rd St. and move the gore for the southbound exit ramp at NW 103rd St. further north	2	3	3	3	2	3	3	3	4
DS-1	Minimize the features that require maintenance (i. e., lights, inlets, etc.)									
3	~~Put tolling equipment on existing bridges instead of adding gantries that span the roadway~~									
4	Retrofit the existing sign structures to accept the signing and tolling equipment	2	2	3	3	3	3	3	2	3
5	Carry three GP lanes under SR 836 and one managed lane	4	4	4	4	2.5	4	4	2	3
6	Consider a 4 + 1 with full shoulders on the managed lane in each direction	5	5	2	4	1	5	5	2	3

Develop Recommendations Phase

Example of the development of a recommendation, which shows the design intent versus the VE alternative

Recommendation No. 22:

RECOMMENDATION No. 22: In Section 5 construct the crown and 11-ft striping for our project to avoid milling and resurfacing rework, also extend the fifth northbound lane further south

Preferred Alternative:
The limits of this project show an overlap with ongoing construction project FIN # 24958115201 – SR 826 Section 5. The overlap is between NW 7th Street and NW 25th Street on SR 826.

The Department is presently negotiating with the Joint Venture Team to revise the scope of work along SR 826 to modify the shoulder pavement and drainage for the future Managed Lane project. This modification does not include changes to friction course and signing & pavement markings.

The concessionaire will have to mill and resurface friction course and install new pavement markings with paint and thermoplastic for the managed lanes delineation on the recently completed Section 5. Managed lane construction will also have to change location of NB & SB roadway crowns in locations where they fall within wheel paths.

VE Alternative:
The Section 5 Joint Venture Team will construct friction course, change crown locations and stripe SR 826 between NW 7th Street and NW 25th Street to match final configuration of the managed lanes project. Friction and striping for the additional managed lanes will be delineated in the interim by gore pavement markings. During construction of managed lanes, friction course and final striping of additional lane and shoulder will be completed by the concessionaire.

Consideration should be given to installation of managed lane sign structures by the Section 5 Joint Venture Team.

Develop Recommendations Phase (Con't)

Example of the development of a recommendation, which shows the design intent versus the VE alternative

Some ideas may require life cycle cost analysis

Advantages :

- Less overall cost due to eliminating rework.
- Less negative public opinion with apparent wasteful construction and additional traffic impact.

Disadvantages:

- Shifts the cost of work to the current Section 5 project
- Re-design effort for Section 5

FHWA CATEGORIES

___Safety ___Operations ___Environment _X__Construction ___Other

Potential Cost Savings: $940,000

Calculations:

Description	Quantity	Unit	Unit Price	Extended Amount
Milling 1" Depth	-96,000	SY	$1.91	($183,360)
Friction Course FC-5	-3,600	TN	$95.00	($342,000)
Paint Striping 6" Solid	-4.5	NM	$650.00	($2,925)
Paint Striping 6" Skip	-9.0	GM	$138.00	($1,242)
Paint Striping 6" Solid	-4.5	NM	$3,720.00	($16,740)
Paint Striping 6" Skip	-9.0	GM	$937.00	($8,433)
Subtotal				($554,700)
MOT (10%)				($55,470)
Mobilization (10%)				($61,017)
Subtotal				($671,187)
Project Unknowns (20%)				($134,237)
CEI (8%)				($59,996)
DB Designing Fee (10%)				($74,995)
		CONSTRUCTION TOTAL		**($940,416)**

Presentation

TABLE 1.4 – 1
SUMMARY OF HIGHEST RATED RECOMMENDATIONS

		PRESENT WORTH (PW) OF COST (FUTURE COST)		
Rec. No.	**Description**	**Management Action**	**Comments**	**Potential Cost Savings (Value Added)**
6	Consider a 4 + 1 with full shoulders on the managed lane in each direction	NA		$5,300,000
13	From NW 36th to NW 58th streets realign the mainline to the east along the frontage road	NA		($1,282,000)
16	At the I-75 interchange the mainline alignment should be shifted to the west to allow for 10-12 ft. inside shoulders	A		($3,428,000)
19	Shift the SR 826 southbound alignment further west to provide 10-12 ft. inside shoulders from NW 74th to Okeechobee Road	NA		($7,632,000)
22	In Section 5 construct the crown and 11-ft striping for our project to avoid milling and resurfacing rework, also extend the fifth northbound lane further south	A		$940,000
23	Add variable speed limits to the General Purpose Lanes	NA		($1,282,000)

Management Action Legend: A=Accepted, NA=Not Accepted, FS=Further Study

Conclusion

Take Away

- Apply VE early in the design to maximize value
- Implement the VE Job Plan and FAST Diagrams
- Use a Multi-disciplinary team and encourage any type of ideas
- Review Value Added recommendations
- Value Engineering is not a cost-cutting or scope reduction exercise

PMA VE Study Efficiencies

by Client and/or Discipline (1998-2019)

VE Studies	Construction Budget	Potential Cost Savings	Implemented Savings	Percentage Implemented
Environmental (Water & Wastewater)	$608,880,000	$158,924,000	$48,140,000	7.9%
Florida Department of Transportation	$6,770,000,000	$1,964,670,000	$1,362,450,000	20.1%
Florida Department of Transportation – Process	$1,250,000,000	$377,000,000	$219,000,000	17.5%
Michigan Department of Transportation	$160,000,000	$24,600,000	$16,800,000	10.5%
Florida's Turnpike	$180,000,000	5,000,000	$4,500,000	2.5%
National Park Service	$56,000,000	$26,000,000	$17,300,000	30.9%
Orange County Convention Center	$500,000,000	$120,000,000	$100,000,000	20.0%
Rail	$9,232,000,000	$2,661,000,000	$2,070,300,000	22.4%
Training	$260,000,000	$92,000,000	$44,000,000	16.9%
New York World Trade Center	$17,500,000,000	$2,600,000,000	$2,100,000,000	12.0%
Military	$78,000,000	$18,000,000	$18,000,000	23.1%
Hotels, Resorts, Medical, Schools, Colleges, Buildings	$176,000,000	$52,000,000	$22,000,000	12.5%
Mississippi Dept of Transportation	$250,000,000	$35,000,000	$15,000,000	6.0%
Airports	$617,000,000	$62,000,000	$52,000,000	8.4%
New Hampshire Department of Transportation	$49,000,000	$13,000,000	$10,000,000	20.4%
Educational/Governmental Facilities	$27,317,000	$8,368,000	$6,958,000	25.5%
Totals	$37,714,197,000	$8,217,562,000	$6,106,448,000	16.2%

Questions comments?

Thanks.