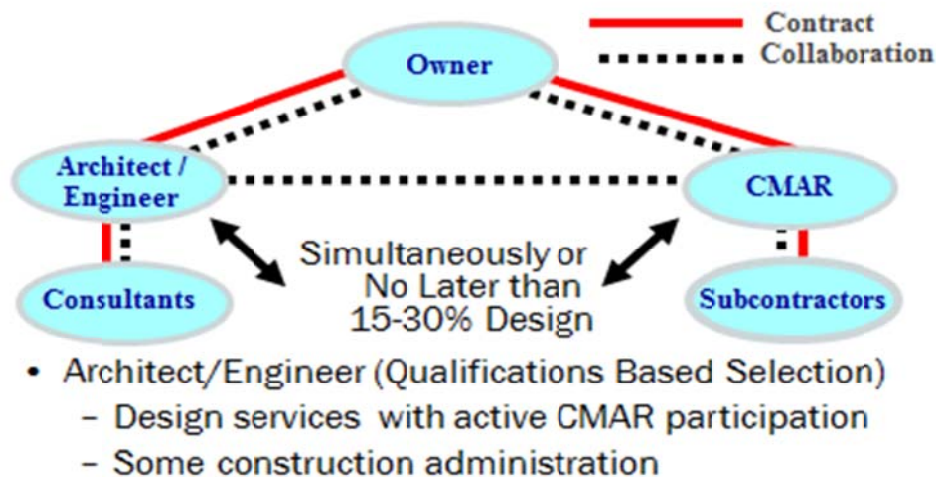


**RISK ANALYSIS AND VALUE ENGINEERING  
IN CONSTRUCTION MANAGER AT RISK (CMAR) PROJECTS  
(An ADOT/FHWA Pilot Project)**

*Presented by Renee L. Hoekstra, CVS, President, RH & Associates, Inc.*

**What is CMAR?**

CMAR is a contracting method where there are two contracts with the contracting entity. One for design, and one for construction. The contracting methodology can be different with each agency, however, the CMAR contract can be advertised at the same time as the design contract or after the design has begun. It is recommended that the CMAR be brought on board no later than 15% into the design. The earlier that the CMAR is brought into the project, the more benefits the agency will gain from the entire process. There have been many agencies that have brought in the CMAR at 90%, which means the complete benefit for early contractor input is not realized. The graphic below illustrates the contractual and collaborative approach to a CMAR contract.



So, now that we have both entities on board at the same time, we should really take advantage of the expertise being provided with a formal VE workshop. FHWA requires an outside team to provide the VE for a traditional Design-Bid-Build project. In order to take advantage of the CMAR process the existing team needs to be a part of the VE study. This allows the project to benefit from the early involvement from the contractor that is going to build the project. This ensures that the project is designed the way the project will be constructed, versus designing so that everyone can bid the project. CMAR is a much more efficient and cost effective way to design and construct a project. With this said, the Risk and VE team needs to include the original designer, the CMAR team, and potentially a couple of other technical experts, as needed. The VE team would also include the owner, both the design and construction disciplines, potential stakeholders that might be involved, and FHWA, as desired. I would recommend that FHWA's involvement is helpful for both design elements and impacts to funding.

It is important to understand that the appropriate composition of the team is absolutely critical to the success of the workshop;

### A Quality Team = Quality Results

The specific team members from the identified organizations should include the existing design team, including the project manager together with the key design discipline members. The CMAR team should include the pre-construction services manager, the construction project manager (if different from the pre-construction services manager), a cost estimator and the project superintendent, if possible. From the agencies' perspective, this would include the design project manager, the key discipline design leads, and the construction resident engineer. Other team members to consider might include FHWA, and in the example of the Loop 303 project for ADOT, the City of Surprise was included as a very important stakeholder in the project. In fact they had two members full time on the VE team. In a CMAR, the team can be a little larger than one might expect in a traditional project VE workshop, but it is very important to have the construction people involved as the team makes decisions related to the design, which will eventually impact construction.

Let's talk about the actual workshop itself, as the approach should change to accommodate the CMAR process and team. In a CMAR project, we are able to reduce the workshop to 3 days and still get an unbelievable amount accomplished. There is a caution here however. The CVS team leader must have the ability to really get the team through these steps in a very efficient and effective manner. A strong leader is required to get the team to focus on specific and measurable outcomes. The following outlines the job plan as followed in a CMAR project with a Risk Analysis included in the workshop.

- Information Phase
- Risk Analysis
- Function Phase
- Creative Phase
- Evaluation Phase
- Development Phase
- Innovation and Opportunities

The presentation phase in a CMAR may not be needed, as the entire team is part of the workshop, so the additional time that is often used to prepare and then present is eliminated from the process. However, since this is a new approach, upper management may want to be debriefed and a formal presentation might be scheduled.

Here is where things change a little for the CMAR project, and it outlines how we are able to complete an amazing amount of work in a very short amount of time.

**Information Phase** – During this first step in the job plan we don't really have to spend much time getting team members up to speed on the project. They have all been involved and know the project fairly well. Now we will still have the design team, if they were selected prior to the CMAR, and the owner should provide a presentation on the project. This would be to ensure

that the entire team will have an understanding of decisions made as to the current approach, or any political drivers that might be involved with the project, such as existing Cooperative Agreements, environmental impacts, etc. We will still develop the study goals and objectives, determine project concerns and constraints, develop performance measures, then rate and rank them (this is an important step as we will use these performance measures during the design process and during construction). We will discuss the budget, and any potential areas of concern for the team to maintain a focus. I would like to point out an interesting point that was made during the Loop 303 CMAR Risk and VE Workshop. Upon completion of the identification and rating/ranking of the performance measures, the contractor stated that he was amazed at the how the performance measures ranked and that he would not have expected the outcome. It was a great ah-hah moment for the team.

**Risk Analysis** – The risk analysis process is a simple yet detailed discussion. The team will populate a simple risk registry by brainstorming all potential risks related to the project. Then the team will determine probability, severity, cost impacts, and schedule impacts. The next step in this process is for the team to decide on a preliminary disposition of the risk. Should it be eliminated, mitigated or accepted. Those risks that need to be eliminated or mitigated will be listed on a flip chart for use during the workshop. Once this is completed, the team will go on to the next step in the job plan. The risk registry becomes a living document for the team to use and update throughout the project. It is always recommended that at each deliverable the registry be updated to ensure the risk was managed during the design, and additional risks that may have been identified are added to the list.

**Risk Matrix**

Risk Matrix										
Probability of Occurrence		Highly Likely	Likely	Possible	Unlikely	Very unlikely	MATRIX KEY			
		> 70%	51 - 70%	21 - 50%	5 - 20%	< 5%				
Severity of Impact		Catastrophic	Substantial	Moderate	Marginal	Negligible				
		100	50	20	5	1				
Risk Rating		Extremely High Red (80 - 90)		High Orange (15 - 49)		Moderate Yellow (3 - 14)		Low Green (0 - 2.9)		
Identify the Risk		Assign the Risk		Classify the Risk			Quantify	Quantify	Risk Response	
Risk ID	Description of Risk	Who does the risk affect?		Probability of Impact %	Severity of Impact (numeric)	Risk Rating	\$S Impact	Schedule Impact	Avoid? Mitigate? Accept?	Plan of action and risk champion/owner.
Identify the Risk										
1.1	Irrigation design by MWD on the south end of the project (Greenway south)	Design and construction		60%	50	100.0	\$ 200,000	120 days	Avoid	
1.2	Right of way acquisition - total	Construction		20%	50	25.0	-	90 days	Avoid	
1.3	Well removal and abandonment at Greenway	Construction		50%	20	20.0	-	90 days	Mitigate	
1.4	Utility relocations	Some design, mostly construction		30%	50	50.0	-	6 month	Mitigate	
1.5	Roadway drainage during construction	Construction and travelling public		70%	50	100.0	500,000	120 days	Mitigate	
1.6	Drainage outfall on south end of the project	Design, construction & property owners		70%	50	100.0	Design Construction	n/a	Mitigate	
1.7	Schedule commitment made to SLR by ADOT	ADOT		5%	50	25.0	20,000,000		Avoid	
1.8	GMP schedule April 15, 2011	Entire Project		5%	100	50.0			Avoid	

**Function Analysis** – This process is no different than a traditional VE workshop, but it is still an important step in helping the team understand the entire project. In a 3-day workshop however,

a FAST diagram is not completed as the team usually has a very good understanding of the project scope since they have been involved for several months through the proposal phase of the project. This provides another opportunity to reduce the length of time needed for the workshop. If we use the Loop 303 CMAR pilot project as an example, sample functions included Increase Capacity, Accommodate Drainage, Accommodate Traffic, Mitigate Sound, Mitigate Dust, and Improve Aesthetics.

**Creativity Phase** – The Creativity Phase of every VE workshop is the fun part of the workshop. This is a great opportunity to really capitalize on the experiences of the VE team and, in this case, in particular the CMAR. One of the key elements of this phase is for the CMAR to bring the ideas that were provided during the proposal phase to the attention of the VE team. A criticism we have heard from other organizations is that *the CMAR firms are proposing ideas that never get brought to the table even though they were selected on their potential ideas*. This is an important step during creativity to bring these ideas forward at this point in the workshop. As in standard VE workshops, the team will also brainstorm additional opportunities by each function identified, by asking the typical question – How else might we accomplish the function? The other additional element during creativity is to have the team review the risk registry that was developed through the risk analysis, and then brainstorm opportunities for managing or eliminating the risk. In the Loop 303 project, an additional 85 ideas were brought to the project including proposal ideas from the CMAR.

**Evaluation** – The Evaluation Phase is not a complicated selection process. The VE team members are very familiar with the project, performance measures and the functions required to ensure the project's success. RHA uses the "GFI" (Gut Feel Index) method to first synthesize the ideas; identifying fatal flaws or ideas that might be deemed out of scope. The second cut is to have the team members, using a group nominal technique, select those ideas that would provide the best value for the project. Those ideas with the most votes will move forward to development.

**Development/Decision-making** – As with the Information Phase, here is where things are different than a traditional VE workshop. The individuals that will be designing, reviewing and constructing the project are all on the VE team as study participants, so the development of the selected ideas is done as a team event, with no individual write-ups, drawings, etc. We still review each idea by discussing the following:

- Identify the existing approach
- Identify the new approach
- Identify advantages and disadvantages
- Evaluate the idea against the performance measures – specific measures
- Determine costs associated with the new idea

The sample form is shown on the next page.

VALUE ENGINEERING ALTERNATIVE		 <small>FEDERAL HIGHWAY ADMINISTRATION</small>	
		IDEA NUMBER	PAGE NO.
			1 of 1
TITLE:			
ORIGINAL CONCEPT:			
ALTERNATIVE CONCEPT:			
ADVANTAGES:		DISADVANTAGES:	
DISCUSSION / JUSTIFICATION:			
IMPLEMENTATION CONSIDERATIONS:			

Performance Criteria						Cost Impacts
Performance Measure						
DISPOSITION: (Accept      Conditional Accept      Reject)						

Rating Scale: Value Add +2 +1 0 -1 -2 Value Destroy

The form shown above is used for our CMAR VE workshops. Please note on the second page we specifically evaluate the impacts of the new idea on the performance measures identified during the information phase. This is an important step since we are going to be asking for decisions upon completion of the form. We will also ask for cost impacts. In a standard VE workshop, the costs are often order of magnitude costs. In a CMAR we often have the cost estimators working in a separate room on the ideas, developing costs so that we have much more accurate costs for the proposed ideas. Immediately below the performance ranking section on the form, the team is asked to make a decision as to the disposition of the idea. We then accept, conditionally accept, or reject the idea. The key here is that decisions are made during the workshop and the design team has the ability to go to work immediately. There is no waiting for the report to be completed and decisions to be made. However, if the conditionally accept designation is used, the team must decide what is needed and the timeline required for completion. No ideas are left for future resolution. The design can either begin or continue immediately based on the decisions made during the workshop.

**Innovation & Opportunities** – FHWA, like many other agencies, has begun to embrace the CMAR approach for projects. Two such pilot projects have been completed for ADOT with FHWA oversight and participation. I have mentioned the Loop 303 project and the second project was for the Cordes Junction Traffic Interchange. A challenge that has been identified with this contracting method is that it has been difficult to show that the CMAR process is beneficial to the agencies using them. In an effort to try and aid in clearly showing how CMAR is beneficial, RHA developed an Innovation & Opportunities Matrix to be used throughout the project to identify and track benefits through both the design and construction phases. The important thing to note here is that we will use the same performance measures as identified

during the VE workshop to ensure that the decisions the team makes into the future are consistent with the project performance attributes. The contractor is usually responsible for managing and jointly updating the matrix with the client, with a copy being provided to the FHWA on a monthly basis. The goal is that by using the form, we can show the benefits that are being gained by the team working together in a CMAR project in a much more effective manner, and able to make more timely decisions saving both time and money. The following is a copy of the Innovation and Opportunities Matrix.

**Loop 303 CMAR  
OPPORTUNITIES/INNOVATION MATRIX**

Performance Ranking Scale:	5 = Significant Value Improvement	4 = Good Value Improvement	3 = No Change Equal to Existing Concept					
	2 = Minor Value Degradation		1 = Significant Value Degradation or Does not Meet Purpose/Need					
Performance Criteria:	MOT	M	S	C	PP	D	R	
Overall Rating Criteria:	Significant Improvement +2, +1, 0, -1, -2 Significant Degradation							

Performance Criteria													
No.	Opportunity/Innovation	MOT	M	S	C	PP	D	R	Cost Impact (\$) = ( ) Savings	Schedule Impact (days)	Overall Rating	Accept/ Reject	Comments Supporting the Rating
xx													
1.00											0		
2.00											0		
3.00											0		
4.00											0		
5.00											0		
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7.00											0		
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CMAR is proving to be a very effective alternative for project delivery, which combined with formal risk analysis and value engineering we have even much more to gain. There are a number of clear benefits, including:

- |   |  |
|---|--|
| <ul style="list-style-type: none"> <li><input type="checkbox"/> Team approach from start to finish</li> <li><input type="checkbox"/> Increased owner control</li> <li><input type="checkbox"/> <b>Value engineering (innovation)</b></li> <li><input type="checkbox"/> Controlled purchasing</li> <li><input type="checkbox"/> "Open book" financial approach</li> <li><input type="checkbox"/> Fewer Claims/Litigation</li> <li><input type="checkbox"/> Improved collaboration</li> <li><input type="checkbox"/> Common goals and objectives</li> </ul> | <ul style="list-style-type: none"> <li><input type="checkbox"/> <b>Increased value for each dollar spent</b></li> <li><input type="checkbox"/> Shorter project schedules</li> <li><input type="checkbox"/> Improved construction quality</li> <li><input type="checkbox"/> Construction planning</li> <li><input type="checkbox"/> Phased construction options</li> <li><input type="checkbox"/> Fewer warranty problems</li> <li><input type="checkbox"/> Improved service response to owner</li> </ul> |
|---|--|